FINAL

FLORIDA DEPARTMENT OF ENVIRONMENTAL PROTECTION

Division of Water Resource Management, Bureau of Watershed Management

NORTHEAST DISTRICT • OCKLAWAHA BASIN

# TMDL Report

# Nutrient TMDL for Alachua Sink, WBID 2720A

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**Identification of Impaired Surface Waters Rule**

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

**STORET Program**

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

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**Allocation Technical Advisory Committee (ATAC) Report**

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## *U. S. Environmental Protection Agency*

**Region 4: Total Maximum Daily Loads in Florida**

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

**National STORET Program**

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# Chapter 1: INTRODUCTION

## 1.1 Purpose of Report

This report documents the development of the nutrient total maximum daily load (TMDL) for Alachua Sink. Located in central Florida near Gainesville **(Figure 1),** Alachua Sink was verified as impaired by nutrients 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 Ocklawaha Basin that was adopted by Secretarial Order on August 28, 2002.

Once a waterbody or waterbody segment has been verified as impaired and referenced in the Secretarial Order adopting the Verified List, work on establishing the TMDL begins. The TMDL process establishes the allowable loadings of pollutants or other quantifiable parameters for a waterbody based on the relationship between pollution sources and instream water quality conditions, so that states can establish water quality–based controls to reduce pollution from both point and nonpoint sources and restore and maintain the quality of their water resources (U. S. Environmental Protection Agency [EPA], 1999).

## 1.2 Identification of Waterbody

Alachua Sink (WBID 2720A) is located on the northern edge of Paynes Prairie, south of the city of Gainesville, and approximately 2.5 miles east of U. S. 441. It consists of a small lake, with a corresponding solution sink that recharges the Floridan aquifer (Jones, Edmunds & Associates, Inc. [JEA], 2003). Alachua Sink has a surface area of about 13.5 acres and a mean depth of around 1 meter (**Figures 1** and **2**).

Alachua Sink lies in a physiographic region of the state known as the Central Valley (McGrail et al., 1998). The center of Alachua Sink is located at latitude 29$^0$ 36’ 18” N. and longitude 82$^0$ 18’ 9” W. **(Figure 1).** The dominant, underlying geologic component of the area is the Ocala limestone formation, with younger, overlying terrace deposits of undifferentiated sediments, sand, and clayey sand (Gottgens and Montague, 1988). The Ocala formation is a soft, porous limestone, interbedded with dense, hard limestone and dolomite (Clark et al., 1964). Sink formations have occurred in the area through subterranean erosion by ground water solution of the limestone.

The surrounding drainage basin for Alachua Sink is approximately 2,758 acres. There are two well-defined inflows into Alachua Sink: Sweetwater Branch and a culverted canal that connects Alachua Lake to Alachua Sink (a combined drainage area of 39,373 acres). Alachua Lake is the inundated portion of Paynes Prairie. Presumably, any runoff coming into Paynes Prairie that does not sink into the ground is incorporated into Alachua Lake and some portion is shunted to Alachua Sink during high-water conditions. Major sources of flow to Paynes Prairie include Bivens Arm, Prairie Creek (which connects the prairie to Newnans Lake), and Camps Canal. Based on long-term U. S. Geological Survey (USGS) flow measurements (1942–91), about 41% of the flow from Newnans Lake goes south into Paynes Prairie, and the rest flows towards Orange Lake by way of Camps Canal (Gottgens and Montague, 1988). As shown in **Figure 2,** the Alachua Sink waterbody has an outlet stream that flows to the primary sink feature.

Historically, Alachua Sink was used for recreation (ACLD, 2003). More recently, Alachua Sink has become dominated by a thriving alligator population that prohibits its use for this purpose. The increased urbanization of the nearby city of Gainesville has contributed pollutants through atmospheric deposition, stormwater runoff, and point source discharges. One domestic wastewater facility and one industrial wastewater facility are permitted to discharge effluent to Sweetwater Creek, which is connected to Alachua Sink via a canal. Septic tanks used in less developed parts of Alachua Sink's drainage may also be contributing pollutants to Alachua Sink via tributaries to Paynes Prairie.

For assessment purposes, the Ocklawaha Basin has been divided into assessment polygons, termed waterbody segments, that are assigned unique **w**ater**b**ody **id**entification numbers (WBIDs).[1]

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[1] Additional information on the derivation and use of WBID numbers is provided in *Documentation for the 2002 Update to the State of Florida's 303(d) List,* October 1, 2002; geographic information system (GIS) shapefiles of the waterbody segments are available at www.dep.state.fl.us/water/basin411/download.htm.

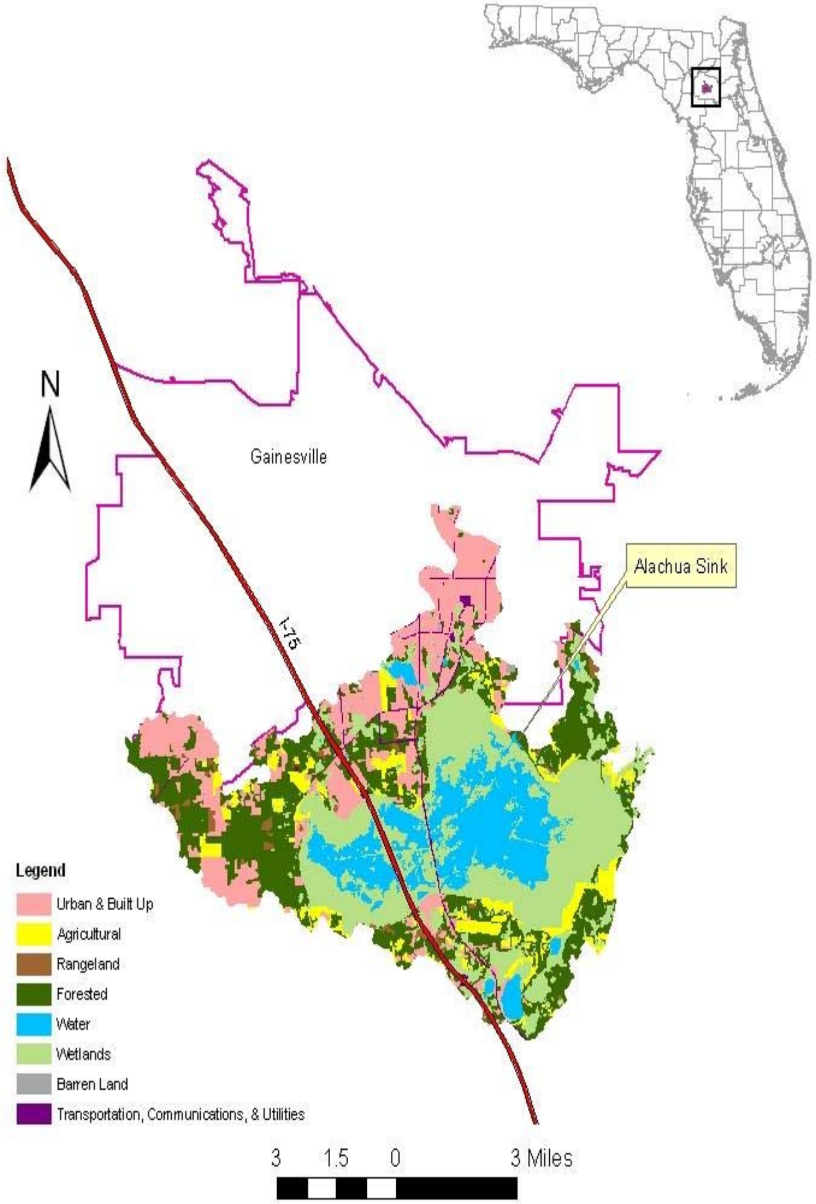

**Figure 1. General location and land uses for the Alachua Sink watershed**

# Chapter 2: STATEMENT OF PROBLEM

Based on the water quality data provided by the St. Johns River Water Management District (SJRWMD), Alachua Sink was determined to have elevated nutrient and chlorophyll *a* (chl*a*) values, with an average Trophic State Index (TSI) score of 78 from 2000 through 2002. For this period, the average annual total nitrogen (TN), total phosphorus (TP), and chl*a* concentrations were 4.33 milligrams per liter (mg/L), 1.279 mg/L, and 40.8 µg/L, respectively. The individual annual averages are provided in **Table 1** and the seasonal averages in **Table 2.** For all years of record, the annual TSI was above 60. The mean color of Alachua Sink during this period was calculated as 106 platinum cobalt units (PCUs).

## 2.1 Current Trophic Status of Alachua Sink

The SJRWMD provided monthly TN, TP, and chl*a* concentrations for Alachua Sink from 2000 through 2002 (Site ID: ALACHCHAN). Quarterly mean values for TN, TP, and chl*a* concentrations were calculated from the monthly data, and quarterly TSIs were calculated based on the quarterly mean values of TN, TP, and chl*a* concentrations. Annual mean values for TN, TP, chl*a*, and TSI represented the mean of quarterly averages of these parameters.

It is important to note that the procedures for calculating the annual or seasonal average TSIs for assessment purposes (**Tables 1** and **2**) are necessarily different from those used to calculate the annual or seasonal averages from modeling results **(Table 38).** The major difference is that the assessment protocol calls for determining a TSI for each quarter based on that quarter's TN, TP, and chl*a* concentrations, and then averaging the four quarterly TSIs to produce the annual average. In contrast, a model run on an annual basis will produce a single set of annual average concentrations from which the annual average TSI is calculated. The arable. For this reason, when comparing the annual or seasonal model TSIs with the measured TSIs calculated by the two different approaches are not necessarily comp data, the measured data were averaged for the entire year to produce a single set of TN, TP, and chl*a* concentrations used to produce the measured annual average TSI. For Alachua Sink, the annual average TSI following the assessment protocol is 78, while the annual average TSI used for comparison with the model results is 81.

The seasonal trend of TN, TP, chl*a*, and TSI were examined by calculating the long-term quarterly mean values based on the quarterly mean values of each year (2000–02). **Table 1** lists the individual annual mean TN, TP, chl*a* , and TSI values, and **Table 2** lists the long-term quarterly TN, TP, chl*a*, and TSI results.

**Table 1. Annual averages of TN, TP, chl*a*, and TSI values of Alachua Sink, 2000–02**

***Data represent the mean ± 1SE (n=4).***

| Year | TN (mg/L) | TP (mg/L) | Chl*a* (µg/L) | TSI |
|---|---|---|---|---|
| 2000 | 4.51± 1.04 | 1.182 ± 0.243 | 46.3 ± 21.3 | 79 ± 2 |
| 2001 | 4.82 ± 0.81 | 1.353 ± 0.109 | 33.2 ± 15.3 | 77 ± 3 |
| 2002 | 3.65 ± 0.39 | 1.302 ± 0.229 | 43.0 ± 15.1 | 77 ± 3 |
| **Mean** | **4.33 ± 0.35** | **1.279 ± 0.051** | **40.8 ± 3.9** | **78 ± 1** |

As shown in **Table 1,** no significant interyear differences were observed for TN, TP, chl*a*, and TSI from 2000 through 2002. The long-term average TN/TP ratio for Alachua Sink is about 4, suggesting that the phytoplankton communities in the lake are nitrogen limited. This suggests that phytoplankton would be sensitive to further nitrogen reductions and the TMDL should consider nitrogen as the primary pollutant of concern. Because the long-term annual average color of Alachua Sink is about 106 PCUs, the IWR threshold for nutrient impairment is an annual average TSI of 60. Alachua Sink was verified as impaired based on annual average TSIs greater than 60.

No statistically significant seasonal variation of TN, TP, chl*a*, and TSI was observed from 2000 through 2002 **(Table 2a).**

**Table 2a. Seasonal variation of TN, TP, chl*a*, and TSI of Alachua Sink**

| Quarter | TN (mg/L) | TP (mg/L) | Chl*a* (µg/L) | TSI |
|---|---|---|---|---|
| 1st quarter | 5.06 ± 1.08 | 1.345 ± 0.335 | 26.6 ± 11.2 | 77 ± 2 |
| 2nd quarter | 3.26 ± 0.38 | 0.915 ± 0.071 | 66.1 ± 12.4 | 81 ± 2 |
| 3rd quarter | 3.75 ± 0.41 | 1.467 ± 0.055 | 50.4 ± 29.5 | 77 ± 5 |
| 4th quarter | 5.25 ± 1.16 | 1.389 ± 0.210 | 20.3 ± 8.4 | 76 ± 2 |

Note: Data represent mean ±1SE; n equals 3 years (2000–02).

No measured flow data were available at the control structure located in the channel from Alachua Lake to Alachua Sink from 2000 through 2002. Even though the rainfall in 2002 was not considered “low,” very little water was discharged into Alachua Sink from Alachua Lake through the control structure during this period, according to observations from local citizens. Therefore, the water quality data for Alachua Sink during 2000 and 2002 were considered representative of dry-period conditions.

To understand the water quality condition of Alachua Sink during wet periods, further sample collections and water quality measurements were conducted by JEA, Inc. in 2003 (and subsequently in 2004). During 2003, flows from Alachua Lake into Alachua Sink increased dramatically over the previous three years. Water quality samples were collected from six sites in Alachua Sink in 2003. **Figure 2** shows the locations of the sampling sites. **Tables 2b, 2c,** and **2d** list tesults from the analyses completed to date. **Table 2e** lists the TN/TP ratios and TSIs calculated based on the mean TN, TP, and chl*a* concentrations.

JEA conducted three additional surveys in 2004 (February 11, 2004; May 19, 2004; and September 23, 2004). The Alachua County Environmental Protection Department (ACEPD) also conducted sampling during 2004, and these measurements were incorporated into **Tables 2f** through **2i**.

**Table 2b. TN concentration of Alachua Sink in 2003 (all values in mg/L)**

| Sampling Date | S1 | S2 | S3 | S4 | S5 | S6 | Mean |
|---|---|---|---|---|---|---|---|
| 02/12/2003 | 4.640 | 6.930 | 4.820 | 4.680 | 4.680 | 4.880 | 5.105 |
| 03/12/2003 | 2.904 | 2.949 | 2.926 | 2.922 | 2.899 | 3.123 | 2.954 |
| 03/27/2003 | 2.572 | 2.510 | 2.604 | 2.695 | 2.585 | 2.492 | 2.576 |
| 05/07/2003 | 2.090 | 2.155 | - | - | - | 2.293 | 2.179 |
| 05/22/2003 | 1.780 | 1.770 | - | - | - | 1.780 | 1.777 |
| 06/09/2003 | 1.825 | 1.681 | - | - | - | 1.813 | 1.773 |
| 10/16/2003 | 1.200 | - | - | - | - | 1.090 | 1.145 |
| 12/09/2003 | 1.411 | - | - | - | - | 1.45 | 1.4301 |
| **Annual mean** | **2.047** | **2.999** | **3.450** | **3.432** | **3.388** | **2.365** | **2.367** |

**Table 2c. TP concentration of Alachua Sink in 2003 (all values in mg/L)**

| Sampling Date | S1 | S2 | S3 | S4 | S5 | S6 | Mean |
|---|---|---|---|---|---|---|---|
| 02/12/2003 | 0.96 | 0.96 | 0.93 | 0.96 | 0.96 | 0.96 | 0.96 |
| 03/12/2003 | 1.13 | 1.14 | 1.12 | 1.16 | 1.14 | 1.13 | 1.14 |
| 03/27/2003 | 0.65 | 0.70 | 0.65 | 0.67 | 0.66 | 0.66 | 0.67 |
| 05/07/2003 | 0.44 | 0.47 | - | - | - | 0.52 | 0.48 |
| 05/22/2003 | 0.21 | 0.22 | - | - | - | 0.22 | 0.22 |
| 06/09/2003 | 0.21 | 0.23 | - | - | - | 0.22 | 0.22 |
| 10/16/2003 | 0.08 | ---- | ---- | ---- | ---- | 0.06 | 0.07 |
| 12/09/2003 | 0.08 | ---- | ---- | ---- | ---- | 0.06 | 0.07 |
| **Annual mean** | **0.42** | **0.62** | **0.90** | **0.93** | **0.920** | **0.48** | **0.48** |

**Table 2d. Chl*a* concentration of Alachua Sink in 2003 (all values in micrograms per liter [µg/L])**

| Sampling Date | S1 | S2 | S3 | S4 | S5 | S6 | Mean |
|---|---|---|---|---|---|---|---|
| 02/12/2003 | 7.33 | 13.10 | 13.90 | 10.70 | 9.25 | 12.80 | 11.18 |
| 03/12/2003 | 1.71 | 1.18 | 1.31 | 2.52 | 1.07 | 2.52 | 1.72 |
| 03/27/2003 | 3.16 | 2.59 | 3.76 | 1.69 | 2.99 | 3.60 | 2.97 |
| 05/07/2003 | 10.7 | 14.5 | ---- | ---- | ---- | 45.60 | 23.60 |
| 05/22/2003 | 8.72 | 14.3 | ---- | ---- | ---- | 8.38 | 10.47 |
| 06/09/2003 | 10.9 | 10.6 | ---- | ---- | ---- | 17.60 | 13.03 |
| 10/16/2003 | 6.49 | ---- | ---- | ---- | ---- | 1.83 | 4.16 |
| 10/09/2003 | 3.86 | ---- | ---- | ---- | ---- | 4.07 | 3.96 |
| **Annual mean** | **5.87** | **9.38** | **6.32** | **4.97** | **4.44** | **12.05** | **8.89** |

### Table 2e. Mean TN/TP ratio and TSI based on all the sampling sites in Alachua Sink in 2003

| Sampling Date | TN/TP | TSI |
|---|---|---|
| 02/12/2003 | 5 | 73 |
| 03/12/2003 | 3 | 54 |
| 03/27/2003 | 4 | 56 |
| 05/07/2003 | 5 | 69 |
| 05/22/2003 | 8 | 61 |
| 06/09/2003 | 8 | 63 |
| 10/16/2003 | 16 | 49 |
| 12/09/2003 | 17 | 50 |
| **Annual mean** | **9** | **64**[*] |

[*] The values are calculated based on the annual average TN, TP, and chl*a* concentrations. The value is not a simple mean of the TSI values for each sampling event.

### Table 2f. TN concentration of Alachua Sink in 2004 (all values in mg/L)

| Sampling Date | S1 | S2 | Middle | S6 | Mean |
|---|---|---|---|---|---|
| 02/11/2004 | 1.84 | 2.38 |  | 2.38 | 2.20 |
| 05/19/2004 | 1.51 | 1.33 |  | 2.06 | 1.63 |
| 06/17/2004 |  |  | 1.4 |  | 1.4 |
| 07/21/2004 |  |  | 1.4 |  | 1.4 |
| 08/11/2004 |  |  | 1.8 |  | 1.8 |
| 09/23/2004 | 2.72 | 2.52 | 2.8 | 2.79 | 2.68 |
| **Annual mean** | **2.02** | **2.08** | **1.85** | **2.41** | **1.85** |

### Table 2g. TP concentration of Alachua Sink in 2004 (all values in mg/L)

| Sampling Date | S1 | S2 | Middle | S6 | Mean |
|---|---|---|---|---|---|
| 02/11/2004 | 0.19 | 0.35 |  | 0.26 | 0.27 |
| 05/19/2004 | 0.36 | 0.45 |  | 0.50 | 0.44 |
| 06/17/2004 |  |  | 0.67 |  | 0.67 |
| 07/21/2004 |  |  | 0.80 |  | 0.80 |
| 08/11/2004 |  |  | 0.69 |  | 0.69 |
| 09/23/2004 | 0.77 | 0.77 | 0.87 | 0.83 | 0.81 |
| **Annual mean** | **0.44** | **0.52** | **0.76** | **0.53** | **0.61** |

### Table 2h. Chl*a* concentration of Alachua Sink in 2004 (all values in μg/L)

| Sampling Date | S1 | S2 | Middle | S6 | Mean |
|---|---|---|---|---|---|
| 02/11/2004 | 5.33 | 1.65 |  | 3.22 | 3.40 |
| 05/19/2004 | 13.30 | 3.88 |  | 27.90 | 15.02 |
| 06/17/2004 |  |  | 45.2 |  | 45.2 |
| 07/21/2004 |  |  | 80.1 |  | 80.1 |
| 08/11/2004 |  |  | 4.7 |  | 4.7 |
| 09/23/2004 | 48.7 | 38.0 | 54.9 | 60.2 | 50.4 |
| **Annual mean** | **22.4** | **14.5** | **46.2** | **30.4** | **33.1** |

**Table 2i. Mean TN/TP ratio and TSI based on all the sampling sites in Alachua Sink in 2004**

| Sampling Date | TN/TP | TSI |
|---|---|---|
| 02/11/2004 | 8 | 55 |
| 05/19/2004 | 4 | 63 |
| 06/17/2004 | 2 | 69 |
| 07/21/2004 | 2 | 73 |
| 08/11/2004 | 3 | 56 |
| 09/23/2004 | 3 | 77 |
| **Annual mean** | **4** | **70***  |

* The values are calculated based on the annual average TN, TP, and chl*a* concentrations. The value is not a simple mean of the TSI values for each sampling event.

According to **Tables 2b** and **2c**, both TN and TP concentrations were high at the beginning of 2003 and gradually decreased towards the end of the year. Chl*a* concentrations peaked in May with a value of 23.60 µg/L, which is low considering that the TN and TP concentrations during the same period were 1.78 mg/L and 0.22 mg/L, respectively. The low mean chl*a* concentration (3.96 µg/L) observed by the end of the year could have been caused by shading from the heavy growth of floating aquatic plants (JEA, August 2005).

Except for the October sampling event, TN/TP ratios of all the other sampling events were lower than 10, suggesting that the aquatic communities were nitrogen limited. The annual average TSI calculated based on the annual average TN and chl*a* concentration is about 66, with individual values ranging between 49 and 73. Apparently, the TSI of Alachua Sink is lower during wet periods than during dry periods.

Based on **Table 2f,** TN concentrations in 2004 started to decline toward summer, and then increased sharply in September. A different pattern occurred in the TP measurements; concentrations increased after February and remained in the range of 0.6 mg/L to 0.8 mg/L throughout the year. Chl*a* concentrations peaked in the summer and declined in August, but increased again in September. As in 2003, TN/TP ratios indicated nitrogen limitation and TSI values averaged about 66.

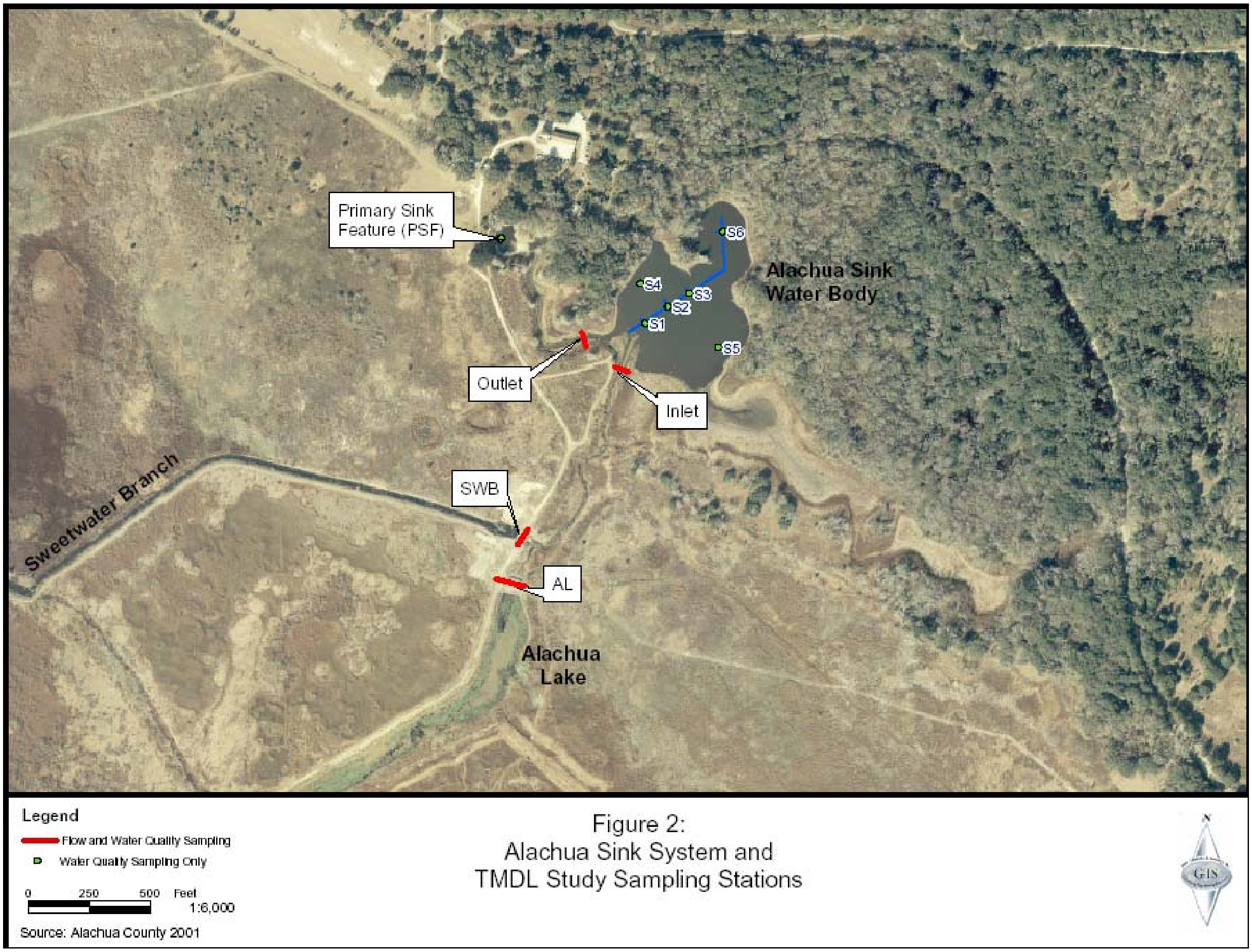

**Figure 2. Locations of JEA sampling sites**

***A total of 11 sites was sampled in 2003 in Alachua Sink. Among these sites, 6 were established in Alachua Sink (S1–S6), and 1 was set up in both the inlet and the outlet of the sink. Two sites were set up near the control structure. One of them was on the Alachua Lake side (AL), and the other was at the mouth of Sweetwater Branch (SWB). JEA also sampled the primary sink feature (PSF), which receives the discharge from Alachua Sink and discharges into the Floridan aquifer.***

# Chapter 3: DESCRIPTION OF APPLICABLE WATER QUALITY STANDARDS AND CRITERIA

Alachua Sink is classified as a Class III freshwater body, with a designated use of recreation, propagation, and maintenance of a healthy, well-balanced population of fish and wildlife. The Class III water quality criterion applicable to the observed impairment is the narrative nutrient criterion (in no case shall nutrient concentrations of a body of water be altered so as to cause an imbalance in natural populations of aquatic flora or fauna, Subsection 62-302.530(48)(b), F.A.C.).

Because Florida's current nutrient criterion is narrative only, a nutrient-related target was needed to represent levels at which an imbalance in flora or fauna is expected to occur. For lakes, the IWR threshold for impairment is based on the TSI and average color (PCUs). As Alachua Sink has a mean color greater than 40 PCUs, the IWR threshold for impairment is an annual mean TSI of 60, unless paleolimnological information indicates that the natural annual average TSI of Alachua Sink was different than 60.

The TSI originally developed by R. E. Carlson (1977) was calculated based on Secchi depth, chlorophyll concentration, and total phosphorus concentration, and was used to describe a lake's trophic state. Carlson's TSI was developed based on the assumption that lakes were all phosphorus limited. In Florida, because the local geology produced a phosphorus-rich soil, nitrogen can be the sole or co-limiting factor for phytoplankton populations in some lakes. In addition, because of the existence of dark-water 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 chl*a*, total nitrogen, and total phosphorus concentrations. The detailed calculation of TSI was described in the *Northwest Florida District Water Quality 1996 305(b) Technical Appendix* (Hand et al., 1996). The report also defines the limiting nutrient based on the TN/TP ratio. Phytoplankton communities are considered to be limited by nitrogen, phosphorus, or both nutrients if the TN/TP ratio is lower than 10, higher than 30, or falls between 10 and 30, respectively.

The Florida-specific TSI was determined based on the analysis of data from 313 Florida lakes. The index was adjusted so that a chl*a* concentration of 20 μg/L was equal to a TSI value of 60. A TSI of 60 was then set as the threshold for nutrient impairment for most lakes (for those with a color higher than 40 PCUs) because generally, phytoplankton may switch to communities dominated by blue-green algae at chl*a* 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 that could harm fish and other animals. In addition, the excessive growth of phytoplankton and the subsequent death of these algae may consume large quantities of dissolved oxygen (DO) and result in anaerobic conditions in lakes, making the conditions in an affected lake unfavorable for fish and other wildlife. All of these processes may negatively affect 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 that a lake was naturally above 60 historically, and the development of site-specific thresholds that better represent the levels at which nutrient impairment occurs. For this study, the Florida Department of Environmental Protection (Department) used modeling to estimate the natural background TSI by setting land uses to natural or forested land, and then compared the resulting TSI with the IWR thresholds. After the natural background TSI was determined, an increase of 5 TSI units above natural background was used as the water quality target for the TMDL.

Analyses of the current water quality condition of Alachua Sink indicate that the long-term annual average TN/TP ratio is less than 10, suggesting that the phytoplankton community of Alachua Sink is nitrogen limited. Therefore, TN is the focus of this analysis. The impact of changes in TP loading was also estimated to provide a complete view of the nutrient dynamics of the watershed.

# Chapter 4:  ASSESSMENT OF SOURCES

## 4.1  Overview of the TMDL Development Process

While TMDL development is a very complex process, the process used for this TMDL is divided into three main steps:

1. TN and TP loadings from various point and nonpoint sources of pollution to Alachua Sink were estimated using the Watershed Management Model (WMM).
2. Loading estimates from the WMM were entered into the Bathtub eutrophication model to establish the relationship between TN and TP loadings and in-lake TN, TP, and chl*a* concentrations.  The model results for in-lake TN, TP, and chl*a* were used to calculate the TSI-predicted (TSI-P) for several different loading scenarios discussed later.
3. The loadings to Alachua Sink were adjusted until the TSI-P calculated from the model was less than the target TSI.  The TN loadings that resulted in achieving the target TSI constituted the nutrient TMDL for Alachua Sink.

## 4.2  Types of Sources

An important part of the TMDL analysis is the identification of source categories, source subcategories, or individual sources of nutrients in the Alachua Sink 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 about the state and federal stormwater programs).

For the purposes of allocating pollutant load reductions required by a TMDL, 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. 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 section does not make any distinctions between the two.

