# Nutrient Total Maximum Daily Load

# For Lake Wauberg Outlet,

# Alachua County, Florida

**T. S. Wu, A. Baniukiewicz, and D. K. Gilbert**

**Watershed Assessment Section**

**Florida Department of Environmental Protection**

**2600 Blair Stone Road, MS 3555**

**Tallahassee, FL 32399-2400**

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## Section 1. Introduction

### 1.1 Purpose of Report

This report presents the efforts to develop a nutrient TMDL for Lake Wauberg. The lake was verified as impaired by nutrients based on elevated levels of the Trophic State Index for lakes, and was included on the verified list of impaired waters for the Ocklawaha Basin that was adopted by Secretarial Order on August 28, 2002.

Section 303(d) of the federal Clean Water Act (CWA) requires States to submit lists of surface waters that do not meet applicable water quality standards (impaired waters). The methodologies used by the state for the determination of impairment are established in Rule 62-303, Identification of Impaired waters (IWR), Florida Administrative Code (FAC). Once a water body or water body segment has been verified as impaired and referenced in the Secretarial Order Adopting the Verified List of Impaired Waters, work on establishment of the Total Maximum Daily Load (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 in-stream water quality conditions (USEPA, 1991).

### 1.2 Identification of Waterbody

Lake Wauberg is located in the Central Valley of the Ocklawaha River Basin (Alachua County), approximately eight miles south of Gainesville (Figure 1). The climate of this area is generally humid and subtropical. Based on records from 1969 to 1999, average annual temperature and rainfall are $71.1^{0}$ F and 51 inches, respectively. About half of the rainfall occurs from June through September when temperatures are at their warmest and evapotranspiration is highest. The basin's average of 51 inches of annual rainfall may enter aquifers through infiltration, fall onto the surface of lakes, enter surface water bodies as runoff from adjacent land, or return to the atmosphere through evaporation and transpiration (ET). The potential annual ET ranges from 41 to 45 inches, with the remaining 6 to 10 inches of rainfall either recharging ground water or entering surface water through runoff.

The Central Valley is a low area with flat to gentle rolling terrain. Most of the area is underlain by sand with a minor amount of silt and clay that acts as a veneer over the underlying limestone bedrock. The Lake is approximately 235 acres with a mean depth of 12 feet (information from LakeWatch). The watershed for the Lake is only slightly more than 700 acres. This indicates that, while the surface runoff could be an important source of water for the lake, the importance of precipitation directly falling on the surface of the lake could be comparable to that of the surface runoff.

For assessment purposes, the State of Florida has been divided into water body assessment polygons termed **W**ater **B**ody **Id**entification numbers or WBIDs. Additional information about derivation and use of these WBIDs is provided in the "Documentation For The 2002 Update To The State Of Florida's 303(d) List" dated October 1, 2002, and GIS shapefiles of the WBIDs can be obtained from the following website: http://www.floridadep.org/water/watersheds/basin411/downloads.htm. For the case of Lake Wauberg, the lake has been assigned WBID 2741, and was named Lake Wauberg Outlet in the verified list adopted by the Secretary.

## 2. Statement of Problem.

In accordance with the IWR procedures, the Lake Wauberg Outlet (Lake), WBID number 2741, was determined to be impaired by nutrients based on the elevated Trophic State Index (TSI) for the lake. Annual TSI values for Lake Wauberg averaged 72.3 (1990-2000)(Table 3), well above the threshold for nutrient impairment for lakes of 60. Evaluation of the available nutrient data indicates that the Lake is co-limited for nitrogen and phosphorus.

## 3. Description of Applicable Water Quality Standards and Criteria

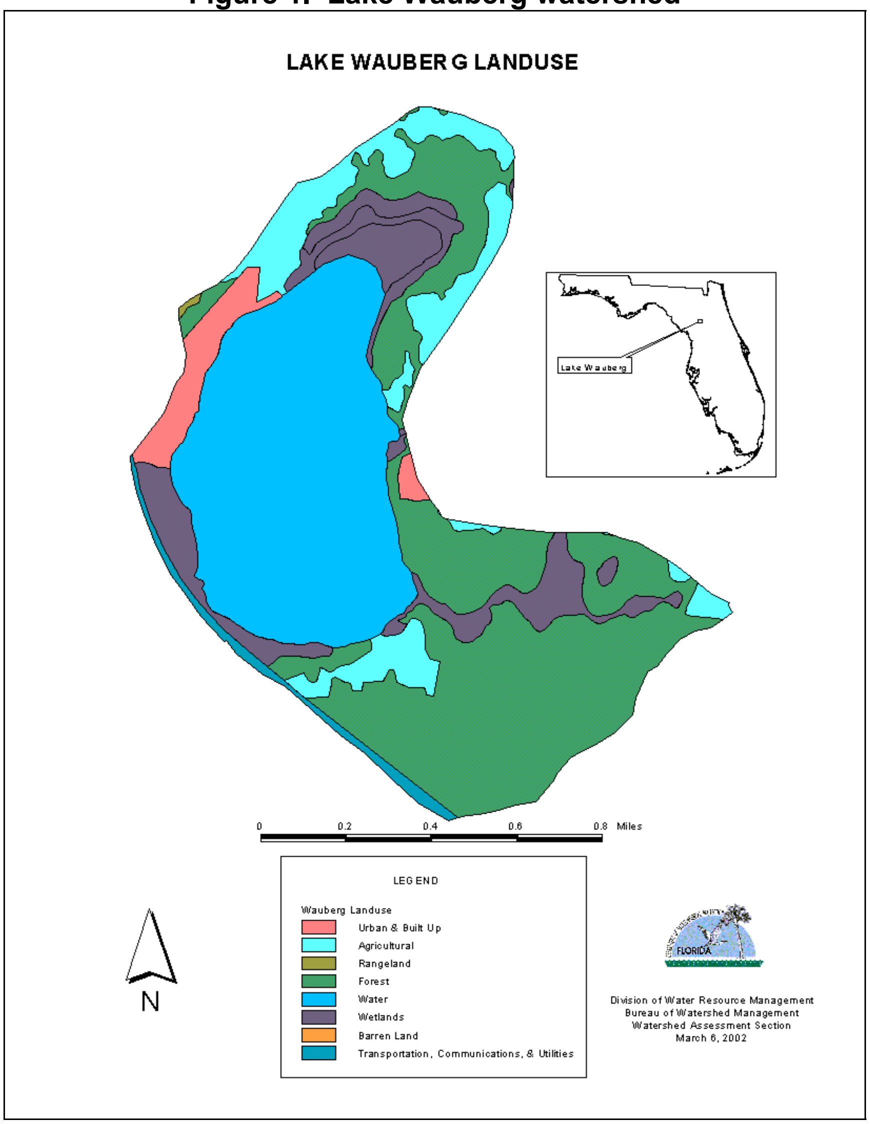
Lake Wauberg Lake is classified as a Class III Freshwater body, with a designated use of recreation, propagation and maintenance of a healthy, well-balanced population of fish and wildlife. The Class III water quality criteria applicable to the observed impairment is the narrative nutrient criterion (nutrient concentrations of a body of water shall not be altered so as to cause an imbalance in natural populations of aquatic flora or fauna). Because the nutrient criterion is narrative only, a nutrient related target was needed to represent levels at which imbalance in flora or fauna are expected to occur. For this TMDL, the IWR threshold for impairment for lakes, which is based on a trophic state index (TSI), was used as the water quality target.

