FLORIDA DEPARTMENT OF ENVIRONMENTAL PROTECTION

Division of Environmental Assessment and Restoration, Bureau of Watershed Management

NORTHEAST DISTRICT • SUWANNEE BASIN • SANTA FE PLANNING UNIT

Final TMDL Report

Nutrient and Dissolved Oxygen TMDLs for Alligator Lake, WBID 3516A

Woo-Jun Kang, Ph.D.,
and
Douglas Gilbert

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Acknowledgments

This analysis could not have been accomplished without significant contributions from staff in the Florida Department of Environmental Protection's (Department) Watershed Assessment Section. The Department also recognizes the substantial support and assistance from its Northeast District Office, the Florida Automated Weather Network (FAWN) at the University of Florida, the Suwannee River Water Management District (SRWMD), and Columbia County, and their contributions of data, information, and assistance towards understanding the issues, history, and processes at work in the Alligator Lake watershed.

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For additional information on the watershed management approach and impaired waters in the Santa Fe Planning Unit of the Suwannee Basin, contact:

Terry Hansen
Florida Department of Environmental Protection
Bureau of Watershed Management
Watershed Planning and Coordination Section
2600 Blair Stone Road, Mail Station 3565
Tallahassee, FL 32399-2400
terry.hansen@dep.state.fl.us
Phone: (850) 245–8561
Fax: (850) 245–8434

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

Douglas Gilbert, Environmental Manager
Florida Department of Environmental Protection
Bureau of Watershed Management
Watershed Evaluation and TMDL Section
2600 Blair Stone Road, Mail Station 3555
Tallahassee, FL 32399-2400
douglas.gilbert@dep.state.fl.us
Phone: (850) 245–8450
Fax: (850) 245–8536

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Chapter 1: INTRODUCTION

1.1 Purpose of Report

This report presents the TMDLs for nutrients and dissolved oxygen (DO) for Alligator Lake, located in Columbia County, within the Suwannee Basin and the Santa Fe Planning Unit. Alligator Lake was verified as impaired by excessive nutrients and low DO using the methodology in the Identification of Impaired Surface Waters Rule (IWR) (Rule 62-303, Florida Administrative Code [F.A.C.]), and was included on the Verified List of impaired waters for the Suwannee Basin that was adopted by Secretarial Order on June 3, 2008. These TMDLs establish the allowable loadings to the lake that would restore the waterbody so that it meets its applicable water quality narrative criteria for nutrients and DO.

1.2 Identification of Waterbody

Alligator Lake (~center at Latitude 30° 09'59.37", Longitude 82°37'55.45") is located in central Columbia County, in the southern portion of Lake City, Florida.[1] It is the largest lake in Columbia County, with a drainage area of about 15.4 square miles (mi^2) (SRWMD, 1988). The lake consists of two unequal basins oriented in a north (larger basin) to south arrangement (**Figure 1.1**). While the average surface area of the lake has been reported as 338 acres (Bishop, 1967), this does not account for major areas of the "natural" lake that were historically diked, drained, and farmed. The agricultural activities within these diked areas resulted in the loss of about 500 acres of productive wetland and shallow lake bottom habitat. As part of the restoration of the lake, these areas are being restored.

The only major drainage feature is Price Creek, which drains much of the eastern portion of the lake watershed. Until recently, the majority of the flow from Price Creek had been diverted from the lake into an adjacent watershed (Clay Hole Creek). Currently, four 48-inch culverts have been installed in the dike/berm along the north side of Price Creek, redirecting more of the flow from the creek back into Alligator Lake. Additionally, two small, unnamed streams drain into the lake from the northern portion of the north watershed of the lake.

For assessment purposes, the Florida Department of Environmental Protection (Department) has divided the Suwannee Basin into water assessment polygons with a unique **w**ater**b**ody **id**entification (WBID) number for each waterbody segment or stream reach. Alligator Lake is WBID 3516A. The Alligator Lake WBID and its sampling/monitoring stations are within the Santa Fe Planning Unit, as illustrated in **Figure 1.1**.

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[1] Two reports prepared by Robert Mattson and published by the Suwannee River Water Management District (SRWMD) form the basis for this description of Alligator Lake. The reports are entitled *Biological Communities of Alligator Lake* (1993) and *Biological Characteristics of Alligator Lake* (2000).

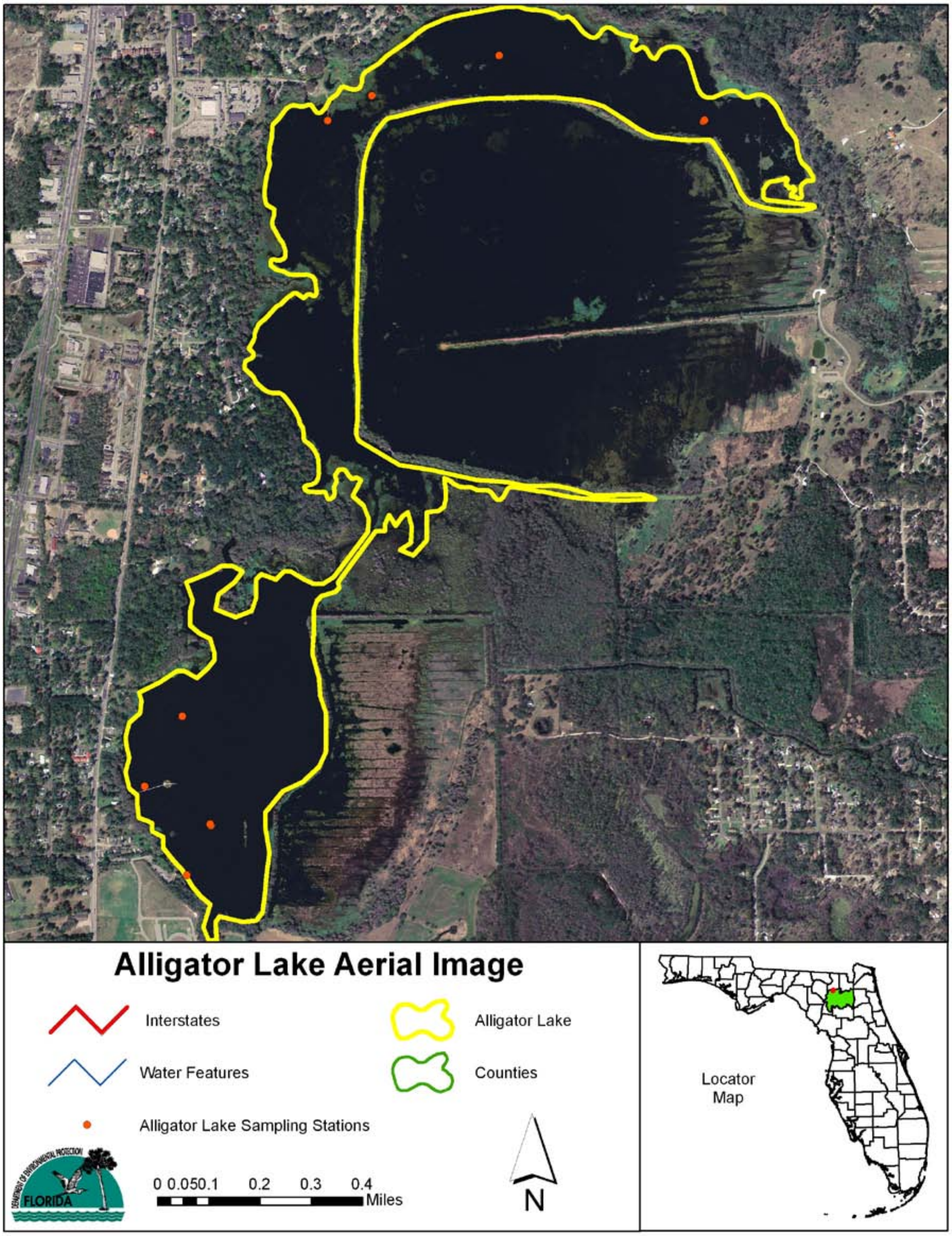


Figure 1.1. **Location of Alligator Lake WBID and Water Quality Sampling Stations Listed in the Florida STOrage and RETrieval (STORET) Database in the Santa Fe Planning Unit**

1.3 Alligator Lake Water Quality Trends

Figures 1.2 through **1.8** present long-term water quality data between 1965 and 2007, obtained from Florida STORET, and calculated Trophic State Index (TSI) values for Alligator Lake. **Figure 1.9** depicts the Alligator Lake watershed. Water quality stations and individual water quality measurements (raw data) used in this report for total nitrogen (TN) from 1967 through 2007, total phosphorus (TP) from 1968 through 2007, chlorophyll *a* (Chla) from 1980 through 2007, color from 1965 through 2007, and DO from 1967 through 2007 are available upon request. A total of seven water quality sampling stations are listed in Florida STORET. Regular recurring measurements for Chla, TN, TP, and DO were not made until 1989.

In general, the historical water quality trends for TN, TP, and Chla concentrations, as shown in **Figures 1.2, 1.3,** and **1.4,** indicate that in-lake concentrations slightly decreased over the period of record through 2005 (no Chla data were available until 1980), with an increase in concentration of all three constituents in 2006 and 2007.

Phaeophyton is a degradation product of chlorophyll that also absorbs light at the same wavelength, impeding the measurement of chlorophyll. Accurate lab analysis accounts for phaeophyton by subtracting it from the chlorophyll concentration. The result is referred to as corrected Chla. **Figure 1.4** shows both uncorrected Chla (containing phaeophyton) and corrected Chla (ChlaC). **Figure 1.5** depicts the TN to TP ratios. The mean TN/TP ratio from 1973 to 1999 (no paired TN and TP data were available until 1973) is 9.4, and for the verified period, from January 1, 2000 to June 30, 2007, it is 10.4.

These data indicate that the lake regularly alternates between nitrogen limitation and co-limitation. **Figure 1.6** depicts the relationship between Chla and the TN/TP ratio. It appears from this graph that the higher Chla concentrations are associated with periods when the TN/TP ratio is close to 10. The IWR methodology for calculating TSI requires at least one set of data for TN, TP, and Chla in each calendar quarter of a year. Chapters 2 and 3 provide the methodology and basis for calculating TSI.

Sufficient data exist to calculate TSIs for 1989 (86.3), 1990 (87.6), 1997 (67.1), 2000 (61.9), 2001 (63.9), 2002 (64.2), 2004 (67.0), 2005 (64.5), and 2006 (80.3). These TSI data (**Figure 1.7**) reflect the same trend as the TN, TP, and Chla data—that is, a general decline from 1989 to 2005, with an increase in 2006 (there were insufficient data to calculate the annual TSI for 2007).

Figure 1.8 depicts the data for DO. These indicate that while there are frequent periods when DO is less than the criterion of 5.0 milligrams per liter (mg/L), the majority of the data are above the criterion value. **Figure 1.9** shows the boundary of the watershed over an aerial photo of the area. The red lines internal to the watershed boundaries in **Figure 1.9** represent the outlines of the land uses in **Figure 4.2**.

Table 1.1 shows summary statistics of historical water quality variables observed from 1965 to 1999. Although the regular Chla data gathering did not begin until 1989, most of the other water quality variables were regularly collected beginning in the mid-1970s. During this period, the concentrations of Chla averaged 54.1 ± 18.0 micrograms per liter (μg/L) (n=136), TN averaged about 2.0 ± 0.19 mg/L (n=438), while concentrations of TP averaged 0.3 ± 0.03 mg/L (n=444).

In comparison, recent (2000–07) observations for water quality variables during the verified period are summarized in **Table 1.2**; concentrations of TN from 2000 to 2007 have increased to an average of 3.0 ± 1.82 mg/L (n=124). TP concentrations have remained about the same, exhibiting an average of 0.3 ± 0.13 mg/L (n=129). Chla concentrations have increased to an average of 69.4 ± 60.2 µg/L, associated with increased TN concentrations in the lake.

Concentrations in parentheses in **Table 1.2** represent values for the censored dataset used to develop the multi-variable regression equation discussed in Chapter 5. The verified period data were censored by removing the data collected on March 29, 2007. Using best professional judgment, these data were not considered representative of conditions in the lake. This data reduction was used to reduce the statistical noise in the long-term data. The censored dataset was used to create the graphs, to calculate the annual TSI values in the report, and to develop the regression equation for the TMDL.

Figure 1.8 shows that while DO values less than the 5 mg/L criterion have occurred throughout the period of record, the majority of the results are greater than the criterion. Over time, it appears that the average DO has been decreasing. This report will evaluate the relationship between the current nutrient loading from the watershed and the observed concentrations in the lake and propose the load reductions required for Alligator Lake to meet water quality standards.

