CITY OF TALLAHASSEE

A WATER QUALITY AND BIOLOGICAL ASSESSMENT OF SELECTED LAKES

Water Resources Engineering

September 2011

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EXECUTIVE SUMMARY

The Lakes Monitoring Program was established by the City of Tallahassee in 1990 with the objective of building a database of information and to monitor the health of area lakes on a continuing basis. The data collected are used to establish ambient water quality conditions, identify lakes with potential water quality problems and to detect water quality trends. Monitoring the condition of area lakes also provides an information feedback loop that can be used to evaluate the effectiveness of current stormwater management practices.

This report, which is the ninth water quality report presented since the program began, provides water quality and biological information from 1990 to 2010 on the following 17 Tallahassee-area water-bodies: Moore Lake, Tom Brown Park (Leon) Lake, A.J. Henry Park Lake, Campbell Pond, Lake Hall, Lake Overstreet, Lake Hilaman, Lake Killarney, Lake Kanturk, Lake Cascade, Lake Hiawatha, Lake Bradford, Piney Z Lake, Goose Pond, Chicken Branch, Eagle Lake, and Hawk Pond.

LAKE SUMMARIES

Moore Lake

Moore Lake is the Lakes Monitoring Program's reference lake located in a small closed basin in the Apalachicola National Forest. This 60-acre water-body has no inlet or outlet streams and essentially no development in its basin and has been previously rated good to excellent on all of the lake rating indices. However in 2001, following passage of two tropical storms, Moore Lake experienced significant increases in watercolor transforming the water-body from a clear water lake to one that had a "tea" color appearance. At the same time high levels of ammonia were detected in the lake. These water quality changes, which are entirely natural in origin, are probably responsible for the "poor" Lake Condition

Index (LCI) rating in 2001. However, the foregoing water quality changes were essentially a transient phenomenon. Evaluation of the 2010 LCI score reveals that the macroinvertebrate community is recovering and is nearly triple than that of 2001, showing improvement in the benthic community. Other parameters show that over the past few years the lake has returned to its former status as an acid-clear, oligotrophic water-body.

Tom Brown Park Lake

Tom Brown Park Lake is one of the more degraded lakes of the seventeen covered in this report. The lake essentially functions as a stormwater treatment facility and receives runoff from areas that include ball fields, roads, and the federal prison. In 2002, notable increases in turbidity and alkalinity were recorded. These water quality changes were attributed to construction activities associated with the Conner Boulevard expansion project. Since the completion of the road improvements, the turbidity and alkalinity in the lake have slowly returned to normal. Its flow-through nature does help it precariously maintain a fishery. Macrophyte coverage in the main lake area has been greatly reduced over the years and is now concentrated around the shoreline, where the herbaceous species elephant ear and the exotic water hyacinth dominate. Under FDEP's Impaired Waters Rule, this lake is considered "impaired" based on the color and trophic state index scores. The establishment of beneficial plants in the littoral zone of this lake could improve the ecological condition of this reservoir.

A. J. Henry Park Lake

A. J. Henry Park Lake is a 14.3-acre reservoir located partially within the City of Tallahassee (COT) Park of the same name. This lake, which receives runoff from a heavily urbanized drainage basin, has been degraded by stormwater and sediment inflows from past erosion and construction in its basin. It is the only lake of the 17 water-bodies covered in this report that merits a hypereutrophic rating based on its water quality results alone. Turbidity levels have consistently been higher than any other lake in this study. Although past construction activities in the basin have been a major contributing factor, algae blooms that are now present in the lake on a perennial basis are the prime cause of the elevated turbidity. However, algal blooms have been notably less intense over the past few years, an observation that is reflected in the lake's TSI scores in 2005; three scores from the 4 quarters were below 40. However, values doubled in October 2005 and have remained high through 2008. These evaluations place this lake in "impaired" status under FDEP's Impaired Waters Rule. Anecdotal evidence suggests the lake sustains a healthy population of catfish, bream, and largemouth bass.

Campbell Pond

Campbell Pond is a 35-acre reservoir located largely within the City's Campbell Pond Park that has survived urbanization somewhat unaltered. The drought of 1999-2001 significantly diminished the size of the lake (to just a few acres) and negatively affected its water quality. However, since the lake has been replenished, water quality values have returned to their long-term averages. Indeed, based on its current TSI and TP values, Campbell Pond would rank among the best of the clear water acidic lakes in this study. It's somewhat higher (worse) bacterial count is the only indication that Campbell Pond is an urban lake and detracts from its otherwise excellent water quality. Campbell Pond overall is a mesotrophic system and supports an abundant aquatic plant community; it is also is a productive fishery.

Lake Hall

Lake Hall, which lies partly within the boundary of Maclay State Park, is classified as an Outstanding Florida Water. Its water quality and biological community, as reflected in its Trophic State Index (TSI) rating and Lake Condition Index (LCI) score, continue to be good. An apparent trend toward decreasing (improving) TSI values is evident over the 20-year monitoring period. This TSI trend appears to be driven mainly by the lake's total nitrogen concentration that is also declining. In 1998, Lakes Monitoring Program staff observed a marked increase in submerged aquatic vegetation. The dominant submerged plant (purple fanwort) became so dense that one of the monitoring stations had to be moved in order to collect water samples. Macrophyte surveys and observations confirm that the fanwort remains the dominant submerged vegetation with coverage throughout approximately 60% of the lake. It is unclear what factors prompted the macrophyte biomass expansion, since purple fanwort is a rooted plant deriving the majority of its nutrients from the lake sediment. Nutrient concentrations in the water column appear to be either stable (in the case of phosphorus) or declining (in the case of nitrogen). Efforts to eradicate hydrilla, which was discovered in the lake in 2001, have been largely successful, but a recent sighting of this invasive exotic around the boat ramp suggests that it has not been totally eliminated.

Lake Overstreet

This scenic 140-acre lake is not easily classified by standard measurements of water quality and lake health. Impacts to this lake are limited due to its relative isolation and lack of development in its basin, and this is reflected in its water quality and biological diversity, which continue to be good. Using water quality-based lake rating methods, Lake Overstreet is classified as a biologically unproductive oligotrophic system. However, using plant biomass as a measurement of productivity it would be classified as eutrophic or hypereutrophic. Macrophyte coverage in this lake appears to be increasing. Based on the 2001 macrophyte survey, the dominant submerged plant (purple fanwort) occupied approximately 60% of the lake area. The 2010 Lake Vegetation Survey conducted by City staff confirmed the dominance of purple fanwort in Lake Overstreet along with many flora taxa that show Overstreet's good water quality. Recent observations identified a new plant for the lake, frog's bit, which has displaced the fragrant water lily that previously dominated the water's edge. The abundant plant biomass has most likely contributed to the buildup of sediment in this lake over the years. This has frequently led to marginal DO conditions and concomitant stresses on the aquatic fauna, especially during the summer months.

Lake Hilaman

Lake Hilaman is a combination of two in-line reservoirs located within the COT's Hilaman Park golf course. The lake, which covers approximately 17 acres, is a flow-through system and part of the East Drainage Ditch that drains approximately 600 urban acres upstream. All of the monitoring evidence to date indicates that water of poor quality (high nutrients and bacterial counts) enters the lake and during its passage through the golf course undergoes some slight improvement. Lake Hilaman is a shallow eutrophic water-body whose TSI score has degraded somewhat, increasing from 47.2 in 2008 to 61.8 in 2010. The recent increase in the TSI score is a direct result of drought conditions from 2006 – 2008. Tropical Storm Fay of August 2008 and the plentiful rain of 2009 replenished the water levels of the heavily vegetated lakes producing nutrient levels to spike during the 2010. This increase in nutrient levels has changed the status from "not impaired" to "impaired" for the year 2010. While it continues to experience problems with an overabundance of filamentous algae, as well as weedy submergent and emergent aquatic vegetation; this nutrient-enriched system supports a healthy fishery and a variety of wildlife.

Lake Killarney

Lake Killarney is an 80-acre shallow, eutrophic, flow-through water-body surrounded by residential development that receives stormwater inputs from a 1,100-acre urban watershed. Over the 20-year monitoring period, non-point source stormwater discharge, have helped change this reservoir from a macrophyte dominated community to one in which algae preponderate. Alligator weed, a pollution tolerant plant, is one of the few aquatic macrophytes present, although its coverage has noticeably decreased over recent years. Efforts to control the alligator weed using herbicides and the introduction of grass carp appear to be having the desired effect. Drought and the reduced hydraulic flow through in the lake have exacerbated the algae blooms, which now seem to have become an almost permanent characteristic of Lake Killarney. Shifts in the biological communities and increases in nutrient concentrations since 2001 contribute to its "impaired" status under FDEP's Impaired Waters Rule.

Lake Kanturk

Lake Kanturk is a 70-acre reservoir located immediately east and downstream of Lake Killarney. Residential development surrounds the majority of the shoreline and undoubtedly accounts for much of the nutrient, sediment and other inputs to the water-body. Macrophyte coverage in Lake Kanturk is greater than in the upstream Lake Killarney. All of the water quality and biological criteria suggest that the lake is eutrophic, a status that has persisted since monitoring commenced in 1990. As with Lake Killarney, the flow-through nature of this lake makes it a less degraded system than it otherwise would be. This lake was dry during some months in 2003 and again in 2006-2007. However, when it has been wet, it has marginally achieved "impaired" status. Indeed, resumption of more typical rainfall patterns would increase its hydraulic flushing rate and consequently decrease the intensity of algal blooms.

Lake Cascade

This 109-acre natural lake receives much of its inflow from Bradford Brook, a blackwater stream that drains a portion of the sparsely developed Apalachicola National Forest. As such, Lake Cascade is one of the least impacted large blackwater lakes in Leon County. Due to natural factors such as low pH, high watercolor and low dissolved oxygen, Lake Cascade functions as an oligotrophic system with a low level of biological productivity. The frequent natural drawdowns of the lake also contribute to its excellent water quality. Lake Cascade's surface is dominated by second growth pond cypress and myrtle-leaved holly, interspersed with doghobble which provides habitat for a diverse assemblage of wildlife. A particularly surprising find in the 2002 macrophyte survey was a small number of shrubs of the "Pond Spice", *Litsea aestivallis*. This species is considered endangered in Florida, and this is the first report of it in Leon County. This plant appears to have survived the long dry period this lake has endured since of 2006.

Lake Hiawatha

Lake Hiawatha is the middle lake in the Bradford Brook chain, between Lake Cascade and Lake Bradford. This scenic 40-acre blackwater lake normally receives water from Lake Cascade and provides flow to Lake Bradford, but occasionally flows are reversed. Lake Hiawatha's transitional character is also reflected in its water quality, which is intermediate between upstream Lake Cascade and downstream Lake Bradford. Although, many of Hiawatha's water quality parameter values are closer to those of the latter than the former. Overall, Lake Hiawatha continues to exhibit good water quality, typical of an oligotrophic blackwater lake system. Perhaps the only evidence of anthropogenic influences on this water-body is its phosphorus concentration that is somewhat elevated in comparison to its essentially pristine upstream neighbor, Lake Cascade. Low water conditions in this lake produced a change in the macrophyte community in 2006. Shallower, less colored waters resulted in an abundance of submersed native vegetation.

Lake Bradford

Lake Bradford, with a surface area of 161 acres, is the largest and most accessible lake in the Bradford Brook Chain of Lakes. Also, it is probably the most important lake included in this report with respect to both recreation potential and the uniqueness of the natural resources found in the lake and its basin. Water quality is still good and comparable to that found in lakes Hiawatha and Cascade. Lake Bradford, unlike the other lakes in the Bradford Brook chain, is susceptible to transient water quality impacts from stormwater that enters the lake from the West Drainage Ditch during major storm events. An explicit example of this phenomenon occurred in July 2001 when a rare, albeit short-lived, algae bloom was observed in the lake. Over the 20-year period that this lake has been monitored, its overall water quality has remained relatively unchanged despite short-term fluctuations in individual water quality parameters.

Piney Z Lake

Piney Z Lake is a 240-acre water-body located in the City of Tallahassee's Lafayette Heritage Trail Park. It is a productive reservoir that historically has provided habitat for numerous waterfowl, wading birds and a plethora of other wildlife. Water quality in the lake has increasingly deteriorated over the last couple of years. TSI scores range from a 54 in 2005 , ("Non-Impaired") to a 63 ("Impaired") in 2010. Piney Z Lake receives stormwater inflows from two major sources, the Piney Z Plantation development and Swift Creek Middle School. Recent efforts to control the abundant growth of aquatic plants in the lake by the introduction of grass carp appears to have resulted in the disappearance of a substantial proportion of the lake's aquatic vegetation and a commensurate increase in the lake's phosphorus level. Total nitrogen and total phosphorus have both increased. These changes are likely due to the reduced aquatic plant coverage; rendering the water-body unable to assimilate the nutrient loading.

Goose Pond

Goose Pond is a 34-acre shallow flow-through reservoir that receives stormwater runoff from a large upstream urban area via the Goose Pond tributary and the Northeast Drainage Ditch. This large catchment area, coupled with inadequate water quality treatment facilities is the primary reason for the poor water quality found in this water-body. Although Goose Pond has not achieved "impaired" status, its chemical and physical parameters indicate that it is a degraded eutrophic water-body whose nutrient inflow far exceeds the assimilative capacity of the system. Goose Pond exhibits higher levels of ammonia and nitrate than any other lake in this report. Its vegetative community is also indicative of a degraded lake system. Most of the surface area of Goose Pond is covered with the pollution-tolerant "Cattail" or invasive exotic species such as "Elephant Ear" and "Chinese Tallow". To begin to improve this water body, it would be necessary to improve the existing stormwater treatment facilities in the reservoir's catchment area together with the removal of the sediment in the pond.

Eagle Lake

Eagle Lake is located in the City of Tallahassee's Sprayfield Expansion area south of Tram Road. With a surface area of approximately 26 acres it is the largest water-body on the sprayfield property and also a productive and scenic blackwater lake. Eagle Lake has good water quality and maintains the second lowest (best) TSI score (24.3) of any lake in this study, despite increasing somewhat in the past few years. This outstanding TSI score is because of the very low levels of phosphorus and chlorophyll-*a* measured in this lake. The lake is somewhat unusual for a blackwater system in that it is heavily vegetated throughout. Dense aquatic vegetation is responsible for creation of a mucky organic lake bottom, which in turn has led to the formation of large numbers of floating islands (tussocks) in Eagle Lake. This water-body continues to have higher than expected bacteriologic counts, which may reflect the influence of windborne bacterial aerosol formation from the sprayfield spray heads.

Hawk Pond

Hawk Pond is a small (21-acre) blackwater lake located in the City of Tallahassee's Sprayfield Expansion area. It is a shallow pond that is ringed by a dense canopy of pond cypress trees. Detritus from the cypress trees coupled with the shallow nature of this pond makes this the most dystrophic (highest color, lowest pH) of any lake in the study. Hawk Pond generally exhibits good water quality typical of blackwater systems with a TSI of 36.1, a value higher than the other two water-bodies monitored in the sprayfield area. This is principally due to the fact that Hawk Pond contains measurable levels of phosphorus. Bacteriological quality continues to be somewhat worse than for many of the more heavily urbanized lakes in this study. Since Hawk Pond is isolated from the cattle grazing areas in the sprayfield, windborne aerosol formation appears to be a more plausible explanation of elevated bacteriological results.

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The author extends his appreciation to all agencies and individuals that contributed to this project. Thanks also to all of the citizens that have provided access to the lakes and insightful anecdotal information on the lakes.

Thanks are also due to the City Commission and especially to Commissioner Deborah Lightsey whose support made the initiation of this program possible. Commissioner Lightsey provided the initial funding for this program from her Municipal Innovation Funds during FY-90 and FY-91, when she was mayor.
The cooperation of the following agencies is appreciated: Florida Department of Environmental Protection, Florida Fish and Wildlife Conservation Commission, Northwest Florida Water Management District, United States Geological Survey, Florida State University and Florida LAKEWATCH Program. The listing of all the individuals who have proved helpful from these entities is probably not possible due to the magnitude of the task. However, some individuals appropriated enough of their wisdom and time that to leave them out could be detrimental to the continuation of this program's monitoring effort. Apologies are in order for those individuals that were inadvertently omitted from the following list.

Loran C. Anderson, retired Professor of Botany and former Curator of the Herbarium, Florida State University, who performed the aquatic plant identifications for the 2001-2002 macrophyte survey of lakes.

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SECTION 1

INTRODUCTION

Introduction

The lakes within and adjoining the City of Tallahassee are among the area's most significant natural resources. Monitoring the ambient (biological/chemical/physical) status of the area lakes is one of several steps necessary to ensure the continuing existence and ecological functioning of these priceless resources. Others include, identifying water-bodies with potential problems and assessing long-term water quality trends to determine if current protection efforts are effective. Conservation of these resources is addressed in the Tallahassee/Leon County Comprehensive Plan (http://www.talgov.com/planning/compln/comp_plan.cfm).

Conservation Element Policy 2.2.6 of the Comprehensive Plan requires that, *"By 1992, an ambient and ongoing surface water quality monitoring program to establish a bank of baseline data"* be developed and implemented. To implement this Comprehensive Plan policy objective, the City Commission approved funding for a lake-monitoring program on March 28, 1990, to "develop the objectives, methods and procedures necessary to monitor and evaluate surface water quality."

At the inception of the pilot phase of the program, in May 1990, six area lakes (eight sampling stations) were designated for monitoring. An interim report on the water quality of the six lakes was published in March 1992 (COT, 1992A). Subsequently, the report was finalized in November 1992 (COT, 1992B). During the years that the program has been operational, the number of lakes (and stations) monitored has greatly expanded. A report on the water quality and biological assessment of 12 Tallahassee lakes was issued in June 1996 (COT, 1996). The most recent report in the series, published in September 2009 (COT, 2009), summarized the findings for 17 area lakes. The Lakes Monitoring Program currently monitors 17 area water-bodies utilizing a total of 31 individual sampling stations.

This report is the ninth biennial water quality report on Tallahassee's lakes presented since the monitoring program began. It provides an overview of the water quality and biological results obtained to date for 17 water-bodies. The report is written for a general audience that includes elected officials as well as private citizens. Section 2 of this report "Lake Assessment Parameters" discusses the various methods used to assess the health and quality of the ecosystem, as well as the significance of individual water quality parameters measured at each of the sampling stations. To those laypersons that have enough interest and concern in our lakes to read this, we hope to inform you and increase your knowledge base as well as stimulate your curiosity to learn more about some of Tallahassee's most important natural resources. Lakes are an important water resource for many reasons. They provide water and food for many organisms, from macroinvertebrates (bugs) to humans and everything in between; as well as providing recreational uses such as fishing, boating or swimming.

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SECTION 2

LAKE ASSESSMENT PARAMETERS

2.1 INTRODUCTION

Each of the lake stations in this report has been sampled for more than 37 parameters. These parameters, individually and in combination, measure different aspects of a lake's condition. The parameters, analyses and interpretation of the results collectively represent the scientific investigation applied to each of the lakes in order to develop baseline and trend information. This information is used to illustrate the ambient condition and some of the important factors for each of the lakes. In addition, analysis of any trends in these parameters can help provide insight as to the efforts needed to help maintain a lake's current overall condition. Lake rating methods provide general overviews of a lake's status. In contrast, the biological, chemical and physical parameters provide specific information about individual characteristics or condition of a water-body.

The lake rating methods, water quality parameters and analytical methods discussed below are the set of measures that were applied to the lakes in this study. When applicable, values are reported as the average of the median values from multiple stations within a lake. Since some lake rating methods are water quality-based while others use macrophyte density as the assessment parameter, not all of these methods will necessarily be in agreement as to the overall water quality of a given water-body.

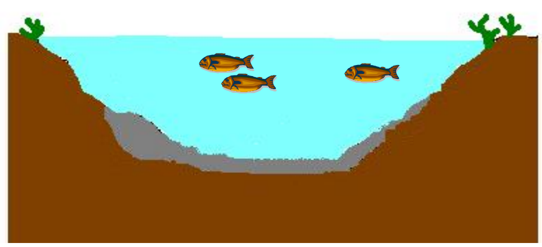
2.2 LAKE RATING METHODOLOGIES

There have been numerous rating methodologies established to assess the water quality or biological health of lakes. For this monitoring program the following methodologies have been selected to provide the information necessary to achieve the goals of the study.

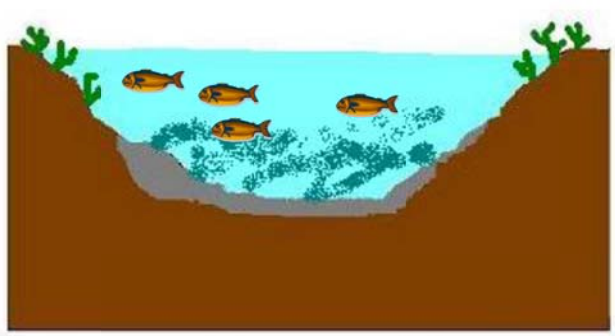
CHLOROPHYLL-*a*

Chlorophyll-*a*, is the green pigment found in plants and nearly all algae that allows them to utilize sunlight in the photosynthetic process for growth. Chlorophyll-*a*, is thought to make up approximately one to two percent of the dry weight of organic material in all planktonic (free-swimming or unattached) algae and is the preferred indicator for algal biomass estimates. If an assumption is made that chlorophyll-*a* constitutes on average 1.55% of the dry weight of organic matter (ash free weight) of algae, the algal biomass can be estimated by multiplying the chlorophyll-*a* content by a factor of 67. From its database of several hundred Florida lakes, the lakes monitoring organization, Florida LAKEWATCH, has used average chlorophyll-*a* concentrations to classify lakes into four trophic states (Florida LAKEWATCH, 2000A). This distribution is based solely on chlorophyll-*a* values.

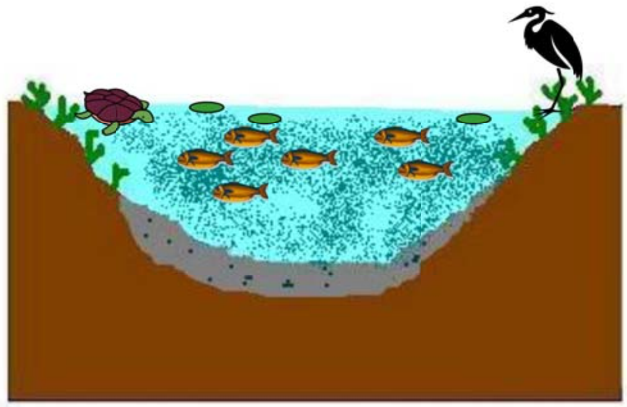
- Lakes with chlorophyll-*a* values less than 4.0 µg/L are classified as oligotrophic. **Oligotrophic** water-bodies typically have low nutrient levels, less abundant aquatic macrophytes and algae and high water clarity.



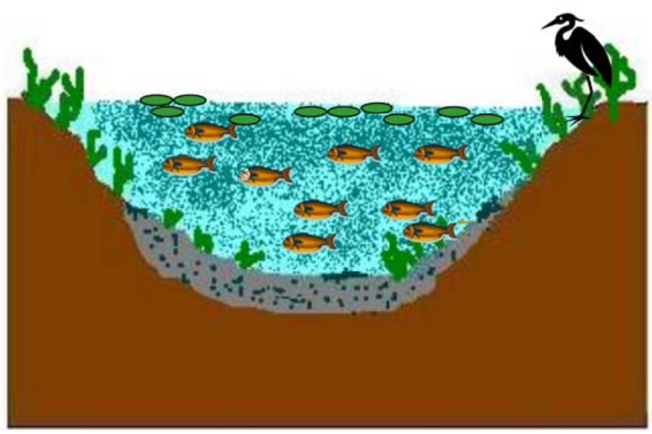
- Lakes with chlorophyll-*a* values between 4.0 µg/L and 7.0 µg/L are classified as mesotrophic. **Mesotrophic** water-bodies have moderate nutrient levels and are able to support moderate growth of algae and aquatic macrophytes.



- Lakes with chlorophyll-*a* values between 7.0 μg/L and 40 μg/L are classified as eutrophic. **Eutrophic** water-bodies are more biologically productive than either oligotrophic or mesotrophic lakes having sufficient nutrient concentrations to support an abundant growth of algae and/or aquatic plants.



- Lakes with chlorophyll-*a* values greater than 40 μg/L are classified as hypereutrophic. **Hypereutrophic** water-bodies typically have extremely high nutrient concentrations, an excessive or nuisance population of algae and/or aquatic plants and significantly reduced water clarity.



TOTAL NITROGEN

Total nitrogen represents the sum of the concentrations of nitrogenous compounds detected in a water sample. It includes nitrate, nitrite, ammonia and total Kjeldahl nitrogen. Florida LAKEWATCH has established a lake rating system based solely on total nitrogen (TN) concentrations (Florida LAKEWATCH, 2000B) in the water-body. Florida lakes are distributed into the following four trophic states:

- Lakes with TN less than 0.40 mg/L are classified as oligotrophic.
- Lakes with TN between 0.40 mg/L and 0.60 mg/L are classified as mesotrophic.
- Lakes with TN between 0.601 mg/L and 1.50 mg/L are classified as eutrophic.
- Lakes with TN greater than 1.5 mg/L are classified as hypereutrophic.

TOTAL PHOSPHORUS

Total phosphorus is the measure of all phosphate compounds in a water sample. Similar to the lake rating system based on TN, Florida LAKEWATCH has also developed one based solely on the total phosphorus (TP) concentration in the water-body (Florida LAKEWATCH, 2000B). Four different trophic states are established with the following TP distribution.

- Lakes with TP less than 0.015 mg/L are classified as oligotrophic
- Lakes with TP between 0.015 mg/L and 0.025 mg/L are classified as mesotrophic.
- Lakes with TP between 0.025 mg/L and 0.100 mg/L are classified as eutrophic.
- Lakes with TP greater than 0.100 mg/L are classified as hypereutrophic.

Impaired Waters Rule

The Impaired Waters Rule (IWR) was created by Florida Department Environmental Protection (FDEP 2001) and adopted for the purpose of evaluating the overall water quality of state water-bodies. It is the basis for the department's decisions with regards to water-body impairment or whether a water-body meets its designated use. Designated uses are listed in Florida Administrative Code 62-302. The designated use of Class III surface waters (including water-bodies in this program) is for "recreation, propagation and maintenance of a healthy, well-balanced population of fish and wildlife." As part of the Environmental Protection Agency's (EPA) Clean Water Act (CWA, section 303(d), 1977) FDEP has a commitment to identify and restore impaired waters. The CWA and FDEP (FL statue 403.067) define an impaired water-body as one that "does not meet water quality standards". This definition includes designated uses, water quality criteria and the FL anti-degradation policy and moderating provisions. In 2001, FDEP established an identification (or listing) and implementation process to meet this obligation (Impaired Waters Rule, 62-303 F.A.C). For lakes, FDEP uses the TSI and the lake's color value, measured in Platinum Cobalt Units (PCU), to identify a lake that does not meet the designated use, water quality criteria or is impaired. When a water-body is determined to be "impaired" it is placed on a planning list. Once a water-body is on the planning list, the data used for this placement is evaluated. If the data does not meet the requirements laid out in 62-303, then the water-body is moved onto the verified list and the implementation of a Total Maximum Daily Load (TMDL) plan is established. The goal of the TMDL is to enact "best management practices" so as to promote a water-body from "impaired" to "not impaired" status.

Trophic State Index

Trophic state relates to the biological productivity, water quality or ecological health, of a lake, i.e., the abundance of algae, aquatic plants and fish that a water-body can produce and sustain. The Trophic State Index (TSI) is an assessment tool that uses a numeric scale from 0 to 100 to indicate the relative trophic state of a lake (Carlson, 1977). Low TSI scores indicate low or relatively balanced levels of biological productivity and do not translate into poor water quality. High TSI values indicate higher and possibly imbalanced levels of biological productivity. Biological productivity, in this context, refers to the ability of a water-body to support life. This is a somewhat broad definition, and one can imagine numerous ways in which to measure this. The method used in this study estimates biological productivity based on concentrations of total nitrogen, total phosphorus and chlorophyll-*a*.

FDEP uses the TSI to evaluate nutrients in lakes as they relate to impairment. The criteria included in the IWR FDEP (2008) used to evaluate whether or not a lake shall be listed for follow-up implementation of a TMDL are as follows:

- Lakes with a mean color greater than 40 platinum cobalt units and annual mean TSI greater than 60, unless paleolimnological information indicates the lake was naturally greater than 60
- Lakes with a mean color less than or equal to 40 platinum cobalt units and annual mean TSI greater than 40, unless paleolimnological information indicates the lake was naturally greater than 40

Lakes that meet either of the above criteria, where the “annual mean” is the average of 4 consecutive quarters of data, are considered to be “impaired” and should be included on the Planning list generated by FDEP.

The Florida TSI must be calculated using the equations below:

$TSI_{Chlor\ a} = 16.8 + [14.4 * LN(Chlor\ a)]$
$TSI_{TN} = 56 + [19.8 * LN(TN)]$
$TSI_{TN2} = 10*[5.96 + 2.15*LN(TN + 0.0001)]$
$TSI_{TP} = [18.6*LN(TP*1000)] – 18.4$
$TSI_{TP2} = 10*[2.36*LN(TP*1000) – 2.38]$

Where LN = Natural Log

Individual TSI values are combined to give an average TSI that generates the above criteria as follows:

$TSI_{AV} = [TSI_{Chlor\ a} + TSI_{NUT}]/2$

Where TSI_{NUT} is determined from limiting nutrient considerations

If TN/TP ratio >30 then TSI_{NUT} = TSI_{TP2}If TN/TP ratio <10 then TSI_{NUT} = TSI_{TN2}
If TN/TP ratio >10 and <30 then = TSI_{NU} = [TSI_{TN} + TSI_{TP}]/2

The older guidelines from 1996 used the same equations as above but different rating categories listed below. The 2008 criteria refined this older evaluation and helped resolve problems with the suppression of algal growth in colored lakes.

The Florida TSI is not without its limitations. While a water-body may not be ideal for swimming or diving because of its limited water clarity or abundance of macrophytes, it has a high level of biological productivity and is fully able to support other recreational activities, such as fishing and bird watching. It is a good monitoring tool, but does not provide a direct measurement of water quality. Used in conjunction with other methods it can be quite useful.

Biological Assessments

There are numerous types of biological assessments (bioassessments) used around the country to determine the condition of water-bodies. Resident flora and fauna function as continual monitors of environmental quality, responding to the effects of episodic and cumulative pollution and habitat alteration (Gerritsen et al., 2000). Therefore biological monitoring provides information that, along with chemical and physical data, indicates an ecosystem's health.

Macrophytes

Macrophytes are those species of aquatic plants and algae readily visible to the unaided eye and are an essential part of the food web in lakes. Photosynthesis, carried out by plants that contain chlorophyll, is the most basic process in the food chain. Using sunlight, plants convert water and carbon dioxide into oxygen and sugars. Inorganic compounds are combined to form organic compounds that are then available to plants and organisms that feed on the plants, as energy sources. Invertebrates and small fish utilize algae and plants as a food source as well as essential habitat; and these consumers in turn serve as food for larger consumers. Additionally, plants use the nutrients that wash into the water, including phosphorus and nitrogen, to grow. When the macrophytes die, their remains are used for food by various decomposers such as fungi, bacteria, detritivorous micro- and macroinvertebrates and fish.

Aquatic plants compete with algae for available nutrients and can form a dense mass that shades out algae. Thus the presence of aquatic plants reduces the likelihood of algal blooms as their respective densities are inversely proportioned. Some floating macrophytes such as duckweed, water hyacinths and water lilies may become so abundant that they shade out other species of plants and algae. Overabundance of these floating macrophytes may also block oxygen transfer at the air/water surface interface. These effects can cause substantial reductions in dissolved oxygen levels. Excessive macrophyte coverage in lakes can also affect some forms of recreational usage if high-density infestations occur.

Biomass of aquatic plants is the one factor not used in the trophic state lake-rating methods. This is a missing feature since the trophic state of a lake is meant to express overall productivity and aquatic macrophytes can comprise a substantial amount of productivity in a lake. Lakes that have large densities of aquatic macrophytes may have good water quality, but may not be truly oligotrophic because they have high productivity in the form of macrophytes instead of algae. For this reason, trophic state lake-rating methods should only be used as an indicator of water quality not the overall trophic condition in lakes that have an abundance of aquatic plants.

There are a number of different methods for assessing lake water quality using macrophytes. One of the more common approaches measures the abundance of macrophytes in a lake and was used for some lakes in this report. It is the percent area covered (PAC) method (discussed later in this section), which is a measure of the percent of a water-body's bottom area that has aquatic plants growing on or over it. Another method that may be used to rate a lake's biological productivity is a measurement of floating-leaved plant biomass (the average weight of fresh floating-leaved plants growing in one square meter of a lake's bottom area) (Florida LAKEWATCH, 2000A). A third method that has not been used for this study as of yet is the Lake Vegetation Index (LVI), developed by FDEP in 2005 and will likely be adopted into the IWR in the near future. This method is planned for future monitoring. It considers characteristics of plants present at the lake such as nativity and disturbance sensitivity, to assess lake condition. Macrophyte surveys that were done in 2001 and 2002 for this program are similar to this method and are described in the next section.

One problem that is arising with macrophytes in our area lakes is the presence of Apple Snails (*Pomacea* spp.). Apple Snails are foragers of many species of plants and algae. Florida's native Apple Snail, *Pomacea paludosa*, occurs throughout the state both in lakes and streams. It's main diet is periphyton algae or algae that is attached to plants, plant vegetation, woody debris and bottom sediment. Exotic Apple Snails, (*P. caniculata, P.* isularum), commonly called Channel Apple Snail and Island Apple Snail respectively, have invaded the state of Florida from South America through the aquarium trade and are present in Tallahassee area lakes. These snails are aggressive foragers and are much larger than the Florida native snail. They also reproduce more frequently in greater quantities (egg count). Snail Kites and Limpkins are the two main predators of Apple Snails, along with raccoons, alligators, otters and other wildlife. Natural population control of exotic Apple Snails by predators is difficult due to their size and rapid reproduction rate. Exotic Apple Snails have been observed in Goose Pond, Killarney, Kanturk, AJ Henry and have been seen in small numbers in Piney Z Lake. Efforts are underway to eradicate the exotic Apple Snail for they are out competing the native species for habitat and causing millions of dollars of lake habitat destruction.

MACROPHYTE SURVEYS

In the fall of 2001 and spring of 2002, aquatic macrophyte surveys were undertaken in all the water-bodies in this study. Lakes Monitoring Program staff were assisted by Dr. Loran C. Anderson, Professor of Botany and Curator of the Herbarium, Florida State University, who performed the plant identifications. Detailed plant inventories for each lake are provided in two reports prepared by

Dr. Anderson (Anderson, 2001 and Anderson, 2002). A brief summary of the macrophyte survey results for each water-body is included in Section 3.0 of this report.

Two different survey protocols were used. For the majority of the lakes, plant species were inventoried using an FDEP form that lists aquatic plants in two categories, woody or herbaceous. The form was developed by FDEP for conducting systematic visual surveys of the macrophytes found submerged and in the littoral zone of a lake in an attempt to relate the plant species found to the water quality of the water-bodies. This approach to bioassessment is based on the premise that because species have different sensitivities to polluted waters, their presence or absence might be useful biological indicators of water quality and ecosystem health in lakes. The lakes were arbitrarily divided into 12 sections, and species were scored for presence and abundance in each section.

For three of the larger lakes in this study (Lake Overstreet, Lake Hall and Moore Lake), a more detailed assessment was conducted in order to map the percent area covered by aquatic vegetation therein. Using GIS techniques, an electronic grid was overlaid on a computerized map of each lake. Coordinates of the center node of each grid cell were recorded and then downloaded into a GPS unit. The GPS unit was used to navigate a boat to the center of each lake cell, where the aquatic vegetation, both floating and submersed, was inventoried. By combining the aquatic plant information from all of the lake cells, electronic maps of the most abundant macrophyte species were then constructed. The maps were used to estimate macrophyte PAC in the three lakes.

Lake Condition Index

The Lake Condition Index (LCI) is another method used to evaluate the ecological health of lakes. This rating system is weighted toward biological factors such as the presence of macroinvertebrate species that indicate good water quality and the diversity of macroinvertebrate fauna present. In this report, an LCI developed by FDEP for Florida water-bodies (FDEP, 2000) is utilized.

This LCI is based on a combination of the following six benthic macroinvertebrate metrics: total number of taxa, number of ephemeropterans (mayflies), odonates (dragonflies) and trichopterans (caddisflies) (EOT) taxa, %EOT, Shannon-Wiener Index, % Diptera and the Invertebrate Hulbert Index. Lake benthic macroinvertebrate assemblages are strongly associated with water color and transparency, with fewer taxa occurring in colored or turbid waters (FDEP, 2000). The LCI should not be used for lakes with high water color, and FDEP uses the following criteria for when benthic sampling would produce meaningful LCI results: water color less than or equal to 20 platinum cobalt units (PCU) and the presence of a sub-littoral zone in the lake between two and four meters in depth. For lakes in this region of the state, FDEP proposed four lake rating categories for each of two pH groups with the following LCI thresholds:

Benthic LCI
Lakes <20 PCU)

Rating	Acid	Alkaline
Very Good	$\geq$ 55	$\geq$ 50
Good	35 - 54	35 - 49
Poor	18 - 34	18 - 34
Very Poor	< 18	< 18

A lake in the Acid pH group is one that has a pH ≤ 6.5. An alkaline lake is one that has a pH >6.5. All of the lakes currently in this program are acidic or have pH values ≤ 6.5.

2.3 WATER QUALITY PARAMETERS

NUTRIENTS

Nitrogen: Nitrogen is an element that is essential for the growth of aquatic macrophytes and algae in water-bodies. As a water quality parameter, it is typically reported as total nitrogen (TN), which includes both organic and inorganic forms of the element. Organic nitrogen is made up of a variety of naturally occurring compounds of which amino acids, proteins and urea are the most important. Inorganic forms consist of elemental nitrogen (N_2), nitrate (NO_3^-), nitrite (NO_2^-), ionized ammonia (NH_4^+) and unionized ammonia (NH_3). The amount of organic nitrogen in a water sample is estimated by subtracting the ionized ammonia concentration from the total Kjeldahl Nitrogen (TKN), which is a measure of organic and ammonia nitrogen.

Aquatic macrophytes and algae cannot directly utilize all of the aforementioned nitrogen species. Aquatic plants generally favor the uptake of ionized ammonia over nitrate; and nitrate must first be reduced to ammonia before it is physiologically available to algae (Reynolds, 1984). All forms of nitrogen are essentially harmless to aquatic organisms except for nitrite and unionized ammonia, which can be toxic to fish and inhibit algal growth. However nitrite, because it is easily oxidized to nitrate, is rarely detected in the water column, and unionized ammonia, which is strongly pH dependent, is not present in sufficiently high concentrations to constitute a problem to fish at the pH of most natural water-bodies.

Phosphorus: Like nitrogen, phosphorus is an essential nutrient for the growth of all plants including aquatic plants and algae. Phosphorus in water-bodies can exist in several different forms including orthophosphates, polyphosphates and organic phosphates. Because of the ready conversion of these different compounds from one form to another in a process called “cycling,” phosphorus is normally measured by analyzing the concentration of total phosphorus (TP) rather than individual compounds in a water-body. Orthophosphate (PO_4^{3-}) is the soluble form of phosphorus that can be directly utilized by algae and aquatic plants, while the other forms are temporarily unavailable for plant growth.

Although an essential nutrient, phosphorus in high concentrations can lead to excessive algae and aquatic plant growth, which results in rapid lake eutrophication. A major source of phosphorus in urban lakes is from stormwater runoff that transports phosphorus to lakes from lawns, driveways and streets. The majority of Florida's eutrophication problems are associated with the phosphorus levels of lakes. The levels of phosphorus that will lead to cultural eutrophication vary widely, and individual limits must be established for each water-body. There is too much variability between systems for any specific standard to apply to all water-bodies.

TP Measurements: A review of historic TP results for all the lakes in this study revealed that more than 80% of the phosphorus data collected over the past 10 years were reported by the COT Water Quality Laboratory (WQL) as “not detectable” or “below the analytical detection limit.” The TP measurement is a critical parameter in lake water quality because it is used to calculate the total nitrogen to total phosphorus (TN:TP) ratio, which in turn is utilized to derive the TSI. Without a numerical TP value it is impossible to determine either the TN/TP ratio or TSI. The phosphorus analytical method used by the WQL is not sufficiently sensitive to measure phosphorus at the low concentrations that is typically present in many of the City’s lakes. In July 2001, the WQL subcontracted all of the lakes water samples phosphorus analyses to United States Geological Survey (USGS) Water Quality Laboratory in Ocala, Florida. When the USGS laboratory closed in July 2004, the low-level phosphorus analyses were subcontracted to a commercial laboratory. The contract laboratory has a routine method detection limit of 0.002 mg/L.

Limiting Nutrient: The limiting nutrient is the nutrient that is present at a concentration, with respect to other nutrients less than that necessary, for algae to increase their abundance. This tool is not indicative of algal growth abundance or chlorophyll-a concentrations but should be used more as a management tool. For example, if algae require one part of phosphorus to ten parts of nitrogen and there is an excess of nitrogen in the water-body then addition of nitrogen will not increase algal growth as long as more phosphorus is unavailable. In this case, phosphorus is the limiting nutrient. Determination of limiting nutrient in this study is based on an FDEP approach that utilizes the TN/TP ratio to predict the limiting nutrient of a water-body (FDEP, 1996). In general, lakes with a TN/TP ratio greater than 30 are phosphorus limited, lakes with a TN/TP ratio less than 10 are nitrogen limited, and lakes with a TN/TP ratio between 10 and 30 are in a gray area where neither nitrogen nor phosphorus is limiting or they may be co-limiting. For most lakes in this study, phosphorus appears to be the limiting nutrient.

Other authors (Schelske, 1999) have suggested the use of TN/TP ratios to assess nutrient limitation status may provide false predictions because both include an unknown fraction that may not be biologically available. Biologically available forms of N consist mainly of the three forms of dissolved inorganic nitrogen (nitrate, nitrite, and ammonia). The biologically available form of P is principally orthophosphate, which is measured as soluble reactive P (SRP). Predictions based on dissolved inorganic nitrogen:SRP ratios provide much more consistent predictions from nutrient enrichment bioassays than those based on TN:TP ratios (Schelske, 1999). Unfortunately for this study, dissolved inorganic nitrogen species and orthophosphate are rarely detected in the lakes in concentrations above the analytical detection limit, and hence this method of assessing nutrient limitation cannot be used.

Dissolved Oxygen

Lakes that do not maintain acceptable dissolved oxygen (DO) levels cannot support the fish, wildlife and all the biota that make lakes complex living systems. Even short periods of low DO can cause shifts in invertebrate populations favoring facultative anaerobes or pioneer species thereby lowering species diversity. Dissolved oxygen levels vary considerably throughout the day. During the day algae and macrophytes produce oxygen as a by-product of photosynthesis that is released into the air or water through the stomata of the plant. Under certain environmental conditions much more oxygen is produced than can be utilized by organisms present in the aquatic environment. When this occurs oxygen is essentially "bubbled" into the water until super-saturation occurs. Super-saturation of water with oxygen can kill aquatic organisms, such as invertebrates and fish. Additionally, when algae and or macrophytes are present in sufficient quantity to cause super-saturation, hypoxia can also result. In this case, during low light conditions, such as night, an over-abundance of plants utilize more oxygen than is present (in the aquatic environment) causing DO sags that can kill fish and other aquatic organisms. During the night, plant respiration continues through photosynthesis has ended, and more oxygen is generally taken from the water by plants than enters the water column through gas exchange and wave action. Thus, dissolved oxygen levels drop throughout the night and are usually lowest just at daybreak.

There is considerable loss of dissolved oxygen at the interface of organic lake sediment and the overlaying water due to bacterial-mediated oxidation of the sediment. In this micro-zone, the oxygen content may be much less than it is just a few centimeters above. For this reason, the morphology of a lake can influence the vertical oxygen curve. Essentially, the greater the area of sediment in contact with the water, the more dissolved oxygen can be used up. The extent and rate of biological activity in the sediments is tremendously variable. Thus, the greater the sediment contact with the water column per volume of water, the greater the potential effect on overall DO level in the lake.

The death and decomposition of large algal blooms or plants also deplete DO levels sometimes causing fish kills. The extent of the fish kill is dependent upon other related factors such as water temperature, weather, season and species of fish present. In addition, the inappropriately timed treatment of macrophytes with herbicides often results in fish kills. The decomposing plant material utilizes what little oxygen is available in the water column in hot weather. If the resulting increase in biological oxygen demand drives the DO concentration below critical levels, then fish kills and the loss of other aquatic fauna will occur.

FDEP has established a surface water quality criterion for DO in Class III freshwaters that states: “Shall not be less than 5.0 mg/L. Normal daily and seasonal fluctuations above this level shall be maintained” (62-302.530(30) F.A.C., 2006). The Lakes Monitoring Program measures DO in the field using a multi-probe monitoring instrument. Wherever feasible, DO is recorded at surface, intermediate and bottom depths in the water-body.

DISSOLVED OXYGEN % SATURATION

Under equilibrium conditions, freshwater exposed to water-saturated air at atmospheric pressure has a predictable DO concentration that varies only with water temperature. Percent saturation DO values are obtained by comparing the measured DO concentration in a water-body to the expected or theoretical DO concentration at that temperature. The latter is available either from tables or equations. This parameter is useful in determining whether a DO surplus or deficit exists in a water-body. In practice, DO % saturation is automatically computed in the field by the monitoring instrument at surface, intermediate and bottom depths from the measured DO and temperature.

CONDUCTIVITY

The specific (electrical) conductance of an aqueous solution is a measurement of the total amounts of dissolved solids or ionized substances present in water. The scientific definition of specific conductance is the reciprocal of the resistance between two platinum electrodes 1 centimeter (cm) apart and with a surface area of 1 cm^2 and is reported as μmho/cm. Conductivity changes as water temperature changes. This can confound comparisons of conductivity measurements across seasonal changes. The use of specific conductance, conductivity normalized to a temperature of 25^o Celsius (C), eliminates this complication and allows valid comparisons to be made. Most scientists use the terms “conductivity” and “specific conductance” synonymously. With meter improvements, “conductance” is usually reported since most instruments today compensate for the water’s temperature and normalize the measurement to 25^o Celsius.

High values of conductivity can be natural or caused by land use activities or discharges of wastewater. A survey of Florida lakes carried out by Canfield and Hoyer (1988) found a median conductivity value of 97 μmho/cm. The Lakes

Monitoring Program measures conductivity in the field using a multi-probe monitoring instrument. Wherever feasible, conductivity is recorded at surface, intermediate and bottom depths in the water-body.

pH

The pH value of a water-body is a measure of its acidity or alkalinity. The scientific definition of pH is “the negative logarithm of the hydrogen ion (H^+) activity (concentration).” While pure water has a pH value of 7.0, lakes can vary considerably into the acid or alkaline region due to natural processes. The overall pH of a water-body depends on its basin characteristics, especially the geology and vegetation composition throughout the watershed. Plant species that may increase acidity (decrease pH) such as pine, cypress trees and sphagnum mosses are particularly significant. Limestone, which frequently occurs as a watershed soil and bedrock material in the central and southern portions of the state, tends to increase the pH of a water-body. Lakes with high pH values are usually eutrophic with the highest values occurring in hyper-eutrophic lakes. This is because carbon dioxide can be reduced in the water column due to high rates of photosynthesis by planktonic algae, which in turn increases the pH.

There are a number of naturally acidic black-water systems in the Tallahassee area. One of the more notable is the Bradford Brook Chain of Lakes. These low pH black-water lakes are generally surrounded by forests and have deeply humic acid stained "black" water with an average pH range of 4.0-5.5. These lakes are often dystrophic i.e., organic matter is plentiful (in contrast to oligotrophic lakes), but naturally acidic conditions often result in slower (when compared to many non-acidic systems) decay and cycling processes due partially to the relative scarcity of detritivores in the sediments, which assist in breaking down the organic material.

Fish, plants and other aquatic life have different sensitivities to pH. Blue-green algae populations do not exist in habitats where the pH is below 4.0 and rarely occur where the pH is below 5.0, although many genera of the more advanced eukaryotic species thrive. Aquatic insects and many macroinvertebrates fall into three broad groups: generally intolerant, generally tolerant and those groups with considerable intraspecific variation. Mayflies (Ephemeroptera) are vulnerable, with species losses at pH less than 6.5 and only a few species survive pH values of 4.5. Alternatively, beetles (coleopterans), true bugs (hemipterans and homopterans), dragonflies and damselflies (odonates) are very tolerant, and many survive pH values of 4.5. The young of some fish species cannot survive in water that has a pH below 5.0. However, with few exceptions, lakes with low pH in Florida are able to support healthy fish populations.

The Lakes Monitoring Program measures pH in the field using a multi-probe monitoring instrument. Wherever feasible, pH is recorded at surface, intermediate and bottom depths in the water-body.

ALKALINITY

The alkalinity of a lake refers to the quantity of components in the water-body that shift the pH to the alkaline side of the pH range. The higher the alkalinity, the more resistance (buffering capacity) to pH shifts toward the acid range. Examples of commonly occurring materials in natural waters that increase the alkalinity are carbonates, bicarbonates, and hydroxides. Generally, lakes with alkalinities below 40 mg/L are considered soft-water lakes, while those with alkalinities over 40 mg/L are considered hard-water lakes. Hard-water lakes tend to be more biologically productive (eutrophic) than soft-water lakes. The majority of the lakes in this study are soft-water lakes.

Alkalinity is important for fish and other aquatic life in freshwater systems because it buffers pH changes that occur naturally as a result of photosynthetic activity. Furthermore, a high correlation has been established between excellent waterfowl habitats and water-bodies with alkalinities greater than 25 mg/L (NTAC, 1968). The FDEP has established a minimum alkalinity standard for Class III freshwaters of 20 mg/L, except where the concentration is naturally lower. In those instances the alkalinity may not be further reduced by more than 25% of the natural background level.

COLOR

Color in natural waters may be caused by the presence of metallic ions (iron and manganese), dissolved organic materials (humic acids from decaying vegetation etc) and plankton. Color is measured by matching the color of a filtered water sample (EPA Standard Method 2120B) to one from a spectrum of standard colors. Each of the standard colors has been assigned a number on a scale of platinum cobalt units (PCU). On this scale, the higher the PCU number of the water sample the darker its color. The location of a lake has a strong influence on its color. Water-bodies that adjoin or receive flow from slow draining cypress swamps often have darker water that has a reddish-brown "tea" color. In some cases the water can appear almost black. The term "black-water" lake is assigned to such water-bodies.

Color in a water-body can reduce both the quantity and quality of sunlight penetrating the water column. High color concentrations may limit the amount and types of algae that grow in the water-body and can also strongly influence the depth of colonization of aquatic plants and invertebrates. Even when black-water systems are rich in nutrients, the growth of algae and submersed aquatic plants tend to be inhibited because the colored water absorbs the sunlight that would otherwise reach them.

BACTERIOLOGICAL

Fecal coliforms are a subset of the total coliform group and indicate the presence of fecal material from warm-blooded animals. This group is used as an indicator of fecal pollution and is a quick test for pollution identification. The most likely sources for fecal coliform bacteria in lake water are municipal sewage collection systems, septic tank leachate and stormwater runoff. However, there are a number of limitations in the use of coliform bacteria for water quality monitoring. One of the most limiting is their relatively short life span of approximately 48 hours in natural waters. This makes the rapid discovery, proper sampling, and analysis of sewage spill sites imperative if valid results are to be obtained. Additionally, the survivability of fecal coliform bacteria decreases markedly with water temperatures at or above 30 degrees Celsius (LaRock, 1990). Water temperatures of lakes in and adjoining the Tallahassee area commonly exceed 30 degrees Celsius during the summer months.

The FDEP has established criteria for the presence of fecal coliform bacteria as an indicator group for potential risks to human health and the maintenance of water quality for fish and wildlife. Florida's fecal coliform criterion for Class III waters is 800-colonies/100 mL for a one-time event (62-302.530(6) F.A.C., 2006).

Fecal streptococcus is a group of bacteria that have been used in conjunction with fecal coliforms to differentiate human fecal contamination from that of other warm-blooded animals. For this reason this additional analysis is used at the sites within the City of Tallahassee sprayfield where contamination from domestic wastewater might be possible.

2.4 PHYSICAL PARAMETERS

TEMPERATURE

Temperature in the aquatic environment is critical to the species composition of a water-body. Without appropriate temperature levels, and fluctuations within those levels, few aerobic organisms can thrive or survive. Since most organisms that continuously occupy the aquatic environment are poikilotherms (cold-blooded), it becomes apparent that the temperature regime in a water-body is critical to all aquatic life. Temperature also affects the "self-purification" processes of a water-body and therefore the aesthetic and sanitary qualities. Increased temperatures accelerate the biodegradation of organic material both in the overlying water and in bottom sediments that in turn increases demands on the dissolved oxygen resources of the system. The higher the temperature is the lower the potential for water to hold oxygen. Consequently, as the demand for oxygen increases due to biological activity, the water's ability to physically hold dissolved oxygen is decreased. This phenomenon can result in total oxygen depletion and result in anaerobic conditions. Velz (1970) has described this relationship between temperature, oxygen and biological activity. Increased water temperature also can intensify water odor due to the increased volatility of odor-causing compounds (Burson, 1938). The Lakes Monitoring Program measures temperature in the field using a multi-probe monitoring instrument. Wherever feasible, temperature is recorded at surface, intermediate and bottom depths in the water-body.

TURBIDITY

Turbidity is a measure of light dispersion caused by particulate matter, such as clay silt, organic matter and plankton, suspended in the water column. Turbidity levels provide an indication of the amount of inorganic and organic muck that may be accumulating in the bottom of a water-body, directly affecting the primary productivity of a water-body. Turbidity levels are also an indication of activities that cause erosion in the watershed such as construction. The biological effects of fine-grained sediments (clays, silts and fine sands) are numerous and can greatly alter the fish and wildlife populations of a water-body regardless of other water quality and biological values.

Sediments change the aquatic environment by screening out sunlight, which inhibits photosynthesis, leading to a decline in benthic invertebrates and plant growth. Consequently, the food chain is disrupted and the population of consumer species is reduced (FDEP, 1999). The elimination or reduction in benthic organisms can decrease the number and variety of food sources for fish, causing the fish to starve or move away. A moderate concentration of sediment can impair fish spawning, while a high concentration clogs the gills of fish and invertebrates. The overall result of prolonged turbidity impacts may be that a clear water-body that once supported populations of predator fish, such as bass or bream, becomes inhabited by more tolerant “trash” fish such as carp or suckers (FDEP, 1999).