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 the 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 population 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 chlorophyll a, total nitrogen, and total phosphorus concentrations.

The Florida-specific TSI was determined based on the analysis of data from 313 Florida lakes. The index was adjusted so that a chlorophyll a concentration of 20 ug/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 platinum cobalt units) because, generally, the phytoplankton may switch to communities dominated by blue-green algae at chlorophyll a levels above 20 ug/L. These blue-green algae are often an unfavorable food source to zooplankton and many other aquatic animals. Some blue-green algae may even produce toxins, which could be harmful to fish and other animals. In addition, excessive growth of phytoplankton and the subsequent death of these algae may consume large quantity of dissolve oxygen and result in anaerobic condition in lakes, which makes conditions in the impacted lake unfavorable for fish and other wildlife. All of these processes may negatively impact the health and balance of native fauna and flora.

Because of the amazing diversity and productivity of Florida lakes, some lakes have a natural background TSI that is different from 60. In recognition of this natural variation, the IWR allows for the use of a lower TSI (40) in very clear lakes, a higher TSI if paleolimnological data indicate the lake was naturally above 60, and the development of site-specific thresholds that better represent the levels at which nutrient impairment occurs. For this study, the Florida Department of Environmental Protection (DEP) used modeling to estimate the natural background TSI by setting land uses to natural or forested land, and then compared the TSI to the IWR thresholds. If the natural background TSI is higher than 60, then the natural background TSI would be used as the water quality target for the TMDL because it is unreasonable to abate the natural background condition. If the natural background TSI is lower than 60, then the IWR threshold (a TSI of 60) would be established as the target for TMDL development (since Lake Wauberg has a mean color greater than 40 platinum cobalt units, the IWR threshold for impairment is 60).

**Figure 1. Lake Wauberg watershed**



## 4. ASSESSMENT OF SOURCES

### 4.1 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 Lake Wauberg 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, runoff from agriculture, runoff from silviculture, runoff from 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 EPA’s National Pollutant Discharge Elimination Program (NPDES). These nonpoint sources included certain urban stormwater discharges, including those from local government master drainage systems, construction sites over five acres, and from a wide variety of industries (see Appendix A for background information about the State and Federal Stormwater Programs).

To be consistent with Clean Water Act definitions, the term “point source” will be used to describe traditional point sources (such as domestic and industrial wastewater discharges) AND stormwater systems requiring an NPDES stormwater permit when allocating pollutant load reductions required by a TMDL (see Section 6). However, the methodologies used to estimate nonpoint source loads do not distinguish between NPDES stormwater discharges and non-NPDES stormwater discharges, and as such, this source assessment section does not make any distinction between the two types of stormwater.

### 4.2 Potential sources of TN and TP in Wauberg Lake watershed

There are no wastewater facilities authorized to discharge to the lake, and based on information provided by EPA, there are no urbanized areas that are currently covered under the MS4 Program in the Lake Wauberg watershed. As such, there are no point sources authorized to discharge to the lake under the NPDES Program.

TN and TP loadings to Lake Wauberg are generated from nonpoint sources. Nonpoint sources addressed in this study include TN and TP loadings from surface runoff, precipitation directly on the surface of the lake, and the contribution from leaking septic tanks. TN and TP loadings through surface runoff were estimated using the Watershed Management Model (WMM) based on the imperviousness and event mean concentration (EMC) of TN and TP from the different landuse types of the watershed. The spatial distribution and acreage of different landuse categories were identified using the St. Johns River Water Management District (SJRWMD) 1995 landuse coverage (scale 1:40,000) contained in the DEP GIS library. Methods used to estimate the TN and TP loadings from precipitation directly on the surface of the lake and the contribution from leaking septic tanks are described in detail in later sections of this report.

Land Use Data

The Lake Wauberg watershed area is approximately 717 acres (including the lake) and is owned mostly by the State of Florida and managed by either the Department of Environmental Protection as part of the Payne's Prairie State Preserve or by the University of Florida as a recreational facility. Boating, fishing, and swimming are allowed, however, gasoline outboard motors may not be used.

Land uses in the lake watershed were aggregated by using the simplified GIS level 1 code and are shown in Table 1. It is not anticipated that any additional development (growth) will occur within the Lake basin that would negatively effect water quality of the Lake.

**Table 1. Main land uses identified in Lake Wauberg watershed**

| CODE | LANDUSE | ACRES | HECTARES |
|---|---|---|---|
| 1000 | Urban | 27.06 | 10.95 |
| 2000 | Agriculture | 79.29 | 32.09 |
| 3000 | Rangeland | 0.69 | 0.28 |
| 4000 | Forest | 274.53 | 111.10 |
| 5000 | Water | 235.56 | 95.33 |
| 6000 | Wetlands | 87.32 | 35.34 |
| 7000 | Barren Land | 0.00 | 0.00 |
| 8000 | Transportation, Communications, Utilities | 12.36 | 5.00 |
| TOTAL SUB-WATERSHED ACRES: | | 716.81 | 290.09 |

Rainfall Data

Direct rainfall and surface/subsurface runoff are the major sources of water to Lake Wauberg. The rainfall gage at the Gainesville Municipal Airport was used for this study (Figure 2). The daily data were retrieved from the Climate Interactive Rapid Retrieval Users System (CIRRUS) database controlled by the Southeast Regional Climate Center at the web site http://water.dnr.state.sc.us/climate/sercc/. Tables 2.1 – 2.3 show the annual, monthly, and wet/dry season rainfall data in inches recorded for 1990 – 2000.