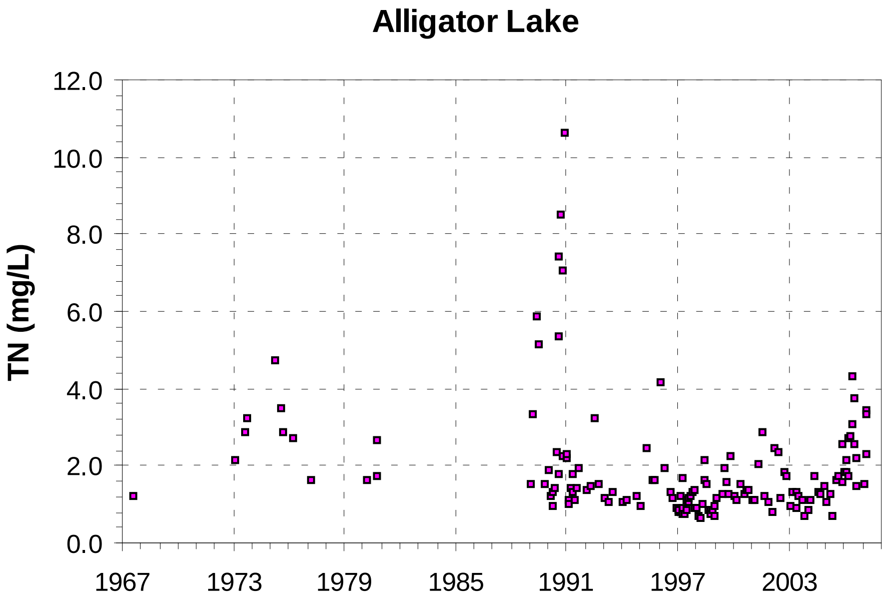
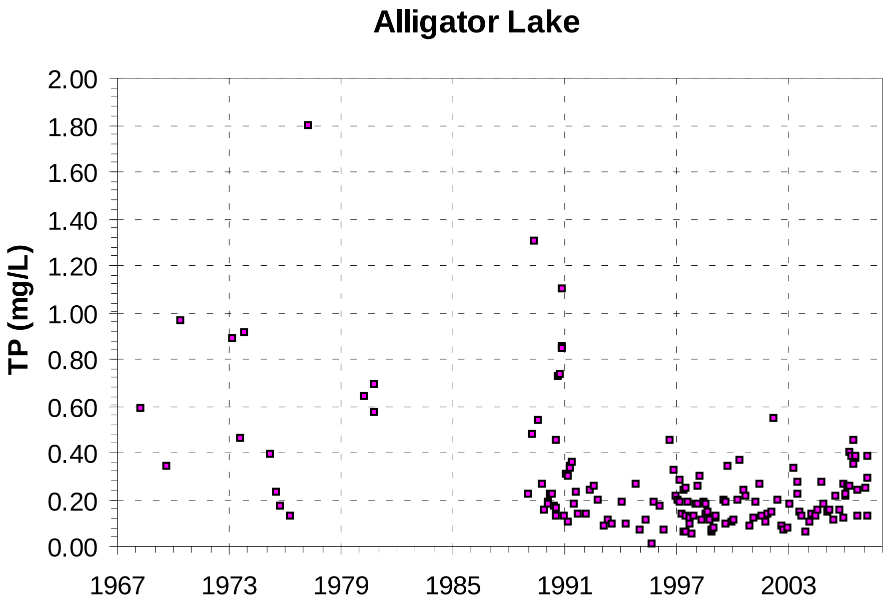


Figure 1.2. TN Concentrations Measured for Alligator Lake, 1967–2007



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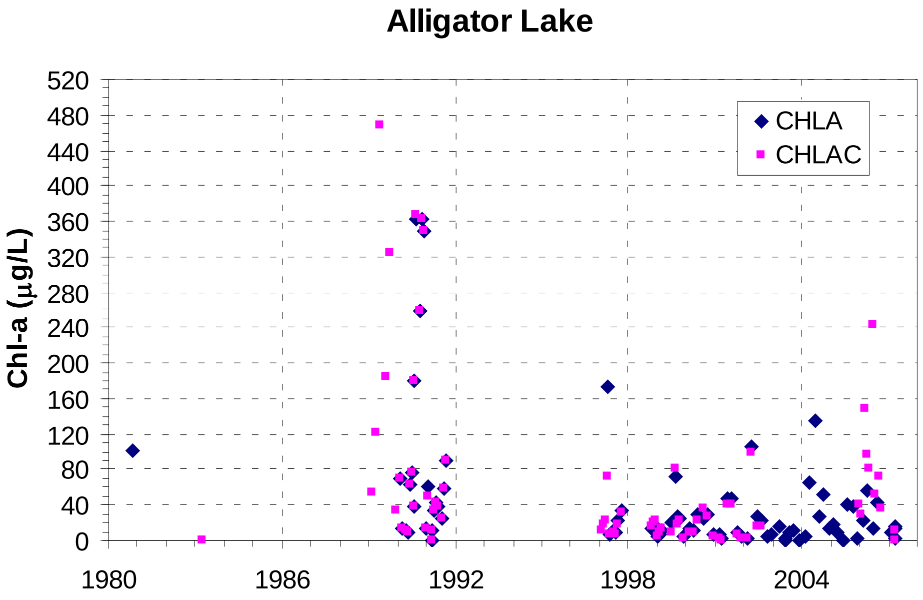
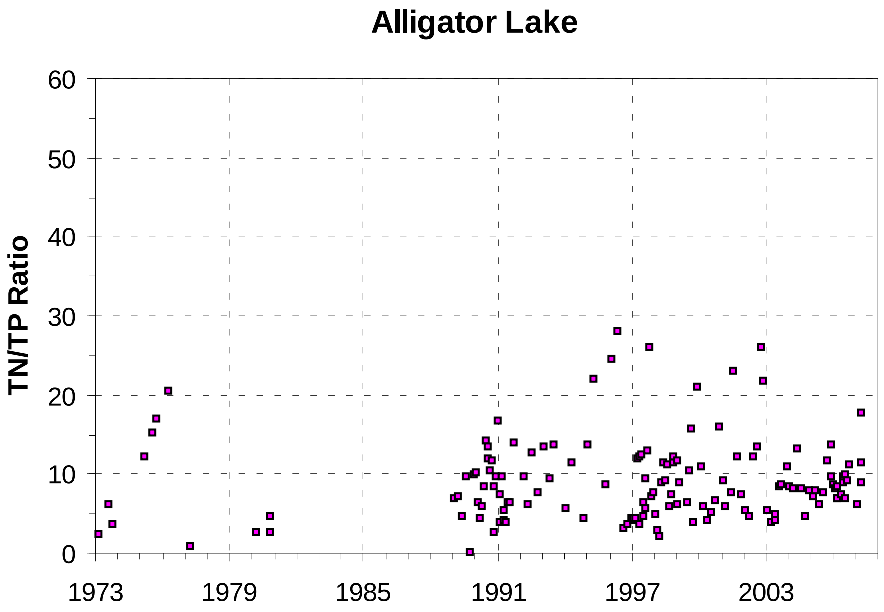


Figure 1.4. Corrected and Uncorrected Chla Concentrations Measured for Alligator Lake, 1980–2007



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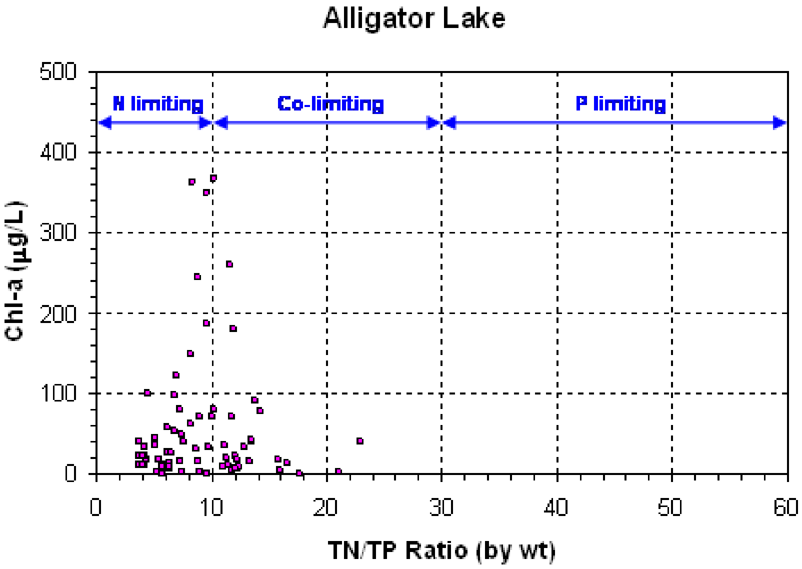
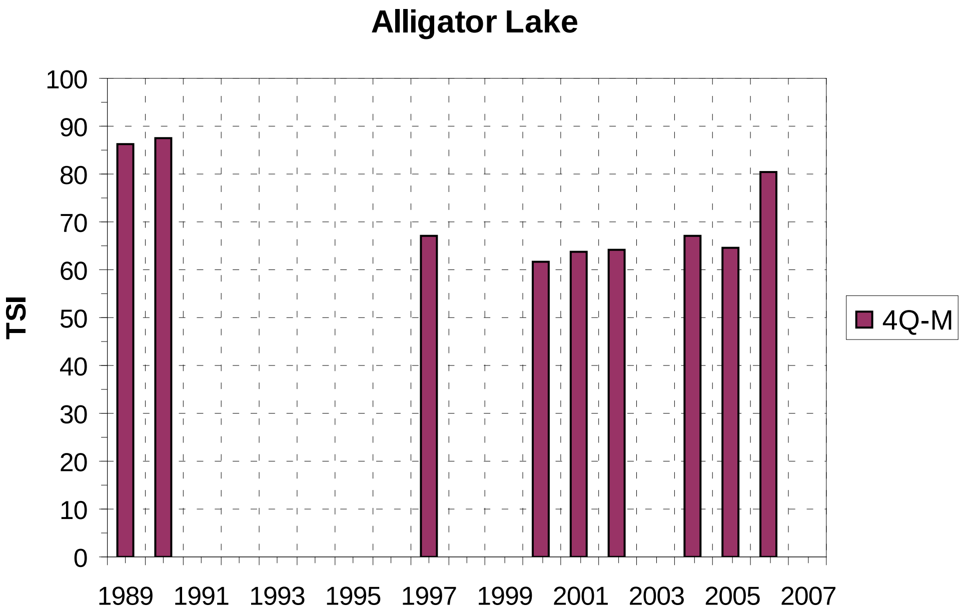


Figure 1.6. Relationship between Corrected Chla Concentration versus TN/TP Ratio Observed for Alligator Lake, 1973–2007



*4QM = TN, TP, and Chla data from all four calendar quarters were used in calculating the annual mean.

Figure 1.7. **Annual Mean TSIs for Alligator Lake, 1989–2007 (insufficient data for 1991, 1998, 1999, 2003, and 2007; no chla data for 1992–96)**

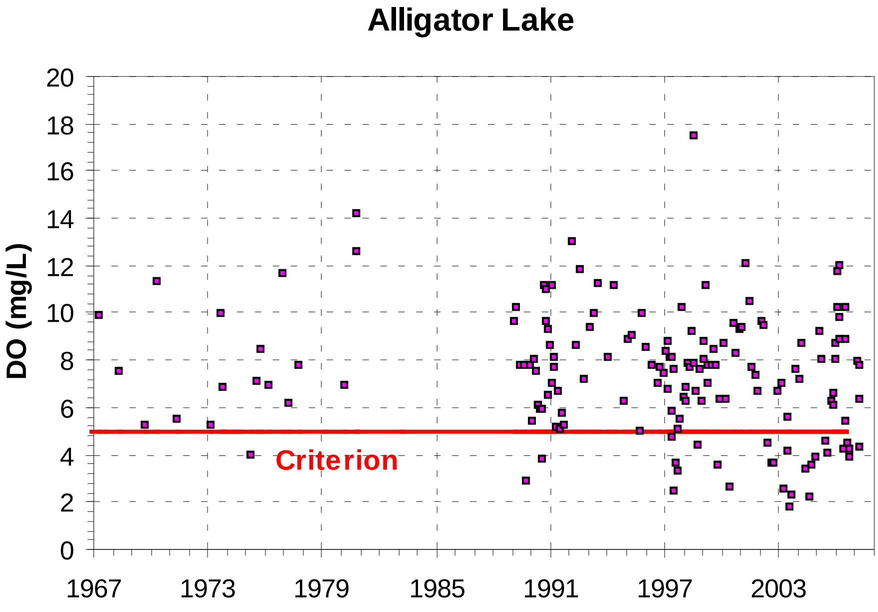


Figure 1.8. **Concentrations of DO Measured for Alligator Lake, 1967–2007**

Table 1.1. Summary Statistics for Water Quality Variables in Alligator Lake, 1965–99

Water Quality Variable	Unit	Number of Observations	Mean	Standard Deviation	Minimum	Maximum	Coefficient Variation
Chla	µg/L	136	54.1	107.1	1.0	699.0	2.0
TN	mg/L	438	2.0	2.1	0.5	19.0	1.2
TP	mg/L	444	0.3	0.3	0.0	2.1	1.1
DO	mg/L	494	7.3	3.2	0.1	31.2	0.4
BOD	mg/L	247	10.7	55.7	0.7	620.0	5.2
Color	Pt-Co	438	62.8	45	13.0	360.0	0.7
TN/TP Ratio	no unit	422	9.4	8.5	0.9	134.0	0.9

BOD – Biochemical oxygen demand.

Table 1.2. Summary Statistics of Water Quality Variables in Alligator Lake over the Verified Period (January 1, 2000, to June 30, 2007). Values in ( ) represent results with data from March 29, 2007 removed.

Water Quality Variable	Unit	Number of Observations	Mean	Standard Deviation	Minimum	Maximum	Coefficient Variation
Chla	µg/L	101 (98)	69.4 (26.4)	308.6 (43.5)	1.0 (1.0)	2,400.0 (260)	4.4 (1.6)
TN	mg/L	124 (121)	3.0 (1.8)	10.3 (0.9)	0.4 (0.4)	110.0 (4.6)	3.5 (0.5)
TP	mg/L	129 (126)	0.3 (0.2)	0.8 (0.1)	0.01 (0.01)	8.3 (0.7)	2.5 (0.6)
DO	mg/L	141	6.7	3.3	0.2	13.9	0.5
BOD	mg/L	29 (26)	12.0 (9.8)	10.1 (4.8)	4.3 (4.3)	45.0 (23)	0.8 (0.5)
Color	Pt-Co	129	78.4	57.9	15.0	300.0	0.7
TN/TP Ratio	no unit	125	10.4	14.6	2.6	165.0	1.4

1.4 Alligator Lake Background Information

Alligator Lake is located along the Cody Scarp within the Hawthorne Formation, and is thought to have formed through the dissolution and collapse of the underlying limestone giving rise to the northern and southern lake basins (Meyer, 1962; Hunn and Slack, 1983). There are two primary sinkholes, one in each lake basin. These sinkhole features open during periods of low ground water levels, allowing water in the lake to drain into the Floridan aquifer. Additionally, there are depressions in the lake bottom along the west shore.

Most of the lake's 15.4-mi^2 watershed lies within the Northern Highlands physiographic province (Meyer, 1962). The drainage area comprises primarily sandy soils in the Blanton, Surrency, and Plummer series (Soil Conservation Service [SCS], 1984). The Alligator Lake watershed is part of the Northern Peninsula Karst Plain lake ecoregion (Griffith et al., 1997). Griffith (1997) and Canfield (1981) characterize lakes within this ecoregion as slightly acidic, with low to moderate alkalinity, moderately colored, and generally with high nutrient levels.

As reported by the SRWMD (2000), the lake stage varies widely. The median lake stage is approximately 96 feet mean sea level (MSL) (this excludes intervals when the lake drained through the sinkholes). The maximum lake stages are usually recorded during the winter months, which are associated with colder temperatures, reduced evapotranspiration, and the passage of temperate cold fronts from the north, with seasonally greater rainfall. Large storm events can periodically produce high lake stages in the fall.

In addition to the alterations discussed above the (diking/farming/diversion of Price Creek), the lake has been impacted by other human activities. As depicted in **Figure 4.1** and tabulated in **Table 4.2**, a large portion of the watershed adjacent to the lake has been developed as residential subdivisions. Additionally, the lake has historically received direct discharge of wastewater effluent from the Lake City Wastewater Treatment Facility and two mobile home parks. The direct discharge from the city was terminated in 1987, and the mobile home parks all currently use rapid infiltration basins.

