FINAL
TOTAL MAXIMUM DAILY LOAD (TMDL)

For
Nutrients
In
Lake Ida
(WBID 3262A)

Prepared by:

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In compliance with the provisions of the Federal Clean Water Act, 33 U.S.C §1251 et. seq., as amended by the Water Quality Act of 1987, P.L. 400-4, the U.S. Environmental Protection Agency is hereby establishing the Total Maximum Daily Load (TMDL) for Nutrients in the Lake Worth Lagoon – Palm Beach Coast Basin (WBID 3262A). Subsequent actions must be consistent with this TMDL.

/s/ James D. Giattina, Director
Water Protection Division

11/09/2012
Date
Acknowledgments

EPA would like to acknowledge that the contents of this report and the total maximum daily load (TMDL) contained herein were developed by the Florida Department of Environmental Protection (FDEP). Many of the text and figures may not read as though EPA is the primary author for this reason. EPA is establishing this TMDL in order to meet consent decree requirements pursuant to the Consent Decree entered in the case of Florida Wildlife Federation, et al. v. Carol Browner, et al., Case No. 98-356-CIV-Stafford. EPA is establishing this TMDL in lieu of FDEP, after full review of public comments.

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Websites

**Florida Department of Environmental Protection, Bureau of Watershed Restoration**

TMDL Program  
http://www.dep.state.fl.us/water/tmdl/index.htm

Identification of Impaired Surface Waters Rule  

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

2008 Integrated Report  

Surface Water Quality Standards  

Basin Status Report for the Lake Worth Lagoon Basin  
http://www.dep.state.fl.us/water/basin411/lwl_pbc/status.htm

**U.S. Environmental Protection Agency**

Region 4: Total Maximum Daily Loads in Florida  
http://www.epa.gov/region4/water/tmdl/florida/

National STORET Program  
http://www.epa.gov/storet/
Chapter 1: INTRODUCTION

1.1 Purpose of Report

This report presents the Total Maximum Daily Load (TMDL) for Nutrients [Trophic State Index (TSI)] for Lake Ida located in the Lake Worth Lagoon Basin. The freshwater lake was verified as impaired for Nutrients (TSI) and, therefore, was included on the Verified List of impaired waters for the Lake Worth Lagoon Basin that was adopted by Secretarial Order on January 15, 2010. The TMDL establishes the allowable Nutrients (TSI) loading to Lake Ida that would restore the waterbody so that it meets its applicable water quality narrative nutrient criterion. The TMDL establishes the maximum amount of a given causative pollutant that a waterbody can assimilate and still meet water quality standards, including its applicable water quality criteria and its designated uses. The causative pollutants are Total Nitrogen (TN) and Total Phosphorus (TP).

1.2 Identification of Waterbody

For assessment purposes, the Florida Department of Environmental Protection (Department) has divided the Lake Worth Lagoon Basin into water assessment polygons with a unique waterbody identification (WBID) number for each water segment. This TMDL addresses Lake Ida (WBID 3262A) for Nutrients (TSI).

The Unique Nature of South Florida

Developed over the past hundred years, the canal-based water management system in South Florida is one of the world’s largest and most complex civil works projects. Over 1300 water control structures, 64 pump stations, and 2600 miles of canals are used by SFWMD to provide flood control, water supply, navigation, water quality improvements, and environmental management. Lake Ida is part of the Chain of Lakes watershed, which is a series of lakes interconnected by the E-4 Canal. Canals were built to meet human needs by controlling the water levels and the movement of water from one place to another for water supply, flood control, drainage, and navigation as well as to provide water needed to sustain natural communities in lakes, rivers, wetlands, and estuaries. One of the primary functions of a canal is to control water levels in order to maintain ground water level in dry conditions. This is particularly important for water supply needs, such as preventing salt water intrusion. Canals also provide the conduit to remove excess water from drainage basins in wet periods, to prevent flooding. Canals differ greatly in their design, construction, and operation. Canal operations depend primarily on their location, intended function, adjacent land use, and development within the basin.