**Figure** 2.  Rainfall Gage and Water Quality Stations

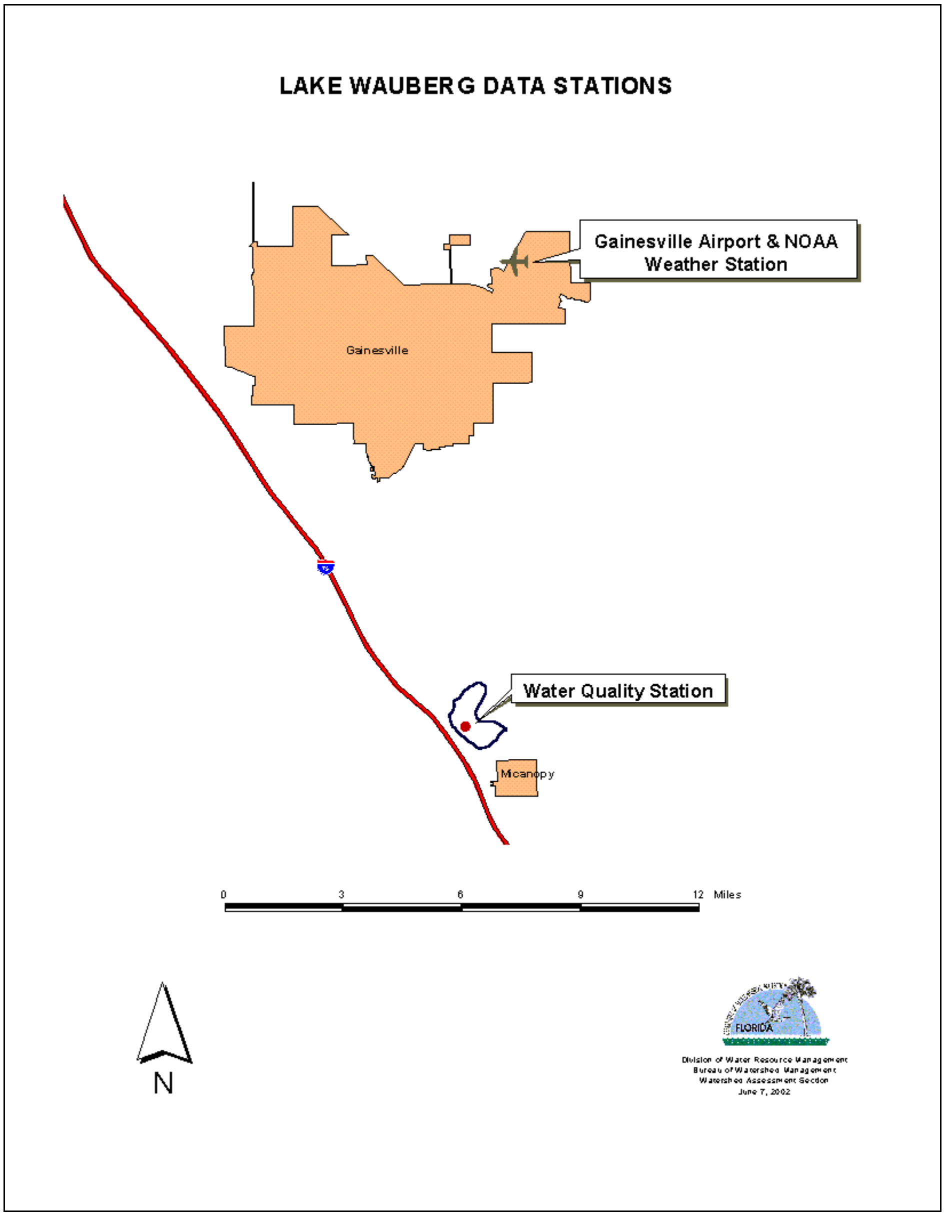


**Table 2.1 Annual Rainfall and Temperature data for years 1990 – 2000**

| Date | SUM Precip (In) | AVG Max Temp (F) | AVG Min Temp (F) | AVG Mean Temp (F) |
|---|---|---|---|---|
| | | | | |
| 1990 | 42.33 | 82.00 | 59.13 | 70.56 |
| 1991 | 50.97 | 79.87 | 59.78 | 69.82 |
| 1992 | 54.28 | 77.85 | 57.97 | 67.91 |
| 1993 | 43.65 | 78.93 | 57.31 | 68.12 |
| 1994 | 48.89 | 79.61 | 59.42 | 69.50 |
| 1995 | 51.22 | 79.87 | 58.23 | 69.05 |
| 1996 | 54.65 | 79.73 | 56.83 | 68.28 |
| 1997 | 58.22 | 80.42 | 58.77 | 69.60 |
| 1998 | 45.62 | 82.22 | 60.14 | 71.18 |
| 1999 | 38.34 | 81.27 | 57.45 | 69.36 |
| 2000 | 34.39 | 80.81 | 55.72 | 68.26 |
| Average | 47.51 | 80.23 | 58.25 | 69.24 |

**Table 2.2**
**Average Monthly Rainfall (1990-2000)**
**(inches)**

| Month | Rainfall |
|---|---|
| Jan | 4.16 |
| Feb | 2.69 |
| Mar | 4.31 |
| Apr | 3.02 |
| May | 2.28 |
| Jun | 7.25 |
| Jul | 6.18 |
| Aug | 5.69 |
| Sep | 4.12 |
| Oct | 3.82 |
| Nov | 1.72 |
| Dec | 2.25 |

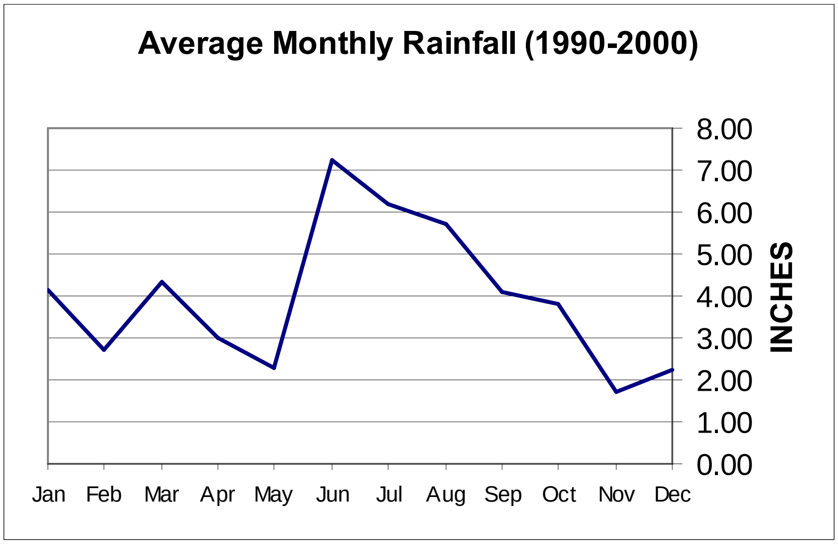



Table 2.3 Estimate of Total Wet and Dry Season Rainfall (inches)
Based on Seasons from (1990-2000)