The most developed area of Lake City was built prior to statewide stormwater regulations, during a time when diverting runoff directly to the local lake was an acceptable practice. As a result, the lake also receives large amounts of urban stormwater runoff. As a result of these physical alterations to the lake and its watershed, in combination with the land use activities described above, the lake was classified as one of the 50 worst lakes in the state for water quality (Myers and Edmiston, 1983).

It is reported (SRWMD, 2000) that at average lake stage, the majority of the lake (68 percent) is less than 6 feet deep, with depths in the sink features running 10 to 18 feet. The generally shallow nature of the lake limits opportunities for thermal stratification, and may place the majority of the water column in the euphotic zone, which taken together may allow for heightened biological production (Wetzel, 1975). The shallow depths also provide conditions supporting the extensive aquatic macrophyte growth often recorded in the lake. The SRWMD (2000) cites Moss et al. (1996) as noting “that nutrient-rich, shallow lakes such as Alligator Lake may alternate between two ’alternative stable states’: a phytoplankton bloom–dominated system or a macrophyte-dominated system. Over the past 10 years, the lake has appeared to alternate between these two states, depending upon antecedent conditions and management activities.”

SRWMD sampling of the phytoplankton communities has revealed that both the north and south lake basins have similar species richness (157 and 146 taxa, respectively), with both areas dominated by blue-green and green algae (total taxa richness and abundance). The data reviewed by SRWMD (2000) indicates that the northern lake basin may have higher organic material and nutrient levels than the southern lake basin. The southern basin had higher median algal abundance, suggesting more persistent or more frequent occurrences of algal blooms, versus a more variable phytoplankton population in the northern basin. The SRWMD (2000) concluded that both lake basins were dominated by blue-green and green algae and that phytoplankton communities in the lake are representative of a eutrophic, hardwater lake, dominated by blue-green and green algae, and subjected to periodic blooms of N-fixing blue-greens such as *Anabaena* spp.

The SRWMD (2000) reports that sediments in both lake basins (one station in each basin) are composed of coarse and medium sands, with a mean sediment organic content of the northern basin of 20.1 percent, and 25.1 percent for the southern basin.

1.5 TMDL Background Information

The TMDL report for Alligator Lake is part of the implementation of the Department's watershed management approach for restoring and protecting water resources and addressing Total Maximum Daily Load (TMDL) Program requirements. The watershed approach, which is implemented using a cyclical management process that rotates through the state's 52 river basins over a 5-year cycle, provides a framework for implementing the requirements of the 1972 federal Clean Water Act and the 1999 Florida Watershed Restoration Act (FWRA) (Chapter 99-223, Laws of Florida). A TMDL represents the maximum amount of a given pollutant that a waterbody can assimilate and still meet the waterbody's designated uses. A waterbody that does not meet its designated uses is defined as impaired. TMDLs must be developed and implemented for each of the state's impaired waters, unless the impairment is documented to be a naturally occurring condition that cannot be abated by a TMDL or unless a management plan already in place is expected to correct the problem.

The development and implementation of a Basin Management Action Plan, or BMAP, to reduce the amount of pollutants that caused the impairment will follow this TMDL report. These activities will depend heavily on the active participation of Columbia County, the SRWMD, local governments, local businesses, and other stakeholders. The Department will work with these organizations and individuals to undertake or continue reductions in the discharge of pollutants and achieve the established TMDLs for the impaired lake.

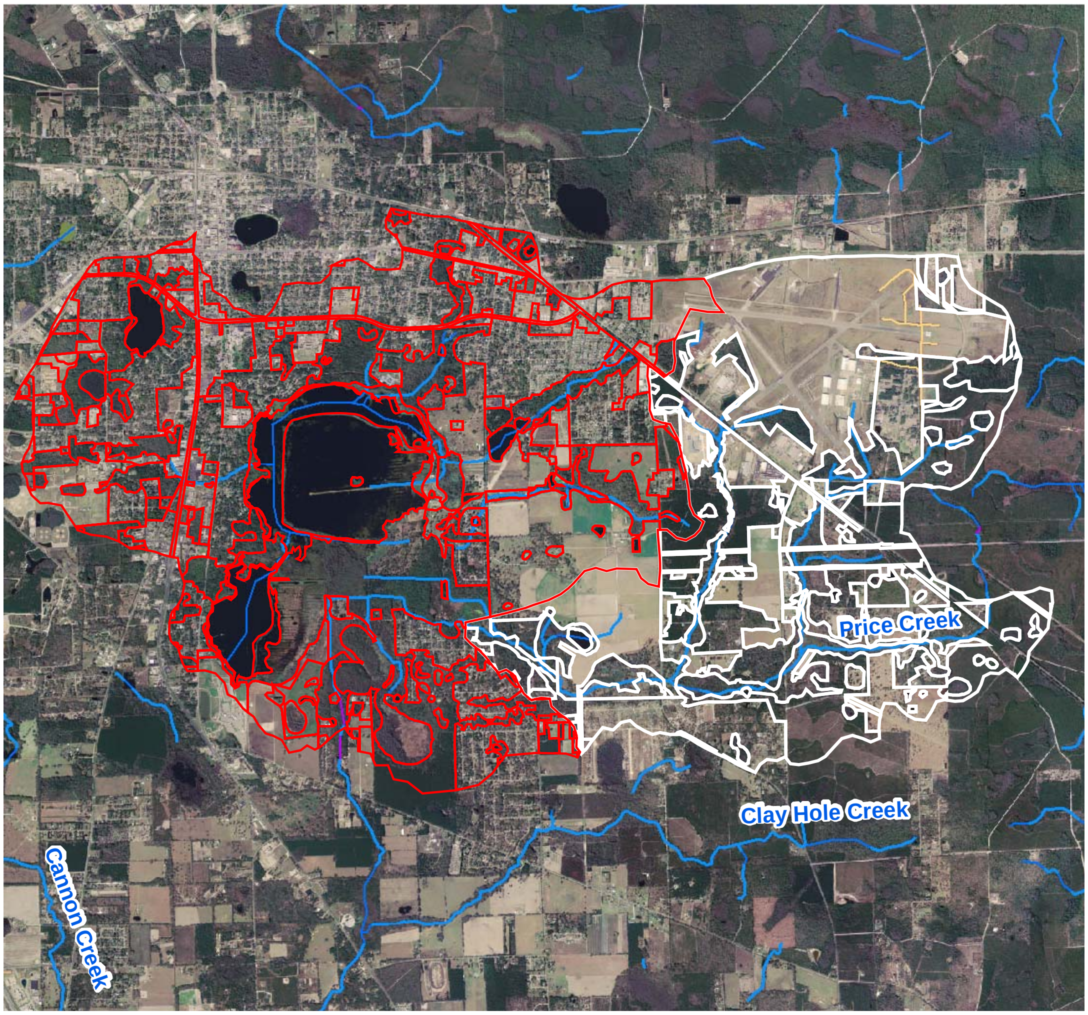


Figure 1.9. **Alligator Lake Watershed Boundary and Surrounding Areas**
Alligator Lake sub-basin on left (thin line in red), Price Creek sub-basin on right (thick white line)

Chapter 2: STATEMENT OF WATER QUALITY PROBLEM

2.1 Legislative and Rulemaking History

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

Alligator Lake is on Florida's 1998 303(d) list. However, the FWRA (Section 403.067, F.S.) stated that all previous Florida 303(d) lists were for planning purposes only and directed the Department to develop, and adopt by rule, a new science-based methodology to identify impaired waters. The Environmental Regulation Commission adopted the new methodology as Rule 62-303, F.A.C.) (IWR) in April 2001; the rule was amended in 2006 and 2007.

2.2 Information on Verified Impairments

2.2.1 Nutrients

The Department used the IWR to assess for water quality impairments in Alligator Lake. The lake was verified as impaired for nutrients based on an elevated annual average TSI value over the verified period (the planning period for the Group 1 basins is January 1, 1995, to June 30, 2004, and the verified period is January 1, 2000, to June 30, 2007). The IWR methodology uses the water quality variables TN, TP, and Chla (a measure of algal mass, corrected and uncorrected) in calculating annual TSI values and in interpreting Florida's narrative nutrient threshold. According to the IWR (Rule 62-303.352, F.A.C.), exceeding a TSI of 60 in any one year of the verified period is sufficient in determining nutrient impairment for a lake with color greater than 40. For Alligator Lake, water quality data obtained by IWR Run31_1 and summarized in **Table 2.1** indicated that the mean color for the verified period was 78.4 platinum cobalt units (Pt-Co) (n=129), resulting in a TSI of 60 for the threshold of lake nutrient impairment.

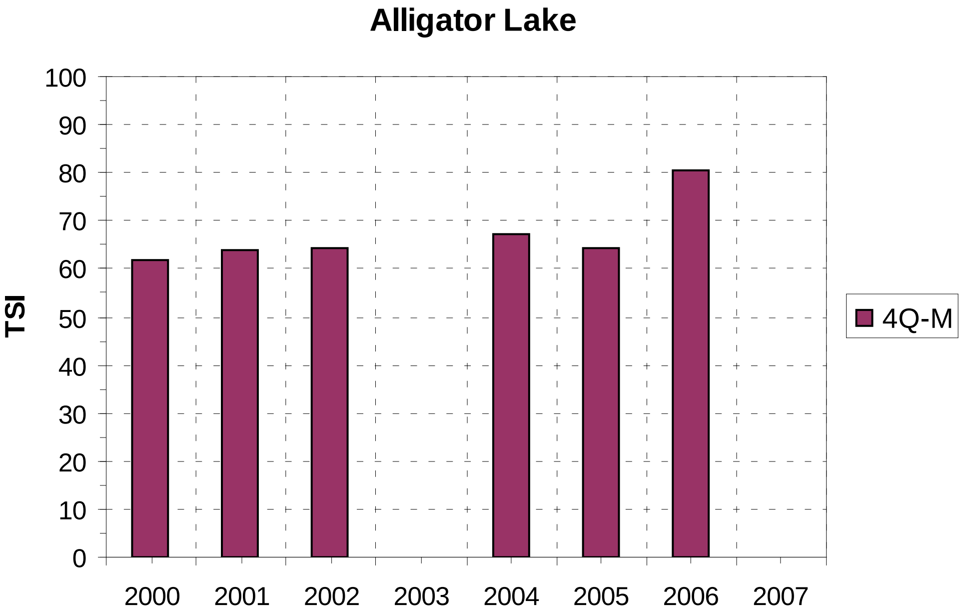
To calculate the TSI for a given year under the IWR, there must be at least one sample of TN, TP, and Chla taken within the same quarter (each season) of the year. The absence of data for at least one of the four seasons for a year will cause the elimination of the year from the analysis of TSI. As seen in **Figure 2.1**, the TSIs in Alligator Lake exceeded the threshold of 60 in each year of the verified period for which a TSI could be calculated (2000 [61.9], 2001 [63.9], 2002 [64.2], 2004 [67.0], 2005 [64.5], and 2006 [80.3]). Exceeding the threshold of 60 in any year of the verified period would result in the lake being placed on the Verified List of impaired waters. Alligator Lake exceeded this threshold value in six of the seven years (insufficient data were available to calculate a TSI for 2003). It should be noted that the last year of the verified period is not a complete year.

The TSI is calculated based on concentrations of TP, TN, and Chla, as follows:

$CHLA_{TSI} = 16.8 + 14.4 * LN(Chl\ a)$ Chla in μg/L
$TN_{TSI} = 56 + 19.8 * LN(N)$ N in mg/L
$TN2_{TSI} = 10 * [5.96 + 2.15 * LN(N + 0.0001)]$
$TP_{TSI} = 18.6 * LN(P * 1000) - 18.4$ P in mg/L
$TP2_{TSI} = 10 * [2.36 * LN(P * 1000) - 2.38]$

If $N/P > 30$, *then* $NUTR_{TSI} = TP2_{TSI}$
If $N/P < 10$, *then* $NUTR_{TSI} = TN2_{TSI}$
if $10 < N/P < 30$, *then* $NUTR_{TSI} = (TP_{TSI} + TN_{TSI})/2$

$TSI = (CHLA_{TSI} + NUTR_{TSI})/2$ (TSI has no units)



4QM = TN, TP, and Chla data from all four calendar quarters used in calculating the annual mean.

Figure 2.1. Annual Mean TSIs for Alligator Lake, 2000–07 (insufficient data for 2003 and 2007)

2.2.2 Dissolved Oxygen

The Department used the IWR to assess water quality impairments in Alligator Lake (WBID 3516A) and verified the impairment for low DO, with nutrients as the causative pollutant. Data in **Table 2.1** provide the median values as opposed to data summarized in **Table 1.2**, which represent the mean values. The summary of DO and potential causative pollutant concentrations for sampling during the verified period is shown in **Table 2.1**. Using the IWR methodology, given 123 sampling events there would need to be at least 18 exceedances for a waterbody to be considered impaired. DO exceeded the criterion for 37 out of 123 sampling events. Based on these data and the requirements of the IWR, Alligator Lake was listed as impaired for DO.

Table 2.1. Summary of DO, BOD, TP, and TN Exceedances During the Verified Period (2000–07) for Alligator Lake in the IWR Database

Parameter of Concern	Number of Samples	IWR-required Exceedances (for impairment)	Actual Number of Exceedances	Median
DO (mg/L) (IWR Run 33_1)	123	18	37	6.7*
BOD (mg/L)	29	*	*	9.1
TP (mg/L)	129	*	*	0.2
TN (mg/L)	124	*	*	1.5

* = Not applicable.

Chapter 3. DESCRIPTION OF APPLICABLE WATER QUALITY STANDARDS AND TARGETS

3.1 Classification of the Waterbody and Criteria Applicable to the TMDL

Florida's surface water is protected for five designated use classifications, as follows:

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

Alligator Lake is classified as a Class III freshwater waterbody, with a designated use of recreation, propagation, and the maintenance of a healthy, well-balanced population of fish and wildlife. The Class III water quality criteria applicable to the observed impairments (nutrients and DO) for Alligator Lake is the state of Florida's narrative nutrient criterion (Rule 62-302.530[48] [b], F.A.C.) and the DO criterion (Rule 62-302.530[30], F.A.C.).

3.2 Interpretation of the Narrative Nutrient Criterion for Lakes

To place a waterbody segment on the Verified List for nutrients, the Department must identify the limiting nutrient or nutrients causing impairment, as required by the IWR. The following method is used to identify the limiting nutrient(s) in streams and lakes.