Water quality in these canals and the inter-connected lakes is affected by tributary sources, surrounding soil types, topography, ground water interaction, adjacent land use, and the operation of the control structures to provide protection from saltwater intrusion during dry periods and flood control during wet periods. In some areas, water quality is strongly influenced by ground water seepage. Sediments (soil types) are also known to have an effect on water quality. Soil types surrounding canals range from sandy upland soils of the Atlantic Coastal Ridge to hydric sands, marls, and peats of the Everglades. Topography differs across South
Florida resulting in differences in canal and lake depths, water levels, and flow rates. Water elevations in the canals and lakes can range from less than 10 feet above sea level to 20 – 60 feet above sea level. Water quality varies greatly among regions of South Florida, individual canals/lakes within regions, and sections of the same canal. In comparison to natural stream and lake systems that are periodically disturbed through natural process (droughts, fires, floods, hurricanes, etc), canals and the inter-connected lakes are disturbed almost continually by human interventions for maintenance, including herbicide treatment, mowing, dredging, removing obstructions, and mechanical harvesting. As artificial conveyances with large variations in flow, stage, and water turnover, these canals and lakes provide less stable and predictable environments than natural systems. South Florida canals and the inter-connected lakes are part of a large water management system and must convey large volumes of water during storm events. At the other extreme, during droughts and dry season operations, the canals and lakes may become stagnant for long periods of time with little to no water movement. At times, water may be absent from some systems.


Lake Ida

Lake Ida is part of the Chain of Lakes watershed, which is a series of lakes interconnected by the E-4 Canal. Lake Ida also experiences inflows from the L-30 Canal. The topography of Lake Ida (WBID 3262A) watershed encompasses 207 acres. The WBID 3262A actually is comprised of a smaller lake north of Lake Ida (Lake Eden) as well as Lake Ida. It should be noted that in this document, references to the Lake Ida WBID typically implies both Lake Ida and Lake Eden. The predominant land uses are approximately 151 acres of water and 55 acres of urban and built-up specifically medium density residential. In addition, the watershed is surrounded by medium and high density residential and transportation, communication, and utilities areas. Lake Ida is located in Palm Beach County. Refer to Figure 1.1 and 1.2. The climate in Palm Beach County, specifically areas surrounding the Lake Ida watershed, is sub-tropical with annual rainfall averaging approximately 60.27 inches, although rainfall amounts can vary greatly from year to year (SERCC, 2011). Based on data from a 30-year period (1971 – 2000), the average summer temperature is 91.0 °F, and the average winter temperature is 76.3 °F (SERCC, 2011). The physiography of the Lake Ida watershed reflects its location within the Miami Ridge/Atlantic Coastal Strip or Southern Florida Coastal Plains ecoregion. Elevations in the watershed range from around 5 – 10 feet above sea level (FDEP, 2010). The predominant soil type is medium fine sand and silt (FDEP, 2008). Boynton Beach, which is a major human population center, exists within the watershed.

1.3 Background

This report was developed as part of the Department’s watershed management approach for restoring and protecting state waters and addressing TMDL Program requirements. The watershed approach, which is implemented using a cyclical management process that rotates through the state’s 52 river basins over a 5-year cycle, provides a framework for implementing the TMDL Program–related requirements of the 1972 federal Clean Water Act and the 1999 Florida Watershed Restoration Act (FWRA) (Chapter 99-223, Laws of Florida).
A TMDL represents the maximum amount of a given pollutant that a waterbody can assimilate and still meet water quality standards, including its applicable water quality criteria and its designated uses. TMDLs are developed for waterbodies that are verified as not meeting their water quality standards. They provide important water quality restoration goals that will guide restoration activities.

This TMDL Report will be followed by the development and implementation of a restoration plan designed to reduce the amount of Nutrients (TSI) or causative pollutants that caused the verified impairment of Lake Ida (WBID 3262A). These activities will depend heavily on the active participation of the South Florida Water Management District (SFWMD), local governments, businesses, and other stakeholders. The Department will work with these organizations and individuals to undertake or continue reductions in the discharge of pollutants and achieve the established TMDL for the impaired waterbody.
Figure 1.1 Location of Lake Ida (WBID 3262A) in Palm Beach County and Major Hydrological Features in the Area
Figure 1.2 Location of Lake Ida (WBID 3262A)
Chapter 2: DESCRIPTION OF WATER QUALITY PROBLEM

2.1 Statutory Requirements and Rulemaking History

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

Florida’s 1998 303(d) Consent Decree list included sixteen waterbodies in the Lake Worth Lagoon Basin. Lake Ida (WBID 3262A) was one of the waterbodies listed on the 1998 303(d) list. However, the FWRA (Section 403.067, F.S.) stated that all Florida 303(d) lists created previous to the adoption of the FWRA were for planning purposes only and directed the Department to develop, and adopt by rule, a new science-based methodology to identify impaired waters. After a long rulemaking process, the Environmental Regulation Commission adopted the new methodology as Rule 62-303, Florida Administrative Code (F.A.C.) (Identification of Impaired Surface Waters Rule, or IWR), in April 2001; the rule was modified in 2006 and 2007.