| | |
|---|---|
| Wet (Apr – Sep) | 28.54 |
| Dry (Oct – Mar) | 18.96 |

Water quality data

Three long-term monthly water quality stations for Lake Wauberg are included in the Florida LakeWatch Database (http://lakewatch.ifas.ufl.edu). The database only provides one latitude and longitude to represent all three of these stations (see Figure 2). The annual average values for Total Phosphorus (TP), Total Nitrogen (TN), Chlorophyll a, and Secchi Depth are shown in Table 3. Average values for each parameter were also calculated for the wet ((April - September) and dry (October - March) seasons over the period of record. As shown in Table 4, chlorophyll a values were much higher in the wet season.

**Table 3. Annual Water Quality Data from 1991 to 2000**

| Year | TP (mg/L) | TN (mg/L) | CHL-A (ug/L)[1] |
|---|---|---|---|
| 1990 | 0.094 | 1.46 | 55.92 |
| 1991 | 0.110 | 1.69 | 86.36 |
| 1992 | 0.118 | 1.73 | 87.19 |
| 1993 | 0.119 | 1.75 | 72.58 |
| 1994 | 0.094 | 1.83 | 76.50 |
| 1995 | 0.108 | 1.91 | 112.40 |
| 1996 | 0.098 | 1.50 | 69.83 |
| 1997 | 0.096 | 1.50 | 77.92 |
| 1998 | 0.193 | 1.46 | 71.03 |
| 1999 | 0.092 | 1.50 | 74.47 |
| 2000 | 0.094 | 1.44 | 61.47 |
| Average | 0.111 | 1.62 | 76.88 |

Table 4. Average Wet and Dry Season Water Quality (Years 1990-2000)

| Season | TP (mg/L) | TN (mg/L) | Chl-a (ug/L) |
|---|---|---|---|
| Wet | 0.120 | 1.75 | 90.08 |
| Dry | 0.101 | 1.49 | 63.68 |

## 4.3 Loading Estimates

Eutromod Model

The Eutromod model was used to estimate loadings to the Lake from the watershed. Eutromod (Reckhow, 1990) is a spreadsheet-based model that is used for the prediction of nutrient runoff and lake eutrophication for lakes in the US. With the model, phosphorus and nitrogen runoff may be predicted using either nutrient loading functions or nutrient export coefficients. The nutrient loading functions are based on the rational formula for dissolved nutrients, and the universal soil loss equation for sediment-attached nutrients. The sediment delivery ratio is addressed with user-defined trapping zones.

Lake eutrophication response is predicted based on a set of regional statistical models. Response variables include total phosphorus concentration, total nitrogen concentration, chlorophyll a level, Secchi disk depth, and in some cases, probability of hypolimnetic anoxia and probability of blue-green algae dominance. The spreadsheet program, and a user's manual, may be ordered from the North American Lake Management Society, NALMS, at phone number 608-233-2836 or at the NALMS homepage (http://www.nalms.org/).

[1] The units for chlorophyll a, ug/L, can be converted to mg/l by dividing the value by 1000.

The set up for runoff and event-mean concentration (EMC) coefficients in Florida lakes is shown in Table 5 (Harvey Harper, 1994).

**Table 5. Runoff and EMC coefficients Used in Florida Lakes**

| Land use | Runoff Coeff. | EMC for TN (MG/L) | EMC for TP (MG/L) |
|---|---|---|---|
| Agriculture | 0.304 | 2.320 | 0.344 |
| Rangeland | 0.250 | 2.480 | 0.476 |
| Forest | 0.220 | 0.350 | 0.050 |
| Urban | 0.675 | 1.770 | 0.177 |
| Water | 0.500 | 1.250 | 0.110 |
| Wetland | 0.225 | 1.600 | 0.190 |
| Transportation, Comm, Utilities | 0.837 | 2.080 | 0.340 |

Loading from Septic Tanks

Estimates of TN and TP loadings from septic tanks were estimated using the following equation from the EUTROMOD model:

(1) **TL = NO x LOAD x ( 1 – RET)**

Where **TL**: total load for TP and TN per year
**NO**: number of people per capita per year
**LOAD**: total load per capita-year (0.876 kg for TP and 4.600 kg for TN)
**RET**: portion of loading retained in the soil (0.110 for TP and 0.085 for TN)

There are about 40 permanent residences within the basin (field observation on September 11, 2001). Assuming 5 people per residence and using equation (1), septic tanks involving permanent residences contribute 31.19 kg TP and 168.36 kg TN per year to the Lake.

Loading from Recreational Uses

The Lake has two recreational areas. The Paynes Prairie Recreational Area, which is managed by the state, averages 3,210 visitors per month. Authorized activities include camping, boating, fishing, and a picnic area (no swimming). This area has dump stations with no septic tanks. The other recreational area is managed by the University of Florida. The activities in this area include swimming, boating, and fishing. This area averages 6,000 visitors/month, with October as the busiest month. This area is served by four septic tanks. All of the septic tanks are at least 500 yards from the Lake.

In order to develop an estimate of the annual loading from recreational use of the septic tanks in the UF recreational area, the average monthly use (6,000) was divided by 30 days. This results in an estimate of an average of 200 visitors/day. For a worst case estimate of the annual average septic tank loading to the Lake from recreational use, these visitors were assumed to be equivalent to the loading of 100 permanent residents. Again using equation (1), this results in an estimated annual average loading from recreational use of 77.96 kg for TP and 420.9 kg for TN.

Therefore, the total annual average loading from septic tanks is estimated as 109.15 kg/year for TP and 589.26 kg/year for TN. It has been reported that large numbers of birds use the Lake as a roosting area. Estimates of TN and TP loadings from birds directly to the Lake have not been determined.