The individual ratios over the entire verified period (i.e., January 1, 2000, to June 30, 2007) are evaluated to determine the limiting nutrient(s). If all the sampling event ratios are less than 10, nitrogen is identified as the limiting nutrient, and if all the ratios are greater than 30, phosphorus is identified as the limiting nutrient. Both nitrogen and phosphorus are identified as limiting nutrients if the ratios are between 10 and 30.

For Alligator Lake, the median TN/TP ratio during the verified period was 8.3, indicating TN limitation for the lake. It should be noted that about half the time the TN/TP ratio is less than 10 and half the time the ratio is between 10 and 30. It appears that the lake is flipping between nitrogen limitation and co-limitation.

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

The TSI originally developed by Carlson (1977) was calculated based on Secchi depth, chlorophyll concentration, and TP concentration, and was used to describe a lake's trophic state. Carlson's TSI was developed based on the assumption that the lakes were all phosphorus limited. In Florida, because the local geology produces a phosphorus-rich soil, nitrogen can be the sole or co-limiting factor for phytoplankton population in some lakes. In addition, because of the existence of higher color lakes in the state, using Secchi depth as an index to represent lake trophic state can produce misleading results.

Therefore, the TSI was revised to be based on TN, TP, and Chla concentrations. This revised calculation for TSI now contains values for TN-TSI, TP-TSI, and Chla-TSI. As a result, there are three different ways of calculating a final in-lake TSI. If the TN to TP ratio is equal to or greater than 30, the lake is considered phosphorus limited and the final TSI is the average of the TP-TSI and the Chla-TSI. If the TN to TP ratio is 10 or less, the lake is considered nitrogen limited and the final TSI is the average of the TN-TSI and the Chla-TSI. If the TN to TP ratio is between 10 and 30, the lake is considered co-limited, and the final TSI is the result of averaging the Chla-TSI with the average of the TN- and TP-TSIs.

The Florida-specific TSI was determined based on the analysis of data from 313 Florida lakes. The index was adjusted so that a Chla concentration of 20 μg/L was equal to a Chla-TSI value of 60. The final TSI for any lake may be higher or lower than 60 depending on the TN-TSI and TP-TSI values. A TSI of 60 was then set as the threshold for nutrient impairment for most lakes (for those with a color higher than 40 Pt-Co) because, generally, phytoplankton may switch to communities dominated by blue-green algae at Chla levels above 20 μg/L. These blue-green algae are often an unfavorable food source for zooplankton and many other aquatic animals. Some blue-green algae may even produce toxins, which could be harmful to fish and other animals. In addition, the excessive growth of phytoplankton and the subsequent death of these algae may consume large quantities of DO and result in anaerobic conditions in lakes, making conditions unfavorable for fish and other wildlife. All of these processes may negatively impact the health and balance of native fauna and flora.

Because of the amazing diversity and productivity of Florida lakes, some lakes have a natural background TSI that is different from 60. In recognition of this natural variation, the IWR allows for the use of a lower TSI (40) in very clear lakes, a higher TSI if paleolimnological data indicate the lake was naturally above 60, and the development of site-specific thresholds that better represent the levels at which nutrient impairment occurs.

For the Alligator Lake TMDL, the Department applied the Watershed Management Model (WMM) to simulate runoff, TN, and TP loadings to the lake. A regression model was developed from in-lake concentrations of TN, TP, and Chla to represent the eutrophication processes in the lake and to determine the appropriate nutrient target. Background was established by setting land uses to natural or forested land. The WMM was used to estimate existing and background loadings to the lake from the watershed. It is the Department's practice, once the background TSI has been determined, to establish the target for TMDL development as an increase of 5 TSI units above the background TSI.

3.3 Narrative Nutrient Criteria Definitions

3.3.1 Chlorophyll a

Chlorophyll, a green pigment found in plants, is an essential component in the process of converting light energy (sunlight) into chemical energy through the process of photosynthesis.

In photosynthesis, the energy absorbed by chlorophyll transforms carbon dioxide and water into carbohydrates and oxygen. The chemical energy stored by photosynthesis in carbohydrates drives biochemical reactions in nearly all living organisms. Thus, chlorophyll is at the center of the photosynthetic oxidation-reduction reaction between carbon dioxide and water.

There are several types of chlorophyll; however, the predominant form is chlorophyll *a* (Chla). The measurement of Chla in a water sample is a useful indicator of phytoplankton biomass, especially when used in conjunction with an analysis of algal growth potential and species abundance. The greater the abundance of Chla, typically the greater the abundance of algae. Algae are the primary producers in the aquatic food web, and thus are very important in characterizing the productivity of lakes and streams. As noted earlier, Chla measurements are also used to estimate the trophic conditions of lakes and lentic waters.

3.3.2 Nitrogen Total as N

TN is the combined measurement of nitrate (NO3), nitrite (NO2), ammonia, and organic nitrogen found in water. Nitrogen compounds function as important nutrients for many aquatic organisms and are essential to the chemical processes that exist between land, air, and water. The most readily bioavailable forms of nitrogen are ammonia and nitrate. These compounds, in conjunction with other nutrients, serve as an important base for primary productivity.

The major sources of excessive amounts of nitrogen in surface water are the effluent from municipal treatment plants and runoff from urban and agricultural sites. When nutrient concentrations consistently exceed natural levels, the resulting nutrient imbalance can cause undesirable changes in a waterbody’s biological community and drive an aquatic system into an accelerated rate of eutrophication. Usually, the eutrophication process is observed as a change in the structure of the algal community and includes severe algal blooms that may cover large areas for extended periods. Large algal blooms are generally followed by depletion in DO concentrations as a result of algal decomposition.

3.3.3 Phosphorus Total as P

Phosphorus is one of the primary nutrients that regulates algal and macrophyte growth in natural waters, particularly in fresh water. Phosphate, the form in which almost all phosphorus is found in the water column, can enter the aquatic environment in a number of ways. Natural processes transport phosphate to water through atmospheric deposition, ground water percolation, and terrestrial runoff. Municipal treatment plants, industries, agriculture, and domestic activities also contribute to phosphate loading through direct discharge and natural transport mechanisms. The very high levels of phosphorus in some Florida streams and estuaries are usually caused by phosphate mining and fertilizer processing activities.

High phosphorus concentrations are frequently responsible for accelerating the process of eutrophication, or accelerated aging, of a waterbody. Once phosphorus and other important nutrients enter the ecosystem, they are extremely difficult to remove. They become tied up in biomass or deposited in sediments. Nutrients, particularly phosphates, deposited in sediments generally are redistributed to the water column. This type of cycling compounds the difficulty of halting the eutrophication process.

3.4 Dissolved Oxygen

Florida’s DO criterion for Class I and III freshwater bodies states that DO “shall not be less than 5.0 mg/L, and the normal daily and seasonal fluctuations above this levels shall be maintained.”

However, DO concentrations in ambient waters can be controlled by many factors, including DO solubility, which is controlled by temperature and salinity; DO enrichment processes influenced by reaeration, which is controlled by flow velocity; the photosynthesis of phytoplankton, periphyton, and other aquatic plants; DO consumption from the decomposition of organic materials in the water column and sediment and oxidation of some reductants such as ammonia and metals; and respiration by aquatic organisms.

Alligator Lake has a variable color ranging between 13 and 360 Pt-Co(1965–2007), with an average value of 66.4. The DO concentration in some seasons could be naturally low because of the high bacteria respiration supported by a large and constant supply of dissolved organic carbon (DOC) originating from the wetland areas that discharge into the lake. Although the major portion of the DOC pool is usually recalcitrant to most bacteria species, some bacteria species adapted to living in blackwater systems can readily use this DOC pool to support their growth.

Bacteria activities can be significantly stimulated if nitrogen and phosphorus are added into the system because they provide bacteria with nutrients. The further stimulation of bacteria activities can be observed if DOCs of human origin (usually represented with BOD) are added to the system. Human DOCs are usually easy to decompose and can be readily used by bacteria. These DOCs not only can enhance the metabolic activities of bacteria species that use recalcitrant DOCs, but also provide the carbon source to those bacteria species that cannot use recalcitrant DOCs. Therefore, the input of human sources of DOC into a blackwater system should be properly controlled to improve the DO condition in these waters.

Another source of DO consumption may originate from the organic materials accumulated in the lake over time. Due to the limited amount of time available for this analysis, factors that control DO concentration in the lake were not examined by measuring the actual DO consumption rate from each source. Instead, TN, TP, Chla, and BOD concentrations were treated as the focus of this analysis.

Chapter 4: ASSESSMENT OF SOURCES

4.1 Overview of Modeling Process

A watershed is the land area that catches rainfall and eventually drains or seeps into a receiving waterbody such as a stream, lake, or ground water (EPA, 1997). A watershed is often referred to as a drainage basin, and the boundaries between watersheds can be determined by ridges of higher ground based on topographic elevations. The watershed, where appropriate, can be further divided into subwatersheds by drainage area for watershed modeling purposes.

Land use pollution loading models have been often used to assess watershed impacts on the water quality of a receiving waterbody when data limitations and time constraints preclude the use of a complex watershed model. Such a simple model would be beneficial for estimating nutrient loads from potential sources in the watershed to predict algal responses in the receiving waterbody, where the time scale of actual biological responses to nutrient loading from the watershed is at least equal to or less than that of the model prediction (EPA, 1997).

The WMM, developed by Camp Dresser and McKee (CDM) for the Department, is a land use pollution loading model used to estimate annual or seasonal pollutant loading from pollution sources (i.e., nonpoint and point source) in a watershed or a sub-basin (CDM, November 1998). The loading estimation using the WMM can be executed based on event mean concentrations (EMCs) of pollutants, land use, percent imperviousness, and annual rainfall. The model also can address watershed management needs for identified nonpoint source pollution as a part of Best Management Practices (BMPs). However, the accuracy of estimated pollution loads can be limited when default values for EMCs, percent imperviousness, and runoff coefficients for each land use are used instead of values derived from site-specific data (EPA, 1997).

The WMM estimates annual pollution loads for each land use based on EMCs for different pollutants and average annual surface runoff from land use. **Table 4.1** lists the EMCs used for this analysis. The pollution loading (M_L in the unit of pounds per acre per year [lbs/ac/yr]) is then computed for each land use by the following equation:

$$\textbf{(1)} \qquad M_L = EMC_L * R_L * K$$

Where:

M_L = loading factor for land use L (lbs/ac/yr);
EMC_L = EMC of runoff from land use L (mg/L); EMC varies by land use and pollutant;
R_L = total average annual surface runoff from land use L (inches per year [in/yr]); and
K = 0.2266, a unit conversion constant.

Annual runoff volumes for each sub-basin can be estimated from constructing site-specific rainfall and runoff relationships. These relationships may vary depending on rainfall intensity and duration, sub-basin characteristics (e.g., soil type, size, vegetation, and slope), percent imperviousness, and antecedent moisture conditions (Brezonik and Stadelmann, 2002). Without site-specific data for these variables, total average annual surface runoff from each land use type can be estimated as follows (CDM, November 1998):

$$\textbf{(2)} \qquad R_L = [C_p + (C_I - C_p)\, IMP_L] * I$$

Where:

R_L = total average annual surface runoff from land use L (in/yr);
IMP_L = fractional imperviousness of land use L;
I = long-term average annual precipitation (in/yr);
C_P and C_I = runoff coefficients for pervious area and impervious area, respectively.

The percent imperviousness for each land use category can be determined using 1-inch-per-200-feet enlargements of U.S. Geological Survey (USGS) Digital Orthophoto Quarter Quadrangle (DOQQ) aerial photographs. Literature values for the impervious area can be used when specific data are limited. In general, pervious areas are dominant for rural and agricultural land uses compared with urban settings, producing reduction of runoff volume.

Additionally, **Table 4.1** shows the relationship between the TN/TP ratio in runoff (EMCs) from various land uses. From these data, it appears that the loadings from residential, commercial and services, cropland and pasture, and transportation land uses are contributing to nitrogen limitation, while loads from tree crops/citrus, rangeland, upland forest/rural open, water, and wetland land uses are contributing to co-limitation.

Table 4.2 contains the percent imperviousness used (as directly connected impervious area [DCIA]) for each land use in the model and runoff coefficients, respectively. Runoff coefficients (**Table 4.3**) are important parameters to estimate runoff volume. Typically, a runoff coefficient of 0.20 can be used for pervious areas, whereas a coefficient of 0.90 is for impervious areas (CDM, November 1998). For use in the Alligator Lake watershed, the governing equations from WMM were incorporated into an Excel spreadsheet. To model the Price Creek sub-basin, runoff coefficients were first adjusted to calibrate to the measured annual flow of Price Creek. Then the calibrated coefficients were applied to the entire Alligator Lake watershed.

Table 4.1. WMM EMC Input Parameters

Land Use Category	TN (mg/L)	TP (mg/L)	TN/TP
Low-density Residential	1.61	0.191	8.4
Medium-density Residential	2.07	0.327	6.3
High-density Residential	2.32	0.520	4.5
Commercial and Services	1.18	0.179	6.6
Cropland and Pastureland	3.06	0.604	5.1
Tree Crops/Citrus	2.24	0.183	12.2
Rangeland	1.15	0.055	20.9
Upland Forests/Rural Open	1.15	0.055	20.9
Water	1.60	0.067	23.9
Wetlands	1.01	0.090	11.2
Transportation	1.64	0.220	8.3

Notes:
Values for the EMCs are obtained from Table 4-17 (Harper and Baker, 2007). Cropland/pastureland EMCs are the average of pasture and cropland. Water and wetland EMCs are from Harper and Baker (2003).

Table 4.2. Percentage of DCIA Used in the WMM

Florida Land Use, Cover and Forms Classification System (FLUCCs) Code	Land Use Category	Alligator Sub-Basin (acres)	Price Creek Sub-Basin (acres)	% DCIA
1100	Low-density residential	147.2	166.7	14.7%[1]
1200	Medium-density residential	1417.8	250.2	18.7%[2]
1300	High-density residential	100.4	11.6	29.6%[2]
1400	Commercial and Services	680.9	257.8	44.38%[3]
2100	Cropland and Pastureland	707.0	542.4	0.0%[1]
2200	Tree Crops/Citrus	8.0	0.0	0.0%[1]
3000	Rangeland	123.3	105.0	0.5%[1]
4000	Upland Forests/Rural Open	901.1	1,290.9	0.5%[1]
5000	Water	463.6	19.3	30.0%[4]
6000	Wetlands	898.1	395.5	30.0%[4]
8200	Transportation	194.4	973.1	36.2%[2]

[1] Percent DCIA referred to Harper and Baker (2003).

[2] Percent DCIA referred to Brown (1995).