## 4.3 Estimating TN and TP Loadings Using the WMM

### 4.3.1 Breakdown of Sub-basins and Land Uses

The majority of the surface water flowing into, or occurring in, Paynes Prairie drains through Alachua Sink. Alachua Sink receives surface water primarily from three sources: Sweetwater Branch, Alachua Lake, and the watershed area directly connecting to Alachua Sink **(Figure 3).** Sweetwater Branch collects surface runoff from the Sweetwater Branch watershed and part of the Extension Ditch watershed (UED).

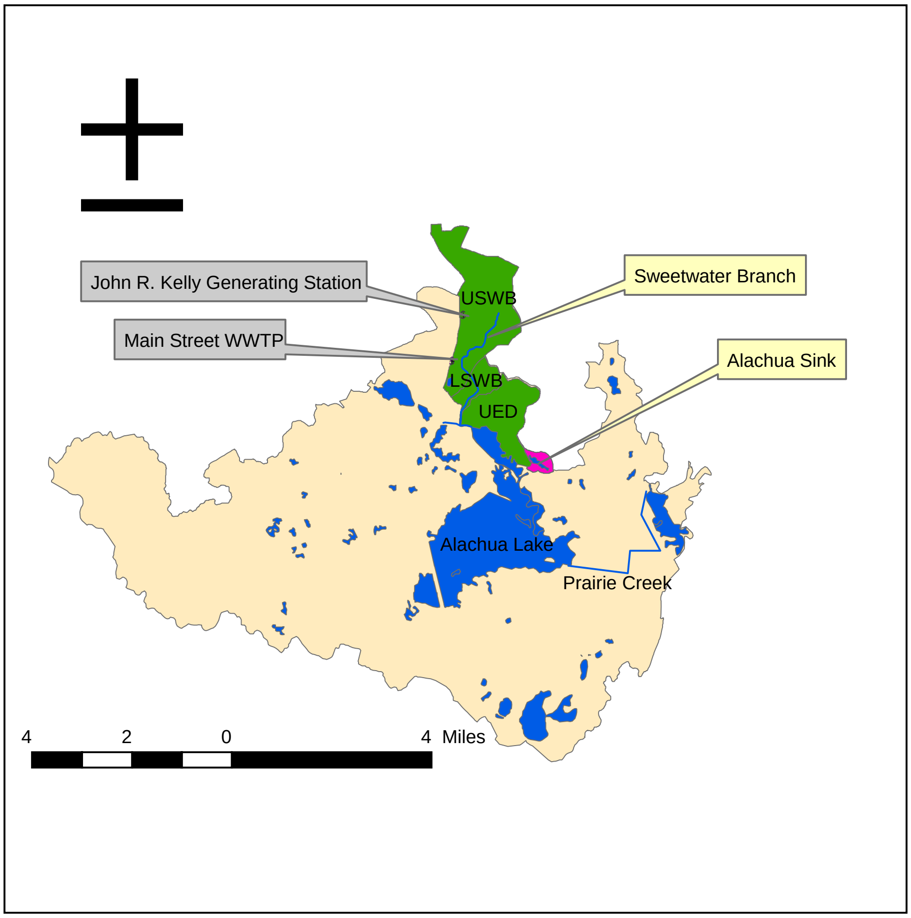

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**Figure 3. Delineation of the Paynes Prairie watershed**

***The area highlighted in green discharges into Sweetwater Branch, including Upper Sweetwater Branch (USWB) and Lower Sweetwater Branch (LSWB); the area highlighted in beige discharges into Alachua Lake; and the area highlighted in magenta discharges directly into Alachua Sink.***

There are two point sources in the watershed: the Main Street Domestic Wastewater Treatment Plant (WWTP) (Permit Number FL0027251) and the Gainesville Regional Utilities' (GRU) John R. Kelly Generating Station (Permit Number FL0026646). The Main Street Water Reclamation Facility is an advanced secondary activated sludge domestic wastewater treatment facility. The facility is permitted to discharge 7.5 mgd annual average daily flow to Sweetwater Branch **(Table 11).** The combined discharge from these facilities turns Sweetwater Branch from an intermittently flowing stream into an annual stream (Gottgens and Montague, 1988).

The John R. Kelly Generating Station is permitted to discharge 0.097 million gallons per day (mgd) directly into Sweetwater Branch. The facility discharges cooling tower blowdown and low-volume wastewater directly to Sweetwater Branch. Other waste streams, including cooling tower overflow, stormwater, pretreated metal cleaning wastes, and boiler blowdown are discharged to the municipal stormwater system and then to Sweetwater Branch **(Table 12).**

Surface runoff from the area labeled Alachua Lake/Paynes Prairie and highlighted in beige in **Figure 3** discharges into Alachua Lake. Portions of the water from Newnans Lake, located northeast of Paynes Prairie, are diverted into Alachua Lake through a control structure on Prairie Creek. A culverted structure controls the flow from Alachua Lake to Alachua Sink. The area highlighted in magenta in **Figure 3** discharges directly into Alachua Sink. Water discharged from Alachua Sink drains to ground water through a sinkhole located in the northeast corner of the Alachua Sink watershed.

For the purpose of calibrating the WMM, the Sweetwater Branch watershed was further divided into two sub-basins: Upper Sweetwater Branch (USWB) and Lower Sweetwater Branch (LSWB). Another area that discharges into Sweetwater Branch is the Upper Extension Ditch, which was designated as the UED sub-basin in this analysis **(Figure 3).**

Land use categories in each sub-basin were aggregated using the simplified Level I codes. **Table 3** lists the acreages of each land use category in areas that discharge directly into Alachua Sink, or through either Sweetwater Branch or Alachua Lake.

**Table 3. Classification of land use categories for Alachua Sink (in acres)**

| Code | Land Use | Directly into Alachua Sink | Through Sweetwater Branch | Through Alachua Lake |
|---|---|---|---|---|
| 1000 | Urban open | 0 | 686 | 1,384 |
| | Low-density residential | 6 | 133 | 2,453 |
| | Medium-density residential | 0 | 1,741 | 1,535 |
| | High-density residential | 0 | 54 | 505 |
| 2000 | Agriculture | 1 | 161 | 2,837 |
| 3000 | Rangeland | 0 | 55 | 674 |
| 8000 | Transportation, communication, and utilities | 0 | 94 | 593 |
| 4000 | Forest/rural open | 62 | 522 | 9,530 |
| 5000/6000 | Water/wetland | 52 | 640 | 15,756 |
| **Total** | | **121** | **4,087** | **35,286** |

### *4.3.2 Potential Sources of TN and TP in the Alachua Sink Watershed*

TN and TP loadings into Alachua Sink from the following sources were estimated for the loading analysis:

- Loading through surface runoff,
- Loading through atmospheric deposition directly into the sink,
- Loading from point sources that discharge into Sweetwater Branch (John R. Kelly Generating Station and Main Street WWTP), and
- Loading from septic tank leakage.

## 4.4 Estimating Watershed Loadings Using the WMM

As noted previously, the WMM was used to estimate TN and TP loading. The Department originally funded the development of the WMM model under contract to Camp Dresser and McKee (CDM). CDM further refined and developed the model to its present state. WMM is designed to estimate the annual or seasonal pollutant loadings from a given watershed and evaluate the effect of watershed management strategies on water quality (User's Manual: WMM, 1998). While the strength of the model is its capability to characterize pollutant loadings from nonpoint sources, such as stormwater runoff, stream baseflow, and septic tank leakage, the model also handles point sources such as discharge from wastewater treatment facilities. The estimation of pollution load reduction due to partial or full-scale implementation of on-site or regional best management practices (BMPs) is also part of the model's functions. The fundamental assumption of the model is that the stormwater runoff from any given land use is in direct proportion to annual rainfall, and is dictated by the portion of the land use category that is impervious and the runoff coefficients of both the pervious and impervious areas.

The governing equation for the model is:

$$R_L = [C_p + (C_I – C_p)\ IMP_L] * I \qquad (1)$$

Where:

$R_L$ = total average annual surface runoff from land use L (inches/year [in/yr]),
$IMP_L$ = fractional imperviousness of land use L,
$I$ = long-term average annual precipitation (in/yr),
$C_P$ = pervious area runoff coefficient, and
$C_I$ = impervious area runoff coefficient.

The model estimates pollutant loadings based on nonpoint pollution loading factors (expressed as pounds per acre per year [lbs/ac/yr]) that vary by land use and the percent imperviousness associated with each land use. The pollution loading factor $M_L$ is computed for each land use, L, by the following equation:

$$M_L = EMC_L * R_L * K \qquad (2)$$

Where:

$M_L$ = loading factor for land use L (lbs/ac/year),

$EMC_L$ = Event mean concentration (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 computed from Equation (1) (in/yr), and
K = 0.2266, a unit conversion constant.

Data required for WMM application include:

- Area of all the land use categories and the area served by septic tanks,
- Percent impervious area of each land use category,
- EMC for each pollutant type and land use category,
- Percent EMC of each pollutant type that is in suspended form,
- Annual precipitation, and
- Point source flows and pollutant concentrations.

The calibration of the WMM was conducted on both runoff quantity and quality. This was a two-step procedure, since the water quality calibration is a function of the predicted runoff volumes. The calibration of water quantity is usually achieved through adjusting the pervious and impervious area runoff coefficients. The typical ranges of runoff coefficients are 0.05 to 0.30 for pervious area (User’s Manual: WMM, 1998) and 0.85 to 1.0 for impervious area (Linsley and Franziani, 1979).

After the water quantity calibration, water quality was calibrated by adjusting the pollutant delivery ratio—i.e., the percentage of pollutant in the surface runoff that is eventually delivered to the destination waterbody. In this analysis, the range of the pollutant delivery ratio was estimated using the method developed by Roehl (1962) that correlates the delivery ratio to watershed area.

### *4.4.1 Estimating Sub-basin Loadings Using the WMM*

As described in the previous section, Alachua Sink receives surface water from Sweetwater Branch, Alachua Lake, and the area directly connecting to Alachua Sink. To estimate the nutrient load from Sweetwater Branch using the WMM, the model was first set up through calibration against the flow data collected at a USGS flow gauging station located on the middle reach of the stream (Site Name: Sweetwater Branch at Gainesville, FL, Site ID: 02240988) **(Figure 4).** The Sweetwater Branch watershed was divided into upper and lower sub-basins during the analysis (Upper Sweetwater Branch [USWB] and Lower Sweetwater Branch [LSWB]) to take advantage of the flow data documented for this gauging station, and model calibration was conducted with the data for USWB.

There were seven full years of daily flow data available for the gauging station (1998–2004). The WMM model was calibrated using flow data for 1998, 1999, and 2000, and the calibrated model was then used to simulate the flow and TN and TP loadings from 2001 through 2004, based on the rainfall and point source discharge data for these years. Because no full-year flow data were available for other areas of Paynes Prairie at the time this analysis was conducted, the WMM calibration for USWB was applied to all the other sub-basins to simulate surface runoff.

No water quality calibration was conducted for the WMM because of the lack of reliable stream water quality data from 1998 through 2002. Model input parameters for TN and TP loading estimation were based on literature values (discussed in a later section). Comparing the TN and TP loadings estimated using these model parameters with the TN and TP loading estimates obtained by a loading analysis conducted by JEA (Alan Foley, personal communication, 2003) indicated a very close match, suggesting that the water quality parameters used in this analysis are reasonably accurate.

To estimate TN and TP loadings into Alachua Sink from Alachua Lake, the discharge from Alachua Lake into Alachua Sink and the TN and TP concentrations of the discharge were required. However, these data were not available for the period from 2000 through 2002. To estimate water quality in Alachua Lake, the WMM model was used to evaluate how the land use pattern of the Alachua Lake watershed influences the water quality of Alachua Lake. The WMM model (calibrated using the USGS gauging station discussed above) was applied to the entire Alachua Lake watershed to estimate the nonpoint flow and TN and TP loadings into Alachua Lake. Average TN and TP concentrations of Alachua Lake from 2000 through 2002 were then simulated using the calibrated Bathtub model.

Some preliminary model runs indicated that estimated chl*a* concentrations did not match with measured values. After consulting with JEA, the Department found that floating macrophytes and aquatic plants heavily covered a significant portion of the Alachua Lake area immediately above the Alachua Sink sampling site. Even if phytoplankton can grow normally in other parts of Alachua Sink, when water flows through this macrophyte-dominated area, a significant portion of the algal biomass is lost due to the shading and filtering effects of the macrophytes. This may have resulted in the low chl*a* concentration in the Alachua Lake water that reached the control structure. This interpretation is consistent with the findings from JEA's study that the percent phaeophytin in the total chl*a* concentration remained high during all the sampling events, indicating that a significant portion of the algal biomass was dead. To adjust for the effects of the floating macrophytes, the chl*a* concentration from Alachua Lake was assumed to be a constant and was set at the annual mean of the chl*a* concentrations measured by JEA.

Because of the low discharge through the control structure at the outlet of Alachua Lake from 2000 through 2002, it was inappropriate to assume that the amount of water discharged into Alachua Lake was the same amount of water being conveyed into Alachua Sink. Therefore, for model runs over the 2000–02 period, the flow from Alachua Lake to Alachua Sink was obtained by calibrating the Bathtub model against the water quality data for Alachua Sink (2000–02). In contrast, for the simulations of 2003 and 2004, flows from Alachua Lake to Alachua Sink predicted by the Alachua Lake Bathtub model were used as the Bathtub input for Alachua Sink.

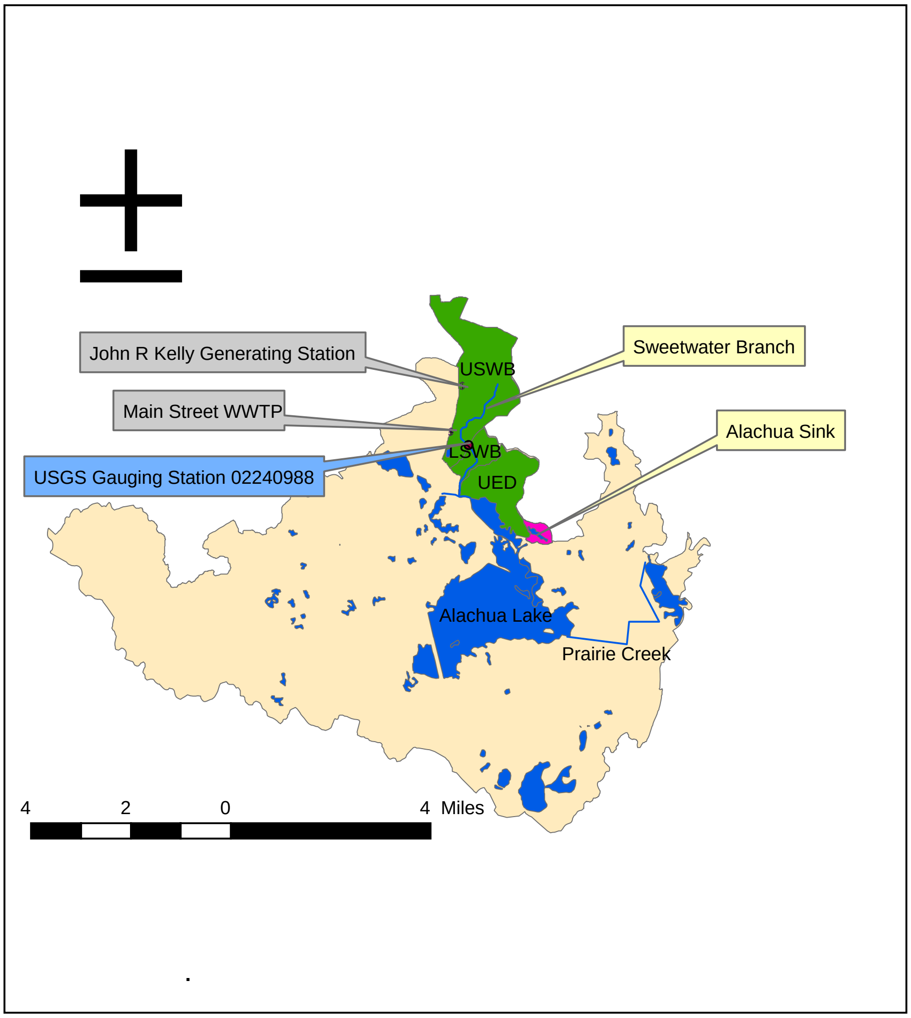


**Figure 4. Location of the USGS gauging station (Site ID: 02240988) used for flow calibration**

### *4.4.2 Data Required for Estimating TN and TP Loadings from Point and Nonpoint Sources Using the WMM*

To calibrate the flow estimates of the WMM, the following data were used:

A. *Rain precipitation data* from the weather station located at the Gainesville Regional Airport (UCAN 3964, COOP 083326) were retrieved from the Climate Interactive Rapid Retrieval User System (CIRRUS) hosted by the Southeast Regional Climate Center. **Table 4** lists annual average precipitation and seasonal variation. The annual average precipitation for 1998, 1999, 2000, 2001, 2002, 2003, and 2004 was calculated based on the whole-year daily rainfall.

**Table 4. Annual precipitation at Gainesville Regional Airport, 1998–2004**

| Year | Annual Precipitation | |
|---|---|---|
| | (in/year) | (meters [m]/yr) |
| 1998 | 45.62 | 1.16 |
| 1999 | 38.34 | 0.97 |
| 2000 | 34.39 | 0.87 |
| 2001 | 42.14 | 1.07 |
| 2002 | 55.33 | 1.41 |
| 2003 | 46.62 | 1.18 |
| 2004 | 58.33 | 1.48 |

B. The SJRWMD provided *daily flow data* for the gauging station on Sweetwater Branch from 1997 through 2004. This analysis excluded the 1997 data because only random measurements were available for each month from January to September, and this was not sufficiently accurate for annual flow calculation. The daily flow data for the other years (1998–2004) were aggregated into annual flows and listed in **Table 5.**

**Table 5. Annual stream flow of Sweetwater Branch at USGS Gauging Station 02240988, 1998–2004**

| Year | Annual Stream Flow | |
|---|---|---|
| | (acre-feet/year [ac-ft/yr]) | (cubic hectometers/year [$hm^3$/yr]) |
| 1998 | 11,238 | 13.9 |
| 1999 | 8,973 | 11.1 |
| 2000 | 8,029 | 9.9 |
| 2001 | 9,767 | 12.1 |
| 2002 | 8,455 | 10.4 |
| 2003 | 9,567 | 11.8 |
| 2004 | 9,538 | 11.8 |

C. *Areas of different land use categories* for each sub-basin were obtained by aggregating the GIS land use coverage based on the simplified Level I code listed in **Table 3. Table 6** lists the acreage of each land use category for each sub-basin. **Table 7** lists the percent area that each land use occupies in each sub-basin.

**Table 6. Area of each land use category of the watershed that discharges into Alachua Sink through Sweetwater Branch**

| Land Use Type | Acreage | | | | |
|---|---|---|---|---|---|
| | USWB | LSWB | UED | Alachua Sink (AS) | Alachua Lake (AL) |
| Forest/rural open | 136 | 94 | 292 | 62 | 9,530 |
| Urban open | 608 | 60 | 18 | 0 | 1,384 |
| Agriculture | 8 | 9 | 144 | 1 | 2,837 |
| Low-density residential | 25 | 106 | 2 | 6 | 2,453 |
| Medium-density residential | 808 | 833 | 100 | 0 | 1,535 |
| High-density residential | 54 | 0 | 0 | 0 | 505 |
| Communication and transportation | 90 | 5 | 0 | 0 | 593 |
| Rangeland | 5 | 39 | 11 | 0 | 674 |
| Water/wetland | 87 | 56 | 498 | 52 | 15,756 |
| **Total** | **1,820** | **1,202** | **1,065** | **121** | **35,287** |

**Table 7. Percent area of each land use category in each sub-basin**

| Land Use Type | Percent Area of Each Land Use Category | | | | |
|---|---|---|---|---|---|
| | USWB | LSWB | UED | AS | AL |
| Forest/rural open | 7 | 8 | 27 | 51 | 27 |
| Urban open | 33 | 5 | 2 | 0 | 4 |
| Agriculture | < 1 | 1 | 14 | 1 | 8 |
| Low-density residential | 1 | 9 | 0 | 5 | 7 |
| Medium-density residential | 44 | 69 | 9 | 0 | 4 |
| High-density residential | 3 | 0 | 0 | 0 | 1 |
| Communication and transportation | 5 | < 1 | < 1 | 0 | 2 |
| Rangeland | < 1 | 3 | 1 | 0 | 2 |
| Water/wetland | 5 | 5 | 47 | 43 | 45 |

As shown in **Table 7,** areas occupied by urban and residential land uses (including low-, medium-, and high-density residential areas) appear to be the dominant land uses for the USWB and LSWB sub-basins. The total areas of these land use types account for 82% and 83% of the total watershed area in the USWB and LSWB, respectively. In contrast, in the AS and AL sub-basins, which contain more natural land use types, including forest/rural open and water/wetland, predominate. The areas occupied by these land use types represent 94% and 72% of the total watershed area in the AS and AL sub-basins, respectively.

The watershed area that discharges to Alachua Sink through Sweetwater Branch appears to be influenced more by urban and residential land uses than the watershed area discharging through Alachua Lake. For the 4,087 acres that discharge into Sweetwater Branch, 2,615 acres are occupied by urban open and residential land uses, which account for 64% of the total watershed area. About 5,878 acres out of 35,286 acres of the watershed discharging into Alachua Lake is dominated by urban and residential land uses, which account for about 17% of total land uses.

D. *Percent impervious area* of each land use category is a very important parameter in estimating surface runoff using the WMM. Nonpoint pollution monitoring studies throughout the United States over the past 15 years have shown that annual "per acre" discharges of urban stormwater pollution are positively related to the amount of imperviousness in a land use (User's Manual: WMM, 1998). Ideally, *impervious area* is considered as the area that does not retain water, and therefore, 100% of the precipitation falling on the impervious area should become surface runoff. In practice, however, the runoff coefficient for impervious area typically ranges between 95% and 100%. Impervious runoff coefficients lower than this range were observed in the literature, but usually this number should not be lower than 80%. For pervious area, the runoff coefficient usually ranges between 10% and 20%. However, values lower than this range were also observed (User's Manual: WMM, 1998). In this analysis, impervious and pervious runoff coefficients were adjusted to fit model estimates to measured data in the process of WMM water quantity calibration.

It should be noted that the impervious area percentages do not necessarily represent directly connected impervious area (DCIA). Using a single-family residence as an example, rain falls on rooftops, sidewalks, and driveways. The sum of these areas may represent 30% of the total lot. However, much of the rain that falls on the roof drains to the grass and infiltrates to the ground or runs off the property, and thus does not run directly to the street. For the WMM modeling, whenever the area of the watershed that contributes to the surface runoff was considered, DCIA was used in place of impervious area. Because local values were not available, DCIAs used in this analysis were collected from literature-published values or results from other studies **(Table 8).**

**Table 8. Percent directly connected impervious area for different land use categories**

| Land Use Categories | DCIA | Reference |
|---|---|---|
| Forest/rural open | 0.5% | User's Manual: WMM, 1998 |
| Urban open | 15.4% | User's Manual: WMM, 1998 |
| Agriculture | 3.7% | Brown, 1995 |
| Low-density residential | 27.9% | User's Manual: WMM, 1998 |
| Medium-density residential | 64.2% | User's Manual: WMM, 1998 |
| High-density residential | 79.5% | User's Manual: WMM, 1998 |
| Communication and transportation | 36.20% | Brown, 1995 |
| Rangeland | 3.7% | CDM |
| Water/wetland | 30% | Harper and Livingston, 1999 |

E. *Local EMCs of TN and TP for different land use categories* were not available and therefore were obtained from literature values **(Table 9).**

**Table 9. EMCs of TN and TP for different land use categories**

| Land Use Categories | TN (mg/L) | TP (mg/L) | Reference |
|---|---|---|---|
| Forest/rural open | 1.25 | 0.053 | Lasi, 1999 |
| Urban open | 1.59 | 0.220 | Lasi, 1999 |
| Agriculture | 2.58 | 0.465 | Lasi, 1999 |
| Low-density residential | 1.77 | 0.177 | Lasi, 1999 |
| Medium-density residential | 2.29 | 0.300 | Lasi, 1999 |
| High-density residential | 2.42 | 0.490 | Lasi, 1999 |
| Communication and transportation | 2.08 | 0.340 | Lasi, 1999 |
| Rangeland | 1.25 | 0.053 | Lasi, 1999 |
| Water/wetland | 1.60 | 0.189 | Lasi, 1999 |

The EMCs of TN and TP for most land use categories were cited from a review prepared by Harper (1992). The review directly provided the EMCs for agriculture, low-density residential, and water/wetland. However, Harper did not directly define the EMCs for urban open, medium- and high-density residential, transportation and communication, and rangeland. Therefore, some extrapolations were made between the land use categories in this analysis and the land use categories defined by Harper. Basically, the urban open area was treated as the low-intensity commercial area in Harper’s review. Medium-density residential was treated as single-family land use; high-density residential was treated as multifamily land use; transportation and communication was treated mainly as highway; and rangeland was treated the same as general agriculture.

F. Not all of the TN and TP transported by stormwater are in the dissolved form. The WMM allows the *percentage of the total EMC represented by TN and TP attached to suspended particles* to be defined. This analysis used percent suspended TN and TP values reported by Lasi (1999) for the Orange Lake watershed **(Table 10).**

**Table 10. Percent TP and TN in suspended form for different land use categories**

| Land Use Categories | TP | TN |
|---|---|---|
| Forest/rural open | 28% | 6% |
| Urban open | 57% | 44% |
| Agriculture | 38% | 20% |
| Low-density residential | 57% | 44% |
| Medium-density residential | 57% | 44% |
| High-density residential | 57% | 44% |
| Communication and transportation | 57% | 44% |
| Rangeland | 38% | 20% |
| Water/wetland | 48% | 77% |

G. The s*ediment delivery ratio* determines how much TN and TP attaching to suspended particles will eventually be delivered to the destination waterbody. In this analysis, the range of the sediment delivery ratio was estimated using the correlation between delivery ratio and watershed area, developed by Roehl (1962), which is 30%.

H. To estimate the TN and TP loadings from the *leakage of septic tanks*, the WMM incorporates the concept of a "septic tank failure loading rate," which defines the percent increase of TN and TP loadings from the land use area with septic tank leakage. The range of loading increase recommended by the WMM User's Manual is a 160% to 250% increase for TP and a 140% to 200% increase for TN. To provide a margin of safety, this analysis adopted the high end of the range in the User's Manual.

I. Another value required by the WMM to estimate the influence from leaking septic tanks on TN and TP loading is the "septic tank failure rate," which defines the frequency with which septic tanks may fail. Studies conducted on water quality in the Ocklawaha Basin found that the annual frequency of septic tank repairs was about 0.97% (Department, 2001). For average annual conditions, it is conservative to assume that septic tank system failures would be unnoticed or ignored for 5 years before repair or replacement occurred (User's Manual: WMM, 1998). Therefore, the septic tank failure rate used in this analysis was calculated by multiplying the repair frequency (0.97%/year) by 5 (years). The result was about 5%.

J. As mentioned previously, there are two point sources in the Upper Sweetwater Branch sub-basin: GRU's John R. Kelly Generating Station (Permit Number: FL0026646) and the Main Street WWTP (Permit Number: FL0027251) **(Figure 1).** GRU provided the annual average daily discharge and the TN and TP concentrations of the discharge from the Main Street WWTP from 1998 through 2004. **Table 11** lists the annual average daily discharge and TN and TP concentrations of the discharges calculated on the basis of these data from 1998 through 2004.

   The discharge permit for the John R. Kelly Generating Station does not require effluent monitoring for either TN or TP, and the only available TN and TP concentrations of the discharge were from two bioassays conducted by the Department in 1991 and 2002. The TN and TP concentrations listed in **Table 12** are the mean values from the TN and TP concentrations of the two bioassays.

**Table 11. Annual average daily discharge and TN and TP concentrations in the discharge from the Main Street WWTP, 1998–2004**

| Year | Daily Discharge (mgd) | TN (mg/L) | TP (mg/L) |
|---|---|---|---|
| 1998 | 7.14 | 4.12 | 0.54 |
| 1999 | 5.36 | 5.29 | 0.86 |
| 2000 | 5.34 | 4.89 | 0.53 |
| 2001 | 6.20 | 5.56 | 1.06 |
| 2002 | 6.05 | 4.41 | 1.07 |
| 2003 | 6.53 | 4.46 | 0.77 |
| 2004 | 5.49 | 3.94 | 0.53 |

**Table 12. Estimated annual average daily discharge and effluent TN and TP concentrations for the John R. Kelly Generating Station, 1998–2004**

| Year | Daily Discharge (mgd) | TN (mg/L) | TP (mg/L) |
|---|---|---|---|
| 1998 | 0.141 | 2.02 | 0.910 |
| 1999 | 0.158 | 2.02 | 0.910 |
| 2000 | 0.119 | 2.02 | 0.910 |
| 2001 | 0.092 | 2.02 | 0.910 |
| 2002 | 0.170 | 2.02 | 0.910 |
| 2003 | 0.102 | 2.02 | 0.910 |
| 2004 | 0.236 | 2.02 | 0.910 |

### 4.4.3 WMM Flow Calibration

The calibration of the WMM on water quantity was primarily conducted by adjusting the runoff coefficients for pervious and impervious land use area to fit the estimates to the actual measurements. **Table 13** lists observations, WMM predictions, errors, and pervious and impervious runoff coefficients for the USB. From the table it can be seen that the model predicted the measured flows reasonably well.