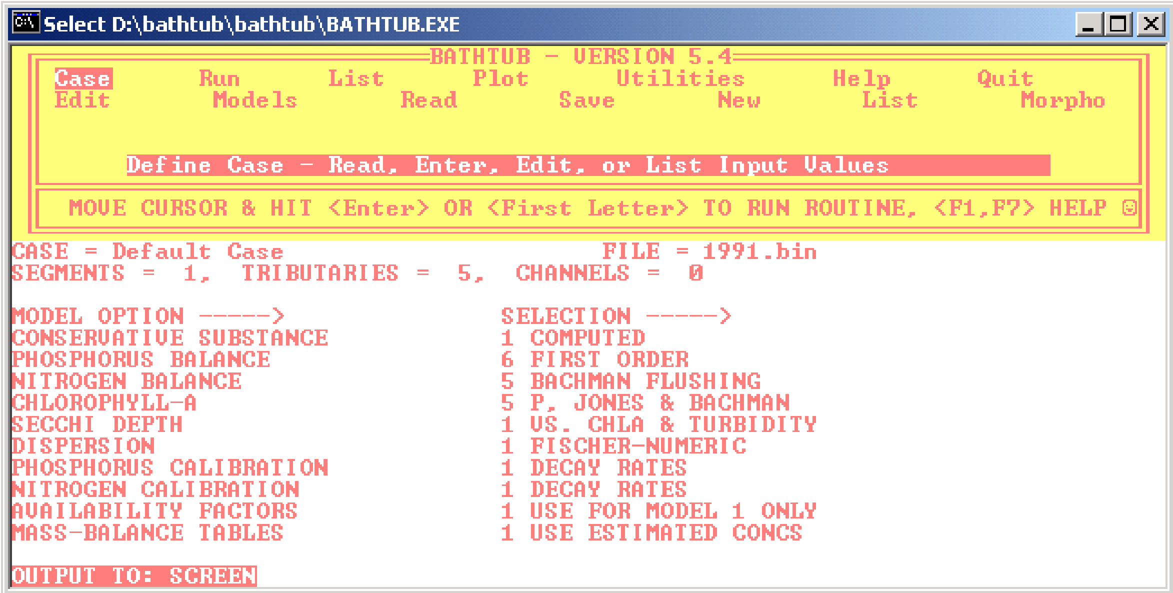
## 5. LOADING CAPACITY

The U.S. Corps of Engineers' BATHTUB model, which is an effective tool for lake and reservoir water quality assessment and management (http://www.epa.gov/owow/tmdl/nutrient/linkage.html), was used to assess in-lake water quality changes for this study. The BATHTUB model is a series of empirical eutrophication models for morphologically complex lakes and reservoirs. The program performs steady-state water and nutrient balance calculations in a spatially segmented hydraulic network, which accounts for advective and diffusive transport, and nutrient sedimentation. Eutrophication-related water quality conditions (total phosphorus, total nitrogen, chlorophyll a, transparency, and hypolimnetic oxygen depletion) are predicted using empirical relationships derived from assessments of reservoir data (Walker, 1985; 1986). The options within BATHTUB were selected based on TN to TP ratios to fit the limiting nutrient concept.

Bathtub model application

Figure 4 shows the selected parameters and model options used for the Bathtub model for the years 1991-1998.

**Figure 4 Parameter Selection from Bathtub Model**




The details of model parameter selections can be found in the user's manual. As an example of the model options selected, presented below is the model parameter selection for Chlorophyll a using "5 Jones & Bachman":

***Model 5: Jones and Bechman (1976)***

**CHL-A = CB x 0.081 x TP** $^{1.45}$

**Normal Turbidity < 0.4 m** $^{-1}$
**Nitrogen/Ortho-Phosphorus concentration > 7**
**(TN-150)/TP > 12**
**Summer Flushing Rate < 25.1 /Year**

Where **CHL-A** is Chlorophyll a concentration (mg/m3) or (µg/l)
**CB** is Calibration factor for Chlorophyll a.

The BATHTUB model was applied to simulate the annual average values for TP, TN, Chlorophyll a, and Secchi Depth from 1990 to 2000. The original model outputs for the comparison between model results and field data are shown in Table 6:

All the results from BATHTUB are within 80-90% of the measured values for TP, TN, chlorophyll a, and secchi depth, except for TP in 1998 when the model underestimated measured TP. Measured TP values were unusually high (greater than 200 mg/m$^3$) in 1998 (Figure 5). At no point in the rest of the seven years of record was the TP higher than 200 mg/m$^3$.

**Table 6. Comparison between measured and model predicted TN, TP, and Chla concentrations.**

**<Year 1991>**

| VARIABLE | | OBSERVED MEAN | CV | ESTIMATED MEAN | CV | RATIO | T STATISTICS 1 | 2 | 3 |
|---|---|---|---|---|---|---|---|---|---|
| TOTAL P | MG/M3 | 110.2 | .00 | 101.4 | .36 | 1.09 | .00 | .31 | .23 |
| TOTAL N | MG/M3 | 1690.0 | .00 | 1447.4 | .40 | 1.17 | .00 | .70 | .39 |
| C.NUTRIENT | MG/M3 | 83.6 | .00 | 74.0 | .30 | 1.13 | .00 | .61 | .40 |
| CHL-A | MG/M3 | 86.4 | .00 | 68.8 | .58 | 1.26 | .00 | .66 | .39 |
| SECCHI | M | 1.9 | .00 | 1.6 | .57 | 1.15 | .00 | .51 | .25 |

**<Year 1992>**

| VARIABLE | | OBSERVED MEAN | CV | ESTIMATED MEAN | CV | RATIO | T STATISTICS 1 | 2 | 3 |
|---|---|---|---|---|---|---|---|---|---|
| TOTAL P | MG/M3 | 89.6 | .00 | 98.0 | .37 | .91 | .00 | -.33 | -.24 |
| TOTAL N | MG/M3 | 1355.0 | .00 | 1558.9 | .45 | .87 | .00 | -.64 | -.31 |
| C.NUTRIENT | MG/M3 | 66.8 | .00 | 75.2 | .32 | .89 | .00 | -.59 | -.37 |
| CHL-A | MG/M3 | 66.8 | .00 | 65.4 | .60 | 1.02 | .00 | .06 | .04 |
| SECCHI | M | 1.5 | .00 | 1.7 | .58 | .84 | .00 | -.61 | -.29 |

**<Year 1993>**

| VARIABLE | | OBSERVED MEAN | CV | ESTIMATED MEAN | CV | RATIO | T STATISTICS 1 | 2 | 3 |
|---|---|---|---|---|---|---|---|---|---|
| TOTAL P | MG/M3 | 101.4 | .00 | 96.9 | .38 | 1.05 | .00 | .17 | .12 |
| TOTAL N | MG/M3 | 1448.9 | .00 | 1607.5 | .47 | .90 | .00 | -.47 | -.22 |
| C.NUTRIENT | MG/M3 | 74.0 | .00 | 75.8 | .33 | .98 | .00 | -.12 | -.07 |
| CHL-A | MG/M3 | 60.2 | .00 | 64.4 | .60 | .94 | .00 | -.19 | -.11 |
| SECCHI | M | 1.5 | .00 | 1.8 | .59 | .88 | .00 | -.47 | -.22 |