2.2 Information on Verified Impairment

The Department used the IWR to assess water quality impairments in Lake Ida (WBID 3262A) and has verified that this waterbody segment is impaired for Nutrients (TSI) during the data period of January 1, 2002 – June 30, 2009, which is also known as the Cycle 2 Verified Period. Using the IWR methodology this waterbody was verified as impaired for Nutrients (TSI) because two TSI annual averages exceeded the threshold (2006, 61.0 TSI – 60 PCU and 2008, 63.7 TSI – 54.4 PCU). According to the TN/TP ratio median the WBID is mainly co-limited by both TN and TP (median = 11.0). The total number of observations for which a TN/TP ratio could be calculated was 65. Table 2.1 summarizes the Nutrients (TSI) monitoring results for the Cycle 2 Verified Period for Lake Ida (WBID 3262A). To ensure that the Nutrients (TSI) TMDL was developed based on current conditions and that recent trends in water quality were adequately captured, monitoring data collected during the data period of January 1, 2002 – June 30, 2009 were used to develop the TMDL. Primarily, the data were collected during 2002 and 2006 – 2009.
Table 2.1 Summary of Nutrients (TSI) Monitoring Data for Lake Ida (WBID 3262A) during the Cycle 2 Verified Period from January 1, 2002 – June 30, 2009

<table>
<thead>
<tr>
<th>WBID</th>
<th>Waterbody Segment</th>
<th>Waterbody Type</th>
<th>Year</th>
<th>Number of Seasons</th>
<th>Number of Samples</th>
<th>Mean TSI</th>
<th>Mean Color (PCU)</th>
<th>Threshold Value</th>
<th>Type of Chlorophyll Used in Calculation of TSI Annual Average</th>
<th>Is TSI Threshold* Exceeded?</th>
<th>Is Delist Criteria** Satisfied?</th>
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</thead>
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</tr>
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</tr>
</tbody>
</table>

(*) Threshold values for TSI used depend on the reported values for color: For lakes with a mean color greater than 40 PCU, the threshold TSI value used is 60; for lakes with a mean color less than or equal to 40 the PCU threshold TSI value used is 40 (unless paleolimnological information suggests otherwise); when color is not reported the threshold TSI value of 60 is used.

(**) Delist criteria is only reported when exceedances of threshold values are observed.
Chapter 3. DESCRIPTION OF APPLICABLE WATER QUALITY STANDARDS AND TARGETS

3.1 Classification of the Waterbody and Criterion Applicable to the TMDL

Florida’s surface waters are protected for five designated use classifications, as follows:

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

Lake Ida (WBID 3262A) is a Class III freshwater waterbody, 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 for Lake Ida is the State of Florida’s narrative nutrient criterion, which is Rule 62-302.530(48)(b), F. A. C.

3.2 Interpretation of the Narrative Nutrient Criterion for Lakes

To place a waterbody segment on the Verified List for nutrients, the Department must identify the limiting nutrient or nutrients causing impairment as required by the IWR. The following method is used to identify the limiting nutrient(s) in streams and lakes: The individual ratios over the entire verified period (January 1, 2002 – June 30, 2009) were evaluated to determine the limiting nutrient(s). If all the sampling event ratios are less than 10, nitrogen is identified as the limiting nutrient, and if all the ratios are greater than 30, phosphorus is identified as the limiting nutrient. Both nitrogen and phosphorus are identified as limiting nutrients if the ratios are between 10 and 30. For Lake Ida, the mean TN/TP ratio was 11.1 (n = 65) for the verified period (January 1, 2002 – June 30, 2009) indicating co-limitation of TP and TN for the lake.