[3] Percent DCIA referred to CDM (November 1998).

[4] Percent DCIA referred to Harper and Livingston (1999).

Table 4.3. Runoff Coefficients by Year Used in the WMM

Year	Impervious*	Pervious*
2000	0.8	0.04
2001	0.8	0.02
2002	0.8	0.07
2003	0.99	0.37
2004	0.99	0.27
2005	0.99	0.27
2006	0.8	0.07
2007	0.8	0.04

*Runoff coefficients are a fractional percentage of 1.

4.2 Potential Sources of Nutrients in the Alligator Lake Watershed

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

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

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

4.2.1 Point Sources

There are no NPDES permitted wastewater treatment facilities or industrial wastewater facilities that discharge directly to Alligator Lake. The non-NPDES facilities listed in **Table 4.4** and depicted in **Figure 4.1** are within the Alligator Lake watershed, but were not included in the model as they do not discharge to surface water. The NPDES-permitted facility (Mead Westvaco) was not included in the model, as the permit is for the discharge from a ground water remediation site that is not expected to contribute nutrient loadings to the lake or otherwise lower DO in the lake.

Table 4.4. Federal NPDES and State Permitted Facilities

NPDES Permit ID	Facility Name	Receiving Water	Permitted Capacity (mgd)	Downstream Impaired WBID	Comments
FL0038300 (NPDES)	Mead Westvaco Corp.	Unnamed ditch to Alligator Creek to Alligator Lake	0.0482	3516A	May be ground water remediation site
FLA113956 (not NPDES)	Lake City WWTF	None	3.0	3516A	Holding pond to sprayfield
FLA011402 (not NPDES)	Eastside Village Mobile Home Park WWTF	None	0.025	3516A	Rapid infiltration basin
FLA011406 (not NPDES)	Pondview Mobile Home Park WWTF	None	0.009	3516A	Rapid infiltration basin
FLA011398 (not NPDES)	Paradise Village Mobile Home Park	None	0.0075	3516A	Rapid infiltration basin

mgd – Million gallons per day.

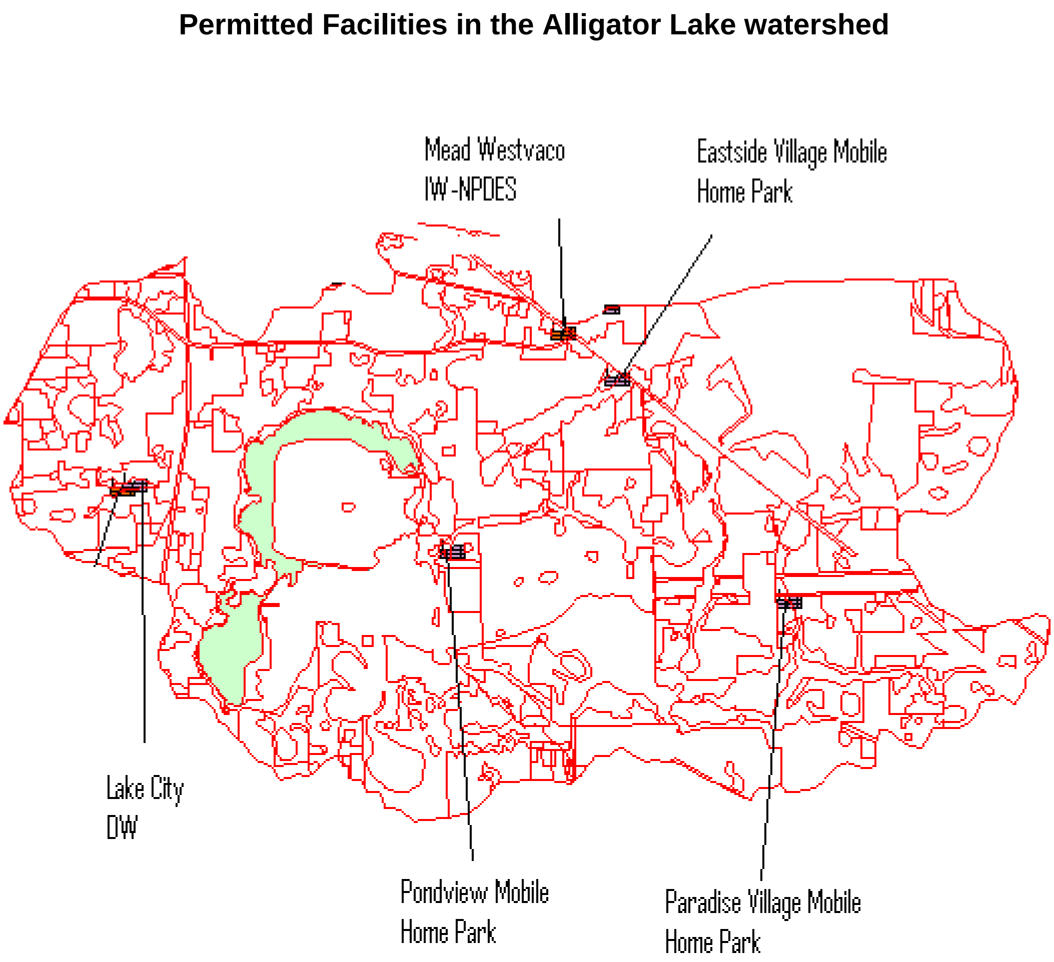


Figure 4.1. **Federal NPDES and State Permitted Facilities in the Alligator Lake Watershed**

Municipal Separate Storm Sewer System Permittees

Like other nonpoint sources of pollution, urban stormwater discharges are associated with land use and human activities, and are driven by rainfall and runoff processes leading to the intermittent discharge of pollutants in response to storms. The 1987 amendments to the Clean Water Act designated certain stormwater discharges from urbanized areas as point sources requiring NPDES stormwater permits. In October 2000, the EPA authorized the Department to implement the NPDES Stormwater Program in all areas of Florida except Indian tribal lands. The Department's authority to administer the NPDES Program is set forth in Section 403.0885, F.S. The three major components of the NPDES stormwater regulations are as follows:

- ***Municipal separate storm sewer system (MS4) permits*** *that are issued to entities that own and operate master stormwater systems, primarily local governments. Permittees are required to implement comprehensive* *stormwater management programs designed to reduce the discharge of pollutants from the MS4 to the maximum extent practicable.*

- ***Stormwater associated with industrial activities,*** *which is regulated primarily by a multisector general permit that covers various types of industrial facilities. Regulated industrial facilities must obtain NPDES stormwater permit coverage and implement appropriate pollution prevention techniques to reduce the contamination of stormwater.*

- ***Construction activity generic permits*** *for projects that ultimately disturb one or more acres of land and that require the implementation of stormwater pollution prevention plans to provide for erosion and sediment control during construction.*

In addition to the NPDES stormwater construction permitting regulations, Florida was the first state in the country to require the treatment of stormwater for all new developments with the adoption of the State Stormwater Rule in late 1981. The Stormwater Rule is a technology-based program that relies on the implementation of BMPs that are designed to achieve a specific level of treatment (i.e., performance standards), as set forth in Rule 62-40, F.A.C. In 1994, state legislation created the Environmental Resource Permitting Program to consolidate stormwater quantity, stormwater quality, and wetlands protection into a single permit. Currently, the majority of Environmental Resource Permits are issued by the state's water management districts, although the Department continues to do the permitting for specified projects.

The NPDES Stormwater Program was implemented in phases, with Phase I MS4 areas including municipalities having a population above 100,000. Because the master drainage systems of most local governments in Florida are interconnected, the EPA implemented Phase 1 of the MS4 permitting program on a countywide basis, which brings in all cities, Chapter 298 urban water control districts, and the Florida Department of Transportation (FDOT) throughout the 15 counties meeting the population criteria. Phase II of the NPDES Program was expanded in 2003 and requires stormwater permits for construction sites between 1 and 5 acres, local governments with as few as 10,000 people or that discharge into Class I or II waters, or Outstanding Florida Waters (OFWs).

Although MS4 discharges are technically referred to as "point sources" for the purpose of regulation, they are still diffuse sources of pollution that cannot be easily collected and treated by a central treatment facility. All Phase 1 MS4 permits issued in Florida include a reopener clause allowing permit revisions for implementing TMDLs once they are formally adopted by rule. Florida's Phase II MS4 Generic Permit has a "self-implementing" requirement once TMDLs are adopted that requires an MS4 permittee to update its stormwater management program as needed to meet its TMDL allocations. All future areas with populations meeting the MS4 requirements will be required to achieve the allocations presented in the TMDL. In addition, Florida may designate an area as a regulated Phase II MS4 in accordance with Rule 62-624.800, F.A.C.

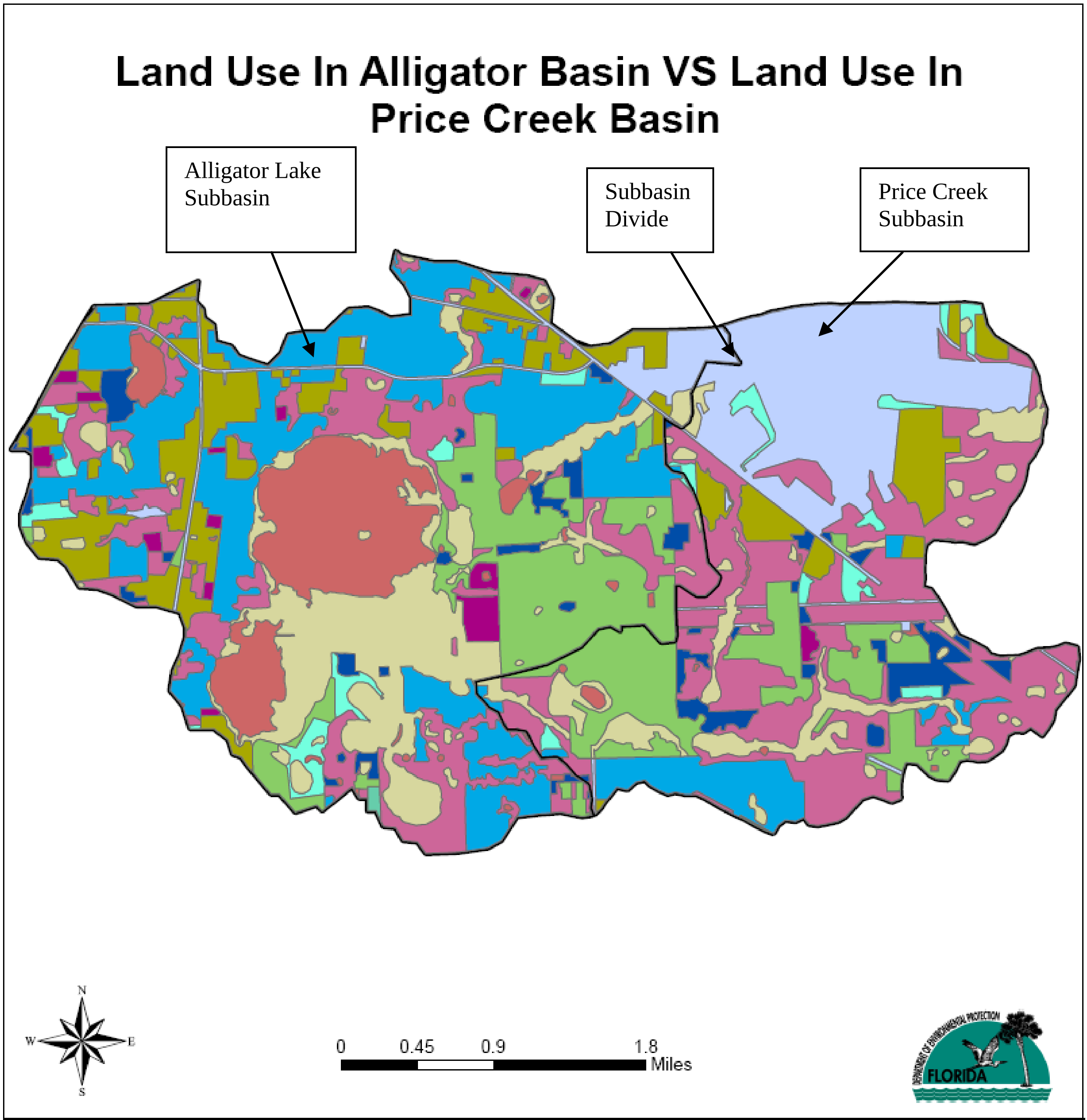
Based on information received from the EPA and FDOT, Columbia County and Lake City do not have MS4 permitted stormwater collection systems in the Alligator Lake watershed.

4.2.2 Nonpoint Sources and Land Uses

Unlike traditional point source effluent loads, nonpoint source loads enter at so many locations and exhibit such large temporal variation that a direct monitoring approach is often infeasible. For the Alligator Lake TMDL, all nonpoint sources were evaluated by the use of a watershed model and a regression model for the lake. Land use coverages for the watershed were aggregated using FLUCCS (1999) into 11 different land use categories: cropland/improved pasture, tree crops, unimproved pasture/rangeland, upland forests/rural open, commercial/industrial, transportation, high-density residential (HDR), low-density residential (LDR), medium-density residential (MDR), water, and wetlands. The spatial distribution and acreage of different land use categories for the WMM were identified using the 2004 land use coverage (scale 1:24,000) provided by the SRWMD.

Table 4.5 shows the existing area of the various land use categories in the Alligator Lake sub-basin, the Price Creek sub-basin, and the entire Alligator Lake watershed (both sub-basins combined). **Figure 4.2** shows the drainage area of the Alligator Lake watershed and the spatial distribution of the land uses shown in **Table 4.5**.

Figures 4.3 and **4.4** depict the land uses for the Alligator Lake and Price Creek sub-basins, respectively. Alligator Lake is within the Alligator Lake sub-basin. As shown in **Figure 4.5**, the predominant land coverages for the Alligator Lake watershed include upland forest/rural open (22.7 percent), MDR (17.3 percent), wetland (13.4 percent), cropland/pastureland (12.9 percent), and transportation (12.1 percent). Other uses include commercial/industrial (9.7 percent), water (not including Alligator Lake) (5.0 percent), LDR (3.3 percent), rangeland (2.4 percent), HDR (1.2 percent), and tree crops (0.1 percent).