**<Year 1994>**

| VARIABLE | | OBSERVED MEAN | CV | ESTIMATED MEAN | CV | RATIO | T STATISTICS 1 | 2 | 3 |
|---|---|---|---|---|---|---|---|---|---|
| TOTAL P | MG/M3 | 93.8 | .00 | 94.2 | .39 | 1.00 | .00 | -.01 | -.01 |
| TOTAL N | MG/M3 | 1832.2 | .00 | 1730.1 | .52 | 1.06 | .00 | .26 | .11 |
| C.NUTRIENT | MG/M3 | 78.0 | .00 | 76.6 | .35 | 1.02 | .00 | .09 | .05 |
| CHL-A | MG/M3 | 76.5 | .00 | 61.7 | .62 | 1.24 | .00 | .62 | .35 |
| SECCHI | M | 2.0 | .00 | 1.8 | .60 | 1.11 | .00 | .38 | .18 |

**<Year 1995>**

| VARIABLE | | OBSERVED MEAN | CV | ESTIMATED MEAN | CV | RATIO | T STATISTICS 1 | 2 | 3 |
|---|---|---|---|---|---|---|---|---|---|
| TOTAL P | MG/M3 | 100.7 | .00 | 98.6 | .37 | 1.02 | .00 | .08 | .06 |
| TOTAL N | MG/M3 | 1768.9 | .00 | 1536.5 | .44 | 1.15 | .00 | .64 | .32 |
| C.NUTRIENT | MG/M3 | 80.7 | .00 | 75.0 | .32 | 1.08 | .00 | .36 | .23 |
| CHL-A | MG/M3 | 105.0 | .00 | 66.0 | .59 | 1.59 | .00 | 1.34 | .78 |
| SECCHI | M | 1.6 | .00 | 1.7 | .58 | .91 | .00 | -.34 | -.16 |

**<Year 1996>**

| VARIABLE | | OBSERVED MEAN | CV | ESTIMATED MEAN | CV | RATIO | T STATISTICS 1 | 2 | 3 |
|---|---|---|---|---|---|---|---|---|---|
| TOTAL P | MG/M3 | 97.7 | .00 | 100.2 | .36 | .98 | .00 | -.09 | -.07 |
| TOTAL N | MG/M3 | 1500.8 | .00 | 1490.3 | .41 | 1.01 | .00 | .03 | .02 |
| C.NUTRIENT | MG/M3 | 73.8 | .00 | 74.6 | .31 | .99 | .00 | -.05 | -.03 |
| CHL-A | MG/M3 | 69.8 | .00 | 67.5 | .59 | 1.03 | .00 | .10 | .06 |
| SECCHI | M | 2.1 | .00 | 1.7 | .57 | 1.23 | .00 | .73 | .36 |

**<Year 1997>**

| VARIABLE | | OBSERVED MEAN | CV | ESTIMATED MEAN | CV | RATIO | T STATISTICS 1 | 2 | 3 |
|---|---|---|---|---|---|---|---|---|---|
| TOTAL P | MG/M3 | 96.0 | .00 | 104.5 | .34 | .92 | .00 | -.31 | -.25 |
| TOTAL N | MG/M3 | 1501.4 | .00 | 1369.5 | .36 | 1.10 | .00 | .42 | .25 |
| C.NUTRIENT | MG/M3 | 73.1 | .00 | 72.9 | .29 | 1.00 | .00 | .02 | .01 |
| CHL-A | MG/M3 | 77.9 | .00 | 71.8 | .56 | 1.08 | .00 | .24 | .14 |
| SECCHI | M | 2.3 | .00 | 1.6 | .55 | 1.45 | .00 | 1.32 | .67 |

**<Year 1998>**

| VARIABLE | | OBSERVED MEAN | CV | ESTIMATED MEAN | CV | RATIO | T STATISTICS 1 | 2 | 3 |
|---|---|---|---|---|---|---|---|---|---|
| TOTAL P | MG/M3 | 193.2 | .00 | 100.8 | .36 | 1.92 | .00 | 2.42 | 1.81 |
| TOTAL N | MG/M3 | 1465.0 | .00 | 1463.2 | .40 | 1.00 | .00 | .01 | .00 |
| C.NUTRIENT | MG/M3 | 95.3 | .00 | 74.2 | .31 | 1.29 | .00 | 1.25 | .82 |
| CHL-A | MG/M3 | 71.0 | .00 | 68.2 | .58 | 1.04 | .00 | .12 | .07 |
| SECCHI | M | 2.3 | .00 | 1.7 | .57 | 1.38 | .00 | 1.16 | .57 |