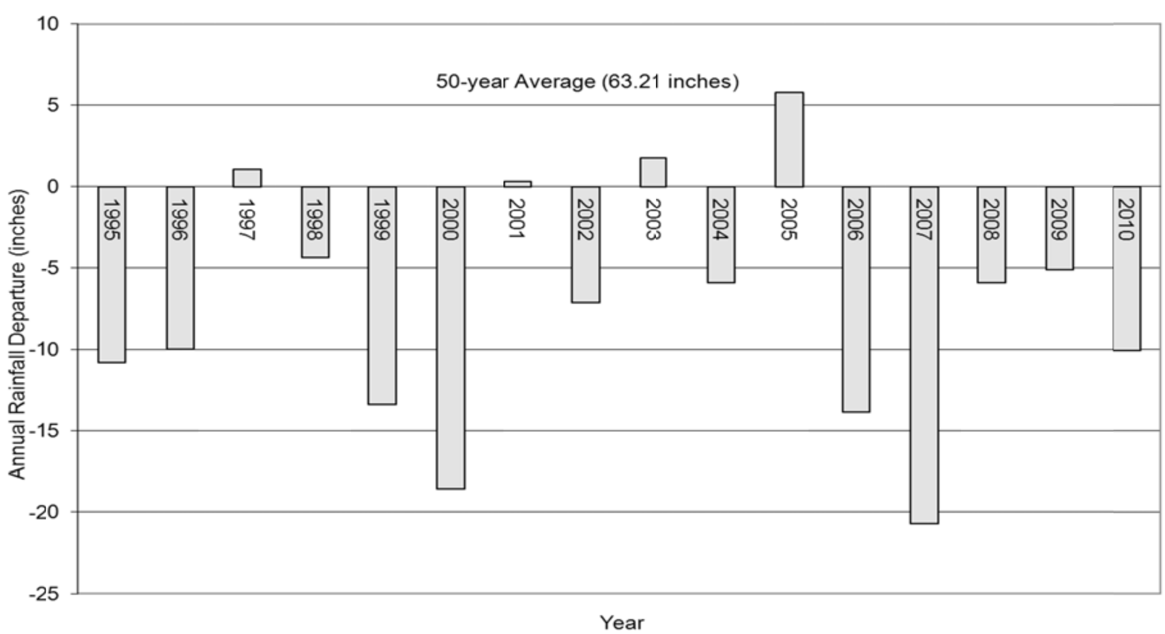
The FDEP criterion for Class III fresh surface waters states that conditions may not exist that cause an increase in turbidity levels in excess of 29 Nephelometric Turbidity Units (NTU) over natural background levels (62-302.530(69) F.A.C, 2006). The term “background” is defined by FDEP as “the condition of waters in the absence of the activity or discharge under consideration, based on the best scientific information available to the Department” (62-302.200(3) F.A.C., 2006).

For most lakes in this study, a background station is not monitored. However, this criterion is applied where a background value is available. The Lakes Monitoring Program measures turbidity values in the field and collects for lab analysis.

RAINFALL

Atmospheric precipitation is the major water source that sustains the lakes in the Tallahassee area, whether it is via direct deposition, stormwater runoff, or shallow groundwater inputs. Indeed, in the absence of rainfall several of the shallower water-bodies in this study, i.e., Lake Cascade and the Killearn-Chain-of Lakes, can and do go dry. Figure 2.1 shows the rainfall amounts in the Tallahassee area for the past 16 years from 1995 to 2010. Data was compiled from National Weather Service rainfall data measured at the Tallahassee Regional Airport and from the City's rain gauges located around town. In the chart, rainfall is expressed in terms of departure from the 50-year average value of 63.21 inches.

Figure 2.1 Tallahassee Rainfall Departure From Average



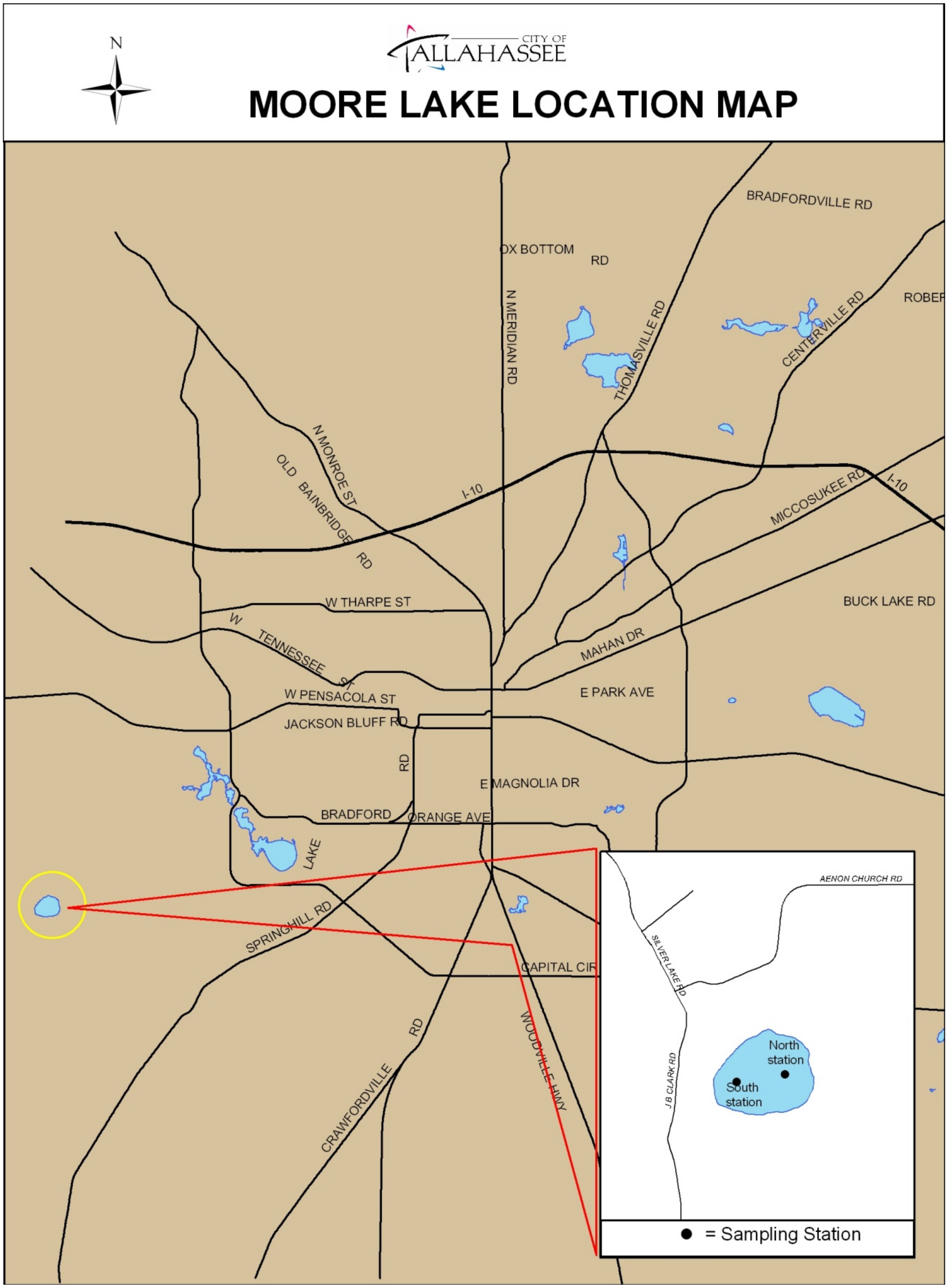
As the graph indicates, over the sixteen-year observation period, there were only four years, 1997, 2001, 2003 and 2005 in which precipitation exceeded the long term average. For deficit years, the shortfall was usually substantially less than the long-term average. The cumulative rainfall deficit from 1998 to 2000 resulted in rare occurrences, i.e., Lake Hiawatha went dry for a period of several months in 2000. More drought-susceptible water-bodies such as Lake Cascade, Lake Killarney and Lake Kanturk also dried up but for more extended time periods. The year 2003 was a surplus rainfall year in which there were no named storms, while 2004 was a deficit rainfall year in which four tropical weather systems affected the Tallahassee area, i.e., Hurricane Ivan, Tropical Storms Bonnie, Frances and Jeane. Combined, these four storms produced little more than six inches of rainfall. In July 2005, the Tallahassee area received almost twelve total inches of rain, seven of which were dropped by Hurricane Dennis contributing to the surplus of almost 6 inches for the year. The surplus made it possible to sample the more ephemeral lakes such as Cascade. However, in 2006 and 2007, the largest rain deficit affected Tallahassee, combined nearly 34 inches below the long-term average. Several months of nearly eight inches of rain in those two years could not ease the rain deficit. Lake Cascade dried up in June of 2006 and therefore has not been sampled since April 2006. On August 22, 2008 Tropical Storm Fay made landfall just west of Tallahassee and for two days dropped fifteen plus inches of rain. This helped to restore water levels to area lakes that haven't been seen for nearly three years. Lake Cascade and the spray-field lakes were once again returned to levels that could be sampled the last quarter of 2008.

Precipitation does contain trace amounts of chemical impurities absorbed from the atmosphere. Concentrations of these chemicals vary widely throughout North America and depend largely on the proximity of sampling sites to the source of the emissions. For the parameters relevant to this study, FDEP has estimated the "effective" (i.e. wet and dry) rainfall TN (mainly in the form of ammonium and nitrate ions) and TP concentrations in the Tallahassee area to be 0.39 mg/L and 0.006 mg/L, respectively (FDEP, 2003).

SECTION 3

LAKE ANALYSIS

SUMMARY BY LAKE


N
CITY OF
TALLAHASSEE
MOORE LAKE LOCATION MAP
BRADFORDVILLE RD
OX BOTTOM
RD
N MERIDIAN RD
THOMASVILLE RD
CENTERVILLE RD
ROBER
N MONROE ST
OLD BAINBRIDGE RD
I-10
MICCOSUKEE RD
I-10
BUCK LAKE RD
W THARPE ST
W TENNESSEE ST
MAHAN DR
W PENSACOLA ST
E PARK AVE
JACKSON BLUFF RD
RD
E MAGNOLIA DR
BRADFORD
ORANGE AVE
LAKE
SPRINGHILL RD
CAPITAL CIR
WOODVILLE HWY
RD
CRAWFORDVILLE
AENON CHURCH RD
SILVER LAKE RD
J B CLARK RD
North station
South station
● = Sampling Station

3.1 MOORE LAKE

Moore Lake is a 60-acre natural lake located in a small closed basin in the Apalachicola National Forest, south of the Cody escarpment in the Munson Sandhills Physiographic Province within the Lake Munson Drainage Basin. The lake is situated in an area of sand ridges; soils are Kershaw-Ortega-Alpin excessively to moderately drained. Loamy lamellae are interspersed in these soils and may be present under Moore Lake, thus keeping this from being one of the many ephemeral lakes in the National Forest. Moore Lake has a very low drainage basin area to surface water area ratio of five to one and a mean surface elevation of approximately 95 feet NGVD. It is slightly perched when compared with other lakes in this area. Maximum lake depth is 10 feet at normal pool elevation, and the average depth is estimated to be five feet.

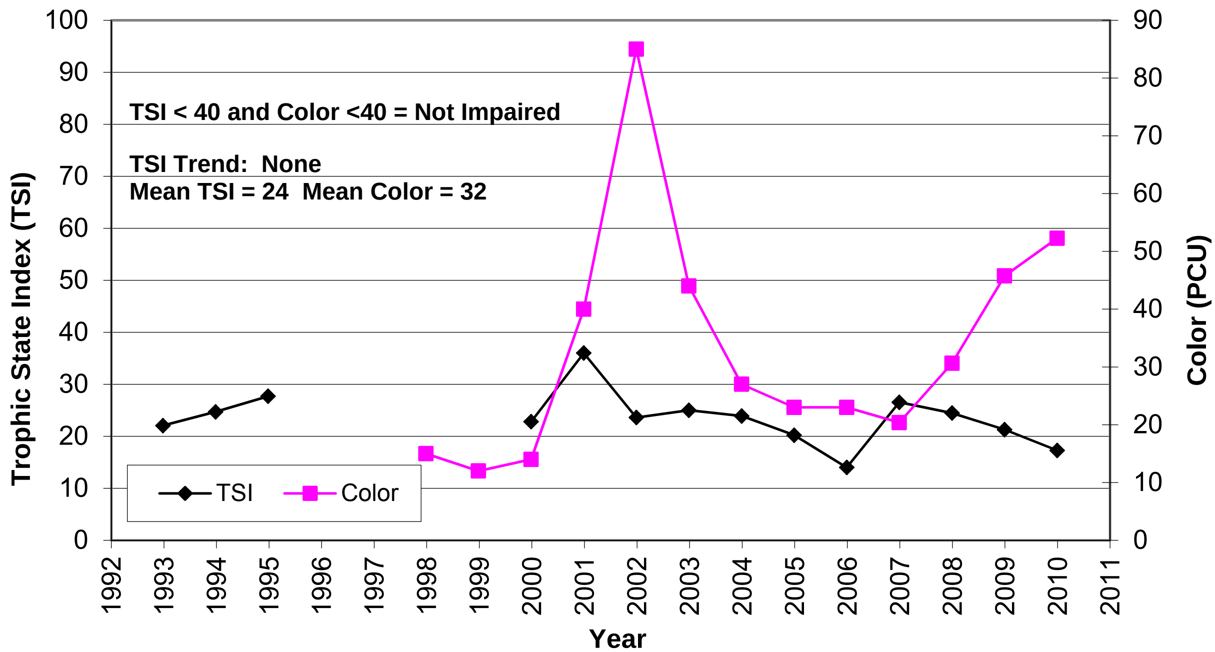
Moore Lake has essentially no development in its drainage basin, and unlike many of the lakes in this study, it has no inflow and outflow streams. Because of these factors, the lake has been utilized as the Lakes Monitoring Program's reference lake since 1992, allowing staff to track changes in water quality due entirely to natural phenomena such as storm events, atmospheric deposition and drought without superimposed influences from anthropogenic pollution sources. The Lakes Monitoring Program has two monitoring stations on this lake, Moore North and Moore South, and the average of the two stations produce the data used for the lake assessment.

LAKE RATING

TROPHIC STATE INDEX AND COLOR

Moore Lake's median trophic state index (TSI) for the years of record, as of 2010 is 24.6, representing good water quality. In 2006, the TSI score was 14.0, the lowest score of record for the lake. The Florida Department of Environmental Protection (FDEP, 1996) rates water-bodies with color less than 40 PCU and TSI values less than 40, such as Lake Moore, as “not impaired and able to fully support the designated use.” Figure 3.1 depicts Moore Lake’s annual average TSI values calculated from 1993 to 2010, which are all less than 40. TSI values for 1996 through 1999 are not included in the plot because of the lack of reliable phosphorus values for this period.

Figure 3.1 Moore Lake Trophic State Index vs. Color



Statistical analysis of the data indicates no trend in TSI values over the monitoring interval.

Chlorophyll-*a*

The median chlorophyll-*a* value for Moore Lake (2.6 µg/L) is by far the lowest of all the lakes in this study. Chlorophyll-*a* values recorded to date have ranged from zero to 30.4 µg/L for 150 samples. Based solely on chlorophyll-*a* values this lake would be classified as oligotrophic. Water-bodies with chlorophyll-*a* levels between 0 and 3.9 µg/L are generally considered oligotrophic. Oligotrophic water-bodies are defined as having the lowest level of biological productivity and typically exhibit lower

NUTRIENT LEVELS AND HAVE LESS ABUNDANT CONCENTRATIONS OF AQUATIC MACROPHYTES AND ALGAE. IN THE CASE OF MOORE LAKE,
algal growth (as determined by chlorophyll-*a* measurement) may be somewhat depressed by the low phosphorus levels in the lake and competition with macrophytes for available nutrients.

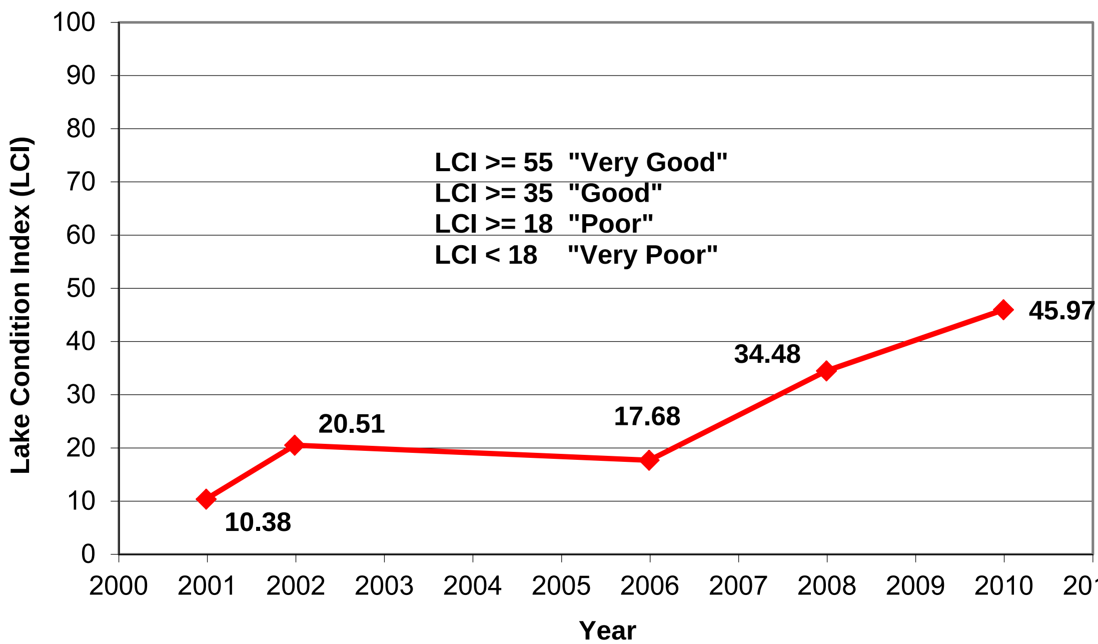
LAKE CONDITION INDEX

Moore Lake is one of three lakes in this study for which a Lake Condition Index (LCI) was recently determined. The others are Lake Hall and Lake Overstreet. Only these lakes met FDEP criteria (FDEP, 2000) for benthic sampling, i.e., water color equal to or less than 20 color units (platinum-cobalt Units-PCU) and the presence of a sublittoral zone in the lake between two and four meters in depth. Benthic macroinvertebrate samples were collected from Moore Lake in May 2010. Samples were not collected in 2004.

As of October 2002, the benthic macroinvertebrate population in this lake did not appear to be particularly diverse. Total taxa identified in the twelve-station composite samples taken in 2001, 2002, 2006, and 2008 were six, nine, ten, and eleven respectively, by far the lowest of any of the lakes sampled. These results are reflected in the lake's overall LCI score: 10.38 in 2001, 20.51 in 2002, 17.68 in 2006 and then doubled to 34.5 in 2008. Based on FDEP's ranking system for lakes in this region of the state (FDEP, 2000), the foregoing LCI values correspond to a "poor" to an improving "good" rating. The 2010 results were better with sixteen taxa identified and a LCI score of 45.9, indicating that the benthic community is improving in diversity. The overall taxa list is not ideal with many oligochaetes. The LCI scores do indicate that the lake's benthic macroinvertebrate population is stressed; which may be a consequence of the significant changes in water quality i.e., increases in color and ammonia concentration, recorded in this lake in 2001 and 2002 (see Water Quality section). Lake benthic macroinvertebrate assemblages are strongly associated with watercolor and transparency, with fewer taxa occurring in colored or turbid waters (FDEP, 2000). Although the watercolor has not returned to pre-2000 levels, the macroinvertebrate community does appear to have recovered some from the changes in 2001 and 2002 (Figure 3.2).

In contrast, benthic samples collected from Moore Lake in 1996 and earlier (when the lake was classified as acid-clear) demonstrated much greater taxonomic variety, e.g., a total of 25 taxa per station were identified (COT, 2001). Although these results are not strictly comparable because of the different sampling protocols employed in 1996 and 2001-2002, they do suggest a correlation between benthic macroinvertebrate populations and the observed water quality changes.

Figure 3.2 Moore Lake - Lake Condition Index



MACROPHYTES

Macrophyte surveys at Moore Lake were conducted in the fall of 2001 and spring of 2002, and subsequent visits, the latest in September 2010, confirm that plant coverages have not changed substantially throughout the years. Bladderwort (*Utricularia* sp.) is the dominant submersed macrophyte in Moore Lake. As Figure 3.3 shows, bladderwort covers greater than 95% of the lake bottom.

Road-grass (*Eleocharis baldwinii*) and Lax water-milfoil (*Myriophyllum laxum*) coverages shown in Figures 3.4 and 3.5, respectively, are the only other

submersed species present in abundance in the lake. The biomass and plant coverage is notably dense near the shoreline of this lake where the depth is less than four feet. As the depth increases the density of the macrophytes in the water column decreases markedly. While the occurrence of macrophytes is high along the shoreline, the biomass is low in the deeper (greater than four feet depth) areas of the lake. The portion of the lake from the shoreline to the three-foot depth contour is dominated by the emergent species maidencane (*Panicum hemitomon*-Figure_3.6), American cupscale (*Sacciolepis striata*) and fragrant water lily (*Nymphaea odorata* - Figure 3.7). Dominant woody species near the shoreline include pond cypress (*Taxodium ascendens* -Figure 3.8), buttonbush (*Cephalanthus occidentalis*), swamp tupelo (*Nyssa sylvatica* var. *biflora*) and titi (*Cyrilla racemiflora*). Other macrophytes commonly encountered in this area of the lake zone include spatterdock (*Nuphar luteum*), St. John's Wort (*Hypericum spp.*), water pennywort (*Hydrocotyle umbellata*) and willow (*Salix caroliniana*). The macrophyte survey conducted in September 2008 indicated that no exotic plant species have established themselves along Moore's shoreline or within the water column. This lake continues to be a good reference for the city's monitoring program.

Figure 3.3 UTRICULARIA SP. (bladderwort)

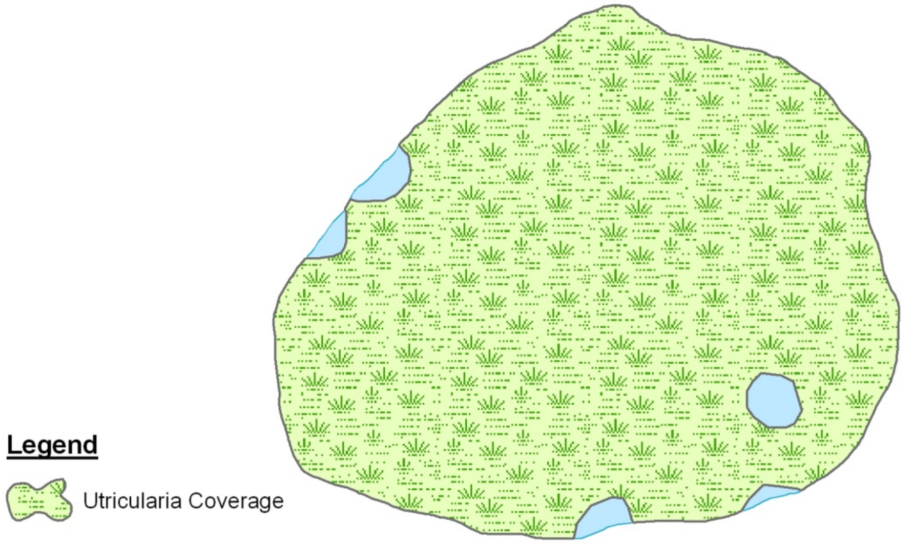
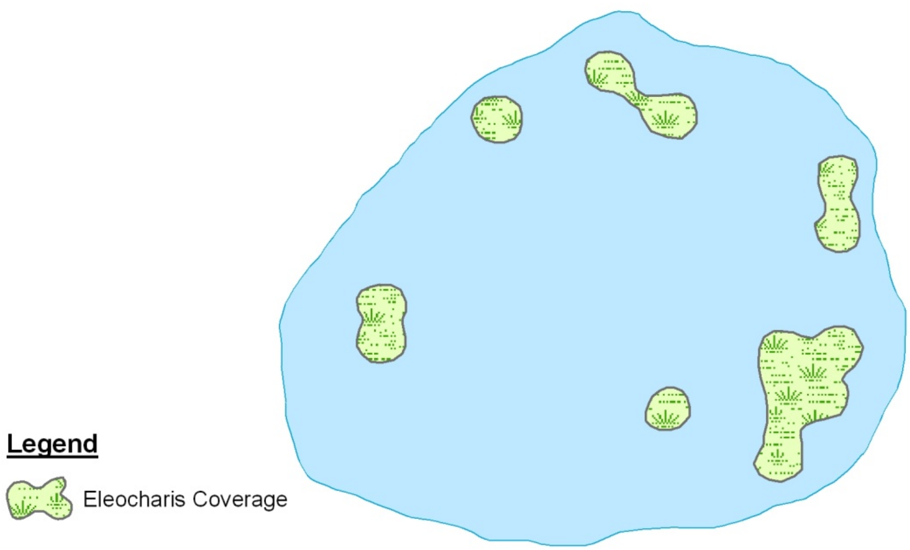


Figure 3.4 ELEOCHARIS BALDWINII (Road-grass)



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CITY OF TALLAHASSEE, FLORIDA

Moore Lake

Survey Date - October 2001

Stormwater Management Division

600 300 0 600 Feet

1 inch equals 600 feet

Figure 3.5 MYRIOPHYLLUM LAXUM (water-milfoil)

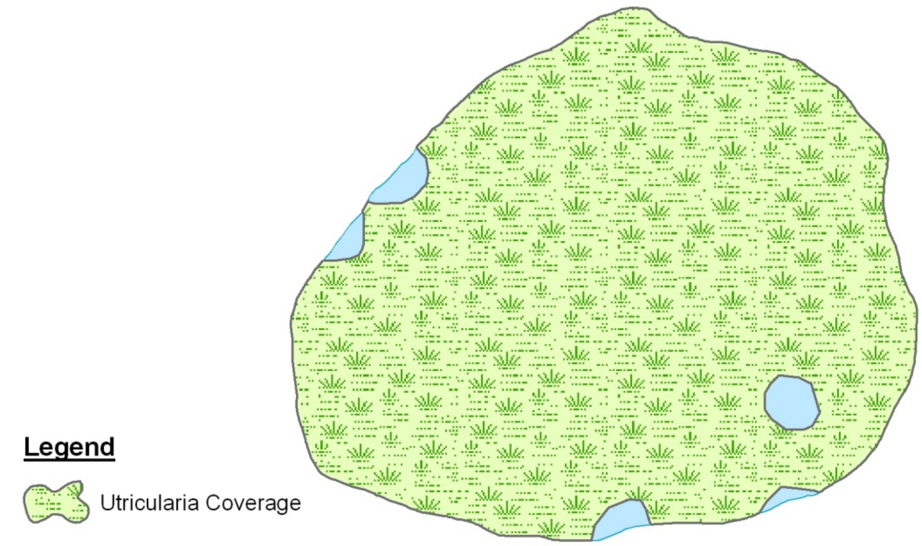
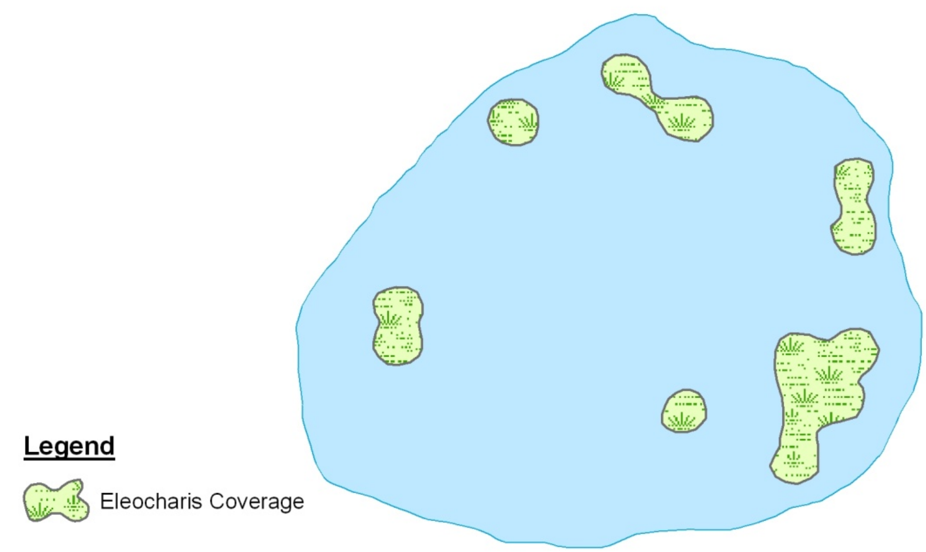


Figure 3.6 PANICUM HEMITOMON (Maidencane)



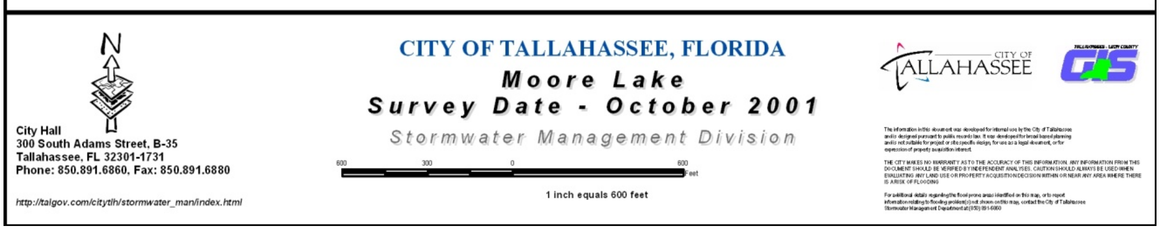


Figure 3.7 NYMPHAEA ODORATA (Fragrant Water Lilly)

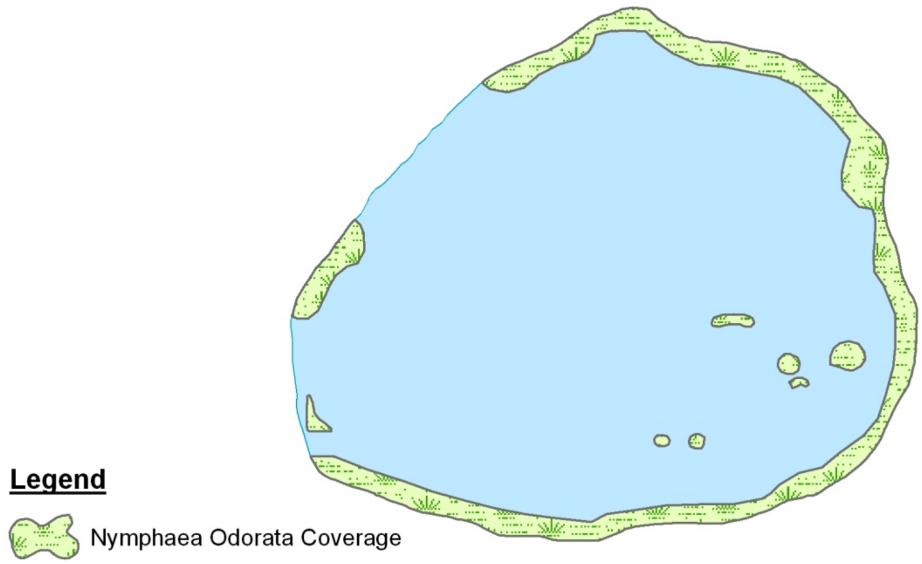
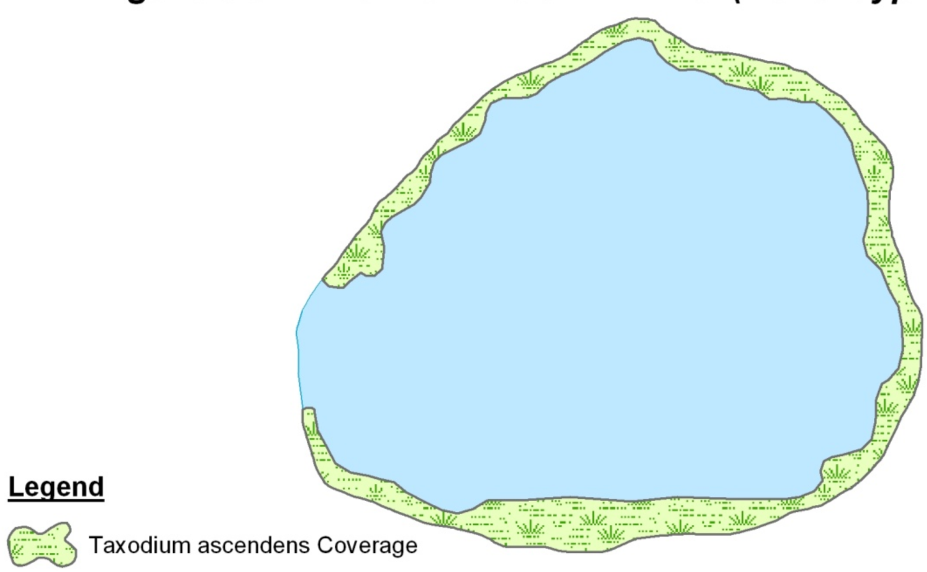


Figure 3.8 TAXODIUM ASCENDENS (Pond Cypress)



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http://talgov.com/citytlh/stormwater_man/index.html

CITY OF TALLAHASSEE, FLORIDA

Moore Lake

Survey Date - October 2001

Stormwater Management Division

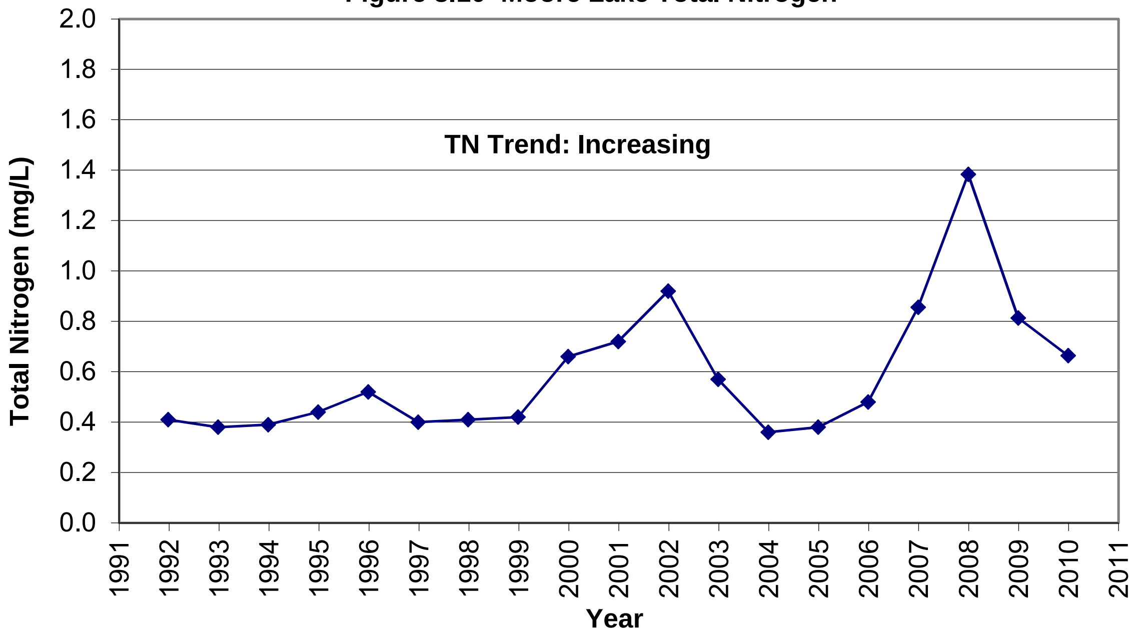
1 inch equals 600 feet

The macrophytes compete with algae for available nutrients and may depress the chlorophyll-*a* levels measured in the lake. The shallow nature of this lake coupled with normally clear water allow the potential for plants to root at almost any point on the lake's bottom. It is unclear why the emergent and floating-leaved macrophyte coverage is not more extensive.

WATER QUALITY PARAMETERS

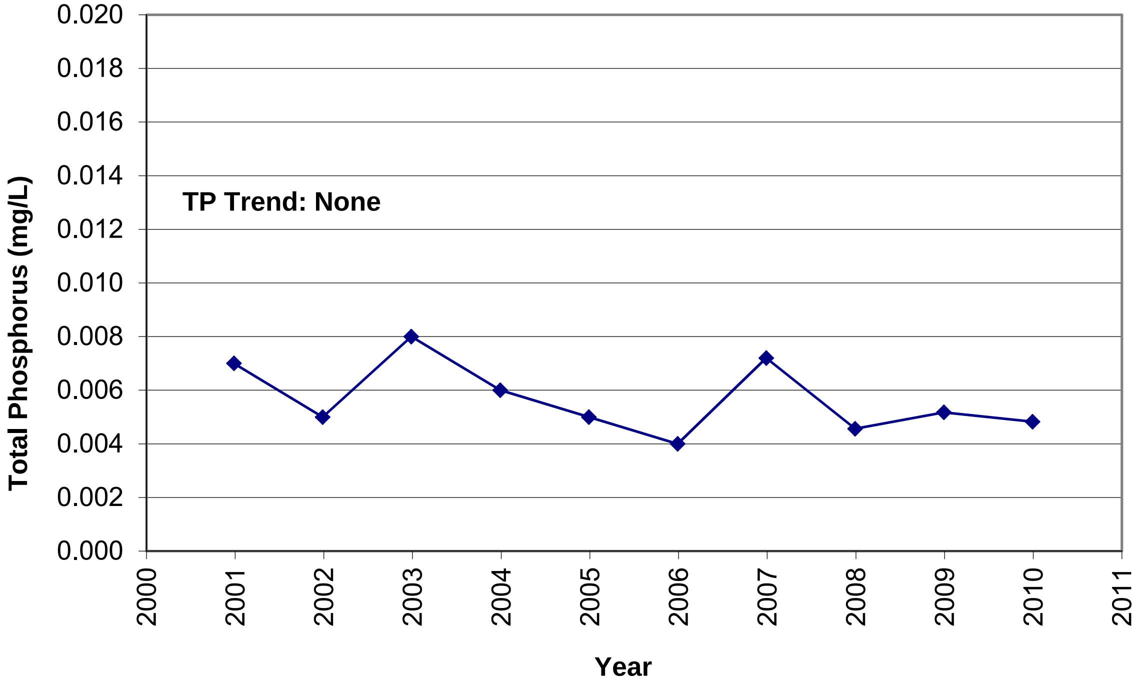
NUTRIENTS

Figure 3.10 Moore Lake Total Nitrogen



Moore Lake's overall nutrient TN values are indicative of a mesotrophic system. The median total Kjeldahl nitrogen (TKN) concentration for its two stations is 0.48 mg/L, which is among the lowest of all of the lakes studied in this report. TKN values for Moore Lake are on the increase and range from 0.29 to 1.75 mg/L for the 152 samples collected. As Figure 3.10 indicates, Moore Lake's average total nitrogen (TN) concentrations have been generally consistent from year to year prior to 2000. Upswings in (TN) values this decade are attributable to the periodic ammonia input.

Figure 3.11 Moore Lake Total Phosphorus



Moore Lake Lake's long term median total phosphorus (TP) value is 0.006 mg/L. The lake's annual average phosphorus concentrations for the ten-year period from 2001 to 2010 are plotted in Figure 3.11. A TN/TP ratio of the median values is 80:1 for Moore Lake indicating that the lake is phosphorus limited with respect to algal growth potential. Moore Lake's median nutrient TSI, which because it is a phosphorus-limited water-body is calculated from the lake's phosphorus values, is a low 18.5.

Conductivity

Typically, many unpolluted clear lakes in the sandy upland Ridge regions of the state exhibit conductivities below 20 µmhos/cm. Moore Lake is no exception with specific conductance levels consistently the lowest of all the lakes in this study.

The lake's median conductance value for both monitoring stations since 1992 is 16 μmhos/cm, similar to that of rainwater.

TURBIDITY

Turbidity in Moore Lake historically has always been very low. This is because the lake has no inflow or outflow streams, and the surrounding sandy terrain allows stormwater runoff from all but the most intense storm events to easily infiltrate. Even the advent of tropical storms Allison and Barry in 2001, Hurricane Dennis 2005 and Tropical Storm Fay August 2008 produced no observable changes in the lake's turbidity. For the one hundred and thirty-eight water samples that were collected from this water-body between July 1992 and October 2006, turbidity values ranged from 0.3 to 3.2 Nephelometric Turbidity Units (NTU) with median value of 1.1 NTU, the best in this study.

ALKALINITY AND PH

Alkalinity in Moore Lake is naturally low with a median concentration of 1.9 mg/L as $CaCO_3$. The alkalinity of a water-body is strongly influenced by the type of soils found in its watershed. For example, lakes in limestone areas tend to have elevated (>40 mg/L) alkalinity levels while those in sandhill regions (such as Moore Lake) that are deficient in limestone, often exhibit low alkalinities. The median pH of 5.4 indicates that Moore Lake is acidic. In the absence of buffering substances, Moore Lake's pH is controlled by soluble organic acids (fulvic and humic) that are generated from decomposition of cypress tree leaf litter and other vegetation that ring this sandhill lake. An additional, albeit more remote, source of organic acid loading to the lake comes from surficial groundwater seepage (see color and nutrient subsections).

BACTERIOLOGICAL

Because of its relative isolation, bacteriological results at Moore Lake are different than those of the urbanized lakes. In spite of occasional recreational usage of a small public beach area, Moore Lake has the lowest bacterial levels of any lake in the study. The median fecal coliform count is 3 colonies per 100 mL of lake water for both stations. An even more notable finding is that this lake does not exhibit the great swings in bacterial levels like urban lakes and those lakes near sewage sources sometimes do following storm events. The FDEP Class III water quality standard for fecal coliforms states that "counts shall not exceed a monthly average of 200 (geometric mean) nor exceed 400 in 10% of the samples nor exceed 800 on any one day."

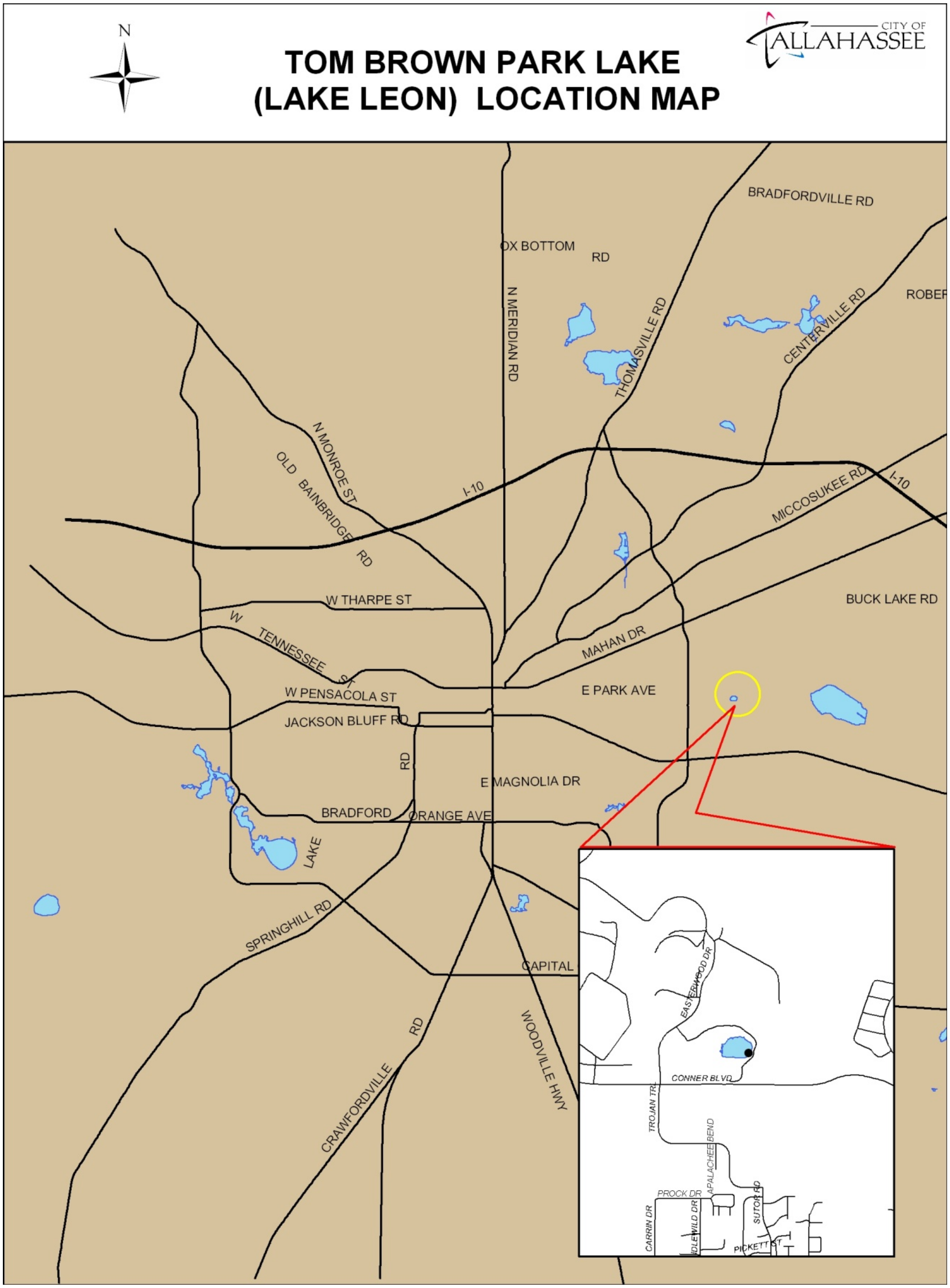
DISSOLVED OXYGEN

Dissolved oxygen (DO) levels in this water-body remained good with over 97% of the 140 surface sample measurements taken to date exceeding the 5.0 mg/L threshold established for DO in Class III freshwaters. The median surface DO concentration in Moore Lake is 7.6 mg/L. Approximately forty-four percent (42%) of the 140 bottom readings (six inches above the bottom of the lake) were below the Class III criterion with 16% of these readings showing signs of hypoxia with levels less than 1.0 mg/L. Sixty-eight percent (68%) of the bottom measurements below 5.0 mg/L have occurred since July 2001, with the most recent measurements in 2006 at the hypoxic level (<1.0 mg/L). In the case of Moore Lake, dissolved oxygen sags are natural and due mainly to oxygen uptake by organic-rich sediments on the lake bottom. The sediment depletes the oxygen in the lower water column faster than it can be supplied from the atmosphere by mixing at the lake surface.

SUMMARY

Moore Lake is a 60-acre oligotrophic lake located in the Apalachicola National Forest. The lake's water chemistry is similar to that of rainwater, being highly dilute in conservative ions with a low buffering capacity and an acidic pH. The lake has no permanent surface inflow or outflow, and hydrologic inputs are primarily rainfall and shallow groundwater inflow. Because of its relative isolation from anthropogenic impacts, Moore Lake serves as the reference lake for this study.

The recent monitoring results from Moore Lake have demonstrated some of the limitations of attempting to interpret water quality changes in lakes located in an urban environment by making comparisons to those in a lake protected from many anthropogenic impacts. The transient increases in color and ammonia concentration recorded in this lake following major rain events occurred in no other lake in this study. These events appear to have had some effect on the lake's ability to support a healthy macroinvertebrate community likely due to the more prevalent dissolved oxygen sags at the bottom where many of these organisms inhabit. The fact that the nitrogen increase is a result of natural processes suggests that inorganic nitrogen species ammonia and nitrate are not particularly useful indictors of anthropogenic pollution. The Florida Department of Environmental Protection uses ammonia in its stream and lake bioassays as a key chemical indicator of human impacts. Each lake appears to be unique with its water chemistry reflecting the geology, hydrology and extent of urbanization of the watershed. Thus, water quality parameter changes observed in one water-body may not be readily transferable to another, an observation that tends to diminish the utility of the reference lake concept.


N
TOM BROWN PARK LAKE
(LAKE LEON) LOCATION MAP
CITY OF TALLAHASSEE
BRADFORDVILLE RD
OX BOTTOM RD
N MERIDIAN RD
THOMASVILLE RD
CENTERVILLE RD
ROBER
N MONROE ST
OLD BAINBRIDGE RD
I-10
MICCOSUKEE RD
I-10
W THARPE ST
BUCK LAKE RD
W TENNESSEE ST
MAHAN DR
W PENSACOLA ST
E PARK AVE
JACKSON BLUFF RD
RD
E MAGNOLIA DR
BRADFORD
ORANGE AVE
LAKE
SPRINGHILL RD
CAPITAL
RD
WOODVILLE HWY
CRAWFORDVILLE
EASTERWOOD DR
CONNER BLVD
TROJAN TR
APALACHEE BEND
PROCK DR
SUTOR RD
CARRIN DR
IDLEWILD DR
PICKETT ST

3.2 TOM BROWN PARK LAKE (LAKE LEON)

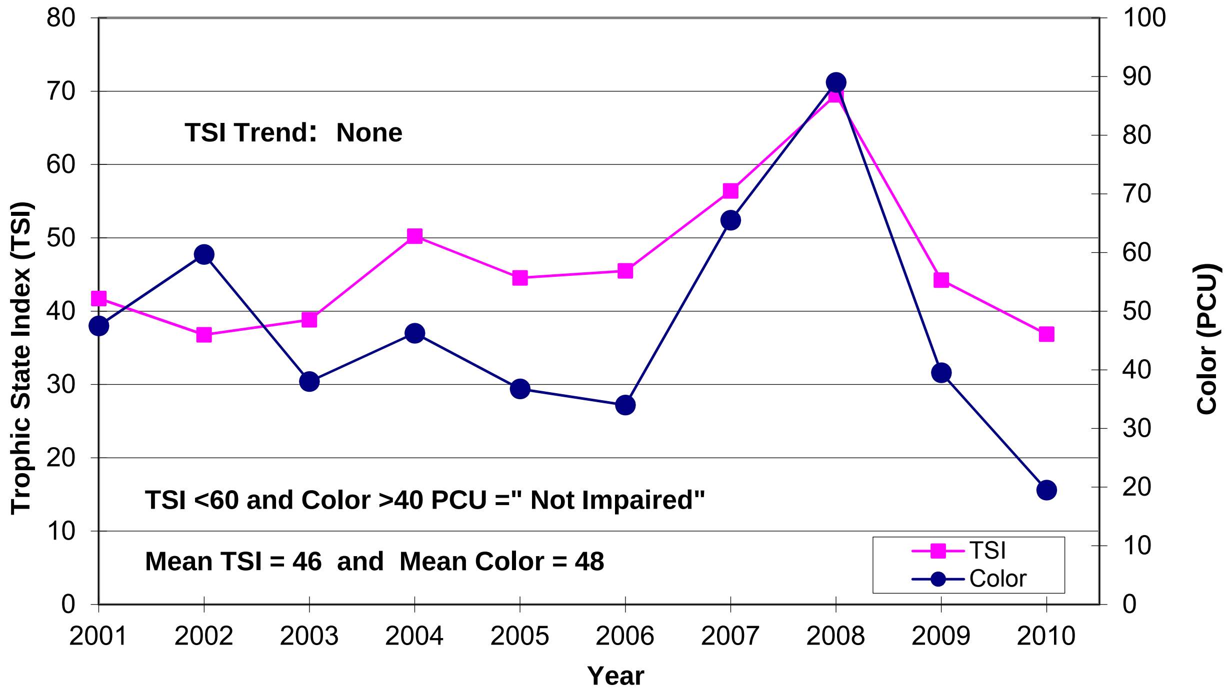
Tom Brown Park Lake has a drainage basin of approximately 180 acres and a surface area of only 6 acres. This reservoir is located in the Tallahassee Redhills Physiographic Province. The soils are a mixture of yellow-orange clays, silts and sands that are weakly cemented. The loamy soil is resistant to erosion and supports a lush vegetative community. The semi-impermeable nature of these soils accounts for the presence of numerous ephemeral ponds and lakes in lower areas. Tom Brown Park Lake receives inflow from nearby ball fields, the Florida Agricultural Museum and the Federal Correction Institution. This small reservoir discharges via a spillway into a small ephemeral stream that runs through a scenic woodland and then into Lake Lafayette during wet periods. Maximum lake depth is 11 feet and average depth is estimated to be six feet. The Lakes Monitoring Program has one monitoring station on this water-body.

LAKE RATING

TROPHIC STATE INDEX AND COLOR

Tom Brown Park Lake has a mean TSI range of 37 to 70 for the years 2001 through 2010. Figure 3.12 depicts the annual average TSI and color values for the ten-year monitoring period. No TSI values are available prior to 2001 because of the lack of reliable phosphorus concentration data for this time period. Using FDEP's IWR lake rating methodology, the TSI and color values would place the lake in the "unimpaired" category with respect to nutrient enrichment. Figure 3.12 indicates that color values increased during 2007 and 2008, with annual mean values of 65 and 89 respectively. However color values dropped significantly the years 2009 and 2010 with yearly average measurements of 40 and 20. Low yearly rain totals for 2009 and 2010 decreased color values. The long term mean color for Tom Brown Park Lake is 48 PCU. Although TSI values have increased slightly since 2004, statistical analysis of the quarterly data indicates decreasing trend in TSI values from 2008 to 2010.

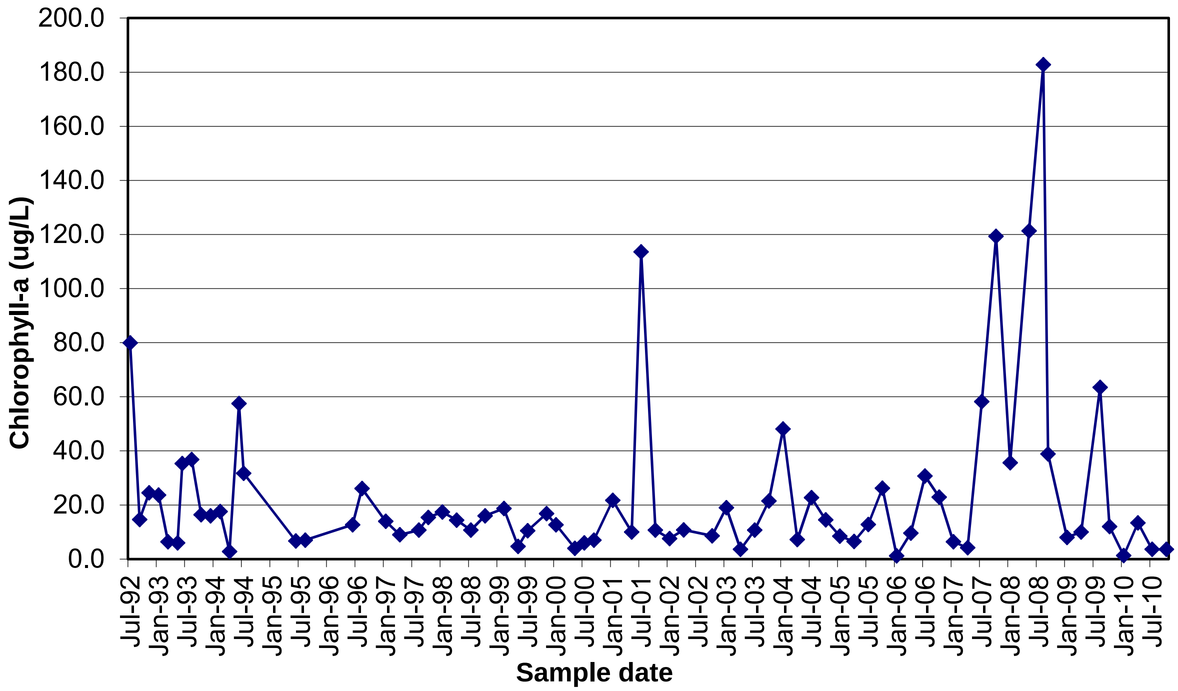
Figure 3.12 Tom Brown Park Lake - TSI and Color



CHLOROPHYLL-*a*

Tom Brown Park Lake has a median chlorophyll-*a* concentration of 13.5 µg/L, which is toward the lower end of the range of values (8 to 40 µg/L chlorophyll-*a*) for it to be classified as eutrophic. Eutrophic water-bodies generally are more biologically productive than either oligotrophic or mesotrophic systems and have sufficient nutrients to be able to support an abundant growth of algae and/or aquatic plants. During the 18-year period that the lake has been monitored, chlorophyll-*a* values have ranged from a low of 1.2 to a high of 183 µg/L with the 1.2 value recorded in January 2006. The maximum chlorophyll-*a* concentration measured in August 2008 is four times the value designating a hypereutrohic lake condition. However in September 2008, chlorophyll-a levels were back down to average readings (Figure 3.13) and have stayed at a lower eutrophic classification level through year 2010.