	FLUCC	Land Use Category	Alligator Basin (Acre)	Price Creek Basin (Acre)
▨	1100	Low Density Residential	148.20158	166.72598
▨	1200	Medium Density Residential	1420.83113	250.2093
▨	1300	High Density Residential	100.33734	11.62368
▨	1400	Commercial and Services	675.52657	257.76792
▨	2100	Cropland and Pastureland	710.46934	542.36172
▨	2200	Tree Crops/Citrus	7.57204	0.00000
▨	3000	Rangeland	122.32664	105.02238
▨	4000	Upland Forests/Rural Open	898.56253	1290.89665
▨	5000	Water	729.24917	19.30059
▨	6000	Wetlands	921.14899	395.45338
▨	8000	Transportation and Communication	194.39768	973.10695

Figure 4.2. Existing Land Use Coverage in the Alligator Lake Watershed (Alligator Lake and Price Creek Sub-Basins)

Table 4.5. Total and Percent Acreage of the Various Land Use Categories in the Alligator Lake Sub-Basin, Price Creek Sub-Basin, and Entire Alligator Lake Watershed

Land Use Code	Attribute	Alligator Lake Sub-Basin Area (acres)	Price Creek Sub-Basin Area (acres)	Alligator Lake Sub-Basin, % of Total Land Use	Price Creek Sub-Basin, % of Total Land Use	Total Watershed Land Use (acres)	Total Watershed Land Use (%)
1100	Low-Density Residential	147.2	166.7	2.6	4.2	313.9	3.3
1200	Medium-Density Residential	1,417.8	250.2	25.1	6.2	1,668.0	17.3
1300	High-Density Residential	100.4	11.6	1.8	0.3	112.0	1.2
1400	Commercial and Services	680.9	257.8	12.1	6.4	938.7	9.7
2100	Cropland and Pastureland	707.0	542.4	12.5	13.5	1,249.4	12.9
2200	Tree Crops/Citrus	8.0	0.0	0.1	0.0	8.0	0.1
3000	Rangeland	123.3	105.0	2.2	2.6	228.4	2.4
4000	Upland Forests/Rural Open	901.1	1,290.9	16.0	32.2	2,192.0	22.7
5000	Water	463.6	19.3	8.2	0.5	482.9	5.0
6000	Wetlands	898.1	395.5	15.9	9.9	1,293.5	13.4
8200	Transportation	194.4	973.1	3.4	24.3	1,167.5	12.1
	TOTAL	**5,641.8**	**4012.5**	**100.0**	**100.0**	**9,654.3**	**100.0**

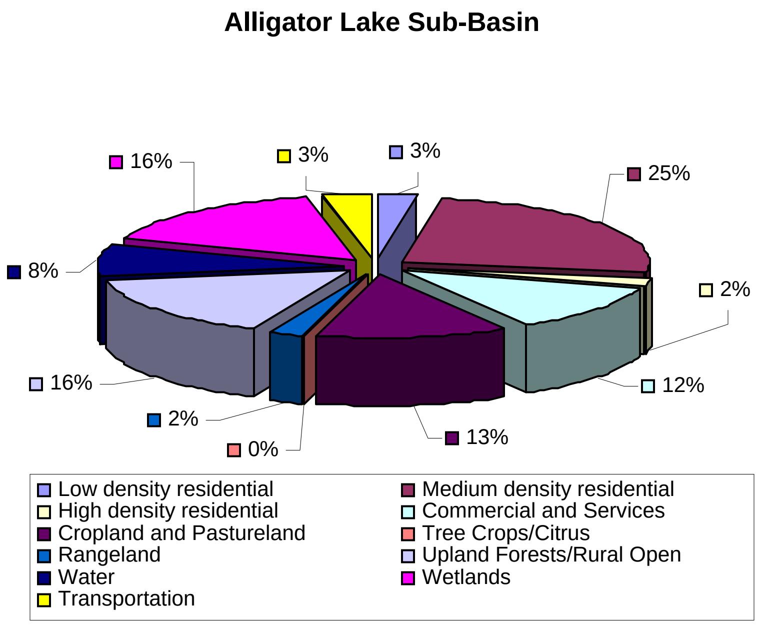


Figure 4.3. Percent Acreage of the Various Land Use Categories in the Alligator Lake Sub-Basin

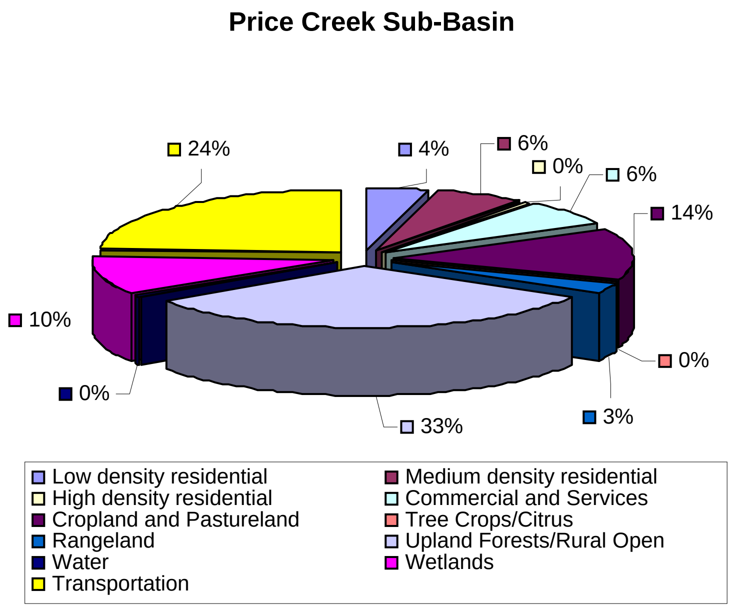


Figure 4.4. Percent Acreage of the Various Land Use Categories in the Price Creek Sub-Basin

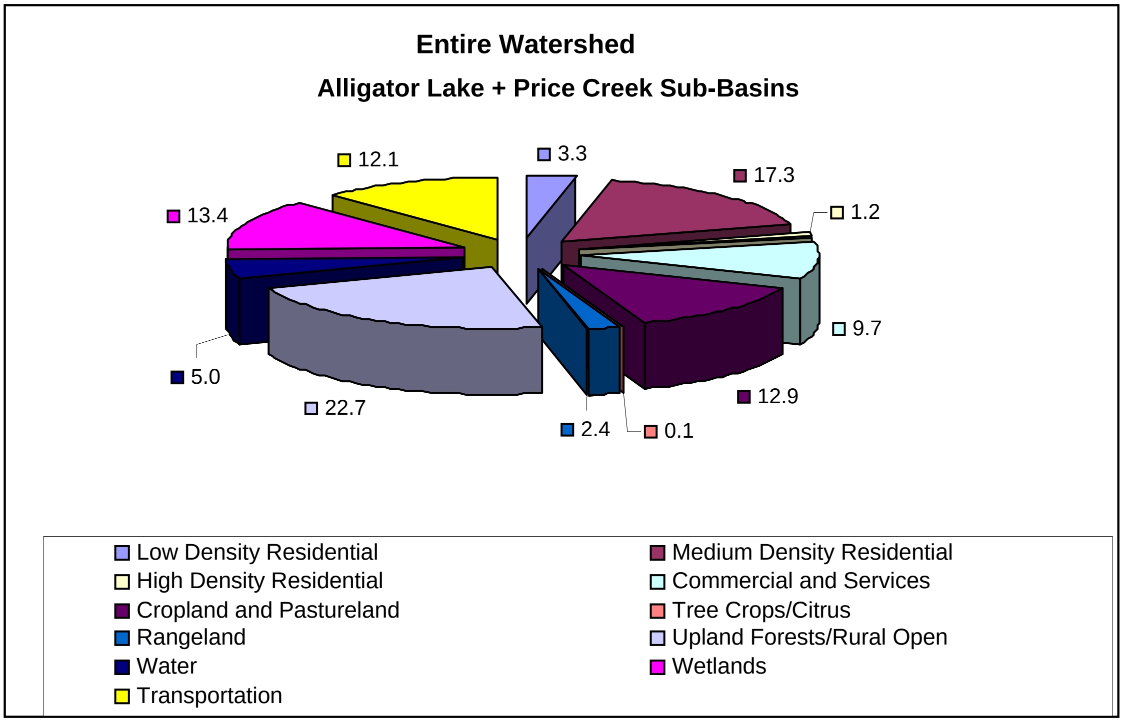


Figure 4.5. Percent Acreage of the Various Land Use Categories in the Entire Alligator Lake Watershed

Columbia County Population

According to the U.S Census Bureau, the county occupies approximately 797.05 mi^2. The total 2000 population estimated for Columbia County, which includes (but is not exclusive to) the Alligator Lake watershed, was 56,513. The population density in Columbia County in the year 2000 was at or less than 70.9 people per mi^2. The estimated population for 2006 is 67,007, a 13.2 percent increase from 2000. For all of Columbia County (2006), the Bureau reported a total occupied number of housing units as 25,530 for a housing density of 32 housing units per mi^2. Columbia County is well below the average housing density for Florida counties of 158 housing units per mi^2 (U.S. Census Bureau Website, 2008).

Septic Tanks

Onsite sewage treatment and disposal systems (OSTDS's), including septic tanks, are commonly used where providing central sewer is not cost-effective or practical. When properly sited, designed, constructed, maintained, and operated, OSTDS's are a safe means of disposing of domestic waste. The effluent from a well-functioning OSTDS is comparable to secondarily treated wastewater from a sewage treatment plant. When not functioning properly, however, OSTDS's can be a source of nutrients (nitrogen and phosphorus), pathogens, and other pollutants to both ground water and surface water.

Septic tank effluent (STE) characteristics and loading rates have been reported in several studies (Charlotte Harbor Environmental Center [CHEC], 2003; CDM, 1991; Institute of Food and Agricultural Sciences [IFAS], 1984). STE contains varied concentrations of nitrogen, phosphorus, chloride, sulfate, sodium, detergent surfactants, and pathogenic bacteria and viruses. OSTDS's use soil adsorption capabilities to remove nutrients and bacteria from the treated effluent.

The removal of TN in soils could vary from 40 to 60 percent (CHEC, 2003; IFAS, 1984) before reaching the water table. Once the nitrogen has reached the form of nitrate (NO_3) in the water table, it remains stable as it is transported to a waterbody.

Phosphorus is removed from the STE at a higher rate, 50 to 98 percent (CHEC, 2003; CDM, 1991; IFAS, 1984), and from ground water by sorption and precipitation. Waterbodies contaminated with phosphorus from OSTDS's are indicative of the proximity of these systems, usually less than 150 feet (CHEC, 2003; IFAS, 1984).

When at least 2 feet of unsaturated soil exist between the infiltration system and the water table, BOD_5 removals of > 90 percent, total suspended solids (TSS) removals of > 95 percent and fecal coliform reductions of > 99 percent (CDM, 2008) can be expected for a functional and properly maintained septic tank. Bacteria and viruses are effectively removed by adsorption and sorption processes in ground water and are not transported far from the STE source.

IFAS (1984) estimated 11 to 18 lbs/yr/capita of TN loading factor to the water table, while Anderson et al. (1994), as reported by CHEC (2003) and EPA (2002), estimated 9.2 lbs/yr/capita. Likewise, for TP, the estimated per capita loading factors were 0.4 to 1.6 and 1.2 lbs/yr, respectively. The difference relies on the decreasing loading rate of nutrients present in the current composition of detergent supplies, a change that was implemented in recent years.

The WMM does not directly account for the impacts of failing septic tanks. Loadings from septic tanks were included in the results from the WMM by increasing the total TN and TP loads from low-density residential land use by 2 percent.

Columbia County Septic Tanks

As of 2007, Columbia County had a cumulative registry of 23,490 septic systems. Data for septic tanks are based on 1970–2007 Census results, with year-by-year additions based on new septic tank construction. The data do not reflect septic tanks that have been removed going back to 1970. From fiscal years 1991 to 2007 (no data for 1992 or 1993), an average of 230 permits per year for repairs was issued in Columbia County (Florida Department of Health [FDOH], 2008). Based on the number of permitted septic tanks estimated for 2006 (23,490) and housing units (25,530) located in the county, approximately 8 percent of the housing units are connected to a central sewer line (i.e., wastewater treatment facility), with the remaining 92 percent using septic tank systems.

4.3 Estimating Point and Nonpoint Source Loadings

4.3.1 Model Approach

The equations from the WMM were incorporated into an Excel spreadsheet and utilized to estimate the nutrient loads in the Alligator Lake watershed, as described previously. Chapter 5 discusses the results from the modeling.

Chapter 5: DETERMINATION OF ASSIMILATIVE CAPACITY

5.1 Determination of Loading Capacity

Nutrient enrichment and the resulting problems related to eutrophication tend to be widespread and are frequently manifested far (in both time and space) from their source. Addressing eutrophication involves relating water quality and biological effects (such as photosynthesis, decomposition, and nutrient recycling), as acted upon by hydrodynamic factors (including flow, wind, tide, and salinity), to the timing and magnitude of constituent loads supplied from various categories of pollution sources. The assimilative capacity should be related to some specific hydrometeorological condition, such as an ”average” during a selected period, or to cover some range of expected variation in these conditions.

The goal of this TMDL development is to identify the maximum allowable TN and TP loadings from the watershed, so that Alligator Lake will meet the narrative nutrient water quality and DO criteria and thereby maintain its function and designated use as a Class III water. In order to achieve the goal, the Department selected the WMM to predict nutrient loadings from the watershed to the lake. A multivariable empirical equation was then developed to relate the watershed loadings from the WMM to the measured in-lake concentrations of Chla, TN, and TP. Annual Chla responses in the lake are predicted as a function of TN and TP concentrations proportional to watershed nutrient loads and to ultimately estimate the assimilative capacity of the lake.

5.1.1 Meteorological and Stage Data

Daily rainfall data for Alligator Lake were obtained from three different stations (**Table 5.1**) within the vicinity of Alligator Lake. **Figure 5.1** shows the annual average rainfall for each year of the verified period. The annual average rainfall contained in **Table 5.2** was used in the model.