Figure 5. Monthly TP data in Three Stations during Year 1991-1998

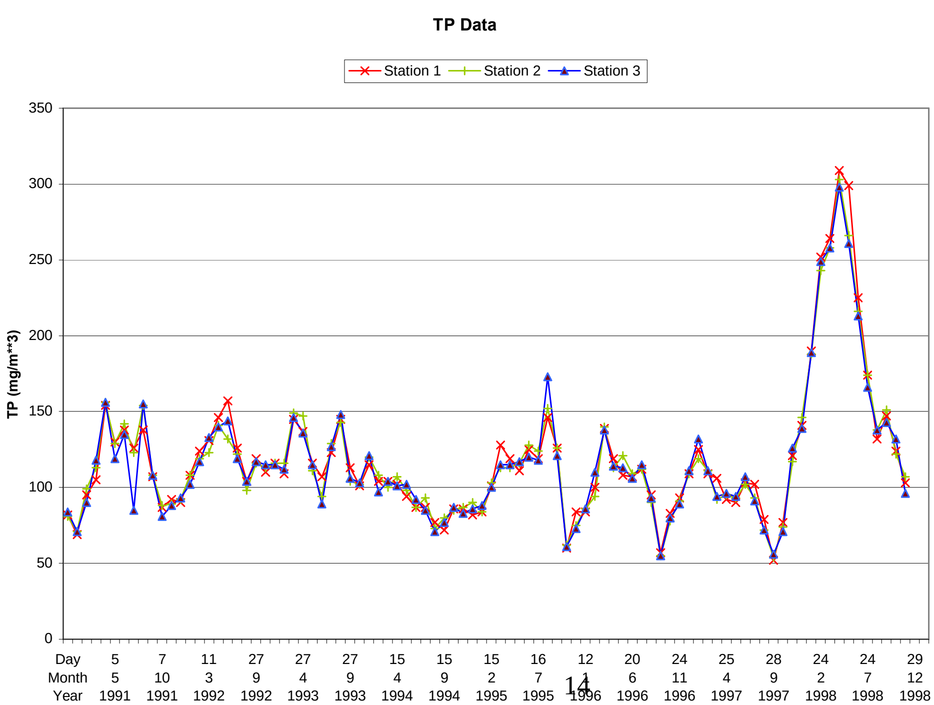
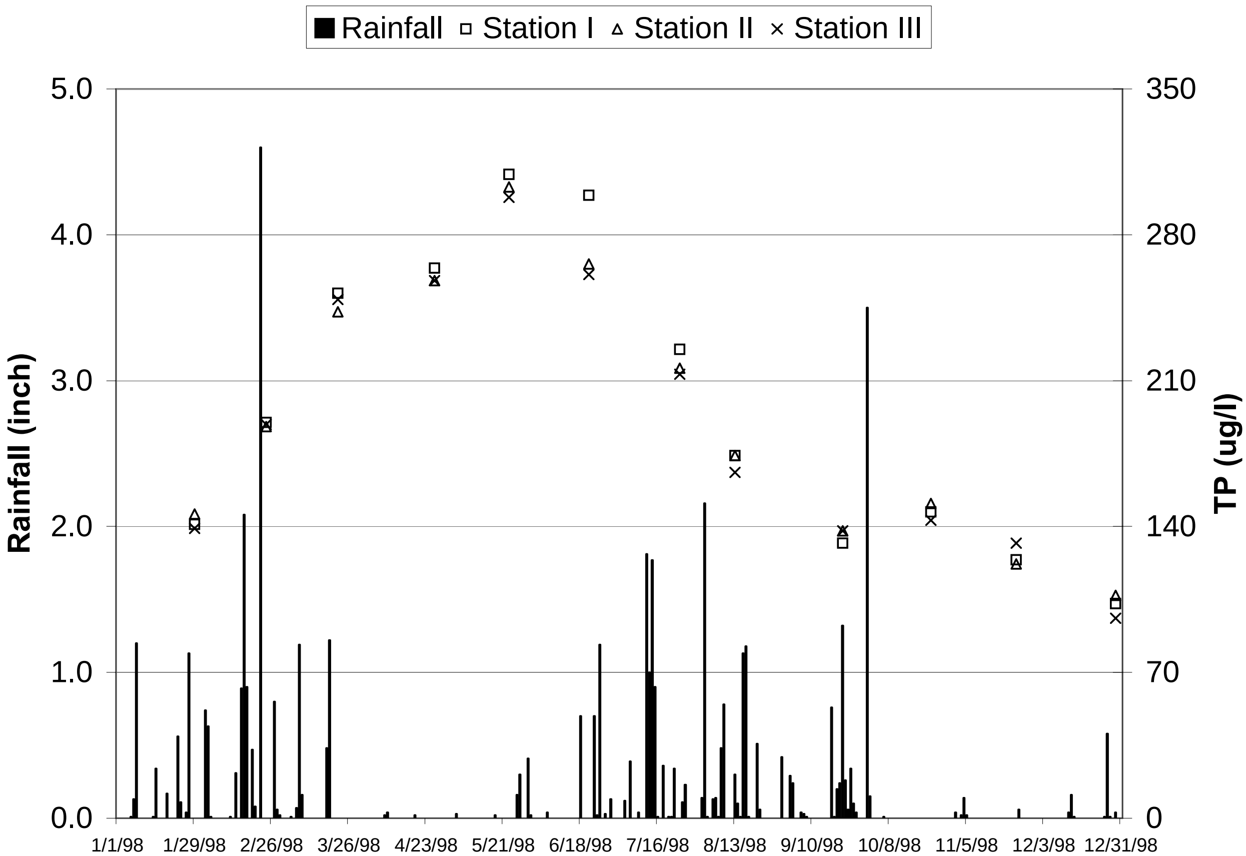


**Figure 6 Rainfall and Total Phosphorus in Year 1998**




One possible explanation for the elevated TP increase in 1998 is the lack of rainfall from March 20 to May 25 (Figure 6). If the seepage from groundwater to the lake has a high TP concentration, then without rainfall, there would be no fresh water input (with a low TP concentration) to dilute the lake water's high TP concentration. A detailed groundwater study is recommended to investigate the ground water concentration and loading of TP.

Despite the inability of the Bathtub model to simulate the high TP concentration in 1998, it still does a good job of simulating the lake system. Given the accuracy of model predictions, the model was determined to be adequately calibrated and sufficient for determining a TMDL. If additional information becomes available on the groundwater in the area and its influence on the lake, the model input can be modified to incorporate that information at a later date.

TMDL Development Based on the TSI index

Using the measured data for TN, TP, and chlorophyll a, annual TSIs for 1990 through 2000 (Table 7) were calculated using the following equation:

**(2) TSI = 0.5 x {16.8 + [14.4 x Ln (CHLA)]}**
**+ 0.25 x {56 + [19.8 x Ln (TN)]}**
**+ 0.25 x {[18.6 + Ln(TP x 1000)] –18.4**

Where: the units for **CHLA**, **TN**, and **TP** are ug/l, mg/l, and mg/l, respectively, and **Ln** is the natural log function.

**Table 7.**
**Annual TSIs Based On Measured Data for Lake Wauberg**

| Year | TSI |
|---|---|
| 1990 | 69.4 |
| 1991 | 73.6 |
| 1992 | 74.5 |
| 1993 | 72.9 |
| 1994 | 72.6 |
| 1995 | 75.8 |
| 1996 | 71.1 |
| 1997 | 71.5 |
| 1998 | 72.4 |
| 1999 | 71.3 |
| 2000 | 70.2 |
| Annual Avg. | 72.3 |

Bathtub was used to estimate loading for current annual average conditions, wet and dry season loads, and natural background. Loadings from current annual average conditions were estimated by using existing landuse data and annual average rainfall. Estimates of wet season and dry season loads were developed based on average dry season rainfall (inches) and average wet season rainfall (inches) and average wet and dry season water quality. Estimates of natural background loadings were developed by using the three rainfall estimates above, changing all man-altered landuses back to forest, and eliminating septic tanks.

- Current Annual Average Condition

For the current average condition, the inputs included the existing landuse (Table 1) and an estimate of loading from septic tanks (about 140 people) discharging in the basin. The TSI values from the model for Years 1991 to 1998 were similar to the TSIs calculated from field data (Table 9).