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

The TSI originally developed by 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. Using Secchi depth as an index to represent lake trophic state can produce misleading results because of the existence of dark-water lakes in the state. Therefore, the TSI was revised to be based on total nitrogen, total phosphorus, and chlorophyll concentrations. This revised calculation for TSI now contains options for determining a TN-TSI, TP-TSI, and Chlorophyll a-TSI. As a result, there are three different ways of calculating a final in-lake TSI. If the TN to TP ratio is equal to or greater than 30, the lake is considered phosphorus-limited and the final TSI is the average of the TP-TSI and the Chlorophyll a-TSI. If the TN to TP ratio is 10 or less, the lake is considered nitrogen-limited and the final TSI is the average of the Chlorophyll a-TSI and the TN-TSI. If the TN to TP ratio is between 10 and 30, the lake is considered co-limited and the final TSI is the result of averaging the Chlorophyll a-TSI with the average of the TN and TP TSIs.

The Florida-specific TSI was determined based on the analysis of data from 313 Florida lakes. The index was adjusted so that a chlorophyll concentration of 20 μg/L was equal to a Chlorophyll a-TSI value of 60. The final TSI for any lake may be higher or lower than 60 depending on the TN-TSI and the TP-TSI values. A TSI of 60 was then set as the threshold for nutrient impairment for most lakes (for those with a color higher than 40 platinum cobalt units) because the phytoplankton generally may switch to communities dominated by blue-green algae at chlorophyll a levels above 20 μg/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 quantities of dissolved oxygen and result in anaerobic conditions 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, almost all lakes have a natural background TSI that is different from 60. Threshold values for TSI depend on the reported values for color. For lakes with a mean color greater than 40 PCU the threshold value used is 60 unless paleolimnological information suggests otherwise; for lakes with a mean color less than or equal to 40 PCU the threshold value used is 40 unless paleolimnological information suggests otherwise; when color is not reported the threshold value of 60 is used [Rule 62-303.352, Florida Administrative Code (F.A.C.) (IWR)]. In recognition of this natural variation, the IWR allows for the use of a lower TSI of 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.

3.3 Narrative Nutrient Criteria Definitions

Chlorophyll a

Chlorophyll is a green pigment found in plants and is an essential component in the process of converting light energy into chemical energy. Chlorophyll is capable of channeling the energy of sunlight into chemical energy through the process of photosynthesis. In photosynthesis, the energy absorbed by chlorophyll transforms carbon dioxide and water into carbohydrates and oxygen. The chemical energy stored by photosynthesis in carbohydrates drives biochemical
reactions in nearly all living organisms. Thus, chlorophyll is at the center of the photosynthetic oxidation-reduction reaction between carbon dioxide and water. There are several types of chlorophyll; however, the predominant form is chlorophyll a. The measurement of chlorophyll a in a water sample is a useful indicator of phytoplankton biomass, especially when used in conjunction with analysis concerning algal growth potential and species abundance. If chlorophyll a is abundant then algae is also abundant. Algae are the primary producers in the aquatic food web, and thus are very important in characterizing the productivity of lakes and streams. As noted earlier, chlorophyll a measurements are also used to estimate the trophic conditions of lakes and lentic waters.

**Nitrogen Total as N (TN)**

Total nitrogen is the combined measurement of nitrate (NO-3), nitrite (NO-2), ammonia, and organic nitrogen found in water. Nitrogen compounds function as important nutrients to many aquatic organisms and are essential to the chemical processes that exist between land, air, and water. The most readily bio-available forms of nitrogen are ammonia and nitrate. These compounds, in conjunction with other nutrients, serve as an important base for primary productivity. The major sources of excessive amounts of nitrogen in surface water are the effluent from municipal treatment plants and runoff from urban and agricultural sites. When nutrient concentrations consistently exceed natural levels, the resulting nutrient imbalance can cause undesirable changes in a waterbody’s biological community and drive an aquatic system into an accelerated rate of eutrophication. Usually, the eutrophication process is observed as a change in the structure of the algal community and includes severe algal blooms that may cover large areas for extended periods. Large algal blooms are generally followed by depletion in dissolved oxygen concentrations as a result of algal decomposition.