**Table 13. Results of the WMM dry period water quantity calibration for the USWB, 1998–2004**

| Year | Measured Annual Flow (ac-ft/yr) | Estimated Annual Flow (ac-ft/yr) | Pervious Runoff Coefficient | Impervious Runoff Coefficient | Percent Error |
|---|---|---|---|---|---|
| 1998 | 11,238 | 11,076 | 0.10 | 0.90 | -1.4 |
| 1999 | 8,973 | 8,614 | 0.10 | 0.90 | -4.0 |
| 2000 | 8,029 | 8,298 | 0.10 | 0.90 | 3.4 |
| 2001 | 9,767 | 9,691 | 0.10 | 0.90 | -0.8 |
| 2002 | 8,455 | 10,475 | 0.10 | 0.90 | 23.9 |
| 2003 | 9,567 | 10,383 | 0.10 | 0.90 | 8.5 |
| 2004 | 9,538 | 10,124 | 0.10 | 0.90 | 6.1 |

### 4.4.4 WMM Flow Simulation

Keeping all of the model input parameters discussed above the same, the calibrated WMM model was then used to simulate surface runoff from all the other sub-basins from 2000 through 2004, since this represented the period when water quality data for Alachua Sink were available **(Table 14).**

**Table 14. Estimated annual flow (ac-ft/yr) for each sub-basin, 2000–04**

| Year | USWB | LSWB | UED | AS | AL |
|---|---|---|---|---|---|
| 2000 | 8,298 | 1,707 | 819 | 73 | 27,081 |
| 2001 | 9,691 | 2,092 | 1,003 | 92 | 33,184 |
| 2002 | 10,475 | 2,747 | 1,318 | 120 | 43,571 |
| 2003 | 10,383 | 2,314 | 1,110 | 101 | 20,812 |
| 2004 | 10,124 | 2,896 | 1,389 | 126 | 45,933 |

### 4.4.5 WMM TN and TP Loading Estimation

Using the EMCs, the percentage of nutrients in suspended form, sediment delivery ratio, and septic tank failure rate discussed in the previous sections, TN and TP loadings were estimated for all the sub-basins from 2000 through 2004 **(Table 15).**

**Table 15. Predicted TN and TP loadings (pounds per year [lbs/yr]) for each sub-basin, 2000–04**

| Year | USWB | | LSWB | | UED | | AS | | AL | |
|---|---|---|---|---|---|---|---|---|---|---|
| | TN | TP | TN | TP | TN | TP | TN | TP | TN | TP |
| 2000 | 90,248 | 10,456 | 8,367 | 1,238 | 2,537 | 370 | 184 | 21 | 81,102 | 11,842 |
| 2001 | 117,679 | 22,105 | 10,252 | 1,517 | 3,109 | 453 | 225 | 26 | 99,379 | 14,510 |
| 2002 | 98,347 | 22,621 | 13,461 | 1,992 | 4,082 | 595 | 296 | 34 | 130,485 | 19,052 |
| 2003 | 103,004 | 17,723 | 11,342 | 1,678 | 3,440 | 502 | 249 | 30 | 109,944 | 16,053 |
| 2004 | 84,245 | 11,987 | 15,275 | 2,100 | 4,304 | 628 | 312 | 38 | 137,560 | 20,085 |

As shown in **Table 15,** TN and TP loadings from Upper Sweetwater Branch were always important. The only sub-basin that contributed a similar amount of TN and TP to Upper Sweetwater Branch was Alachua Lake. However, the lake has a much larger area than Upper Sweetwater Branch **(Table 6),** and a significant portion of the TN and TP loadings from the Alachua Lake sub-basin would be attenuated in the lake before being introduced into Alachua Sink. Therefore, it is reasonable to say that the water quality of Alachua Sink was most significantly influenced by the TN and TP loadings from Upper Sweetwater Branch.

**Tables 16** through 19 list the TN and TP loadings from various point and nonpoint sources. **Tables 16** through **17** list the TN and TP loadings to Alachua Sink through Sweetwater Branch and the area directly connecting to Alachua Sink. **Tables 16a–e** list the TN loading from various point and nonpoint sources in 2000, 2001, 2002, 2003, and 2004, respectively. **Tables 17a–e** list the TP loading from various point and nonpoint sources. **Tables 18** through **19** list TN and TP loadings into Alachua Lake.

**Table 16a. Contribution of TN (lbs/yr) from different sources in the watershed that discharged into Alachua Sink through Sweetwater Branch in 2000**

| Land Use Type or Source | USWB | LSWB | UED | AS | Total | Percent Contribution |
|---|---|---|---|---|---|---|
| Forest/rural open | 131 | 91 | 283 | 60 | 565 | 0.6% |
| Urban open | 1,165 | 115 | 35 | 0 | 1,315 | 1.3% |
| Agriculture | 17 | 21 | 323 | 1 | 363 | 0.4% |
| Low-density residential | 76 | 327 | 6 | 18 | 565 | 0.6% |
| Medium-density residential | 6,125 | 6,313 | 756 | 0 | 13,195 | 13.0% |
| High-density residential | 520 | 0 | 0 | 0 | 520 | 0.5% |
| Transportation/communication | 392 | 20 | 0 | 0 | 413 | 0.4% |
| Rangeland | 6 | 42 | 12 | 0 | 60 | 0.1% |
| Water/wetland | 168 | 109 | 969 | 101 | 1,347 | 1.3% |
| Septic tank | 1,344 | 1,328 | 153 | 4 | 2,829 | 2.8% |
| Main Street WWTP | 79,563 | - | - | - | 79,563 | 78.5% |
| J. R. Kelly Generating Station | 738 | - | - | - | 738 | 0.7% |
| **Subtotal** | **90,248** | **8,367** | **2,537** | **184** | **101,336** | **100%** |

### Table 16b. Contribution of TN (lbs/yr) from different sources in the watershed that discharged into Alachua Sink through Sweetwater Branch in 2001

| Land Use Type or Source | USWB | LSWB | UED | AS | Total | Percent Contribution |
|---|---|---|---|---|---|---|
| Forest/rural open | 161 | 112 | 346 | 74 | 693 | 0.5% |
| Urban open | 1,428 | 141 | 43 | 0 | 1,612 | 1.2% |
| Agriculture | 21 | 26 | 396 | 2 | 445 | 0.3% |
| Low-density residential | 94 | 401 | 8 | 22 | 525 | 0.4% |
| Medium-density residential | 7,506 | 7,736 | 927 | 0 | 16,168 | 12.3% |
| High-density residential | 637 | 0 | 0 | 0 | 637 | 0.5% |
| Transportation/communication | 481 | 25 | 0 | 0 | 506 | 0.4% |
| Rangeland | 7 | 51 | 15 | 0 | 73 | 0.1% |
| Water/wetland | 206 | 133 | 1,187 | 123 | 1,650 | 1.3% |
| Septic tank | 1,647 | 1,627 | 187 | 4 | 3,466 | 2.6% |
| Main Street WWTP | 104,925 | - | - | - | 104,925 | 79.9% |
| J. R. Kelly Generating Station | 566 | - | - | - | 566 | 0.4% |
| **Subtotal** | **117,679** | **10,252** | **3,109** | **225** | **131,266** | **100.0%** |

### Table 16c. Contribution of TN (lbs/yr) from different sources in the watershed that discharged into Alachua Sink through Sweetwater Branch in 2002

| Land Use Type or Source | USWB | LSWB | UED | AS | Total | Percent Contribution |
|---|---|---|---|---|---|---|
| Forest/rural open | 211 | 147 | 455 | 97 | 910 | 0.8% |
| Urban open | 1,875 | 185 | 57 | 0 | 2,116 | 1.8% |
| Agriculture | 28 | 34 | 520 | 2 | 584 | 0.5% |
| Low-density residential | 123 | 527 | 10 | 29 | 689 | 0.6% |
| Medium-density residential | 9,855 | 10,157 | 1,217 | 0 | 21,229 | 18.3% |
| High-density residential | 837 | 0 | 0 | 0 | 837 | 0.7% |
| Transportation/communication | 631 | 33 | 0 | 0 | 664 | 0.6% |
| Rangeland | 9 | 68 | 20 | 0 | 96 | 0.1% |
| Water/wetland | 271 | 175 | 1,559 | 162 | 2,166 | 1.9% |
| Septic tank | 2,163 | 2,137 | 245 | 6 | 4,551 | 3.9% |
| Main Street WWTP | 81,298 | - | - | - | 81,298 | 70.0% |
| J. R. Kelly Generating Station | 1,046 | - | - | - | 1,046 | 0.9% |
| **Subtotal** | **98,347** | **13,461** | **4,082** | **296** | **116,187** | **100.0%** |

### Table 16d. Contribution of TN (lbs/yr) from different sources in the watershed that discharged into Alachua Sink through Sweetwater Branch in 2003

| Land Use Type or Source | USWB | LSWB | UED | AS | Total | Percent Contribution |
|---|---|---|---|---|---|---|
| Forest/rural open | 178 | 124 | 383 | 81 | 766 | 0.6% |
| Urban open | 1,580 | 155 | 48 | 0 | 1,783 | 1.5% |
| Agriculture | 23 | 29 | 438 | 2 | 492 | 0.4% |
| Low-density residential | 104 | 444 | 9 | 25 | 581 | 0.5% |
| Medium-density residential | 8,304 | 8,558 | 1,025 | 0 | 17,887 | 15.2% |
| High-density residential | 705 | 0 | 0 | 0 | 705 | 0.6% |
| Transportation/communication | 532 | 27 | 0 | 0 | 559 | 0.5% |
| Rangeland | 8 | 57 | 16 | 0 | 81 | 0.1% |
| Water/wetland | 228 | 148 | 1,313 | 136 | 1,825 | 1.5% |
| Septic tank | 1,823 | 1,800 | 207 | 5 | 3,835 | 3.2% |
| Main Street WWTP | 88,720 | - | - | - | 88,720 | 75.2% |
| J. R. Kelly Generating Station | 800 | - | - | - | 800 | 0.7% |
| **Subtotal** | **103,004** | **11,342** | **3,440** | **249** | **118,035** | **100.0%** |

### Table 16e. Contribution of TN (lbs/yr) from different sources in the watershed that discharged into Alachua Sink through Sweetwater Branch in 2004

| Land Use Type or Source | USWB | LSWB | UED | AS | Total | Percent Contribution |
|---|---|---|---|---|---|---|
| Forest/rural open | 223 | 156 | 479 | 102 | 960 | 0.9% |
| Urban open | 1,977 | 207 | 60 | 0 | 2,243 | 2.2% |
| Agriculture | 29 | 37 | 548 | 2 | 616 | 0.6% |
| Low-density residential | 130 | 598 | 11 | 31 | 770 | 0.7% |
| Medium-density residential | 10,390 | 11,716 | 1,283 | 0 | 23,389 | 22.5% |
| High-density residential | 882 | 0 | 0 | 0 | 882 | 0.8% |
| Transportation/communication | 666 | 37 | 0 | 0 | 703 | 0.7% |
| Rangeland | 9 | 73 | 21 | 0 | 103 | 0.1% |
| Water/wetland | 286 | 199 | 1,643 | 171 | 2,299 | 2.2% |
| Septic tank | 2,280 | 2,253 | 259 | 6 | 4,798 | 4.6% |
| Main Street WWTP | 65,922 | - | - | - | 65,922 | 63.3% |
| J. R. Kelly Generating Station | 1,452 | - | - | - | 1,452 | 1.4% |
| **Subtotal** | **84,245** | **15,275** | **4,304** | **312** | **104,136** | **100.0%** |

### Table 17a. Contribution of TP (lbs/yr) from different sources in the watershed that discharged into Alachua Sink through Sweetwater Branch in 2000

| Land Use Type or Source | USWB | LSWB | UED | AS | Total | Percent Contribution |
|---|---|---|---|---|---|---|
| Forest/rural open | 5 | 3 | 10 | 2 | 20 | 0.2% |
| Urban open | 140 | 14 | 4 | 0 | 158 | 1.3% |
| Agriculture | 3 | 3 | 50 | 0 | 56 | 0.5% |
| Low-density residential | 7 | 28 | 1 | 2 | 37 | 0.3% |
| Medium-density residential | 697 | 718 | 86 | 0 | 1,501 | 12.4% |
| High-density residential | 91 | 0 | 0 | 0 | 91 | 0.8% |
| Transportation/communication | 56 | 3 | 0 | 0 | 59 | 0.5% |
| Rangeland | 0 | 2 | 0 | 0 | 2 | 0.0% |
| Water/wetland | 29 | 19 | 167 | 17 | 232 | 1.9% |
| Septic tank | 477 | 448 | 52 | 0 | 977 | 8.1% |
| Main Street WWTP | 8,622 | - | - | - | 8,622 | 71.3% |
| J. R. Kelly Generating Station | 330 | - | - | - | 330 | 2.7% |
| **Subtotal** | **10,456** | **1,238** | **370** | **21** | **12,086** | **100.0%** |

### Table 17b. Contribution of TP (lbs/yr) from different sources in the watershed that discharged into Alachua Sink through Sweetwater Branch in 2001

| Land Use Type or Source | USWB | LSWB | UED | AS | Total | Percent Contribution |
|---|---|---|---|---|---|---|
| Forest/rural open | 6 | 4 | 12 | 3 | 25 | 0.1% |
| Urban open | 171 | 17 | 5 | 0 | 193 | 0.8% |
| Agriculture | 3 | 4 | 61 | 0 | 68 | 0.3% |
| Low-density residential | 8 | 35 | 1 | 2 | 46 | 0.2% |
| Medium-density residential | 854 | 880 | 105 | 0 | 1,840 | 7.6% |
| High-density residential | 112 | 0 | 0 | 0 | 112 | 0.5% |
| Transportation/communication | 68 | 4 | 0 | 0 | 72 | 0.3% |
| Rangeland | 0 | 2 | 1 | 0 | 3 | 0.0% |
| Water/wetland | 36 | 23 | 205 | 21 | 284 | 1.2% |
| Septic tank | 585 | 549 | 64 | 1 | 1,198 | 5.0% |
| Main Street WWTP | 20,007 | - | - | - | 20,007 | 83.0% |
| J. R. Kelly Generating Station | 255 | - | - | - | 255 | 1.1% |
| **Subtotal** | **22,105** | **1,517** | **453** | **27** | **24,103** | **100.0%** |

**Table 17c. Contribution of TP (lbs/yr) from different sources in the watershed that discharged into Alachua Sink through Sweetwater Branch in 2002**

| Land Use Type or Source | USWB | LSWB | UED | AS | Total | Percent Contribution |
|---|---|---|---|---|---|---|
| Forest/rural open | 8 | 5 | 16 | 3 | 33 | 0.1% |
| Urban open | 225 | 22 | 7 | 0 | 254 | 1.0% |
| Agriculture | 4 | 5 | 80 | 0 | 90 | 0.4% |
| Low-density residential | 11 | 46 | 1 | 3 | 60 | 0.2% |
| Medium-density residential | 1,121 | 1,156 | 138 | 0 | 2,415 | 9.6% |
| High-density residential | 147 | 0 | 0 | 0 | 147 | 0.6% |
| Transportation/communication | 90 | 5 | 0 | 0 | 94 | 0.4% |
| Rangeland | 0 | 2 | 1 | 0 | 3 | 0.0% |
| Water/wetland | 47 | 30 | 269 | 28 | 373 | 1.5% |
| Septic tank | 768 | 721 | 84 | 2 | 1,573 | 6.2% |
| Main Street WWTP | 19,730 | - | - | - | 19,730 | 78.2% |
| J. R. Kelly Generating Station | 471 | - | - | - | 471 | 1.9% |
| **Subtotal** | **22,621** | **1,992** | **595** | **36** | **25,244** | **100.0%** |

**Table 17d. Contribution of TP (lbs/yr) from different sources in the watershed that discharged into Alachua Sink through Sweetwater Branch in 2003**

| Land Use Type or Source | USWB | LSWB | UED | AS | Total | Percent Contribution |
|---|---|---|---|---|---|---|
| Forest/rural open | 6 | 4 | 14 | 3 | 27 | 0.1% |
| Urban open | 190 | 19 | 6 | 0 | 214 | 1.1% |
| Agriculture | 4 | 4 | 67 | 0 | 76 | 0.4% |
| Low-density residential | 9 | 39 | 1 | 2 | 50 | 0.3% |
| Medium-density residential | 945 | 974 | 117 | 0 | 2,035 | 10.2% |
| High-density residential | 124 | 0 | 0 | 0 | 124 | 0.6% |
| Transportation/communication | 76 | 4 | 0 | 0 | 79 | 0.4% |
| Rangeland | 0 | 2 | 1 | 0 | 3 | 0.0% |
| Water/wetland | 39 | 25 | 226 | 23 | 315 | 1.6% |
| Septic tank | 647 | 607 | 70 | 1 | 1,326 | 6.7% |
| Main Street WWTP | 15,324 | - | - | - | 15,324 | 76.9% |
| J. R. Kelly Generating Station | 360 | - | - | - | 360 | 1.8% |
| **Subtotal** | **17,723** | **1,678** | **502** | **30** | **19,933** | **100.0%** |

### Table 17e. Contribution of TP (lbs/yr) from different sources in the watershed that discharged into Alachua Sink through Sweetwater Branch in 2004

| Land Use Type or Source | USWB | LSWB | UED | AS | Total | Percent Contribution |
|---|---|---|---|---|---|---|
| Forest/rural open | 8 | 6 | 17 | 4 | 34 | 0.2% |
| Urban open | 237 | 23 | 7 | 0 | 268 | 1.8% |
| Agriculture | 4 | 5 | 84 | 0 | 95 | 0.6% |
| Low-density residential | 11 | 48 | 1 | 3 | 63 | 0.4% |
| Medium-density residential | 1,182 | 1,218 | 146 | 0 | 2,546 | 17.3% |
| High-density residential | 155 | 0 | 0 | 0 | 155 | 1.1% |
| Transportation/communication | 95 | 5 | 0 | 0 | 99 | 0.7% |
| Rangeland | 0 | 3 | 1 | 0 | 4 | 0.0% |
| Water/wetland | 49 | 32 | 283 | 29 | 394 | 2.7% |
| Septic tank | 809 | 760 | 88 | 2 | 1,659 | 11.2% |
| Main Street WWTP | 8,782 | - | - | - | 8,782 | 59.5% |
| J. R. Kelly Generating Station | 654 | - | - | - | 654 | 4.4% |
| **Subtotal** | **11,987** | **2,100** | **628** | **38** | **14,753** | **100.0%** |

### Table 18a. Contribution of TN (lbs/yr) from different sources in the watershed that discharged into Alachua Lake in 2000

| Land Use Type or Source | AL | Percent Contribution |
|---|---|---|
| Forest/rural open | 9,229 | 11.4% |
| Urban open | 2,652 | 3.3% |
| Agriculture | 6,378 | 7.9% |
| Low-density residential | 7,568 | 9.3% |
| Medium- density residential | 11,634 | 14.3% |
| High-density residential | 4,849 | 6.0% |
| Transportation/communication | 2,593 | 3.2% |
| Rangeland | 735 | 0.9% |
| Water/wetland | 30,653 | 37.8% |
| Septic tank | 4810 | 5.9% |
| Prairie Creek | 0 | 0% |
| **Subtotal** | **81,102** | **100%** |

**Table 18b. Contribution of TN (lbs/yr) from different sources in the watershed that discharged into Alachua Lake in 2001**

| Land Use Type or Source | AL | Percent Contribution |
|---|---|---|
| Forest/rural open | 11,309 | 11.4% |
| Urban open | 3,250 | 3.3% |
| Agriculture | 7,816 | 7.9% |
| Low-density residential | 9,274 | 9.3% |
| Medium-density residential | 14,256 | 14.3% |
| High-density residential | 5,942 | 6.0% |
| Transportation/communication | 3,178 | 3.2% |
| Rangeland | 900 | 0.9% |
| Water/wetland | 37,560 | 37.8% |
| Septic tank | 5,894 | 5.9% |
| Prairie Creek | 0 | 0% |
| Subtotal | 99,379 | 100% |

**Table 18c. Contribution of TN (lbs/yr) from different sources in the watershed that discharged into Alachua Lake in 2002**

| Land Use Type or Source | AL | Percent Contribution |
|---|---|---|
| Forest/rural open | 14,848 | 10.9% |
| Urban open | 4,267 | 3.1% |
| Agriculture | 10,262 | 7.5% |
| Low-density residential | 12,177 | 8.9% |
| Medium-density residential | 18,718 | 13.7% |
| High-density residential | 7,802 | 5.7% |
| Transportation/communication | 4,173 | 3.1% |
| Rangeland | 1,182 | 0.9% |
| Water/wetland | 49,317 | 36.2% |
| Septic tank | 7,739 | 5.7% |
| Prairie Creek | 5,716 | 4.2% |
| **Subtotal** | **136,201** | **100%** |

**Table 18d. Contribution of TN (lbs/yr) from different sources in the watershed that discharged into Alachua Lake in 2003**

| Land Use Type or Source | AL | Percent Contribution |
|---|---|---|
| Forest/rural open | 12,511 | 4.7% |
| Urban open | 3,596 | 1.3% |
| Agriculture | 8,646 | 3.2% |
| Low-density residential | 10,260 | 3.8% |
| Medium-density residential | 15,772 | 5.9% |
| High-density residential | 6,574 | 2.4% |
| Transportation/communication | 3,516 | 1.3% |
| Rangeland | 996 | 0.4% |
| Water/wetland | 41,553 | 15.5% |
| Septic tank | 6,521 | 2.4% |
| Prairie Creek | 157,444 | 58.9% |
| **Subtotal** | **267,389** | **100%** |

**Table 18e. Contribution of TN (lbs/yr) from different sources in the watershed that discharged into Alachua Lake in 2004**

| Land Use Type or Source | AL | Percent Contribution |
|---|---|---|
| Forest/rural open | 15,653 | 4.5% |
| Urban open | 4,499 | 1.3% |
| Agriculture | 10,818 | 3.1% |
| Low-density residential | 12,837 | 3.7% |
| Medium-density residential | 19,733 | 5.6% |
| High-density residential | 8,225 | 2.3% |
| Transportation/communication | 4,399 | 1.3% |
| Rangeland | 1,246 | 0.4% |
| Water/wetland | 51,991 | 14.8% |
| Septic tank | 8,159 | 2.3% |
| Prairie Creek | 212,748 | 60.7% |
| **Subtotal** | **350,308** | **100%** |

### Table 19a. Contribution of TP (lbs/yr) from different sources in the watershed that discharged into Alachua Lake in 2000

| Land Use Type or Source | AL | Percent Contribution |
|---|---|---|
| Forest/rural open | 331 | 2.8% |
| Urban open | 318 | 2.7% |
| Agriculture | 981 | 8.3% |
| Low-density residential | 657 | 5.5% |
| Medium-density residential | 1,324 | 11.2% |
| High-density residential | 853 | 7.2% |
| Transportation/communication | 368 | 3.1% |
| Rangeland | 27 | 0.2% |
| Water/wetland | 5,283 | 44.6% |
| Septic tank | 1,700 | 14.4% |
| Prairie Creek | 0 | 0% |
| **Subtotal** | **11,842** | **100%** |

### Table 19b. Contribution of TP (lbs/yr) from different sources in the watershed that discharged into Alachua Lake in 2001

| Land Use Type or Source | AL | Percent Contribution |
|---|---|---|
| Forest/rural open | 405 | 2.8% |
| Urban open | 390 | 2.7% |
| Agriculture | 1,202 | 8.3% |
| Low-density residential | 805 | 5.5% |
| Medium-density residential | 1,622 | 11.2% |
| High-density residential | 1,045 | 7.2% |
| Transportation/communication | 451 | 3.1% |
| Rangeland | 33 | 0.2% |
| Water/wetland | 6,474 | 44.6% |
| Septic tank | 2,083 | 14.4% |
| Prairie Creek | 0 | 0% |
| **Subtotal** | **14,510** | **100%** |

**Table 19c. Contribution of TP (lbs/yr) from different sources in the watershed that discharged into Alachua Lake in 2002**

| Land Use Type or Source | AL | Percent Contribution |
|---|---|---|
| Forest/rural open | 532 | 2.8% |
| Urban open | 512 | 2.7% |
| Agriculture | 1,578 | 8.3% |
| Low-density residential | 1,058 | 5.6% |
| Medium-density residential | 2,130 | 11.2% |
| High-density residential | 1,372 | 7.2% |
| Transportation/communication | 592 | 3.1% |
| Rangeland | 43 | 0.2% |
| Water/wetland | 8,501 | 44.6% |
| Septic tank | 2,736 | 14.4% |
| Prairie Creek | 236 | 1.2% |
| **Subtotal** | **19,288** | **100%** |

**Table 19d. Contribution of TP (lbs/yr) from different sources in the watershed that discharged into Alachua Lake in 2003**

| Land Use Type or Source | AL | Percent Contribution |
|---|---|---|
| Forest/rural open | 448 | 1.6% |
| Urban open | 432 | 1.6% |
| Agriculture | 1,329 | 4.9% |
| Low-density residential | 891 | 3.3% |
| Medium-density residential | 1,794 | 6.6% |
| High-density residential | 1,156 | 4.2% |
| Transportation/communication | 499 | 1.8% |
| Rangeland | 36 | 0.1% |
| Water/wetland | 7,162 | 26.4% |
| Septic tank | 2,305 | 8.5% |
| Prairie Creek | 11,146 | 41.0% |
| **Subtotal** | **27,199** | **100%** |

**Table 19e. Contribution of TP (lbs/yr) from different sources in the watershed that discharged into Alachua Lake in 2004**

| Land Use Type or Source | AL | Percent Contribution |
|---|---|---|
| Forest/rural open | 561 | 1.6% |
| Urban open | 540 | 1.5% |
| Agriculture | 1,663 | 4.7% |
| Low-density residential | 1,115 | 3.2% |
| Medium-density residential | 2,245 | 6.39% |
| High-density residential | 1,446 | 4.1% |
| Transportation/communication | 624 | 1.8% |
| Rangeland | 45 | 0.1% |
| Water/wetland | 8,962 | 25.5% |
| Septic tank | 2,884 | 8.2% |
| Prairie Creek | 15,062 | 42.8% |
| **Subtotal** | **35,147** | **100%** |

During the five years from 2000 through 2004, the total TN loadings conveyed through Sweetwater Branch and from the area directly connecting to Alachua Sink (including the Upper and Lower Sweetwater Branch, Extension Ditch, and Alachua Sink sub-basins) averaged 114,192 (std. dev. 12,007) lbs/yr **(Tables 16a–e).** Total TP loadings averaged 19,224 (std. dev. 5,733) lbs/yr for the same period **(Tables 17a–e).**

Of the total TN and TP loadings carried through these sub-basins, TN and TP loadings from the Main Street WWTP were the dominant components throughout the period. For TN, the loadings contributed by the Main Street WWTP were 79,563, 104,925, 81,298, 88,720, and 65,922 pounds per year in 2000, 2001, 2002, 2003 and 2004, respectively. This represents 78.5%, 79.9%, 70.0%, 75.2%, and 63.3% of the total TN loadings to Alachua Sink from its contributing watershed (excluding the contribution from Alachua Lake). Surface runoff from the watershed (Upper and Lower Sweetwater Branch, Extension Ditch, and Alachua Sink) contributed 21,035, 25,775, 33,843, 28,615, and 35,763 pounds of TN per year, which represents 21.5%, 20.1%, 30.0%, 24.8%, and 36.7% of the total TN loading in 2000, 2001, 2002, 2003, and 2004, respectively.

For TP, the loadings contributed by the Main Street WWTP were 8,622, 20,007, 19,730, 15,324, and 8,782 pounds per year in 2000, 2001, 2002, 2003, and 2004, respectively. These loads represent 71.3%, 83.0%, 78.2%, 76.9%, and 59.5% of the total TP loadings carried through Sweetwater Branch in this period (2000–04). Surface runoff from the watershed (including Upper and Lower Sweetwater Branch, Extension Ditch, and Alachua Sink) contributed 3,134, 3,841, 5,943, 4,249, and 5,317 pounds of TP per year over the same period, which represents about 28.7%, 17.0%, 21.8%, 13.1%, and 40.5% of the total TP loading.

Both TN and TP loadings from nonpoint sources from the Sweetwater Branch watershed predicted by this analysis are close to the loading estimates from a study conducted by JEA (1999–2001). The years of overlap between the studies are 2000 and 2001. JEA's estimate of the nonpoint source TN loading was about 21,966 pounds per year compared with 23,405 pounds per year in this analysis (an average of years 2000 and 2001), and JEA's nonpoint source TP loading was about 3,614 pounds per year compared with 3,488 pounds per year in this analysis (an average of years 2000 and 2001).

TN and TP loadings from the other point source, the John R. Kelly Generating Station, are relatively insignificant and represent less than 2% of the total TN and TP loadings carried through Sweetwater Branch in the period of this analysis.

Among the nonpoint sources that discharge into Sweetwater Branch and in the area directly connected to Alachua Sink, urban and residential land uses appear to dominate the percent contribution of TN and TP loadings (**Tables 16** and **17**). These results indicate that the TN and TP loadings in Sweetwater Branch and from the area directly connected to Alachua Sink are highly influenced by human activities.

No point sources were identified in the watershed area that discharges into Alachua Lake. The largest contributors of TN and TP in this sub-basin are forest/rural open and water/wetland. Among the total loading from the sub-basin, about 49.2% of the TN and 47.2% of the TP came from forest/rural open and water/wetland land uses from 2000 through 2002 (and natural background wet and dry cases). Prairie Creek can represent a large source of TN and TP into Alachua Lake. Based on model simulations for 2003 and 2004, Prairie Creek contributed about 35% of the TP load to Alachua Lake and nearly 60% of the TN input. Note that in the absence of actual gauged inflow data, simulations for both years assumed that 41% of the annual Prairie Creek flow went to Paynes Prairie.

The majority of the TN and TP loading contributed by human land use types comes from urban and residential land uses (**Tables 18** and **19**).

# Chapter 5: Determination of Assimilative Capacity

## 5.1 Lake Modeling Using the Bathtub Model

### 5.1.1 Bathtub Eutrophication Model

The Bathtub eutrophication model is a suite of empirically derived, steady-state models developed by the U. S. Army Corps of Engineers (USACOE) Waterways Experimental Station. The primary function of these models is to estimate nutrient concentrations and algal biomass resulting from different patterns of nutrient loadings. The procedures for selection of the appropriate model for a particular lake are described in the User's Manual. The empirical prediction of lake eutrophication using this approach typically can be described as a two-stage procedure using the following two categories of models (Walker, 1999):

- The *nutrient balance model* relates in-lake nutrient concentration to external nutrient loadings, morphometry, and hydrology.
- The *eutrophication response model* describes relationships among eutrophication indicators within the modeled lake, including nutrient levels, chl*a*, transparency, and hypolimnetic oxygen depletion.

**Figure 5** describes the conceptual scheme used by Bathtub to relate the external loading of nutrients to in-lake nutrient concentrations, and the physical, chemical, and biological response of Alachua Sink to the level of nutrients.

The *nutrient balance model* adopted by Bathtub assumes that the net accumulation of nutrients in a lake is the difference between nutrient loadings into the lake from various sources and the nutrients carried out through outflow and the losses of nutrients through whatever decay process occurs inside the lake. The net accumulation in the lake is calculated using the following equation:

Net accumulation = Inflow – Outflow – Decay (3)

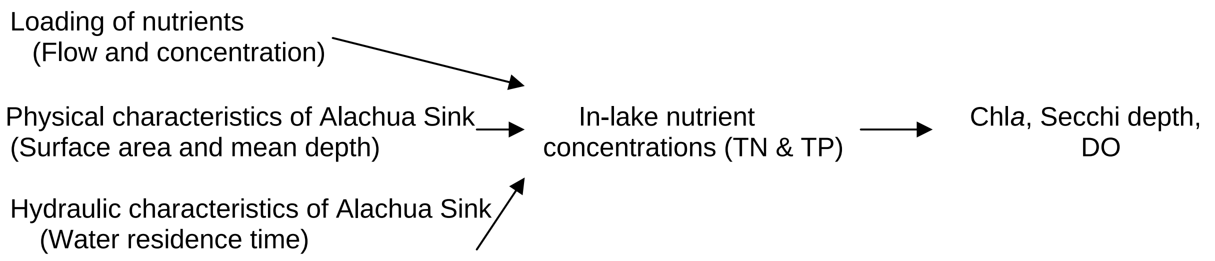


**Figure 5. Bathtub conceptual scheme**

Equation (3) is solved by assuming that the pollutant dynamics in the lake are at a steady state, i.e., the net accumulation of the pollutant in the lake equals zero.