Figure 3.13 Tom Brown Park Lake Chlorophyll-a



MACROPHYTES

Macrophyte coverage in the main lake area has been greatly reduced for several years with most of the remaining aquatic vegetation concentrated around the shoreline. In the 2002 macrophyte survey, the lake had less woody vegetation associated with it than any of the other lakes in this survey; however native woody species such as Carolina willow (*Salix caroliniana*) and buttonbush (*Cephalanthus occidentalis*) are well established on the west side of the lake. During the aquatic plant survey (LVI) conducted in August 2008, the invasive exotic (FLEPPC, 2005) herbaceous species alligator weed (*Alternanthera philoxeroides*) and elephant ear (*Colocasia esculata*) were well established on the north bank and dominated the plant community. Native quality plant species consist of willow, cypress (*Taxodium* sp.), button bush, St. John's Wort (*Triadenum virginicum*) along with nuisance communities of cattail (*Typha*), barnyard grass (*Echinochloa crusgalli*) and water pennywort (*Hydrocotyle* sp.). In the past water hyacinth (*Eichhornica crassipes*) was a problem species that had been controlled by City Parks and Recreation Dept. with aquatic based herbicide.

WATER QUALITY PARAMETERS

NUTRIENTS

Tom Brown Park Lake has long-term median total nitrogen and total Kjeldahl nitrogen (TKN) concentrations of 0.55 mg/L each, indicating that almost all of the nitrogen present in the lake is in the organically bound state. Figure 3.14 is a plot of annual average total nitrogen concentrations from 1992 to 2010. Trend analysis suggests no trends in annual TN values over the 18-year monitoring period. Ammonia, in concentrations above the analytical detection limit, has been reported in approximately half of the water samples collected to date. The median ammonia concentration for these samples is 0.01 mg/L. The persistent presence of ammonia in the water column often indicates that nutrients are being introduced (whether from natural or anthropogenic sources) into the system faster than they can be utilized. There does not appear to be a pattern of higher ammonia values associated with any known activity that would affect the lake.

Figure 3.14 Tom Brown Park Lake Total Nitrogen

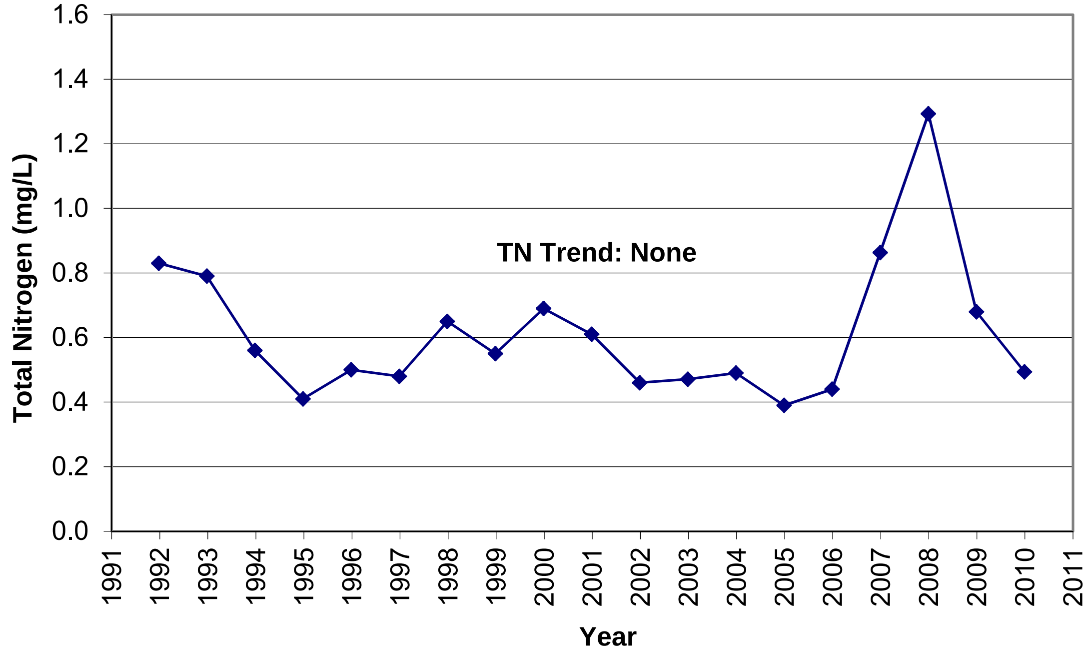
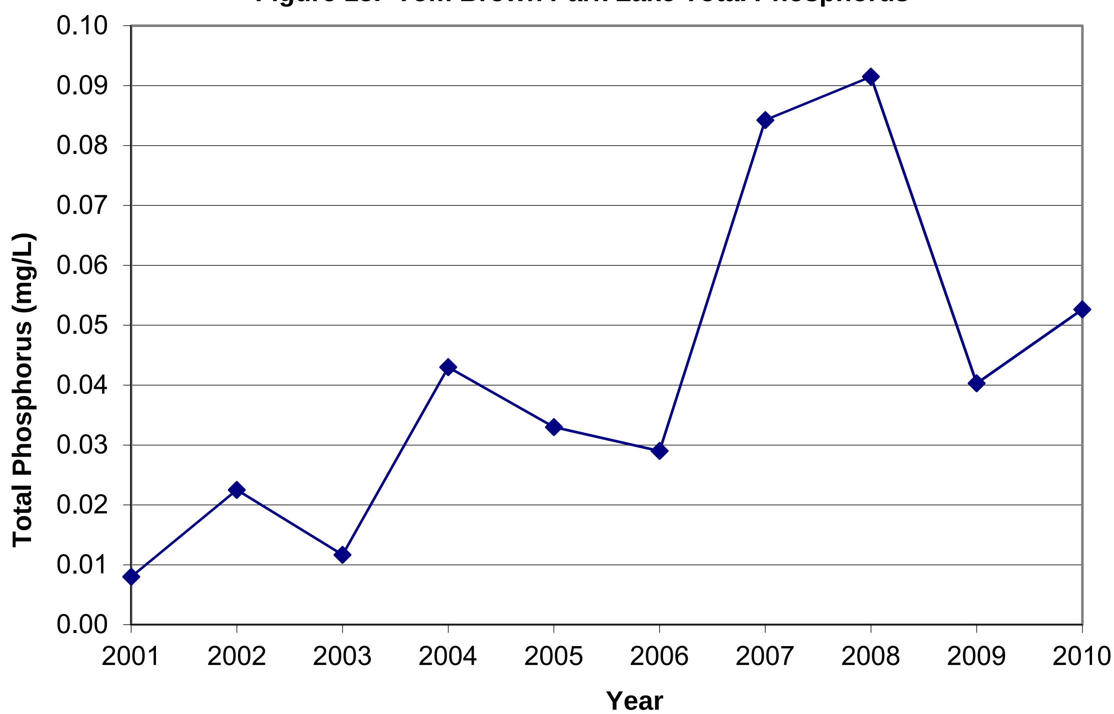


Figure 15. Tom Brown Park Lake Total Phosphorus



Tom Brown Park Lake's long term median total phosphorus (TP) value is 0.033 mg/L. The lake's annual average phosphorus concentrations for the ten-year period from 2001 to 2010 are plotted in Figure 3.15. For the reason previously noted, reliable total phosphorus measurements for this lake have only been available since 2001. Large fluctuations in TP are not unusual in lakes that receive the majority of their water input directly from urban stormwater runoff. Although concentrations in the past three years are higher than those from the previous three years, the mean TN/TP ratio is 50.3 indicating that the reservoir is phosphorus limited with respect to nitrogen and phosphorus inputs. The TP trend analysis is showing an upward slope since 2001 with fluctuations in between. This increasing trend is likely due to increased development on the east side of Tallahassee. Along with increased development is the potential for more stormwater input from impervious surfaces, which provide increased nutrient loads.

CONDUCTIVITY

Specific conductance measurements for this water-body are toward the high end of the range of lake conductivities measured in this study with a median value of 69 μmhos/cm. Only Goose Pond, Lake Hilaman, and Silver Lake exhibit higher conductivities. The lake's conductivity reflects contributions from stormwater runoff, which typically tends to have an elevated conductance in comparison to rainwater. Some of the highest values were measured in 2009 and early 2010, following periods of high rainfall.

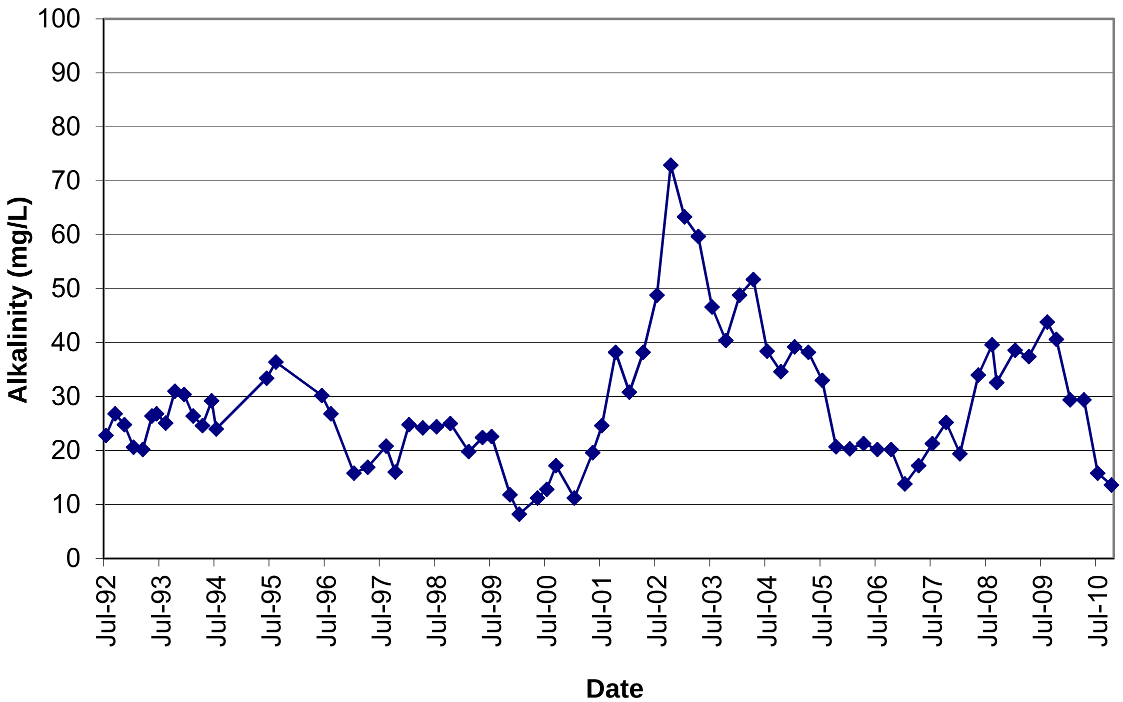
TURBIDITY

Turbidity levels are higher in Tom Brown than any other lake in this study with the exception of A. J. Henry Park Lake. Measurements range from 1.7 to 41.6 with a median value of 7.3 NTU. Given the 30:1 ratio of basin area to water surface area, the stormwater control structures that drain directly from nearby roadways, ball fields and a portion of the federal prison property near this lake, turbidity levels are not surprisingly high. A recent spike in turbidity (25.7 NTU) in early 2002 was likely associated with stormwater runoff from the Conner Boulevard road-widening project. This was among the highest turbidity values recorded since monitoring of this lake began in 1993. Since completion of the road project in November 2002, measured turbidities in the lake have notably decreased, although in August of 2008 Tropical Storm Fay dropped 15 plus inches of rain on Tallahassee and contributed to a spike (41.6 NTU) in turbidity. During the years of 2009 and 2010, a pilot test program for removing nutrients (nitrogen and phosphorus) using floating vegetated islands was trialed in Tom Brown Park lake. Although minimal nutrients were removed during this study water clarity seemed to have improved and turbidity levels were at some other there lowest readings. Stormwater runoff and continuing algae blooms in this water-body will still contribute to an elevated turbidity environment.

ALKALINITY AND PH

Tom Brown Park Lake has a 18-year median alkalinity value of 25.2 mg/L. This relatively high alkalinity value makes it one of the best lakes in the study with respect to buffering capacity and one of only four lakes that meets the State minimum water quality criterion for alkalinity of 20 mg/L. The Lakes Monitoring Program has been tracking changes in alkalinity in Tom Brown Park Lake, values of which are plotted in Figure 3.16.

Figure 3.16 Tom Brown Park Lake Alkalinity



As previously noted (COT, 2003), annual average alkalinity concentrations almost doubled in the lake in 2002, a change that was attributed to high alkalinity stormwater runoff from the Connor Boulevard expansion project. Since peaking at a concentration of 72.9 mg/L at the end of 2002, alkalinity values have declined, settling just above 22 mg/L by the end of 2010. Roadwork on the Conner Boulevard expansion was completed in November 2002. Values for pH have fluctuated between 5.3 and 10.1 with a median value of 7.3. The annual mean pH is 7.4, which has slightly decreased since 2008.

BACTERIOLOGICAL

Tom Brown Park Lake's bacteriological results are relatively high among the lakes in this study, with a eighteen year mean fecal coliform count of 104 colonies per 100 mL of water and a median fecal coliform count of 33 colonies per 100 mL of water. Although counts are well below the water quality criterion, it is one of the poorer lakes in this study from a bacteriological standpoint. The high fecal coliform results are indicative of the large amounts of stormwater this water-body receives during storm events. There are stormwater inflows that are diverted directly into this lake. However, the maximum fecal coliform count of 1000 colonies per 100 mL of water recorded at this lake in 1992 was the only sampling event that exceeded the FDEP Class III fecal coliform criterion (800 colonies per 100 mL on any one day).

DISSOLVED OXYGEN

The median surface dissolved oxygen concentration of 8.2 mg/L appears to be excellent; however, this result is misleading. In approximately 26% of the sampling events, oxygen super-saturation of the water column was observed at the surface depth, most of which were measured during the warmer months when temperature and available light are optimal for algal growth. Super saturation of oxygen, in the absence of natural oxygenation processes, is often a result of algal blooms that produce copious amounts of oxygen during photosynthesis. In the absence of this episodic oxygen saturation, the median DO concentration would be considerably lower. Unlike the results for some lakes, all dissolved oxygen data collected to date indicates this lake is eutrophic.

SUMMARY

Tom Brown Park Lake (Lake Leon) is a small (6-acre) water-body that drains an area nearly 30 times its surface area. In addition, as is often the case, stormwater has been routed directly into this lake. The results are predictable and evident. Frequent algal blooms resulting from nutrient inflows have been the norm since monitoring of this lake commenced. In 2002, notable increases in turbidity and alkalinity were recorded in the lake. These water quality changes were attributed to construction activities associated with the Conner Boulevard expansion project. Since completion of road improvements, turbidity levels in the lake have generally been lower and the alkalinity has returned to its long-term average. Tom Brown Park Lake continues to be expectedly eutrophic. However, its flow through characteristic does help it precariously maintain a fishery. The adjoining, undeveloped park area probably does provide some natural buffer that serves to slow the eutrophication process when compared to lakes with an even higher percentage of impervious area in their watershed.

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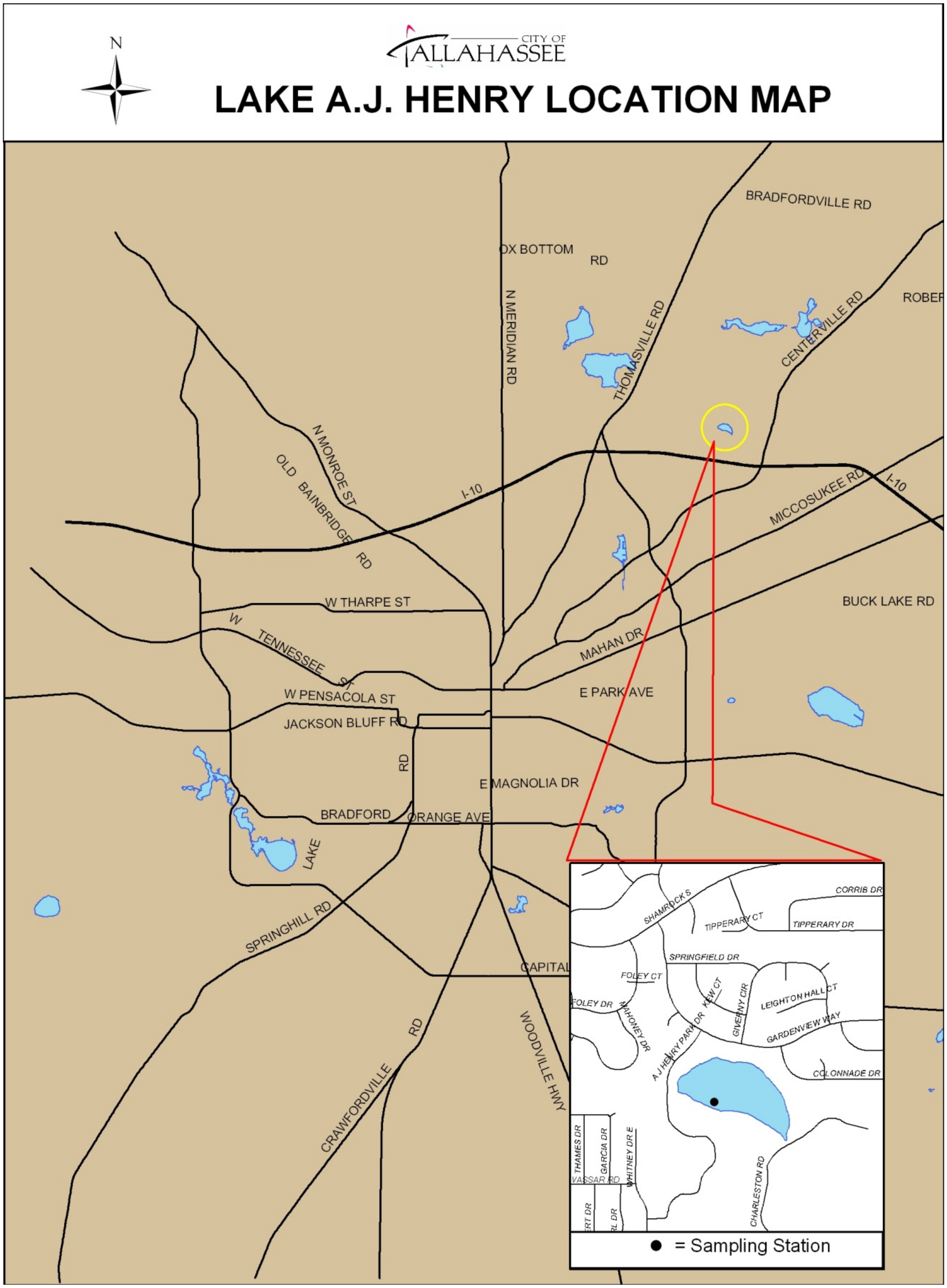

N
CITY OF TALLAHASSEE
LAKE A.J. HENRY LOCATION MAP
BRADFORDVILLE RD
OX BOTTOM RD
N MERIDIAN RD
THOMASVILLE RD
CENTERVILLE RD
ROBER
N MONROE ST
OLD BAINBRIDGE RD
I-10
MICCOSUKEE RD
I-10
BUCK LAKE RD
W THARPE ST
W TENNESSEE ST
MAHAN DR
W PENSACOLA ST
E PARK AVE
JACKSON BLUFF RD
RD
E MAGNOLIA DR
BRADFORD
ORANGE AVE
LAKE
SPRINGHILL RD
CAPITAL
WOODVILLE HWY
RD
CRAWFORDVILLE
CORRIB DR
SHAMROCK S
TIPPERARY CT
TIPPERARY DR
SPRINGFIELD DR
FOLEY CT
FOLEY DR
MAHONEY DR
KEW CT
GIVERNY CIR
LEIGHTON HALL CT
GARDENVIEW WAY
A J HENRY PARK DR
COLONNADE DR
THAMES DR
GARCIA DR
WHITNEY DR E
VASSAR RD
CHARLESTON RD
● = Sampling Station

3.3 A. J. HENRY PARK LAKE

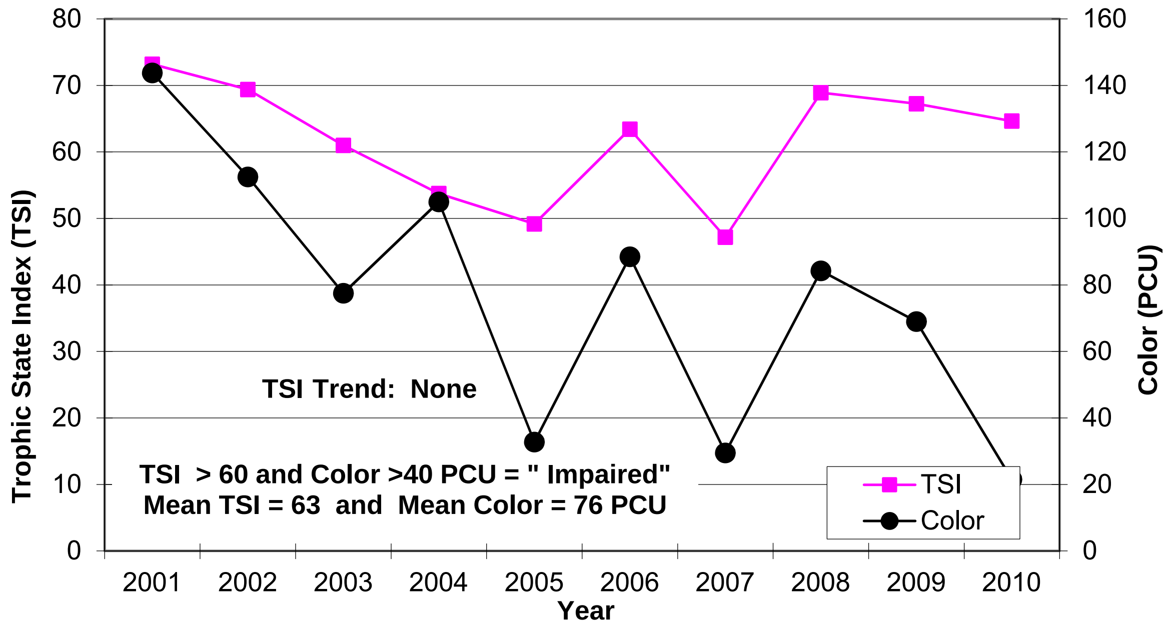
A. J. Henry Park Lake is a 14.3-acre reservoir located partially within the City of Tallahassee (COT) park of the same name. This lake is located at an elevation of 115 feet and has a drainage basin of approximately 275 acres, much of which is heavily urbanized. This lake is situated in the Tallahassee Red Hills Physiographic Province, and the reddish-clay soils are often evident in the lake. A. J. Henry Park Lake is a flow-through system (draining to the Alford Arm Tributary via Cascade Lake) with a 20 to 1 drainage basin area to water surface area. Maximum lake depth is 10 feet at normal pool elevation and average depth is estimated to be five feet. The Lakes Monitoring Program has one monitoring station on this lake.

LAKE RATING

TROPHIC STATE INDEX AND COLOR

A. J. Henry Park Lake currently scores a median TSI value of 65.9. Based on FDEP's TSI rating methodology, the annual average scores for 2001-2003 and 2005-2010, excluding 2004, indicate that the lake is "impaired" for nutrients. The lake's rating is determined by its elevated nutrient and chlorophyll-*a* concentrations, which are, respectively, the primary cause and an indicator of the algal blooms that plague this lake. As Figure 3.17 indicates, A.J. Henry Park Lake's TSI values have consistently been above 40 and often above 60; while the color has ranged from 22 to 144 PCU. TSI values prior to 2001 are not available because of lack of reliable phosphorus values. Trend analysis reveals no trend in TSI scores over the ten-year monitoring period from 2001 to 2010.

Figure 3.17 A.J. Henry Park Lake - TSI and Color



CHLOROPHYLL-*a*

A. J. Henry Park Lake's median chlorophyll-*a* concentration of 46.8 µg/L is by far the highest (worst) of any lake in the study. Lakes with median chlorophyll-*a* concentrations in excess of 40 µg/L are considered to be hypereutrophic. Hypereutrophic water-bodies generally have high nutrient concentrations and either an abundant population of algae or extensive aquatic macrophyte coverage. Chlorophyll-*a* concentrations in this lake have ranged from 1.6 µg/L to 306 µg/L, with the latter figure representing one of several high-density blooms of blue-green algae in 1996. Clarity of the lake approaches zero during the heavier blooms and the unicellular algae becomes so dense as to coalesce into a contiguous, unsightly, odiferous mass. Algal blooms were notably less intense in 2002-2004 and again in 2007, with median chlorophyll-*a* values ranging from 62.2 to 18.5, respectively. However much higher levels were recorded in October 2005 and July 2006, with 273 µg/L of chlorophyll-*a* measured in July

2006 when an intense blue-green algae bloom was evident. Elevated chlorophyll-*a* values were measured during the summer months of 2008 when another bloom was recorded documenting the presence of *Microcystis* sp., a toxic blue-green algal.

MACROPHYTES

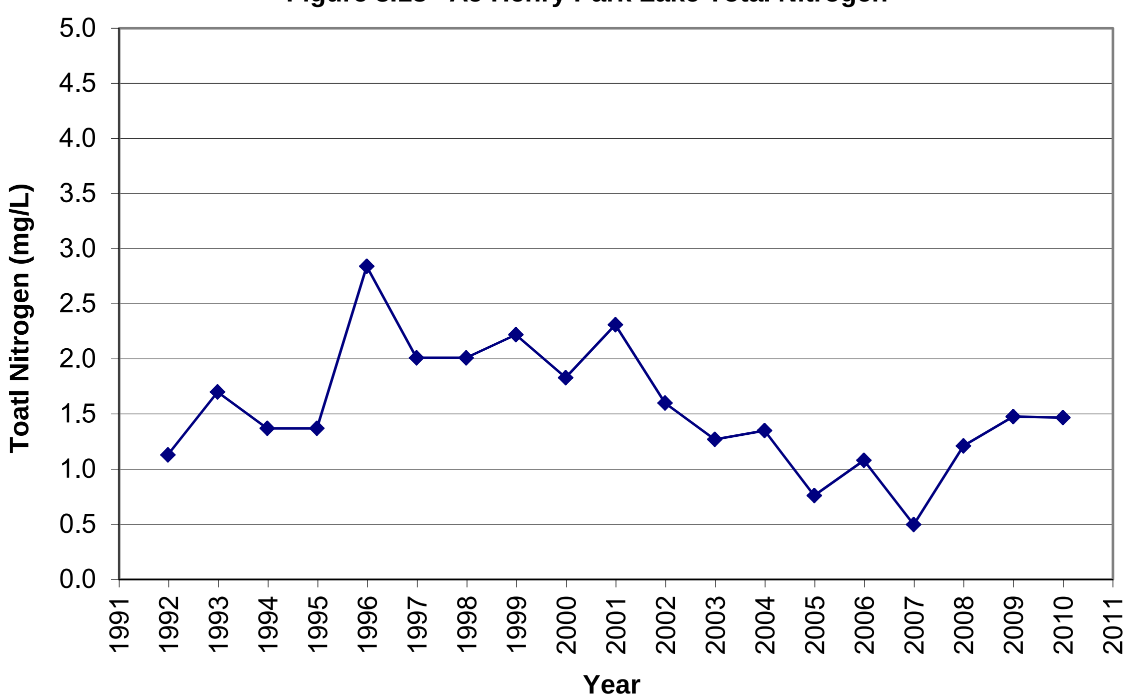
The 2002 macrophyte survey indicated A.J. Henry Park Lake has little aquatic vegetation, other than that along the margins of the lake. Within the boundaries of the city park, on the south side of the lake, a shrubby thicket is present in which the dominant woody species is willow (*Salix caroliniana*), and the two dominant herbaceous species is the native smartweed (*Polygonum densiflorum*) and the exotic alligatorweed (Alternanthera philoxeroides). Other species frequently observed include, wax myrtle (*Myrica cerifera*), buttonbush (*Cephalanthus occidentalis*), the invasive exotic wild taro (*Colocasia esculenta*) and duckweed (*Lemna valdiviana*), a floating macrophyte that is highly tolerant of elevated nutrient concentrations. The north side of the lake is very sparsely vegetated with less environmentally friendly maintained lawns making up the buffer from the water's edge. Since 2002, the lake was covered by more macrophytes with the submersed plant coon tail (*Ceratophyllum demersum*) covering almost the entire bottom of the lake. However, during September 2008 a first ever Lake Vegetation Index survey (LVI) was conducted, the coontail seems to have dissappeared An extensive algal bloom was present throughout the water column; *Microcystis* sp. one of the toxic algal genus was identified. This could be a reason why phosphorus levels have increased during 2008. Other plants include cat's tongue (*Salvinia minima*) and water primose (*Ludwigia* spp.). The LVI survey was performed again in 2010 resulting with same water conditions, high chlorophyll levels (algal blooms), and very little to no floating or submerged aquatic vegetation.

WATER QUALITY PARAMETERS

NUTRIENTS

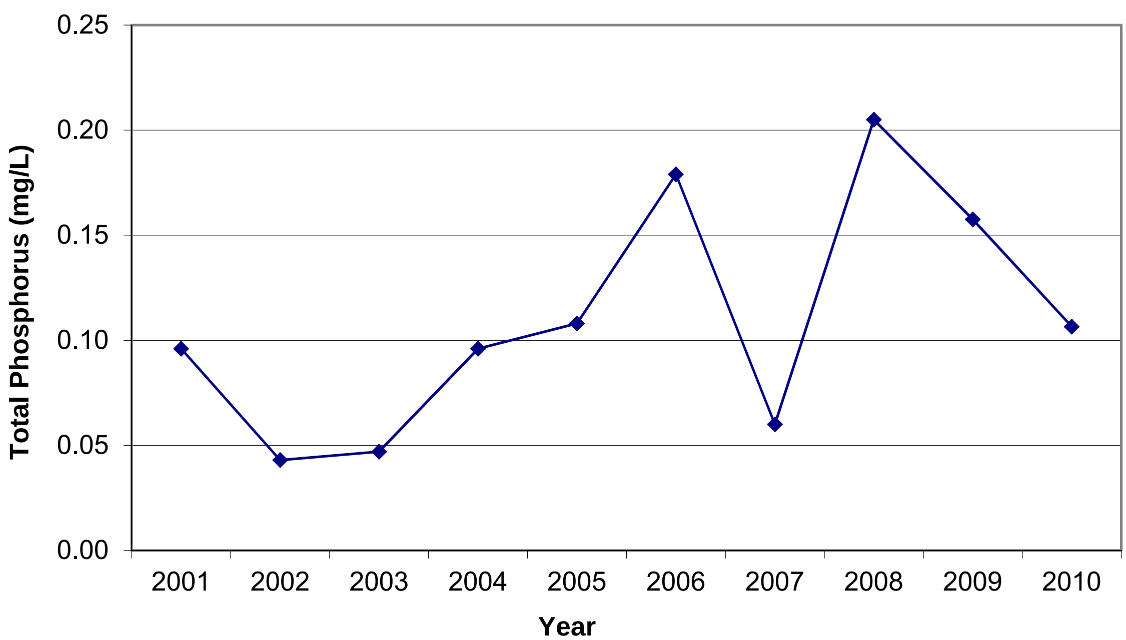
Nutrient concentrations in A. J. Henry Park Lake have been consistently higher (worse) than any other lake in this study. Median values of total nitrogen (1.42 mg/L), TKN (1.40 mg/L), ammonia nitrogen (0.02 mg/L) and total phosphorus (0.10 mg/L), indicate the lake is hypereutrophic. Figure 3.18 shows the annual average total nitrogen concentrations from 1992 to 2010. While there are substantial variations from year to year, there appears to be an apparent declining trend in TN values over the past 9-years. Although the nitrogen in A.J. Henry Park Lake is predominantly in the organically-bound form (and hence not biologically available to algae), greater than 50% of all water samples collected from the lake had detectable amounts of ammonia, the nitrogen form whose uptake by algae is most favorable.

Figure 3.18 AJ Henry Park Lake Total Nitrogen



A.J. Henry Park Lake's phosphorus concentrations from 2001 through 2010 are plotted in Figure 3.19. The annual average TP values indicate a trend of increasing TP concentrations since 2003, likely due to the high proportion of direct input from urban stormwater. The lake's median TP concentration is 0.10 mg/L; only Goose Pond and Lake Hilaman have higher TP values. A.J. Henry Park Lake's mean TN/TP ratio is 16.8, suggesting that neither nitrogen nor phosphorus are limiting with respect to algal growth. According to FDEP's approach (FDEP, 1996), TN/TP ratios below 10 indicate that nitrogen is a limiting nutrient, while lakes with TN/TP ratios greater than 30 are considered to be phosphorus limited. Although both nutrient concentrations are "balanced" or are not in excess compared to the other, both are in high enough concentrations to promote abundant algal growth.

Figure 3.19 AJ Henry Park Lake Total Phosphorus



Conductivity

Specific conductance values ranged from a low of 33 to a high of 125 µmhos/cm. The long term median conductivity value is 65 µmhos/cm, among the highest of the lakes in this report. Undoubtedly, the inorganic compound bicarbonate

(HCO_3^-), which is responsible for the lake's elevated alkalinity, is also a major contributor to the measured conductivity.

TURBIDITY

Turbidity levels in this lake have consistently been the highest of any lake in this study and have often exceeded the FDEP Class III surface water quality criterion. The values for A.J. Henry Park Lake range from 0.7 NTU to 273 NTU with a median turbidity value of 17.7 NTU. Although in the past, construction in the vicinity of the lake has been a major contributing factor to the measured turbidity levels, algal blooms that are now present in the lake on a perennial basis are the prime cause of the observed turbidity. It is the excess nutrient concentrations in the stormwater that flows into this lake that is responsible for the observed algal blooms. One such event occurred in July 2006, when the turbidity reached 191 NTU.

ALKALINITY AND PH

A.J. Henry Park Lake has a median alkalinity value of 24.1 mg/L, a relatively high value that makes it, somewhat ironically, one of the best lakes in the study with respect to buffering capacity, and one of only four lakes that meets the state minimum criterion for alkalinity of 20 mg/L. The variation in alkalinity measurements (13.2 to 38.6) has been fairly low over the 18-year observation record. Values for pH in this lake ranged from 5.5 to 9.5 with a median of 7.3 at the surface depth. The frequent excursions into the more alkaline end of the pH range (8.6 to 9.4) during sunny days reflect the high algal growth in this lake.

BACTERIOLOGICAL

The mean fecal coliform count of 118 colonies per 100 mL of water, with a standard deviation of 220 colonies per 100 mL, attests to the dramatic swings in bacteriological quality that this lake is prone to. The median coliform count for this lake is substantially less at 20 colonies per 100 mL. The median value is a measure of the central tendency of the data and is less skewed by extreme values than is the mean. Such bacteriological fluctuations, however, are typical of lakes in urban areas that receive substantial amounts of urban stormwater. Fecal coliform counts for A.J. Henry Park Lake have ranged from 2 to 1140 colonies per 100 mL of water. The latter value, which was recorded in 2000, exceeds the FDEP Class III surface water quality criterion of 800 colonies per 100 mL of water on any one day. Since then, there have been no exceedances, although counts from July 2006 (656 colonies/100mL) and May 2006 (505 colonies/100mL) were some of the highest recorded.

DISSOLVED OXYGEN

A.J. Henry Park Lake's eighteen year median dissolved oxygen concentration is 8.7 mg/L. This seemingly very healthy DO level, however, is misleading because almost 25% of the 73 sampling events to date at this lake the water column has been super-saturated with oxygen. It is the combination of sunlight and the abundance of algae that is responsible for the elevated DO concentrations. During the night and on hot cloudy days, the algal respiratory process can cause DO levels in the water column to decrease substantially below the level (5.0 mg/L) considered minimal for the sustainability of the fish population. Super-saturation was observed January of 2009, 14.2 mg/L. However surface measurements in the hot months of July 2005 (4.4 mg/L), 2006 (2.9 mg/L) and again October 2007 (4.89 mg/L), July 2008 (4.9 mg/L), were below 5.0 mg/L. DO levels generally decrease the deeper the measurements are taken; therefore a die-off of fish would not be unexpected under these conditions.

SUMMARY

A. J. Henry Park Lake continues to be in the poorest condition of any lake covered in this report. All water quality indices suggest that the water-body is hypereutrophic, a condition resulting from stormwater inflows with excessive concentrations of nutrients that are insufficiently utilized by the existing, rather poor, macrophyte community. The lake has become an algal-dominated system, subject to all of the problems normally observed with such status. The “pea-green soup” appearance presents a less than aesthetic visual experience for the casual observer. Elevated turbidity levels caused by the dense algal community reduce light penetration and prevent the rooting and growth of aquatic macrophytes. Substantial swings in water pH and DO levels due to the algal photosynthesis and respiratory processes continually stress the fish population. The slight improvements in lake water quality documented over 2001-2004 did not appear to represent an enduring trend indicated by the 2005 and 2006 data. Planting native non-invasive plants along the shoreline and littoral zone could create a better buffer and improve water quality in this lake. Additionally limitations on fertilizer application (i.e. application zones) by residents could also benefit the lake.

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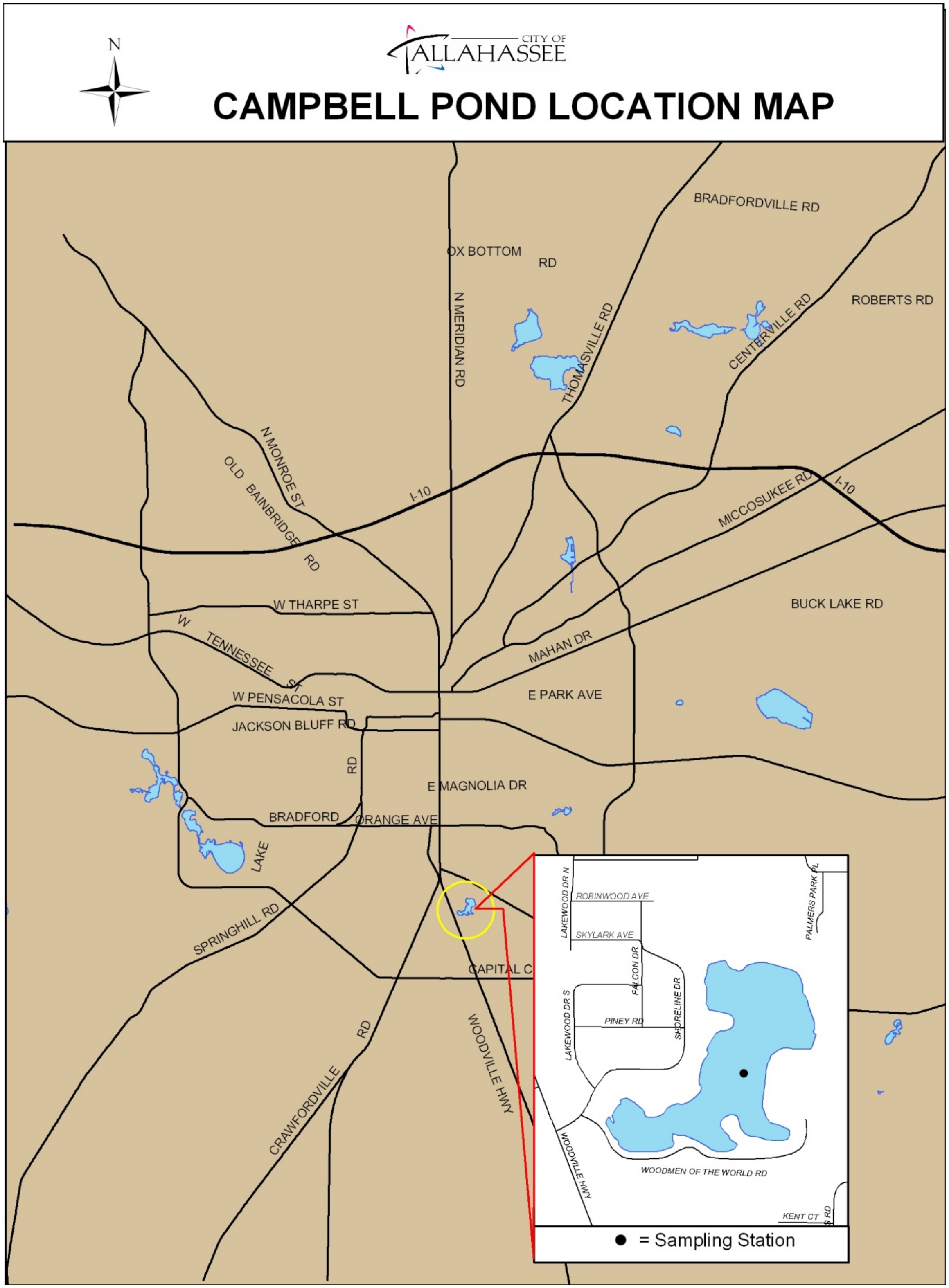

CITY OF TALLAHASSEE
N
CAMPBELL POND LOCATION MAP
BRADFORDVILLE RD
OX BOTTOM
RD
ROBERTS RD
N MERIDIAN RD
THOMASVILLE RD
CENTERVILLE RD
N MONROE ST
OLD BAINBRIDGE RD
I-10
MICCOSUKEE RD
I-10
W THARPE ST
BUCK LAKE RD
W TENNESSEE ST
MAHAN DR
W PENSACOLA ST
E PARK AVE
JACKSON BLUFF RD
RD
E MAGNOLIA DR
BRADFORD
ORANGE AVE
LAKE
SPRINGHILL RD
CAPITAL C
WOODVILLE HWY
CRAWFORDVILLE RD
LAKEWOOD DR N
ROBINWOOD AVE
SKYLARK AVE
PALMERS PARK PL
FALCON DR
LAKEWOOD DR S
SHORELINE DR
PINEY RD
WOODVILLE HWY
WOODMEN OF THE WORLD RD
KENT CT
S RD
● = Sampling Station

3.4 CAMPBELL POND

Campbell Pond is situated largely within the city park of the same name and is located south of the Cody Escarpment in the Woodville Karst Plain Physiographic Province. Soils in this physiographic province are characterized as loose quartz sands that thinly veneer limestone substrata. Dissolution of the underlying limestone has resulted in sinkhole sand dune topography. Campbell Pond may have originated from the dissolving of this relatively insoluble limestone over a period of hundreds of years and appears as a shallow, vegetated sand-filled depression. Campbell Pond is a relatively small lake (approximately 30-35 acres) that receives inflow from over 1000 acres of mostly urban watershed. Few perennial streams are found in this area and Campbell Pond has no perennial inflow or outflow. Possibly due to the inherently nutrient-poor soils and the high percolation rate in the immediate area, this lake has survived urbanization somewhat intact. Maximum depth is 12 feet with an estimated average lake depth of five feet. The Lakes Monitoring Program has one water quality station on Campbell Pond.

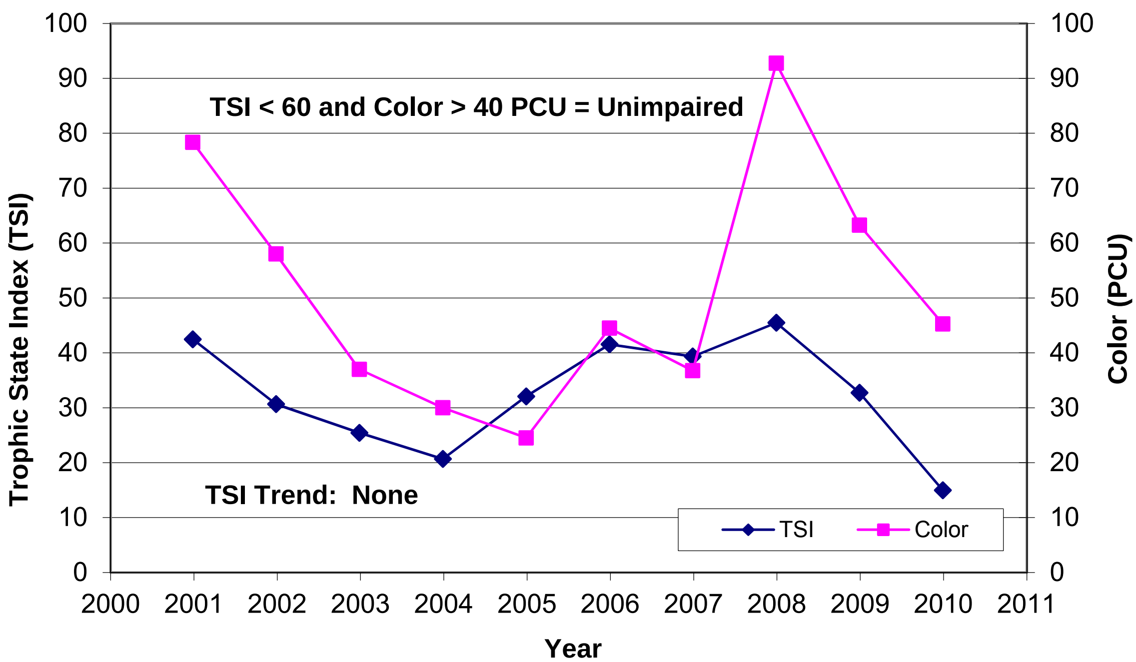
LAKE RATING

TROPHIC STATE INDEX AND COLOR

At times, Campbell Pond has a TSI value over 40; however, its 10-year median TSI value is 32.1. Using FDEP's TSI rating methodology, this result would be consistent with meeting Campbell Lake's "threshold" in terms of water quality. Campbell Lake is able to fully support its designated use and be considered "unimpaired" with respect to nutrients. No other heavily urbanized lake in this study scored as well. Figure 3.20 depicts Campbell Pond's annual average TSI and color values calculated from 2001 to 2010. TSI values prior to 2001 are not plotted because of the lack of reliable phosphorus values for this period.

Although the previous report showed an improving TSI value due primarily to lower concentrations of chlorophyll-*a* in the lake, this pattern did not persist as some of the highest TSI scores and chlorophyll-*a* values were observed in early 2006 and again in 2008. The annual mean values displayed in Figure 3.20 do not show these high individual scores from those quarters. The highest score for this lake was calculated from data collected in January 2006 (65.0) and January 2008 (53.6). FDEP protocols require using data from an entire year for the TSI assessment; therefore the overall annual average scores remained low. Color results for Campbell Pond typically average below 40 platinum cobalt units (PCU), however, towards the end the of summer of 2008 the color increased significantly due to increased summer rains and Tropical Storm Fay in August that drenched the city. Trend analysis of annual average TSI data over the ten-year monitoring period indicates no apparent trend.

Figure 3.20 Campbell Pond TSI and Color



CHLOROPHYLL-*a*

Although algal blooms have occasionally been detected in this lake, the eighteen year median chlorophyll-*a* value of 4.7 μg/L indicates a mesotrophic lake classification. Mesotrophic water-bodies are capable of producing and supporting moderate populations of fish and aquatic plants and in general exhibit average nutrient concentrations and good water clarity. Chlorophyll-*a* concentrations ranged from a low of 0.7 μg/L to a high of 90.2 μg/L, with the higher concentrations detected during summer months. The 90.2 μg/L represents the sample collected in October 2006. This value and the one from April 2005 (38.8 μg/L) are 6 to 15 times higher than the average of all other values reported from 2005 to 2010. From 2001 to 2004, algal blooms were conspicuously absent in Campbell Pond, a fact that was reflected both in lower chlorophyll-*a* concentrations and decreasing TSI values for this period.

MACROPHYTES

Campbell Pond's aquatic plant biomass tends to belie this lake's mesotrophic designation with emergent, floating and submersed vegetation covering approximately 50% of the lake surface area. Based on a lake vegetation macrophyte survey conducted in 2010, the lake is supporting a very good native plant community. Some examples of excellent plant species in Campbell Pond are, "Watershield" (*Brasenia schreberi*), "Willow Herb" (*Decodon* verticillatus), "Gulf Coast Spike Rush" (*Eleocharis cellulosa*), "Stream Bogmoss" (*Mayaca fluviatilis*) and a type of "St. Johns Wort" (*Triadenum virginicum*). These particular species are excellent water quality representatives and are listed by FLDEP as sensitive plants to water pollution. The more common emergent herbaceous species included "Maidencane" (*Panicum sp.*), several species of "SmartWeed" (*Polygonum* sp.) and "Blue Water Hyssop" (*Bacopa caroliniana*). Frequently seen floating plants included white or fragrant "Water Lily" (*Nymphaea odorata*) which could be considered the dominant herbaceous plant and "Floating Hearts" (*Nymphoides aquatica*). The lake has relatively little woody flora, mainly

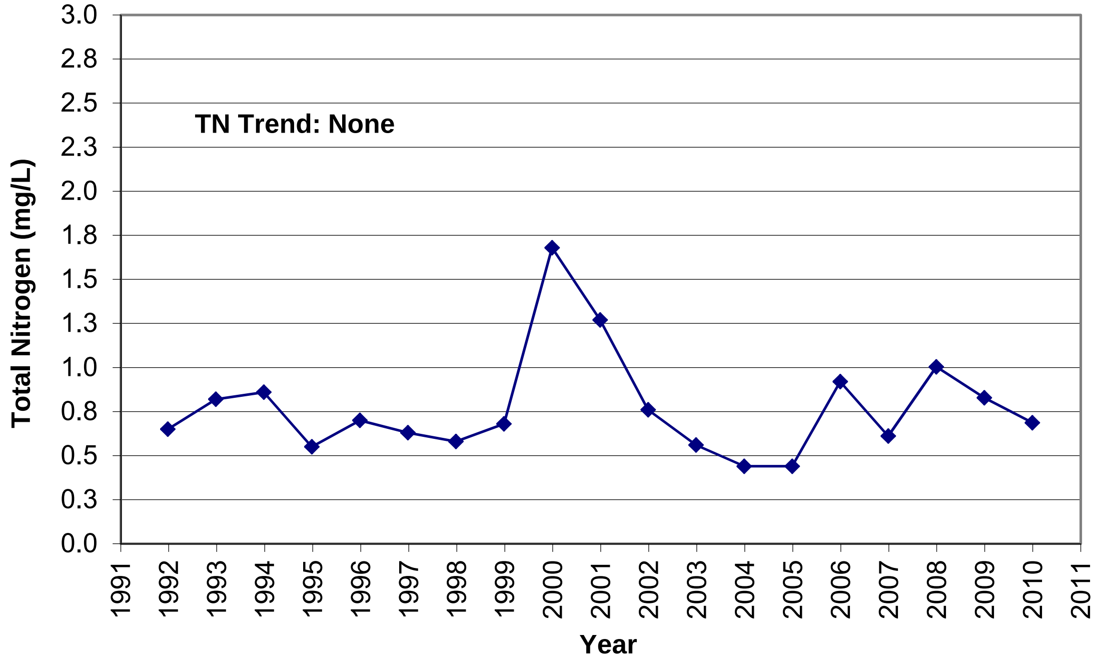
"Carolina Willow" (*Salix caroliniana*), "Buttonbush" (*Cephalanthus occidentalis*) and the invasive exotic "Chinese Tallow" tree (*Sapium sebiferum*), with "Buttonbush" as the dominant woody species. Observations since 2002 documented a change that began in late 2005 in the macrophytes to a community that is dominated by the submersed "Purple Fanwort" (*Cabomba caroliniana*). One tool to measure a lake's floral health is the Lake Vegetated Index (LVI). This tool was developed by Florida Department of Environmental Protection's Bureau of Laboratories and has been adopted in the state's Impaired Waters Rule (IWR). The LVI survey conducted on Campbell Pond (September 2010), again showed that the flora community within Campbell Pond is healthy. The dominant plant(s) during this survey are the "Water Lily" (*Nymphaea odorata)* and "Cupscale Grass" (*Sacciolepis striata).*

WATER QUALITY PARAMETERS

NUTRIENTS

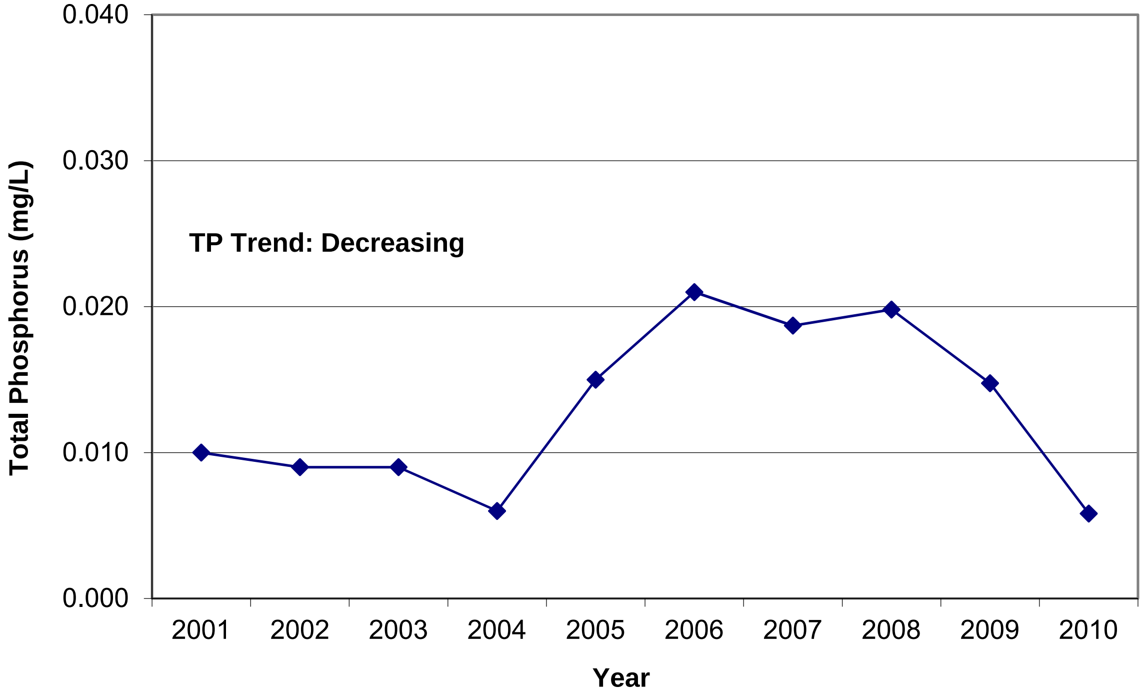
Campbell Pond's long term, median total nitrogen level of 0.68 mg/L is somewhat higher than many of the other water-bodies in this study. The nitrogen is predominantly in the organic form with median TKN and ammonia values of 0.67 mg/L and 0.01 mg/L, respectively. Ammonia, in low levels, has been detected in approximately 35% of the water quality samples taken from Campbell Pond since 1992. Figure 3.21 is a plot of mean annual TN values from 1992 to 2010. TN concentrations are relatively uniform until 2000 when there was a significant spike in TN. The increase was probably due to the concentrating effects of the three-year drought prior to 2001 when Campbell Pond's surface area shrunk to just a few acres. By 2002, the lake's TN concentration had returned to the long-term average. A similar trend was noted in the lake's color value, which peaked in 2008 at a level (200 PCU) more than four times the long-term average.