Table 5.1. General Information on Weather Stations for Alligator Lake

Location Name	Start Date	End Date	Frequency	Facility	County	Comment
Lake City 2 E	01/01/2000	12/31/2007	Daily	NOAA	Columbia	No data available for July 2000
02322601	07/20/2002	12/31/2007	Daily	SRWMD	Columbia	
Alachua	01/01/2000	12/31/2007	Daily	FAWN	Alachua	Data used for July, 2000

NOAA – National Oceanic and Atmospheric Administration
FAWN – Florida Automated Weather Network

Table 5.2. Annual Rainfall Used in the Model

Year	Rainfall (inches)
2000	36.7
2001	42.3
2002	49.1
2003	58.9
2004	70.8
2005	56.7
2006	45.7
2007	38.3
Average	**49.8**
Std*	**11.7**

* Std – Standard deviation

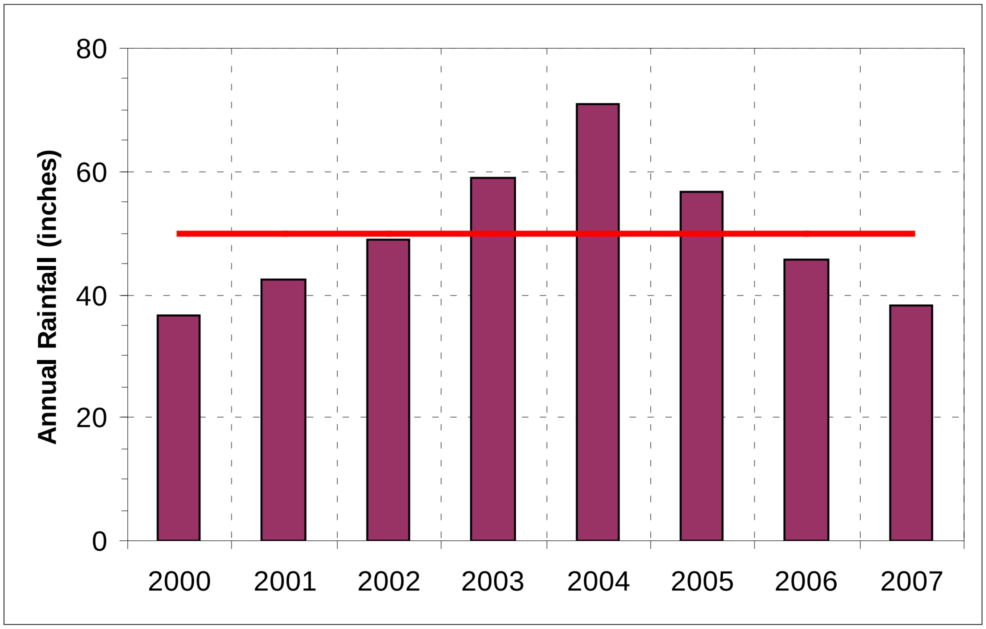


Figure 5.1. Total Annual Rainfall (Inches) Observed during the Verified Period (January 1, 2000–June 30, 2007)

5.1.2 Model Calibration

Using the annual rainfall data, the WMM spreadsheet was used to estimate the volume of water and the loading of TN and TP from the watershed. First, the annual runoff volume from the Price Creek sub-basin was modeled for the verified period (January 1, 2000–June 30, 2007). Observed flow data were available for Price Creek for 2000 to 2004. The measured annual runoff volumes varied significantly over the observed period, ranging from 1,947 acre-feet per year (ac-ft/yr) to 9,421 ac-ft/yr (**Table 5.3**). These measured volumes are in good agreement with the simulated runoff volumes from the model, as shown in **Table 5.3**.

For the calibration, the calibrated runoff coefficients ranging from 0.80 to 0.99 for impervious areas and from 0.02 to 0.37 for pervious areas were used for the Price Creek sub-basin.

Subsequent to the calibration of flows from the Price Creek sub-basin, the same DCIA and runoff coefficients (per each land use) were applied to the entire Alligator Lake watershed (the Alligator Lake and Price Creek sub-basins combined) to produce runoff volumes, as shown in **Table 5.4,** and TN and TP loads, as shown in **Table 5.5**.

Table 5.3. Measured and Simulated Flows for the Price Creek Sub-Basin

Year	Price Creek Measured Flow (ac-ft/yr)	Price Creek Sub-Basin Simulated Runoff (ac-ft/yr)	Difference (ac-ft/yr)	% Error
2000	2,016.1	2,054.7	-38.6	1.91
2001	1,947.0	2,132.8	-185.8	9.54
2002	3,028.9	3,090.5	-61.6	2.03
2003	9,420.6	9,334.4	86.2	0.91
2004	9,247.2	9,249.9	-2.7	0.03
2005	N/A	7,407.8	N/A	N/A
2006	N/A	2,876.5	N/A	N/A
2007	N/A	2,144.3	N/A	N/A
Average	**5,132.0**	**5,172.5**	**-40.5**	**0.79**
Std*	**3,860.2**	**3,782.9**		

* Std – Standard deviation
N/A – Not available

Table 5.4. Simulated Flows for the Alligator Lake Sub-Basin

Year	Alligator Lake Sub-Basin Simulated Flow (ac-ft/yr)
2000	5,307.8
2001	5,562.3
2002	7,907.1
2003	22,936.0
2004	22,921.4
2005	18,356.6
2006	7,359.6
2007	5,539.2
Average	**11,986.2**
Std*	**7,978.0**

* Std = standard deviation

Table 5.5. Simulated TN and TP Loads for the Entire Alligator Lake Watershed

Year	TN (lbs/yr)	TP (lbs/yr)
2000	21,872	2,864
2001	22,653	2,958
2002	32,970	4,328
2003	100,476	13,330
2004	99,384	13,157
2005	79,591	10,537
2006	30,687	4,028
2007	22,825	2,988
Average	**59,491**	**7,862**
Std*	**37,818**	**5,032**

* Std = Standard deviation

Given the flows and loads calculated above, an empirical multivariable equation was developed to predict the assimilative capacity of the lake, using the long-term water quality data from 1989 to 2007. During the review of the data, several results were identified as possible outliers. In order to reduce the statistical noise these data introduced into the overall dataset, 4 of 237 sampling events (1.7 percent) for Chla were censored.

For example, on March 29, 2007, the Chla data indicate the same lake had concentrations ranging from 1 to 1,400 µg/L corrected Chla. Only one sampling event out of ~ 567 events (0.1 percent) was censored for TN and TP. Using best professional judgment, these data, contained in **Table 5.6**, were removed from the overall dataset used to develop the multivariable equation. Additionally, there were no corrected Chla results from August 2002 through December 2005, and for selected dates during 2006 and 2007. The uncorrected Chla results were incorporated with the TN and TP data for these dates.

Table 5.7 depicts the uncorrected Chla data as highlighted, while **Figures 5.4** and **5.5** depict the uncorrected Chla data as UChla. The equation was derived from the Chla to TN to TP relationship, showing that Chla is well-correlated to TN and TP, with r=0.852 for n equals 94. Based on the equation below, Chla can be predicted (as well as TSI) as a function of the TN and TP concentrations proportional to the TN and TP loadings to the lake.

$$\mathbf{Chla = 29.74*TN + 91.66*TP - 30.0}$$

Table 5.6. Data Not Used in Development of Multivariable Regression Equation

Parameter	Station	Date	Depth	Method	Result	Units
CHLAC	21FLBRA 3516A-B	3/29/2007	0.20	32209	1,400	µg/L
CHLAC	21FLBRA 3516A-B	3/29/2007	0.20	32209	91	µg/L
CHLAC	21FLBRA 3516A-A	3/29/2007	0.20	32209	1	µg/L
TN	21FLBRA 3516A-B	3/29/2007	0.20	600	110.0	mg/L
TN	21FLBRA 3516A-B	3/29/2007	0.20	600	40.0	mg/L
TN	21FLBRA 3516A-A	3/29/2007	0.20	600	1.71	mg/L
TP	21FLBRA 3516A-B	3/29/2007	0.20	665	8.3	mg/L
TP	21FLBRA 3516A-B	3/29/2007	0.20	665	3.5	mg/L
TP	21FLBRA 3516A-A	3/29/2007	0.20	665	0.49	mg/L
CHLAC	21FLSUW ALL010C1	11/19/1990	0.66	32211	1	µg/L
CHLAC	21FLSUW ALL030C1	12/3/1990	0.33	32211	36.4	µg/L
CHLAC	21FLSUW ALL020C1	12/3/1990	0.33	32211	661	µg/L
CHLAC	21FLSUW ALL030C1	6/5/1989	0.66	32211	67	µg/L
CHLAC	21FLSUW ALL020C1	6/5/1989	1.97	32211	810	µg/L
CHLAC	21FLSUW ALL020C1	6/5/1989	0.66	32211	530	µg/L

Table 5.7. Chla Data

Highlighted data are uncorrected Chla results. All other results are corrected Chla.

Date	Chla (µg/L)	Date	Chla (µg/L)	Date	Chla (µg/L)
2/6/1989	54.08333	7/23/1997	6.75	4/1/2003	15.2
4/3/1989	121.15	8/8/1997	17.7	6/16/2003	2.67
8/7/1989	185	10/3/1997	32.5	8/11/2003	7.99
12/4/1989	33.26667	10/19/1998	15.075	10/1/2003	10.965
2/5/1990	70.4	11/10/1998	20.17333	2/12/2004	4.003333
3/5/1990	13.26667	12/8/1998	21.9	4/5/2004	66.2025
4/9/1990	11.36667	1/18/1999	4.333333	6/17/2004	134.805
5/7/1990	10.06	2/1/1999	8.325	8/17/2004	26.43333
6/4/1990	62.668	3/1/1999	14.43333	10/11/2004	52.325
7/9/1990	77.45	7/7/1999	9.8	12/8/2004	13.85667
8/6/1990	39	8/10/1999	80	2/15/2005	18.05667
8/7/1990	180	9/7/1999	17	4/5/2005	9.5475
9/4/1990	366.775	10/20/1999	21.66667	6/13/2005	1.023333
10/8/1990	258.6	12/8/1999	1.3	8/3/2005	39.96667
11/5/1990	362.3	2/14/2000	8.6	10/10/2005	39.225
12/3/1990	348.7	4/5/2000	9.5	12/8/2005	2.646667
1/7/1991	13.2	6/6/2000	21.7	12/28/2005	41
2/4/1991	49.424	8/15/2000	35.6	1/18/2006	30.06667
3/4/1991	10.635	10/2/2000	26.3	2/14/2006	21.76667
4/8/1991	34.26	12/7/2000	4.6	3/22/2006	148.6667
5/6/1991	43.16667	2/14/2001	2.8	4/3/2006	56.55
6/3/1991	38.82	6/14/2001	39.4	4/4/2006	97.66667
7/8/1991	25.75	8/7/2001	39.7	5/9/2006	80.66667
8/5/1991	57.83333	10/16/2001	7.1	6/20/2006	243.3333
9/19/1991	90.83333	12/11/2001	3.2	6/26/2006	13.55
1/31/1997	10.45	2/18/2002	1.6	7/26/2006	52.25
2/24/1997	18.65	4/1/2002	98.46667	8/7/2006	42.72667
3/21/1997	22.625	6/19/2002	16.75	9/13/2006	71
4/15/1997	71	8/19/2002	15.55	10/3/2006	35.5
5/16/1997	6.93	10/16/2002	4.4	2/19/2007	8.283333
6/18/1997	8.5625	12/10/2002	5.87	4/2/2007	14.8
				4/5/2007	12

Figure 5.2 depicts a strong relationship (R^2 0.63) between Chla and TP in the lake. **Figure 5.3** depicts an even stronger relationship (R^2 0.72) between Chla and TN in the lake. **Figure 5.4** compares the results from predicting Chla from TN with the measured Chla concentration. This graph supports the conclusion that the equation is well-calibrated. **Figure 5.5** compares the results of predicting Chla from TP with the measured Chla concentration. This graph supports the conclusion that the equation is well-calibrated.

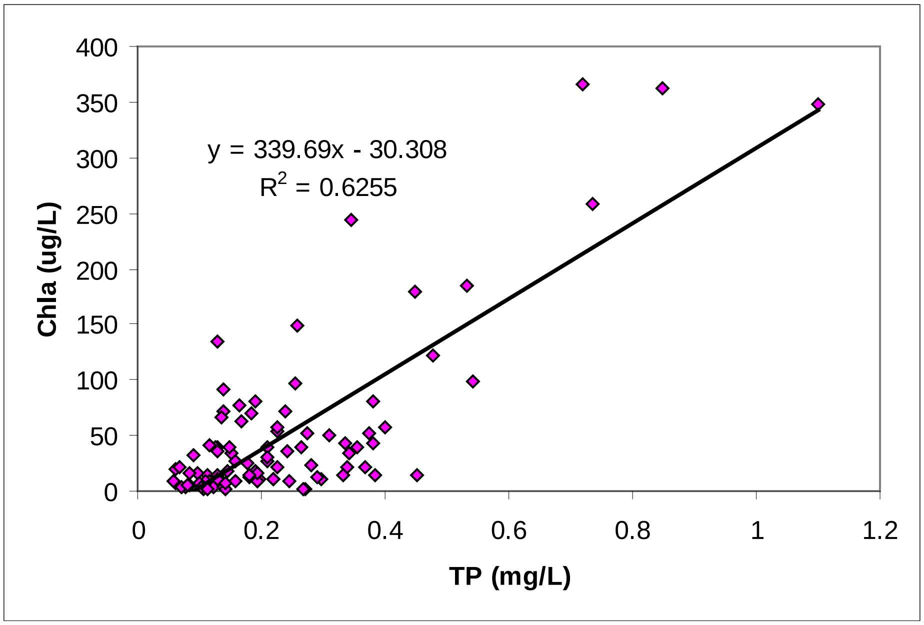


Figure 5.2. Relationship between Chla and TP Observed in Alligator Lake, February 1989–April 2007