In this study, “inflow” included TN and TP loadings through surface stormwater runoff from various land use categories, point sources, the leakage of septic tanks, and atmospheric deposition (bulk) directly on the surface of Alachua Sink. To address nutrient decay in Alachua Sink, Bathtub provided several alternatives, depending on the inorganic/organic nutrient partitioning coefficient and reaction kinetics. The major pathway of decay for TN and TP in the model is through sedimentation to the bottom of Alachua Sink.

Prediction of the *eutrophication response* by Bathtub also involves choosing one of several alternative models, depending on whether the algal communities are limited by phosphorus or nitrogen, or co-limited by both nutrients. The suite of models also contains scenarios that include algal communities limited by light intensity or controlled by the Alachua Sink flushing rate. In addition, the response of chl*a* concentration to the in-lake nutrient level is characterized by two different kinetic processes: linear or exponential. The variety of models available in Bathtub allows the user to choose specific models based on the particular condition of the project lake. **Section 5** discusses the specific Bathtub models used in this analysis.

One feature offered by Bathtub is the “calibration factor.” The empirical models implemented in Bathtub are mathematical generalizations about lake behavior. When applied to data from a particular lake, measured data may differ from predictions by a factor of two or more. Such differences reflect data limitations (measurement or estimation errors in the average inflow and outflow concentrations), the unique features of a particular lake (Walker, 1999), and unexpected processes inherent to a lake such as Alachua Sink. The calibration factor offered by Bathtub provides model users with a method to calibrate the magnitude of lake response predicted by the empirical models. The model calibrated to current conditions (against measured data from Alachua Sink) can then be applied to predict changes in lake conditions likely to result from specific management scenarios, under the condition that the calibration factor remains constant for all prediction scenarios.

### *5.1.2 Data Requirements for Running Bathtub*

Data requirements for the Bathtub model include the following:

- Physical characteristics of Alachua Sink (surface area, mean depth, length, and mixed layer depth),
- Meteorological data (precipitation and evaporation retrieved from CIRRUS),
- Measured water quality data (TN, TP, and chl*a* concentrations of Alachua Sink water, TN and TP concentrations in precipitation, etc.),
- Loading data (flow and TN and TP concentrations of the flow from various point and nonpoint sources of pollution), and
- Coefficient of variance (CV) of all the measured data.

### *5.1.3 Calculation of the Trophic State Index*

TSI values were calculated using the procedures outlined in Florida's 1996 305(b) report:

$$TSI = (CHLA_{TSI} + NUTR_{TSI})/2 \qquad (4)$$

Where:

$CHLA_{TSI} = 16.8 + 14.4 \times LN\ (CHLA)]$
$TN_{TSI} = 56 + [19.8 \times LN(TN)]$
$TN2_{TSI} = 10 \times [5.96 + 2.15 \times LN(TN + 0.0001)]$
$TP_{TSI} = [18.6 \times LN(TP \times 1000)] –18.4$
$TP2_{TS} = 10 \times [2.36 \times LN(TP \times 1000) – 2.38]$

The procedure addresses limiting nutrient considerations by calculating $NUTR_{TSI}$:

If $TN/TP > 30$ then $NUTR_{TSI} = TP2_{TSI}$
If $TN/TP < 10$ then $NUTR_{TSI} = TN2_{TSI}$
If $10 < TN/TP < 30$ then $NUTR_{TSI} = (TP_{TSI} + TN_{TSI})/2$

## 5.2 TMDL Scenario Development for Alachua Sink

Once the WMM and Bathtub model calibrations were achieved (described in the next section), the TMDL for Alachua Sink was developed by evaluating the TSIs representative of both a dry period and a wet period for each of the following scenarios:

A. The TSI for the current condition.

B. The TSI after the DCIA and EMC of runoff from all the human land use categories (urban open; low-, medium-, and high-density residential; agriculture and rangeland; and transportation, communication, and utilities) were improved to the level of natural land (forest/ rural open), and the point source contributions were reduced to current annual average flow and given the concentration of the EMC for forest/rural open.

C. The TSI after the DCIA and EMC of runoff from all the human land use categories (urban open; low-, medium-, and high-density residential; agriculture and rangeland; and transportation, communication, and utilities) were improved to the level of natural land (forest/rural open) and the point source contributions were totally removed.

Scenario C was considered the natural background condition of Alachua Sink. The TN and TP loadings that result in a TSI of 60 would typically be considered as the TMDL for Alachua Sink. However, if the TSI for Scenario C were different from 60, the TSI for Scenario C plus 5 TSI units would become the new target TSI threshold for Alachua Sink.

## 5.3 Establishing the Relationship between TN and TP Loading to Alachua Sink and In-lake Concentrations

### *5.3.1 Atmospheric Loading of TN and TP into Alachua Sink and Alachua Lake*

One source of TN and TP loading to Alachua Sink and Alachua Lake that the WMM did not was TN and TP falling directly onto the surface of these waterbodies. In this analysis, the atmospheric loading of TN and TP was calculated by multiplying the amount of precipitation directly falling on Alachua Sink (calculated by multiplying the annual precipitation by the surface area of Alachua Sink) by the TN and TP concentration of the rainfall. Because no data for the TN and TP concentration of rainfall were available for the area, published values were used; these were 0.1 mg/L and 0.05 mg/L for TN and TP, respectively (Stites et al., 2001). **Table 20** tabulates the calculated annual TN and TP loadings from atmospheric loading.

**Table 20. Atmospheric loading of TN and TP (lbs/yr) into Alachua Lake and Alachua Sink, 2000–04**

| Year | Into Alachua Sink | | Into Alachua Lake | |
|---|---|---|---|---|
| | TN | TP | TN | TP |
| 2000 | 10 | 5 | 2,373 | 1,187 |
| 2001 | 12 | 6 | 2,909 | 1,454 |
| 2002 | 17 | 8 | 3,820 | 1,910 |
| 2003 | 16 | 8 | 5,114 | 2,538 |
| 2004 | 16 | 8 | 4,990 | 2,495 |

### *5.3.2 Simulated TN, TP, and Chla Concentrations in Alachua Lake Using the Bathtub Model*

Another source of TN and TP loadings into Alachua Sink is the loadings from Alachua Lake. Because no flow and water quality data were available from 2000 through 2002, the Bathtub model after calibration was used to simulate annual average TN and TP concentrations of Alachua Lake, using the TN and TP concentrations measured by JEA in 2003. Because a significant portion of the channel that conveys Alachua Lake water into Alachua Sink may be covered by floating macrophytes and aquatic plants—which limit the growth of phytoplankton in the covered area by blocking light and serve as a filter system that removes the biomass of phytoplankton grown in other areas of Alachua Lake—using the model-simulated chl*a* concentration as the algal biomass input from Alachua Lake to Alachua Sink may not match well with measured levels. Therefore, the chl*a* concentration of the outlet water from Alachua Lake was based on measurements by JEA and the ACEPD in 2003 and 2004.

### *5.3.3 Data Required for the Simulation of TN and TP Concentrations in Alachua Lake*

This section describes how the data required to simulate the TN and TP concentrations for Alachua Lake were developed. It should be noted that the physical characteristics data listed in **Table 21** for Alachua Lake from 2000 through 2004 are not based on measured results. No measured data on lake characteristics were available from 2000 through 2004. The following procedures were used to calculate the surface area and mean depth of Alachua Lake:

1. Jim Weimer (personal communication), Paynes Prairie Park biologist, provided a spreadsheet of prairie water levels from 1976 through 1999. Annual average water

levels were calculated from the spreadsheet. In addition, annual average flows for Prairie Creek from 1979 through 1999 were calculated from daily gauge records.

2. A regression equation was developed for the relationship between the annual average Prairie Creek flow (cubic feet per second [cfs]) and annual prairie water surface elevation:

   Alachua Lake surface elevation = 0.030 * annual average Prairie Creek flow + 53.61
   ($r^2 = 0.39$, significant at $\alpha = 0.05$)

3. Alachua Lake surface elevations from 2000 through 2004 were calculated based on the above equation and the elevation data provided by JEA as part of sampling efforts in 2003 and 2004.
4. Alachua Lake surface area and lake volume from 2000 through 2004 were estimated using Alachua Lake characteristic curves developed by the SJRWMD for Paynes Prairie (Robison, 1997) (see **Appendix B**).
5. The mean depth of Alachua Sink was calculated by dividing the volume of Alachua Sink by the surface area of Alachua Sink.
6. Because Alachua Lake is shallow, the mixed layer depth was assumed to be equal to the mean depth of Alachua Lake.
7. Annual evaporation rates were only available for Gainesville through 2000. Rates for 2001 through 2004 were based on a regression relationship between the Gainesville and Lake City sites:

   Annual evaporation (inches) = 32.83 + 0.405*Lake City
   ($r^2 = 0.44$, significant at $\alpha = 0.05$)

Estimating lake physical characteristics using these procedures results in additional uncertainties, because the regression equation developed may not totally match the current situation of Alachua Sink or incorporate other factors such as prolonged drought conditions. **Tables 21** through **23** list the data used for the model simulation.

**Table 21. Physical characteristics of Alachua Lake, 2000–04**

| Year | Lake Surface Area (square kilometers [$km^2$]) | Mean Depth (m) | Mixed Layer Depth (m) |
|---|---|---|---|
| 2000 | 12.33 | 0.385 | 0.385 |
| 2001 | 12.33 | 0.385 | 0.385 |
| 2002 | 12.33 | 0.385 | 0.385 |
| 2003 | 28.78 | 0.57 | 0.57 |
| 2004 | 15.28 | 0.60 | 0.60 |

**Table 22. Precipitation and evaporation (m/yr), 2000–04**

| Year | Precipitation | Evaporation |
|---|---|---|
| 2000 | 0.87 | 1.66 |
| 2001 | 1.07 | 1.48 |
| 2002 | 1.41 | 1.48 |
| 2003 | 1.18 | 1.65 |
| 2004 | 1.48 | 1.48 |

**Table 23. Alachua Lake flow and the TN and TP concentrations of different sources in 2003**

| Land Use Type or Source | Flow ($hm^3$/yr) | TN (mg/L) | TP (mg/L) |
|---|---|---|---|
| Forest/rural open | 4.75 | 1.19 | 0.04 |
| Urban open | 1.48 | 1.10 | 0.13 |
| Agricultural | 1.76 | 2.23 | 0.34 |
| Low-density residential | 3.8 | 1.22 | 0.11 |
| Medium-density residential | 4.52 | 1.58 | 0.18 |
| High-density residential | 1.78 | 1.67 | 0.29 |
| Transportation, communications, and utilities | 1.11 | 1.44 | 0.20 |
| Rangeland | 0.42 | 1.08 | 0.04 |
| Water/wetland | 25.68 | 0.73 | 0.13 |
| Prairie Creek | 31.6 | 2.26 | 0.16 |

**Notes:**

[a] Bathtub does not allow the direct input of loading. Therefore, the data presented here are flow and the TN and TP concentrations of the flow.

[b] The TN and TP concentrations presented for each source were calculated by dividing the TN and TP loadings from the entire watershed by the total flow associated with each source.

c Based on the results of a TMDL study conducted on Newnans Lake, Prairie Creek diverts about 41% of the outflow from Newnans Lake into Paynes Prairie (Gao and Gilbert, 2003). Carol Lippincott (personal communication) from the SJRWMD provided TN concentrations of canals for 2003 and 2004. The TP concentrations used for Prairie Creek were the average over the period from 2000 through 2002.

### *5.3.4 Calibrating Bathtub Using the TN and TP Concentrations of Alachua Lake Measured in 2003*

**Table 24** lists the TN and TP concentrations measured by JEA in 2003 (data on 11/05/03 were from the ACEPD). However, only TN and TP concentrations from the sampling trips of May 22 and June 9 were used to calibrate the model because, as described subsequently, Alachua Lake was not at a steady-state condition before and after these dates. Data from other sampling periods were not used because Bathtub is a steady-state model, and the modeling requires that the target waterbody be as close to the steady state as possible.

**Table 24. TN and TP concentrations of Alachua Lake in 2003 (all values in mg/L)**

| Sampling Events | TN | TP |
|---|---|---|
| 02/12/03 | 2.739 | 1.11 |
| 03/12/03 | 2.840 | 1.17 |
| 03/27/03 | 2.290 | 0.62 |
| 05/07/03 | 2.130 | 0.38 |
| 05/22/03 | 1.880 | 0.14 |
| 06/09/03 | 1.921 | 0.13 |
| 10/16/03 | 1.170 | 0.01 |
| 11/05/03 | 0.980 | 0.10 |
| 12/09/03 | 1.500 | 0.03 |

**Figure 6** shows the load of TN and TP in the water column of Alachua Lake over the sampling period in 2003. The load of water column TN and TP was relatively low in February because of the small lake volume at the time. The amount of TN and TP decreased significantly from March to late May, and stayed relatively constant in the late May and early June sampling events. By June, the water column TN decreased by about 13 tons and reduced to about 77% of the water column TN in February. The phosphorus decrease was even more dramatic. By June, the water column phosphorus decreased by about 20 tons and reduced to about 13% of the water column TP in February.

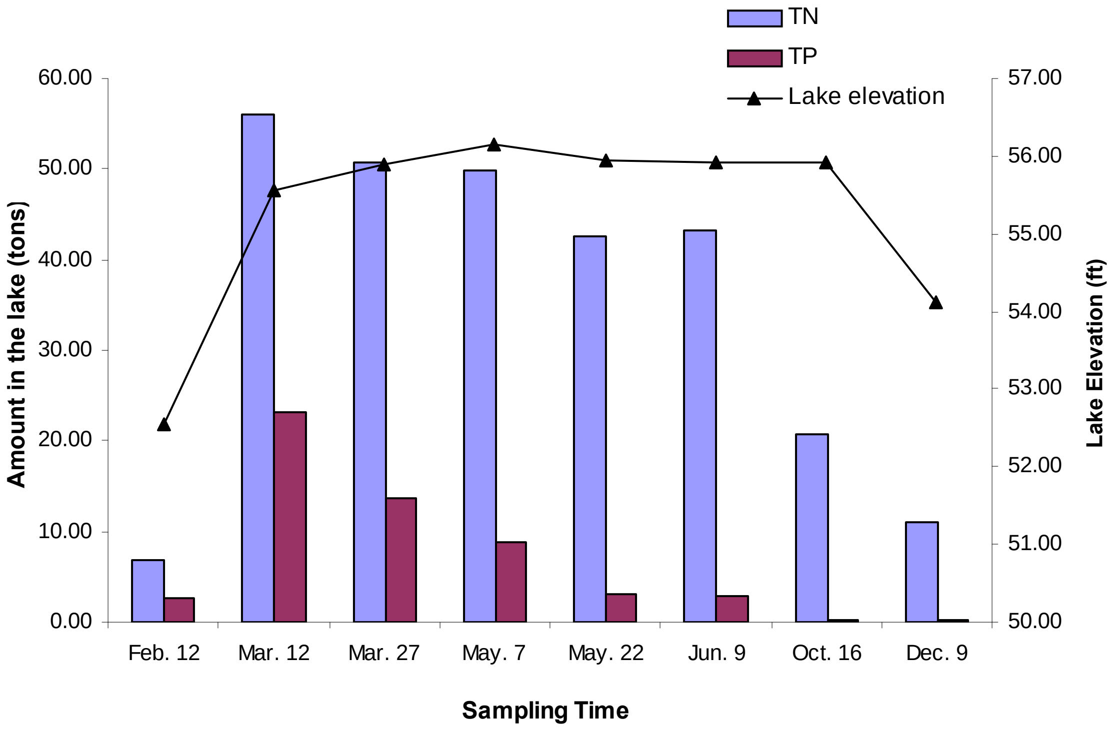


**Figure 6. TN and TP Load in Alachua Lake in 2003**

One explanation for the dramatic increase in water column TN and TP observed at the beginning of the year and the subsequent gradual decrease is that Alachua Lake was not at a steady state throughout 2003. Alachua Sink went through several dry years before 2003, and a significant portion of the lake bottom was exposed to the air. This process may have caused the organic materials containing nitrogen and phosphorus to be oxidized. When Alachua Lake was reflooded in early 2003, oxidized nitrogen and phosphorus-containing materials, which are more soluble than the original organic materials in the sediment, would have been released into the water column and would have resulted in the high water column TN and TP concentrations when the lake reached its highest level in March (Wetzel, 2001). However, the high water column TN and TP content created through this internal recycling process is usually not stable over an extended period, and water column TN and TP content usually decreases through sedimentation. The subsequent sedimentation of TN and TP may have caused the decrease of the water column TN and TP since March.

Further decreases of TN and TP concentrations were observed during the October sampling event, and the concentrations increased slightly during the December sampling event. The TP concentration was below the detection limit during the October sampling event, which is not very common for central Florida lakes. Based on communications with JEA and the park biologist who has been constantly surveying Alachua Sink’s condition, the Department found that floating aquatic plants, including water hyacinth, duck weed, salvinia, and water lettuce, developed heavily after June. Alachua Lake was almost entirely covered by floating aquatic plants during the October sampling event. A significant portion of the surfaces of both Alachua Lake and Alachua Sink remained covered by these plants during the December sampling event. Nutrient uptake by these aquatic plants could have contributed significantly to the low TN and TP concentration observed in the October and December sampling events.

It should be noted that if the TN and TP were taken up by phytoplankton, it would remain in the water column and be included in surface water samples. In contrast, surface water samples would not include that portion of TN and TP that is fixed by floating aquatic plants. Therefore, the October TN and TP concentrations were considered underestimates of the actual TN and TP concentrations of Alachua Lake and Alachua Sink, because the data were collected when both waterbodies were heavily influenced by floating aquatic plants.

Based on the discussion above, the Department believes that it would be inappropriate to calibrate the Bathtub model using all the TN and TP data measured in 2003. Only the TN and TP concentrations measured in the sampling events of May 22 and June 9 were used for the model calibration, because during this period, Alachua Sink reached a relatively stable condition and was still not heavily influenced by the colonization of floating aquatic plants.

To calibrate the Bathtub model, each source of TN and TP was designated as an independent tributary. Flow and the TN and TP concentration from leaking septic tanks are not defined in **Table 23** because in Bathtub, septic tank loading is characterized differently from other point and nonpoint sources. Instead of being defined by flow and the pollutant concentration of the flow, septic tank loading is defined by the flux of TN and TP into Alachua Sink and is calculated by dividing the septic tank TN and TP loadings by the surface area of Alachua Sink. In this analysis, annual average septic tank loads to Alachua Lake in 2003 were 6,521 pounds per year for TN and 2,305 pounds per year for TP. The annual average surface area of Alachua Lake for 2003 was 28.78 square kilometers ($km^2$). Utilizing appropriate conversion units and dividing the loading by the surface area yields an average flux of 0.282 milligrams per square meter per day ($mg/m^2/day$) for TN and 0.099 $mg/m^2/day$ for TP.

Bathtub provides several alternative submodels for estimating the influence of sedimentation on the in-lake TN and TP concentrations. In this analysis, the settling velocity submodel was chosen for both TN and TP calculations. This submodel assumes that the sedimentation of TN and TP is in first-order kinetics and should linearly correlate with in-lake TN and TP concentrations. The submodel also assumes that the depth of Alachua Sink influences sedimentation—i.e., the deeper Alachua Sink is, the slower the sedimentation. The submodel fit the conditions for Alachua Lake because the lake is relatively shallow and large in surface area. Continued wind mixing prevents the lake from forming thermal stratification, which would otherwise prevent the particles from being resuspended once they settled to the bottom. Continued wind mixing through the entire water column also reduces the particle-settling rate by continuously bringing the settled particles back into the water column. These processes produce a relatively low settling rate in Alachua Lake.

Other sedimentation submodels provided by Bathtub assume second-order kinetics, which fit reasonably well with lakes that form thermal stratification during the summer. However, these models would overestimate the sedimentation of Alachua Lake, and in turn cause the underestimation of in-lake TN and TP concentrations.

**Table 25** shows the measured and Bathtub-predicted TN and TP concentrations for Alachua Lake. The relative percentage error is based on a comparison between the measured average for May through June (discussed in the text) and the annual mean predicted by the model. In the case of TN, the annual mean and median based on measurements are very similar to the model prediction.

**Table 25. Bathtub calibration for Alachua Lake in 2003)**

| | Mean/Median for year | Measured May–June | Bathtub Predicted | Error |
|---|---|---|---|---|
| TN (mg/L) | 1.941/1.92 | 1.901 | 1.945 | 2.3% |
| TP (mg/L) | 0.41/0.14 | 0.140 | 0.152 | 8.6% |

### *5.3.5 Simulation of TN and TP concentrations of Alachua Lake for 2004*

As discussed earlier, JEA conducted three additional surveys in 2004. The ACEPD also sampled Sweetwater Branch, Alachua Lake, and Alachua Sink in 2004. **Tables 26** and **27** summarize Alachua Lake flow and TN and TP concentrations in 2004 and sampling results in 2004, respectively. A simulation of the Bathtub model was completed for 2004, and **Table 28** presents the results. Measurements over the January through September period were averaged and compared with the annual average predicted by Bathtub. The model underpredicted both the TN and TP in 2004.

A few factors could be contributing to the underpredictions. First, note that the last sampling event for Alachua Lake occurred on September 23, 2004 (both JEA and Alachua County), and reported concentrations for both TN and TP were the highest of the year. If measurements for the two common sampling dates are averaged (5/19 and 9/23) to yield a single measurement for each date, the observed average for TN and TP becomes 2.092 mg/L and 0.195 mg/L, respectively, and the respective errors are reduced to -22.6% and 22.0%, respectively. Second, in 2004 there were only about half the elevation measurements compared with the number in 2003. The available elevations in 2004 indicated greater fluctuations in both Alachua

Lake and Alachua Sink compared with 2003. Elevations were used to estimate the surface area, storage volume, and ultimately, in-lake concentrations and discharge. Third, inflow from Prairie Creek was a major contributor of TN and TP loading to Alachua Lake, and due to limited water quality information, similar concentrations were assumed for both 2003 and 2004.

### Table 26. Alachua Lake flow and TN and TP concentrations of different sources in 2004

| Land Use Type or Source | Flow (hm$^3$/yr) | TN (mg/L) | TP (mg/L) |
|---|---|---|---|
| Forest/rural open | 5.94 | 1.19 | 0.04 |
| Urban open | 1.85 | 1.10 | 0.13 |
| Agricultural | 2.21 | 2.23 | 0.34 |
| Low-density residential | 4.76 | 1.22 | 0.11 |
| Medium-density residential | 5.65 | 1.58 | 0.18 |
| High-density residential | 2.23 | 1.67 | 0.29 |
| Transportation, communications, and utilities | 1.39 | 1.44 | 0.20 |
| Rangeland | 0.52 | 1.08 | 0.04 |
| Water/wetland | 32.13 | 0.73 | 0.13 |
| Prairie Creek | 42.7 | 2.26 | 0.16 |

**Notes:**

[a] Bathtub does not allow the direct input of loading. Therefore, the data presented here are flow and TN and TP concentrations of the flow.

[b] TN and TP concentrations presented for each source were calculated by dividing the TN and TP loadings from the entire watershed by the total flow created in the watershed.

[c] Based on the results of a TMDL study conducted on Newnans Lake, Prairie Creek diverts about 41% of the outflow from Newnans Lake into Paynes Prairie (Gao and Gilbert, 2003). Carol Lippincott (personal communication) from the SJRWMD provided TN concentrations of canals for 2003 and 2004. The TP concentrations used for Prairie Creek were the average over the period from 2000 through 2002.

### Table 27. TN and TP concentrations of Alachua Lake in 2004 (all values in mg/L)

| Sampling Events | TN | TP |
|---|---|---|
| 01/15/2004 | 1.50 | 0.1 |
| 02/11/2004 | 2.18 | 0.09 |
| 03/10/2004 | 2.10 | 0.21 |
| 04/14/2004 | 2.40 | 0.1 |
| 05/19/2004 | 1.69 | 0.12 |
| 05/19/2004 | 2.00 | 0.098 |
| 06/17/2004 | 1.60 | 0.2 |
| 07/21/2004 | 2.1 | 0.14 |
| 08/11/2004 | 2.2 | 0.1 |
| 09/23/2004 | 2.96 | 0.62 |
| 09/23/2004 | 2.85 | 0.81 |

### Table 28. Bathtub calibration for Alachua Lake in 2004

| | Mean/Median for year | Bathtub Predicted | Error |
|---|---|---|---|
| TN (mg/L) | 2.144/2.18 | 1.619 | -24% |
| TP (mg/L) | 0.237/0.12 | 0.152 | -36% |

### *5.3.6 Simulation of TN and TP concentrations of Alachua Lake from 2000 through 2002*

To estimate the water quality condition of dry years, the calibrated Bathtub model was used to simulate the TN and TP concentrations of Alachua Lake from 2000 through 2002. The physical characteristics of the lake, and precipitation in to and evaporation out of Alachua Lake, used for simulation were the mean values calculated based on the annual average values of 2000 through 2002 (listed in **Tables 21** and **22**). **Table 29** lists the flow from different sources and the TN and TP concentrations of the flow used for the model simulation. These values are also the mean values calculated based on the values for 2000, 2001, and 2002. The method used to calculate these values is described in the note to **Table 23**. **Table 30** lists the simulated TN and TP concentrations for Alachua Lake from 2000 through 2002.

**Table 29. Alachua Lake flow, and TN and TP concentrations of different sources, 2000–02**

| Land Use Type or Source | Flow ($hm^3$/yr) | TN (mg/L) | TP (mg/L) |
|---|---|---|---|
| Forest/rural open | 4.48 | 1.19 | 0.04 |
| Urban open | 1.40 | 1.10 | 0.13 |
| Agricultural | 1.66 | 2.23 | 0.34 |
| Low-density residential | 3.58 | 1.22 | 0.11 |
| Medium-density residential | 4.26 | 1.58 | 0.18 |
| High-density residential | 1.68 | 1.67 | 0.29 |
| Transportation, communications, and utilities | 1.05 | 1.44 | 0.20 |
| Rangeland | 0.40 | 1.08 | 0.04 |
| Water/wetland | 24.21 | 0.73 | 0.13 |
| Prairie Creek | 0.22 | 3.87 | 0.16 |

**Table 30. Bathtub-simulated TN and TP concentrations of Alachua Lake, 2000–02**

| Year Simulated | TN (mg/L) | TP (mg/L) |
|---|---|---|
| 2000 | 1.534 | 0.157 |
| 2001 | 1.384 | 0.155 |
| 2002 | 1.188 | 0.143 |
| **Composite of 2000–02** | **1.340** | **0.156** |

## 5.4 Bathtub Calibration for the Alachua Sink Model

### *5.3.1 Data Required for Calibrating the Bathtub Model for Alachua Sink*

The relationship between TN and TP loading and the in-lake TN and TP concentrations in Alachua Sink were established by fitting the Bathtub model predictions for Alachua Sink with the measured TN and TP concentrations for Alachua Sink. No flow measurements were available from Alachua Lake to Alachua Sink from 2000 through 2002. Because of the control structure located in the channel from Alachua Lake to Alachua Sink, it is also difficult to model the flow using Bathtub. Flow data were available for the year 2003. Therefore, two Bathtub calibrations were conducted. For the period from 2000 through 2002, Bathtub calibration used flow and TN and TP concentrations of the flow from various point and nonpoint sources estimated using the WMM. Based on discussions with area experts, it is the Department’s understanding that there was little or no discharge from Alachua Lake from 2000 through 2002. Annual rainfall totals for 1999 through 2001 were between 3 and 9 inches below normal each year (a 3-year deficit of 20.2 inches), and 2002 ended approximately 4 inches above normal. Consequently, a minimal annual discharge of 1 $hm^3$ from Alachua Lake was assumed for 2000 through 2002. For 2003 and 2004, the measured flow from Alachua Lake to Alachua Sink was used together with the flows from all the other point and nonpoint sources (established using the WMM) to calibrate the Bathtub model.

The data used for the Bathtub calibration for Alachua Sink from 2000 through 2002 were the mean annual averages calculated from the values for each year from 2000 through 2002. The model calibration for 2003 and 2004 only used data from those respective years. **Tables 31** through **38** list the data required for model calibration.