Figure 3.21 Campbell Pond Total Nitrogen



Campbell Pond's median TP concentration of 0.01 mg/L is low for a water body in an urban environment. The TP value is comparable to that of Lake Hall and Lake Overstreet, two very good water quality lakes. Figure 3.22, which plots annual average total phosphorus concentrations in the lake from 2001 to 2010, shows an decreasing trend in TP since 2008 which the pond peaked at 0.02 mg/L. The over-all ten-year observation period of 2001-2010 shows a stabilization of very low TP values. Although Campbell Pond has a mean TN/TP ratio of 132 indicating that the lake is phosphorus limited with respect to nutrient inputs, the frequency with which ammonia is detected in the water column and the higher phosphorus concentration, increased the production of significant algal blooms in the lake in 2005 and 2006.

Figure 3.22 Campbell Pond Total Phosphorus



CONDUCTIVITY

The median specific conductance value for Campbell Pond of 22 µmhos/cm is among the lowest (best) of the lakes covered in this report. Conductivity values range from 8 µmhos/cm to 103 µmhos/cm for the record of observations from 1992 to 2010 with recent measurements nearly three times the median.

TURBIDITY

The median turbidity level for this lake is a very low 1.3 NTU with only one sampling event since 1992 showing turbidity significantly above average. The park and slightly developed property immediately adjacent to this lake appear to do an excellent job in reducing particulate inflows to the water-body. No turbidity levels that exceed the FDEP Class III surface water quality criterion have been detected.

ALKALINITY AND PH

Campbell Pond is a soft water system with alkalinity values ranging from 3.0 mg/L to 39 mg/L and a median alkalinity of 7.0 mg/L, among the lowest of the clear water lakes in this study. Although the FDEP standard implies that an alkalinity of at least 20 mg/L is desirable for Class III water-bodies, the observed alkalinity is entirely natural. Campbell Pond pH values, which were generally less variable than many lakes in the study, ranged from 4.6 S.U. to 7.8 S.U with a slightly acidic median value of 6.5 S.U.

BACTERIOLOGICAL

Campbell Pond has higher than average fecal coliform counts. The median fecal coliform count for the period 1992 to 2010 is 20 colonies per 100 mL of water. The elevated bacterial count, which is higher (worse) than that of the majority of the lakes in this study, is one water quality indicator that might suggest the lake is a receptor for urban stormwater. The maximum-recorded fecal coliform count was 680 colonies per 100 mL of water in 1995. Nothing that high has been recorded since January 2000 although one sample taken, July 2010, contained 566 colonies per 100 mL of water after a heavy thunderstorm released a few inches of rain.

DISSOLVED OXYGEN

Campbell Pond has generally exhibited a healthy dissolved oxygen profile throughout the monitoring period with only 22% of the surface samples having DO values below the FDEP Class III surface water quality criterion of 5.0 mg/L DO. The lake’s median DO value is 6.9 mg/L. Approximately 15% of the surface DO samples showed evidence of super-saturation. This is a common occurrence in systems where algal blooms exist or where there is an abundance of macrophytes in the system. Excess oxygen is introduced into the water column by macrophytes and algae as a by-product of their food making and storing process (photosynthesis). During the hot summer months, this lake's mucky, organic bottom sediments exercise a considerable oxygen demand that results in hypoxic conditions; such that 43% of bottom DO measurements are less than 1 mg/L.

SUMMARY

Monitoring results indicate that Campbell Pond is a phosphorus-limited, mesotrophic system (based on chlorophyll-*a*) or an oligotrophic system (based on total phosphorus median) that experiences occasional algal blooms. Based on its current TSI and TP median values, Campbell Pond would rank as one the best among all of the clear water acidic lakes in this study. Its bacteriological count is the only indicator that suggests the lake receives urban stormwater and detracts from its otherwise excellent water quality. The reasons for the slight decrease in lake water quality are unclear. However, it may be that the large land area to surface area of this lake and the increase in rain totals, consequently more stormwater runoff, is affecting the lake's water quality. This lake supports a good fishery and is heavily utilized by the public for that purpose, especially in the springtime. A number of large bass have been caught from the lake, and it should continue to provide a good fishery into the future.

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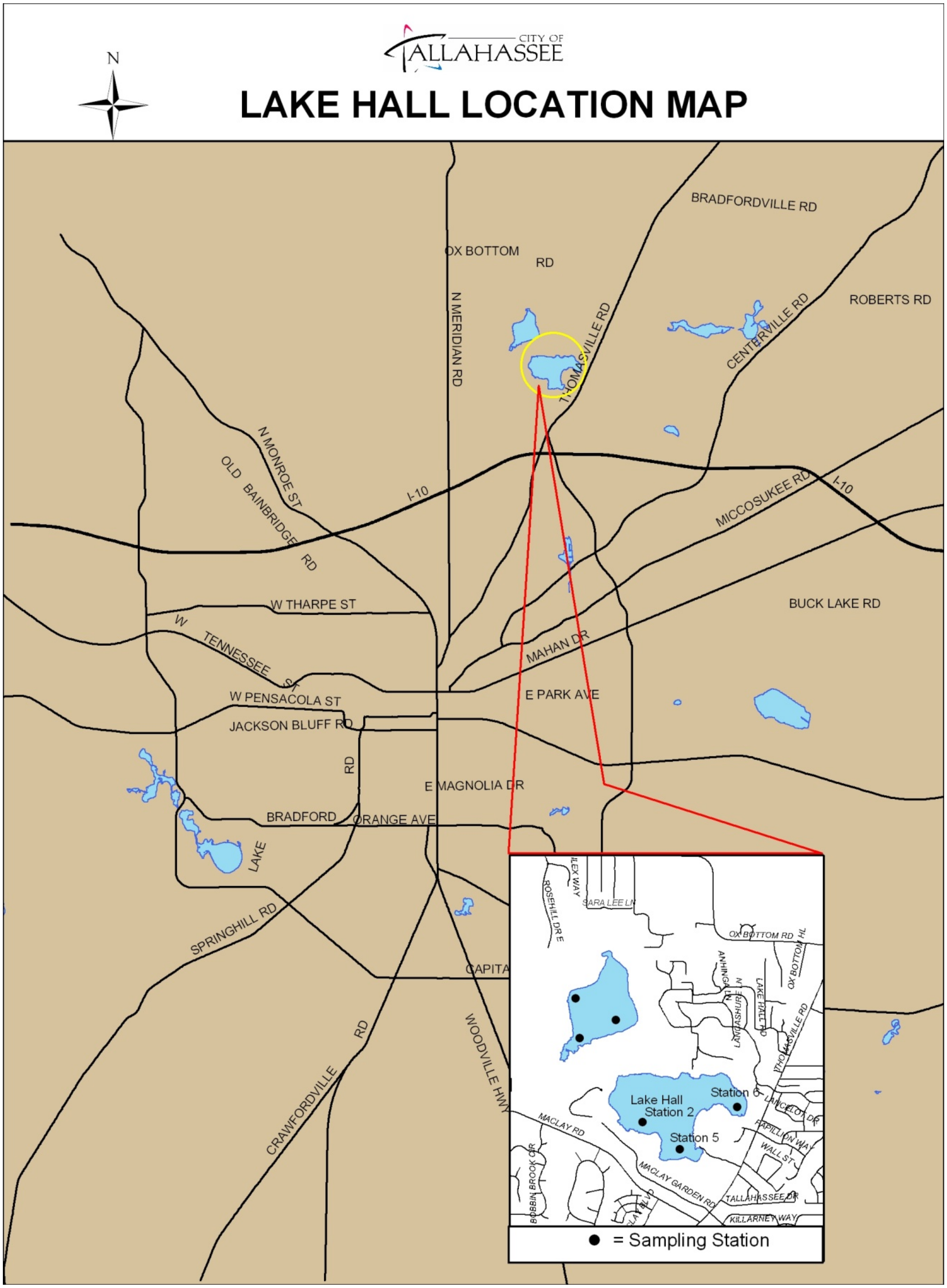

N
CITY OF TALLAHASSEE
LAKE HALL LOCATION MAP
BRADFORDVILLE RD
OX BOTTOM
RD
ROBERTS RD
N MERIDIAN RD
THOMASVILLE RD
CENTERVILLE RD
N MONROE ST
OLD BAINBRIDGE RD
I-10
MICCOSUKEE RD
I-10
W THARPE ST
BUCK LAKE RD
W TENNESSEE ST
MAHAN DR
E PARK AVE
W PENSACOLA ST
JACKSON BLUFF RD
RD
E MAGNOLIA DR
BRADFORD
ORANGE AVE
LAKE
SPRINGHILL RD
CAPITA
WOODVILLE HWY
CRAWFORDVILLE RD
ILEX WAY
ROSEHILL DR E
SARA LEE LN
OX BOTTOM RD
OX BOTTOM HL
LAKE HALL RD
LANCASHIRE LN
THOMASVILLE RD
Lake Hall
Station 2
Station 6
Station 5
LANCELOT DR
MACLAY RD
MACLAY GARDEN RD
PAPILLON WAY
WALL ST
TALLAHASSEE DR
KILLARNEY WAY
BOBBIN BROOK CIR
● = Sampling Station

3.5 LAKE HALL

Lake Hall is located west of Highway 319, north of Interstate 10 and partially within Maclay Gardens State Park. The former Maclay residence is located on a grassy knoll overlooking this lake, and the Maclay gardens are located adjacent to the lake on the west and south shores. The park and lake, which are managed by the Florida Department of Environmental Protection, Division of Parks, are heavily utilized for recreation. The lake provides numerous leisure opportunities including swimming, sunbathing, fishing, sculling, sailing and canoeing. There are a number of private residences on large lots adjoining this lake on its east and northeast side. However, overall the basin is moderately developed.

With a surface area of over 160 acres, Lake Hall is the largest lake covered in this report of selected Tallahassee area lakes. Lake Hall is located in the Tallahassee Red Hills Physiographic Province. Lake Hall's sub-basin catchments encompass an area of just over 1000 acres with a ratio of approximately 6:1 for watershed surface acreage to lake surface area. This is a very low ratio of land to water surface area, and with due diligence this Outstanding Florida Water (designated by FDEP 62-302.700(1) F.A.C.) could survive urbanization somewhat intact. Maximum depth at mean high water is approximately 30 feet, and the estimated average depth is fourteen feet.

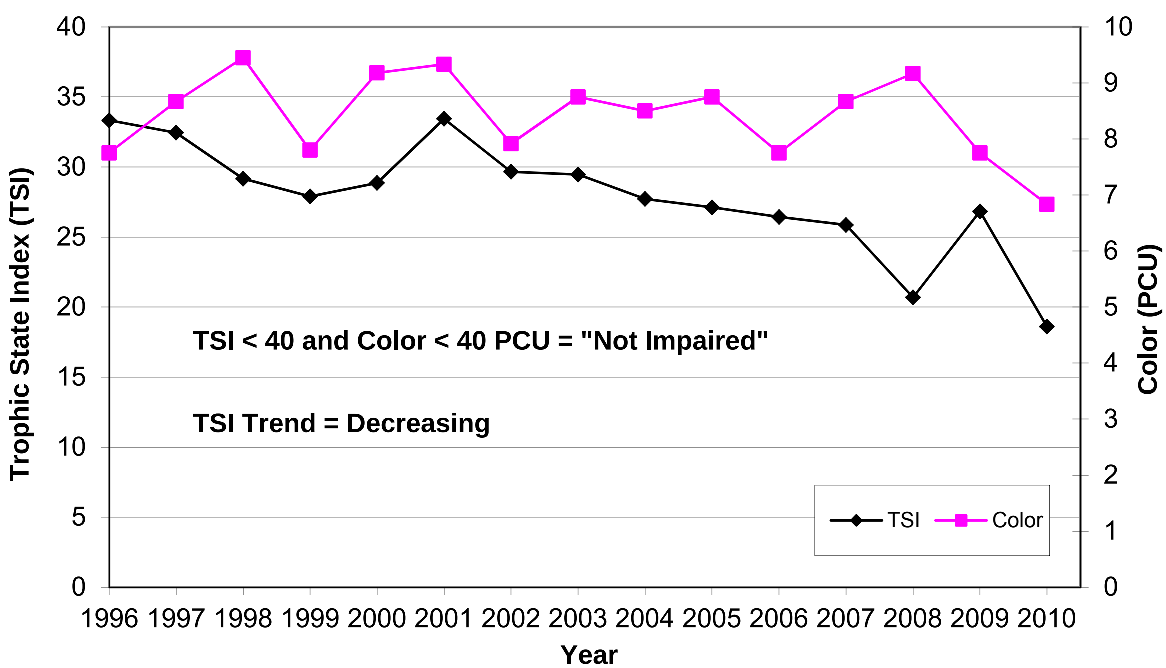
An ephemeral stream, the only defined stream that discharges into Lake Hall, receives stormwater runoff from Maclay Boulevard and the Village Commons shopping center before discharging into the lake. Judging by the monitoring results from the Villages at Maclay holding pond, the water quality that is discharged into the stream that flows into Lake Hall is much more nutrient enriched than the ambient concentrations found in this Outstanding Florida Water (OFW). Lake Hall discharges into nearby Lake Overstreet via the Lake Hall Tributary, a perennial stream of low capacity. Due to low water conditions, the Villages at Maclay holding pond did not discharge into Lake Hall in 2005 or 2006. The Lakes Monitoring Program has three monitoring stations on this lake.

LAKE RATING

TROPHIC STATE INDEX AND COLOR

Lake Hall is a clear (color less than 40 PCU) lake that consistently has an annual mean TSI score below 40. The results represent "unimpaired" water quality based on FDEP's Impaired Water Rule. Figure 3.23 is a plot of Lake Hall's annual mean TSI and color values calculated from 1996 to 2010. An apparent trend toward decreasing (improving) TSI values is evident over this 14-year monitoring period. Monitoring of Lake Hall has been conducted since 1993 by the City of Tallahassee. The TSI trend appears to be driven mainly by the lake's total nitrogen (TN) concentration that is also declining.

Figure 3.23 Lake Hall Trophic State Index vs. Color (PCU)

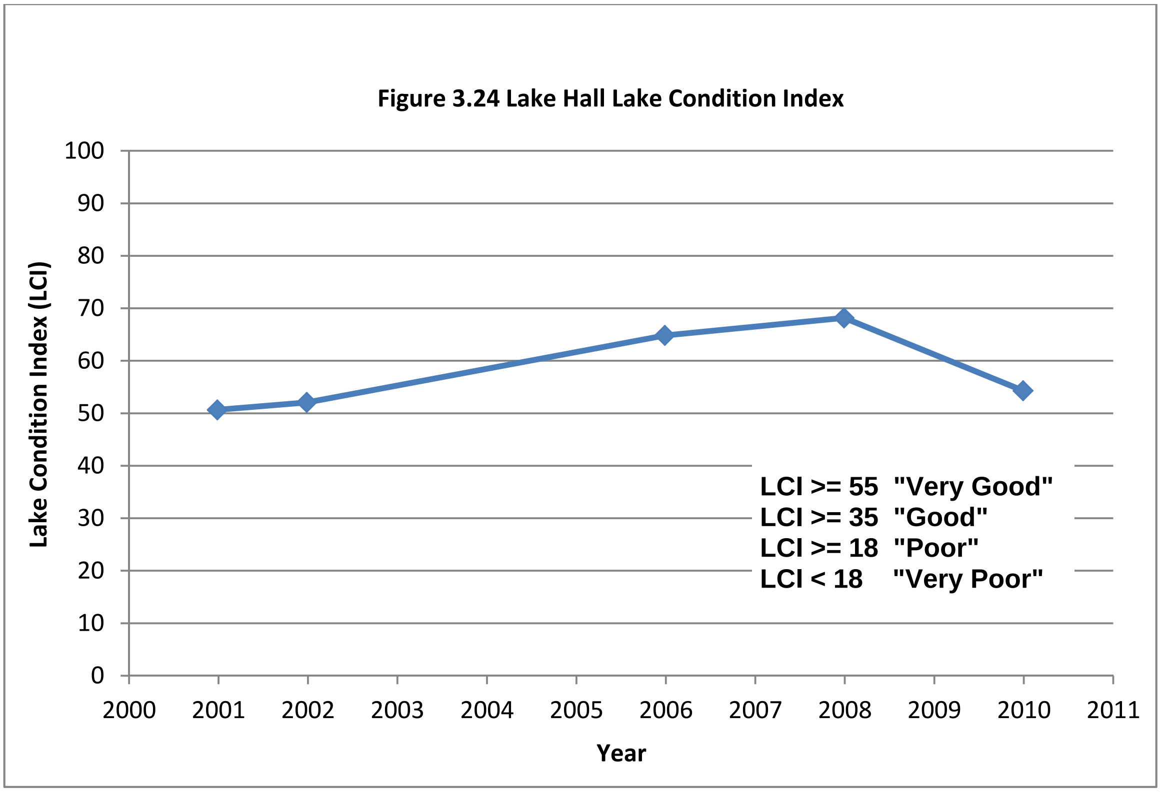


CHLOROPHYLL-*a*

Using only chlorophyll-*a* levels to rate this lake, the median chlorophyll-*a* concentration of 2.7 μg/L places this lake in the oligotrophic category. Lakes with chlorophyll-*a* levels between 0 and 4 μg/L are generally thought to be oligotrophic and typically exhibit lower nutrient levels and have less abundant concentrations of aquatic macrophytes and algae. Lake Hall's chlorophyll-*a* values recorded to date from all stations have ranged from 0 to 24.1 μg/L for 244 samples. In July 2004 and 2006, Lake Hall experienced an unusual occurrence, a gelatinous blue-green algae bloom. The algae blooms, although not dense, were widely distributed throughout the lake. Also, it was relatively short-lived, disappearing completely from the lake by the end of August. The algae were subsequently identified as a cyanobacterium of the genus Oscillatoria (Van Dyke, 2004). No increased chlorophyll-*a* concentrations were recorded as a result of this algae bloom.

LAKE CONDITION INDEX

Benthic macroinvertebrate samples were collected from Lake Hall in October 2001, 2002, 2006, 2008, and 2010 by Lakes Monitoring Program staff. The 2001 sampling effort was conducted in conjunction with FDEP personnel who also performed the taxonomic identifications. The taxonomy for the benthic samples collected in 2002 and 2006 were contracted to a private consultant. The Lakes Monitoring Staff identified the 2008 samples. Total taxa identified in the 2001 and 2002 samples were 22 and 24, respectively and reached an all-time high of 28 in 2006 while the 2008 total taxa dipped a bit to 25 and again lower in 2010 with 23 taxa.. These excellent and apparently reproducible taxa translate into LCI scores of 50.7, 52.1, 64.8, 68.2, and 54.3 (Figure 3.24). Based on FDEP's LCI ranking methodology, acid-clear lakes in this region of the state with LCI scores between 35 and 55 are rated as "good" and demonstrate that the lake is fully supporting its designated use; while lakes with LCI scores above 55 are rated as "very good". These consistently "good" scores confirm continued good water quality in Lake Hall.



MACROPHYTES

Macrophyte Lake Vegetation survey was conducted at Lake Hall in the summer of 2010. This survey showed that vegetation has remained stable without invasive exotics overtaking Lake Hall and that the lake has moderately dense macrophyte biomass that belies its oligotrophic status. As indicated in Figure 3.25, purple fanwort (*Cabomba caroliniana*) is one of the submersed native aquatic plants that dominates the lake and perhaps only the excessive depths in Lake Hall prevent this rooted plant from vegetating the entire lake. Other submersed species identified that have a significant presence on the lake bottom include water naiad (*Najas filifolia*), road-grass (*Eleocharis baldwinii*) and *Sagittaria filiformis* (Figures 3.26, 3.27 and 3.28, respectively). Cone-spur bladderwort (*Utricularia gibba*), variable-leaf milfoil (*Myriophyllum heterophyllum*) and coontail (*Ceratophyllum demersum*) were also frequently observed.

Floating plant coverage is notably dense near the shoreline of this lake, making navigation in these areas quite difficult. White water lily (*Nymphaea odorata* Figure 3.28), American lotus (*Nelumbo lutea* Figure 3.29) and water shield (*Brasenia schreberi*, Figure 3.30) dominate the vegetation in the shallower reaches of the lake. Water hyacinth (*Eichhornia crassipes,* Figure 3.31) is present in small isolated locations on the eastern lobe of the lake. Water hyacinth, which is listed as a Category I Invasive Exotic by the Florida Exotic Pest Control Council, FLEPCC), is controlled by FDEP by occasional herbicide treatment.

One of the more “fortuitous” consequences of the detailed aquatic plant mapping undertaken at Lake Hall in 2001/2002 was the discovery of hydrilla (*Hydrilla verticillata*) in an isolated area of the lake. Despite many previous qualitative aquatic plant surveys conducted in Lake Hall, this was the first time that the presence of hydrilla had been observed in the lake. Hydrilla was not detected in any of the other 17 lakes in which macrophyte surveys were performed. Hydrilla is a noxious invasive exotic weed that forms large monotypic stands and can quickly overwhelm many types of native aquatic plants. In addition to these biological impacts, hydrilla excess can severely impair navigation and recreational uses of the lake. FDEP’s Bureau of Aquatic Plant Management took steps to aggressively control the hydrilla outbreak before it became a problem. In the fall of 2001, the hydrilla stands were spot treated on several occasions with an aquatic herbicide (Fluoridone). The entire lake was treated with Fluoridone in March 2002. Additionally, in January 2002, grass carp were introduced into Lake Hall. It was anticipated that the low density of grass carp (approximately one per acre) would suppress the hydrilla while allowing native aquatic vegetation to continue to thrive. In August 2004, another patch of hydrilla was found adjacent to and beneath the floating dock at the Park’s boat ramp. To the extent that it was possible, the plant was harvested by hand, and then, the area was treated with pelletized Fluoridone (Van Dyke, 2004). As of 2010, Hydrilla is still present in the lake and has expanded from just a couple of small areas to somewhat larger areas. However, based on the absence of hydrilla at the lake’s surface and the lack of visible mats, it appears to be well controlled by the grass carp

Figure 3.25 CABOMBA CAROLINIANA (Purple Fanwort)

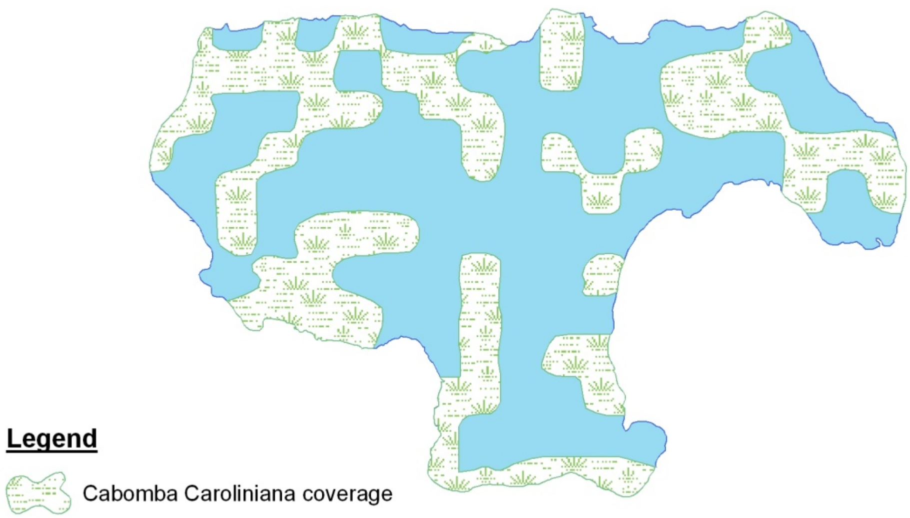
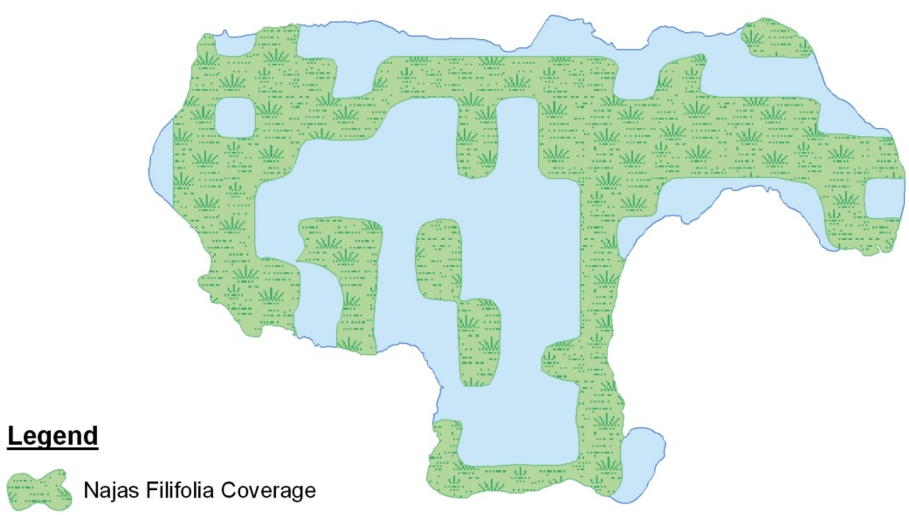


Figure 3.26 NAJAS FILIFOLIA



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CITY OF TALLAHASSEE, FLORIDA

Lake Hall

Survey Date - Sept. 2001/June 2002

Stormwater Management Division

1 inch equals 1,000 feet

Figure 3.26 ELEOCHARIS BALDWINII (Road Grass)

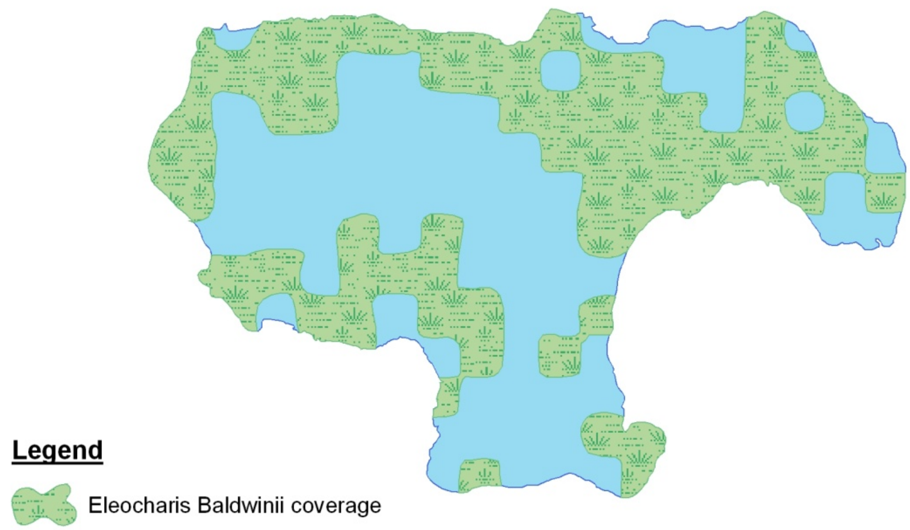

Figure 3.27 SAGITTARIA FILIFORMOSII

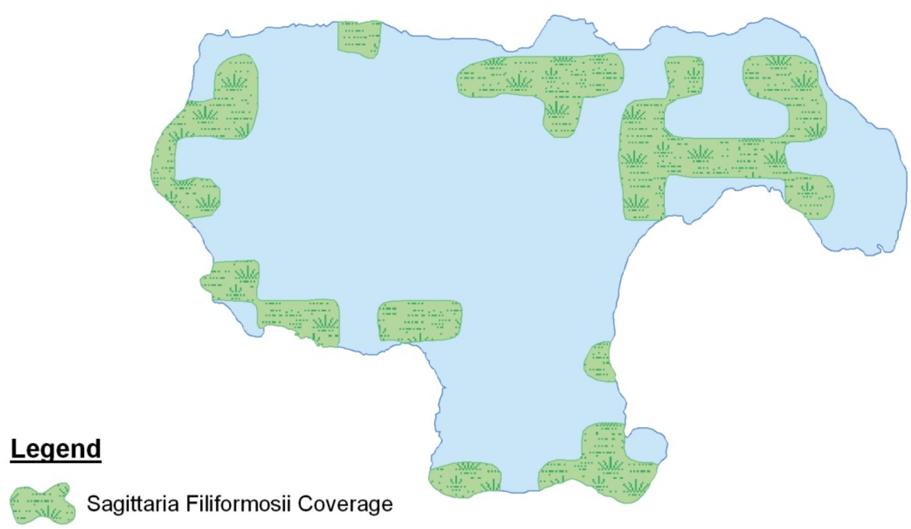

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Figure 3.28 NYMPHAEA ODORATA (Fragrant Water Lilly)

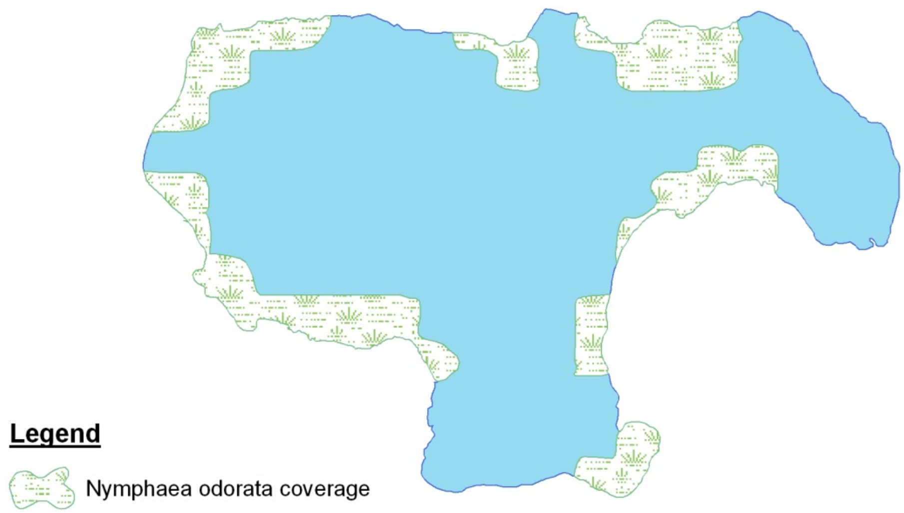
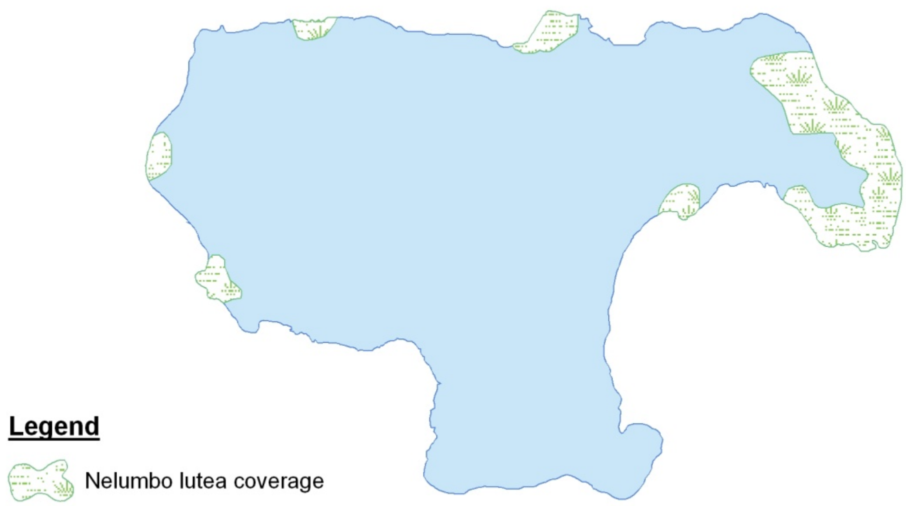


Figure 3.29 NELUMBO LUTEA (American Lotus)



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CITY OF TALLAHASSEE, FLORIDA

Lake Hall

Survey Date - Sept. 2001/June 2002

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600 300 0 600 1,200 1,800 2,400 Feet

1 inch equals 1,000 feet

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Figure 3.30 BRASENIA SCHREBERI (Water Shield)

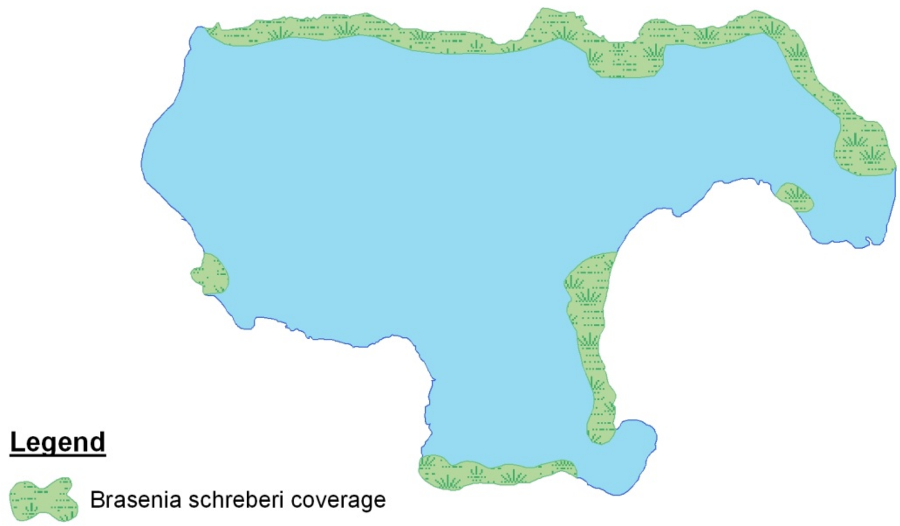
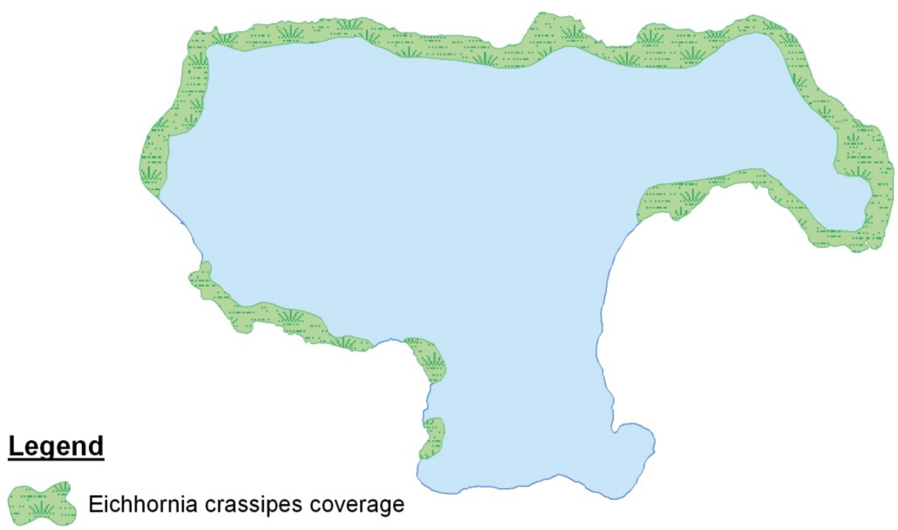


Figure 3.31 EICHHORNIA CRASSIPES (Water Hyacinth)



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CITY OF TALLAHASSEE, FLORIDA

Lake Hall

Survey Date - Sept. 2001/June 2002

Stormwater Management Division

1 inch equals 1,000 feet

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WATER QUALITY PARAMETERS

NUTRIENTS

The median TN and TKN concentrations for Lake Hall are both 0.31 mg/L. Since neither ammonia nor nitrate, are detected in the lake, all of the nitrogen is present in the organically bound form. The TN value is one of the lowest of all the lakes in this study, with only Lake Overstreet's TN value being lower. Based on the TN value alone, Lake Hall would be classified as oligotrophic. As Figure 3.32 indicates, Lake Hall's mean TN concentration has declined perceptibly from 1993 to 2010, a trend that also has influenced the lake's TSI value.

Lake Hall has a median total phosphorus (TP) concentration of 0.011 mg/L. A plot (Figure 3.33) of annual mean TP values from 1993 to 2010 indicates some variation of the lake's annual average TP concentration over time with values from 2005 and 2006 being the lowest. As noted elsewhere in this report, TP data used to construct the plot prior to the year 2001 was obtained from LAKEWATCH reports (LAKEWATCH, 2001). Lake Hall's median TN/TP ratio is 26.4, meaning that the lake is balanced with respect to nitrogen and phosphorus inputs. However, the occurrence of a cyanobacteria bloom in the lake in July 2004 is significant. Cyanobacteria possess the unique ability to assimilate (fix) gaseous atmospheric nitrogen (N_2) if growth is limited by nitrogen from other sources. The development of the cyanobacteria bloom could suggest there are insufficient amounts of the other nitrogen species in the lake and that it is a nitrogen-limited water body.

Figure 3.32 Lake Hall Total Nitrogen

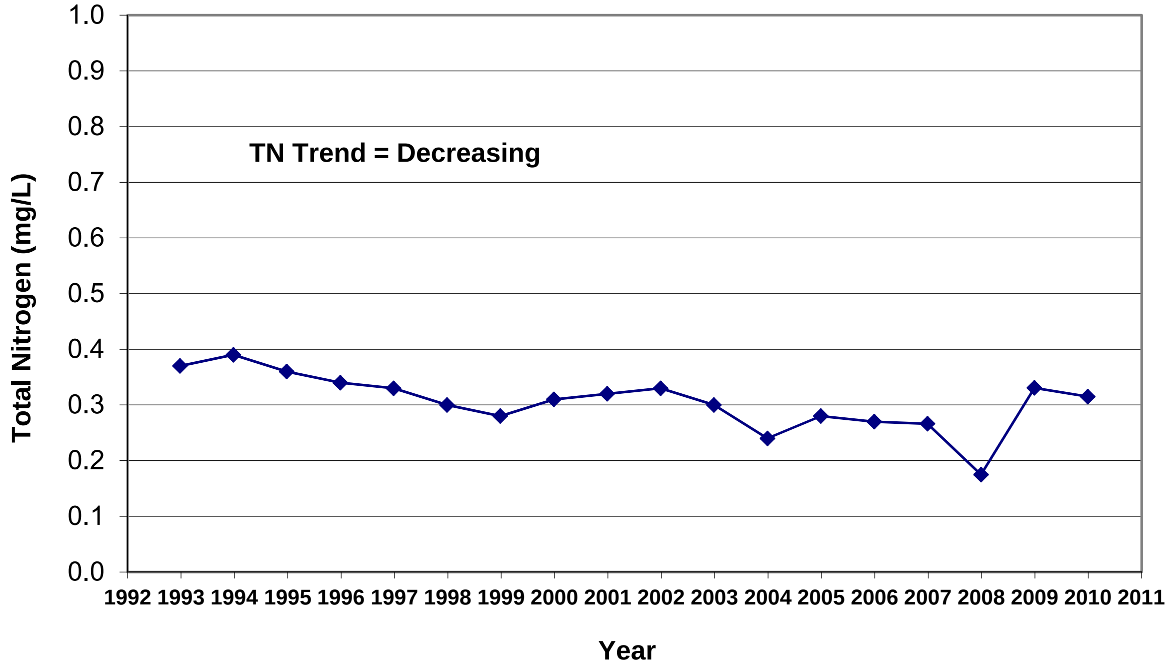
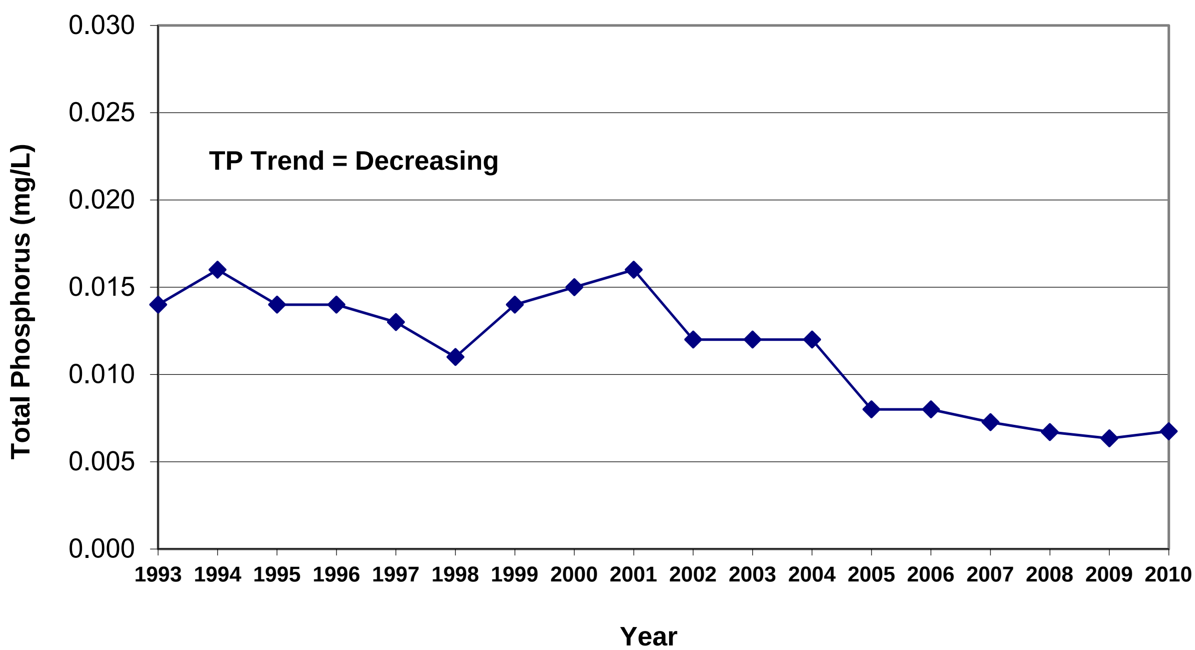


Figure 3.33 Lake Hall Total Phosphorus



CONDUCTIVITY

Lake Hall's median specific conductivity of 24 μmhos/cm is very low compared to the statewide average of 97 μmhos/cm for freshwater lakes (Canfield and Hoyer, 1988). Conductivity levels are a general indicator of inorganic constituents in freshwater lakes. Therefore, the conductivity of Lake Hall indicates low level of metals or other inorganic constituents.

TURBIDITY

Turbidity values for Lake Hall have ranged from a low of 0.1 NTU to a high of 12.2 NTU for 216 samples. The median turbidity value of 0.8 NTU, attests to the excellent long-term clarity of the water in this lake. Only Moore Lake and Lake Overstreet exhibit better turbidity levels.

ALKALINITY AND pH

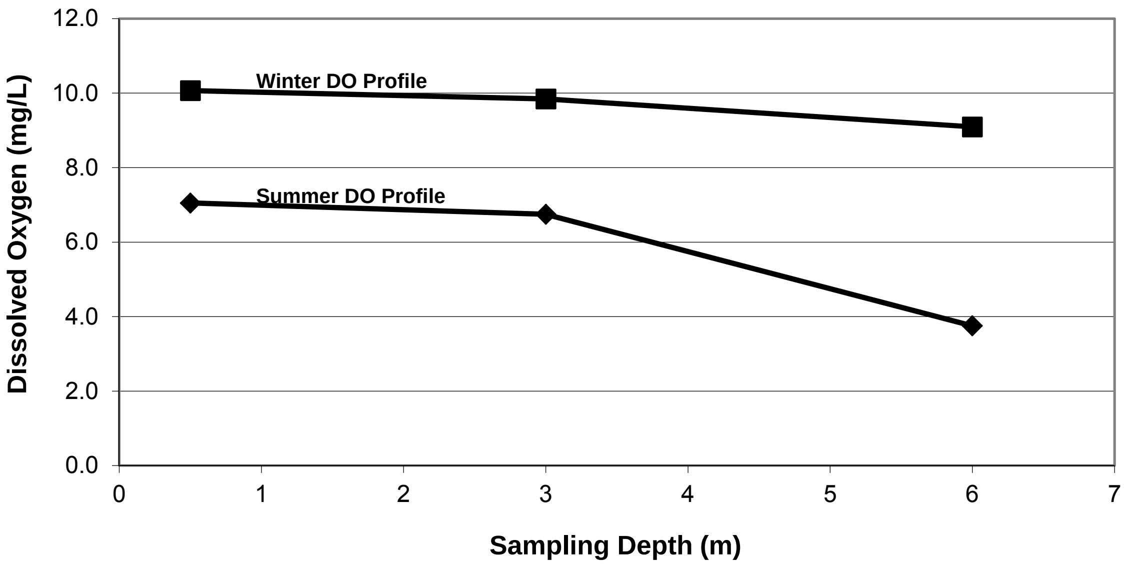
Lake Hall has a median alkalinity value of 4.8 mg/L. Although well below FDEP minimum standard of 20 mg/L, low alkalinity values are natural and normal for soft water lakes in this region of the state. The mean pH in Lake Hall is a slightly acidic 6.4 S.U.

BACTERIOLOGICAL

The median fecal coliform count for the stations on Lake Hall is 4 colonies per 100 mL of water. This is an excellent result considering the heavy recreational use of this lake. Fecal coliform counts from Lake Hall samples are similar to those from Moore Lake. However, there was a record high count reported from samples collected in July 2005. Counts since then have been much closer to normal levels for this lake.

DISSOLVED OXYGEN

Figure 3.34 Lake Hall Seasonal DO Profiles



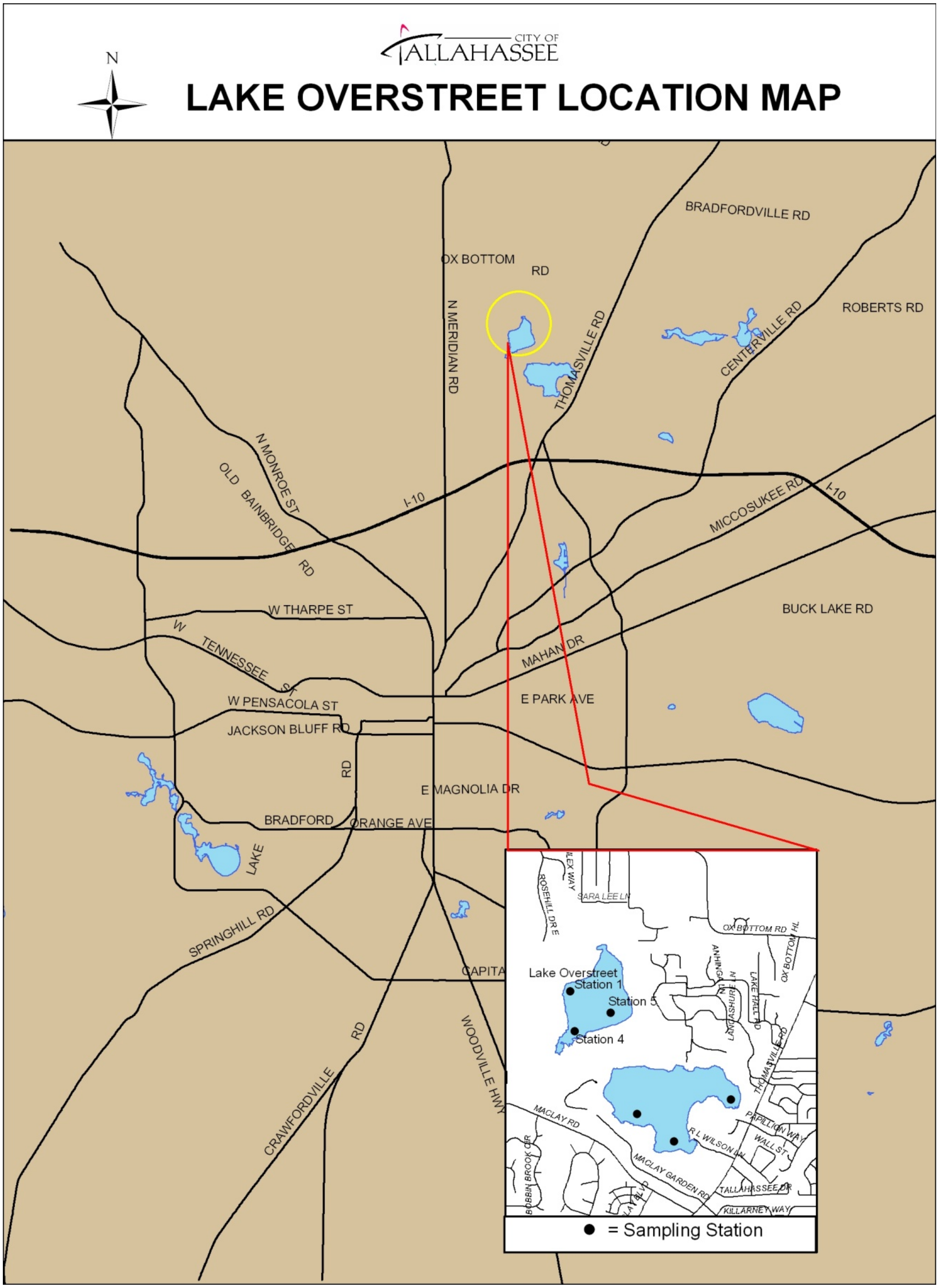
Lake Hall's DO profile has remained generally good throughout the entire period of observation from 1993 to 2010. Median dissolved oxygen concentrations at the surface, intermediate and bottom depths are 8.1 mg/L, 7.8 mg/L and 6.8 mg/L, respectively. Occasional anoxic conditions (DO values less than 1.0 mg/L) are encountered at the bottom depth, particularly in the summer months. Oxygen depletion at the bottom depth is enhanced by the thermal stratification that occurs in this lake, mainly in the summer but sometimes in the winter months. Temperature differentials of up to 10 degrees Celsius between the surface and bottom zones are not uncommon at station 5, the deepest part of the lake. Figure 3.34 displays DO profiles for summer and winter. Dissolved oxygen levels are high and well above the Class III water quality criterion; while levels are lower at depth in the summer months, dropping below the 5.0 mg/L Class III water quality criterion.

Low DO levels at depth do not immediately impact the more vertically motile fauna directly (these organisms could just ascend in the water column to reach more favorable DO levels); however, the sessile (non-motile) fauna such as many micro and macroinvertebrates can be severely impacted by the occasionally low dissolved oxygen levels. Indeed, one such occasion was in July 2003 when numerous specimens of the freshwater clam *Anodonta imbecilis* were found dead and floating on the lake surface. This normally bottom-dwelling organism, which is considered an indicator of good water quality, had previously been identified in the October 2002 LCI study of Lake Hall as the only bivalve mollusk present in the lake. The mollusk mortality was attributed to low DO concentrations at the lake bottom. Measured bottom depth DO levels at two of three Lake Hall stations were below 1 mg/L in July 2003. While the lake has had no exceedances of the Class III surface water quality criterion for dissolved oxygen at surface or intermediate depths, there have been numerous measurements below 5.0 mg/L at the bottom depth; most of these being measured in July. Seventy-eight percent of July bottom measurements are below the Class III minimum, while only 24% of all other bottom measurements, (218), are <5.0 mg/L. Fortunately these low levels do not persist, as levels in the next quarter are generally much higher. The LCI results confirm that these short-lived low DO events do not stress the macroinvertebrate community beyond recovery.

SUMMARY

Lake Hall is classified as an Outstanding Florida Water (OFW) by the state of Florida. The water quality and biological assessment as reflected in its Trophic State Index rating and Lake Condition Index score continue to validate this classification. An apparent trend toward decreasing TSI values (improving water quality) is evident over the fifteen-year monitoring period. The TSI trend appears to correlate with the lake's total nitrogen concentration that is also declining. Inputs to this OFW have occurred via the Villages at Maclay stormwater treatment facility and turbid run off from the widening of Thomasville Road. However, since the completion of the widening project in 1998, stormwater runoff from the road is directed to a holding pond which discharges to Lake Hall only in extreme rainfall events.

In 1998, Lakes Monitoring Program staff observed a marked increase in this lake's coverage of submerged aquatic vegetation. The dominant submerged vegetation (purple fanwort) became so dense that one of the monitoring stations had to be moved in order to collect chemical and biological samples. The 2001/2002-macrophyte survey and more recent observations confirm that the fanwort remains the dominant submerged vegetation with coverage throughout approximately 60% of the lake. It is unclear what factors prompted the macrophyte biomass expansion, since purple fanwort is a rooted plant deriving the majority of its nutrients from the lake sediment. Nutrient concentrations in the water column appear to be either stable (in the case of phosphorus) or declining (in the case of nitrogen). Efforts to eradicate hydrilla, which was discovered in the lake in 2001, have been largely successful. However, the continued presence of hydrilla suggests that this invasive exotic is tenacious and will not be easily eliminated.


CITY OF TALLAHASSEE
N
LAKE OVERSTREET LOCATION MAP
BRADFORDVILLE RD
OX BOTTOM RD
ROBERTS RD
N MERIDIAN RD
THOMASVILLE RD
CENTERVILLE RD
N MONROE ST
OLD BAINBRIDGE RD
I-10
MICCOSUKEE RD
I-10
W THARPE ST
BUCK LAKE RD
W TENNESSEE ST
MAHAN DR
W PENSACOLA ST
E PARK AVE
JACKSON BLUFF RD
RD
E MAGNOLIA DR
BRADFORD
ORANGE AVE
LAKE
SPRINGHILL RD
CAPITA
RD
CRAWFORDVILLE
WOODVILLE HWY
ILEX WAY
ROSEHILL DR E
SARA LEE LN
OX BOTTOM RD
OX BOTTOM HL
ANHINGA LN
LANCASHIRE NT
LAKE HALL RD
Lake Overstreet
Station 1
Station 5
Station 4
THOMASVILLE RD
MACLAY RD
PAPILLION WAY
WALL ST
R L WILSON LN
BOBBIN BROOK CIR
MACLAY GARDEN RD
TALLAHASSEE DR
KILLARNEY WAY
= Sampling Station

3.6 LAKE OVERSTREET

Lake Overstreet is located west of Highway 319 and two miles north of Interstate 10. Lake Overstreet is situated within the Tallahassee Red Hills physiographic province, soils are predominately clay-sand from the Hawthorn formation. The FDEP Division of Recreation and Parks, with assistance from the City of Tallahassee, acquired this scenic lake in 1994 as an addition to Maclay Gardens State Park. Lake Overstreet serves as a refuge for a diverse array of wildlife and was utilized for waterfowl hunting and fishing by its previous owners. Fishing and boating are not allowed in Lake Overstreet due to concerns about the possible spread of noxious exotic vegetation into this lake. Historically, most of the land in this lake's watershed was row crops, however, most of this activity was discontinued prior to 1937.

Lake Overstreet has a surface area of approximately 140 acres. This lake's maximum depth is 26 feet, and much of this lake is in excess of 20 feet in depth at mean pool elevation. Lake Overstreet is one of the larger lakes covered in this report and is the largest lake in Leon County that does not have significant development within its 640 acre sub-basin catchment area. Lake Overstreet's watershed surface acreage to lake surface area ratio is approximately 6:1. This is a very low ratio of land to water surface area, and given the relative isolation of this lake from urban development, this lake should remain essentially natural and unchanged for many years.