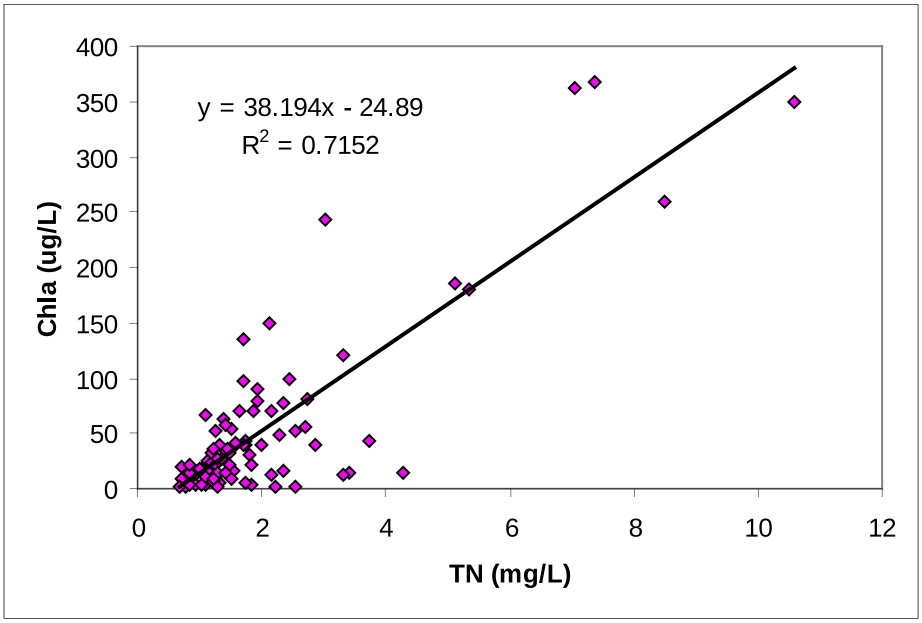
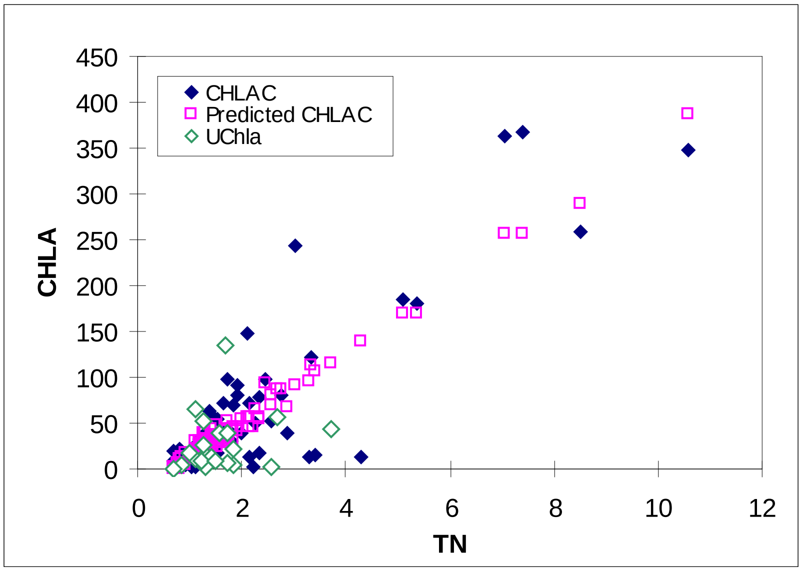
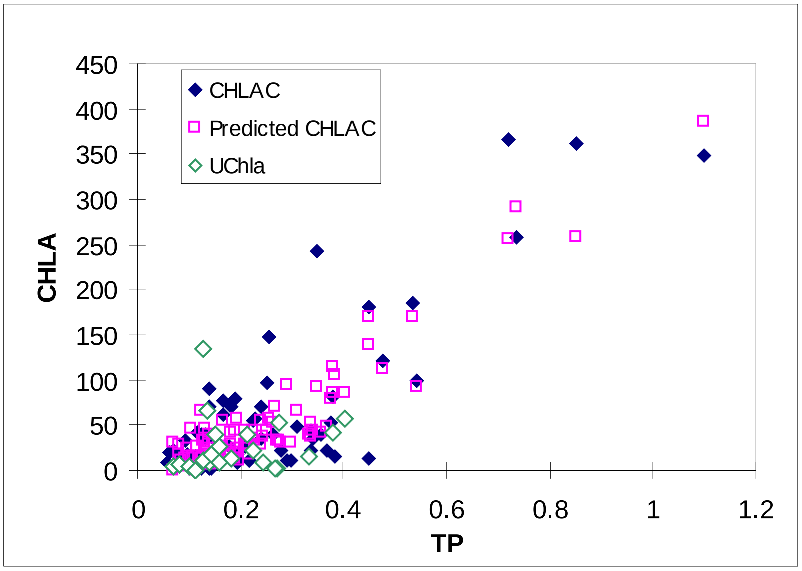


Figure 5.3. Relationship between Chla and TN Observed in Alligator Lake, February 1989–April 2007



* UChla = Uncorrected Chla values

Figure 5.4. Predicted versus Observed Chla as a Function of Observed TN Concentration



* UChla = uncorrected Chla values

Figure 5.5. Predicted versus Observed Chla as a Function of Observed TP Concentration

5.2 Selection of TMDL Target

Using the WMM-based spreadsheet model and the Chla predictive equation developed for existing conditions, all human land uses in the watershed were assigned a natural land use category based on the current proportion of natural land uses in the watershed, and the models were run for the natural land use background condition. **Table 5.8** provides the results for the existing measured condition, existing calibrated model, and natural land use condition.

Table 5.8. Measured Data, Regression Model, Natural Land Use for Chla, TN, TP, and TSI

Scenario	Chla (µg/L)	TN (mg/L)	TP (mg/L)	TSI	TN/TP
Existing Measured Data	33.5	1.62	0.191	68.7	8.5
Existing Model Predicted	35.7	1.62	0.191	69.1	8.5
Natural Land Use	6.9	1.06	0.059	51.0	17.9

Table 5.9 contains the acreages of natural land uses incorporated into the natural background loading analysis. **Table 5.10** contains the estimated TN and TP loadings to Alligator Lake under natural land use conditions.

Table 5.9. Natural Background Land Use

Land Use Category	Area (acres)
Upland Forest/Open	5,329
Water*	1,178
Wetland	3,147

* Acreage of water does not include area of Alligator Lake.

As explained in **Section 3.2**, the Department has selected the TSI plus 5 units from the natural land use predictions (51.0 + 5 = 56.0) as the target for TMDL development.

Table 5.10. Natural Background Annual TN and TP Loads

Year	TN (lbs/yr)	TP (lbs/yr)
2000	13,518	914
2001	13,732	949
2002	20,767	1,374
2003	68,094	4,147
2004	66,381	4,110
2005	53,161	3,292
2006	19,329	1,279
2007	14,107	954
Average	**39,275**	**2,464**
Std*	**26,140**	**1,557**

* Std = Standard deviation

5.3 Simulations for TMDL Load Reduction

The load reductions were obtained from the difference in the loads between the existing conditions versus the background land use conditions. Then the percent reductions were applied to obtain the TN and TP concentrations predicted for the natural background conditions. Based on the multiple regression equation (Chla = 29.74*TN + 91.66*TP – 30.0) and estimated TN and TP load reductions under different scenarios, the TSI for Alligator Lake was thus calculated using predicted Chla, TN, and TP until the TSI of 56.0 was achieved.

The in-lake concentrations for Chla, TN, and TP that result in attaining the target TSI are 11.3 µg/L, 1.16 mg/L, and 0.074 mg/L, respectively. The load reduction required to achieve the TSI target of 56.0 (assuming that loading is proportional to the in-lake concentrations of TN and TP) is 28.4 percent for TN and 61.2 percent for TP. The existing annual average load for TN is 59,491 lbs/yr. A 28.4 percent reduction of TN is 16,895 lbs/yr, resulting in an annual average allowable TN load of 42,595 lbs/yr, or 116.7 lbs/day. The existing annual average load for TP is 7,862 lbs/yr. A 61.2 percent reduction of TP is 4,811 lbs/yr, resulting in an annual average allowable TP load of 3,050 lbs/yr, or 8.36 lbs/day.

Chapter 6: DETERMINATION OF THE TMDL

6.1 Expression and Allocation of the TMDL

A TMDL can be expressed as the sum of all point source loads (wasteload allocations, or WLAs), nonpoint source loads (load allocations, or LAs), and an appropriate margin of safety (MOS) that takes into account any uncertainty about the relationship between effluent limitations and water quality:

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

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

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

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

This approach is consistent with federal regulations (40 CFR § 130.2[I]), which state that TMDLs can be expressed in terms of mass per time (e.g., pounds per day), toxicity, or **other appropriate measure**. The TMDL for Alligator Lake is expressed in terms of pounds per year (converted from kilograms per year, as shown in Chapter 5) and percent reductions, and represents the long-term annual average load of TN and TP the waterbody can assimilate and maintain the Class III narrative nutrient criterion (see **Table 6.1**).

Table 6.1. Alligator Lake TMDL Load Allocations

WBID	Parameter	WLA Wastewater (lbs/yr)	WLA Stormwater (% reduction)	LA (lbs/yr)	MOS	TMDL (lbs/yr)	% Reduction
3516A	TN	N/A	N/A	42,595	Implicit	42,595	28.4 %
3516A	TP	N/A	N/A	3,050	Implicit	3,050	61.2 %

N/A – Not applicable
*The load reductions of TN and TP will correct the impairments for nutrients and DO. The allowable loads are TN, 116.7 lbs/day; and TP, 8.36 lbs/day. Achieving a long-term TSI of 56.0 results in an average Chla of 11.3 µg/L, TN of 1.16 mg/L, TP of 0.074 mg/L, and a TN/TP ratio of 15.7.

6.2 Load Allocation

The allowable LA is 42,595 lbs/yr for TN and 3,050 lbs/yr for TP. This corresponds to reductions from the existing loadings of 28.4 percent for TN and 61.2 percent for TP. It should be noted that the LA may include loading from stormwater discharges regulated by the Department and the SRWMD that are not part of the NPDES Stormwater Program (see **Appendix A**).

6.3 Wasteload Allocation

6.3.1 NPDES Wastewater Discharges

As noted in Chapter 4, **Section 4.2.1**, there are no active NPDES-permitted facilities that have a direct surface water discharge to Alligator Lake. The only NPDES surface water discharger in the watershed is Westvaco (FL), located along the edge of the watershed. The permit describes the discharge as part of a ground water remediation project with a discharge to a ditch, to a creek that then runs to Alligator Lake. It is not anticipated that the discharge from this facility is impacting Alligator Lake, and therefore no reductions for TN or TP are proposed.

6.3.2 NPDES Stormwater Discharges

There are no known NPDES stormwater dischargers covered under any MS4 permit. Any future MS4 permittee will need to meet the TMDL load reductions in **Table 6.1**. It should be noted that any MS4 permittee will only be responsible for reducing the loads associated with stormwater outfalls that it owns or otherwise has responsible control over, and it is not responsible for reducing other nonpoint source loads in its jurisdiction.

6.4 Margin of Safety

TMDLs must address uncertainty issues by incorporating an MOS into the analysis. The MOS is a required component of a TMDL and accounts for the uncertainty about the relationship between pollutant loads and the quality of the receiving waterbody (Clean Water Act, Section 303[d][1][c]). Considerable uncertainty is usually inherent in estimating nutrient loading from nonpoint sources, as well as in predicting water quality response. The effectiveness of management activities (e.g., stormwater management plans) in reducing loading is also subject to uncertainty.

The MOS can either be implicitly accounted for by choosing conservative assumptions about loading or water quality response, or explicitly accounted for during the allocation of loadings. Consistent with the recommendations of the Allocation Technical Advisory Committee (Department, February 2001), an implicit MOS was used in the development of the Alligator Lake TMDL. An implicit MOS was used because the TMDL was based on the conservative decisions associated with a number of the modeling assumptions and allowing a TSI increase of only 5 units above natural background conditions. The IWR allows a TSI increase of 10 units over background conditions. Therefore, establishing the TMDL TSI target with an increase of only 5 TSI units incorporates an additional 5 TSI units into the MOS and allows for future changes in determining the assimilative capacity (i.e., loading and water quality response) for Alligator Lake. Additionally, the estimates of septic tank failures were set to the maximum values instead of the mean values.

6.5 Evaluating Effects of the TMDL on DO

Alligator Lake is expected to attain water quality standards following the implementation of the TMDL for nutrients, because the lake TMDL will require a 28.4 percent reduction in TN loadings and a 61.2 percent reduction in TP loadings, and will result in a 66.4 percent reduction in Chla (from 33.5 to 11.3 μg/L). These reductions will significantly improve overall water quality in the lake, including DO levels. For example, the proposed nutrient reductions for the lake are predicted to decrease algal biomass from the current Chla average in the lake of 33.5 μg/L to approximately 11.3 μg/L. This will have a positive effect on reducing the diurnal fluctuations in DO and will improve the DO levels of water in the lake. These in-lake reductions in algal biomass (66.4 percent) will reduce the DO fluctuations and the BOD that results from the breakdown of the algal cells in the lake by a relative amount. As the total BOD is composed of both a carbonaceous fraction and a nitrogenous fraction, additional reductions in BOD will occur as a result of reducing the mass of TN entering the lake by 28.4 percent.

6.6 Evaluating Effects of the TMDL on BOD

The high BODs measured in Alligator Lake are contributing to the low DO. These high values could in part be related to the occasionally high Chla concentrations measured in the lake. The lake is described as containing large areas of emergent vegetation; it could be that some fraction of the total BOD is also related to senescing “natural” macrophyte-derived biomass. Once the external sources of BOD and nutrients (from stormwater, agriculture, and any remaining wastewater contributions) are reduced through the implementation of the TMDL, it is expected that the in-lake BOD concentrations will be reduced to levels that attain water quality standards.

Chapter 7: NEXT STEPS: IMPLEMENTATION PLAN DEVELOPMENT AND BEYOND

Following the adoption of this TMDL by rule, the next step in the TMDL process is to develop an implementation plan for the TMDL, which will be a component of the Basin Management Action Plan (BMAP) for the Alligator Lake watershed. This document will be developed in cooperation with local stakeholders and will attempt to reach consensus on more detailed allocations and on how load reductions will be accomplished.

The BMAP will include the following:

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

It should be noted that TMDL development and implementation is an iterative process, and this TMDL will be re-evaluated during the BMAP development process and subsequent watershed management cycles. The Department acknowledges the uncertainty associated with TMDL development and allocation, particularly in estimates of nonpoint source loads and allocations for NPDES stormwater discharges, and fully expects that the TMDL may be further refined or revised over time. If any changes in the estimate of the assimilative capacity **AND/OR** allocation between point and nonpoint sources are required, the rule adopting this TMDL will be revised, thereby providing a point of entry for interested parties.

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Appendices

Appendix A: Background Information on Federal and State Stormwater Programs

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

Rule 62-40, F.A.C., also requires the state's water management districts to establish stormwater pollutant load reduction goals (PLRGs) and adopt them as part of a Surface Water Improvement and Management (SWIM) plan, other watershed plan, or rule. Stormwater PLRGs are a major component of the load allocation part of a TMDL.

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

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

Appendix B: TN, TP, Chla Raw Data, and WMM Input Information Used in the TMDL Analysis for Alligator Lake

All data, copies of the model, and model input decks used to produce the Alligator Lake TMDL report are available upon request by contacting.

Douglas Gilbert, Environmental Manager
Florida Department of Environmental Protection
Bureau of Watershed Management
Watershed Evaluation and TMDL Section
2600 Blair Stone Road, Mail Station 3555
Tallahassee, FL 32399-2400
douglas.gilbert@dep.state.fl.us
Phone: (850) 245–8450
Fax: (850) 245–8536

Florida Department of Environmental Protection
Division of Environmental Assessment
and Restoration
Bureau of Watershed Management
2600 Blair Stone Road, Mail Station 3565
Tallahassee, Florida 32399-2400