**Table 31. Physical characteristics of Alachua Sink, 2000—04**

| Year | Lake Surface Area ($km^2$) | Mean Depth (m) | Mixed Layer Depth (m) |
|---|---|---|---|
| 2000 | 0.02 | 0.78 | 0.78 |
| 2001 | 0.02 | 0.82 | 0.82 |
| 2002 | 0.02 | 0.85 | 0.85 |
| **Mean** | **0.02** | **0.82** | **0.82** |
| 2003 | 0.062 | 1.94 | 1.94 |
| 2004 | 0.048 | 1.50 | 1.50 |

For 2003 and 2004, the surface area and volume of Alachua Sink were determined based on the water surface elevation **(Table 32)** and the bathymetry data **(Table 33)** provided to the Department by GRU and JEA. Because no measured surface elevation was available from 2000 through 2002, a correlation was developed between the surface elevation and the total flow into Alachua Sink, using the surface elevations and flows measured in 2003 **(Figure 7).** The WMM-predicted average annual flow from 2000 through 2002 was then used with this correlation to estimate the surface elevation of Alachua Sink from 2000 through 2002. The volume and surface area of Alachua Sink during this period was then estimated using the bathymetry data provided in **Table 33.** The mean depth of Alachua Sink was calculated by dividing the volume of Alachua Sink by the surface area of Alachua Sink. Due to the shallowness of Alachua Sink, the mixed layer depth was assumed to be equal to the mean depth **(Table 31).**

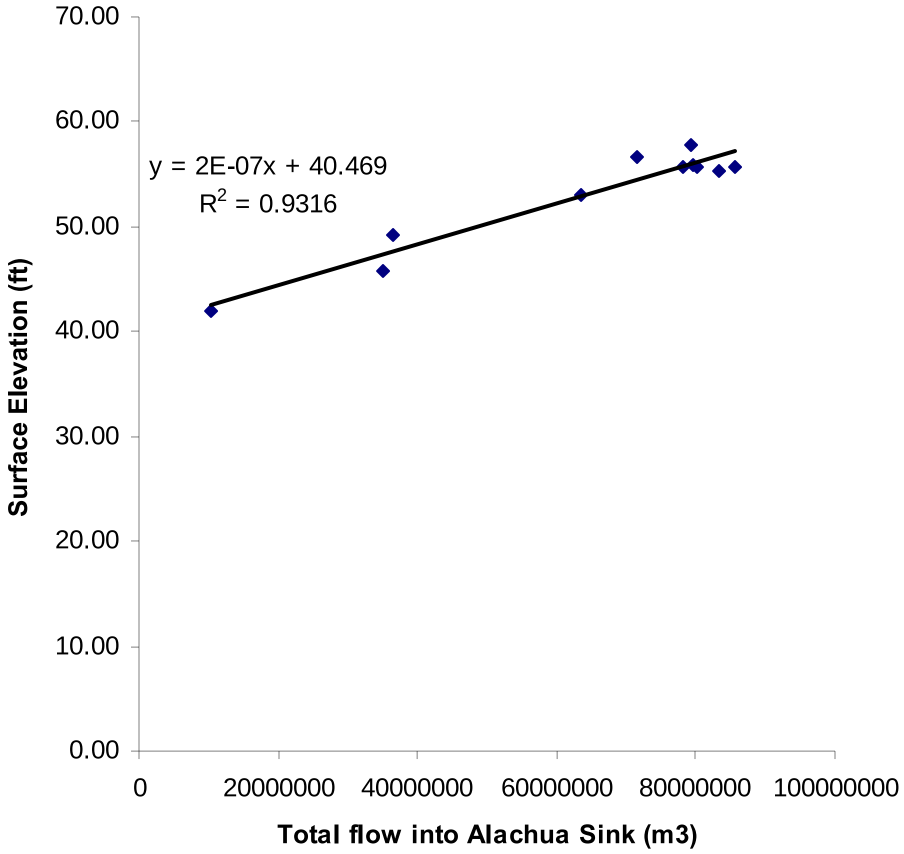


**Figure 7. Correlation between the surface elevation of Alachua Sink and total flow into the waterbody**

## Table 32. Physical characteristics of Alachua Sink in 2003 and 2004

| Sampling Events | Surface Elevation (ft) | Volume ($m^3$) | Surface Area ($m^2$) | Mean Depth (m) | Water Residence (days) |
|---|---|---|---|---|---|
| 30-Jan-03 | 45.38 | 33,655 | 34,741 | 0.969 | - |
| 5-Feb-03 | 45.4 | 33,826 | 34,873 | 0.970 | - |
| 12-Feb-03 | 45.82357 | 37,554 | 37,689 | 0.996 | 0.390 |
| 12-Mar-03 | 55.22 | 171,904 | 74,290 | 2.314 | 0.754 |
| 27-Mar-03 | 55.7675 | 182,780 | 72,941 | 2.506 | 0.781 |
| 7-May-03 | 55.855 | 184,549 | 72,670 | 2.540 | 0.849 |
| 22-May-03 | 55.6425 | 180,267 | 73,301 | 2.459 | 0.822 |
| 9-Jun-03 | 55.725 | 181,924 | 73,067 | 2.490 | 0.852 |
| 16-Oct-03 | 56.59 | 199,750 | 69,772 | 2.863 | 1.022 |
| 17-Nov-03 | 55.08 | 169,177 | 74,543 | 2.270 | - |
| 9-Dec-03 | 52.99 | 131,073 | 74,287 | 1.764 | 0.756 |
| 31-Dec-03 | 48.8 | 69,413 | 56,891 | 1.220 | - |
| 7-Jan-04 | 48.747 | 68,759 | 56,576 | 1.215 | - |
| 11-Feb-04 | 49.58 | 79,403 | 61,329 | 1.295 | 0.794 |
| 19-May-04 | 46.2 | 41,035 | 40,202 | 1.021 | 1.434 |
| 23-Jun-04 | 45.376 | 33,621 | 34,715 | 0.968 | - |
| 11-Aug-04 | 45.112 | 31,406 | 32,973 | 0.952 | - |
| 23-Sep-04 | 57.72 | 224,299 | 62,994 | 3.561 | 1.035 |
| **Annual Mean (2003)** | **52.36** | **131,323** | **62,422** | **1.947** | **0.778** |
| **Annual Mean (2004)** | **48.79** | **79,754** | **48,131** | **1.502** | **1.088** |

## Table 33. Bathymetry data for Alachua Sink

| National Geodetic Vertical Datum (NGVD) Elevation (ft) | Volume Below ($ft^3$) | Surface Area ($ft^2$) |
|---|---|---|
| 35 | 0 | 0 |
| 36 | 0 | 0 |
| 37 | 1,406 | 3,762 |
| 38 | 28,717 | 36,341 |
| 39 | 84,125 | 60,077 |
| 40 | 166,811 | 95,556 |
| 41 | 283,386 | 126,625 |
| 42 | 426,919 | 154,287 |
| 43 | 598,705 | 181,714 |
| 44 | 792,130 | 206,824 |
| 45 | 1,009,316 | 260,284 |
| 46 | 1,312,134 | 367,883 |
| 47 | 1,689,643 | 486,161 |
| 48 | 2,111,866 | 576,256 |
| 49 | 2,574,655 | 637,523 |
| 50 | 3,050,122 | 681,805 |
| 51 | 3,527,167 | 703,873 |
| 52 | 4,004,651 | 707,087 |

### Table 34. Calculating the volume, surface area, and mean depth of Alachua Sink, 2000–02

| Year | Total Flow ($m^3$) | Calculated surface elevation (ft) | Calculated sink volume ($m^3$) | Calculated surface area ($m^2$) | Calculated mean depth (m) |
|---|---|---|---|---|---|
| 2000 | 17,303,721 | 42.2 | 12,155 | 15,581 | 0.78 |
| 2001 | 20,401,573 | 42.8 | 15,345 | 18,768 | 0.82 |
| 2002 | 23,672,289 | 43.4 | 18,938 | 22,204 | 0.85 |
| **Mean** | **20,459,194** | **42.8** | **15,480** | **18,851** | **0.82** |

### Table 35. Precipitation and evaporation (m/yr)

| Year | Precipitation | Evaporation |
|---|---|---|
| 2000 | 0.87 | 1.66 |
| 2001 | 1.07 | 1.48 |
| 2002 | 1.41 | 1.48 |
| **Mean** | **1.12** | **1.54** |
| SE | 0.2 | 0.1 |
| 2003 | 1.18 | 1.65 |
| 2004 | 1.48 | 1.48 |

### Table 36. Measured TN, TP, and Chl*a* concentrations of Alachua Sink

| Year | TN (mg/L) | TP (mg/L) | Chl*a* (µg/L) |
|---|---|---|---|
| 2000 | 4.51 | 1.182 | 46.3 |
| 2001 | 4.82 | 1.353 | 33.2 |
| 2002 | 3.65 | 1.302 | 43.0 |
| **Mean** | **4.33** | **1.279** | **40.8** |
| SE | 0.35 | 0.051 | 3.93 |
| CV | 8% | 4% | 10% |
| 2003 | 2.78 | 0.63 | 8.15 |
| 2004 | 2.07 | 0.58 | 13.0 |

### Table 37. Alachua Sink flow and TN and TP concentrations of different sources, 2000–02

| Land Use Type or Source | Flow ($hm^3$/yr) | TN (mg/L) | TP (mg/L) |
|---|---|---|---|
| Forest/rural open | 0.74 | 1.19 | 0.04 |
| Urban open | 0.75 | 1.10 | 0.13 |
| Agricultural | 0.49 | 2.23 | 0.34 |
| Low-density residential | 0.60 | 1.22 | 0.11 |
| Medium-density residential | 5.49 | 1.58 | 0.18 |
| High-density residential | 0.46 | 1.67 | 0.29 |
| Transportation, communications, and utilities | 0.21 | 1.44 | 0.20 |
| Rangeland | 0.05 | 1.08 | 0.04 |
| Water/wetland | 1.37 | 0.73 | 0.13 |
| Main Street WWTP | 8.10 | 4.95 | 1.19 |
| J. R. Kelly Generating Station | 0.18 | 2.01 | 0.90 |
| Alachua Lake | (1)* | 1.34 | 0.16 |

* Because no flow data from Alachua Lake to Alachua Sink were available at the control structure between them from 2000 through 2002, the flow from Alachua Lake to Alachua Sink was characterized through Bathtub calibration to fit the predicted TN and TP concentrations to the measured TN and TP concentrations of Alachua Sink.

### Table 38. Alachua Sink flow and TN and TP concentrations of different sources in 2003

| Land Use Type or Source | Flow ($hm^3$/yr) | TN (mg/L) | TP (mg/L) |
|---|---|---|---|
| Forest/rural open | 0.29 | 1.19 | 0.04 |
| Urban open | 0.73 | 1.10 | 0.13 |
| Agricultural | 0.10 | 2.23 | 0.34 |
| Low-density residential | 0.22 | 1.22 | 0.11 |
| Medium-density residential | 5.12 | 1.58 | 0.18 |
| High-density residential | 0.19 | 1.67 | 0.29 |
| Transportation, communications, and utilities | 0.18 | 1.44 | 0.20 |
| Rangeland | 0.03 | 1.08 | 0.04 |
| Water/wetland | 1.15 | 0.73 | 0.13 |
| Main Street WWTP | 9.03 | 4.58 | 0.77 |
| J. R. Kelly Generating Station | 0.14 | 2.02 | 0.91 |
| Alachua Lake | 63.5 | 1.94 | 0.15 |

### Table 39. Alachua Sink flow and TN and TP concentrations of different sources in 2004

| Land Use Type or Source | Flow ($hm^3$/yr) | TN (mg/L) | TP (mg/L) |
|---|---|---|---|
| Forest/rural open | 0.36 | 1.19 | 0.04 |
| Urban open | 0.92 | 1.10 | 0.13 |
| Agricultural | 0.13 | 2.23 | 0.34 |
| Low-density residential | 0.27 | 1.22 | 0.11 |
| Medium-density residential | 6.41 | 1.58 | 0.18 |
| High-density residential | 0.24 | 1.67 | 0.29 |
| Transportation, communications, and utilities | 0.24 | 1.44 | 0.20 |
| Rangeland | 0.04 | 1.08 | 0.04 |
| Water/wetland | 1.41 | 0.73 | 0.13 |
| Main Street WWTP | 7.61 | 3.94 | 0.52 |
| J. R. Kelly Generating Station | 0.33 | 2.02 | 0.91 |
| Alachua Lake | 99.4 | 1.62 | 0.15 |

To calibrate the model, each source of TN and TP was designated as an independent tributary. Flow and the TN and TP concentrations of the flow were defined for each tributary as listed in **Tables 37** through **39**. The septic tank TN and TP flux into Alachua Sink were calculated as previously described, with values of 145.6 milligrams of nitrogen per square meter per day ($mgN/m^2/day$) and 51.8 milligrams of phosphorus per square meter per day ($mgP/m^2/day$) for the period from 2000 through 2002, and 76.9 $mgN/m^2/day$ and 26.6 $mgP/m^2/day$ for 2003. Septic tank inputs of TN and TP were 124.2 $mgN/m^2/day$ and 42.9 $mgP/m^2/day$ for 2004.

As discussed in the previous section for Alachua Lake modeling, the settling velocity submodel was chosen to estimate the in-lake concentrations of TN and TP.

Calibration factors were applied to fit TN and TP predictions to the measured data. Bathtub provides two calibration methods for phosphorus and nitrogen: Method 0 calibrates decay rates, and Method 1 calibrates concentration. In the first case, the calibration factors are applied to estimated sedimentation rates in computing nutrient balances. In the second case, the factors are applied to estimated concentrations. In Method 0, it is assumed that the error is attributed primarily to the sedimentation model. In Method 1, the error source is unspecified (some combination of input error and sedimentation model error). The latter may be used when predicted nutrient profiles are insensitive to errors in predicted sedimentation rate, because the mass balance is dominated by inflow and outflow terms (low hydraulic residence times) (Walker, 1999). In this study, Method 1 was adopted to calibrate the concentration in Alachua Sink. Typical calibration factors for TN and TP recommended by the Bathtub User's Manual are 0.5 to 2.0 for TP and 0.33 to 3 for TN. In this analysis, 2.0 and 1.3 were used for calibrating TP and TN for all the simulations. Method 0 was adopted to calibrate decay rates for Alachua Lake based on its greater residence time and limited water quality data. Calibration factors of 0.9 and 1.5 were used for calibrating TP and TN for all simulations. **Table 40** shows the results of the model calibration.

**Table 40. Bathtub calibration results for Alachua Sink**

| | **TN (mg/L)** | | | **TP (mg/L)** | | |
|---|---|---|---|---|---|---|
| | **Measured** | **Predicted** | **Error** | **Measured** | **Predicted** | **Error** |
| 2000 | 4.51 | 4.04 | -10.4% | 1.18 | 0.77 | -35.1% |
| 2001 | 4.82 | 4.33 | -10.1% | 1.35 | 1.19 | -11.9% |
| 2002 | 3.65 | 3.44 | -5.7% | 1.30 | 1.10 | -15.1% |
| **Composite 2000–02** | **4.33** | **3.95** | **-8.8%** | **1.28** | **1.05** | **-17.7%** |
| 2003 | 2.78 | 2.85 | 2.5% | 0.63 | 0.46 | -26.9% |
| 2004 | 2.07 | 2.30 | 11.1% | 0.58 | 0.37 | -36.2% |

As noted previously, flow from Alachua Lake to Alachua Sink from 2000 through 2002 was estimated during the Bathtub calibration. The calibrated flow during this period was 1 $hm^3/year$ (about 810 acre-feet/year). Simulation results for nitrogen were close to observed values, while phosphorus was consistently underpredicted. Part of this underprediction is likely due to the limited total phosphorus data available for the Main Street WWTF. Typically only 3 to 4 total phosphorus values were available in a given year (2000 has only 1 total phosphorus value), and averages for individual years ranged from 0.53 mg/L (2000 and 2004) to 1.07 mg/L (2002).

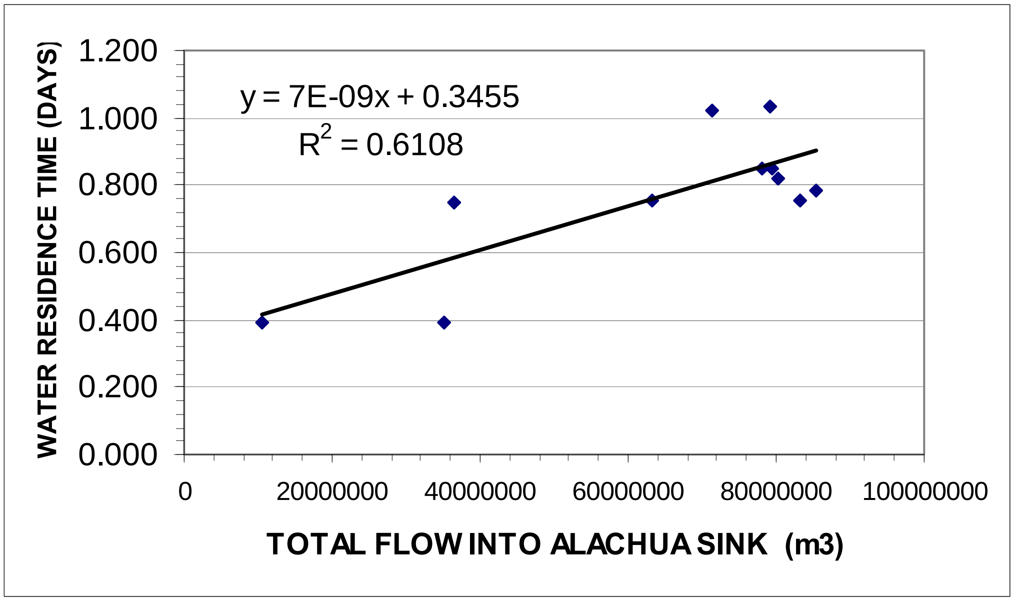


**Figure 8. Correlation between water residence time $\tau_o$ and total flow into Alachua Sink**

The Bathtub model could not be used to estimate chl*a* concentrations for Alachua Sink, because all of the eutrophication response submodel options provided with Bathtub assume a steady-state condition where the water residence time is long enough for the phytoplankton biomass to respond to changes in TN and TP concentrations. This assumption in the model allows the use of characteristic regression curves to predict chl*a* concentrations from TN and TP concentrations. The volume of Alachua Sink was only about 12.6 acre-feet (15,480 $m^3$) from 2000 through 2002, and 94.3 acre-feet (116,355 $m^3$) in 2003. The average annual flow from all the point and nonpoint sources into Alachua Sink was 15,922 acre-feet (19,648,200 $m^3$) from 2000 through 2002, 65,438 acre-feet (80,750,000 $m^3$) for 2003, and 95,105 acre-feet (117,360,200 $m^3$) for 2004. Given the above volumes and flows, and assuming a completely mixed waterbody where evaporation balances precipitation, the water residence time for Alachua Sink was about 1.13 days from 2000 through 2002, 0.78 days for 2003, and 1.09 days for 2004. This residence time is not sufficient to allow the phytoplankton to fully use all the available nutrients in the water (most empirical relationships between chl*a* and nutrient concentrations were developed based on *ANNUAL* chl*a* concentrations and *ANNUAL* nutrient concentrations). Therefore, this analysis did not use an empirical model. Instead, chl*a* concentrations in Alachua Sink were estimated using the following equation:

$$\frac{da}{dt} * V = Q_{in} * A_{in} + K * A * V - Q_{out} * A \qquad (5)$$

where:

da/dt is the change rate of chl*a* in Alachua Sink,
V is the volume of Alachua Sink,
$Q_{in}$ is the inlet flow,

$A_{in}$ is the inlet chl*a* concentration,
K is the intrinsic growth rate of phytoplankton, which is usually considered about 0.5/day under natural conditions (Chapra, 1997),
A is the chl*a* concentration of Alachua Sink, and
$Q_{out}$ is the outlet flow.

Assuming that Alachua Sink is at a steady state:

$$\frac{da}{dt} = 0 \tag{6}$$

Therefore:

$$0 = Q_{in} * A_{in} + K * A * V - Q_{out} * A \tag{7}$$

Re-arranging Equation (7),

$$(Q_{out} - K * V) * A = Q_{in} * A_{in} \tag{8}$$

and

$$A = \frac{Q_{in} * A_{in}}{(Q_{out} - K * V)} \tag{9}$$

Assuming $Q_{in} = Q_{out}$ (i.e., the volume of Alachua Sink did not change during the period of analysis) Equation (9) can be converted to:

$$A = \frac{A_{in}}{(1 - K * \tau)} \tag{10}$$

Where:

$\tau$ is the water residence time of Alachua Sink (Alachua Sink).

In this analysis, $A_{in}$ was calculated as the mean chl*a* concentration of Sweetwater Branch and Alachua Lake weighted over the flow from these two sources. **Table 41** lists the mean value of the measured chl*a* concentration for Sweetwater Branch, based on data provided by the SJRWMD (2000 through 2002), GRU and JEA (2003 and 2004), and the ACEPD (2003 and 2004). The mean flow of Sweetwater Branch was predicted from the WWM model for each year, while the Bathtub model was used to predict the mean flow from Alachua Lake in 2003 and 2004. A mean flow of 1 $hm^3$ ($1x10^6$ $m^3$) was used for the discharge from Alachua Lake from 2000 through 2002.

## Table 41. Annual average flow and chl*a* concentrations in Sweetwater Branch and Alachua Lake used to calculate $A_{in}$

| Parameter | Sweetwater Branch | Alachua Lake |
|---|---|---|
| Flow (acre-feet) (2000–02) | 15,112* | 810** |
| Flow (acre-feet) (2003) | 13,922* | 51,459 |
| Flow (acre-feet) (2004) | 14,554* | 80,551 |
| Average annual chl*a* (µg/L) (2000–02) | 0.51 | 6.51*** |
| Average annual chl*a* (µg/L) (2003) | 2.02 | 6.51*** |
| Average annual chl*a* (µg/L) (2004) | 1.60 | 9.28 |
| $A_{in}$ (µg/L) (2000–02) | 0.80 | |
| $A_{in}$ (µg/L) (2003) | 5.55 | |
| $A_{in}$ (µg/L) (2004) | 8.10 | |

* The flow from Sweetwater Branch includes the discharges from the Main Street WWTP and John R. Kelly Generating Station and the surface runoff created in the Upper Sweetwater Branch, Lower Sweetwater Branch, and Extension Ditch sub-basins.

** Measured data were not available. This value was characterized in the Bathtub calibration for Alachua Sink for the period from 2000 through 2002.

*** Because of the thick mat of floating aquatic plants in the channels from Alachua Lake to Alachua Sink, chl*a* concentration in the flow from Alachua Lake to Alachua Sink could not be modeled. This value is the mean chl*a* concentration of the measured chl*a* concentration of the May 22 and June 9 sampling trips in 2003. During these two trips, Alachua Lake was considered to be at its steady state.

The water residence time for Alachua Sink was calculated by dividing the volume of Alachua Sink by the total flow into Alachua Sink, assuming the waterbody was completely mixed. However, the inlet from Alachua Lake to Alachua Sink and the outlet from Alachua Sink to the primary sink feature are so close to each other that the complete mixing of Alachua Sink by the inlet water from Alachua Lake may not happen regularly. This was in fact demonstrated by a study of the spatial distribution of the chl*a* concentration across Alachua Sink conducted by JEA (2003); the study showed that the chl*a* concentration at the sampling site farthest away from the inlet could be higher than the chl*a* concentration right at the inlet. This indicates that the $\tau$, which is the actual water residence time of phytoplankton communities in Alachua Sink, could be longer than what is predicted by only considering the volume of Alachua Sink and total flow into Alachua Sink ($\tau_0$) because of the existence of the nonmixed area.

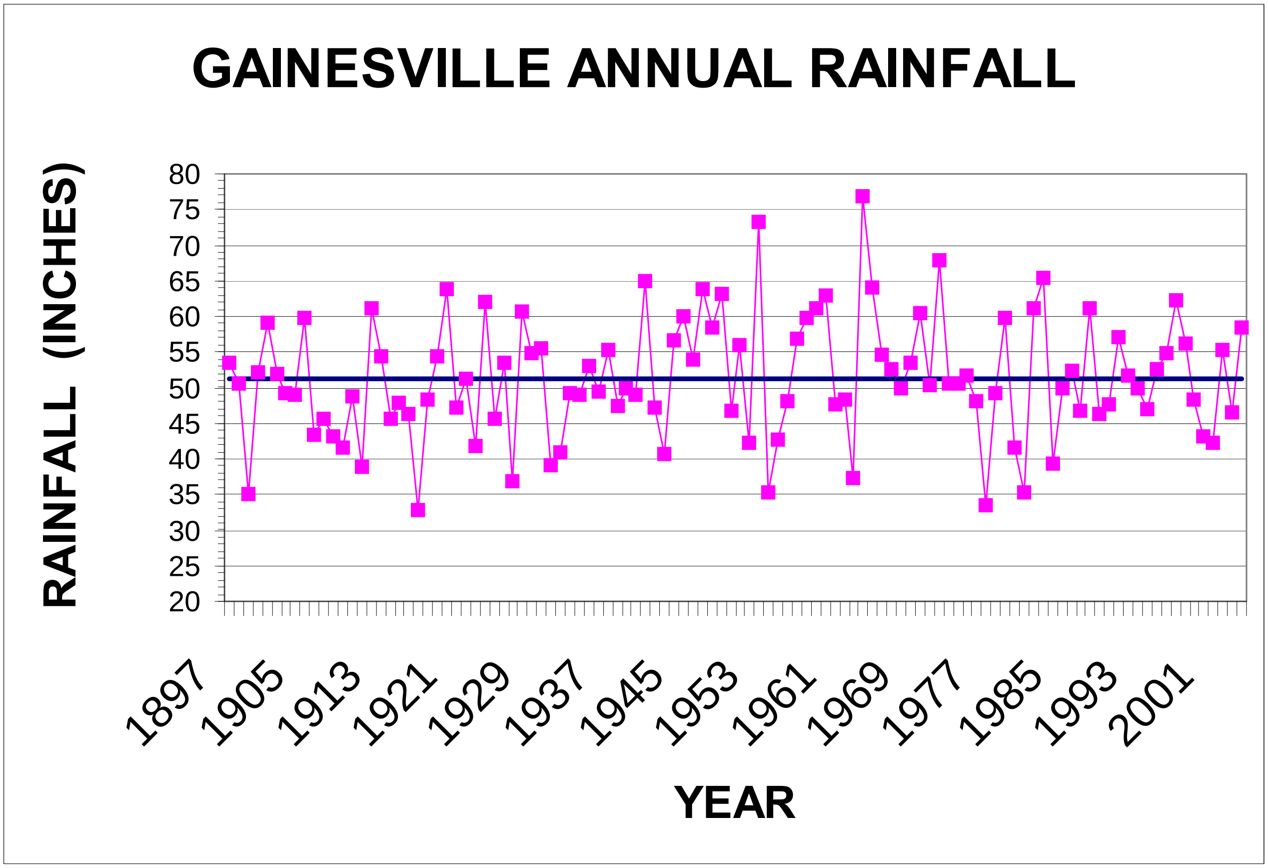
Because the actual $\tau$ of the phytoplankton community could not be calculated by simply dividing the volume of Alachua Sink by the total flow, a ratio was calculated between the actual $\tau$ of phytoplankton and the water residence time calculated by dividing the volume of Alachua Sink by the total flow into Alachua Sink ($\tau_0$). This ratio was later used to calculate the $\tau$ after the hydrology of the watershed was changed due to a change in the land use pattern and/or the removal of point sources.

To determine the actual $\tau$, the measured in-lake chl*a* concentration (A) and the average chl*a* concentration in the inlet water ($A_{in}$) **(Table 39)** were substituted into Equation (10) to solve for $\tau$. By assuming that the phytoplankton intrinsic growth rate is 0.5/ days, the estimated $\tau$ is about 1.96 days, based on an annual average chl*a* concentration of 40.8 µg/L for Alachua Sink from 2000 through 2002 **(Table 36).** This yields a ratio between $\tau$ and $\tau_0$ (1.13 days as calculated previously) of 1.73 for the period from 2000 through 2002. For 2003, the $\tau$ calculated using the same method is 0.64 days based on an annual mean chl*a* concentration of 8.15 µg/L **(Table 36)** and an average $A_{in}$ of 5.55 µg/L **(Table 41).** The $\tau_0$ calculated previously was 0.69. The $\tau/\tau_0$

ratio for 2003 was 0.94. In 2004, the $\tau$ calculated was 1.46 days, based on an annual mean chl*a* concentration of 29.77 μg/l and an average $A_{in}$ of 8.10 μg/l. The $\tau/\tau_0$ ratio for 2004 was 1.33. Except for 2003, the calculated $\tau/\tau_0$ ratio exceeded 1, indicating that the exposure time of phytoplankton to nutrients and the time available for growth were greater than the simple hydraulic residence time calculated by the Bathtub model. According to Jim Weimer (personal communication), Paynes Prairie Park biologist, 2003 was the first time that he had seen Alachua Sink completely covered by floating macrophytes (this was the case by October 2003). Consequently, although nutrients were readily available in 2003, floating macrophytes limited the available light for phytoplankton growth in the water column, and increased plant biomass was in the form of macrophytes rather than algal chlorophyll.

### 5.3.2 Determination of Wet and Dry Periods for Model Simulation and TMDL Development

Annual rainfall records for Gainesville from 1897 through 1995 were obtained from Rao et al. (1997) and updated through 2004. Over this period of record, the annual rainfall average was 51.3 inches. **Figure 8** illustrates the long-term rainfall pattern along with cumulative frequency information. For example, the 25th percentile for annual rainfall is 46.63 inches, meaning that 75% of the years have rainfall totals that exceed 46.63 inches. The years 2000, 2001, and 2003 were in the 16th–25th percentile, while 2002 and 2004 were in the 70th–78th percentile with respect to annual rainfall.



| HISTORICAL RAIN STATISTICS | | | |
|---|---|---|---|
| | Rainfall (inches) | | |
| N of cases | 108 | | |
| Minimum | 32.79 | | |
| Maximum | 76.95 | | |
| Median | 50.415 | | |
| Mean | 51.298 | | |
| 95% CI Upper | 52.917 | | |
| 95% CI Lower | 49.679 | | |
| Standard Dev | 8.488 | | |
| 1% | 33.24 | | |
| 5% | 36.73 | 60% | 52.78 |
| 10% | 40.79 | 70% | 55.33 |
| 20% | 45.56 | 75% | 56.83 |
| 25% | 46.63 | 80% | 59.66 |
| 30% | 47.31 | 90% | 62.21 |
| 40% | 48.93 | 95% | 64.13 |
| 50% | 50.42 | 99% | 74.83 |

**Figure 9. Annual rainfall at Gainesville, 1897–2004**

It was noted earlier that annual rainfall totals were below average for 1999 through 2001. The frequency of cycles of wet or dry periods was explored by calculating a running 3-year average annual rainfall total over the period of record **(Figure 10).** The 1999–2001 average of 44.56 inches represented the 11th percentile. The 2001–03 average of 48.03 inches ranked at about the 25th percentile. When the 2002–04 period was ranked, the average of 53.43 inches was at the 68th percentile. It appears that the 2000–04 period encompassed some rather large ranges in individual yearly rain totals, as well as large ranges in multiple-year averages, such as the 3-year average presented here.