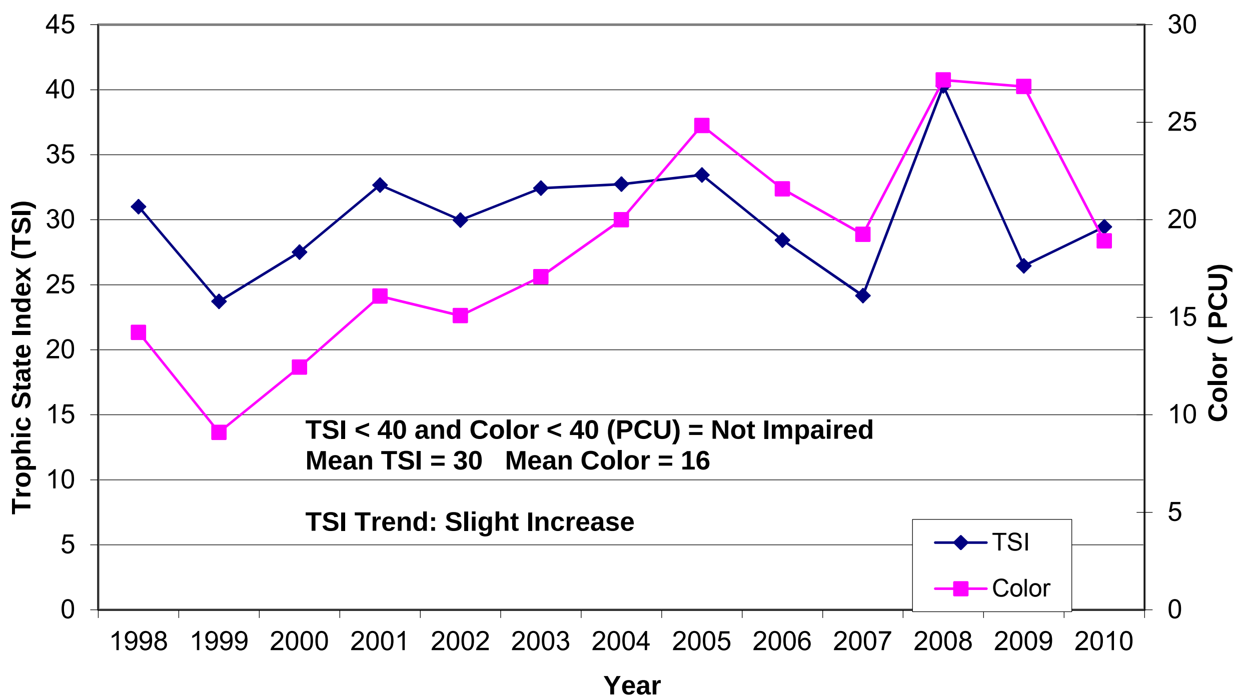
The Lake Hall Tributary is the only defined perennial stream that discharges into Lake Overstreet and, as the name suggests, originates from Lake Hall. The volume of water that enters this lake through this stream is generally very low (estimated to be less than five cubic feet per second). The channel appears to have been altered to facilitate flow from Lake Hall into Lake Overstreet. The work may have been completed in the Antebellum Period. The Lakes Monitoring Program currently has three monitoring stations on this lake.

LAKE RATING

TROPHIC STATE INDEX AND COLOR

Lake Overstreet's long-term median TSI score of 30.8 is among the lowest TSI scores of the acid-clear lakes in this study, with only Moore Lake (TSI = 23.5) having a better score and with Campbell Pond (TSI = 33.9) just slightly higher. Figure 3.35 is a plot of Lake Overstreet's annual mean TSI values calculated from 1998 to 2010. All scores are below 40 except when Tropical Storm Fay produced rains in August 2008 that increased Overstreet's 2008 TSI average slightly above 40. Overall with the median color at 16 (PCU) and annual running TSI at 31, Lake Overstreet is not impaired based on FDEP's IWR rating scheme. Lakes that have color values less than 40 PCU and TSI scores less than 40 are considered not impaired. The year-to-year TSI values are relatively unchanging, however, statistical analysis of the individual data points indicate that an increasing trend in TSI is occurring over the monitoring period.

Figure 3.35 Trophic State Index vs. Color



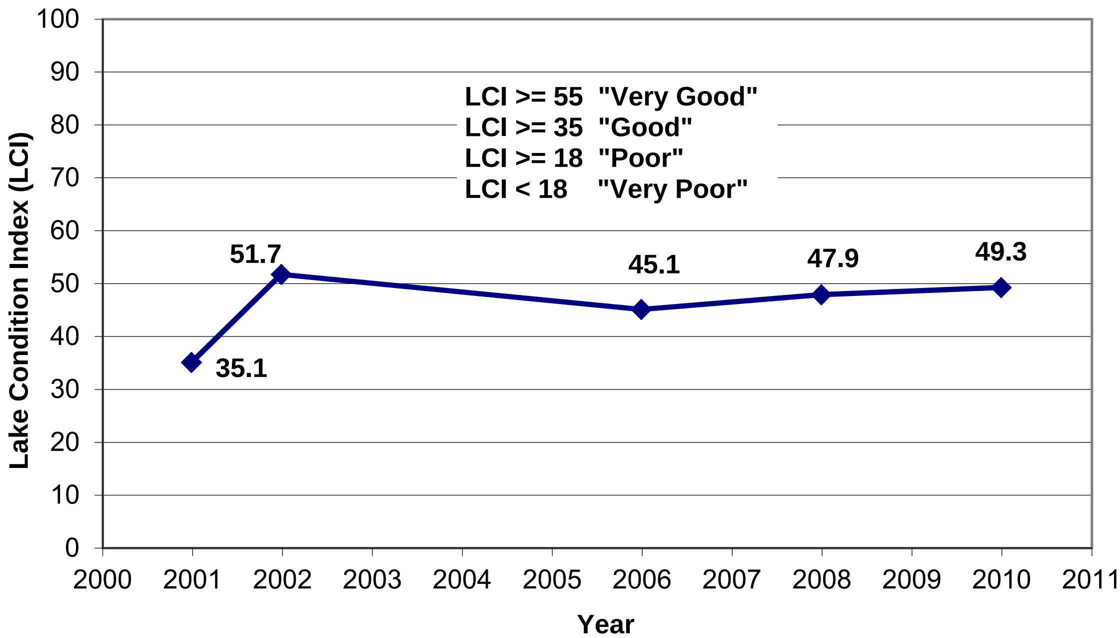
CHLOROPHYLL-*a*

If only chlorophyll-*a* levels are used to rate this lake, the median chlorophyll-*a* concentration of 3.1 μg/L places this lake in the oligotrophic category. Lakes with chlorophyll-*a* levels between 0 and 3.9 μg/L are classified as oligotrophic and typically exhibit lower nutrient levels and have less abundant concentrations of aquatic macrophytes and algae. Although the abundance of aquatic plants in this lake tends to belie its oligotrophic ranking, the macrophyte biomass probably out competes algae for available nutrients and depresses the aqueous chlorophyll-*a* concentration. Maximum-recorded secchi depths of nearly 20 feet and a median color value of 16 platinum cobalt units attest to the paucity of sediment and algae in the water column.

LAKE CONDITION INDEX

Benthic macroinvertebrate samples were collected from Lake Overstreet in five different years, in 2001, 2002, 2006, 2008 and 2010 by Lakes Monitoring Program staff. The 2001 sampling effort was conducted in conjunction with FDEP personnel who also conducted the taxonomic identification. A consultant performed the taxonomy for the benthic samples collected in 2002 and 2006, while City lakes staff identified 2008 and 2010 collections. Total taxa identified in 2002 (30) was double that reported in 2001 (15), giving mean LCI scores of 51.7 and 35.1, respectively. The LCI scores (45.1) for the 2006 sample was slightly lower than that from 2002 (Figure 3.36). Samples from years 2008 and 2010 produced improvement LCI scores of (47.9) and (49.3) respectively. Previous macroinvertebrate sampling performed in this lake in 1996 (COT, 2001) also indicated substantial differences in the total number of taxa per station. Based on FDEP's LCI ranking methodology, acid-clear lakes in this region of the state with mean LCI scores between 35 and 55 are rated as "good." Lake Overstreet scores have consistently fallen into this range, establishing that the lake continues to maintain good water quality. Although scores are good, the macroinvertebrate taxa found in the lake are indicative of an organic bottom. Numerous types of worms and fly larvae have been found while dragonflies and bottom-dwelling mayflies are absent.

Figure 3.36 Lake Overstreet Lake Condition Index



MACROPHYTES

Lake Overstreet, a relatively large lake with little disturbance from human activity, supports diverse and dense flora and for this reason is one of only three lakes in this study whose vegetation was mapped in the 2001-2002 surveys. In 2008 and 2010 the City Lakes Monitoring staff conducted a FDEP sanctioned Lake Vegetation Index (LVI) test to see if the plant community has changed since the initial 2001-2002 survey was performed. Plant communities are still present as seen in 2002. Purple fanwort (*Cabomba caroliniana*) is the dominant submersed aquatic plant (Figure 3.37). It is rooted over approximately 80% of the lake's bottom area with slender stems rising through the water column to the surface. Probably, it is only the greater water depths that inhibit this plant from colonizing the entire lake. White water lily (*Nymphaea odorata*), a rooted floating-leaved plant, is present throughout the shallower reaches of the lake. In 2001-2002, as illustrated in Figure 3.36, this plant occupied approximately 50% of the lake's surface area. However, over the past few years a thick fringe of frog's bit

(*Limnobium spongia*) has developed competing with Nymphaea odorata (Figure 3.36). The American lotus (*Nelumbo lutea*) and yellow pond lily or spatterdock (*Nuphar luteum*) was much less common than white water lily. Interestingly, water shield (*Brasenia schreberi*) is very limited in this lake; it is frequently co-dominant with *Cabomba caroliniana*. The bladderwort (*Utricularia purpurea*) is another submersed aquatic plant that is well established with almost 35% lake surface area coverage (Figure 3.38). Pickerelweed (*Pontederia cordata*-Figure 3.39), bur marigold (*Bidens laevis*-Figure 3.40) and American cupscale (*Sacciolepis striata*-Figure 3.41) are prominent emergent plants around the lake fringe. Plentiful amounts of filamentous algae were encountered in the extreme southern portion of the lake, where the depth is much shallower. The dominant woody species in Lake Overstreet is buttonbush (*Cephalanthus occidentalis*), along with swamp loosestrife (*Decadon verticillatus*), a very good indicator of a healthy lake. All of the plants encountered at this lake are native and typically indicate good water quality.

Figure 3.36 NYMPHAEA ODORATA (white water lily)

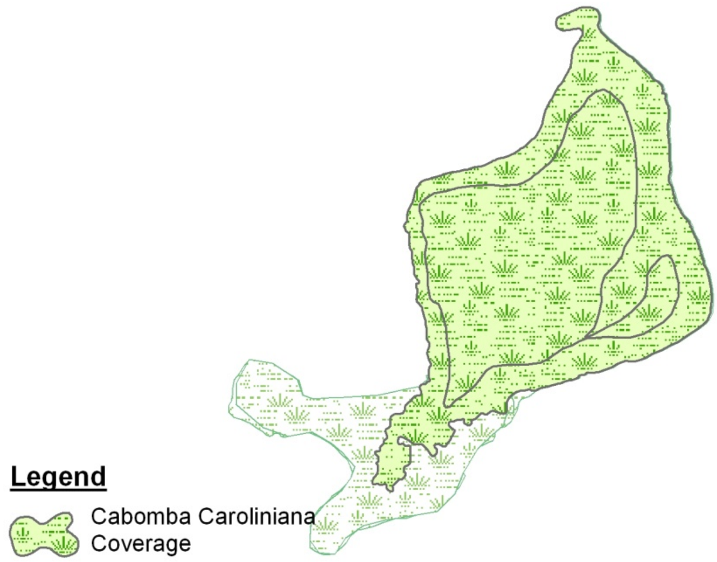
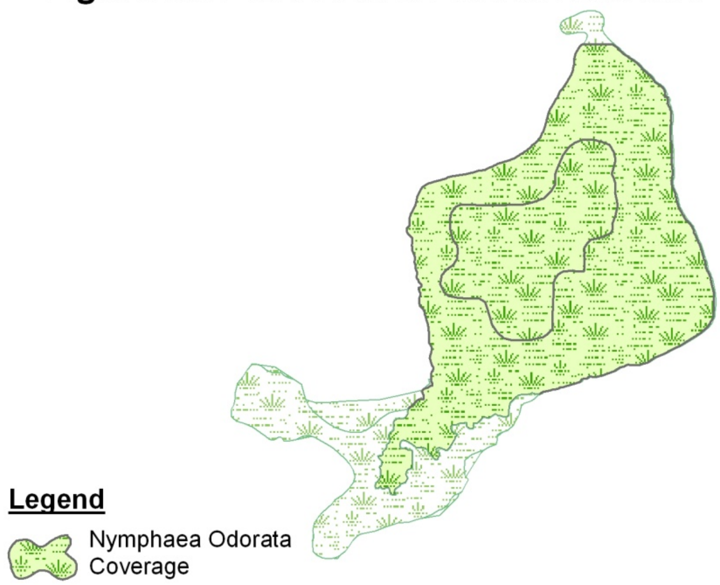


Figure 3.37 CABOMBA CAROLINIANA (Purple Fanwort)



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Lake Overstreet
Survey Date - July 2002

Stormwater Management Division

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Figure 3.38 UTRICULARIA PURPUREA (Purple Bladderwort)

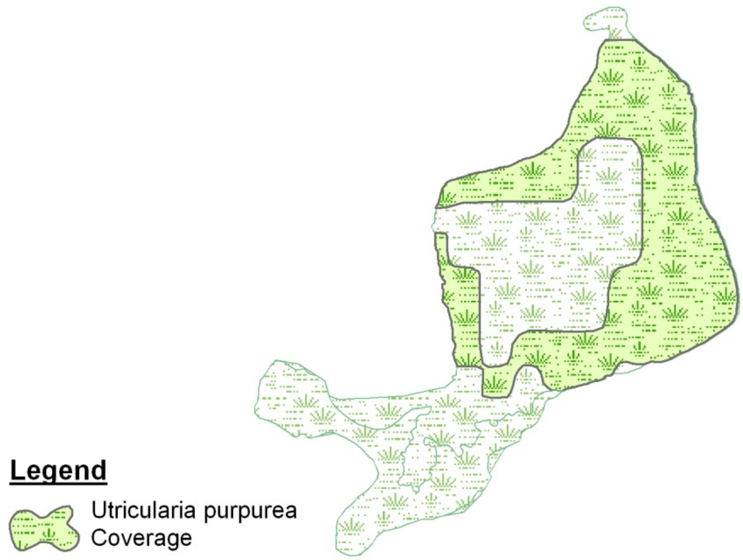
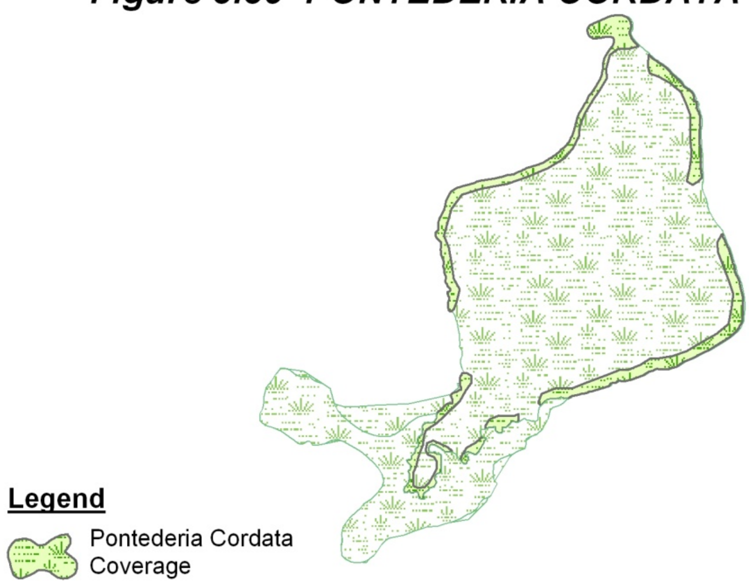


Figure 3.39 PONTEDERIA CORDATA (Pickerelweed)



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Lake Overstreet
Survey Date - July 2002

Stormwater Management Division

1,250 625 0 1,250 2,500 Feet

1 inch equals 1,250 feet

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Figure 3.40 BIDENS LAEVIS (Bur Marigold)

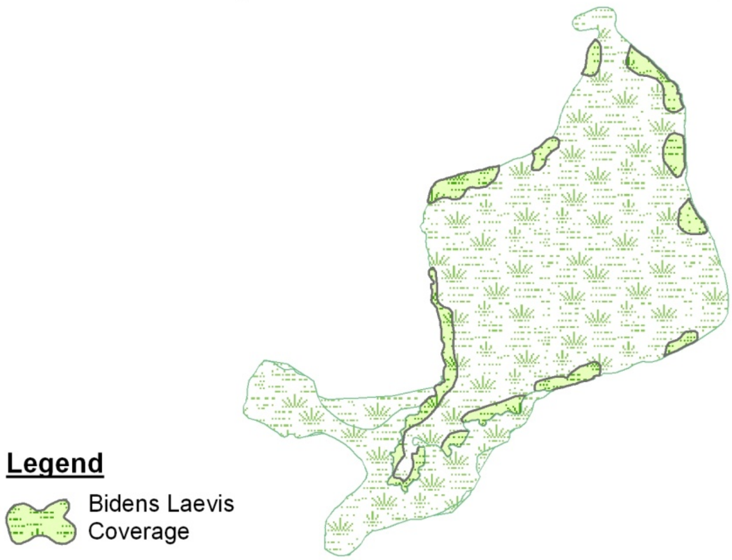
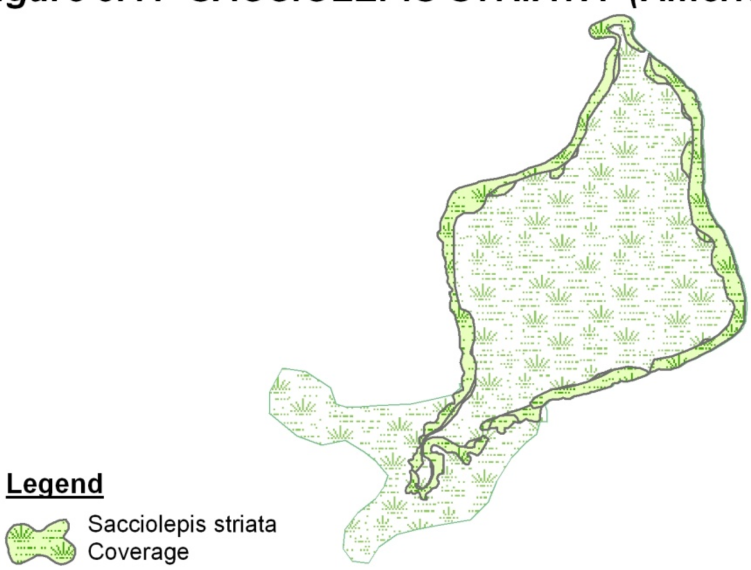
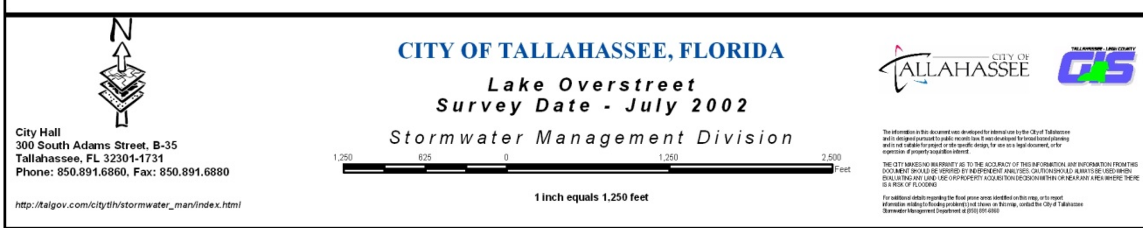


Figure 3.41 SACCIOLEPIS STRIATA (American Cupscalegrass)



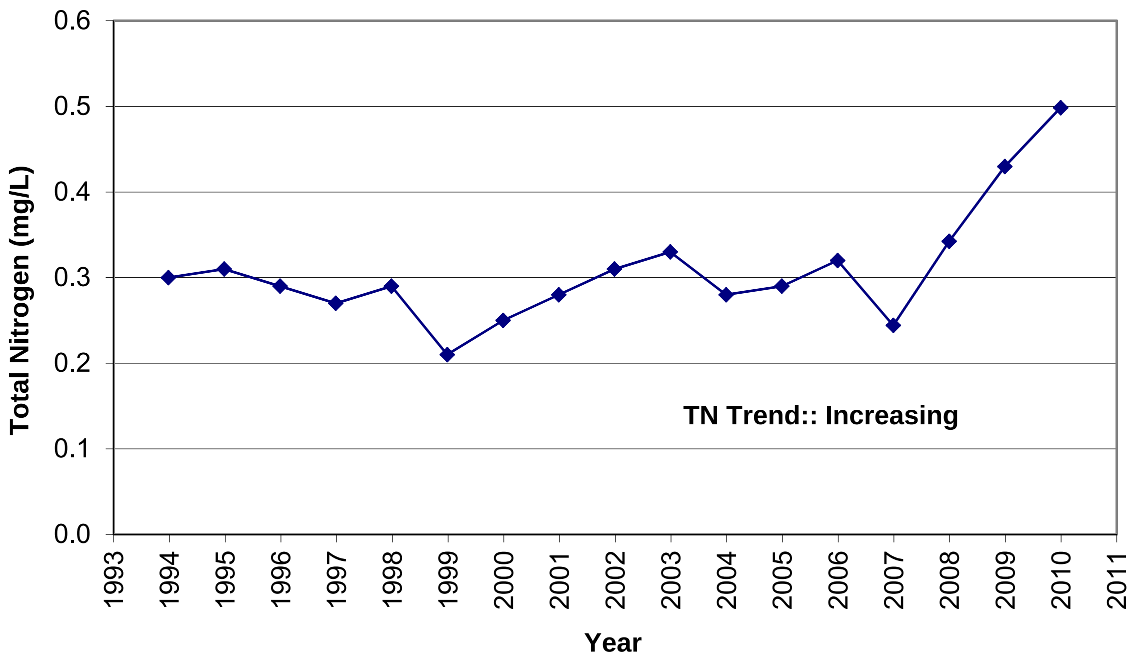


WATER QUALITY PARAMETERS

NUTRIENTS

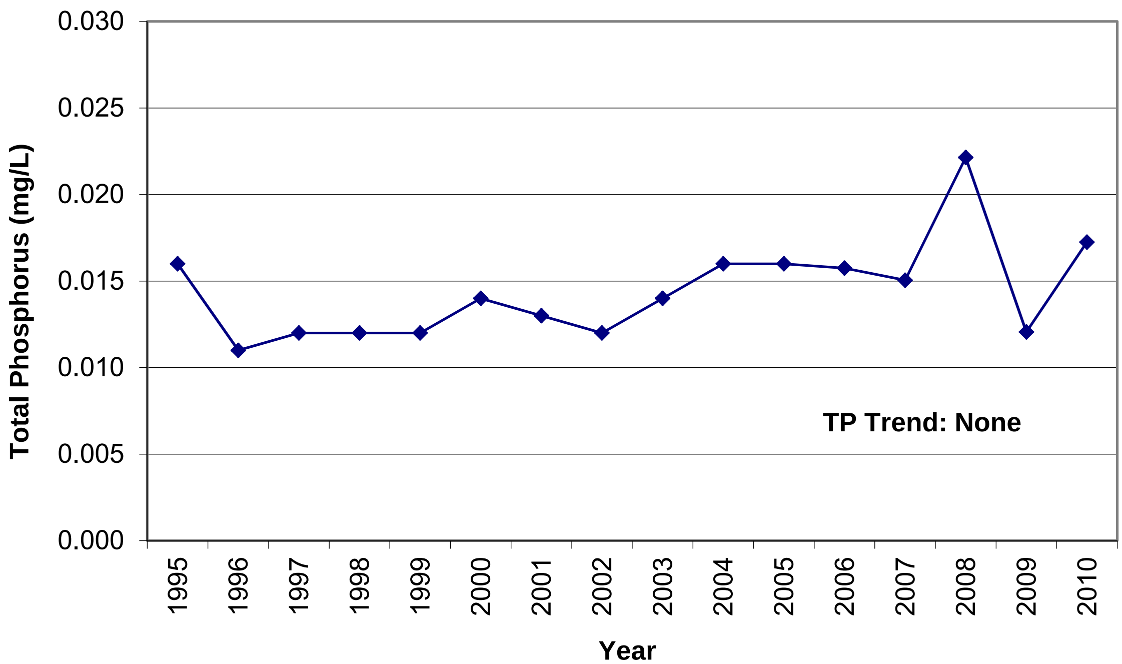
Lake Overstreet's median TN and TKN values of 0.29 mg/L and 0.29 mg/L. respectively, are the lowest of any of the lakes in this study. Ammonia, although it has been detected, has a median concentration below the analytical detection limit, and nitrate has never been detected above the analytical detection limit (0.013 mg/L). Based on the TN value alone, Lake Overstreet would be classified as an oligotrophic system. Figure 3.43 shows the lake's mean annual TN concentration from 1994 to 2010. No trend in the TN data is evident over the observation period.

Figure 3.43 Lake Overstreet Total Nitrogen



Lake Overstreet has a median total phosphorus (TP) concentration of 0.014 mg/L, is slightly higher to that of Lake Hall. A plot of annual mean TP values from 1995 to 2010 (Figure 3.44) indicates little variation of the lake's annual mean TP concentration over time. As noted elsewhere in this report, TP data used to construct the plot prior to the year 2001 was obtained from LAKEWATCH reports (LAKEWATCH, 2000).

Figure 3.44 Lake Overstreet Total Phosphorus



The median TN/TP ratio of 21.0 suggests either nitrogen or phosphorus could be the limiting nutrient with respect to algal growth. However, aquatic plants appear to easily out compete algae for available nutrients in this macrophyte-dominated lake.

CONDUCTIVITY

Lake Overstreet's median specific conductance of 19 μmhos/cm is among the lowest values of all the lakes in this study and is very low compared to statewide averages for freshwater lakes. High conductivity levels are often thought of as a general indicator of inorganic pollutant levels in freshwater lakes.

TURBIDITY

The outstanding water clarity that this lake maintains is reflected in its turbidity values which have ranged from a low of 0 NTU to a high of 2.0 NTU during monitoring events. Lake Overstreet's median turbidity value is 0.7 NTU, the second lowest of all the lakes in this report. Secchi disk measurements are also excellent and occasionally approach 20 feet. The only lakes in this study that maintain exceedingly low turbidity values are in basins with little to no development activity.

ALKALINITY AND PH

The median alkalinity value recorded for all Lake Overstreet stations is 3.7 mg/L, a naturally low value and typical of many soft water lakes in this region of the state where no limestone is encountered near the surface This low alkalinity value indicates that this lake would be potentially susceptible to pH shifts that could occur through anthropogenic impacts. Lake Overstreet's median pH value of 5.5 is fairly acidic and comparable to that found in many blackwater systems. The lake is somewhat unusual for lakes in this study in that its low pH is not associated with notable color. In fact, with a median color value of 16 platinum cobalt units, there is less true color in this system than in 80% of all lakes in Florida including those with high alkalinity values.

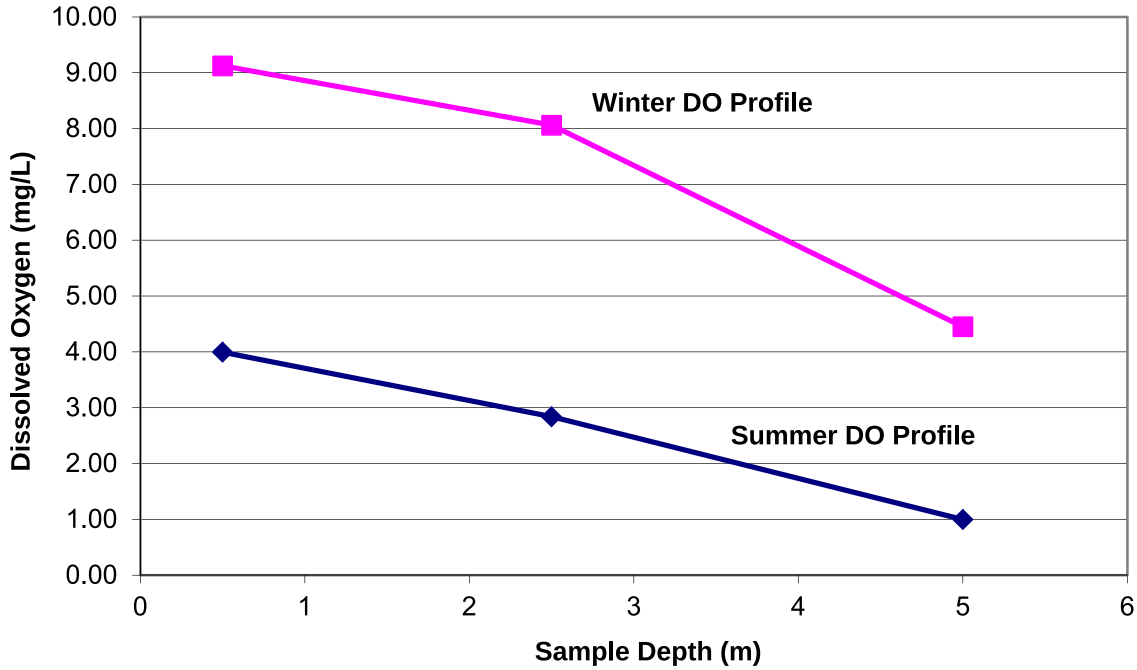
Bacteriological

Lake Overstreet has exhibited consistently low fecal coliform counts since monitoring of the lake began in 1994. The median overall fecal coliform count for all five monitoring stations is 3 colonies per 100 mL of water. Therefore fecal coliforms are not a water quality concern for Lake Overstreet. The highest recorded fecal coliform count for a single station was 140 colonies per 100 mL of water recorded in July 2004.

Dissolved Oxygen

Unlike Lake Hall, Lake Overstreet's DO profile is generally marginal and has remained so throughout the sixteen-year monitoring period. Median DO concentration at the surface is 5.9 mg/L and approximately 37% of the surface samples from this lake had DO levels less than FDEP's criterion for Class III waters of 5.0 mg/L. At bottom depths of the lake, oxygen depletion is more significant with a median DO level of 1.0 mg/L. Indeed, more than half of the bottom depth DO readings in Lake Overstreet were in the anoxic range, i.e., less than 1.0 mg/L. Figure 3.45 displays the average DO measurement at various depths over the summer and winter seasons. It demonstrates that DO levels at all depths in Lake Overstreet are consistently below the Class III criterion during the summer with anoxic conditions at five meters. During the winter months, DO levels are higher at shallower depths, but below the water quality criterion at 5 meters. The observed low DO readings are natural and mainly due to the abundance of aquatic plant biomass in the lake. Oxygenation of the water column takes place at the water's surface, and this process can be hindered by the presence of floating and floating-leaved plants. As previously noted, one floating leaved plant, white water lily, covers much of Lake Overstreet's surface area. Secondly, during their lifetime, aquatic plants slough off dead leaves and other plant parts that sink to the lake bottom and contribute to the formation of sediment. The oxygen demand exercised by the decaying vegetation can result in severe oxygen depletion in the water column especially during summer months, as shown in Figure 3.45. As the benthic macroinvertebrate sampling demonstrated, this lake has accumulated an excess of organic sediment.

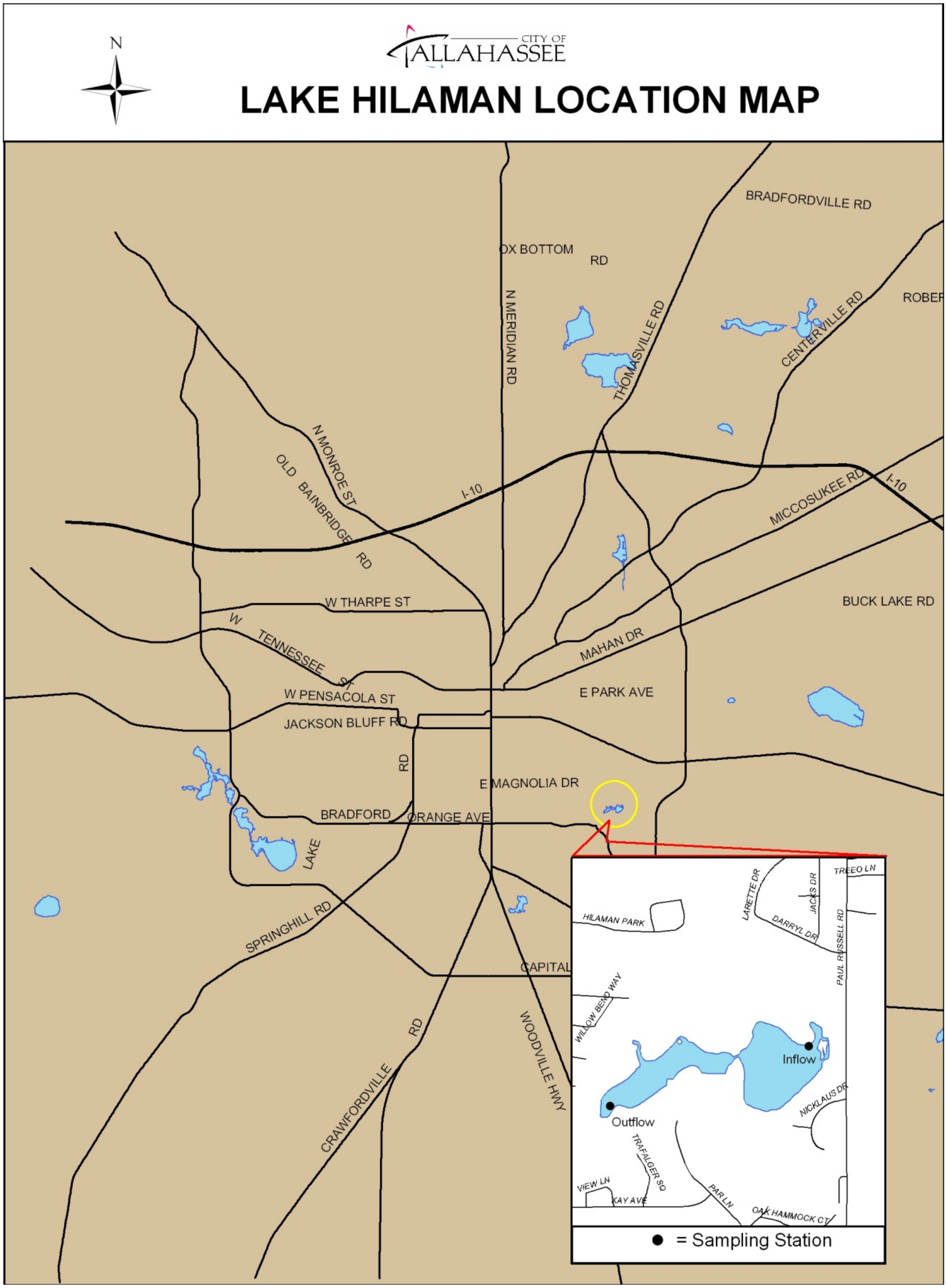
Figure 3.45 Lake Overstreet Seasonal DO Profiles



Low DO levels at depth do not immediately impact the more vertically motile fauna directly (these organisms could just ascend in the water column to reach more favorable DO levels); however, the sessile (non-motile) fauna such as many micro- and macroinvertebrates can be severely impacted by low dissolved oxygen levels. This may account for observed differences in the benthic macroinvertebrate taxa between sampling events.

SUMMARY

Lake Overstreet is not classified as an Outstanding Florida Water (OFW) by the state of Florida, but it probably should be in the future. The water quality and biological variety reflected in the macroinvertebrate fauna and macrophyte community are good. Impacts to this lake are limited due to the lack of development in this lake's basin and its relative isolation. Although using water quality-based lake rating methods, Lake Overstreet is classified as biologically unproductive, oligotrophic system, its macrophyte abundance suggests otherwise. These methods do not take into account biological productivity expressed in the form of aquatic macrophytes. Indeed, using floating-leaved plant biomass as a measurement of biological productivity, Lake Overstreet is in the highly productive (eutrophic) or most highly productive (hypereutrophic) category. Even though aquatic macrophytes provide excellent habitat for fish and for the organisms that fish feed on, they also play a major role in the oxygen depletion in this water-body. The frequent marginal DO conditions observed in Lake Overstreet stress fish populations, but fortunately because of their ability to adapt to lower oxygen environments, no fish kills have been reported.


N
CITY OF TALLAHASSEE
LAKE HILAMAN LOCATION MAP
BRADFORDVILLE RD
OX BOTTOM
RD
N MERIDIAN RD
THOMASVILLE RD
CENTERVILLE RD
N MONROE ST
OLD BAINBRIDGE RD
I-10
MICCOSUKEE RD
I-10
W THARPE ST
BUCK LAKE RD
W TENNESSEE ST
MAHAN DR
W PENSACOLA ST
E PARK AVE
JACKSON BLUFF RD
RD
E MAGNOLIA DR
BRADFORD
ORANGE AVE
LAKE
SPRINGHILL RD
CAPITAL
WOODVILLE HWY
RD
CRAWFORDVILLE
HILAMAN PARK
LARETTE DR
JACKS DR
TREEO LN
DARRYL DR
PAUL RUSSELL RD
WILLOW BEND WAY
Inflow
Outflow
NICKLAUS DR
TRAFALGER SQ
VIEW LN
KAY AVE
PAR LN
OAK HAMMOCK CT
= Sampling Station

3.7 LAKE HILAMAN

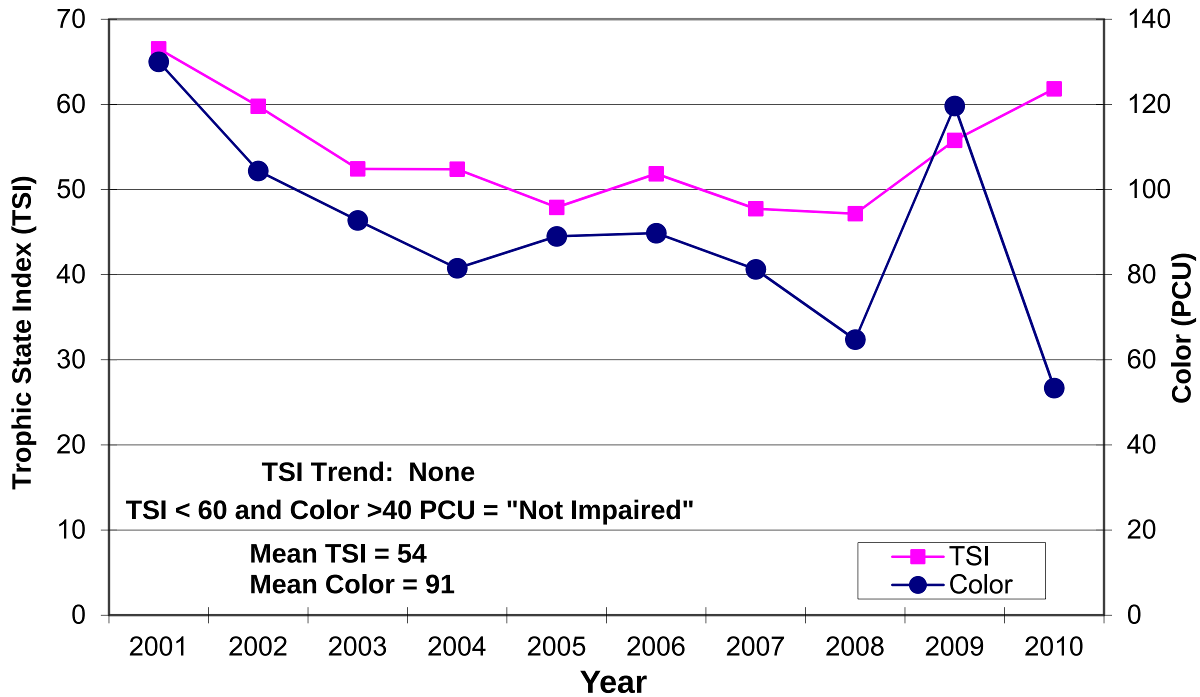
Lake Hilaman is essentially a combination of two adjoining reservoirs located within Hilaman Park on the City of Tallahassee's Hilaman Park golf course. The lake is part of the East Drainage Ditch system that drains stormwater from approximately 600 urbanized acres in the Koger Watershed upstream of the lake. The East Drainage Ditch enters Hilaman Park via a culvert under Paul Russell Road and exits at Blair Stone Road. Lake Hilaman has a surface area of approximately 17 acres with an estimated maximum depth of 10 feet and average depth of four feet at mean pool elevation. A high capacity (1200 GPM) pump regularly withdraws water from the first of the two reservoirs to irrigate the golf course greens, tees and, if necessary, the fairways. During periods of low rainfall or drought, the lake is supplemented by groundwater pumped from an onsite Floridan aquifer well. Two stations are used to monitor Lake Hilaman, one at the inflow point and the other at the outflow.

LAKE RATING

TROPHIC STATE INDEX AND COLOR

Lake Hilaman's annual mean scores on the trophic state index (mean of two stations) have frequently been greater than 50. With a mean color value of 91 PCU and a mean TSI score of 54 and comparing these results to FDEP's TSI rating scheme in the IWR, Lake Hilaman is "not impaired" as Figure 3.46 demonstrates. Water-bodies with annual TSI values less than 60 when the color is greater than 40 are rated as "not impaired" or "able to support designated use." Although this lake system scores among the worst of all the lakes in this study, there has been some apparent improvement over the past few years. The stabilization of the TSI may be attributed to the flowing nature of the lake. This allows for movement of nutrients and other constituents that may enter the lake via stormwater to move through the system. Figure 3.46 shows annual average TSI and color values from 2001 to 2010. TSI scores prior to 2001 are not available because of the lack of reliable phosphorus concentration data.

Figure 3.46 Lake Hilaman - TSI and Color



CHLOROPHYLL-*a*

Median chlorophyll-*a* values for this lake were in the eutrophic range at both the inflow (9.4 µg/L) and the outflow (15.4 µg/L) station, giving an overall chlorophyll-a of 12.5 µg/L classifying it on the lower (better) end of eutrophic. Lakes with chlorophyll-*a* concentrations between 8 µg/L and 40 µg/L are classified as eutrophic. Chlorophyll-*a* values ranged from below detection limits (BDL) to an extremely high 363 µg/L (July 2001). Such elevated chlorophyll levels are indicative of severe algal blooms. Floating mats of algae are frequently observed within Lake Hilaman, especially during the summer months. Chlorophyll-a levels since 2002 have been much lower, especially in months with good rainfall.

MACROPHYTES

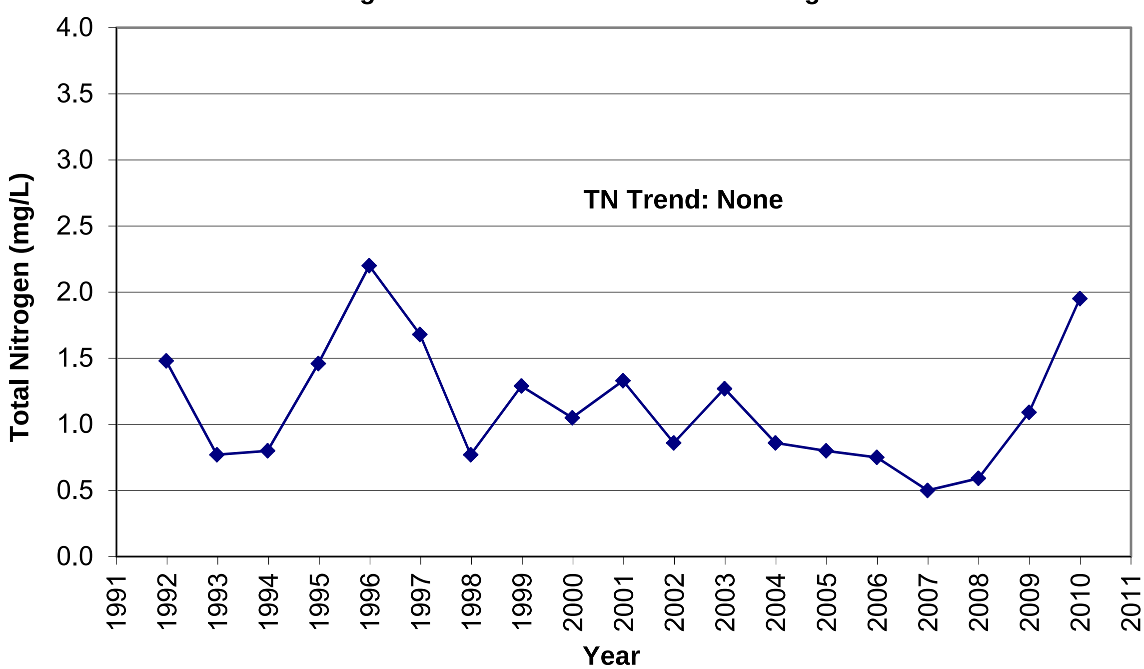
The 2002 macrophyte survey revealed the dominant herbaceous species present in the lake to be the invasive exotic alligator weed (*Alternanthera philoxeroides*); a sprawling, pollution-tolerant, perennial plant that often forms dense mats of vegetation. Other significant aquatic species include maiden cane (*Panicum hemitomon*), soft rush (*Juncus effusus*) and southern cutgrass (*Leersia hexandra*). Floating marsh pennywort (*Hydrocotyle ranunculoides*) is an annoying weed that is also well established in this lake. Among the woody species, buttonbush (*Cephalanthus occidentalis*) is dominant, with fair numbers of Carolina willow (*Salix caroliniana*) and Chinese tallow tree (*Sapium sebiferum*), a Category I invasive exotic (FLEPPC). In July 2004, the entire upstream half of Lake Hilaman was covered in a thick mat of cat's tongue (*Salvinia minima*). The mat was subsequently dissipated by winds from Tropical Storm Bonnie, which passed through Tallahassee in August 2004. However, by July 2005 the mat had expanded to cover both lobes of the lake. This native floating plant thrives in nutrient-rich, stagnant water-bodies. Such dense surface cover can cause adverse water quality impacts by significantly reducing DO levels in a water-body, a factor that severely stresses fish populations and can lead to fish kills. In August 2007 a solar-powered water circulation device (SolarBee™), was installed in the eastern lobe of the lake. The circulator was used to automatically distribute a particulate sequestration polymer (FlocLog™) throughout the water column. The intent of this experiment was to improve lake water quality by reducing suspended particulate and dissolved phosphorus concentrations, thereby minimizing potential algal blooms and improving the aesthetics and recreational value of the golf course. Since the SolarBee™ circulator has been operational, cats tongue (*Salvinia minima*) infestations have not been observed in the lake.

WATER QUALITY PARAMETERS

NUTRIENTS

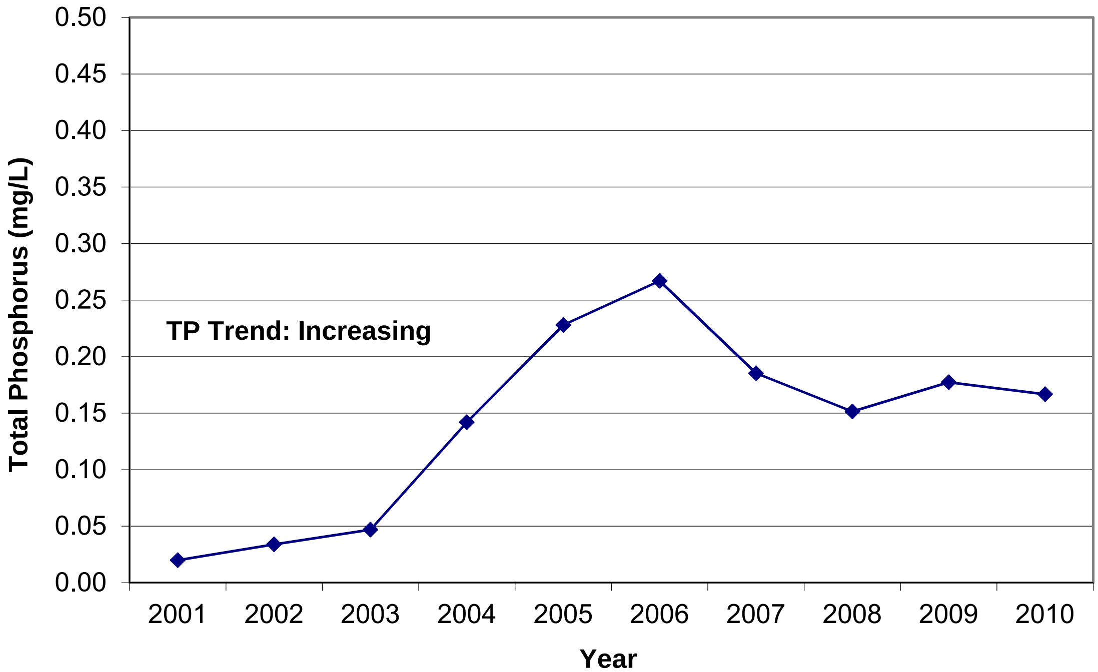
Nutrient levels in Lake Hilaman are among the highest in the study. The levels in the water column are probably significantly reduced due to the over-abundance of filamentous algae and aquatic plant biomass. The two station median total nitrogen and TKN concentrations (both 0.77 mg/L) were higher at Lake Hilaman than at any lake except for A. J. Henry Park Lake. Figure 3.47 is a plot of Lake Hilaman's mean annual average TN values from 1993 to 2010. Although substantial fluctuations in yearly TN values do occur, there is no apparent trend in the data. Results from 2004 to 2010 have been very similar.

Figure 3.47 Lake Hilaman Total Nitrogen



Lake Hilaman's annual TP concentrations from 2001 through 2010 are plotted in Figure 3.48. The lake exhibited a large increase in its average TP value in 2004 compared to previous years and has continued to increase through 2007. Since 2002, the lake's median TP value has increased from 0.021 mg/L to 0.12 mg/L, the highest TP concentration of all lakes in this study. These increases are likely attributed to development occurring upstream of the lake. However, the SolarBee installation in 2007 may have an effect on keeping the phosphorus level steady or even helping to decrease levels indicated in lower values recorded in 2007 and 2008. Thus far the phosphorus loading has not resulted in higher algal productivity or affected the lake's TSI score. Comparing median nutrient values between inflow and outflow stations reveals some interesting differences. Nutrient concentrations are significantly lower at the outflow station compared to the inflow station. This can likely be attributed to the uptake of nutrients by plants and algae as the water moves from the inflow to the outflow. Ammonia is frequently observed at both monitoring stations. For example, ammonia was detected in 65% of the samples collected at the inflow station and 50% of the samples from the outflow. Algae and aquatic plants generally favor the uptake of ammonia over other forms of nitrogen, and its presence probably accounts for the high macrophyte density and frequency of algal blooms observed in this lake.

Figure 3.48 Lake Hilaman Total Phosphorus



CONDUCTIVITY

Specific conductivity levels were higher in Lake Hilaman than in any of the lakes in the study, with the exception of Goose Pond. Inflow and outflow median values are very comparable, (84 and 73 μmhos/cm, respectively), giving an overall median specific conductance for Lake Hilaman of 79 μmhos/cm. However, conductivity values could be skewed by the occasional replenishment of the lake by groundwater from the Floridan aquifer during periods of low rainfall. Groundwater characteristically exhibits significantly higher specific conductance than surface water.

TURBIDITY

Turbidity levels were occasionally high at both the inflow and outflow (up to 82 NTU) stations. Median turbidity levels are lower at the outflow (4.9 NTU) than at the inflow (8.9 NTU), indicating that some settling of sediment occurs as the water flows through the golf course.

ALKALINITY AND PH

Median alkalinity concentrations are slightly higher at the inflow station (32.7 mg/L) compared to the outflow station (26.4 mg/L), making Lake Hilaman one of only four lakes in this study to meet the FDEP Class III alkalinity standard of 20 mg/L. The lake has exhibited considerable swings in alkalinity ranging from a low of 14 mg/L to a high of 61 mg/L. The higher alkalinity levels might be attributable to occasional recharge of the lake with water pumped from the Floridan aquifer, which has a considerably greater alkalinity than the lake water. Values for pH are generally in the circum-neutral range with no unusual shifts in pH detected. Stormwater runoff has caused the biggest shifts in pH that have been observed; with the largest swings in pH coinciding with large rainfall events. Median pH values are 6.7 at the inflow and 7.1 at the outflow.

BACTERIOLOGICAL

Lake Hilaman has by far the highest recorded fecal coliform counts of any lake in this study. The mean and median fecal coliform counts for the inflow station are 4,695 and 275 colonies per 100 mL of water, respectively. The mean and median coliform counts at the outflow station are better with 347 and 50 colonies per 100 mL of water, respectively. The substantial difference in mean and median bacteriological values at each station indicates that there have been large swings in recorded fecal coliform counts over the 18-year monitoring period. Indeed, the FDEP Class III standard of 800 colonies per 100 mL on any one day has been frequently exceeded at both inflow and outflow stations. The highest recorded value is 150,000 colonies per 100 mL, measured at the inflow station in July 2006; while the highest fecal count measured at the outflow station is 6400 colonies per 100 mL in August 1996. These high counts are possibly due to upstream development that has been occurring these last few years.

DISSOLVED OXYGEN

Median dissolved oxygen (DO) levels for Lake Hilaman inflow and outflow stations are 3.7 mg/l and 7.4 mg/L, respectively, giving a two-station mean DO of 6.1 mg/L for the lake overall. DO sags are much more common at the inflow to this lake than at the outflow. For example at the inflow station, DO levels dropped below the state Class III water quality standard of 5.0 mg/L approximately 64% of the time, but only 14% of the time at the outflow station. Oxygen super saturation (a factor that increases the median DO concentration) resulting from algae blooms was observed in approximately 10% of the sampling events at the inflow station and 27% of the events at the outflow station.

SUMMARY

Lake Hilaman is a flow-through reservoir and part of the East Drainage Ditch system that receives stormwater runoff from a large upstream urban area and maintains a base flow on a more or less continuous basis. All monitoring evidence to date indicates that water of poor quality enters the lake and during its passage through the golf course undergoes some slight improvement. This result is somewhat counter intuitive given the potential for nutrient-enriched runoff from the golf course's fertilized greens, tees and fairways to discharge directly or indirectly into the lake. The lake is a shallow eutrophic water-body that continues to experience problems with an overabundance of filamentous algae, as well as weedy submergent and emergent aquatic vegetation. Nevertheless, this nutrient enhanced system supports a healthy fishery and a variety of wildlife species.

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CITY OF
TALLAHASSEE
N
LAKE KILLARNEY LOCATION MAP
BRADFORDVILLE RD
OX BOTTOM RD
N MERIDIAN RD
THOMASVILLE RD
CENTERVILLE RD
ROBERTS RD
N MONROE ST
OLD BAINBRIDGE RD
I-10
MICCOSUKEE RD
I-10
W THARPE ST
BUCK LAKE RD
W TENNESSEE ST
MAHAN DR
W PENSACOLA ST
E PARK AVE
JACKSON BLUFF RD
RD
E MAGNOLIA DR
BRADFORD
ORANGE AVE
LAKE
SPRINGHILL RD
CAPITAL C
RD
CRAWFORDVILLE
WOODVILLE HWY
Upstream station
Downstream station
SHAMROCK N
● = Sampling Station

3.8 LAKE KILLARNEY

Lake Killarney is located in the northeast quadrant of Tallahassee within the Red Hills Physiographic Province. This lake has sub-basin catchments of approximately 1,100 acres. The lake is surrounded by residential development and receives runoff from the associated subdivisions. Other inflow sources include Lake Kinsale, Lake Tom John and the Killearn Country Club. Lake Killarney is a shallow man-made reservoir. Prior to construction of the lake a heavily wooded ravine dissected by a stream was located here. Aerial photographs from 1937 show the lake with far more vegetation within and adjacent to the reservoir. A natural stream course once connected Lakes Killarney and Kanturk, in contrast to the channelized ditch and box culverts now serving as the conduit. Lake Killarney is located upstream and to the west of Lake Kanturk. Both lakes are shown at an elevation of 76 feet on United States Geological Survey (USGS) maps; however, all observed flows are from Lake Killarney into Lake Kanturk. Lake Killarney has a surface area of approximately 80 acres at normal pool elevation of 75 feet. Maximum lake depth is eight feet at normal pool elevation and the average depth is estimated to be less than four feet.