The error range is from 0.41% to 3.69% and the error formula is shown as follows:

$$\textbf{Error (\%)} = \mathbf{100 \times |Model - Data| / Data}$$

- Natural Background

  The natural background condition is an important scenario to run to determine whether TSI values were naturally above 60. This natural condition was estimated by reducing the loadings from the human landuses to mimic the loadings from forests and by removing the loadings from septic tanks as shown in Table 8. The annual average natural background TSI is 46.5. It should be pointed out that this low value for natural background could occur due to the low drainage area to lake area in this watershed (the lake is 33 percent of the total acreage of the watershed). From the results in the BATHTUB model, the precipitation directly onto the surface of the lake represents 65 percent of the total annual inflows to the lake.

**Table 8. The acreage of land use in Lake Wauberg for Natural Background**

| Land use | Area (ha) |
|---|---|
| Agriculture | 0.00 |
| Rangeland | 0.00 |
| Forest | 159.42 |
| Urban | 0.00 |
| Water | 95.33 |
| Wetland | 35.34 |
| Transportation | 0.00 |
| Sum | 290.09 |

Table 9 Comparison of TSI values between Data and Model Results

| Year | Data | Model | % error |
|---|---|---|---|
| 1990 | 69.4 | 73.79 | 6.32 |
| 1991 | 73.6 | 73.31 | 0.40 |
| 1992 | 74.5 | 72.82 | 2.25 |
| 1993 | 72.9 | 73.33 | 0.58 |
| 1994 | 72.6 | 73.08 | 0.66 |
| 1995 | 75.8 | 72.81 | 3.94 |
| 1996 | 71.1 | 72.36 | 1.77 |
| 1997 | 71.5 | 71.65 | 0.21 |
| 1998 | 72.4 | 72.00 | 0.55 |
| 1999 | 71.3 | 72.71 | 1.98 |
| 2000 | 70.2 | 73.76 | 5.08 |
| AVERAGE | 72.3 | 73.29 | 1.36 |
| WET | | 72.44 | |
| DRY | | 74.32 | |
| NatureAVE | | 46.56 | |
| NatureWET | | 46.31 | |
| NatureDRY | | 47.06 | |

To estimate the required load reductions that would result in an annual average TSI of 60 or less, the current scenario loadings were iteratively reduced until a TSI of 60 was achieved to mimic the implementation of BMPs. The current average in-lake TSI is 72.3, with concentrations for TN, TP, and Chla of 1.62 mg/L, 0.111 mg/L, and 76.9 ug/L, respectively. At a TSI of 60 (the TMDL), the in-lake annual average TN, TP, and Chla concentrations should be 1.01 mg/L, 0.056 mg/L, and 29.2 ug/L, respectively. Under current annual average conditions, the loadings to the lake are 1,843.6 kg/year TN and 339.5 kg/year TP. Under the TMDL, the annual average loadings to the Lake should be 935.5 kg/year TN (51 percent reduction) and 169.5 kg/year TP (50 percent reduction). For the TMDL, loadings in pounds per year are 2,062.4 lbs/year (5.65 lbs/day) for TN and 373.7 lbs/year (1.02 lbs/day) for TP.

## 6. DETERMINATION OF TMDL

The objective of a TMDL is to provide a basis for allocating acceptable loads among all of the known pollutant sources in a watershed so that appropriate control measures can be implemented and water quality standards achieved. A TMDL is expressed as the sum of all point source loads (Waste Load Allocations), nonpoint source loads (Load Allocations), 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 a 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.

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 Lake Wauberg (Table 10) is expressed in terms of pounds per year and percent reduction.

**Table 10. TMDL Components**

| WBID | Parameter | WLA Wastewater (lbs/year) | WLA NPDES Stormwater | LA (lbs/year) | MOS | TMDL (lbs/year) | Percent Reduction |
|---|---|---|---|---|---|---|---|
| 2741 | TN | None | NA | 2,062.4 | Implicit | 2,062.4 | 51 |
| 2741 | TP | None | NA | 373.7 | Implicit | 373.7 | 50 |

### 6.1 Load Allocation

The allowable LA is 373.7 lbs/year for TP and 2,062.4 lbs/year for TN. This corresponds to reductions from the existing loadings of 51 percent for TN and 50 percent for TP. It should be noted that the LA includes loading from stormwater discharges regulated by the Department and the Water Management Districts that are not part of the NPDES Stormwater Program (see Appendix A).

### 6.2 WasteLoad Allocation

NPDES Stormwater Discharges

As noted in Sections 4 and 6.1, load from stormwater discharges permitted under the NPDES Stormwater Program are placed in the WLA, rather than the LA. This includes loads from municipal separate storm sewer systems (MS4s). However, based on the information provided by EPA, no MS4 area was found overlapping the Lake Wauberg watershed and no stormwater loads were assigned to the WLA.

NPDES Wastewater Discharges

There are no known Point Sources in the Watershed.

### 6.3 Margin of Safety

The margin of safety exists due to conservative assumptions used in the modeling process. For example, it was assumed that loadings from recreational use of park septic tanks were equivalent to full time residences. It was also assumed that 100 percent of the rainfall was available to generate runoff.

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

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

The Basin Management Action Plan (B-MAP) will include:

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

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

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Appendix A

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, Florida Statutes (F.S.), was established as a technology-based program that relies upon 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, Florida Administrative Code (F.A.C.).

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

In 1987, the U.S. Congress established section 402(p) as part of the Federal Clean Water Act Reauthorization. This section of the law amended the scope of the federal NPDES to designate certain stormwater discharges as "point sources" of pollution. These stormwater discharges include certain discharges that are associated with industrial activities designated by specific Standard Industrial Classification (SIC) codes, construction sites disturbing five or more acres of land, and master drainage systems of local governments with a population above 100,000 [which are better known as "municipal separate storm sewer systems" (MS4s)]. However, because the master drainage systems of most local governments in Florida are interconnected, EPA has implemented Phase 1 of the MS4 permitting program on a county-wide basis, which brings in all cities (incorporated areas), Chapter 298 urban water control districts, and the DOT (Department of Transportation) throughout the 15 counties meeting the population criteria.

An important difference between the federal and the 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 stormwater permitting program will expand the need for these permits to construction sites between one and five acres, and to local governments with as few as 10,000 people. These revised rules require that these additional activities obtain permits by 2003. While these urban stormwater discharges are now technically referred to as "point sources" for the purpose of regulation, they are still diffuse sources of pollution that can not be easily collected and treated by a central treatment facility similar to other point sources of pollution, such as domestic and industrial wastewater discharges. The DEP recently accepted delegation from 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.