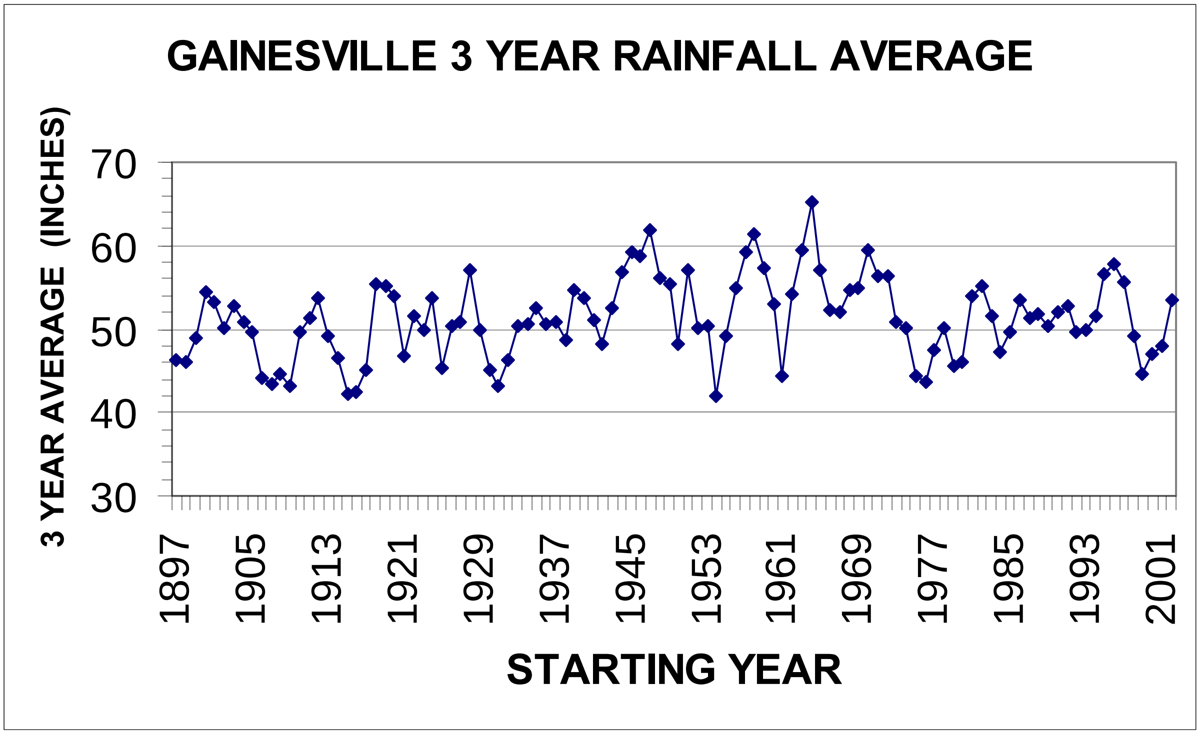


**Figure 10. Running three-year average rainfall for Gainesville**

Flow records for the Sweetwater Branch gauging site near Williston Road were also evaluated with respect to the influence of the Main Street WWTP flow. **Figure 11a** illustrates daily flow records at this site from 1998 through 2004. Daily flows for Sweetwater Branch are plotted along with the daily discharge flows from the Main Street WWTF (Brett Goodman, GRU, personal communication). Cumulative frequency plots are provided for daily flow at the site with and without the Main Street WWTP contribution **(Figure 11b). Table 44** summarizes various flow percentiles based on the total flow at the Sweetwater gauge, as well as flow with the Main Street WWTF flow removed. According to the table, without the Main Street WWTF discharge, the 25th percentile is less than 1 cfs, and the 25th percentile flow with the Main Street WWTF is nearly 14 times higher.

**Figure 11a. Daily flow (cfs) on Sweetwater Branch near Williston Road, 1998–2004**

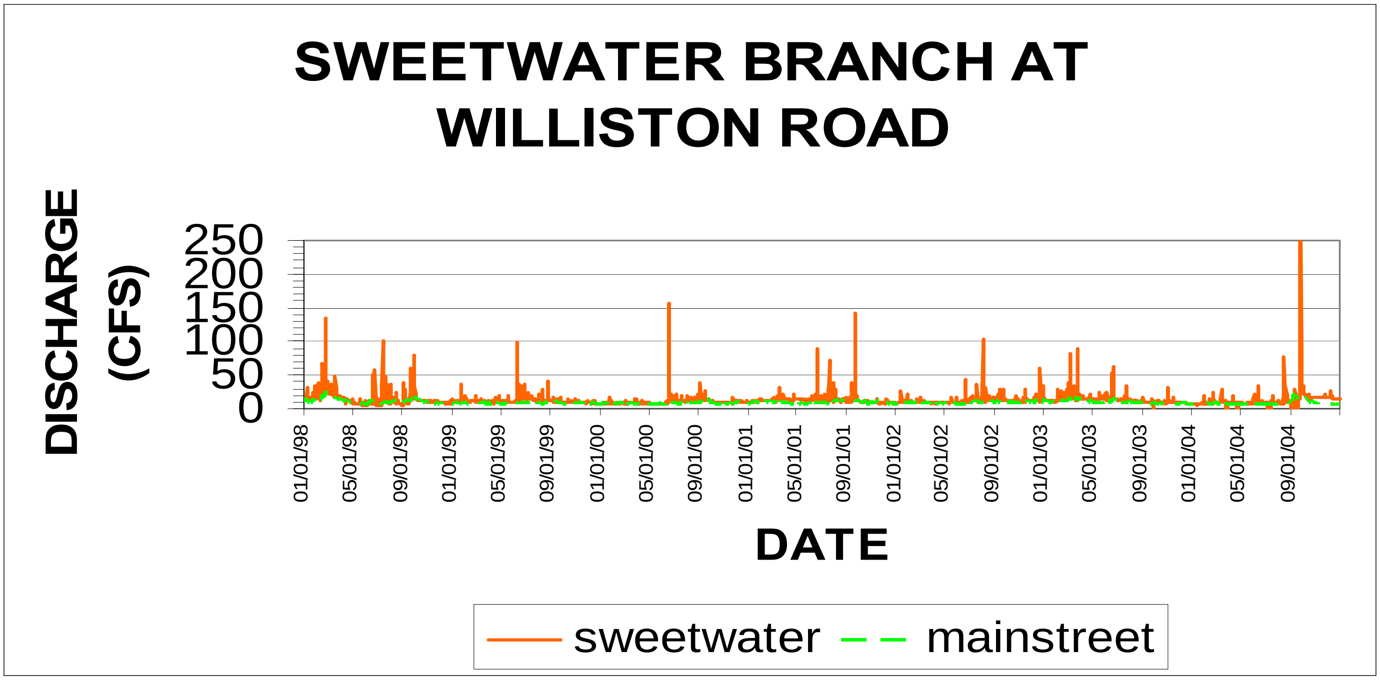


**Figure 11b. Cumulative frequency flow plot for Sweetwater Branch with and without the Main Street WWTP**

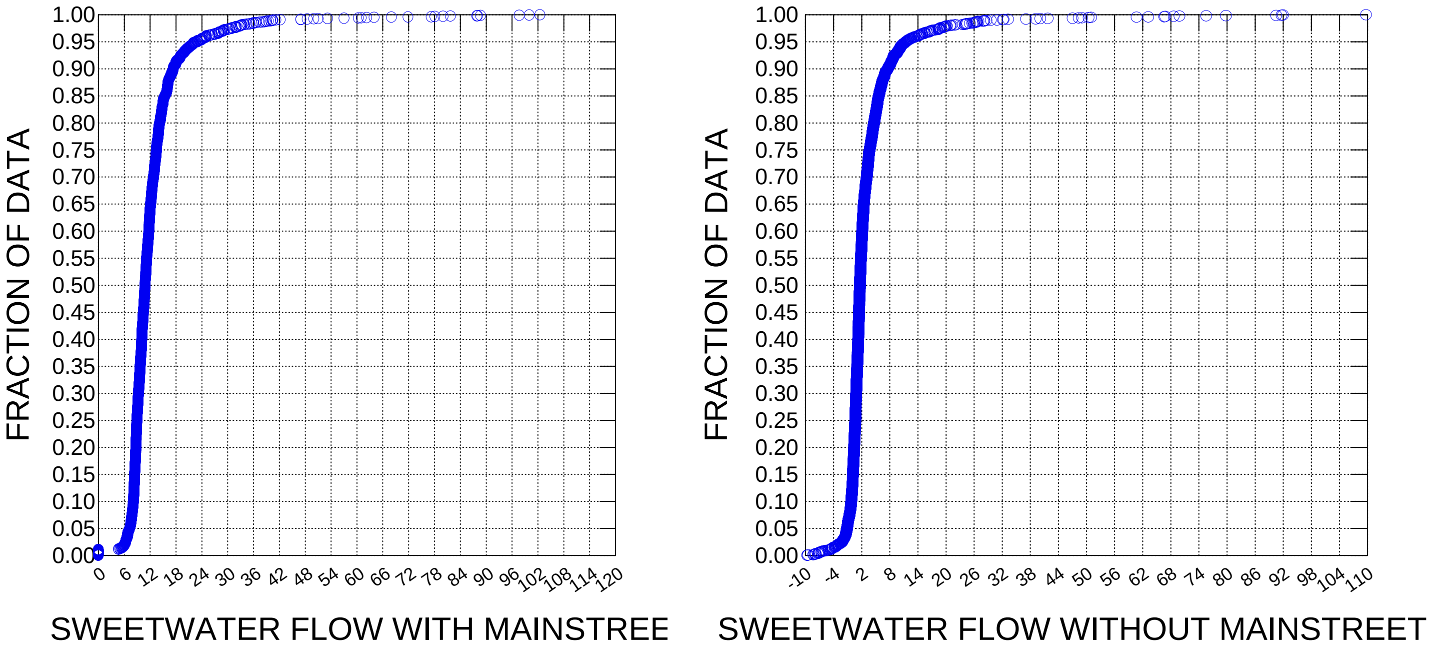


**Table 42. Percentile flow at the Sweetwater Branch gauge with and without the Main Street WWTF, 1998–2004**

| Percentile | With Main Street (cfs) | Without Main Street (cfs) |
|---|---|---|
| 5 | 7.24 | -1.18 |
| 10 | 8.13 | -0.25 |
| 25 | 8.96 | 0.65 |
| 50 | 10.84 | 1.63 |
| 75 | 13.52 | 3.73 |
| 90 | 17.41 | 7.65 |
| 95 | 23.00 | 11.67 |
| 99 | 47.00 | 33.27 |

Based on the historical record, a dry-weather critical condition corresponding to the 25th percentile of rainfall (46.6 inches) and a wet-weather critical condition corresponding to the 75th percentile of rainfall (56.7 inches) were selected for simulation and use in TMDL development. From 2000 through 2004, there were individual years that bracketed each of these percentiles, and the model calibration of these individual years presented earlier supported the continued application of the models to establish nutrient TMDLs for Alachua Sink.

### *5.3.3 Evaluating the Background TSI of Alachua Sink*

Two scenarios were analyzed for the background TSI of Alachua Sink. For the first scenario, the discharges from the two point sources (the Main Street WWTP and John R. Kelly Generating Station) were kept, but the TN and TP concentrations from these facilities were reduced to the EMC level of forest/rural open land. For the second scenario, the discharges from the two facilities were totally removed.

In addition to the above modification of the TN and TP loadings, the following procedures were followed to analyze the background TSI of Alachua Sink for both scenarios:

- All the man-made land use categories (urban open; agricultural, low-, medium-, and high-density residential; transportation and communication; and rangeland) in both the watershed areas that discharge into Sweetwater Branch, directly to Alachua Sink, and into Alachua Lake were evaluated as forest/rural open. All of the loadings from septic tanks were also removed.
- TN and TP loadings through surface runoff into both Sweetwater Branch, directly to Alachua Sink, and Alachua Lake were then re-estimated for both a dry year and a wet year using the calibrated WMM.
- TN and TP concentrations from forest/rural open and water/wetland were calculated by dividing the total loadings by the total flow from the watershed.
- TN and TP concentrations of the flow from Alachua Lake to Alachua Sink were re-estimated using the Bathtub model set up previously for Alachua Lake. TN and TP concentrations for Prairie Creek were reduced to 1.192 mg/L and 0.068 mg/L, respectively. These are the concentrations for Newnans Lake, assuming the attainment of the nutrient TMDL for Alachua Sink (Gao and Gilbert, 2003). Based on TN data provided by Carol Lippincott (personal communication) of the SJRWMD that

documented a consistent reduction in TN between 2 monitoring locations in Prairie Creek, the TN concentration was further reduced to 0.88 mg/L.

The dry-weather critical condition simulated (46.6 inches of rainfall) was very similar to the climatic and hydrologic conditions present in 2003. The Bathtub model was used to simulate the natural background dry-weather conditions for Alachua Lake. Based on the simulation, the annual flow from Alachua Lake to Alachua Sink was 52.0 $hm^3$. The Main Street WWTP and John R. Kelly Generating Station plant flows were set at 9.03 $hm^3$ and 0.14 $hm^3$, respectively. The wet-weather critical condition rainfall was slightly less than the total recorded in 2004. Again a Bathtub model simulation was completed to determine the flow and nutrient contributions from Alachua Lake. Under the wet-weather critical condition, the annual discharge from Alachua Lake was 74.6 $hm^3$. The Main Street WWTP and John R. Kelly Generating Station plant flows were set at 9.03 $hm^3$ and 0.18 $hm^3$, respectively.

**Table 43. Background flow and TN and TP concentrations of surface runoff into Alachua Sink and Alachua Lake in a dry year**

| Land Use Type or Source | Flow to Alachua Sink ($hm^3$/yr) | Flow to Alachua Lake ($hm^3$/yr) | TN concentration (mg/L) | TP concentration (mg/L) |
|---|---|---|---|---|
| Forest/rural open | 1.75 | 9.73 | 1.190 | 0.040 |
| Water/wetland | 1.13 | 25.68 | 0.730 | 0.130 |
| Main Street WWTP | 9.03 | - | 1.190 | 0.040 |
| J. R. Kelly Generating Station | 0.14 | - | 1.190 | 0.040 |
| Alachua Lake | Bathtub predicted | - | Bathtub predicted | Bathtub predicted |
| Prairie Creek | - | 30 | 0.88 | 0.068 |

-

**Table 44. Background flow and TN and TP concentrations of surface runoff into Alachua Sink and Alachua Lake in a wet year**

| Land Use Type or Source | Flow to Alachua Sink ($hm^3$/yr) | Flow to Alachua Lake ($hm^3$/yr) | TN concentration (mg/L) | TP concentration (mg/L) |
|---|---|---|---|---|
| Forest/rural open | 2.13 | 11.83 | 1.190 | 0.040 |
| Water/wetland | 1.37 | 31.23 | 0.730 | 0.130 |
| Main Street WWTP | 9.03 | - | 1.190 | 0.040 |
| J. R. Kelly Generating Station | 0.18 | - | 1.190 | 0.040 |
| Alachua Lake | Bathtub Predicted | - | Bathtub predicted | Bathtub predicted |
| Prairie Creek | - | 40 | 0.88 | 0.068 |

The flow and TN and TP concentrations of surface runoff from forest/rural open, water/wetland, and Alachua Lake into Alachua Sink were then entered into the calibrated Bathtub model to re-estimate the in-lake TN and TP concentrations. As presented in **Table 41,** a mass balance approach was used to estimate an average chl*a* concentration ($A_{in}$) that entered Alachua Sink based on flow rates and chl*a* concentrations from Sweetwater Branch and Alachua Lake. Following a similar approach for the critical background wet and dry scenarios, chl*a* concentrations of 8.64 µg/l and 8.16 µg/l were calculated for the dry natural conditions with and without point sources at forest concentrations. Chl*a* concentrations of 8.16 µg/l and 8.91 µg/l were calculated for the wet natural conditions with and without point sources at forest conditions.

Water residence times in 2003 and 2004 averaged 0.78 days and 1.09 days, respectively. Comparisons between the algal biomass levels in Alachua Sink from 2000 through 2004 and inflow concentrations indicated that phytoplankton residence times exceeded the water residence times by up to a factor of 2. Water residence times calculated by the Bathtub model for the background wet and dry scenarios were multiplied by a factor of 1.5 to yield residence times of 1.20 days for the dry scenario and 0.71 days for the wet scenario. Based on Equation (10), the corresponding chl*a* concentrations in Alachua Sink for the natural background dry and wet conditions with point sources at forest conditions would be 20.1 $\mu$g/l and 11.7 $\mu$g/l, respectively. Chl*a* concentrations in Alachua Sink for the background dry and wet conditions without the point sources would be 20.3 $\mu$g/l and 13.8 $\mu$g/l, respectively.

The TSI represents the average of a $TSI_{NUT}$ and a $TSI_{CHL}$. The Bathtub model provided acceptable predictions for annual TN and TP concentrations in Alachua Sink over a variety of hydrologic conditions for the 2000–04 period. Chlorophyll predictions were problematic for a variety of reasons, however, including the response of the Alachua Lake and Alachua Sink systems to increased rainfall after a prolonged dry period, as well as the proliferation of floating macrophytes in both systems. Portions of Sweetwater Branch are periodically covered by floating macrophytes as well as emergent macrophytes; these compete with phytoplankton for nutrients and limit available light for phytoplankton growth. Alachua Lake/Paynes Prairie is an extensive wetland system where emergent and floating macrophytes dominate over phytoplankton. In addition, the Alachua Sink waterbody represents a rather small, shallow system, particularly with respect to the application of lake or reservoir models to predict steady-state chl*a* levels. Finally, as seen in the available data, chl*a* concentrations could change dramatically (spatially and temporally) and even the existing information was not likely to fully capture and characterize those fluctuations.

Consequently, the TMDL focused on the $TSI_{NUT}$ component of the TSI. It should also be noted that there is a growing concern statewide regarding the quality of surface water that enters the aquifer system via both natural and man-made pathways. The state continues to fund a number of research and remediation projects to reduce nitrogen, particularly nitrates in ground water and springs. The background $TSI_{NUT}$, with point source discharges set at forest EMC concentrations, was 68.04 for the dry period and 65.86 for the wet period. The natural background TSI with no point source discharges was 67.87 for the dry period and 65.46 for the wet period. Based on current Department practice, where the natural background TSI of a lake is different from the target TSI in Rule 62-303, F.A.C., natural background plus 5 TSI units will be used as the target for TMDL development. In this case, the TN and TP loadings under the TMDL should be those loads that result in a TSI of no more than 73.04 in dry periods and 70.86 in wet periods.

**Table 45. Simulated natural background TN and TP concentrations for Alachua Lake in dry and wet years**

| Variable | Dry year | Wet year |
|---|---|---|
| TP (mg/L) | 0.089 | 0.080 |
| TN (mg/L) | 1.14 | 1.01 |

**Table 46. Simulated background TN, TP, and chl*a* concentrations and TSI for Alachua Sink in dry and wet years**

| Variable | Dry Year | | Wet Year | |
|---|---|---|---|---|
| | Point Source Discharge Not Removed | Point Source Discharge Removed | Point Source Discharge Not Removed | Point Source Discharge Removed |
| TP (mg/L) | 0.162 | 0.176 | 0.152 | 0.160 |
| TN (mg/L) | 1.481 | 1.469 | 1.338 | 1.313 |
| Chla (µg/L) | 20.5 | 20.1 | 11.7 | 13.8 |
| $TSI_{NUT}$ | 68.04 | 67.87 | 65.86 | 65.46 |

### *5.3.4 Summary of TN and TP Loading for Current and Background Conditions*

**Table 47** summarizes the TN and TP loadings into Alachua Sink from point and nonpoint sources under current conditions and background conditions. Based on **Table 46,** the natural background $TSI_{NUT}$ for Alachua Sink is between 65.48 and 68.04, depending on the climatic condition and whether a background point source flow is included.

#### *Critical Condition*

**Table 48** lists the current and background TN and TP loadings from major sources to Alachua Sink during the period of this analysis. For the current condition, the TN and TP loadings are 382,062 lbs/yr and 40,478 lbs/yr for the dry year, and 462,457 lbs/yr and 91,888 lbs/yr for the wet year, respectively. Because the goal of TMDL development is for a waterbody segment to meet water quality criteria all the time, whether it is a dry-weather condition or a wet-weather condition, the TMDL for Alachua Sink was based on 2 separate conditions. A dry-year loading was used as the critical condition for the NPDES facilities that discharge to Alachua Sink ($TSI_{NUT}$ limit of 73.04), and a wet-year loading was used as the critical condition for the NPDES municipal separate storm sewer system (MS4) and load allocation (LA) portion of the TMDL ($TSI_{NUT}$ limit of 70.86).

The model was then used to estimate the TN and TP loadings that result in a $TSI_{NUT}$ of 73.04. To reduce the TN and TP loadings during the dry year, some portions of the area of human land use categories were changed to have the runoff coefficients and EMCs of the forest/rural open land area. At the same time, the same percent load reduction was applied to the point sources by allowing the current TN and TP concentrations (Main Street WWTF discharge assumed TN and TP concentrations of TN = 4.46 mg/L, TP = 0.77 mg/L) of the discharges to remain the same, but the discharge flow from the Main Street WWTF was gradually reduced. No changes were made to the John R. Kelly Generating Station discharge. Using the above calibrated models, a 54.5% reduction in TN loading from the current dry condition is required to achieve the target, and the allowable TN loading is 40,380 lbs/yr. This corresponds to a daily discharge of 2.97 mgd at a total nitrogen concentration of 4.46 mg/L from the Main Street WWTP. **Table 48** lists the detailed TN and TP loadings from different sources.

Because the wet-year natural background $TSI_{NUT}$ is 65.86, the appropriate $TSI_{NUT}$ threshold for wet years is 70.86. A similar procedure was followed to determine the level of reduction from the current wet-weather loading level necessary to achieve the target. Based on the calibrated models above, wet-weather loadings need to be reduced by 44.4% to reach the target **(Figure 13). Table 48** lists the TN and TP loadings from the different sources.

**Table 47. Alachua Sink TN and TP loadings (lbs/yr) from point and nonpoint sources under current and background conditions**

| Sources | Current Condition | | | | Background Condition | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Dry Year | | Wet Year | | Dry Year | | | | Wet Year | | | |
| | | | | | Point Source Discharge Not Removed | | Point Source Discharge Removed | | Point Source Discharge Not Removed | | Point Source Discharge Removed | |
| | TP | TN | TP | TN | TP | TN | TP | TN | TP | TN | TP | TN |
| Watershed | 2,928 | 24,642 | 3,551 | 29,910 | 497 | 6,984 | 497 | 6,984 | 581 | 7,800 | 581 | 7,800 |
| Septic Tanks | 1,326 | 3,837 | 1,614 | 4,667 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Precipitation | 8 | 16 | 11 | 23 | 8 | 16 | 8 | 16 | 11 | 23 | 11 | 23 |
| Main Street WWTP | 15,329 | 88,748 | 15,329 | 88,748 | 796 | 23,690 | 0 | 0 | 796 | 23,690 | 0 | 0 |
| J. R. Kelly Generating Station | 281 | 623 | 361 | 802 | 12 | 367 | 0 | 0 | 16 | 472 | 0 | 0 |
| Alachua Lake | 20,606 | 264,196 | 71,022 | 338,307 | 10,203 | 130,230 | 10,203 | 130,230 | 13,157 | 166,108 | 13,157 | 166,108 |
| **Total** | **40,478** | **382,062** | **91,888** | **462,457** | **11,516** | **161,287** | **10,708** | **137,230** | **14,561** | **198,093** | **13,749** | **173,931** |

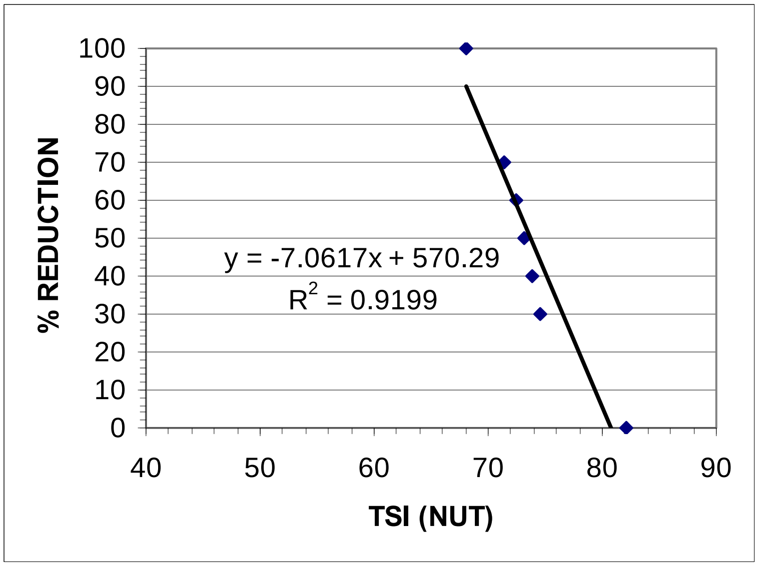


**Figure 12.** Correlation plot of $TSI_{NUT}$ versus reduction from the current dry-condition case

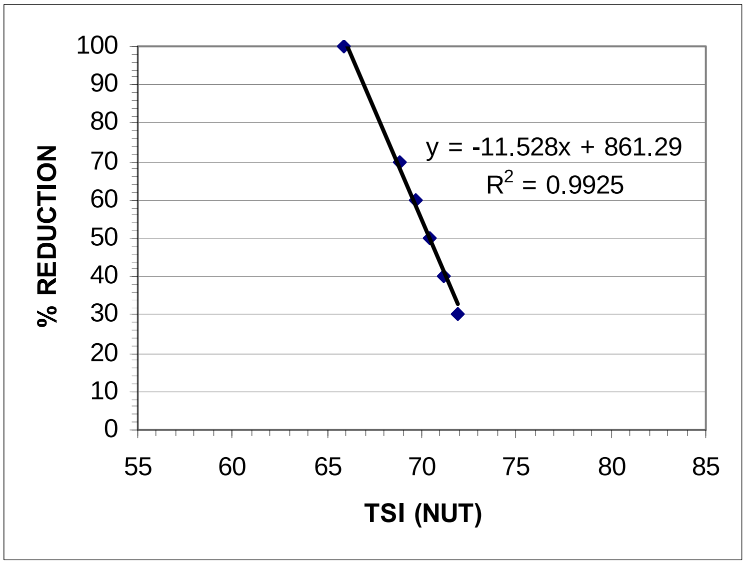


**Figure 13.** Correlation plot of $TSI_{NUT}$ versus reduction from the current wet-condition case

### Table 48. TN and TP loadings from different sources resulting in the target TSI (lbs/yr)

| | **Dry Year** | | **Wet Year** | |
|---|---|---|---|---|
| | **TP** | **TN** | **TP** | **TN** |
| Watershed | 1,586 | 14,255 | 2,245 | 20,111 |
| Precipitation | 8 | 16 | 11 | 23 |
| Main Street WWTP | 6,975 | 40,380 | 6,975 | 40,380 |
| J. R. Kelly Generating Station | 281 | 623 | 361 | 801 |
| Alachua Lake | 12,954 | 149,596 | 17,565 | 195,007 |
| **Total** | **21,804** | **204,870** | **27,157** | **256,322** |
| **Load reduction (lbs/yr)** | **18,674** | **177,192** | **64,731** | **206,135** |
| **Percent load reduction (lbs/yr)** | **46%** | **46%** | **70%** | **45%** |

# Chapter 6: DETERMINATION OF THE TMDL

## 6.1 Expression and Allocation of the TMDL

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

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

As mentioned in **Section 4.1,** the WLA is broken out into separate subcategories for wastewater discharges and stormwater discharges regulated under the NPDES Program:

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

It should be noted that the various components of the 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 is also different than 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 best management practices (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 nutrient TMDL for Alachua Sink **(Table 49)** is expressed in terms of lbs/yr and/or percent reduction. Based on a TN/TP ratio smaller than 10 for the current condition, TN is the limiting nutrient for Alachua Sink phytoplankton communities and the Alachua Sink TMDL was only developed for TN loadings **(Table 49).**

**Table 49. TMDL Components**

| WBID | Parameter | WLA | | LA (lbs/yr)[2] | MOS | TMDL (lbs/yr)[2] | Percent Reduction[2] |
|---|---|---|---|---|---|---|---|
| | | Wastewater (lbs/yr)[1] | NPDES Stormwater[2] | | | | |
| 2720A | TN | 41,003 | 45% reduction | 215,319 | Implicit | 256,322 | 45% |

[1] Based on the critical dry-period (dry) allowable loadings.
[2] Based on the wet-period allowable loadings and contains the total allowable stormwater loading (NPDES stormwater and non-NPDES stormwater).

**Note:** The low-flow loadings represent the water quality–based effluent limit (WQBEL) for the facilities. As this loading is based on dry-weather conditions with a limited nonpoint source contribution, pollutant trading with nonpoint sources would not be appropriate at this time.

It should be noted that, for this TMDL, the Department did not follow the "standard" three-step allocation procedure outlined in the *Report to the Governor and the Legislature on the Allocation of Total Maximum Daily Loads in Florida* (Department, February 1, 2001). However, as described in the report, the Department should use its best professional judgment to determine whether all of the allocation steps are warranted in a given TMDL. For this TMDL, the Department allocated loadings between point and nonpoint sources based on dry- and wet-year conditions, respectively, rather than sequentially reducing nonpoint sources and then point sources. This approach was appropriate because the point sources are the dominant source of TN loading during dry-weather conditions, particularly during very low-flow conditions under which WQBELs for point sources are typically determined.

## 6.2 Load Allocation

The total allowable nonpoint loading is 215,319 lbs/yr for TN. Given that current TN nonpoint source loadings were 372,907 lbs/yr for the wet year, the TMDL requires a 45% reduction in existing nonpoint source loadings to the Alachua Sink watershed. This represents the combined nonpoint loading from MS4 areas, as well as discharges regulated by the Department and the water management districts that are not part of the NPDES Stormwater Program (see **Appendix A**).

It should be noted that the TMDL developed for Alachua Sink assumes that the Newnans Lake TMDL will be met. Nitrogen and phosphorus TMDLs were adopted for Newnans Lake and limit the annual load of TN and TP to the lake to 85,470 lbs and 10,924 lbs, respectively.

## 6.3 Wasteload Allocation

### *6.3.1 NPDES Wastewater Discharges*

The WLAs for NPDES wastewater discharges are 40,380 lbs/yr of TN for the Main Street WWTP (FL0027251) and 623 lbs/yr of TN for the John R. Kelly Generating Station (FL0026646). The WLA was based on the water quality data measured from 2000 through 2004. Both a critical dry and wet condition were simulated to assess the impacts associated with point and nonpoint source discharges to Alachua Sink. In both cases, a 54.5 % reduction of the point source loading from current conditions was needed to achieve the corresponding $TSI_{NUT}$ targets.

TN loading from point sources, especially the loading from the Main Street WWTP, played a very important role in influencing the water quality of Alachua Sink. Of the existing dry-year total of 382,062 lbs of TN discharged into Alachua Sink **(Table 44),** the Main Street WWTP currently contributes 88,748 lbs, which represents about 23% of the total current critical period TN loading into Alachua Sink. The total allowable critical period TN loading is 204,870 lbs/yr of TN.

### *6.3.2 NPDES Stormwater Discharges*

As noted in **Sections 4** and **6.1**, the load from stormwater discharges permitted under the NPDES Stormwater Program is placed in the WLA, rather than the LA. This includes loads from MS4s. Based on the 2000 census, the Alachua Sink watershed includes areas that are covered by the MS4 Program, and the WLA for stormwater discharges is a 45% reduction in current loading from the MS4. This percent reduction is the same percent reduction required under the LA for nonpoint sources. However, it should be noted that any MS4 permittee is only responsible for reducing the loads associated with stormwater outfalls that it owns or otherwise has responsible control over, and it is not responsible for reducing other nonpoint source loads in its jurisdiction.

## 6.4 Margin of Safety

The methodology used to determine this TMDL includes an implicit MOS because it relies on the dry-year background TSI as the target for the TMDL. Additional implicit MOSs exist due to some of the assumptions made during the modeling process, including the use of maximum septic tank loading rates and maximum rates of septic tank failure.