The shallow nature of Lake Killarney makes it more susceptible to stagnation during periods of low rainfall. Indeed, the approximately three-year drought that Tallahassee experienced from mid-1998 to mid-2001 caused this water-body to dry up almost completely. The lake was replenished by abundant rainfall from Tropical Storm Allison in June 2001 and, subsequently, Tropical Storm Barry in August 2001. However, there was a two-year period from 1999 to 2001 when no water quality samples could be collected from Lake Killarney. The Lakes Monitoring Program has two monitoring stations on this lake.

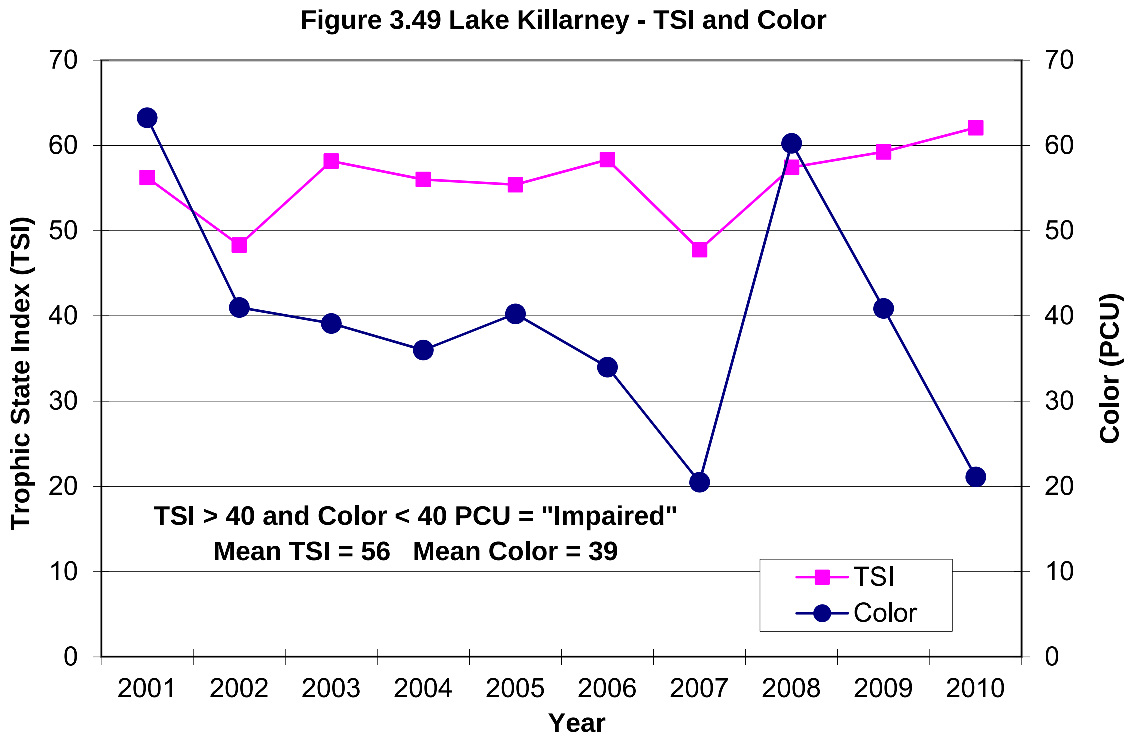
LAKE RATING

TROPHIC STATE INDEX AND COLOR

Lake Killarney's long term median score on the trophic state index (mean of two stations) is 56 and annual average scores are between 47 and 62. Based on FDEP's TSI rating scheme, the lake would be rated as "impaired", although this evaluation has changed from year to year reflecting the water-body's susceptibility to stormwater inputs. Figure 3.49 depicts Killarney's annual average TSI and color values for the ten-year monitoring period from 2001 to 2010. No TSI values are available prior to 2001 because of the lack of reliable phosphorus concentration data for this period.

Figure 3.49 indicates stable TSI scores from 2001 to 2010 and color values which fluctuated around 40 PCU from 2002 to 2006 and then decreased to the lowest annual median value of 20.5 PCU in 2007. Drought like conditions during late 2007 through most of 2008 minimized Lake Killarney to just one sampling station on the eastern portion. However significant rainfall returned late summer of 2008 with Tropical Storm Fay replenishing water tables and color values consequently increased with stormwater runoff. Therefore depending on whether or not the annual average color is slightly above or below 40 PCU, the lake may or may not be considered impaired for nutrients. Using the long term average TSI and color (27 PCU), Lake Killarney meets an IWR rating of impaired waters.

High chlorophyll-*a* levels in the lake resulting from persistent algal blooms are the main factor keeping the TSI scores elevated. Statistical analysis of the quarterly data indicates no trend in TSI values over the ten year monitoring interval.



CHLOROPHYLL-*a*

Lake Killarney's median chlorophyll-*a* concentration of 17.8 μg/L indicates that the lake is eutrophic. Water-bodies with chlorophyll-*a* concentration between 8 and 40 μg/L are classified as eutrophic and generally exhibit high levels of biological productivity. The lake's downstream (eastern) station has a slightly higher median chlorophyll-*a* level (18.4 μg/L) than the upstream station (17.6 μg/L). The highest values ever were recorded in July of 2008 (362.5 μg/L) at the downstream station, probably due to an algal bloom at low water conditions. Throughout its 18-year monitoring history, this lake has always experienced algae blooms, with the most intense blooms coinciding with high water temperatures and reduced water flows. Frequently algae concentrations in the water column are so high that clustering occurs in which large and unsightly floating mats of algae are formed. These filamentous algal mats generally develop below the water surface and during the day entrained oxygen (from the photosynthetic process) causes the mats to move up through the water column and float at the surface. During the night, the mats sink again. Sometimes these floating mats have covered large portions of the lake's surface. Ironically, the measured chlorophyll-a concentration in the water column decreases because the mass of algae is floating on the surface and is not collected in the water sample. Lake Killarney will continue to experience algal blooms and other associated water quality problems during periods of no or very low flow that coincide with high water temperatures.

MACROPHYTES

Lake Killarney is depauperate in terms of macrophyte coverage. The lakes in the Killearn chain were illegally treated with the herbicide diuron in the late 1970's and early 1980's. These treatments, with the soil-active persistent herbicide, probably helped convert Killarney from the macrophyte-dominated community that appears on early aerial photographs to the algal community that presently exists. The aquatic plants that do survive in this system inhabit a narrow margin along the shoreline. Exotic alligator weed (*Alternanthera philoxeroides*) is the dominant herbaceous species, followed closely by another exotic, wild taro (*Colocasia esculenta*) and native maidencane (*Panicum hemitomon*). Willow (*Salix caroliniana*) and buttonbush (*Cephalanthus occidentalis*) are the dominant woody species. During the 1999-2001 drought, facultative upland plant species, principally dog fennel (*Eupatorium capillifolium*), became well established throughout the lake. However, since the water has returned, the dog fennel has disappeared. The infestation of the invasive of Island Apple Snail, *Pomacea insularum* has decimated the plant community and has added another stressor for this lake. This exotic snail is an aggressive plant forager and reproduces at a high rate. There is no top predator to keep this snail population in check and the only productive eradication tool the apple snail is by means of trapping and disposing.

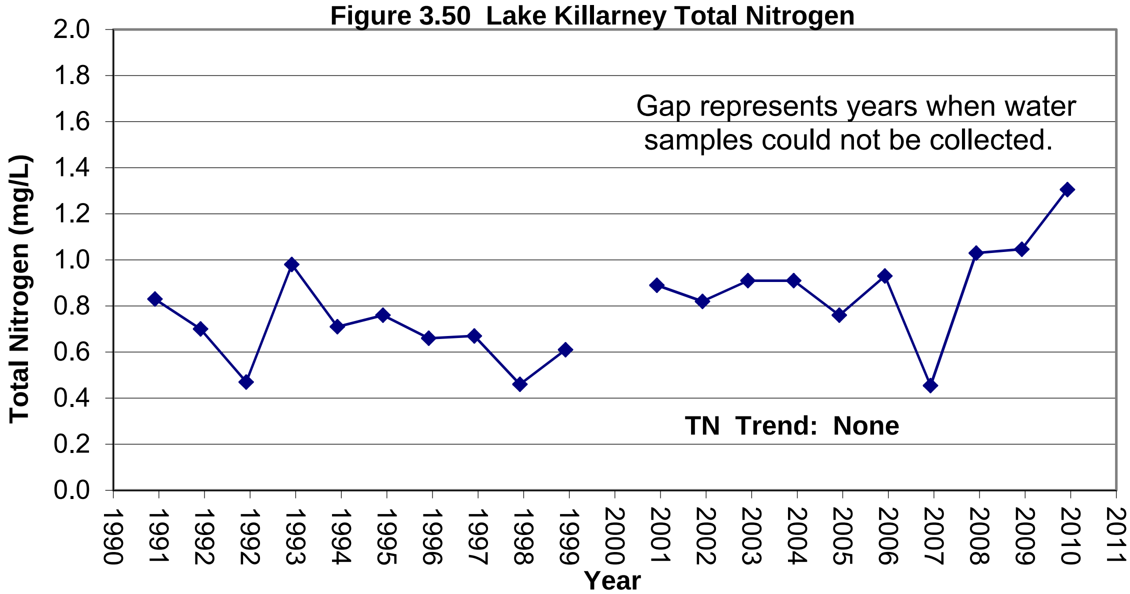
In late 2002 and 2003, the dominant herbaceous species (alligator weed) underwent a remarkable expansion that resulted in vegetative mats covering several acres of the lake, principally at its western end where the water is shallower. Complaints from area residents prompted the Killearn Homes Association to utilize herbicide to kill the unwanted vegetation and to introduce grass carp into all three lakes in the Killearn Chain in 2003 (KHA, 2005).

Apparently, no controls were instituted to prevent the carp from migrating downstream from Lake Kanturk to Lake Lafayette via the Alford Arm Tributary. As of the end of 2004, the aquatic weed eradication efforts in Lake Killarney had been only partially successful. Vegetation surveys conducted in 2008 and again in 2010 show a noticeably decreased coverage of alligator weed, however, alligator weed is still the dominant plant species throughout Lake Killarney. Calculating the plant surveys with the FLDEP's Lake Vegetation Index, Lake Killarney comes up "Impaired" as far as available plant quality.

WATER QUALITY PARAMETERS

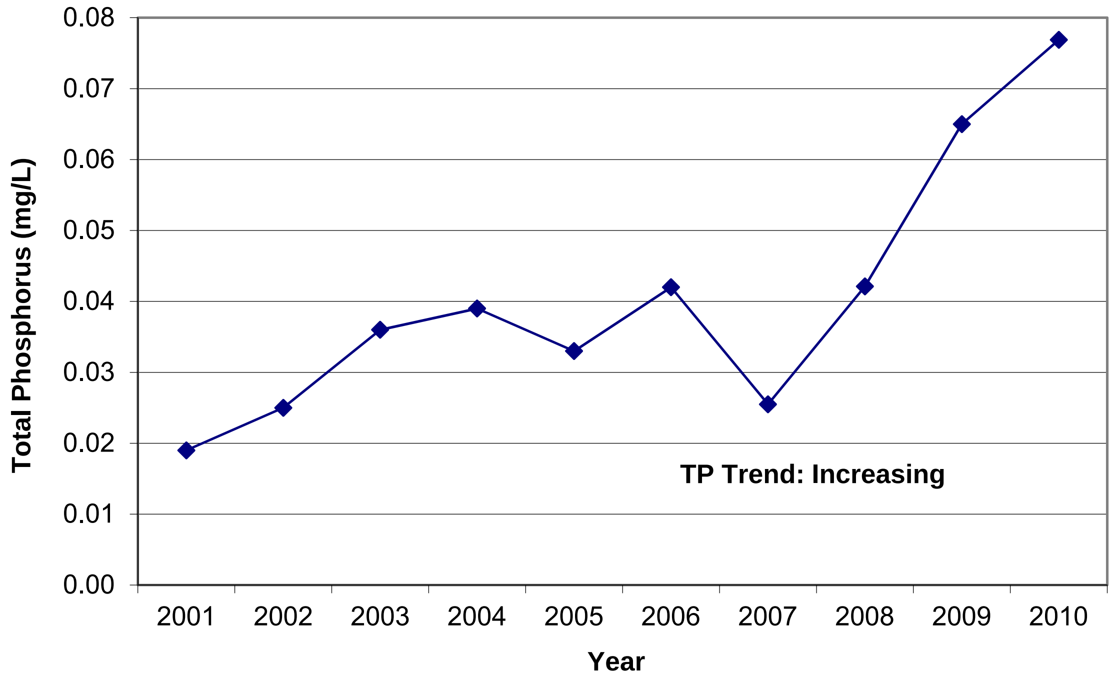
NUTRIENTS

Lake Killarney's long-term median TN value (mean of two stations) is 0.75 mg/L. The nitrogen is predominantly in the organic form with median TKN and ammonia values of 0.74 mg/L and 0.01 mg/L, respectively. Ammonia, in low levels, has been detected in approximately 40% of the water quality samples taken from Lake Killarney since 1990, but nitrate concentrations above the detection limit have rarely been reported. Based only on the TN value, the lake would be classified as eutrophic. Figure 3.50 shows Lake Killarney's mean annual TN concentrations from 1990 to 2010. Although there is considerable fluctuation about the mean value, the data exhibit no trend.



Lake Killarney's two-station long-term median total phosphorus (TP) value is 0.035 mg/L. The TP concentration measured at the upstream (west) station (0.038 mg/L) is very similar to that of the downstream (east) station (0.039 mg/L). Figure 3.51 is a graph of the lake's annual average TP concentrations from 2001 to 2010. As the curve indicates, TP values have increased every year, except 2005 and 2007, during the ten-year monitoring period, indicating an upward trend. Although there has been increased phosphorus loading to the lake, it has had no effect on Lake Killarney's TSI score thus far. The TN/TP ratio for the lake is 21.6 suggesting that it is balanced with respect to nitrogen and phosphorus inputs.

Figure 3.51 Lake Killarney Total Phosphorus



CONDUCTIVITY

The median specific conductance level in Lake Killarney is 46 μmhos/cm. The west station and east station conductivity are 45 and 46 μmhos/cm respectively. Overall conductivity values ranged from a low of 26 μmhos/cm to a high of 121 μmhos/cm measured in August of 2009 on the eastern portion during low water conditions.

Turbidity

Based on long-term averages nearly 16% of turbidity measurements at Lake Killarney are above 10 NTU, higher than all lakes except A.J. Henry Lake and Goose Pond. Since the higher turbidity measurements have been observed in the warmer months of April and July, when algal growth is more profuse, these readings are probably more a result of algal blooms than sediment inflows. Generally, turbidity levels are slightly lower at the east station (5.1 NTU) than at the west station (6.9 NTU), giving a median lake turbidity of 5.4 NTU.

ALKALINITY AND PH

Lake Killarney's median alkalinity (16.4 mg/L) is, along with most of the lakes in this study, below FDEP's recommended level for alkalinity of 20 mg/L. However, this is a normal level for clear-water lakes in this region. Alkalinity values ranged from a low of 4.4 mg/L to a high of 53.4 mg/L. One interesting observation is that Lake Killarney's median alkalinity value has doubled since the end of the 1999-2001 drought. For the nine years prior to the drought, the lake's median alkalinity was computed to be 11.9 mg/L, whereas after the drought it was 20.9 mg/L. The reason for the lake's alkalinity increase is unclear. Incorporating data from 2004-2010, the median has dropped from 23.3 to 20.3 mg/L indicating the alkalinity of the lake may be declining to pre-drought conditions. The median pH value in this lake is 7.8 S.U. at the surface depth with a range from 5.5 to 10.2 S.U. Frequent excursions into the more alkaline end of the pH range during the summer months generally coincide with emergent algal blooms.

BACTERIOLOGICAL

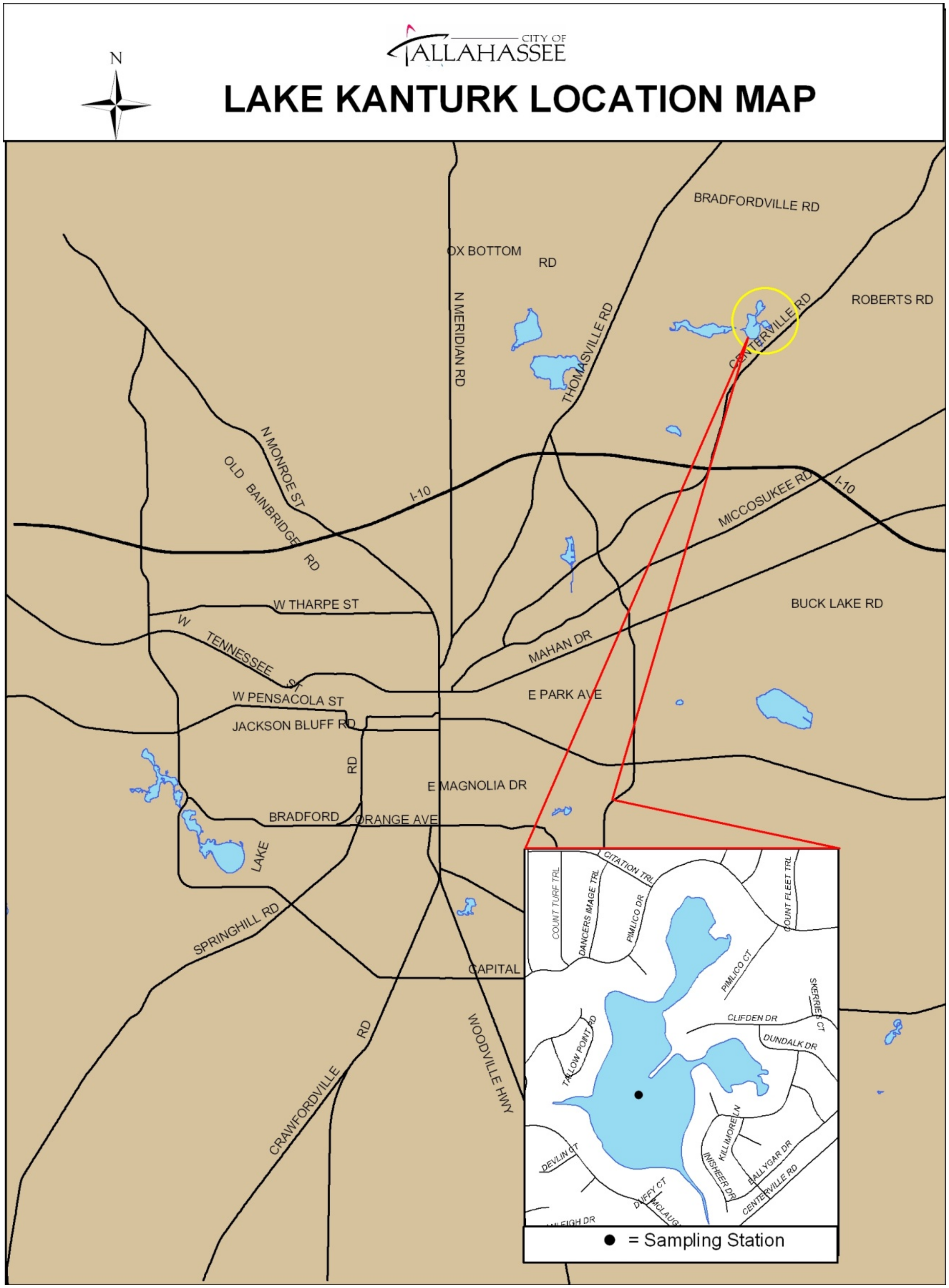
Apart from several well-documented sewage leaks into Lake Killarney in the early 1990's following major storm events (COT, 2001), fecal coliform levels have remained relatively low since 1993. One exception was the November 1999 monitoring event when a count of 910 colonies per 100 mL was recorded. Median coliform counts are 20 and 10 colonies for the west and east stations, respectively, with an overall count of 17 colonies per 100 mL for the lake. Data collected in conjunction with the aforementioned sewage spills is not included in the calculation of the median coliform count. In comparison to other flow-through lakes that drain heavily urbanized areas, e.g., Lake Hilaman, Lake Killarney's average bacteriological quality appears to be fairly unremarkable. Resident Canadian geese have become exceedingly numerous on the Killearn Chain-of-Lakes and have undoubtedly contributed to the odor and water quality problems that Lake Killarney experienced during the 1999-2001 drought when the lake was reduced to a few isolated stagnant water pools. With the exception of August 2009 when counts were 478 at the west sampling point, the highest fecal coliform counts have been around 100 with most being ≤10 colonies/100mL.

Dissolved Oxygen

Lake Killarney has generally maintained a good DO profile throughout the 20-year monitoring period. Long-term median DO levels at the east and west monitoring stations are 9.0 mg/L and 8.4 mg/L, respectively, giving a two-station mean DO of 8.4 mg/L for the lake overall. Daytime DO sags below the state Class III water quality criterion of 5.0 mg/L are quite rare in this lake. In contrast, DO super saturation is a common occurrence, especially during the summer months. For example, DO concentrations in excess of 100% oxygen saturation were measured at 49% and 50% of the sample events at both the west and east stations. As previously noted, it is algal photosynthesis that is responsible for the elevated oxygen levels.

SUMMARY

Lake Killarney is a very shallow, eutrophic, flow-through water body that over the years has been noticeably degraded by several drought periods throughout the 20 year monitoring period. Degraded water quality, infestation of exotic apple snails and past herbicide applications have helped change this lake from a macrophyte dominated community to one in which algae preponderate. Alligator weed, a pollution-tolerant, aquatic weed is one of the few aquatic plants identified that appears to be thriving. Recent efforts to control the alligator weed with herbicides and the introduction of grass carp have so far been largely successful. The absence of adequate littoral vegetation has negatively impacted this water body. Algal blooms seem to have become an almost permanent characteristic of Lake Killarney. However, a return to more normal rainfall patterns in 2005 and 2008 assisted in reducing the intensity of algae blooms by increasing the lake's hydraulic flushing rate.


CITY OF
TALLAHASSEE
LAKE KANTURK LOCATION MAP
N
BRADFORDVILLE RD
OX BOTTOM
RD
ROBERTS RD
N MERIDIAN RD
THOMASVILLE RD
CENTERVILLE RD
N MONROE ST
OLD BAINBRIDGE RD
I-10
I-10
MICCOSUKEE RD
W THARPE ST
BUCK LAKE RD
W TENNESSEE ST
MAHAN DR
W PENSACOLA ST
E PARK AVE
JACKSON BLUFF RD
RD
E MAGNOLIA DR
BRADFORD
ORANGE AVE
LAKE
SPRINGHILL RD
CAPITAL
RD
WOODVILLE HWY
CRAWFORDVILLE
COUNT TURF TRL
DANCERS IMAGE TRL
CITATION TRL
PIMLICO DR
COUNT FLEET TRL
PIMLICO CT
SKERRIES CT
CLIFDEN DR
DUNDALK DR
TALLOW POINT RD
KILLIMORE LN
DEVLIN CT
INISHEER DR
BALLYGAR DR
CENTERVILLE RD
DUFFY CT
● = Sampling Station

3.9 LAKE KANTURK

Lake Kanturk is in the Tallahassee Red Hills Physiographic Province, northeast of the Killearn Estates Subdivision and southwest of the Killearn Lakes Subdivision. With a surface area of approximately 70 acres and a sub basin catchment area of approximately 8,200 acres, giving a sub-basin area to surface area ratio of 110:1. Lake Kanturk receives runoff from an area roughly bounded by Bradfordville Road to the North, Centerville Road to the East, Killearn Estates and Shannon Forest to the South, and highway 319 to the west, and includes 800 acres west of Highway 319 north of Ox Bottom Road including Lake McBride. The lake is adjacent to and immediately downstream of Lake Killarney. Other lakes in the drainage basin that flow intermittently into Lake Kanturk include Gilbert Pond (via Lake Saratoga) and Lake Belmont. Water discharging from Lake Kanturk drains to lower Lake Lafayette and ultimately the St. Marks River via Alford Arm.

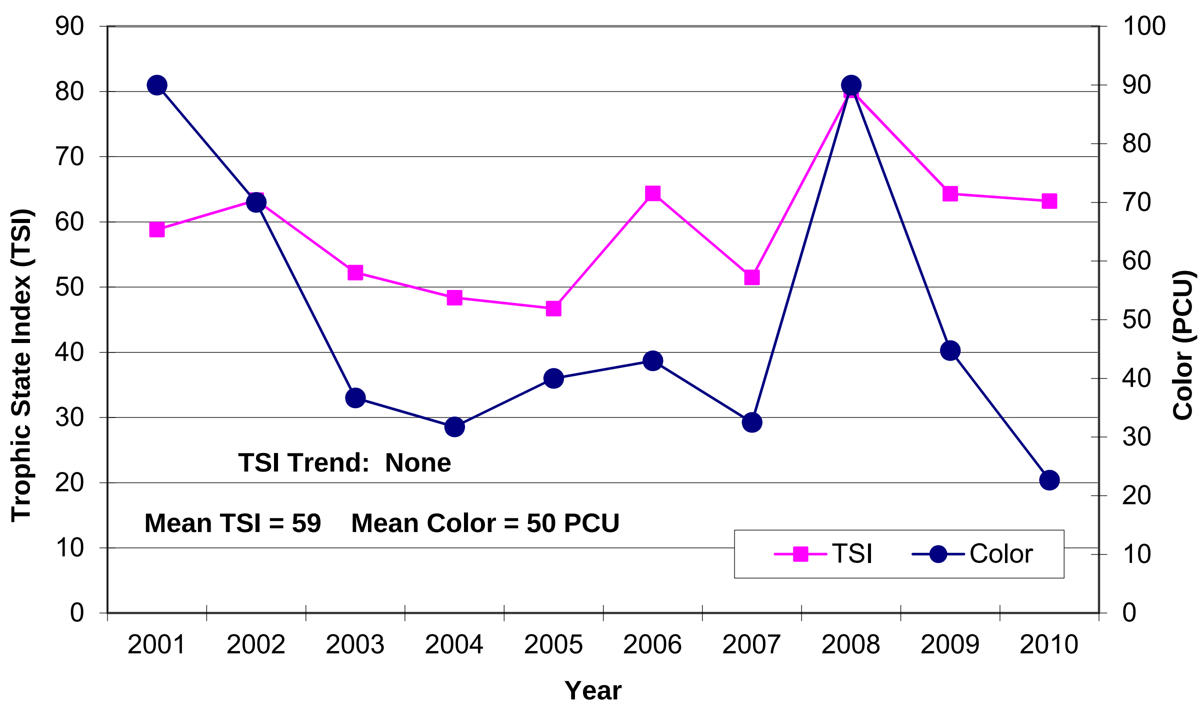
Information on the origin of this lake is limited. Historical records that are available indicate that both Lakes' Killarney and Kanturk were created by the owners of the former Velda Dairy Farm to help water their livestock and create a fishery. The lake is surrounded by residential subdivisions and has almost 90% of its three-mile length shoreline developed. Lake Kanturk is a very shallow reservoir with maximum depth of seven feet and an average depth of four feet at normal pool elevation. As with Lake Killarney, this reservoir's shallow nature makes it more susceptible to dessication during periods of low rainfall or drought. The 1998-2001 drought prevented collection of water quality samples from Lake Kanturk for approximately two years, from mid-1999 to mid-2001. The Lakes Monitoring Program has one monitoring station on the lake.

LAKE RATING

TROPHIC STATE INDEX AND COLOR

The long–term median TSI and color values for Lake Kanturk are 59.3 and 50 (PCU) respectively. Lake Kanturk's annual average TSI scores and color values from 2001 to 2010 are plotted in Figure 3.52. As the figure indicates and trend analysis confirms, there is no trend in TSI values over the 10-year monitoring period. Any apparent improvement was largely due to decreased chlorophyll-*a* and nutrient concentrations in the lake. However, both nutrients and chlorophyll-*a* resumed higher levels in 2006. A longer monitoring record is needed to draw any conclusions as to any water quality trends in the lake. Because of its shallow nature, Lake Kanturk has gone dry on numerous occasions. Most recently, Lake Kanturk was dry during the latter part of 2006 and for over a year from Fall 2007 through Summer 2008. Tropical Storm (T.S.) Fay, which produced fifteen plus inches of rain replenished the lake in August 2008. Based on FDEP's IWR protocol, it is not possible to provide an IWR rating for this lake, because there have been only a couple of times during the monitoring period when samples have been collected in all four quarters of a given calendar year.

Figure 3.52 Lake Kanturk - TSI and Color



CHLOROPHYLL-*a*

Chlorophyll-*a* values indicate that Lake Kanturk is eutrophic, with a median chlorophyll-*a* value of 13 µg/L. This value may have been skewed downward by the presence of macrophytes and filamentous green algae that cover approximately 10% of the surface area of this lake. Under bloom conditions, a chlorophyll-*a* concentration of 150 µg/L was recorded in April of 2005 surpassing the previous high of 115 µg/L from April 2002.

MACROPHYTES

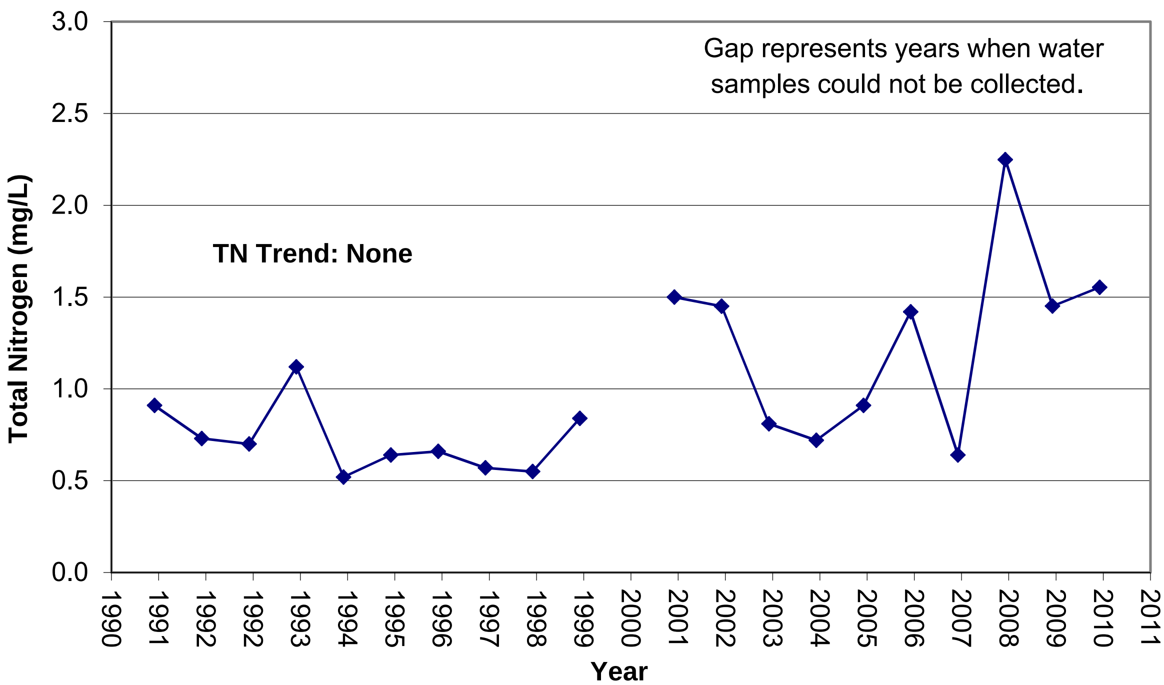
Residential lawns comprise much of this lake's shoreline, however macrophyte coverage in Lake Kanturk is greater than that in the adjoining Lake Killarney. Based on the 2001-2002 macrophyte surveys, the combined coverage of emergent and submersed aquatic plants is estimated to be approximately 10% of the lake area. However, the recent introduction of grass carp into the lake may diminish the current macrophyte coverage. Aerial photographs from 1937 show the lake with far more vegetation than presently exists. As in Lake Killarney, the dominant herbaceous species is the exotic plant, alligator weed (*Alternanthera philoxeroides*). Maidencane (*Panicum hemitomon*) and a couple of species of smartweed (*Polygonum densiflorum* and *Polygonum pensylvanicum*) are also commonly encountered in the lake. The Carolina willow (*Salix caroliniana*) is the most abundant woody species, with buttonbush (*Cephalanthus occidentalis*) and the invasive exotic Chinese tallow (*Sapium sebiferum*) well represented. A few pond cypress trees (*Taxodium ascendens*) are also present bordering the lake and were probably planted.

WATER QUALITY PARAMETERS

NUTRIENTS

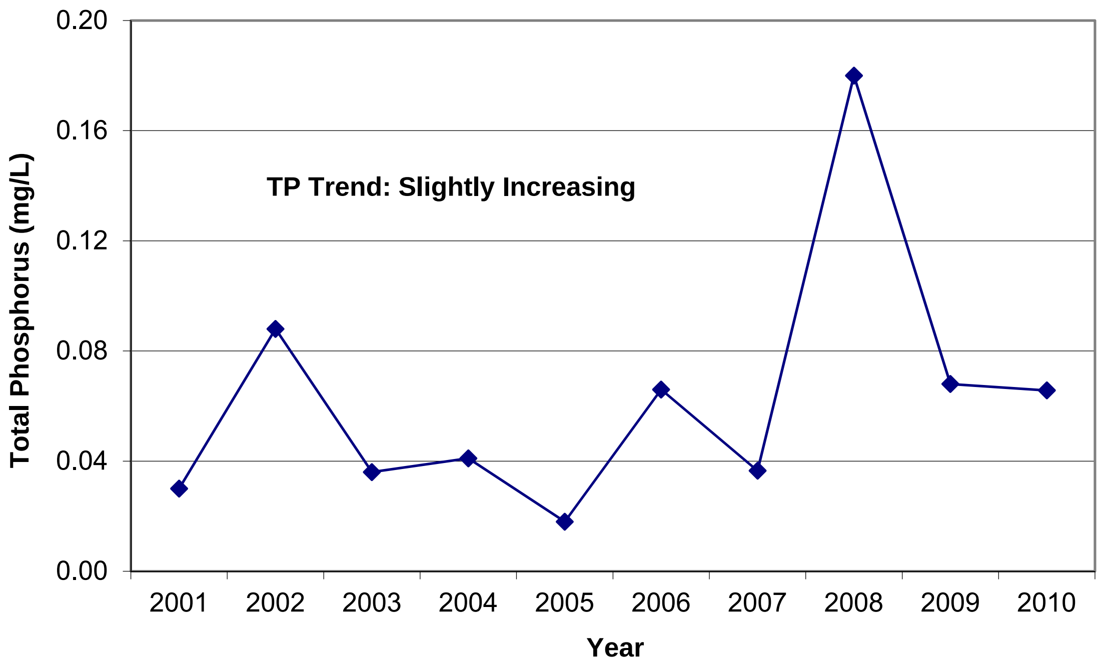
Kanturk's median TN and TKN values are 0.69 mg/L and 0.68 mg/L, respectively, slightly lower than those for Lake Killarney. Ammonia was detected in approximately 50% of the samples collected from this lake, however, during near drought conditions from late 2007 to the summer 2008, ammonia was nearly undetectable. August 2008, T.S. Fay returned the normal water level to Kanturk and with that, ammonia increased to an all time high of 0.22 mg/L. Figure 3.53 depicts the median annual TN concentrations from 1990 to 2010. As with Lake Killarney, there is substantial variation in annual TN values over the monitoring period, something not unusual for flow-through lake systems that drain large urban areas. Figure 3.53 also indicates an apparent spike in the lake's TN concentration following the 1999-2001 drought and again during 2008. TN values were declining every year thereafter and had almost returned to the long-term average. However TN concentrations began rising again in 2006 and 2008. More information is needed to determine the cause, but it is likely due to normal wet / dry years and the stress put upon the lake.

Figure 3.53 Lake Kanturk Total Nitrogen



Kanturk's median TP concentration is 0.04 mg/L, slightly higher than that of Lake Killarney. Also, unlike Killarney, there is no apparent trend in annual average TP values (plotted in Figure 3.54) for the ten-year observation period from 2001 to 2010. The lake's TN/TP ratio is 18.1, indicating it is balanced with respect to nitrogen and phosphorus inputs. However, in August 2008, Tropical Storm Fay produced 15 plus inches of rain causing phosphorus levels to spike to a recorded high of 0.18 mg/L. Lake Kanturk has somewhat re-stabilized in regards to phosphorus concentration since T.S. Fay and is now at 0.067 mg/L for the last two years, 2009-2010.

Figure 3.54 Lake Kanturk Total Phosphorus



CONDUCTIVITY

The median specific conductance for Lake Kanturk is 42 μmhos/cm, which is quite comparable to that of Lake Killarney. The range of conductivity values measured over the 20-year monitoring period is from 15 μmhos/cm to 137 μmhos/cm with the high value having been measured in August 2009.

TURBIDITY

Lake Kanturk's median turbidity value of 5.9 NTU is better than many comparable lakes in this study. The range of turbidity values recorded for this lake was from 0.6 to 34.2 NTU. Many of the higher turbidity measurements in this lake are associated with algal blooms. Lake Kanturk's median turbidity is slightly lower than that found in upstream Lake Killarney. Some turbidity improvement from upstream to downstream water-body would be expected due to settling of sediment in Lake Killarney plus algal blooms appear to be less frequent and less severe in Kanturk.

ALKALINITY AND PH

Alkalinity values in Lake Kanturk ranged from a low of 4.9 mg/L to a high of 27.6 mg/L with a median alkalinity of 11.9 mg/L. Although the median alkalinity value is below FDEP's recommended level, it is naturally occurring and not unusual for clear-water lakes in this area of the state. In contrast to Lake Killarney, Kanturk exhibited only a minor increase in alkalinity pre- and post- the 1999-2001 drought. Median pH in this lake is circum neutral at 7.4 S.U.

BACTERIOLOGICAL

The median fecal coliform count in Lake Kanturk is 10 colonies per 100 mL of water, marginally lower than that of the upstream Lake Killarney and overall a good result considering the large urban area that this lake drains. No violations of FDEP's Class III criterion for bacteriological quality have ever been documented in Kanturk. The maximum count was 498 colonies per 100 mL water and was recorded in November 2009. This high fecal count can, in all probability, be attributed to large numbers of Canada Geese that have become somewhat permanent residents of this lake.

Dissolved Oxygen

DO values continue to be high in Lake Kanturk when compared with most other lakes in the study. The median surface dissolved oxygen concentration is 8.3 mg/L. Only 3% of the surface DO readings were below the FDEP Class III DO standard of 5.0 mg/L. In contrast, oxygen super saturation resulting from algal blooms is a frequent occurrence in this lake, especially in the summer months. Approximately 19% of the daytime surface DO readings in Lake Kanturk have exhibited super saturation, a factor that has the effect of biasing the apparent median DO concentration higher.

SUMMARY

Residential development surrounds the majority of Lake Kanturk's shoreline and undoubtedly accounts for much of the nutrient, sediment and other inputs into the water-body. All of the water quality and biological criteria suggest that the lake is eutrophic, a status that it has maintained since monitoring commenced in 1990. The effects of excessive nutrification are most obvious during periods of warm or hot weather when the capacity of the water to hold oxygen is at its lowest and the biological activity is the highest. As with Lake Killarney, the flow-through component of this lake (it both receives and discharges water) makes it a less degraded system than it otherwise would be. Indeed, the return to more normal rainfall patterns after the 1999-2001 drought resulted in an apparent improvement in water quality. The drought of 2007-2008 will likely have detrimental effects on the water quality of this lake. When the hydraulic flushing rate is greatly reduced or terminated, Lake Kanturk suffers from nutrient enhancement and increased algal blooms. It appears that temporal and flow variations account for much of the variation in ambient lake conditions.


N
CITY OF TALLAHASSEE
LAKE CASCADE LOCATION MAP
BRADFORDVILLE RD
OX BOTTOM
RD
ROBERTS RD
N MERIDIAN RD
THOMASVILLE RD
CENTERVILLE RD
N MONROE ST
OLD BAINBRIDGE RD
I-10
MICCOSUKEE RD
I-10
W THARPE ST
BUCK LAKE RD
W TENNESSEE ST
MAHAN DR
W PENSACOLA ST
E PARK AVE
JACKSON BLUFF RD
RD
E MAGNOLIA DR
BRADFORD
ORANGE AVE
LAKE
SPRINGHILL RD
CAPITAL CIR
WOODVILLE HWY
CRAWFORDVILLE RD
JACKSON BLUFF RD
BILL CAMPBELL RD
SAND RD
TRANQUILITY PL
HARLEY DR
DECKER CT
DECKER DR
CAPITAL CIR SW
BELINDA ST
GENIE DR
W.H. BROWN RD
SULLIVAN RD
Station near Culvert
Bradford Brook Station
● = Sampling Station

3.10 LAKE CASCADE

Lake Cascade is located just outside Capital Circle Southwest, northwest of and adjoined to Lake Hiawatha, and is part of the Bradford Brook Chain of Lakes. Lake Cascade is situated in the Munson Hills Physiographic Province and is contained within the 3,000-acre drainage basin of Lake Bradford. Water generally enters the lake from Bradford Brook, a natural blackwater stream that drains a portion of the Apalachicola National Forest to the west of Lake Cascade. Occasionally, water flows into this lake from Lake Hiawatha via the culvert under Capital Circle Southwest. Lake Cascade's surface area is divided into several "arms", and limited residential development occurs almost exclusively along the shoreline of the lake’s northern arm. The southern arm of this lake has virtually no development along its shoreline and receives inflows directly from Bradford Brook. This arm appears undisturbed except for the cutting of mature cypress trees over 70 years ago. The canopy of cypress trees over both arms of this lake has since been re-established through natural regeneration.

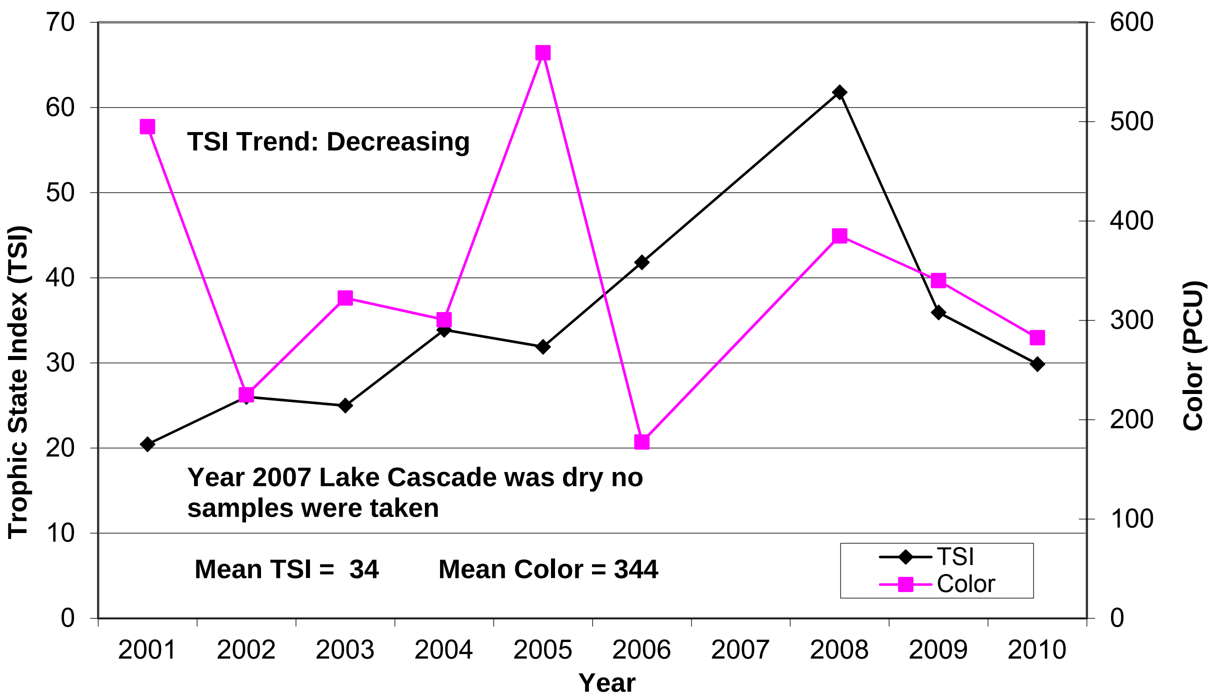
Lake Cascade’s surface area of 109 acres makes this the second largest lake in the Bradford Brook Chain, and one of the largest lakes covered in this report. Maximum lake depth is approximately eight feet at normal pool elevation, and the average depth is estimated to be less than five feet. Cascade’s sandy bottom is substantially permeable and thus has a higher filtration rate than any other lake in this study. As a consequence, the lake is prone to going dry during periods of low rainfall or drought. Records indicate that the lake disappeared completely for parts of 1990, 1992, 1999, 2000 and 2001. It also went dry in 2006 and stayed dry until Tropical Storm Fay replenished the water levels in August 2008. The Lakes Monitoring Program has two monitoring stations on the lake, Bradford Brook on the southwestern lobe and Cascade Culvert in the eastern arm of the lake.

LAKE RATING

TROPHIC STATE INDEX AND COLOR

Lake Cascade's long-term median TSI score is 29.6 (mean of two stations), and until 2006, its annual mean TSI score had been below 40. These TSI scores in conjunction with the extremely high color of Lake Cascade and based on FDEP's TSI rating protocols list this lake as "not impaired". In 2008, Lake Cascade received an all-time high TSI score of 61.8. However, statistical analysis of the data indicates an increasing trend in TSI values over the monitoring interval. This trend can be attributed to the increasing TP values over the same monitoring period. The TSI score of 61.8 is based on just one sampling event due to drought conditions from 2006 to 2008. Figure 3.55 depicts Lake Cascade's annual average TSI and color values calculated from 2001 to 2010. TSI values prior to 2001 are not included in the plot because of the lack of reliable phosphorus values for this period.

Figure 3.55 Trophic State Index vs. Color



CHLOROPHYLL-*a*

Cascade's median chlorophyll-*a* level of 5.4 μg/L is among the lowest of the lakes in this study and places this lake in the mesotrophic category. Approximately 30% of Florida lakes are mesotrophic (chlorophyll-*a* concentrations between 4 and 7 μg/L). These lakes generally exhibit moderate levels of nutrients, algae, aquatic macrophytes, and have good water clarity. However, due to the abundance of cypress trees in and around the lake, this lake is highly colored (median 330 platinum cobalt units) essentially making light the primary limiting factor for phytoplankton (algal) biomass. Even if sufficient nutrients are available, algal growth and hence chlorophyll-*a* levels in this highly tannic-stained lake tend to be depressed due diminished light transmission caused by the highly colored tannic water.

MACROPHYTES

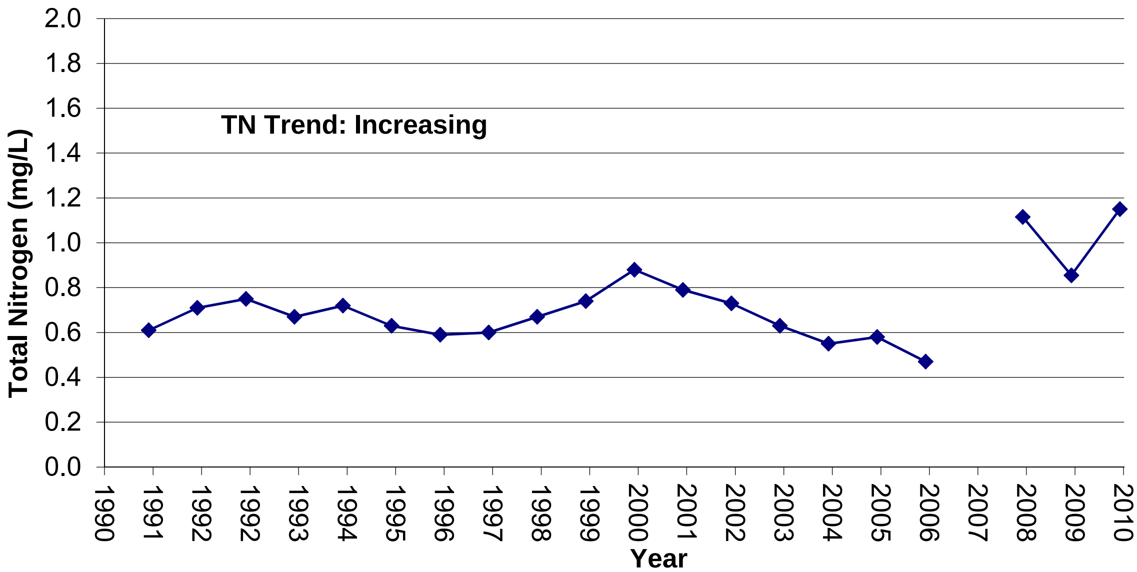
Lake Cascade supports a good native plant community indicative of good water quality. Pond cypress (*Taxodium ascendens*) dominates the lake margin and is also common throughout the entire lake, especially in the southern and northern arms. Other significant woody species identified include buttonbush (*Cephalanthus occidentalis*), red maple (*Acer rubrum*) and titi (*Cyrilla racemiflora*). The lake's high color and lack of light penetration severely limits the growth of emergent and submersed aquatic vegetation. Maidencane (*Panicum hemitomon*) is the most common emergent and occurs mainly along the shoreline fringe. The northern arm of the lake has an extensive population of white water lily (*Nymphaea odorata*); these plants appear to be especially robust with floating leaves two or three times larger than representatives of the species seen on other lakes in this study. A particularly surprising find of the 2002 macrophyte study was about 10 shrubs of the pond spice (*Litsea aestivallis*) in the southern arm of the lake. This species is considered endangered in Florida, and this was the first report for it in Leon County.

WATER QUALITY PARAMETERS

NUTRIENTS

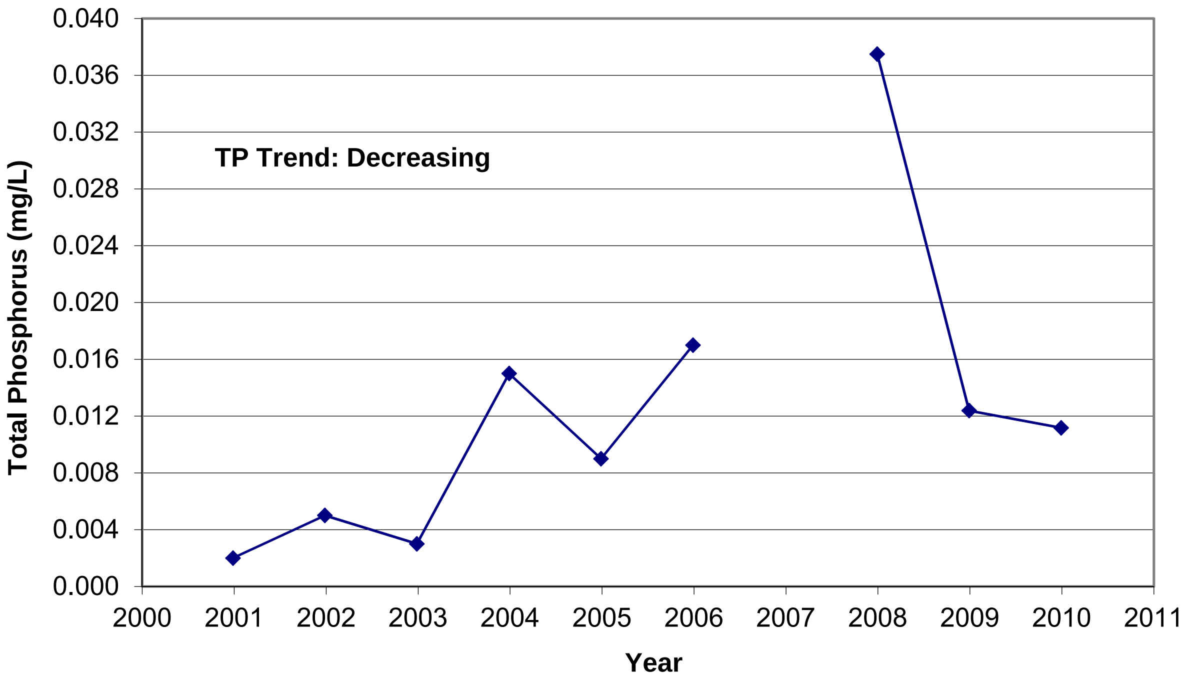
Lake Cascade's median TN and TKN values (mean of two stations) are both the same at 0.64 mg/L. Ammonia, in concentrations above the analytical detection limit was reported in more than 64% of the samples collected from this lake. However, the median ammonia concentration is fairly low at 0.015 mg/L. Frequent detection of ammonia in this lake system is not unexpected given the findings for Moore Lake. Figure 3.56 plots annual TN values from 1990 to 2010. There has been little variation in the year-to-year TN values although there has been a declining trend since 2001, with an all time low value recorded in 2005 (0.42 mg/L). The TN spike in 2008 was based on a single sample collected that year, August, following T.S. Fay and is not considered significant to the overall trend. Using only the average TN concentration to classify this lake, it would be considered eutrophic.

Figure 3.56 Lake Cascade Total Nitrogen



The median TP value for the lake's two monitoring stations combined is 0.010 mg/L, one of the lowest of the lakes in this study. Figure 3.57 is a graph of Lake Cascade's annual average TP values for 2001 through 2010. As previously noted, no phosphorus data is available for this lake prior to 2001. For unknown reasons (possibly leaf litter during drought periods) there was a substantial spike in the lake's TP concentration in 2004, 2006 and again in 2008, reflected in an almost doubling of its overall median TP value. With the increase in phosphorus the TN/TP ratio has significantly lowered from 160 (2004), 91 (2006) to 85 (2008). However this does not change the fact that the lake would be strongly phosphorus-limited with respect to algal growth potential if light was not the primary limiting factor. Lake Cascade, especially in the Bradford Brook arm, receives little anthropogenic phosphorus, and this accounts for the above TN/TP ratio and median TP value.

Figure 3.57 Lake Cascade Total Phosphorus



CONDUCTIVITY

Specific conductance is very comparable at both stations in Lake Cascade. Median conductivity values are 38 μmhos/cm and 36 μmhos/cm at Lake Cascade at Bradford Brook and Lake Cascade at Culvert stations, respectively, giving an overall specific conductance of 36 μmhos/cm.

TURBIDITY

Median turbidity levels are 1.3 NTU and 1.2 NTU at both stations indicating excellent water clarity in Lake Cascade over the 18-year monitoring period. One exception was during the 1991 flood event when a turbidity value of 11.8 NTU was recorded. During times of drought few significant erosional forces are operating, keeping turbidity levels low. Lack of algae blooms also helps maintain the average turbidity in the lake at a low level.

ALKALINITY AND PH

Alkalinity in Lake Cascade is less than 1.0 mg/L, a value so low that it normally cannot be quantified by the analytical method used to measure the parameter. Lake Cascade's pH ranged from a low of 3.1 to a high of 6.9, with a median value of 4.1 for both stations. This acidic pH value is due to naturally occurring humic and tannic acids dissolved in the water and not indicative of poor water quality. What it shows is that Lake Cascade is a very tannic lake. Its low buffering capacity also makes this lake potentially susceptible to pH swings, more so than any other lake in this report. However, this should not be cause for concern as long as Bradford Brook continues to be the key water source for Lake Cascade.

BACTERIOLOGICAL

Bacteriological water quality remains good in Lake Cascade with an overall median coliform count of 5 colonies per 100 mL. The maximum fecal coliform count was recorded at the Cascade Culvert station in July of 1998 at 500 colonies per 100 mL of water. No violations of FDEP's Class III criterion for bacteriological quality have ever been documented in Cascade. There were only two lakes in the study with median fecal coliform counts lower than Lake Cascade.