# Chapter 7: NEXT STEPS: IMPLEMENTATION PLAN DEVELOPMENT AND BEYOND

## 7.1 Basin Management Action Plan

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

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

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

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# Appendices

## Appendix A: Background Information on Federal and State Stormwater Programs

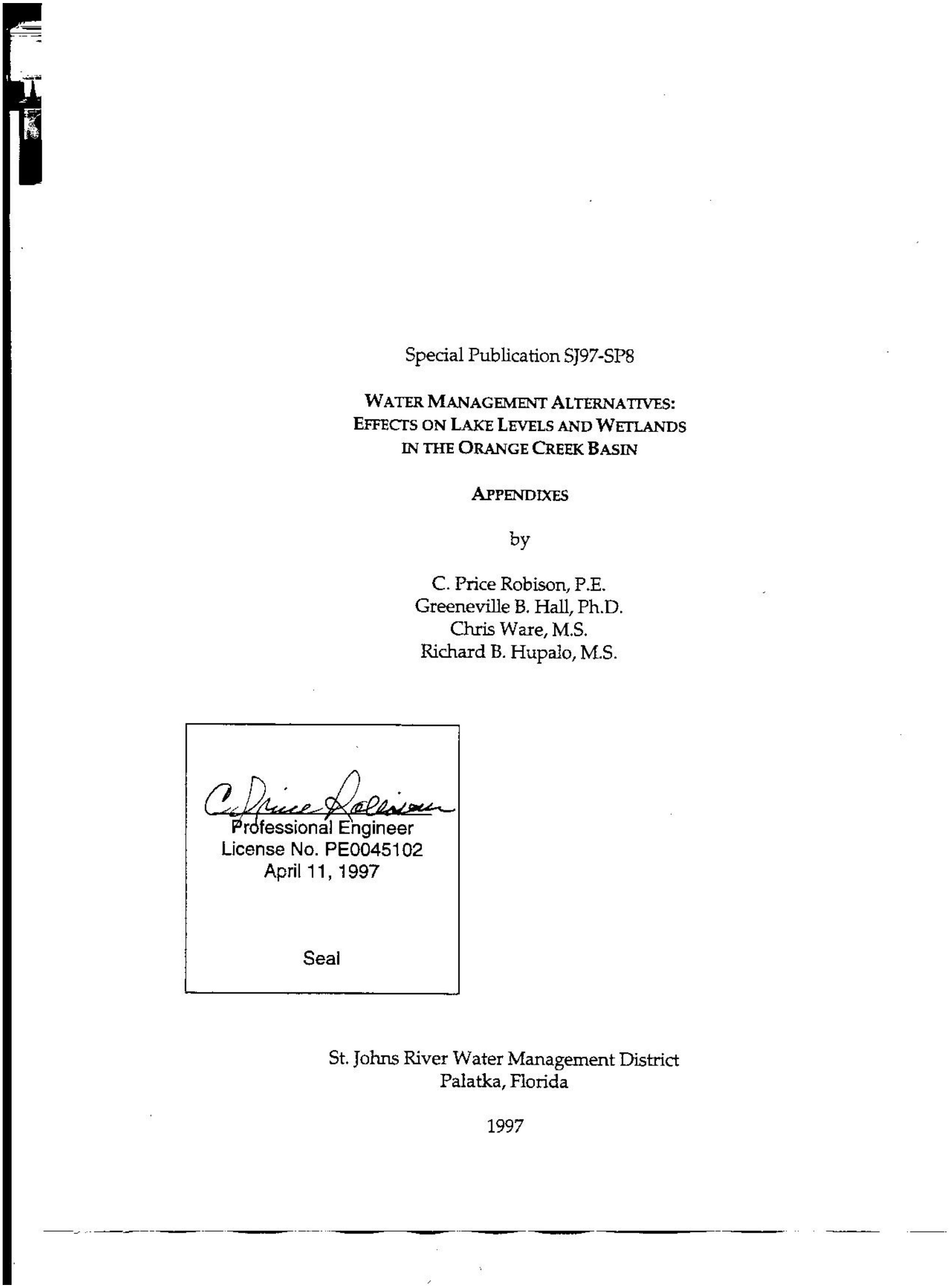
In 1982, Florida became the first state in the country to implement statewide regulations to address the issue of nonpoint source pollution by requiring new development and redevelopment to treat stormwater before it is discharged. The Stormwater Rule, as authorized in Chapter 403, F.S., was established as a technology-based program that relies on the implementation of BMPs that are designed to achieve a specific level of treatment (i.e., performance standards) as set forth in Chapter 62-40, F.A.C.

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

In 1987, the U. S. Congress established Section 402(p) as part of the federal Clean Water Act Reauthorization. This section of the law amended the scope of the federal NPDES stormwater permitting program to designate certain stormwater discharges as "point sources" of pollution. These stormwater discharges include certain discharges that are associated with industrial activities designated by specific standard industrial classification (SIC) codes, construction sites disturbing 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 has implemented Phase 1 of the MS4 permitting program on a countywide basis, which brings in all cities (incorporated areas), Chapter 298 urban water control districts, and the FDOT throughout the 15 counties meeting the population criteria.

An important difference between the federal and state stormwater permitting programs is that the federal program covers both new and existing discharges, while the state program focuses on new discharges. Additionally, Phase 2 of the NPDES Program will expand the need for these permits to construction sites between 1 and 5 acres, and to local governments with as few as 10,000 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, as are other point sources of pollution such as domestic and industrial wastewater discharges. The Department recently accepted delegation from the EPA for the stormwater part of the NPDES Program. It should be noted that most MS4 permits issued in Florida include a re-opener clause that allows permit revisions to implement TMDLs once they are formally adopted by rule.

## Appendix B: Paynes Prairie Elevation, Area, and Volume Information



Special Publication SJ97-SP8

# WATER MANAGEMENT ALTERNATIVES:
# EFFECTS ON LAKE LEVELS AND WETLANDS
# IN THE ORANGE CREEK BASIN

## APPENDIXES

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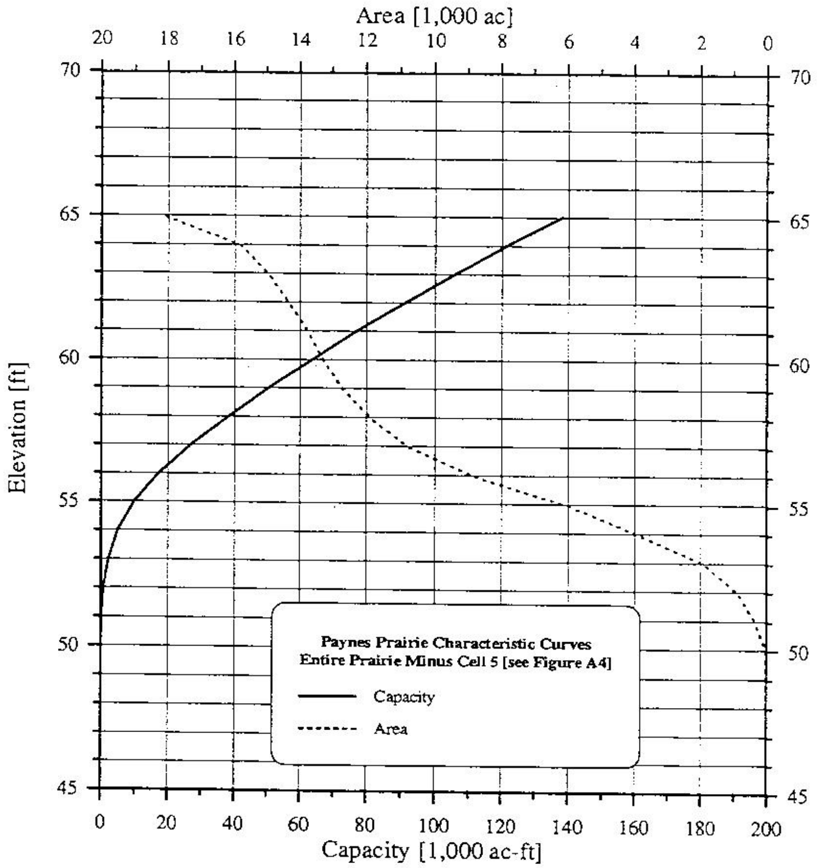

**Figure B4.** Characteristic curves for Paynes Prairie

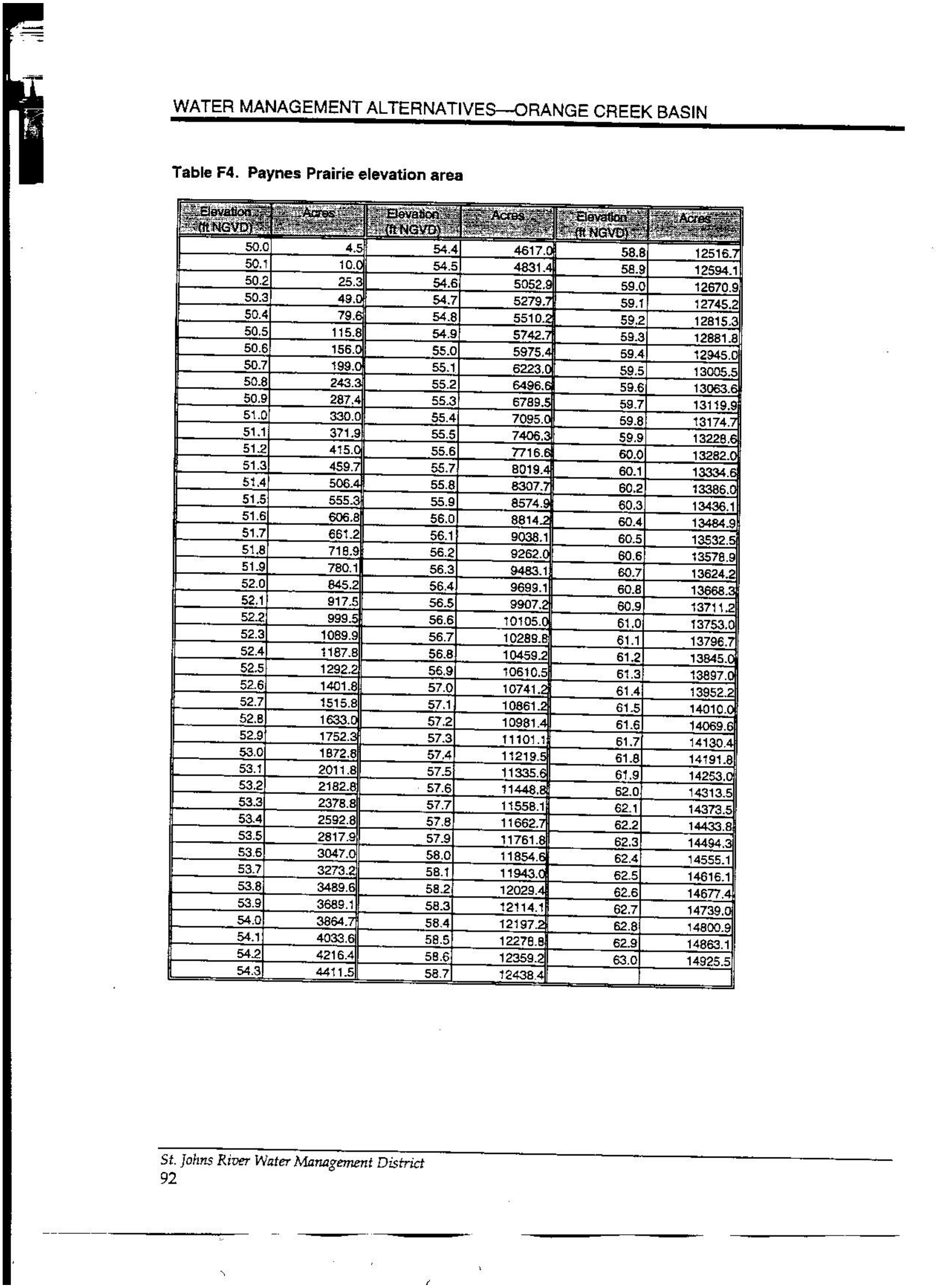

**Table F4. Paynes Prairie elevation area**

| Elevation (ft NGVD) | Acres | Elevation (ft NGVD) | Acres | Elevation (ft NGVD) | Acres |
|---|---|---|---|---|---|
| 50.0 | 4.5 | 54.4 | 4617.0 | 58.8 | 12516.7 |
| 50.1 | 10.0 | 54.5 | 4831.4 | 58.9 | 12594.1 |
| 50.2 | 25.3 | 54.6 | 5052.9 | 59.0 | 12670.9 |
| 50.3 | 49.0 | 54.7 | 5279.7 | 59.1 | 12745.2 |
| 50.4 | 79.6 | 54.8 | 5510.2 | 59.2 | 12815.3 |
| 50.5 | 115.8 | 54.9 | 5742.7 | 59.3 | 12881.8 |
| 50.6 | 156.0 | 55.0 | 5975.4 | 59.4 | 12945.0 |
| 50.7 | 199.0 | 55.1 | 6223.0 | 59.5 | 13005.5 |
| 50.8 | 243.3 | 55.2 | 6496.6 | 59.6 | 13063.6 |
| 50.9 | 287.4 | 55.3 | 6789.5 | 59.7 | 13119.9 |
| 51.0 | 330.0 | 55.4 | 7095.0 | 59.8 | 13174.7 |
| 51.1 | 371.9 | 55.5 | 7406.3 | 59.9 | 13228.6 |
| 51.2 | 415.0 | 55.6 | 7716.6 | 60.0 | 13282.0 |
| 51.3 | 459.7 | 55.7 | 8019.4 | 60.1 | 13334.6 |
| 51.4 | 506.4 | 55.8 | 8307.7 | 60.2 | 13386.0 |
| 51.5 | 555.3 | 55.9 | 8574.9 | 60.3 | 13436.1 |
| 51.6 | 606.8 | 56.0 | 8814.2 | 60.4 | 13484.9 |
| 51.7 | 661.2 | 56.1 | 9038.1 | 60.5 | 13532.5 |
| 51.8 | 718.9 | 56.2 | 9262.0 | 60.6 | 13578.9 |
| 51.9 | 780.1 | 56.3 | 9483.1 | 60.7 | 13624.2 |
| 52.0 | 845.2 | 56.4 | 9699.1 | 60.8 | 13668.3 |
| 52.1 | 917.5 | 56.5 | 9907.2 | 60.9 | 13711.2 |
| 52.2 | 999.5 | 56.6 | 10105.0 | 61.0 | 13753.0 |
| 52.3 | 1089.9 | 56.7 | 10289.8 | 61.1 | 13796.7 |
| 52.4 | 1187.8 | 56.8 | 10459.2 | 61.2 | 13845.0 |
| 52.5 | 1292.2 | 56.9 | 10610.5 | 61.3 | 13897.0 |
| 52.6 | 1401.8 | 57.0 | 10741.2 | 61.4 | 13952.2 |
| 52.7 | 1515.8 | 57.1 | 10861.2 | 61.5 | 14010.0 |
| 52.8 | 1633.0 | 57.2 | 10981.4 | 61.6 | 14069.6 |
| 52.9 | 1752.3 | 57.3 | 11101.1 | 61.7 | 14130.4 |
| 53.0 | 1872.8 | 57.4 | 11219.5 | 61.8 | 14191.8 |
| 53.1 | 2011.8 | 57.5 | 11335.6 | 61.9 | 14253.0 |
| 53.2 | 2182.8 | 57.6 | 11448.8 | 62.0 | 14313.5 |
| 53.3 | 2378.8 | 57.7 | 11558.1 | 62.1 | 14373.5 |
| 53.4 | 2592.8 | 57.8 | 11662.7 | 62.2 | 14433.8 |
| 53.5 | 2817.9 | 57.9 | 11761.8 | 62.3 | 14494.3 |
| 53.6 | 3047.0 | 58.0 | 11854.6 | 62.4 | 14555.1 |
| 53.7 | 3273.2 | 58.1 | 11943.0 | 62.5 | 14616.1 |
| 53.8 | 3489.6 | 58.2 | 12029.4 | 62.6 | 14677.4 |
| 53.9 | 3689.1 | 58.3 | 12114.1 | 62.7 | 14739.0 |
| 54.0 | 3864.7 | 58.4 | 12197.2 | 62.8 | 14800.9 |
| 54.1 | 4033.6 | 58.5 | 12278.8 | 62.9 | 14863.1 |
| 54.2 | 4216.4 | 58.6 | 12359.2 | 63.0 | 14925.5 |
| 54.3 | 4411.5 | 58.7 | 12438.4 | | |

## Appendix C: Responses to Comments

April 6, 2005

Mr. Daryll Joyner, P.E.
TMDL Program Administrator
Florida Department of Environmental Protection
2600 Blair Stone Road, MS: 3510
Tallahassee, FL 32399-2400

RE: Nutrient Total Maximum Daily Load (TMDL) for Alachua Sink TMDL, February 24, 2005 Stakeholder Comments

Dear Mr. Joyner:

In response to our telephone conference held on March 28th, 2005, the following are Gainesville Regional Utilities' comments on the referenced TMDL. As indicated, GRU is generally accepting of the total maximum daily load for Alachua Sink calculated in the revised TMDL dated February 24, 2005. However, we request the Florida Department of Environmental Protection (FDEP) address the following comments before finalizing and moving forward with the Basin Management Action Plans (BMAP) for the Alachua Sink. We are specifically concerned about the equitability of load allocations between non-point source and point source inputs. We appreciate FDEP's previous efforts to analyze and incorporate local stakeholder input into the TMDL development.

**General Comments**

1. The Alachua Sink (Sink) water body is complex. FDEP's model is limited to steady state scenarios, and does not adequately predict a key component of the water quality criterion for which it was listed: Chlorophyll-a. Future assessment phases should focus on ways of improving our understanding of the Sink's hydrodynamics and response to nutrient inputs. Future TMDL analyses should be conducted that incorporate more sophisticated analysis of transient conditions in the waterbody and the upstream watershed.

   Response: We concur that the Alachua Sink waterbody is complex and work that furthers our understanding of the sink's hydrodynamic and response to nutrient inputs would be beneficial. This is also true in the larger context of surface water/ground water interactions. An increasing number of springs in the state have increasing levels of nitrates, and there is a real concern regarding surface water impacts associated with these springs, as well what actions will be necessary to limit further degradation of the ground water basin.

2. The load allocation methodology is not equitable and runs counter to FDEP policy. A pound of total nitrogen from a non-point source is not equal to a pound of total nitrogen from the Main Street Water Reclamation Facility (MSWRF) in the TMDL allocation. The distribution of load reductions is such that the MSWRF, which currently provides approximately 19% of the TN load, is assigned a 65% reduction, while the Alachua Lake subwatershed, which provides approximately 67% of the current TN load, is assigned a 44% reduction. If the allowable load for MSWRF is applied to the permitted capacity of 7.5 mgd and an estimated total nitrogen effluent concentration of 5.0 mg/l, the current allocation results in a 73% reduction to MSWRF. We feel that this is inconsistent with past guidance from FDEP (***A Report to the Governor and the Legislature on the Allocation of Total Maximum Daily Loads in Florida, FDEP 2001)*** that indicates that all anthropogenic loads would be reduced equally during the initial allocation when loads from non-point sources could not achieve the TMDL (see Section 4.2.3, p. 24-25 of above referenced document). In addition, Section 4.2.4, Item 6 (p. 27) of the referenced report indicates that the percent load reductions in the allocation process will consider the full permitted load for the existing wastewater facility. Based these guiding principles established by FDEP for load

allocations, the percent reductions for the Alachua Sink TMLD should be applied equally among sources and this equal percent reduction should be applied to the full permitted capacity of MSWRF rather than the current load condition. This proposed allocation strategy recognizes the prior investments in best available treatment technologies that have been made by traditional point sources such as the MSWRF. As an example of our prior investments, GRU spent over $13 million in upgrading the MSWRF in the early 1990s. This upgrade was solely to meet water quality based effluent limits set by FDEP and was not related to plant expansion.

For all the specific detail that is provided regarding the BATHTUB and WMM modeling, there is little information that is disclosed for the load allocation methodology employed in establishing load reductions. It is curious why FDEP's current approach of converting anthropogenic landuse to natural conditions is not yielding a higher reduction in total nitrogen when compared to the reductions achieved in total phosphorus with this method.

Response: First, based on the Department's efforts to address comments raised by GRU and the city, the TMDL reductions have changed and differences between the point source and nonpoint source required reductions are smaller. Second, the allocation guidance that was cited focused on "leveling the playing field," particularly in areas where very little implementation of stormwater controls has occurred. The guidance was particularly toward areas that had multiple surface water dischargers with varying degrees of treatment and a combination of MS4 or other stormwater-regulated and nonregulated activities. In this case, Sweetwater Branch is an effluent-dominated stream that discharges into a sink. In fact, Sweetwater Branch was on the 1998 303(d) list based on elevated nutrient levels. The Sweetwater Branch watershed is highly urbanized and is part of an MS4. Nonregulated stormwater type activities do not appear to be significant in this watershed. Alachua Lake is the other major source contributing to Alachua Sink. Alachua Lake receives drainage from the city of Gainesville from the Bivans Arm area as well as the Newnans Lake watershed via a flow diversion from Prairie Creek. Alachua Lake is part of the Paynes Prairie Preserve and there is a long-term restoration strategy for that system. Third, the process used was based on the fact that reductions from the existing condition were necessary; consequently, the existing characteristics of the Main Street WWTF discharge became the starting point. Presumably, starting with the permitted discharge flow would have led to a similar result. Based on previous conversations, it appeared that efforts to reduce nitrogen levels were most successful when inflows were limited to about 5 mgd. Fourth, as noted prior investments should be taken into consideration. As part of the Orange Creek Basin BMAP team, the Department's staff have worked with all the stakeholders to try and develop summaries of completed, current, and proposed projects by both the point source and nonpoint stakeholders that quantify costs as well as pollutant reductions. Based on some recent projects, there has been a considerable investment to reduce and improve stormwater in the basin.

3. The load allocation to Alachua Sink is directly affected by the achievement of the Newnans Lake nutrient TMDL. The required total nitrogen load reduction for Newnans Lake, 243,260 lbs/yr, should be explicitly stated in the Alachua Sink TMDL to give the reader a better understanding of the total reductions necessary from all contributing sources for the Alachua Sink TMDL to be achieved. As an example of the relative impact of different sources, removing all of MSWRF's nitrogen load from Alachua Sink only achieves a 10% reduction in total nitrogen concentrations in Alachua Sink.

   Response: The influence of implementing other TMDLs in the Orange Creek Basin such as the Newnans Lake nutrient TMDL will be added to the document.

4. For the BATHTUB calibrations, FDEP had access to inflow and water quality data collected by Jones Edmunds & Associates, Inc. (JEA) between February 2003 and September 2004. There were eight sampling events in 2003 and three in 2004. For calibration of the dry weather scenario, FDEP chose only 2 events with which to calibrate the Alachua Lake model, citing both inflow and concentration variations in the other events as reasons for their exclusion. Investigation of the 2003 Alachua Lake data indicates that lake levels were consistently between

55 and 56 feet from March through October of 2003. Water column nutrient concentrations for the October sampling event were very low, and the presence of floating macrophytes was also noted at the time. It is expected that water column nutrients were depleted by the macrophytes. This is an appropriate reason to exclude the October sample from the process of characterizing typical water quality for 2003. However, three other events from March to early May were also excluded, based on the continuously decreasing nutrient concentrations that were observed over those dates. FDEP speculated that these changes occurred due to the dissolution of sediment nutrients back into the water column, immediately after a rapid increase in the lake level. While this may have occurred, the maximum observed Alachua Lake TN loads over the 5 samples were just 25% greater than the observed TN loads from the 2 sampling dates used by FDEP. Given the relative stability of Alachua Lake elevation levels between March and June, the nitrogen-limited nature of Alachua Lake in early 2003, and the direct hydraulic linkage between the Lake and the Sink (another historically N-limited water body), the observational data from all five samples within the March-June time frame should be used to re-calibrate the 2003 scenario.

For 2004, FDEP used all three sampling events to characterize the Alachua Lake and Alachua Sink water bodies. Based on the total observed inflow for 2004 (close to the 75th percentile), the year was classified as a wet year. Unfortunately, two of the three sampling events documented very dry conditions, especially for Alachua Sink. The third sampling event occurred in September, after a major hurricane event had passed through Gainesville. As such, all three sampling events represent extreme conditions and the average of the three events is not indicative of a wet year. For 2004, characteristic hydraulic and water quality conditions of the Lake and the Sink would be better estimated from numerical relationships associated with inflow.

Response: A similar comment was made in the detailed comments attachment and a response is provided there. It is worth noting that the TN average for all the samples in 2003 was 1.94 mg/L and the May–June sample mean was 1.90 mg/L. The predicted value from the model was 1.94 mg/L. With respect to the 2004 dataset, additional nutrient data was provided by ACEPD and is included in the report.

5. The selection of 2003 and 2004 as representative of dry and wet conditions appears to be reasonable based on the total inflows recorded for those years and their comparisons to historical flow records. However, it should be noted that the Alachua Sink BATHTUB calibrations for those years were conducted for the exact same set of Alachua Sink dimensions (surface area = 70,000 $m^2$, mean depth = 2.2 m). This is counterintuitive, since one would typically expect lake volumes to be greater during wet years than during dry years. The simulations for Alachua Sink current conditions are even more confusing; with the dry year mean depth set at 2.1 m and the wet year mean depth set lower at 1.4 m. These dry year and wet year depths were also carried through for the load reduction scenarios. While the source of the 2003 (dry year) mean depth is unknown, Table 29 in the TMDL document shows the 1.4 m value as the 2004 mean depth. Table 30 presents alternative mean depth calculations of 2.32 m (2003) and 1.86 m (2004). While the 2003 mean depth is based on 8 sampling events, the 2004 depth is based on only three. Each of the three 2004 samples represent extreme volumetric conditions in Alachua Sink, with the first two collected at low elevations of approximately 49 and 42 feet and the last collected shortly after 2 hurricanes had passed through Gainesville. The Sink elevation for that sampling event was recorded as slightly less than 58 feet. As a result of the small sample set, the wet year volumetric data for Alachua Sink is essentially skewed to the sample dates when Sink dimensions were more representative of lower flows. Based on the estimated lake dimensions and annualized inflows, the residence times were 0.78 days and 0.72 days, respectively. As for the respective dry and wet year mean depths, this is also counterintuitive, and suggests that, as inflows to Alachua Sink increase, outflows increase at a higher rate, leaving less proportionate storage in the water body. The TMDL document also discusses a methodology for predicting lake elevations based on inflow (Figure 7). This was originally done to fill in elevation data gaps for the 2000-2002 period, when FDEP was considering using the average of those years as the dry year critical condition. While the linear relationship established was somewhat simplistic, the concept of using estimated elevations is reasonable, and would also provide the rationale for

estimating 2004 Sink dimensions, rather than relying on the skewed set of sample observations. Rather than using a linear relationship, we recommend a logarithmic relationship to eliminate over predicting stage at higher flow regimes.

Based on additional information from ACEPD and elevation observations outside the specific sampling dates, refined estimates of water depth, volume, and surface area were obtained. Note that the elevation of 42 ft was in error and subsequently corrected by JEA. In 2003, 9 values were used to establish elevations, surface areas, and volumes for Alachua Lake. There were 17 values in 2004. Similarly, 12 values were used for Alachua Sink in 2003 and 6 in 2004.

6. Given the wet year–dry year approach for developing the TMDL and the differences in the Sink between these flow regimes, we recommend independent calibrations of the wet year and dry year conditions rather than a “one size fits all” approach. This essentially means developing and applying different calibration factors between wet and dry years to improve the model’s predictions. The calibration factors for Alachua Sink are applied to concentrations where as the calibration factors applied to Alachua Lake are more ambiguous in the text and are applied to the decay rates. We recommend a consistent approach that applies the calibration factors to concentrations.

   By consistently applying calibration factors to absolute concentrations, creating unique sets of wet and dry year calibration factors, and revising hydraulic dimensions to be reflective of varying annualized conditions, improvements in TN predictions can be realized for every scenario.

Attached are comments that address specific sections of the TMDL document. As stated earlier, we have several concerns with regard to the model. Given the limitations of available data and time and our ability to re-visit the TMDL in coming basin cycles, we are generally accepting of the calculated total maximum daily load for the waterbody. However, we feel that the proposed load allocation is not equitable and is not consistent with FDEP’s policies. We appreciate FDEP’s efforts on the TMDL and look forward to the BMAP process. If you need any additional information, please contact me at 352-393-1613.

Response: Several of these items are specific comments in the attachment and responses can be found there.

Sincerely,

Brett Goodman, P.E.

Attachments: Specific Comments

ec: Mary Paulic, FDEP
Wayne Magley, FDEP
Terry Pride, FDEP
Fred Calder, FDEP
Jeff Martin, FDEP
Jennifer Eason, USEPA
Carol Lippincott, SJRWMD
Jim Weimer, PPPS
Chris Bird, ACEPD
April Grippo, ATM
Bill Saunders, ATM
Brett Cunningham, JEA

Alice Rankeillor, CGPW
Sally Adkins, CGPW
David Richardson, GRU
Kim Zoltek, GRU
Rick Hutton, GRU
Paul Davis, GRU

# Attachment #1
# Alachua Sink TMDL
# GRU Specific Comments

a. Throughout the document, the use of the expression “the lake” to describe Alachua Sink is confusing, especially when used in describing any hydraulic connection or loadings from the adjacent Alachua Lake. While standard protocol at FDEP may be to refer to the water body under analysis as “the lake”, this document would be much clearer if all references to “the lake” were changed to “the sink”.

Response: References to “the lake” have been changed to “Alachua Sink”.

b. Section 2.1, end of first paragraph, “Quarterly TN, TP, Chl a, and TSI values were then used to calculate annual mean values.” This description should specifically state whether the calculated annual values are the mean of the quarterly values and whether that approach applies for the annual TSI values, also.

Response: Annual mean values for TN, TP, chl*a*, and TSI represented the mean of the quarterly averages.

c. Table 1 and 2, the TSI values in these tables don’t appear to have been calculated using the Florida TSI methodology documented on page 36. The document should be specific about how these TSIs were determined.

Response: The values calculated in Table 1 follow the procedure on page 36 and are described in Section 2.1. Attached is the spreadsheet that documents the values presented in Table 1. The section indicates that the model does not provide quarterly average concentrations for TN, TP, and chl*a*. In Table 2 the quarterly averages for each year for 2000 to 2002 are presented and illustrate the degree of seasonal variation in these parameters over this period.

| | | **Color** | **TN** | **TP** | **TN/TP** | **Chla** | **Chla-TSI** | **TN2-TSI** | **NUTR-TSI** | **TSI** |
|---|---|---|---|---|---|---|---|---|---|---|
| | | **CPU** | **(mg/L)** | **(mg/L)** | | **(µg/L)** | | | | |
| 2000 | 1st Quarter | 20 | 4.055 | 0.726 | 5.585 | 27.2 | 64.38 | 89.70 | 89.70 | 77.04 |
| | 2nd Quarter | 10 | 3.455 | 0.848 | 4.073 | 41.5 | 70.46 | 86.26 | 86.26 | 78.36 |
| | 3rd Quarter | 20 | 2.987 | 1.383 | 2.160 | 107.1 | 84.10 | 83.13 | 83.13 | 83.62 |
| | 4th Quarter | 35 | 7.552 | 1.772 | 4.262 | 9.3 | 48.99 | 103.07 | 103.07 | 76.03 |
| 2001 | 1st Quarter | 15 | 7.222 | 1.436 | 5.030 | 6.9 | 44.66 | 102.11 | 102.11 | 73.38 |
| | 2nd Quarter | 37 | 3.804 | 1.056 | 3.603 | 75.3 | 79.04 | 88.33 | 88.33 | 83.68 |
| | 3rd Quarter | 450 | 4.412 | 1.570 | 2.810 | 36.0 | 68.41 | 91.51 | 91.51 | 79.96 |
| | 4th Quarter | 197 | 3.858 | 1.348 | 2.862 | 14.6 | 55.41 | 88.63 | 88.63 | 72.02 |
| 2002 | 1st Quarter | 28 | 3.916 | 1.874 | 2.089 | 45.6 | 71.82 | 88.95 | 88.95 | 80.38 |
| | 2nd Quarter | 20 | 2.521 | 0.841 | 2.999 | 81.4 | 80.14 | 79.48 | 79.48 | 79.81 |
| | 3rd Quarter | 287 | 3.850 | 1.448 | 2.659 | 8.0 | 46.83 | 88.58 | 88.58 | 67.71 |
| | 4th Quarter | 160 | 4.330 | 1.047 | 4.137 | 36.9 | 68.75 | 91.11 | 91.11 | 79.93 |

d. Table 2d: It is unclear how the annual mean TSI value was calculated in this table. The TSI value calculated from the annual mean TN, TP, and Chl-a values from the previous three tables is 63. The document should be specific about how this TSI was determined.

Response: 2003 Average TN = 2.779 mg/L (31 samples) Average TP = 0.631 mg/L (31 samples)
Average chl*a* = 8.15 µg/l (31 samples) TN/TP = 4.40
$TSI_{CHL}$ = 47.01 $TSI_{NUT}$ = 81.57 TSI = ($TSI_{CHL}$ + $TSI_{NUT}$ )/2 = 64
There is a note below Table 2d describing the calculation of the annual mean TSI value.

e. Table 2h: Contrary to the note, the annual mean value IS the simple mean of the individual TSI values. The TSI value calculated from the annual mean TN, TP, and chl*a* values from the previous three tables is 70.

Response: Table 2e average TN = 2.071 mg/L (13 values); Table 2f average TP = 0.677 mg/L (13 values)
Table 2g average chl*a* = 29.77 ug/l (13 values) TN/TP = 3.59
$TSI_{CHL}$ = 65.66 $TSI_{NUT}$ = 75.25 TSI = ($TSI_{CHL}$ + $TSI_{NUT}$ )/2 = 70
There is a note below Table 2h describing the calculation of the annual mean TSI value.

f. Section 3.0, last sentence: “impact of changes in TP loading was also estimated”. There is no discussion in this document about the impact of changes in TP. It isn’t until the % reductions are disclosed in Table 45 that there is any mention of TP reductions. Discussions with FDEP personnel have indicated that, rather than pursuing targeted TP decreases, the identified TP reductions are completely due to the nonpoint source management practices applied for the TN reduction scenarios. This should be made clear in the document. Also, since the system is so highly N-limited, the TP concentrations should not affect the TSI (i.e. the calculated $TSI_{NUT}$ value is based on TN concentrations only).

Response: Since nitrogen has been identified as the limiting nutrient, this TMDL will be based on nitrogen. Modeling tools used in the TMDL process provide estimates of both total nitrogen and total phosphorus. Summary tables for both will be included in the report as appropriate to provide a more complete view of nutrient dynamics in the watershed.

g. Section 4.2, last paragraph: It appears that permitted NPDES stormwater discharges are included in both the point source and nonpoint source analyses. The document should clarify how the allocated NPDES stormwater load reductions are not accounted for twice.

Response: Text has been added in Section 6.1, and Attachment A describes the responsibilities for stormwater management under state and federal regulations.

h. Section 4.4, page 15, bottom of page: The 2005 TMDL states, “To estimate TN and TP loadings into **the Lake** from Alachua Lake, the discharge from Alachua Lake into **the Lake** and TN and TP concentrations of **the discharge** were required. However, these data were not available for the period from 2000 – 2002. To **estimate water quality in Alachua Lake**, the WMM was **used to evaluate how the land use pattern of the watershed area (AL) influences the water quality of Alachua Lake.** The WMM (calibrated using the USGS gauging station) applied to the **entire AL watershed** to estimate the nonpoint flow and TN and TP loadings into Alachua Lake.” Again, it is unclear whether the author meant to substitute “the Lake” for Alachua Sink in the 2005 TMDL.

Response: Text has been modified to distinguish between Alachua Lake and Alachua Sink.

i. Section 4.4, page 17 & Table 4: there’s no “seasonal variation” that can be derived from Table 4.

Response: Reference to seasonal variation has been deleted.

j. Section 5.3, page 38 (Data Required for Alachua Lake concentrations): the referenced lake characteristic curve (Robison 97) should be included with a figure or table here.

Response: Appendix B has been added to the document; it includes capacity curves and elevation/surface area information.

k. Section 5.3, Table 23: equivalent tables for the other simulated years should be included.

Response: Tables have been added for 2004.

l. Section 5.3, Table 23, note b: "by the total flow created in the watersheds" should be replaced with "by the individual flows associated with each source."

Response: Text changed.

m. Section 5.3, Table 23, note c: It should be specified how much (i.e. what percentage) of the 31.6 $hm^3$/yr assigned to Prairie Creek comes from the Newnans Lake diversion.

Response: The footnote indicates that approximately 41% of the flow leaving Newnans Lake is diverted to Paynes Prairie. That percentage was applied to the annual flow records from the Prairie Creek gauge.

n. Section 5.3, Table 24: The use of only the 5/22/03 and 6/9/03 observations for calibration of the Alachua Lake model creates a system imbalance that overestimates the N loadings received from other subwatersheds (i.e. Sweetwater Branch, direct runoff) to Alachua Sink. For these two samples, the N/P ratio is in the 13-15 range, significantly above the generally assumed value of 4 for Alachua Sink. This characterization of Alachua Lake as co-limited, combined with an Alachua Sink characterization as N-limited, is dubious, considering their proximity and direct linkage. As can be seen from Figure 6 and from JEA's Phase 1 and Phase 2 loading study data, the lake elevation values for Alachua Lake were between 55 and 56 feet (NGVD) for every sampling event between March 12, 2003 and October 16, 2003. FDEP makes a significant point regarding exclusion of the October sampling event, due to the presence of floating aquatic plants at the time. However, the exclusion of the March and early May events, due to the potential for elevated nutrient levels from previously oxidized nutrients in the inundated sediment, is primarily based on conjecture. Conversely, inclusion of the samples from March and May lead to TN and TP averages of 2.21 and 0.49 mg/L, respectively (representing an N/P ratio of approximately 4.5). Given what is known about the trophic state of Alachua Sink and the relative stability of Alachua Lake elevation levels between March and June, observational data from all samples within that time frame should be used to re-calibrate the 2003 scenario.

Response: Table 25 summarizes observations and model predictions of TN and TP for Alachua Lake in 2003. The May–June average TN was 1.901 mg/L, while the average of all samples collected in 2003 was 1.941 mg/L. The model prediction was 1.945 mg/L. As noted, the greatest difference occurred in TP, where the May–June average was 0.14 mg/L and the average over the year was 0.41 mg/L. The average was high due to values above 1 mg/L in February and March. Historical data for Florida streams and lakes have median TP concentrations of 0.08 mg/L and 0.04 mg/L, respectively. Although the median TP for Alachua Lake in 2003 (0.14 mg/L) was elevated compared with these medians, it was much more representative of the year compared with the mean. With respect to the comment that due to their proximity and direct linkage it dubious that Alachua Sink and Alachua Lake could reflect different nutrient limitations, the statement may be true in general, but one must also consider whether different types of sources contribute to the waterbodies. Certainly a waterbody receiving a discharge from a domestic wastewater facility that typically is nitrogen limited can have a significant influence on what nutrient might be limiting.

o. Figure 6 should encompass the monitoring performed in 2004 to provide additional information on the nitrogen and water level fluctuations in the sink and to check the validity of using only May 22 and June 9, 2003 as calibration points.

Response: Figure 6 illustrated sampling and loading estimates for 2003. Each year was run separately. Table 27 was added to provide information on TN and TP measurements in 2004. Unfortunately, flow measurements were available for only three dates in 2004.

p. Section 5.3, Table 26: 2004 calibration of the Alachua Lake Bathtub model is given light treatment in the text, especially in comparison to the discussion provided for the 2003 calibration. Although 2004 surveys by JEA and the Alachua County Environmental program are referenced, there is no analysis of that sampled data and how it relates to the calibration. TN and TP are significantly under predicted, compared to the 2003 calibration. Since the point source discharges are relatively well quantified via DMR data for all years, one would suspect that this under prediction is associated with the nonpoint source load received by Alachua Lake.

Response: Tables have been added for 2004 that include sampling data and model estimates of flow from various sources. Part of the difficultly in 2004 was the limited set of flow measurements and elevations. During the spring and summer there was a steady decline in water level elevation at Alachua Sink and Alachua Lake. Each of the months from March–July was below average in rainfall, and then August had 14.32 inches, followed by 16.45 inches in September. Nearly 58% of the total rainfall for 2004 occurred in the August (24.6%) and September (28.2%). As a consequence, there were large fluctuations in the size and volume of Alachua Lake.

q. Section 5.3, page 43 (simulation of TN, TP for Alachua Lake 2000-2002): Table 27 is incorrectly referenced as Table 26.

Response: Table numbers have been corrected.

r. Section 5.3, Multiple Tables have values which do not match up with the bathtub input files:

- Table 21: Lake Surface Area in the 2004 year does not match up with the physical characteristics surface area value in the as2004.btb bathtub file.
- Table 22: Evaporation in years 2001-2002 do not match up with the evaporation
- values in the Bathtub input files (as2001.btb and as2002.btb)
- Table 29: Most of the values in this table do not match up with the physical characteristics in the Bathtub input files (i.e. as2000.btb – as2004.btb)
- Table 35: The TP value for Main Street WWTP is listed as 1.19, however it is .89 in the bathtub file, as202122.btb.
- Table 36: The TP and TN values for Main Street WWTP do not match up exactly with the bathtub file, as2003.btb
- Table 37: The TP and TN values for Main Street WWTP do not match up with the bathtub file, as2004.btb

Response: Bathtub files have been revised.

s. Section 5.3, Table 31: The bathymetry data in this table doesn’t go high enough to accommodate determination of Alachua Sink volume and surface area for 2003 or 2004.

Response: The table summarized bathymetry data provided by JEA based on a field study. The data were curve fit to predict volume and surface area for elevations above 52 ft.

t. Section 5.3, page 49, paragraph after Table 37: “The septic tank fluxes were calculated as previously described.” The source of the annualized septic tank loading data (and preferably the loading values), for which these fluxes were calculated, should be identified here.

Response: Items H and I describe the procedure used in WMM to estimate loadings from septic tanks. The following table summarizes the TN and TP loadings by year and drainage area.

| **Septic Tank Loadings** | **Upper Sweetwater Branch** | **Lower Sweetwater Branch** | **Upper Extension Ditch** | **Alachua Sink Watershed** | **Paynes Prairie Total** |
|---|---|---|---|---|---|
| **TN (lbs/yr)** | | | | | |
| 2000 | 1344.4 | 1328.1 | 152.6 | 3.7 | 4810.4 |
| 2001 | 1647.4 | 1627.4 | 186.9 | 4.5 | 5894.4 |
| 2002 | 2163.0 | 2136.7 | 245.4 | 5.9 | 7739.4 |
| 2003 | 1822.5 | 1800.4 | 206.8 | 5.0 | 6521.1 |
| 2004 | 2280.2 | 2252.6 | 258.8 | 6.2 | 8159.0 |
| **TP (lbs/yr)** | | | | | |
| 2000 | 477.0 | 448.0 | 52.0 | 0.1 | 1700.3 |
| 2001 | 584.5 | 549.0 | 63.7 | 1.2 | 2083.4 |
| 2002 | 767.5 | 720.8 | 83.6 | 1.5 | 2735.5 |
| 2003 | 646.7 | 607.4 | 70.4 | 1.3 | 2304.9 |
| 2004 | 809.1 | 759.9 | 88.1 | 1.6 | 2883.9 |

u. Section 5.3, page 49-50, Calibration Factors: The calibration factors for Alachua Sink are based on concentration and are discussed in the write-up. However, there is no commensurate discussion of the Alachua Lake calibration factors. A review of the Alachua Lake Bathtub input files shows that those calibration factors are based on decay rates and not concentrations. We recommend a consistent approach that applies the calibration factors to concentrations. Also, while the Alachua Sink TN and TP calibration factors are set at 1.0 and 2.0, respectively, the Alachua Lake TN and TP factors are 1.5 and 0.9. Based on these two differences, it is not surprising that the TN and TP percent errors for the 2004 Alachua Lake calibration are so much greater than those for the 2003 calibration (table 26 vs. table 25).

Response: Concentration factors were used in Alachua Sink since detailed information existed for flow and water quality characteristics of the point and nonpoint sources discharging to Sweetwater Branch and Alachua Sink. In contrast, very little flow, water quality input characteristics, or lake characteristics (surface area, volume, etc.) were available for Alachua Lake. Therefore, calibration factors that relied more on lake processes such as decay rates (that had a certain range based on numerous studies) were used in Alachua Lake. The same calibration factors were used for Alachua Lake in the 2000–02, 2003, 2004, wet and dry simulations. A number of factors that could have affected the model prediction in 2004 were previously discussed.

v. Section 5.3, Page 50, Table 38 and discussion: The annual averages of observed TP concentrations referenced in the paragraph (for 2000, 2002, and 2004) do not match the measured values in the table and would change the calibration results from “consistent under prediction” to “over predicted in 2000, close to observed in 2002, and under predicted in 2004”. Also, the 2004 annual averages of both TN and TP don’t appear to be calculated from the JEA and ACEPD data. The document should be specific about how these measured values were calculated.

Response: The table has been corrected. Tables 2e, 2f, and 2g summarize the JEA and ACEPD data collected in Alachua Sink. The middle station represents measurements by ACEPD. Annual averages were calculated by summing all the observations in the respective table and taking the average. A table was also added with JEA and ACEPD TN and TP measurements for Alachua Lake in 2004.

w. Section 5.3, Page 53: last paragraph: $tua_0$ values do not match those referenced on page 51 and elsewhere in the text.

Response: The text has been revised along with some changes based on additional calculations.

x. Section 5.3, Page 57, (evaluation of Alachua Sink background TSI), first bullet: statement does not include the anthropogenic land use categories in the watershed draining directly to Alachua Sink.

Response: The text has been modified to indicate that the analysis considered direct drainage to Alachua Sink.

y. Section 5.3, Page 57, (evaluation of Alachua Sink background TSI), last bullet: the justification or basis for the additional Prairie Creek TN concentration reduction (1.2 mg/L from the Newnans Lake TMDL to 0.88 mg/L) should be explicitly identified in this section.

Response: Text has been added to indicate that there was a consistent reduction in TN concentrations based on monthly monitoring at two stations in Prairie Creek. The mean percent reduction was applied to the TN TMDL target value for Newnans Lake.

z. Section 5.3, Tables 40 and 41: The notes for these tables are in error with respect to TN and TP concentrations listed in Table 39. There are no TN and TP concentrations in that table. Also, the flows in table 39 from Alachua Lake to Alachua Sink do not match up with the flows quoted in the paragraph preceding Table 40.

Response: Text and tables have been corrected.

aa. It should be noted that the wet year septic loadings in Table 44 appear to be in error, since they are shown as only 20% of the dry year loads. GRU estimates that the corrected wet year septic loading should be 29,209 lbs/yr (resulting in a corresponding adjustment of the total wet year load to 530,902 lb/yr). This estimate was calculated from the internal load TN flux information and surface area in the *aswetcur.btb* input file. The total TN load was also adjusted to accommodate the revised septic load.

U. S. Environmental Protection Agency. 1999. Protocol for developing nutrient TMDLs. Washington, DC: Office of Water. EPA 841-B-89-007.

bb. Section 5.3, Page 60, Critical Conditions: reference to table 45 should be table 44.

Response: Text has been changed.

cc. Section 5.3, Page 62??. Page numbers skip from 61 to 63. Is there actually a page 62 that is missing from the document??

Response: Page 62 was blank and was due to a formatting problem changing from landscape to portrait.

dd. The document should provide tables in Section 5.3 consistent with table 18 and 19 that show the reduced loads from non-point source inputs.

Response: Table 45 in the earlier report was intended to summarize allowable point and nonpoint source loadings that would achieve the TMDL target.

ee. Section 5.3, Page 63, top paragraph:

- "TN and TP loadings during the dry year were reduced until a TSI of 63 was achieved". This value should be 69 (or 68.95).
- Also, there is no discussion about how the relative TN and TP reductions were implemented. Based on the percent reductions in Table 45, they were not done equally.
- A reconciliation between the 65% TN reductions quoted in the paragraph and the 50% reductions identified in Table 45 is warranted.
- The allowable TN loading of 31, 057 lbs/yr quoted in the paragraph appears to be for the Main Street WWTF only. It should include all point sources.
- Table 45 is incorrectly referenced as table 46.

Response: The text has been corrected. Reductions were based on a uniform reduction in human-influenced land uses. The difference between nitrogen and phosphorus responses has to do with the differences in EMC values of the specific land uses and runoff differences. Separate loads of nitrogen have been allocated to the two permitted point sources (Main Street WWTF and John R. Kelly Generating Station) and are specified in the document.

ff. Input files: The wet and dry "current" scenarios for Alachua Lake mistakenly have the Prairie Creek TP input concentration as 0.88 mg/L. The value should be 0.16 mg/L, in accordance with Table 23 and the calibration input files.

Response: Input files have been corrected.

gg. In Table 46, it appears that the LA load allocation is double counting the NPDES stormwater allocation. If one subtracts the LA from the TMDL, the result is approximately the wastewater portion of the load allocation which leaves no allowable load for the NPDES stormwater source (249,612 – 217,754 = 31,858 lb/yr). From Table 45, it appears that the LA in Table 46 should be 195,090 lbs/yr. Section 6.1 on page 66 should be revised to reflect the revised LA load allocation number.

Response: Table 46 is confusing in that the LA value really represents the complete allowable nonpoint source load of nitrogen from both MS4 and nonregulated areas. Text has been added to try and clarify this. Without specific information on MS4s, the Department has considered all of the stormwater loading together and used a percent reduction approach that would apply equally to MS4 and no MS4 areas.

hh. The second sentence in the last paragraph in Section 6.2 on page 66 is not correct. The current total nitrogen loading to Alachua Sink is 413,000 lbs/yr of which 88,748 lbs/yr come from MSWRF, which is 21% of the loading rather than the reported 43%.

Response: The text has been corrected.

**CITY OF GAINESVILLE**

*Public Works Department*

April 15, 2005

Mr. Daryll Joyner, P.E.
TMDL Program Administrator
Florida Department of Environmental Protection
2600 Blair Stone Road, MS 3510
Tallahassee, FL 32399-2400

RE: Nutrient Total Maximum Daily Load (TMDL) for Alachua Sink TMDL, February 24th, 2005

Dear Mr. Joyner:

The City of Gainesville supports moving forward with formal adoption of the TMDL for Alachua Sink with the following reservations. We request that a revision to the contributing watershed area to Alachua Sink be made and we also request a clarification concerning the urban stormwater load allocation.

The Alachua Sink WIBID number 2720A includes a 2.66 square mile watershed known locally as Calf Pond Creek. I have attached a map of the watershed taken from Gainesville's Stormwater Management Master Plan. Calf Pond Creek is drained by an active sink hole at Calf Pond. The Calf Pond sink and Alachua Sink are separate and distinct and are not connected through surfacewater flow. We request that the Calf Pond watershed be removed as a contributing surfacewater source to Alachua Sink TMDL.

Secondly, the methodology used to establish the urban stormwater load allocation is inconsistent with the guidance provided in ***A Report to the Governor and the Legislature on the Allocation of Total Maximum Daily Loads in Florida,*** FDEP 2001. In **section 4.2.3 Process for the Initial Allocation**, pollutant reductions for urban stormwater treatment are made as a percent of all urban areas that met stormwater treatment requirements for new construction. In the Alachua Sink TMDL model, pollutant reductions for urban stormwater treatment have been made by assuming that the land use is changed from an urban to a forested condition, there by removing all anthropogenic sources of pollutants. The removal of all pollutants through implementation of stormwater Best Management Practices (BMPs) is not practical.

The total nitrogen mean removal efficiency for stormwater retrofit projects varies widely according to the BMP used. In the Sweetwater Branch watershed, wet detention treatment is most often used for sub-regional stormwater projects due to high water table conditions. The total nitrogen mean removal efficiency for wet detention is 26%

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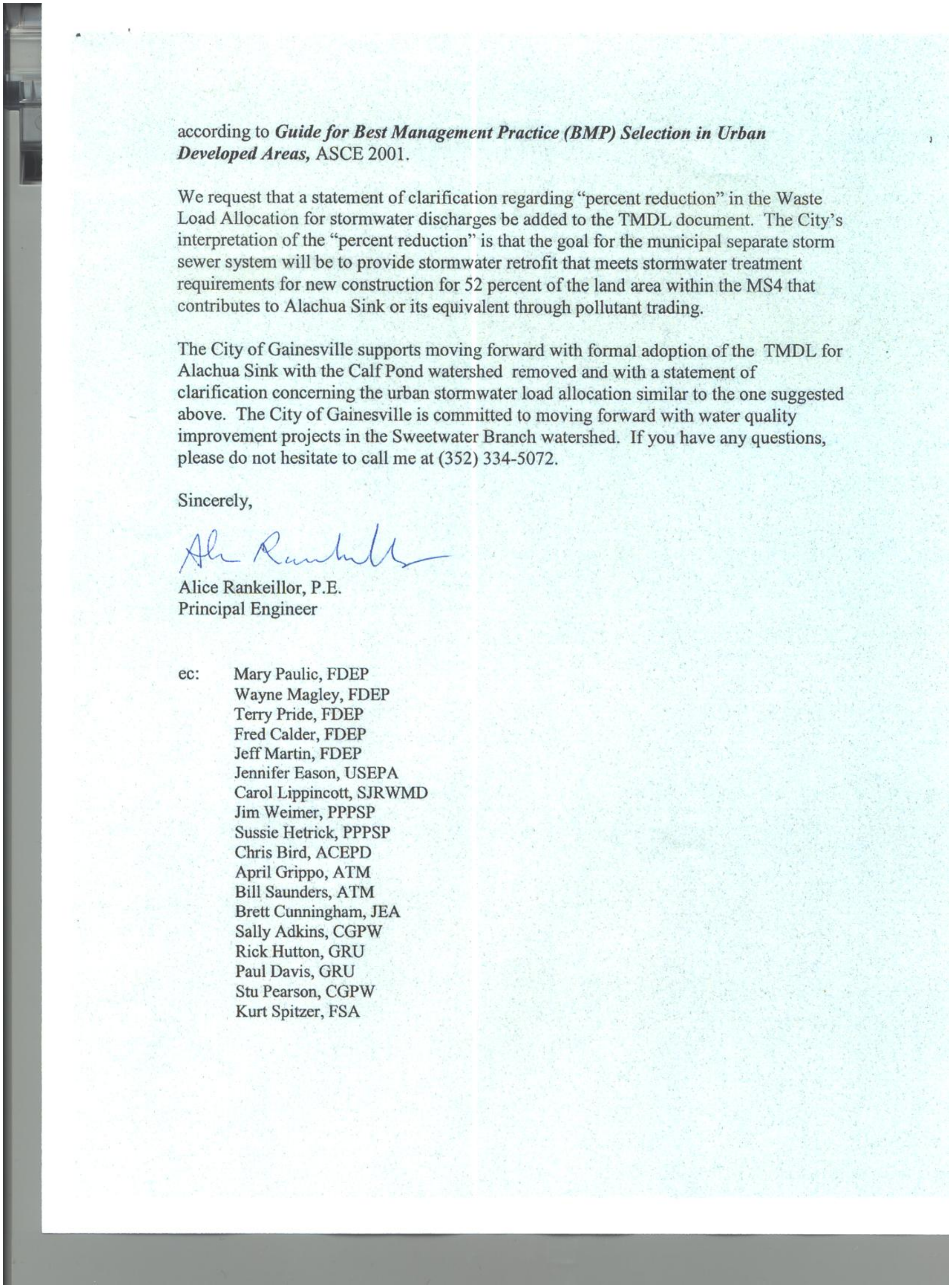

according to ***Guide for Best Management Practice (BMP) Selection in Urban Developed Areas,*** ASCE 2001.

We request that a statement of clarification regarding "percent reduction" in the Waste Load Allocation for stormwater discharges be added to the TMDL document. The City's interpretation of the "percent reduction" is that the goal for the municipal separate storm sewer system will be to provide stormwater retrofit that meets stormwater treatment requirements for new construction for 52 percent of the land area within the MS4 that contributes to Alachua Sink or its equivalent through pollutant trading.

The City of Gainesville supports moving forward with formal adoption of the TMDL for Alachua Sink with the Calf Pond watershed removed and with a statement of clarification concerning the urban stormwater load allocation similar to the one suggested above. The City of Gainesville is committed to moving forward with water quality improvement projects in the Sweetwater Branch watershed. If you have any questions, please do not hesitate to call me at (352) 334-5072.

Sincerely,

Alice Rankeillor, P.E.
Principal Engineer

ec: Mary Paulic, FDEP
Wayne Magley, FDEP
Terry Pride, FDEP
Fred Calder, FDEP
Jeff Martin, FDEP
Jennifer Eason, USEPA
Carol Lippincott, SJRWMD
Jim Weimer, PPPSP
Sussie Hetrick, PPPSP
Chris Bird, ACEPD
April Grippo, ATM
Bill Saunders, ATM
Brett Cunningham, JEA
Sally Adkins, CGPW
Rick Hutton, GRU
Paul Davis, GRU
Stu Pearson, CGPW
Kurt Spitzer, FSA

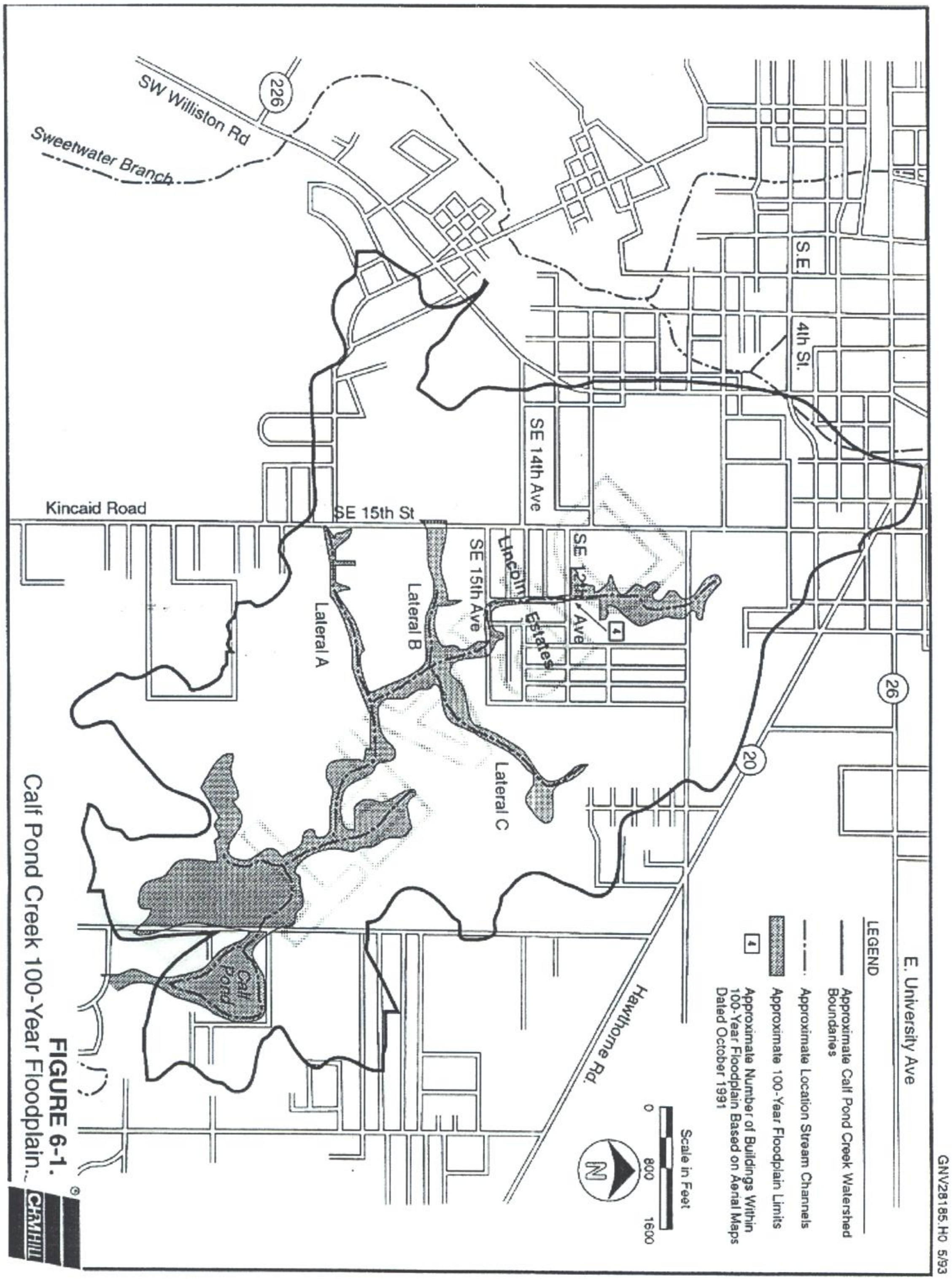

**FIGURE 6-1.**
Calf Pond Creek 100-Year Floodplain

Response:  As discussed at the March 28, 2005 teleconference, the sub-basin identified as Alachua Sink represents the original delineation of 120.24 acres and does not include the Calf Pond watershed.  Figures, tables, and model simulations presented in this document reflect this change.

The revised TMDL requires a 45% reduction in nonpoint source loads of total nitrogen from both MS4 permitted, other regulatory non-MS4, and nonregulated nonpoint source–generating activities.  As part of the Basin Management Action Plan (BMAP) process, Department staff have been working with stakeholders to document and quantify recent, current, and proposed projects within the basin that have improved water quality.  This will assist in determining what progress has been made toward achieving the TMDL, what remains, and how the remainder will be allocated most effectively.

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