Dissolved Oxygen

Dissolved oxygen (DO) levels in Lake Cascade have been low throughout much of the 20-year monitoring period. The median surface DO concentrations are 5.7 mg/L at the Bradford Brook station and 5.5 mg/L at the Culvert Station. DO profiles reveal that the top 12-13 cm of the water column often contain low but adequate dissolved oxygen levels to support most aquatic life. Most profiles of the water column indicate that at mid-depth the DO concentrations were less than one half of those found at the surface. Very few of the summer season sampling events indicated sufficient oxygen for the survival of most aquatic organisms below mid-depth in the water column. Low DO levels in blackwater lakes are a natural phenomenon and due mainly to the oxygen demand exercised by humic substances in the sediment and dissolved in the water column. Oxygen demand is significantly greater during the summer months when water temperatures are higher. Low DO levels at depth would not immediately impact the more vertically motile fauna directly (these organisms could just ascend in the water column to reach more favorable DO levels); however, the sessile (non-motile) fauna such as many micro- and macroinvertebrates would be detrimentally impacted by occasionally low dissolved oxygen levels.

SUMMARY

Although Lake Cascade may be classified as either mesotrophic or eutrophic depending on which lake-rating method is chosen, a closer look at the biota indicates that the lake functions essentially as an oligotrophic system with a low level of biological productivity. The most important factors limiting productivity in this lake include low dissolved oxygen, low pH and highly colored humic water.
These conditions, although natural, are stressful to aquatic biota. For this type of system, the macrophyte community is often a better indicator of ecological integrity and Lake Cascade maintains a healthy, although somewhat uniform, native plant community. At present this lake remains in an essentially natural state due to the relatively low level of degradation in the lake's drainage basin,

which mostly encompasses portions of the Apalachicola National Forest. Lake Cascade's dystrophic nature and flow-through characteristics, in addition to the frequent dewatering that the lake undergoes, inhibit the eutrophication process. Effects from the 2006-2008 drought, specifically on the endangered pond spice, remains to be seen. The lake's median water quality values to date are much better than average for the lakes in this report, indicating that it is a healthy system.

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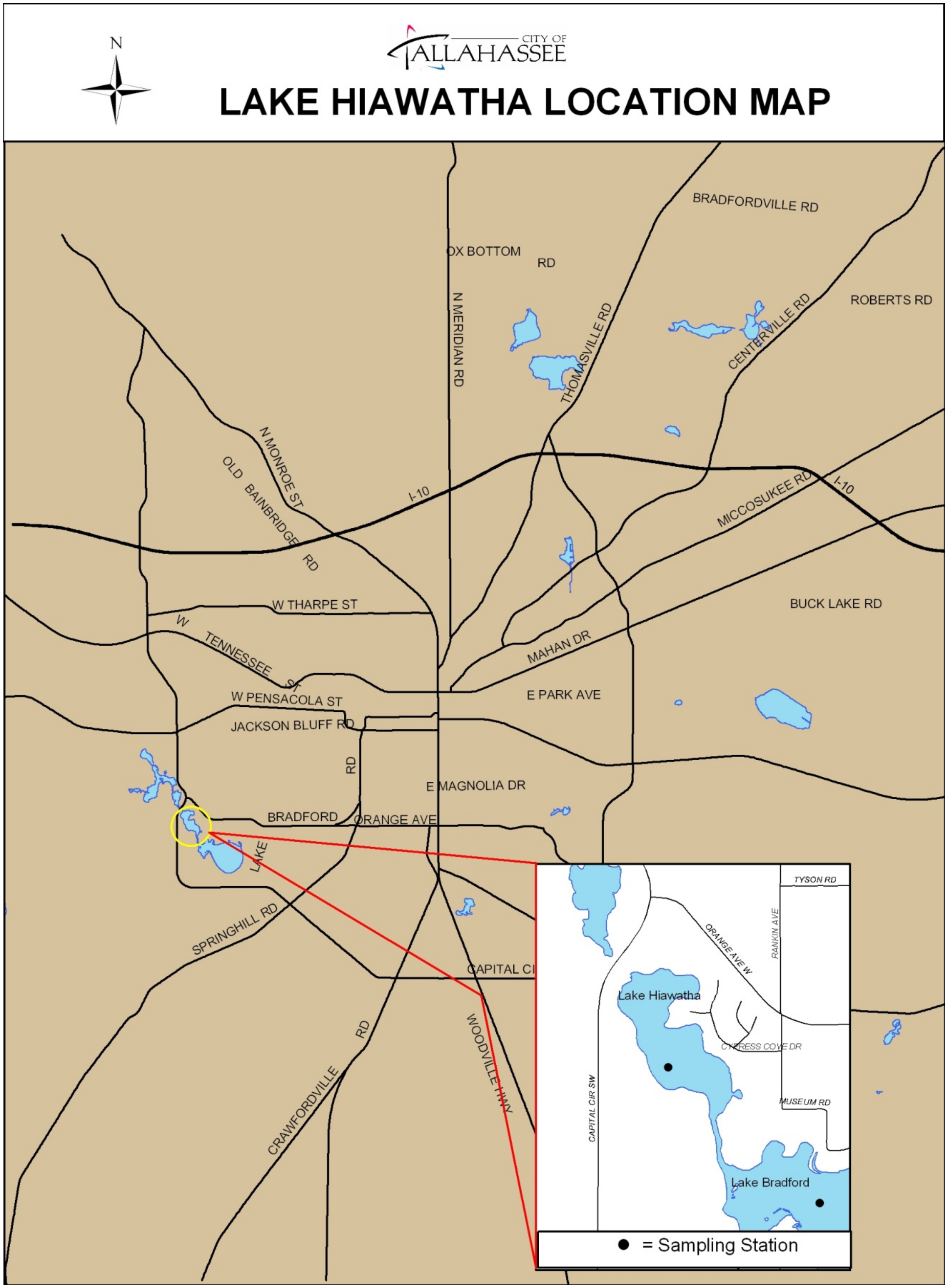

CITY OF TALLAHASSEE
LAKE HIAWATHA LOCATION MAP
N
BRADFORDVILLE RD
OX BOTTOM
RD
N MERIDIAN RD
THOMASVILLE RD
CENTERVILLE RD
ROBERTS RD
N MONROE ST
OLD BAINBRIDGE RD
I-10
I-10
MICCOSUKEE RD
W THARPE ST
BUCK LAKE RD
W TENNESSEE ST
MAHAN DR
W PENSACOLA ST
E PARK AVE
JACKSON BLUFF RD
RD
E MAGNOLIA DR
BRADFORD
ORANGE AVE
LAKE
SPRINGHILL RD
CAPITAL CI
RD
WOODVILLE HWY
CRAWFORDVILLE
TYSON RD
ORANGE AVE W
RANKIN AVE
Lake Hiawatha
CYPRESS COVE DR
MUSEUM RD
CAPITAL CIR SW
Lake Bradford
● = Sampling Station

3.11 LAKE HIAWATHA

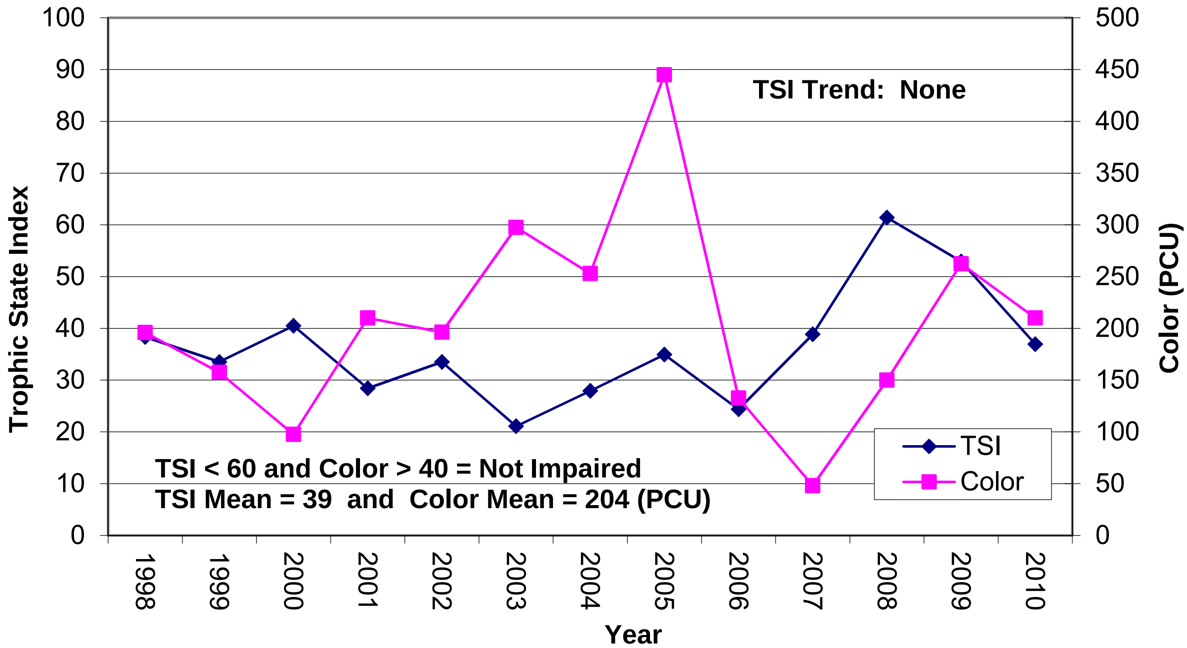
Located just inside Capital Circle Southwest and between lakes Bradford and Cascade, Lake Hiawatha is the middle lake in the Bradford Brook Chain of Lakes. Lake Hiawatha, with a surface area of approximately 40 acres and an elevation of approximately 35 feet NGVD, drains a portion of the 3,000-acre Lake Bradford basin and usually flows into Lake Bradford. Lake Hiawatha receives inflow from Lake Cascade via a culvert beneath Capital Circle Southwest. However during low rainfall, flows are occasionally reversed and Lake Hiawatha flows into Lake Cascade while Lake Bradford flows into Lake Hiawatha. Residential dwellings dot much of the northern shoreline of this lake. Maximum depth at mean high water is nine feet, and the estimated average depth is five feet. Due to their shared basin and rather unusual hydrology, the fate of lakes in this chain are closely intertwined. The Lakes Monitoring Program has one monitoring station on this lake.

LAKE RATING

TROPHIC STATE INDEX AND COLOR

Lake Hiawatha's median TSI score is 39, somewhat higher than that of its upstream neighbor, Lake Cascade. With a low TSI and high color value, Lake Hiawatha is considered "not impaired" by FDEP's Impaired Waters Rule. Figure 3.58 depicts Hiawatha's annual average TSI values versus color values calculated during a 12-year monitoring period from 1998 to 2010. Towards the end of 2007 and most of 2008, Hiawatha experienced low water levels to the extent that samples could not be taken. It wasn't until Tropical Storm (T.S.) Fay, (August 2008), replenished water levels that Hiawatha became accessible again. Because of that, the September 2008 TSI score is elevated. TSI values for Lake Hiawatha prior to 2001 were determined from phosphorus data published by LAKEWATCH (LAKEWATCH, 2001). With a few exceptions of slightly higher than average values, the data indicates Hiawatha's TSI score has decreased over the observation period, which may reflect some gains in water quality. The improvement is mainly attributable to lower phosphorus values in the lake over the past few years.

Figure 3.58 Lake Hiawatha Trophic State Index



CHLOROPHYLL-*a*

The median chlorophyll-*a* concentration for Hiawatha is 5.2 μg/L, quite comparable to that of Lake Cascade. Lakes with chlorophyll-*a* levels between 4 and 7 μg/L are classified as mesotrophic with respect to algal populations. Even if sufficient nutrient levels were available, algal growth and hence chlorophyll-*a* levels are suppressed in "blackwater" lakes due to lower light penetration through the dark-stained tannic water. Hiawatha has a long-trend median color value of 164 PCU, substantially less than Lake Cascade.

MACROPHYTES

Pond cypress (*Taxodium ascendens*) is the dominant woody species with tupelo (*Nyssa sylvatica* var. *biflora*) and titi (*Cyrilla racemiflora*) well represented. Lake Hiawatha has a narrow band of maidencane (*Panicum hemitomon*) along its shore but is otherwise normally lacking in emergent, non-woody and submergent vegetation. The highly colored water and corresponding diminished light penetration limits the spread of most species of aquatic plants beyond the shoreline of this lake. However in the latter part of 2006, after many months of little rainfall, the lake was shallow and less colored than usual. This change in color allowed for dense mats of *Websteria confervoides,* a submerged plant, to develop in the lake. Once more water entered the lake, the plant disappeared. In September 2008, a vegetation survey was once again conducted with rains from T.S. Fay allowing lake accessibility. Macrophytes are critical to populations of wildlife and fish that inhabit and/or utilize the littoral zones of lakes. The survey concluded that there was no shift in plant community, with maidencane and dog fennel (Eupatorium leptophyllum) as the co-dominant species. Blackwater systems are generally not very productive and fish growth rates and size for many species are usually less than systems without these natural stresses.

WATER QUALITY PARAMETERS

NUTRIENTS

With median TN and TKN values of 0.59 mg/L, Lake Hiawatha's median organic nitrogen content is somewhat lower than that of Lake Cascade. Its median ammonia value of 0.017 mg/L is very similar and has decreased compared to the median value previously reported (0.03 mg/L). Approximately 54% of the sample events recorded positive ammonia results, i.e., levels above the analytical detection limit. Hiawatha's median TP concentration is 0.014 mg/L, two times Lake Cascade's TP value. Plots of Lake Hiawatha's annual TN and TP values from 1990 to 2010 are provided in Figures 3.59 and 3.60, respectively. As noted from these graphs, a spike in both nitrogen and phosphorus occurred during the September 2008 sampling collection. This spike is probably due to low water levels from 2007 through most of 2008 until T.S. Fay produced large rain amounts in the later days of August 2008 causing significantly increased TN and TP values. TP concentrations prior to 2001 (used to construct Figure 3.60) were obtained from published LAKEWATCH data (LAKEWATCH, 2000). As with most flow through lakes, there is considerable year-to-year variability about the TN and TP means, but overall there is no trend in the data over the 20-year monitoring period. The TN/TP ratio for Lake Hiawatha is 42 indicating phosphorus, amongst other previously discussed factors, is the nutrient that may also limit algal growth in this lake.

Figure 3.59 Lake Hiawatha Total Nitrogen

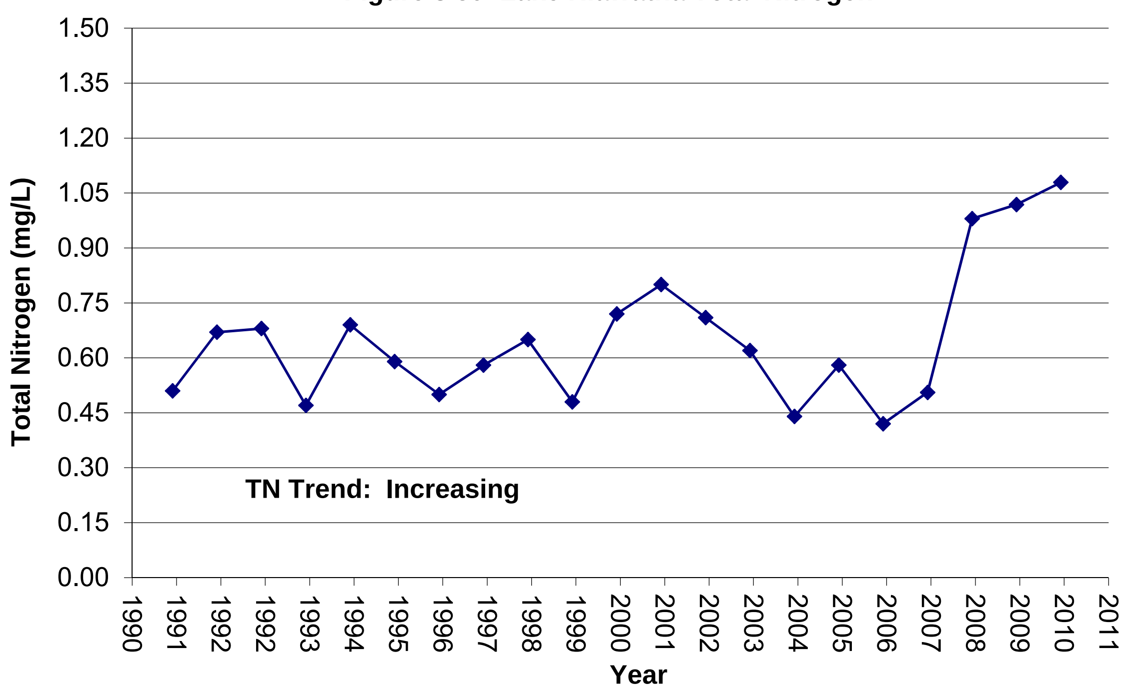
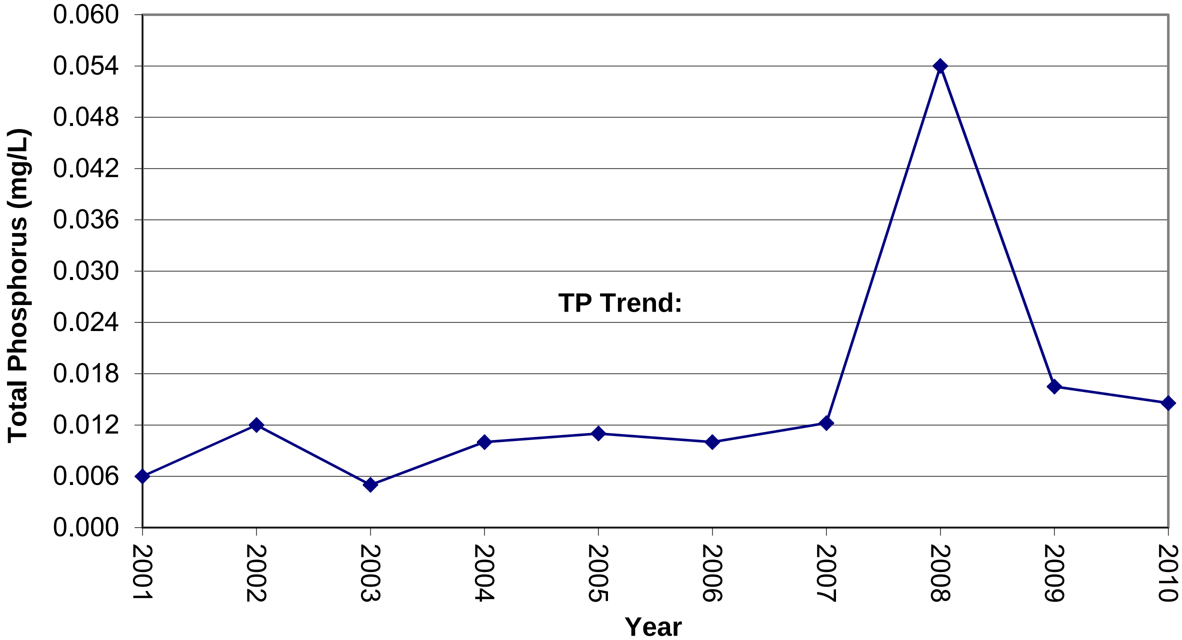


Figure 3.60 Lake Hiawatha Total Phosphorus



CONDUCTIVITY

Lake Hiawatha's median specific conductance is 28 μmhos/cm, with a range from a very low 7 μmhos/cm to an all-time high 69 μmhos/cm, which was measured in July 2005.

TURBIDITY

Turbidity levels in Lake Hiawatha generally have been low over the 20-year monitoring period. The median turbidity value is 1.3 NTU, with a range of zero to 24 NTU. Hiawatha's true mean turbidity is probably a little higher than the value reported above. This is because of the color inherently present in the lake, (160 PCU), and indeed all blackwater lakes tend to adsorb light reaching the turbidity meter detector, thus biasing the measured turbidity to a lower reading.

ALKALINITY AND PH

Lake Hiawatha exhibits a low median alkalinity of 1.8 mg/L. Alkalinity values measured in this acidic blackwater system are usually close to or below the analytical detection limit for the parameter. However, spikes in lake alkalinity do sometimes occur corresponding to transitory increases in lake pH. The observed range of pH values for the lake is from 3.3 to 7.9. This pH range suggests that large swings in pH, although quite rare, are a possibility. Lake Hiawatha has a median pH value of 4.6, indicating that on the whole this lake's water is strongly acidic.

BACTERIOLOGICAL

Lake Hiawatha's median fecal coliform count is 4 colonies per 100 mL of water, among the lowest of the lakes in this study. The fecal coliform counts ranged from below detection (less than 2 colonies per 100 mL) to a high of 166 colonies per 100 mL in September 2000. Since then, most counts have been below 20 colonies/100mL.

DISSOLVED OXYGEN

As with Lake Cascade, Lake Hiawatha's dissolved oxygen levels have been generally low throughout the monitoring period. This is mainly due to the oxygen demand from naturally occurring humic substances in the sediment and dissolved in the water column. The median DO concentration at the surface sampling interval of this lake is 6.6 mg/L, with approximately 18% of the readings below FDEP's 5.0 mg/L criterion for Class III surface waters. Most of the low DO readings occur during the summer months when the water temperatures are higher. DO levels at the bottom depth of this lake are generally considerably lower than at the surface depth with a median concentration of 4.6 mg/L. Many of the bottom depth DO readings were anoxic, i.e., less than 1.0 mg/L. Fish present in the lake can move near the surface layer and obtain adequate oxygen during this period. However, very low oxygen levels on and near the bottom of the lake may cause losses to the macroinvertebrate fauna that are the base of the animal food chain for this lake.

SUMMARY

Lake Hiawatha's character is intermediate between the shallow cypress-dominated Lake Cascade and the deeper, more open Lake Bradford. Lake Hiawatha’s transitional nature is also reflected in its water quality parameters. For example, TN, color, and specific conductance are higher in Hiawatha than in Lake Bradford, but are lower than in Lake Cascade. Conversely, TP, pH, and alkalinity are lower in Hiawatha than in Lake Bradford but higher than in Lake Cascade. It appears that exchange of water between Lake Bradford and Lake Hiawatha may influence the latter’s water chemistry more readily than exchange of water between Lake Cascade and Lake Hiawatha. Hiawatha’s average TSI, alkalinity, color and TP values are closer to those of Lake Bradford than those of Lake Cascade. Due to the lake’s characteristic dark color it can only maintain an emergent macrophyte community, although the lake did show that when the color is reduced it could also support a healthy submersed plant community. All of the macrophytes observed at Lake Hiawatha are indicative of good water quality.

Lake Hiawatha is valuable in terms of aesthetics, recreation potential, and providing wildlife habitat due to the generally unspoiled nature of this lake system. The "black water" and scenic corridors of pond cypress and tupelo make Lake Hiawatha a popular destination for canoeists.


N
CITY OF TALLAHASSEE
LAKE BRADFORD LOCATION MAP
BRADFORDVILLE RD
OX BOTTOM RD
N MERIDIAN RD
THOMASVILLE RD
CENTERVILLE RD
ROBERTS RD
N MONROE ST
OLD BAINBRIDGE RD
I-10
MICCOSUKEE RD
I-10
W THARPE ST
BUCK LAKE RD
W TENNESSEE ST
MAHAN DR
W PENSACOLA ST
E PARK AVE
JACKSON BLUFF RD
RD
E MAGNOLIA DR
BRADFORD
ORANGE AVE
LAKE
SPRINGHILL RD
CAPITAL CIR
RD
CRAWFORDVILLE
WOODVILLE HWY
RANKIN AVE
MUSEUM RD
LAKEVIEW DR
North Station
South Station
LONGLEAF RD
LONGLEAF CT
FLASTACOWO RD
LAKE BRADFORD RD
● = Sampling Station

3.12 LAKE BRADFORD

Lake Bradford is located near Capital Circle Southwest and just north of the airport. With a surface area of 149 acres, Lake Bradford is the largest and most accessible member of the Bradford Brook Chain of Lakes. All of the lakes in this chain are located within the Munson Sandhills Physiographic province. Lake Bradford's watershed encompasses an area in excess of 3,000 acres, which represents the largest watershed of any lake in this study. This ratio of approximately 20:1 for watershed surface acreage to lake surface area, along with its low assimilative capacity and naturally low alkalinity should serve as an indicator of the potential sensitivity of this lake to future development in the basin. Maximum depth at mean high water is 13 feet, and the estimated average depth is six feet. Much of the stream inflow to this lake is from Lake Hiawatha via a braided-channel that connects the two lakes. Lake Bradford also receives inflows from Grassy Lake through several conduits beneath Lakeview Drive. It is the hydraulic head difference between Lake Bradford and Grassy Lake that determines whether water flows from the former into the latter or vice versa. Generally, water flow is from Bradford to Grassy. However, major flows from Grassy Lake into Lake Bradford originating in the West Drainage Ditch occur during significant storm events; sometimes overtopping Lakeview Drive because of the inability of the conduits to handle the storm surge. Indirect evidence (based on pH and alkalinity changes) of groundwater seepage from the underlying Floridan aquifer into Lake Bradford has been discussed in previous reports (COT, 2001).

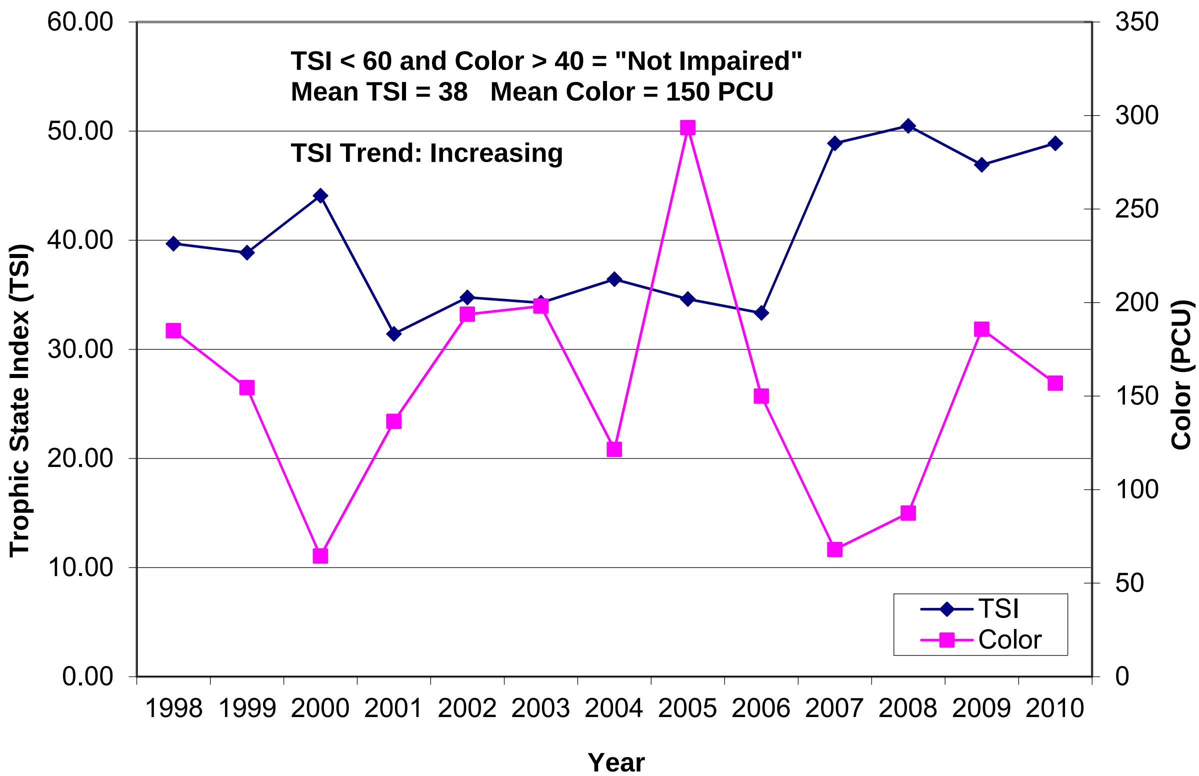
Lake Bradford provides numerous forms of recreation including swimming, waterskiing, sunbathing, fishing, sailing and canoeing. Lake Bradford is home to Florida State University's "Seminole Reservation," a recreational facility heavily utilized by the student population. There are also a number of residential properties along the shoreline; however, overall this lake basin is lightly developed. The Lakes Monitoring Program has two monitoring stations on the lake.

LAKE RATING

TROPHIC STATE INDEX AND COLOR

Lake Bradford's long-term median TSI score is 40, quite comparable to Lake Hiawatha's TSI but higher than that of Lake Cascade. Figure 3.61 is a plot of Bradford's annual average TSI and Color values for the 12-year monitoring period from 1998 to 2010. Color analysis has only been collected the last ten years in Lake Bradford. Phosphorus data published by LAKEWATCH (LAKEWATCH, 2000) was used to calculate TSI values for Lake Bradford prior to 2001. Lake Bradford's TSI values have been generally consistent from year to year, and statistical analysis of the data indicates no trend in TSI. Since 2001, TSI scores have generally been below 40, although the TSI has been a on an increasing trend since 2006. This fact, in conjunction with annual mean color values well over 100, raises little concern that this lake would ever achieve "impaired" status under FDEP's Impaired Waters Rule (IWR) rating scheme.

Figure 3.61 Lake Bradford Trophic State Index vs. Color (PCU)



CHLOROPHYLL-*a*

If using only chlorophyll-*a* levels to rate this lake, the two-station median chlorophyll-*a* concentration of 6.4 μg/L places Bradford in the mesotrophic category. Lakes with chlorophyll-*a* levels between 4 and 7 μg/L are classified as mesotrophic, and generally support a moderate level of biological productivity. This lake's nutrient levels are adequate to grow algae, however, the high color (median value 120 PCU) generally inhibits the establishment of a significant algal population in this lake. One exception to this general statement occurred in the summer of 2001, when a widespread, if short-lived, algal bloom developed in the lake. The bloom was attributed to stormwater runoff from the West Drainage Ditch into Lake Bradford following a tropical storm that passed through the area (COT, 2003). The influx of so much nutrient-rich stormwater into the lake probably changed its water chemistry (including its color) allowing a transient algae bloom to develop.

MACROPHYTES

As with the other blackwater lakes in the Bradford Chain, Lake Bradford has limited aquatic plant life. The dominant woody plant around the border of the lake is pond cypress (*Taxodium ascendens*), while the dominant herbaceous plant is the grass, maidencane (*Panicum hemitomon*). A few other plants (*Salvinia minima* and *Juncus marginatus*) were observed, but these were probably washed in from Grassy Lake or brought in on a boat from another water-body. No submersed aquatic plants are present in Lake Bradford.

WATER QUALITY PARAMETERS

NUTRIENTS

Median TN and TKN levels in Lake Bradford are 0.53 mg/L and 0.52 mg/L, respectively, are slightly lower than the other two blackwater lakes in the Bradford Brook Chain of Lakes. Median ammonia values at both stations are below the analytical detection limit. Lake Bradford's annual average TN values over the 20-year monitoring period are plotted in Figure 3.62. An increasing trend in annual TN values is evident over the last couple of years.

Figure 3.62 Lake Bradford Total Nitrogen

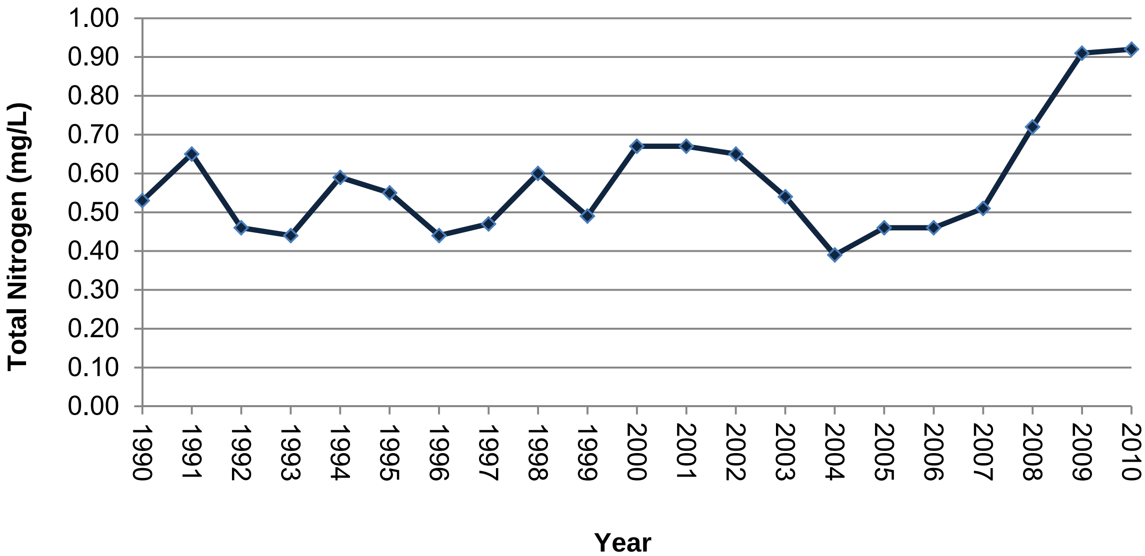
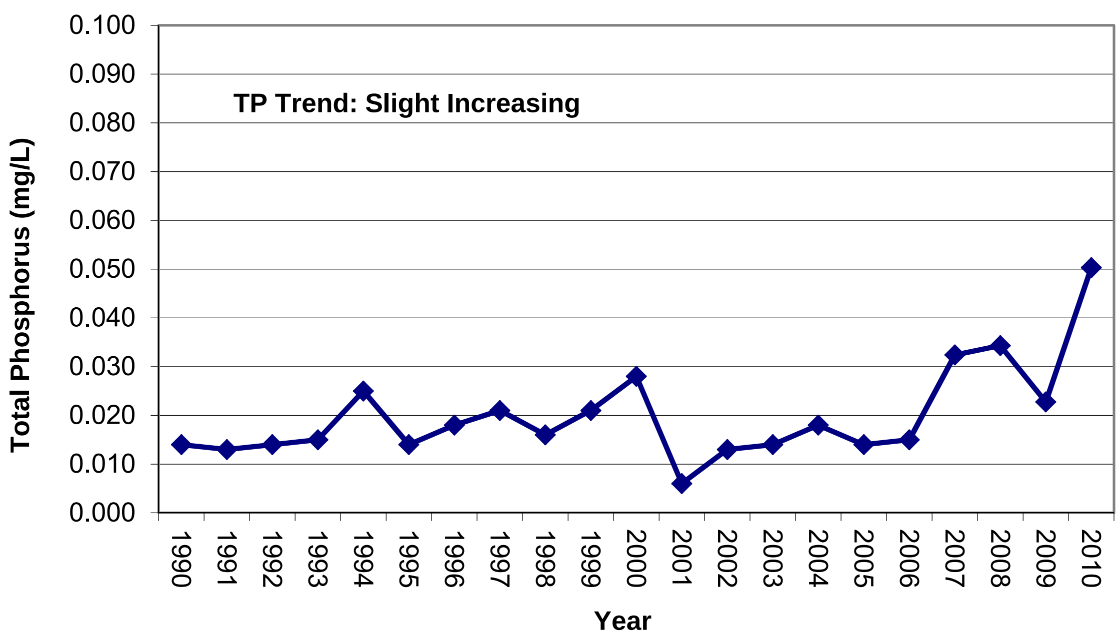


Figure 3.63 Lake Bradford Total Phosphorus



Bradford's median TP concentration is 0.016 mg/L, slightly higher than the TP in the upstream lake (Hiawatha). Figure 3.63 shows the annual average TP values from 1990 to 2010. TP concentrations prior to 2001 (used to construct Figure 3.62) were obtained from published data (LAKEWATCH, 2001). Although there are large fluctuations in this lake's annual phosphorus content, perhaps reflecting its complex hydrology especially during large storm events, overall there is a slight increasing trend in the TP data. The median total nitrogen to total phosphorus ratio (TN/TP) of 33 suggests the lake could be phosphorus limited with respect to algal productivity. However, Lake Bradford's high color limits the usual effects of excess nutrients on lake water quality.

CONDUCTIVITY

Lake Bradford's median specific conductivity of 25 μmhos/cm (at both stations) is lower than the other two lakes in the Bradford Brook chain and very low compared to state averages for lakes (best 5%).

TURBIDITY

Turbidity values for the two Lake Bradford stations are low with the median turbidity of 1.5 NTU. However, to date, lake water samples have not been collected during flood events when water flows into Lake Bradford from the West Drainage Ditch via Grassy Lake. Stormwater entering Lake Bradford from the West Drainage Ditch normally has considerably higher turbidity than the receiving water. A turbidity value of 33.9 NTU was recorded for the inflowing water during a March 2002 storm event.

ALKALINITY AND pH

Alkalinity values in Lake Bradford appear to have increased slightly in the past few years. Over the entire monitoring period, Bradford's median alkalinity value is 3.1 mg/L, higher than the other two lakes in the Bradford chain reflecting its generally higher pH value. The averaged median pH at the two stations is 5.5.

However, due to its inherent low alkalinity, pH swings have been fairly common in the lake since the beginning of this study. For example pH measurements in Lake Bradford have ranged from a low 3.5 to a high of 8.1. The influx of stormwater from the West Drainage Ditch could account for some of the elevated pH readings.

BACTERIOLOGICAL

Lake Bradford's bacteriological quality has been generally good over the monitoring period with a median count of 9 colonies per 100 mL for the two stations. The west station has a median fecal coliform count of 10 colonies per 100 mL of water; slightly higher than the east station that has a median count of 8 colonies per 100 mL of water. The south station is located in proximity to the channel connection to Grassy Lake, and perhaps, if scheduled sampling had coincided more often with a major storm event, the observed bacteriological quality at this station might be considerably poorer. Stormwater runoff typically has far higher bacterial counts than the receiving water-bodies. The south station has had two occasions (July 1998 and January 2008) when the bacterial count was in violation of the FDEP Class III criterion of 800 colonies per 100 mL of water on any one day, 800 and 1567 counts per 100 mL respectively. The bacterial counts for the north station on the same days in 1998 and 2008 was 220 and 366 colonies per 100 mL of water respectively, which is also well above the median for these stations.

DISSOLVED OXYGEN

Lake Bradford maintains a better overall DO profile than either of the other two lakes in this chain. Bradford's median DO level at the surface is 7.6 mg/L for both stations, approximately 2 mg/L higher than Lake Cascade and 1 mg/L greater than Hiawatha. DO sags below 5.0 mg/L are also far less frequent in Lake Bradford, occurring in only 7% of the surface samples collected. While at the bottom depths of this lake, where the median DO level is 6.3 mg/L, oxygen depletion was more common with approximately 20% of the sample events recorded below 5.0 mg/L. Occasionally anoxic conditions (DO less than 1.0

mg/L) were encountered at the bottom depth. The excellent DO profile in Lake Bradford is a result of lower concentrations of oxygen demand (humic) substances both in the water column and bottom sediment. Lake Bradford is the only lake in the chain where diurnal monitoring has been conducted (COT, 2001). Diurnal monitoring is useful in determining changes in dissolved oxygen, pH and conductivity during a 24-hour cycle. The data revealed that DO levels at bottom depth were in violation of the Class III criterion (less than 5.0 mg/L DO) during 90% of the monitoring period. DO levels remained good at the surface depth during the entire 24-hour monitoring event.

SUMMARY

Lake Bradford may be the most important lake included in this study in terms of both recreation potential and the unique natural resources found in the lake and its basin. Based on the foregoing lake rating methods, Lake Bradford would be considered a blackwater system with nutrient inputs in the mesotrophic range. As long as the natural hydraulic gradient prevails allowing water of comparatively good quality to flow from Lake Cascade and Hiawatha to Lake Bradford, the latter should continue to remain relatively unspoiled. However, Lake Bradford's unique hydrology makes it vulnerable to anthropogenic impacts. The July 2001 algal bloom in Bradford is a case in point. In this instance a major storm event caused a reversal, albeit transitory, of the normal hydraulic flow direction, allowing urban stormwater from the West Drainage Ditch to flow directly into Lake Bradford via Grassy Lake. Significant storms have occurred with increased frequency in the past few years. Grassy Lake may offer some limited nutrient uptake and sediment filtration of water from the West Ditch during lesser storms that do not overwhelm this lake's hydraulic capacity.

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CITY OF TALLAHASSEE
PINEY Z LAKE LOCATION MAP
N
BRADFORDVILLE RD
OX BOTTOM
RD
N MERIDIAN RD
THOMASVILLE RD
CENTERVILLE RD
ROBER
N MONROE ST
OLD BAINBRIDGE RD
I-10
MICCOSUKEE RD
I-10
BUCK LAKE RD
W THARPE ST
W TENNESSEE ST
MAHAN DR
E PARK AVE
W PENSACOLA ST
JACKSON BLUFF RD
RD
E MAGNOLIA DR
BRADFORD
ORANGE AVE
LAKE
SPRINGHILL RD
CAPITAL C
WOODVILLE HWY
RD
CRAWFORDVILLE
GROVELAND HILLS DR
TUNG HILL DR
CELTIC RD
DEVONSHIRE DR
AVONDALE CT
EMMA LN
BRAVEHEART WAY
Station 1
Station 2
Station 3
Station 4
LAKE PARK DR
PARK VIEW DR
HIGH MEADOW DR
DANSBY PL
CADDO DR
TAPLEY TRL
MARCH RD
TROUT TRL
HAVEN LN
SINAI RD
WEEPING WILLOW WAY
● = Sampling Station

3.13 PINEY Z LAKE

Piney Z Lake is located one mile north of Highway 27 and is one and one-half miles due east of Tom Brown Park's Lake Leon within the City of Tallahassee Park of the same name. Piney Z Lake is situated within the Woodville Karst Plain Physiographic Province with surficial soils that consist of Plummer, Orangeburg, and Lucy series. The lake is sandwiched between and separated from Upper Lake Lafayette to the west and Lower Lake Lafayette to the east by man-made earthen berms. Historically, most of the land in this lake's watershed was utilized for row crops and grazing, however, much of this activity was discontinued when the land was converted to residential development. Piney Z reservoir serves as a refuge for a diverse array of wildlife and was utilized for waterfowl hunting and fishing by its previous owners. Piney Z Lake has a surface area of approximately 240 acres with a drainage basin of 1,000 acres. This lake's maximum depth is 8 feet, with an average depth of approximately 5 feet at mean pool elevation. The Lakes Monitoring Program has four monitoring stations on the lake.

In 1997,a joint effort between the Florida Fish Wildlife conservation Commission (FWCC) and the City of Tallahassee, Piney Z lake was drawn down to allow for restoration. Years of accumulated sediment and detritus were removed and the spread of aquatic plants that dominated most of the lake's surface was halted. Rough fish populations were decreased and restocked (FWCC) with selected game fish, large-mouth bass and sunfish. Most of the lake's bottom was scraped and the organic, nutrient-enriched sediment was used to construct fingers that project northward from the lake's southern shore. Also, an existing berm in the center of the lake was extended and now bisects the entire lake from east to west. Restoration was completed at the end of 1998. In 2004, the City of Tallahassee in conjunction with the Florida Department of Environmental Protection opened Piney Z Lake to recreational users as part of the Lafayette Heritage Trail Park.

Piney Z Lake receives stormwater inflow from the Piney Z Plantation development and the Swift Creek Middle School stormwater pond on its northern shore. Prior sediment and stormwater releases into the lake from the Piney Z Plantation development and Swift Creek Middle School have been well documented (COT, 2001, 2003).

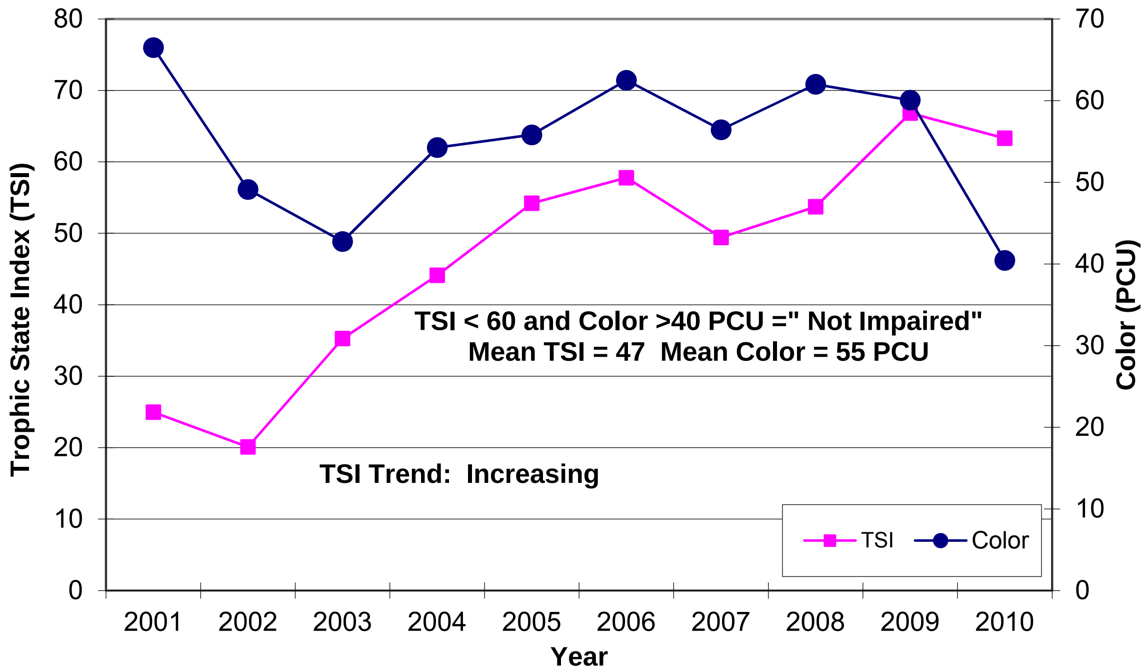
LAKE RATING

TROPHIC STATE INDEX AND COLOR

Piney Z Lake's median TSI from 2001–2010 is 51.2, and its annual mean TSI scores are typically below 60. Using this data and the lake's average color value of 47 PCU, FDEP's Impaired Waters Rule rating scheme indicates the water-body is not impaired with respect to nutrient enrichment[1]. However, the lake's TSI scores have been increasing as depicted in Figure 3.64. The rise is mainly due to increases in TP loading recorded in the lake in 2003 and is probably associated with loss of aquatic macrophytes and their subsequent decay. No TSI data is available for Piney Z Lake prior to 2001 because of the lack of reliable phosphorus data. Annual average color values in Piney Z Lake range from a high of 72 in 2004 to a low of 38 in 2010. Figure 3.64 demonstrates that the water-body has yet to achieve "impaired" status, but came very close in 2006. If Piney Z's current TSI trend continues, it could lead to a change in the lake's IWR nutrient status in the future.

[1] FDEP has placed Lake Piney Z on its Verified List for nutrient impairment. This evaluation was based on water quality data collected by FDEP and other agencies, which indicated that the lake has an average color value less than 40 PCU, and hence the TSI values would now be above the IWR standard for nutrient impairment. COT has challenged FDEP's evaluation because a different analytical method was used to determine color.

Figure 3.64 Piney Z Lake - TSI and Color



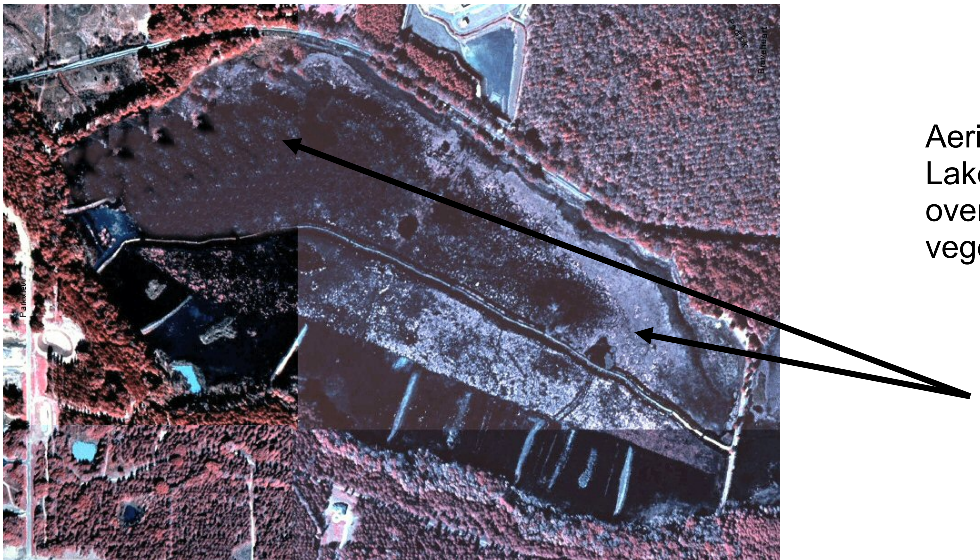
CHLOROPHYLL-*a*

Piney Z Lake's median chlorophyll-*a* concentration of 6.9 μg/L places this waterbody in the mesotrophic category. Mesotrophic lakes are considered to be those with chlorophyll-*a* values between 4.0 μg/L and 7.0 μg/L. Chlorophyll-*a* values for the four stations used to monitor this lake range from a low of 0.3 μg/L (February 2000) to a high of 104.2 μg/L (September 2008 after the rain event of Tropical Storm Fay). Median chlorophyll-*a* concentrations have generally been much lower post lake restoration (6.2 μg/L) than pre-restoration (14.9 μg/L). Two events may have combined to intensify algal populations and hence caused some higher chlorophyll-*a* levels in the lake. One is an increase in phosphorus concentration since 2004 (see nutrients section), and the other is the disappearance of a significant portion of the lake's aquatic vegetation. Phytoplankton and periphyton communities no longer have to compete with macrophytes for available nutrients.

MACROPHYTES

Until recently Piney Z Lake had, perhaps, the most abundant submersed and floating vegetation of any of the lakes surveyed in this report. Macrophyte coverage was so dense that many areas of the lake were difficult or impossible to navigate by boat. Herbicide treatment of exotic plants and some limited mechanical harvesting of submersed and floating plants has always been an on-going project in this lake. However, in 2002 (Goodheart, 2005) grass carp were introduced into the northern portion of the lake at a fairly high stocking rate (approximately 50 per acre) as an alternative method to control plant growth. Based on observations of the northern half of the lake, it appears the carp have been effective because it is essentially devoid of aquatic vegetation. In the southern portion of the lake much of the dense vegetation remained until 2008. In August 2008, Lake Piney Z was inundated by flood waters from T.S. Fay. The lake level rose several feet above the central berm and fishing fingers and remained for several weeks. White water lily, (*Nympahea odorata*), the dominant vegetation in the southern portion of the lake, was submerged and did not re-establish itself when the water level returned to normal. The lake is now almost entirely devoid of aquatic vegetation, apart from that within the littoral zone. Per the 2002 vegetation survey, white water lily (*Nymphaea odorata*) was the most dominant floating leaved aquatic plant; but other floating plants such as water shield (*Brasenia schreberi*), frog's-bit (*Limnobium spongia*), American lotus (*Nelumbo lutea*) and banana lily (*Nymphoides aquatica*), were also prominently represented. Significant elements of submersed flora include leafy bladderwort (*Utricularia foliosa*), purple bladderwort (*Utricularia purpurea*), coon tail (*Ceratophyllum demersum*) and purple fanwort (*Cabomba caroliniana*). Major contributors to the emergent plant population in the lake include smartweed (*Polygonum* spp.), American cupscale (*Sacciolepis striata*), maidencane (*Panicum hemitomon*) and pickerelweed (*Pontederia cordata*). All of these macrophytes were native and generally indicated good water quality.

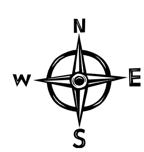
The following aerial photographs of Lake Piney Z are from different years and are meant to present different stages of aquatic vegetation coverage. The first is from 1999, 3 years before the grass carp were introduced. The next one is from 2004; two years after the fish were added. Notice the coverage of vegetation is somewhat less but still quite evident in the northern portion of the lake. The last photograph is from 2007; the vegetation is noticeably reduced in the upper portion of the lake. The photographs document the progress the grass carp have made in consuming the abundant vegetation that existed in Lake Piney Z.



Aerial photo of Piney Z Lake from 1999, note the overall coverage of vegetation.

Aerial photo of Piney Z Lake from 2004, note the overall coverage of vegetation. The green patches represent

Aerial photo of Piney Z Lake from 2007, note the reduced coverage of vegetation in the northern portion of the lake.

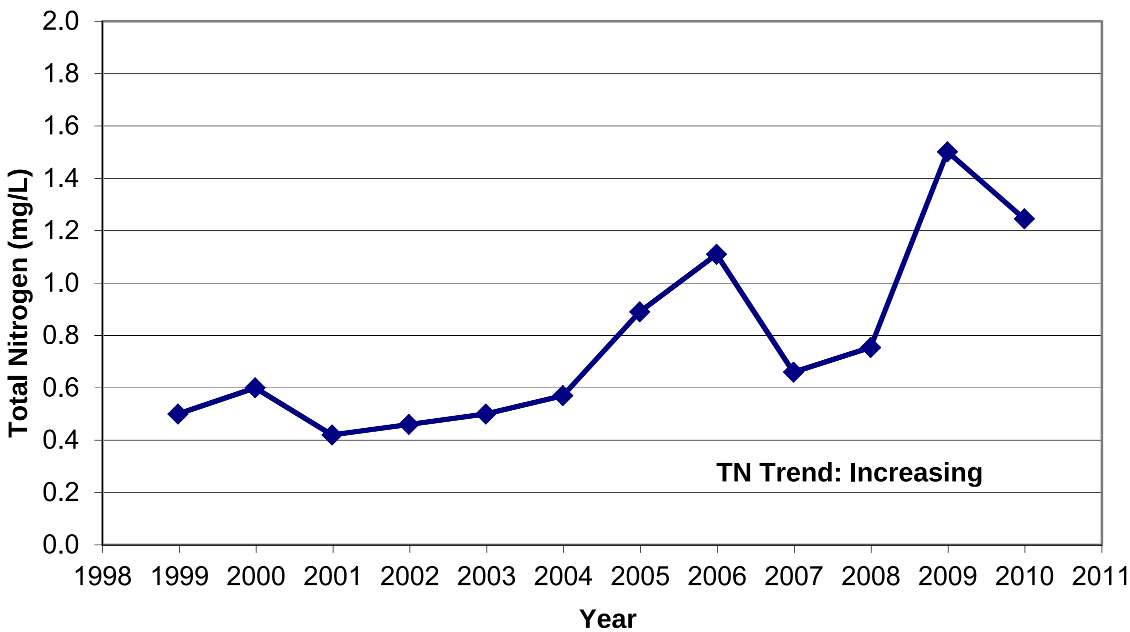


WATER QUALITY PARAMETERS

NUTRIENTS

Piney Z Lake's long-term median TN value (mean of four stations) is 0.61 mg/L. The nitrogen is predominantly in the organic form with a median TKN value of 0.60 mg/L. Ammonia, in low levels, has been detected in approximately 40% of the water quality samples taken from the lake since 1996, but the median concentration is low at 0.008 mg/L. Nitrate has rarely been reported above the detection limit. Based on the TN value only, the lake would be classified as a mesotrophic system. Figure 3.65 shows Piney Z Lake's average annual TN concentrations from 1999 to 2010. No TN values are available for 1998 due to lake restoration activities, and the data point for 1997 is based on a single sampling event. Since the completion of the lake restoration, year-to-year lake TN values were relatively unvarying until 2005 when the value increased by 64% and has since reached an all-time high at 1.6 mg/L in 2009. TN values have steadily increased since 2006 and are presently averaging 1.1 mg/L. Plant decay from overgrazing of diploid carp is a guess on the source of the nitrogen and its steady concentration increase.

Figure 3.65 Piney Z Lake Total Nitrogen



The long-term median TP value for the lake's four monitoring stations is 0.033 mg/L and the concentration has increased significantly since 2002.

Figure 3.66 Piney Z Lake Total Phosphorus

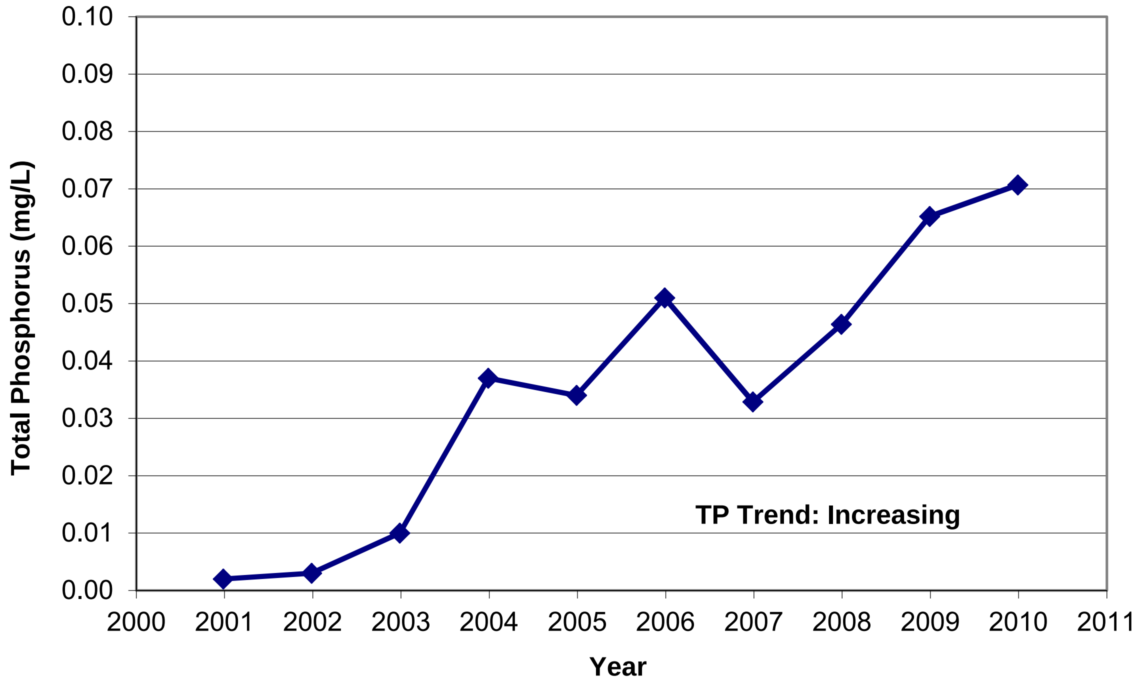


Figure 3.66 shows Piney Z Lake's annual average TP values from 2001 to 2010. An upward trend in the data is evident, and in 2009 the lake exhibited its highest TP measurement (0.118 mg/L) for the ten years the parameter has been monitored. The reason for the increase in this nutrient appears to be related to the disappearance of the aquatic vegetation and the fact that the reduced macrophyte density has decreased the ability of the lake ecosystem to assimilate the incoming and ambient phosphorus load.

CONDUCTIVITY

Piney Z Lake's median specific conductance of 26 μmhos/cm is among the lowest of all the lakes in this study and very low compared to statewide averages for freshwater lakes. Conductivity measurements from the four stations ranged from a low of 8 μmhos/cm to a high of 75 μmhos/cm (April 2010). All stations have increased conductivity levels in year 2010. Frequent algal blooms have been attributed to these increased levels.

TURBIDITY

Historic turbidity levels in Piney Z Lake are generally low with median values for all four stations in the range of 1.5 to 2.5 NTU. However since the depletion of aquatic vegetation both by the overstocking of carp and the flooding of Tropical Storm Fay, turbidity averages have drastically increased. Frequent algal blooms are contributing to the increased turbid water. The overall median turbidity for the lake is 2.4 NTU. Prior discharges of sediment from the Piney Z Plantation development into the lake have been well documented (COT, 2001). These influxes have resulted in elevated turbidity measurements at Station #3, the closest station to the discharge point.

ALKALINITY AND PH

Piney Z Lake's long-term median alkalinity value (mean of four stations) is 9.2 mg/L, a relatively robust buffering capacity compared to many of the other lakes in this study. Although natural, it is still well below FDEP's criterion for Class III surface waters of 20 mg/L. Alkalinity increased nearly two-fold after Tropical Storm Fay released nearly 15 inches of rain in the City's surrounding area. Extensive flooding and runoff into Piney Z caused the alkalinity to rise an average of 12.4 mg/L during the year 2009. The alkalinity differences have since decreased to long-term readings in 2010. Piney Z Lake is mildly acidic with a median pH of 6.3 (mean of four stations). The pH together with the lake's relatively low color value (51 platinum cobalt units) places it in the "acid-colored" lake category.

Bacteriological

Bacteriological quality in Piney Z Lake is somewhat poorer than the other acid-colored lakes in this report. Median coliform counts at Station #1 through Station #4 are 17, 18, 16 and 18 colonies per 100 mL respectively, with an overall median count of 17 colonies per 100 mL for the lake. Piney Z stations #1 and #2 both receive moderate stormwater inflows and have similar median fecal coliform counts. Station #1 is located directly in front of the boat ramp, while Station #2 is in the vicinity of the stormwater discharge from the Swift Creek Middle School pond. Station #3 receives stormwater inflows from the Piney Z Plantation development and frequent high coliform counts recorded at this station have been attributed to failures of its stormwater pond (COT, 2001). Piney Z station #4, which receives no direct stormwater inflows, has the lowest median fecal coliform count. Paradoxically, the highest recorded value was 1233 colonies per 100 mL, measured at Station #4 in July 2004, a result that is probably more related to waterfowl than stormwater influences. The next event with high colony counts occurred in July 2005 when 2839 and 3340 colonies/100mL were reported from Stations #3 and #4, respectively. These 3 instances are the most recent excursions of the FDEP Class III criterion of 800 colonies per 100 mL on any one day has been violated. Fecal coliform colony counts are generally low in this lake as evidenced by the median value for the lake.

Dissolved Oxygen

As with Lake Overstreet, the overabundance of aquatic vegetation has at different times depressed DO levels in this water-body below the Class surface water criterion (5.0 mg/L); however, the median DO concentration at the surface interval is 6.9 mg/L. All four stations exhibit approximately the same average DO concentration, although Station #2 tends to be higher with a mean of 7.2 mg/L. Approximately 35% of all the surface DO samples collected from Piney Z Lake to date are below the FDEP Class III criterion. Oxygenation of the water column takes place at the water's surface and this process can be hindered by the presence of floating plants and floating-leaved plants. Over time, the loss of vegetation in the northern portion of the lake has caused DO levels to rise in the area. There is insufficient water quality data to determine if loss of aquatic vegetation in the southern half of the lake has influenced D.O. concentrations. The highly organic sediment present on this lake's bottom also imposes an oxygen demand, especially in the summer months, that frequently results in hypoxia (DO readings below 1.0 mg/L) at the bottom depth. Almost 30% of all bottom depth DO readings reflected this condition.

SUMMARY

Piney Z Lake is a productive reservoir that has historically provided habitat for numerous waterfowl, wading birds and a plethora of other wildlife. This lake has been one of the primary foraging areas for at least one (probably two) generation of bald eagles that have nested near its shore for over twenty-five years. This lake has a well-deserved reputation as a fishery for oversized largemouth bass, and is a popular destination since it has been open to the public as a recreational fishery. Stormwater inflows from Swift Creek Middle School pond and the Piney Z Plantation development appear to influence the lake water quality, which is deteriorating. Efforts to control aquatic vegetation in the lake by use of grass carp appear to have resulted in a substantial reduction in aquatic vegetation density and a commensurate increase in the lake's phosphorus level. The reduced aquatic plant coverage renders the water-body unable to assimilate the current phosphorus loading. Since macrophytes compete with algal communities for available nutrients, the change in nutrient status may lead to an increased propensity of algal blooms in Piney Z Lake.


CITY OF
TALLAHASSEE
N
GOOSE POND LOCATION MAP
BRADFORDVILLE RD
OX BOTTOM
RD
N MERIDIAN RD
THOMASVILLE RD
CENTERVILLE RD
ROBERTS RD
N MONROE ST
OLD
BAINBRIDGE
RD
I-10
MICCOSUKEE RD
I-10
W THARPE ST
BUCK LAKE RD
W
TENNESSEE
ST
MAHAN DR
W PENSACOLA ST
E PARK AVE
JACKSON BLUFF RD
RD
E MAGNOLIA DR
BRADFORD
ORANGE AVE
LAKE
SPRINGHILL RD
CAPITAL
RD
CRAWFORDVILLE
WOODVILLE HWY
DENNIS ST
NOBLE DR
POTTS RD
WEDNESDAY CT
WEDNESDAY ST
NOBLE CT
TECH PL
CENTERVILLE RD
Inflow
CENTRE POINTE BLVD
WOODGATE WAY
Outflow
EVERETT LN
DOOMAR DR
OWENBY DR
MARSTON
TEDDY
● = Sampling Station

3.14 GOOSE POND

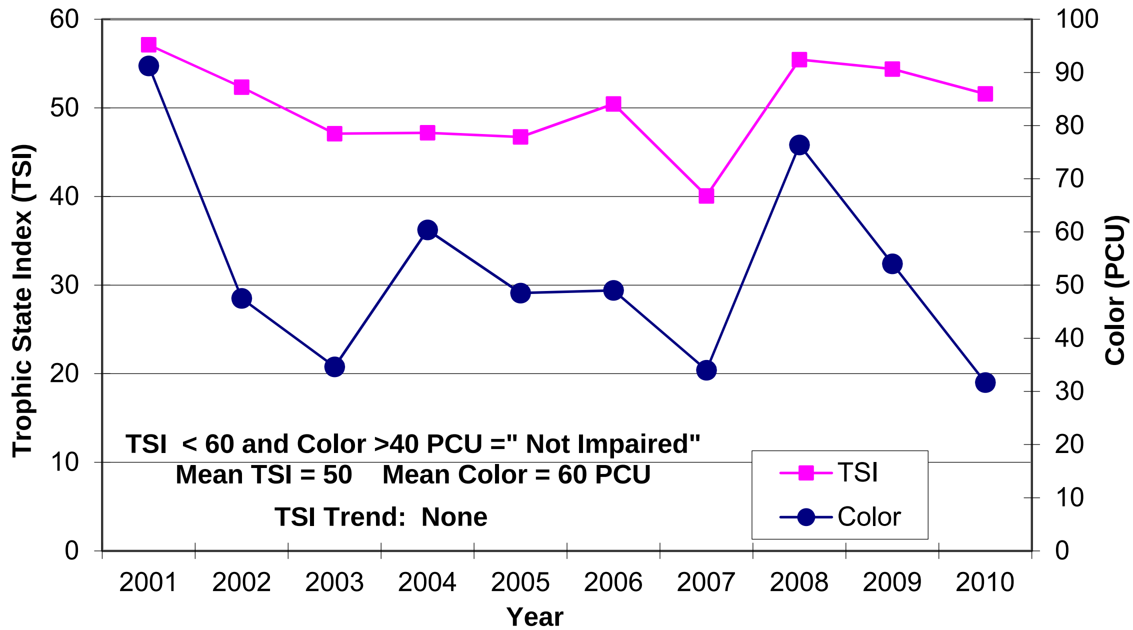
Goose Pond, is located adjacent to Potts Road and just north of Centerville Road in the Tallahassee Red Hills Physiographic Province. It is a shallow, flow-through reservoir with a surface area of approximately 34 acres that drains a mostly urban watershed area of 2545 acres and receives inflow from four major sources; the Northeast Drainage Ditch, Wednesday Street Pond, the Woodgate subdivision, and Goose Pond Tributary. The Goose Pond Tributary, in turn, receives inflow from the Hermitage Subdivision and extends west of Thomasville Road. Peak inflow rates from the Northeast Drainage Ditch have been calculated to be up to 100 cubic feet per second. The water-body is a narrowly elongated pool whose natural water flow pattern is disrupted by large earthen berms constructed to support power line poles. Outflow from Goose Pond discharges under Centerville Road to the Northeast Drainage Ditch and ultimately to Upper Lake Lafayette. Turbid inflows and decaying aquatic vegetation have contributed to the buildup of sediment in this water-body over the years, making it progressively shallower. Maximum depth and average depth at mean pool elevation are estimated to be five feet and three feet, respectively. The Lakes Monitoring Program has two monitoring stations on this lake, one at the junction with the Northeast Drainage Ditch inflow and the other at the pond outflow just north of Centerville Road.

LAKE RATING

TROPHIC STATE INDEX AND COLOR

Goose Pond's long-term median score on the trophic state index (mean of two stations) is 49.7. Figure 3.67 is a plot of Goose Pond's annual average TSI and color values for the monitoring period 2001 through 2010. No TSI values are available prior to 2001 because of the lack of reliable phosphorus concentration data for the water-body. Although casual observation of the graph suggests a decreasing (improving) to an increasing TSI score, statistical analysis of the individual data points indicates no trend in the data. Goose Pond's mean color, (60 PCU), and mean TSI score (50) gives this water body a "not impaired" water quality rating according to FDEP Impaired Waters Rule.

Figure 3.66 Goose Pond - TSI and Color



CHLOROPHYLL-*a*

Chlorophyll-*a* values for the two monitoring stations in this water-body are significantly different. Goose Inflow has a median chlorophyll-*a* concentration of 11.1 µg/L while Goose Outflow's median chlorophyll-*a* concentration is slightly higher at 9.4 µg/L. Excessive macrophyte growth from within Goose Pond proper are associated with the chlorophyll-*a* concentration by shading the water and using nutrients that would otherwise be available to algae. Evaluating only chlorophyll-a values to rate this water-body, Goose Pond would be classified as eutrophic at both monitoring stations.

MACROPHYTES

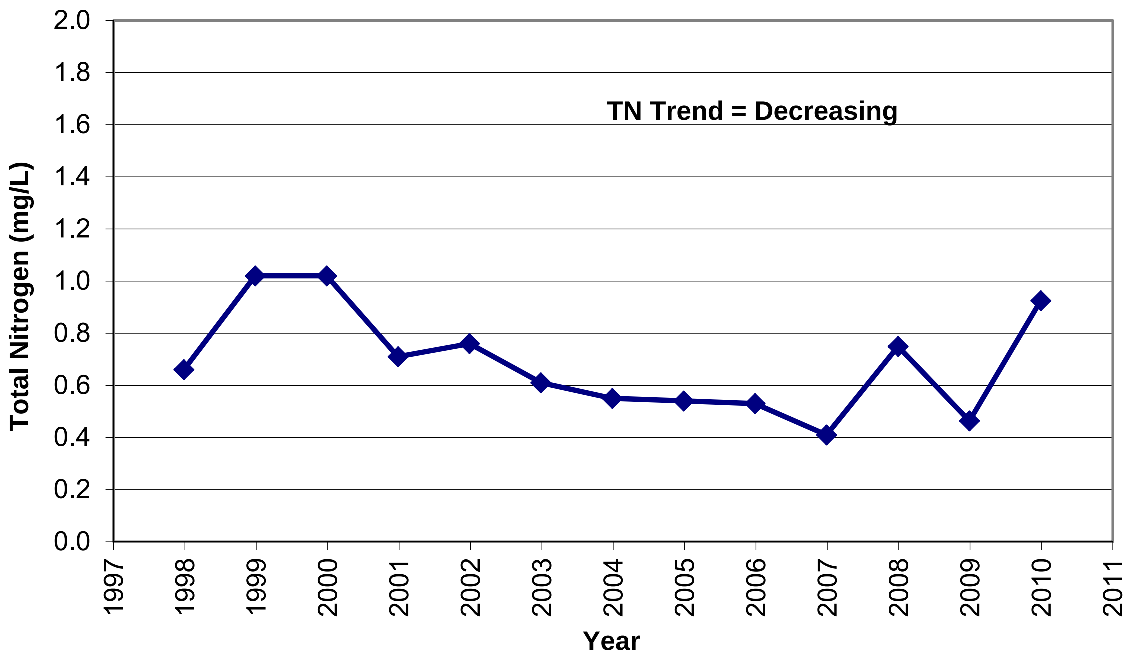
The plant community at Goose Pond is one that is indicative of anthropogenic disturbance and poor water quality. Based on the 2002 vegetation survey, over 90% of Goose Pond is dominated by invasive exotics and cattail (*Typha latifolia*). Some of Florida's most problematic invasive exotics are found in Goose Pond, including alligator weed (*Alternanthera philoxeroides*), rattlebox (*Sesbania punicea*), Chinese tallow tree (*Sapium sebiferum*), and elephant ear (*Colocasia esculenta*). Of these exotics, elephant ear (*Colocasia esculenta*) and Chinese tallow tree (*Sapium sebiferum*) are listed as Category I Exotics by the Florida Exotic Pest Plant Council (FLEPPC). Category I plants are considered the most damaging invasive exotics in Florida and are defined by demonstrating one or more of the following characteristics; causing displacement of native plants and altering native plant communities, hybridizing with native species, and/or changing community structures. Both rattlebox (*Sesbania punicea*) and alligator weed (*Alternanthera philoxeroides*) are considered Category II Invasive Exotics by the FLEPPC. Category II Invasive Exotics are exotics that have increased in abundance or frequency but have not yet altered natural Florida plant communities to the extent of Category I Invasive Exotics. Cattail (*Typha latifolia*) is by far the most dominant herbaceous plant in Goose Pond, with large stands present throughout. This pollution-tolerant species is an aggressive invader of disturbed shallow aquatic habitats that demonstrates great growth potential. Other notably abundant wetland plant species found in this pond include black willow (*Salix nigra*), wax myrtle (*Myrica cerifera*), buttonbush (*Cephalanthus occidentalis*), elderberry (*Sambucus canadensis*), red maple (*Acer rubrum*), smartweed (*Polygonum* spp.), wooly bulrush (*Scirpus cyperinus*), two species of pennyworts (*Hydrocotyle bonariensis*) and (*Hydrocotyle ranunculoides*), white water lily (*Nymphaea odorata*) and pickerelweed (*Pontederia cordata*).

WATER QUALITY PARAMETERS

NUTRIENTS

Goose Pond's median TN and TKN values (mean of two stations) are 0.57 mg/L and 0.56 mg/L, respectively. Figure 3.67 graphs the annual TN values from 1998 to 2010. While some variation in the year-to-year TN values is evident, the data overall exhibits a decreasing trend. A slight spike in TN, 2008, is illustrated in Figure 3.67 indicating significant rainfall from Tropical Storm (T.S.) Fay causing nutrient increases. If the TN trend continues as shown, TN values should stabilize and continue on a decreasing trend.

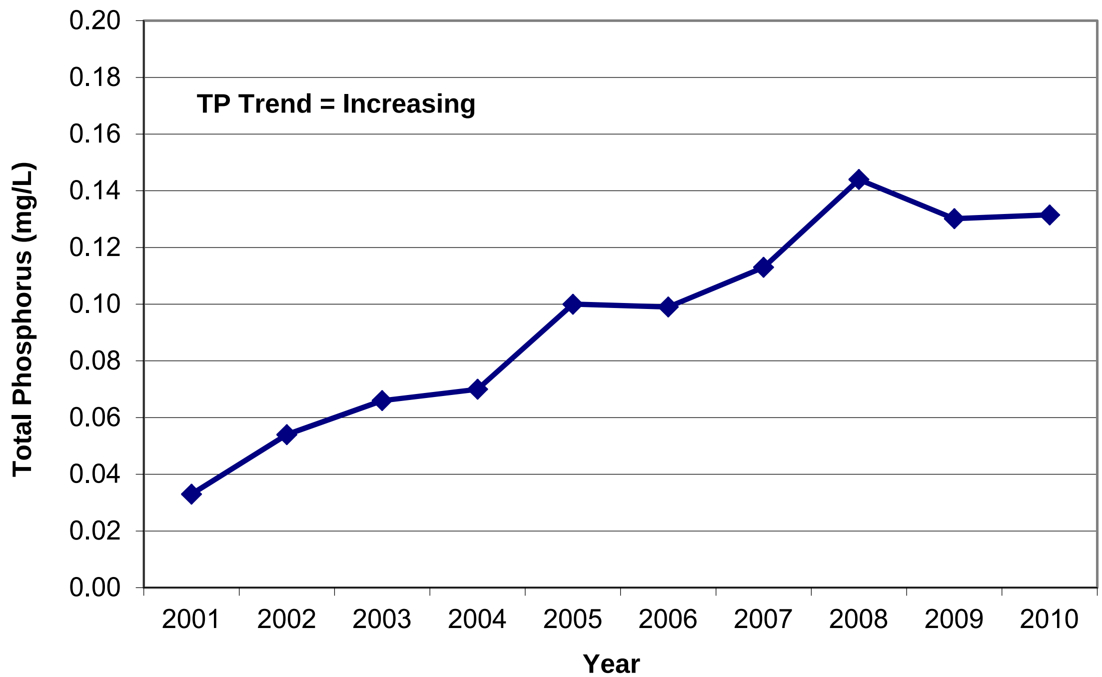
Figure 3.67 Goose Pond Total Nitrogen



Using only the average TN concentration, to classify this water-body, it would be considered eutrophic. Goose Pond's two-station median ammonia concentration (0.03 mg/L) is the highest (worst) of all the lakes in this study. Ammonia values are comparable at each station, however almost 80% of the samples collected from Goose Inflow had ammonia concentrations above the analytical detection limit, while at Goose Outflow it was 35%. Ammonia found in this water-body in these concentrations is an indicator of the breakdown of organic matter and the influx of nutrients at a rate faster than can be utilized by macrophytes and algae. Goose Pond is also one of the few water-bodies in this study that exhibits measurable levels of nitrate, especially at the inflow station where the median nitrate concentration is 0.03 mg/L.

The median TP value for the pond's two monitoring stations is 0.07 mg/L; only Lake Hilaman has a higher value of all the lakes in this study. The TP concentration at the inflow station (0.059 mg/L) is somewhat less than that at the outflow (0.085 mg/L), although both are high compared to other lakes in this study. A plot of Goose Pond's annual TP values from 2001 to 2010 is provided in Figure 3.68. The yearly averaged TP values have nearlyquadrupled from 2001 (0.033 mg/L) to 2010 (0.132 mg/L). A statistical analysis of individual data points suggests that an increasing trend in the TP data over the ten-year monitoring period. The TN/TP ratio for the pond is 7.86 indicating this water-body may be slightly nitrogen-limited with respect to algal growth and that decaying plant matter from the pond is causing the TP values to rise year to year.

Figure 3.68 Goose Pond Total Phosphorus



CONDUCTIVITY

Goose Pond's overall median specific conductance value of 103 μmhos/cm is the highest (worst) by far of any of the lakes in this study. The median conductivity value is much higher at the inflow station (121 μmhos/cm) than at the outflow station (91 μmhos/cm) with a range from 32 to 320 μmhos/cm. Conductivity is useful as a rough measure of the inorganic substances dissolved in freshwater and persistently elevated readings at the Goose Pond inflow station would indicate a source of inorganic pollution upstream in the Northeast Drainage Ditch.

TURBIDITY

The turbidity levels at Goose Pond are relatively high compared to the other lakes in this study. These high turbidity readings are indicative of frequent algal blooms and sediment inflows to Goose Pond. The water-body has an overall median turbidity value of 7.1 NTU, with mean turbidities approximately the same at both monitoring stations. Elevated turbidity values were often recorded at the

Goose Inflow station in 2003 and 2004 stemming from the construction activities for the Blair Stone Road Extension and the paving of Potts Road.

ALKALINITY AND PH

The alkalinity levels at Goose Pond are the highest in the study with median values of 55.4 mg/L at the inflow station and 38.0 mg/L at the outflow. These values meet FDEP's minimum alkalinity criterion for Class III surface waters of 20 mg/L, however they are not necessarily indicative of good water quality. In this area, surficial soils are lacking in carbonate minerals and hence alkalinity levels are naturally very low. The observed alkalinity level at the inflow station is due to high alkalinity in the source water, i.e., stormwater in the Northeast Drainage Ditch. The lower alkalinity at Goose Pond Outflow suggests that the other stormwater inflows to Goose Pond contain considerably less alkalinity. As would be expected, the high alkalinity values do keep the pH rather stable. Higher alkalinity waters are often more biologically productive than lower alkalinity waters, a factor that might help explain the abundance of cattail and other invasive plants in this water-body. The pH readings recorded at Goose Pond range from a low of 5.3 S.U. (inflow) to a high of 8.3 S.U. (outflow). In general, the inflow at Goose Pond exhibits a smaller range of pH values than the outflow station. The median pH values recorded at Goose Pond inflow and outflow are circum neutral at 7.1 S.U.

BACTERIOLOGICAL

Goose Pond consistently exhibits high fecal coliform counts emphasizing its role as a receptor of stormwater runoff. The inflow station, which tends to reflect water quality in the Northeast Drainage Ditch, has a higher median fecal coliform count (60 colonies/100 mL) than the outflow station (42 colonies/100 mL). Except for Hilaman Inflow, the median fecal coliform count at Goose Inflow is higher than any other individual lake sampling station in this study. Two of the Inflow samples have exceeded the FDEP Class III criterion for a one-time event of >800 colonies per 100 mL of water, and the first exceedances of the criterion occurred at the Goose Outflow site in April 2010 (1120 colonies/100mL). Previously, the highest count had been 1040 colonies/100mL, reported in October 2006. Generally, there is some improvement in Goose Pond's bacteriological quality between inlet and outlet stations, perhaps due mainly to the hydraulic residence time.

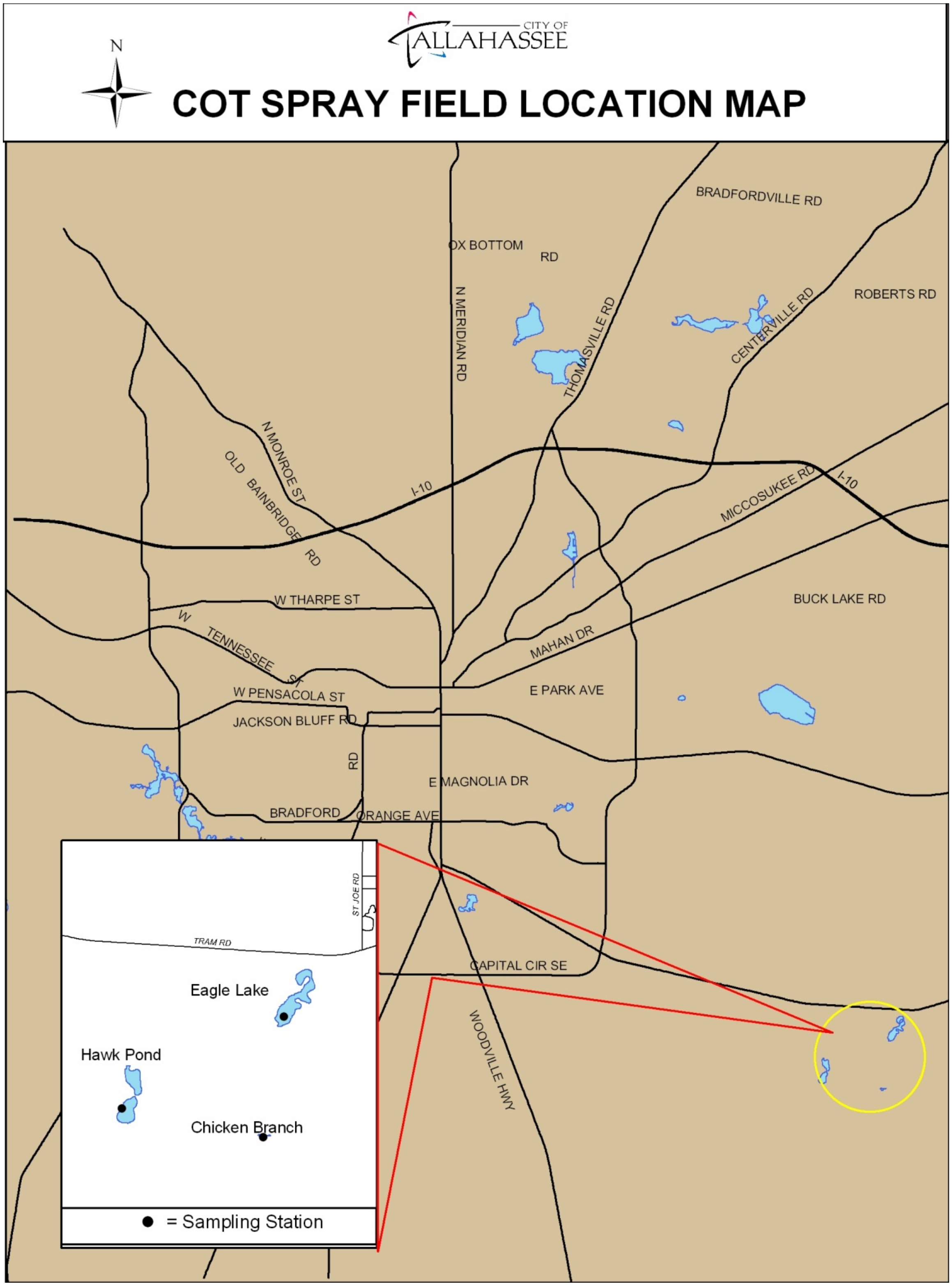
Dissolved Oxygen

Median DO levels for Goose Pond inflow and outflow stations are 5.5 mg/l and 6.9 mg/L, respectively, giving a two-station mean DO of 6.1 mg/L for the pond overall. DO sags were much more common at Goose Inflow than at the outflow. At the inflow station, DO levels dropped below the state Class III water quality standard of 5.0 mg/L in approximately 35% of the sample events, but in only about 7% of samples collected at the outflow station. The median DO concentration at the outflow station tends to be higher than at the inflow because oxygen super-saturation due to algal blooms occurring more frequently at the inflow station.

SUMMARY

Goose Pond is a shallow flow-through reservoir that receives stormwater runoff from a large upstream urban area. Its drainage basin to "lake" surface area is greater than 75:1, a ratio that should serve as an indicator of Goose Pond's current predicament. All monitoring evidence to date indicates inflow of nutrients far exceeds the assimilative capacity of this system. Goose Pond exhibits higher concentrations of phosphorus, ammonia and nitrate and a higher specific conductance than any other lake in this report. The trophic state index score, not withstanding all other water quality indices, suggests this continues to be a degraded eutrophic system. The vegetative community within this water-body is also indicative of a degraded lake system. Most of the surface area of Goose Pond is covered by the pollution-tolerant species cattail or invasive exotic vegetation including elephant ear, rattlebox, Chinese tallow and alligator weed.

Coverage by invasive exotics exceeds 90% in many areas of the lake. In summary, Goose Pond is a neglected reservoir/wetland that exhibits some of the poorest water quality found in any lake system in this area.


CITY OF TALLAHASSEE
N
COT SPRAY FIELD LOCATION MAP
BRADFORDVILLE RD
OX BOTTOM RD
N MERIDIAN RD
THOMASVILLE RD
CENTERVILLE RD
ROBERTS RD
N MONROE ST
OLD BAINBRIDGE RD
I-10
MICCOSUKEE RD
BUCK LAKE RD
W THARPE ST
W TENNESSEE ST
MAHAN DR
W PENSACOLA ST
E PARK AVE
JACKSON BLUFF RD
RD
E MAGNOLIA DR
BRADFORD
ORANGE AVE
CAPITAL CIR SE
WOODVILLE HWY
ST JOE RD
TRAM RD
Eagle Lake
Hawk Pond
Chicken Branch
● = Sampling Station

3.16 COT SPRAYFIELD LAKES EAGLE LAKE

Eagle Lake is part of the City of Tallahassee's Sprayfield Expansion. This lake is located approximately one third of a mile south of Tram Road and 1.5 miles west of W.W. Kelly Road. This lake is located in the Woodville Karst Plain Physiographic Province. Eagle Lake has a drainage basin of approximately 79 acres. The total surface area of Eagle Lake is approximately 26 acres, giving a drainage basin to surface area ratio of 3:1. The soils around the lake consist of Chipley fine sand, Leon sand, and Ortega sand. The maximum depth of Eagle Lake is approximately ten feet at mean pool elevation. The Lakes Monitoring Program has one monitoring station on this lake.

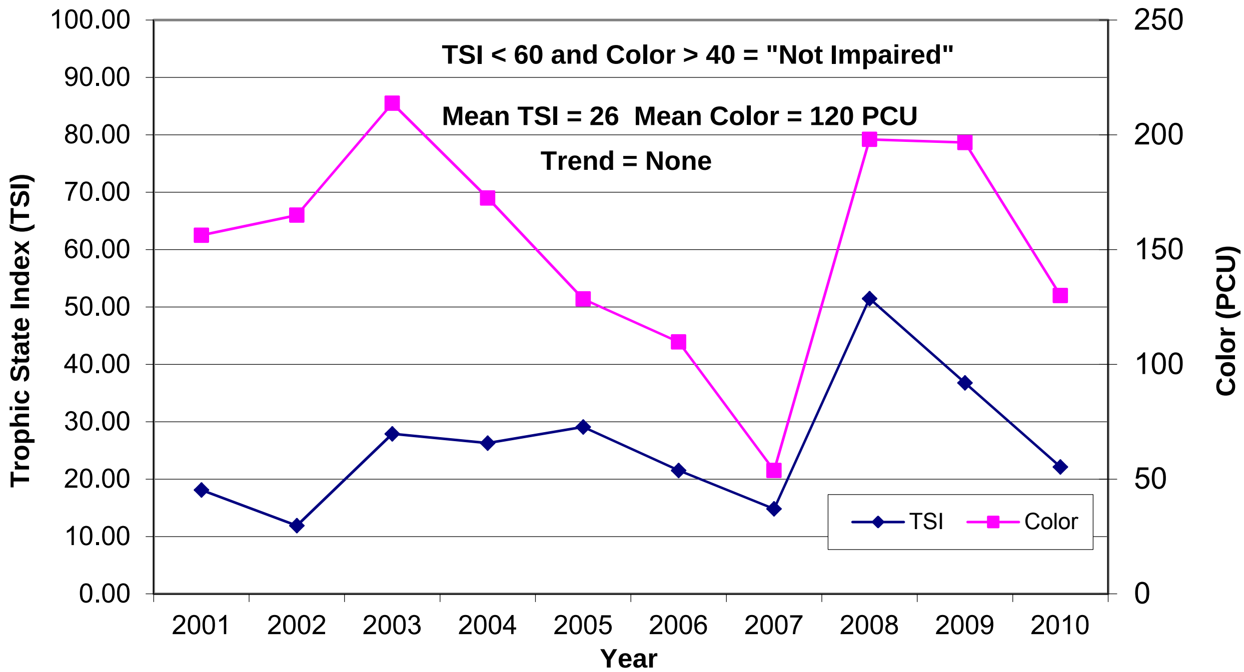
Eagle Lake is a picturesque blackwater lake that supports a diverse fishery. There is evidence that American Indians formerly settled near this lake for an extensive period of time. This gives some indication of the historical permanence of the pool in this lake and may provide some insight into its historic water quality.

LAKE RATING

TROPHIC STATE INDEX AND COLOR

Eagle Lake's median TSI is 25.9; the second best TSI score of all the lakes covered in this report. This is a dark lake with annual mean color values over 120 PCU. Using FDEP's protocols, the color values being greater than 40 PCU and annual average TSI scores < 60 indicate the water-body is "meeting its threshold" and "not impaired". TSI values are calculated by averaging chlorophyll-*a* and nutrient TSI scores over the monitoring period. Eagle Lake's notable TSI score is achieved because both the chlorophyll-*a* and nutrient (total phosphorus) levels in this water-body are extremely low. Annual average TSI scores for the monitoring period 2001 through 2010 are plotted in Figure 3.69. As with several other lakes in this study, TSI values prior to 2001 are not available because of the lack of reliable phosphorus measurements. Although annual average TSI scores in Figure 3.69 may not readily reflect an increasing trend, statistical analysis of the individual scores from each sampling event indicates an upward trend.

Figure 3.69 Eagle Lake TSI vs. Color



CHLOROPHYLL-*a*

The median chlorophyll-*a* value for Eagle Lake of 2.7 μg/L is very low with only this report's reference water-body (Moore Lake) exhibiting a lower chlorophyll-a concentration. Using only chlorophyll-*a* levels to rate this lake, the lake would be characterized as an oligotrophic water-body. However, this lake is a blackwater system and, as such, it does not utilize the available nutrients due to natural limiting factors such as colored water or low pH. Additionally, the abundant macrophyte coverage in this lake, which unlike other blackwater systems does not appear to be limited by its high color (median value 120 platinum cobalt units) or low pH, has probably contributed to a further suppression of algae found in the water column.

Macrophytes

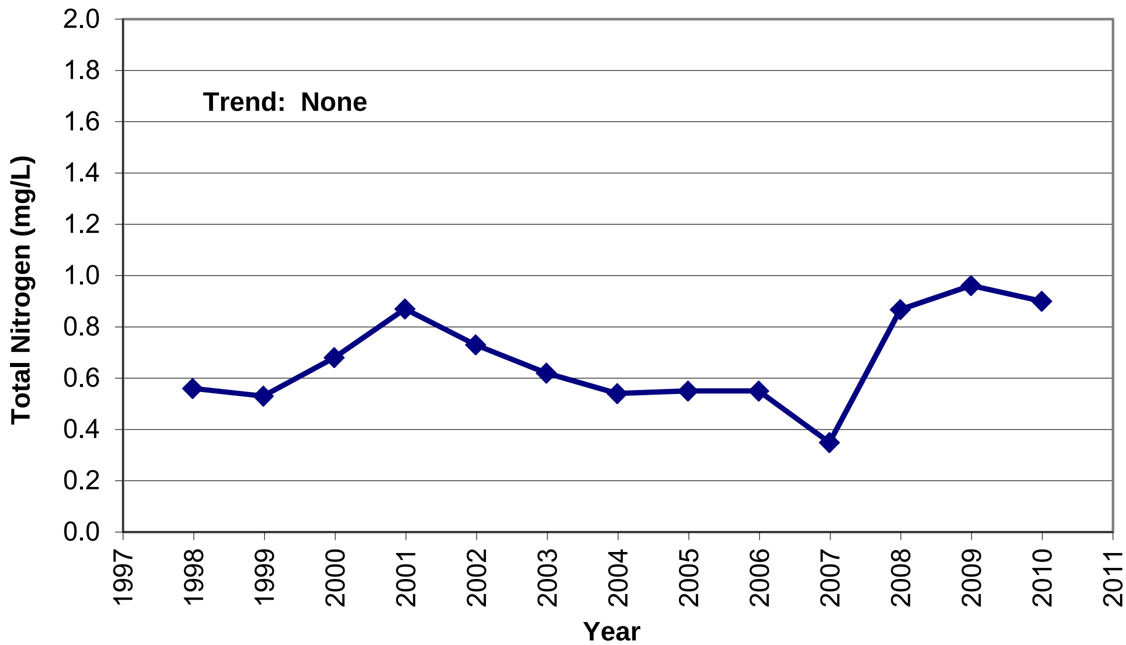
Compared to the other blackwater lakes in this report, Eagle Lake has dense coverage of aquatic vegetation with white water lily (*Nymphaea odorata)* being the dominant herbaceous plant covering much of the lake's surface. Purple fanwort (*Cabomba caroliniana*) is also well established. Unique among water-bodies in this study, Eagle Lake has a number of floating islands (tussocks) covered with vegetation. Tussocks are created when marsh gases (principally methane) from decaying vegetation raise large clumps of organic muck from the bottom of the lake, subsequently becoming vegetated after reaching the surface. This lake had considerable amounts of the spikerush (*Eleocharis robbinsii*-a fairly rare species in Florida) growing on the tussocks and *Eleocharis equisetoides* as an emergent species, rooted on the lake bottom. Pond cypress (*Taxodium ascendens*), swamp tupelo (*Nyssa sylvatica* var. *biflora*), water primrose (*Ludwigia* spp.), meadow beauty (*Rhexia* sp.), titi (*Cyrilla racemiflora*) and smartweed (*Polygonum* sp.) are notably abundant in the littoral zone of this lake.

WATER QUALITY PARAMETERS

Nutrients

Eagle Lake's median TN and TKN values are the same, 0.56 mg/L, similar to the other blackwater lakes in this study. Overall, concentrations have been very consistent over the last few years. Ammonia in concentrations above the analytical detection limit is detected only very infrequently in this water-body, and nitrate not at all. Figure 3.73 is a plot of the lake's annual TN values from 1998 to 2010. The reservoir's TN content peaked in 2008, 1.24 mg/L, when T.S. Fay produced nutrient spikes with the heavy rains. Trend analysis suggests a slight decrease of the TN data over the ten-year monitoring period. This water-body would be classified as eutrophic using only the average TN concentration as the basis for comparison with other lakes in Florida.

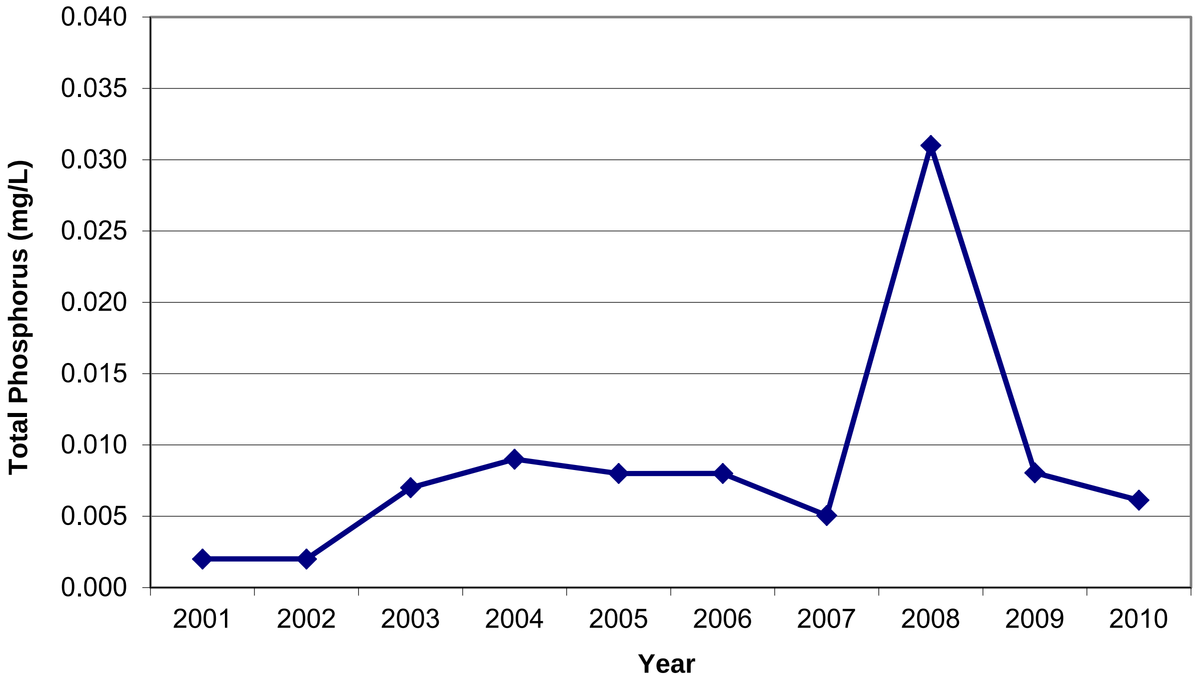
Figure 3.70 Eagle Lake Total Nitrogen



Eagle Lake exhibits a median TP concentration of 0.01 mg/L, a substantial increase from the last publication of this report in 2006 when TP median value was 0.006. Again substantial rains from tropical systems and recovering from a two-year drought will release natural nutrient spikes from decaying detritus from lake bottom sediments. Figure 3.71 depicts the water-body's annual average TP values for 2001 through 2010. Prior to 2003, the lake's TP was too low to be measured (less than 0.002 mg/L) but this parameter has increased slightly over the past six years. The TN/TP ratio is 84 indicating that it is strongly phosphorus limited with respect to the potential for algal proliferation. However, lack of phosphorus in the water column does not inhibit macrophyte growth in Eagle

Lake. Many of the dominant aquatic plants are rooted and derive their nutrients from the bottom sediment.

Figure 3.71 Eagle Lake Total Phosphorus



CONDUCTIVITY

Eagle Lake's median specific conductance is 26 μmhos/cm, quite comparable to the other blackwater lakes in this study. Over the ten-year monitoring period, conductivity in this water-body has ranged from a low of 12 μmhos/cm to a high of 60 μmhos/cm (May 2001).

TURBIDITY

The mean and median turbidity value at Eagle Lake is an extremely low 0.9 NTU. The range turbidity readings exhibited over the monitoring period is from 0.0 NTU to 2.5 NTU. Turbidity levels this low are generally associated with non-impacted lake systems. Although color at levels in this water-body can interfere with turbidity measurements, the bias is minimal.

ALKALINITY AND PH

Typical of blackwater, acidic lakes, Eagle Lake has a low median alkalinity value of 2.6 mg/L. Over the ten-year monitoring period, alkalinity values ranged from 0.6 mg/L to 8 mg/L. The pH readings varied from a low of 4.3 to a high of 6.6 with a median pH value recorded at 5.1. The low alkalinity value and relatively small size of this essentially unimpaired natural lake indicate that it is extremely susceptible to anthropogenic impacts.

BACTERIOLOGICAL

Eagle Lake has median fecal coliform and fecal streptococci counts of 20 colonies per 100 mL and 5 colonies per 100 mL, respectively. Although the fecal streptococci value represents an improvement over 2004 results, the fecal coliform count remains stubbornly high; higher than for some of the more heavily urbanized lakes in this study, i.e., Lake Killarney and Lake Kanturk. Eagle Lake is an isolated natural water-body within the several hundred-acre sprayfield expansion area and these results may reflect the influence of cattle grazing in the nearby pastures. Another possibility could be windborne aerosol formation from the sprayfield spray heads; however, this cannot be confirmed without further investigation, which is beyond the scope of this program.

DISSOLVED OXYGEN

Eagle Lake is a naturally stressed water-body with respect to dissolved oxygen concentrations. Its median DO content for the ten-year monitoring period is 2.8 mg/L with greater than 70% of the surface DO readings below FDEP's criterion for Class III waters of 5.0 mg/L. In addition, the median DO at the bottom of this lake is 0.6 mg/L. More than 75% of the bottom depth DO readings were in the anoxic range, i.e., less than 1.0 mg/L DO. As previously noted, Eagle Lake has an abundance of aquatic vegetation, especially the floating-leaved variety. During their lifetime aquatic plants slough off dead leaves and other plant parts that sink to the lake bottom and contribute to the formation of sediment. As indicated by the presence of numerous floating islands of organic muck (tussocks), over the decades this lake has accumulated an excess of organic sediment. The oxygen demand exercised by the decaying vegetation can frequently exceed the rate at which oxygen is replenished at the water surface, resulting in severe oxygen depletion in the water column.

SUMMARY

Eagle Lake is an isolated, picturesque blackwater lake located in the City of Tallahassee's relatively undeveloped sprayfield expansion area. The water-body exhibits good water quality with almost the lowest (best) trophic state index (TSI) score of any lake in this study. The outstanding TSI score is mainly due to the very low levels of chlorophyll-*a* and phosphorus measured in the lake. As with most of the clean lakes in this study, Eagle Lake is not nutrient-enriched and chlorophyll-*a* concentrations are consistently low. The lake is somewhat unusual for a blackwater system in that it is heavily vegetated throughout. Typically, the high water color in such water-bodies inhibits the rooting of aquatic vegetation at depth.

Water quality-based lake rating methods suggest Eagle Lake is a comparatively unproductive, oligotrophic system. However, these methods ignore biological productivity expressed in the form of aquatic macrophytes. Using only its floating-leaved plant biomass as a measurement of biological productivity, Eagle Lake would be in the ultra-productive (hypereutrophic) category. Even though aquatic macrophytes provide excellent habitat for fish and for the organisms that fish feed on, they also play a major role in the natural oxygen depletion in this water-body. The frequent marginal DO conditions observed in Eagle Lake stresses fish populations, but fortunately they have the ability to adapt to lower oxygen environments.

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SECTION 4

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Appendix

GLOSSARY OF TERMS

algae a group of autotrophic plants (or plant-like organisms) that are unicellular or multicellular and typically grow in water or humid environments.

alkalinity* a measure of the capacity of water to neutralize acids because of the presence of one or more of the following substances in water: carbonate (CO_3^{2-}), bicarbonate (HCO_3^-), or hydroxide (OH^-).

ammonia nitrogen* reduced form of nitrogen that is present in surface waters in low concentrations either in the ionized state (NH_4^+) or unionized state (NH_3). Ammonia is produced naturally in the environment or may be derived from anthropogenic sources. In high concentrations in its unionized form, it frequently causes fish suffocation by decreasing the ability of hemoglobin to bind oxygen.

anoxic pertaining to the absence of all oxygen (both free and chemically bound oxygen).

anthropogenic having its origin in the activities of humans.

autotrophic the production of organic carbon form inorganic chemicals. Photosynthesis is an example of an autotrophic process.

benthic referring to bottom zones or bottom-dwelling forms.

benthos bottom-dwelling biota; the benthic community.

biomass the total mass of living tissues (plant and animal).

biota the living portion of a system.

biotic of or relating to life; esp. if caused or produced by living beings.

blackwater water containing high concentrations of humic substances or other phenolic compounds resulting from vegetation decomposition; water is acidic and appears dark and colored.

chlorophyll *a* green, organic pigment found in plants and algae.

Color the aspect of water that allows for the differentiation of samples due to its hue, lightness, and saturation. Color results from the decomposition of organic matter; especially plant material such as cypress needles, titi, tupelo and oak leaves. Blackwater streams and lakes exhibit high *true* color values. Color decreases light penetration and decreases the productivity of lakes and streams.

depauperate falling short of natural development or size

detritivores organisms that feed upon the detritus and decaying plant matter usually found in the hypolimnion of lakes

detritus dead organic matter and its associated microbial elements, particulate(POM) or dissolved(DOM).

discharge the volume of stream flow passing a point during some period of time; often expressed as cubic feet/second (cfs).

diurnal having a daily cycle.

dystrophy the condition in water in which decay is hindered and recycling of nutrients is slowed.

dystrophic waters waters which contain and are stained by natural organic materials that also renders the water low in dissolved oxygen and pH.

ecosystem the total living and nonliving components of a community.

EOT abbreviation for **e**phemeroterans (mayflies), **o**donates (dragonflies and damselflies), and **t**richhopterans (caddisflies).

emergent macrophyte aquatic plant rooted in bottom sediments with leaves protruding above water surface. Cattail and maidencane are examples of emergent plants.

eutrophication the process of enrichment of water bodies by plant growth nutrients that typically results in algal blooms and extreme (high and low) dissolved oxygen concentrations.

fecal coliform* bacteria found in the intestines of homeotherms and released via the feces; density determined in water samples by a membrane-filter technique and analyzed via microscopy

fecal streptococcus* a bacteria also found in vertebrate intestines, but occurring in pairs or chains; determined in water samples by membrane-filter technique

floating-leaved macrophyte aquatic plant that is primarily rooted to the bottom sediments and also has leaves that float on the water surface. Water lilies and lotus are examples of floating-leaved plants.

Hulbert Index a computed index that identifies macroinvertebrate taxonomic variety.

humic substance high molecular-weight organic molecule, polymeric, derived mostly from plant decay; humic acids with the carboxyl (-COOH) group; and humolimnic acids in lake waters and sediments.

hypereutrophic Pertaining to a lake or other body of water characterized by excessive plant nutrient concentrations such as nitrogen and phosphorous and resulting high biological productivity

hypoxia A condition in which natural waters have a low concentration of dissolved oxygen (about 2 milligrams per liter as compared with a normal level of 8 to 10 milligrams per liter).

impervious ability to repel water or not let water infiltrate, usually thought of in terms of constructed, nonporous surfaces such as asphalt and concrete.

leachate liquid that has percolated through soil or permeable solid waste and extracted soluble or suspended materials from it.

littoral referring to the marginal region of a body of water; the shallow, near-shore region; often defined by the band from zero depth to the outer edge of the rooted plants

macrobenthos bottom-dwelling organisms retained by screens with interstices from 1.00 to 0.425 mm (arbitrary); this study utilized 0.595 mm screens.

macrophytes plant life found in a body of water with individual members being readily discernible to the unaided eye.

motile exhibiting or capable of moving spontaneously.

NTU Nephelometric Turbidity Units- a measure of the concentration or particle size of suspended matter by means of absorbed or reflected light, thereby determining water clarity.

nitrite* (NO_2^-) is the intermediate oxidation state of nitrogen formed both in the oxidation of ammonia and the reduction of nitrate; not usually present in high concentrations in water bodies because it is readily converted to nitrate.

nitrate* (NO_3^-) is the highest oxidized state of nitrogen and the most stable form of oxidized nitrogen species in water.

N/P the ratio of total nitrogen (TN) to total phosphorus (TP); best expressed as a mass ratio.

oligotrophic having a low concentration of plant nutrients resulting in low biological productivity.

orthophosphate inorganic phosphate (PO_4^{3-}) usually found in fertilizers; their presence in natural waters indicates pollution via storm runoff.

periphyton the biota attached to submersed surfaces; community of sessile organisms on lake and stream substrata.

pH measure of the acidity or alkalinity of a water body that is defined scientifically as the negative logarithm of the hydrogen ion (H^+) activity (concentration). Methods of determination include acid-base indicators or electrodes with meters.

phytoplankton that portion of the plankton community composed of algae and cyanobacteria.

pioneer species biological species that immigrate first and establish growth after a site is disturbed.

poikilotherm	an organism (such as a frog) with variable body temperature that is slightly higher than the temperature of its environment; a cold-blooded organism
primary	the production of "energy" from sunlight through the process
productivity	of photosynthesis, accomplished by green plants and algae.
Secchi disc	a white disc about 20 cm in diameter, lowered into water to measure transparency on the basis of visibility.
Shannon-Wiener diversity index*	a statistical calculation that is used to calculate mean diversity of macroinvertebrate, thereby indicating the condition of a body of water.
specific conductance*	is a measurement of the total amounts of dissolved solids and ionized substances present in water; it is reported in units of micromhos per centimeter (mmhos/cm).
sublittoral	referring to the bottom region; lying between the littoral and the profundal zones
submerged macrophyte	large aquatic plant that grows primarily below the water's surface. Hydrilla and coontail are examples of submersed plants.
super saturation	the condition of a liquid when it has taken into solution the maximum possible quantity of a given substance at a given temperature and pressure.
taxa	plural of taxon, the name applied to taxonomic groups in a formal system of nomenclature.
total coliform*	a measurement of bacteria present in water samples that originate from vertebrate feces, as well as other environmental sources.
total Kjeldahl nitrogen (TKN) *	a measure of reduced nitrogen forms equal to the sum of organic-nitrogen and $NH4^{+}$-nitrogen.
total nitrogen (TN)*	a measure of all organic and inorganic nitrogen forms in water.

total phosphorus (TP) * a measure of the total phosphorus in a water sample including organic and inorganic phosphorus in particulate and soluble forms.

trophic state the degree of biological productivity of a water body as it relates to the amount of algae, aquatic macrophytes, fish, and wildlife a water body can produce and sustain.

turbidity* a measurement of the dispersion of light in water from scattering and absorption, as determined by the frequency distribution of suspended particles

watershed land area from which water drains toward a common watercourse in a natural basin.

* denotes parameter utilized for lakes monitoring