**Phosphorus Total as P (TP)**

Phosphorus is one of the primary nutrients that regulates algal and macrophyte growth in natural waters, particularly in fresh water. Phosphate, the form in which almost all phosphorus is found in the water column, can enter the aquatic environment in a number of ways. Natural processes transport phosphate to water through atmospheric deposition, ground water percolation, and terrestrial runoff. Municipal treatment plants, industries, agriculture, and domestic activities also contribute to phosphate loading through direct discharge and natural transport mechanisms. The very high levels of phosphorus in some of Florida’s streams and estuaries are sometimes linked to phosphate mining and fertilizer processing activities. High phosphorus concentrations are frequently responsible for accelerating the process of eutrophication, or accelerated aging, of a waterbody. Once phosphorus and other important nutrients enter the ecosystem, they are extremely difficult to remove. They become tied up in biomass or deposited in sediments. Nutrients, particularly phosphates, deposited in sediments generally are redistributed to the water column. This type of cycling compounds the difficulty of halting the eutrophication process.
Chapter 4: ASSESSMENT OF SOURCES

4.1 Types of Sources

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

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

To be consistent with Clean Water Act definitions, the term “point source” will be used to describe traditional point sources (such as domestic and industrial wastewater discharges) and stormwater systems requiring an NPDES stormwater permit when allocating pollutant load reductions required by a TMDL (see Section 6.1). 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 Nutrients within the Lake Ida WBID Boundary

4.2.1 Point Sources

Wastewater Point Sources

No NPDES permitted facilities exist within the Lake Ida WBID boundary; therefore, facilities have no impact on Nutrients (TSI) concentrations within the lake.

Municipal Separate Storm Sewer System Permittees

One NPDES municipal separate storm sewer system (MS4) permit covers the Lake Ida (WBID 3262A) watershed, which is held by Palm Beach County & Co Permittees (Phase I FLS000018), which includes FDOT Turnpike District/District 4.

4.2.2 Land Uses and Nonpoint Sources

Accurately quantifying the Nutrients (TSI) loadings from nonpoint sources requires identifying nonpoint source categories, locating of the sources, determining the intensity and frequency at which these sources create high Nutrients (TSI) loadings, and specifying the relative contributions from these sources. Depending on the land use distribution in a given watershed,
frequently cited nonpoint sources in urban areas include failed septic tanks, leaking sewer lines, and pet feces. For a watershed dominated also by rangeland land uses, Nutrients (TSI) loadings can come from the runoff from areas with animal feeding operation or direct animal access to the receiving waters. In addition to the sources associated with the anthropogenic activities, birds and other wildlife forms can also act as Nutrients (TSI) contributors to the receiving waters. While detailed source information is not always available for accurately quantifying the Nutrients (TSI) loadings from different sources, land use information, can provide some hints on what can be the potential sources of observed Nutrients (TSI) impairment.

Land Uses

The spatial distribution and acreage of different land use categories were identified using the SFWMD’s year 2004 - 2005 land use coverage contained in the Department’s geographic information system (GIS) library. Land use categories within the Lake Ida WBID boundary were aggregated using the simplified Level 1 codes and tabulated in Table 4.1. Figure 4.1 shows the spatial distribution of the principal land uses within the WBID boundary and surrounding area.

As shown in Table 4.1, the total area within the Lake Ida WBID boundary is about 207 acres. The predominant land uses are approximately 151 acres of water and 55 acres of urban and built-up specifically medium density residential. In addition, the watershed is surrounded by medium and high density residential and transportation, communication, and utilities areas.

Table 4.1 Classification of Land Use Categories within the Lake Ida WBID Boundary

<table>
<thead>
<tr>
<th>Level 1 Code</th>
<th>Land Use</th>
<th>Acreage</th>
<th>% Acreage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1000</td>
<td>Urban and built-up</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>1100</td>
<td>Low-density residential</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>1200</td>
<td>Medium-density residential</td>
<td>56</td>
<td>27%</td>
</tr>
<tr>
<td>1300</td>
<td>High-density residential</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>2000</td>
<td>Agriculture</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>3000</td>
<td>Rangeland</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>4000</td>
<td>Upland forest</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>5000</td>
<td>Water</td>
<td>151</td>
<td>73%</td>
</tr>
<tr>
<td>6000</td>
<td>Wetland</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>7000</td>
<td>Barren land</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>8000</td>
<td>Transportation, communication, and utilities</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>207</strong></td>
<td><strong>100%</strong></td>
<td></td>
</tr>
</tbody>
</table>
Figure 4.1 Principal Land Uses within the Lake Ida WBID Boundary and Surrounding Area
Figure 4.2 Distribution of Onsite Sewage Disposal Systems (Septic Tanks) and Sewer Systems in the Residential Land Use Areas within and surrounding the Lake Ida WBID Boundary
Sources of Nutrients Loads within the Lake Ida Watershed

**Septic Tanks**

Septic tanks are another potentially important source of nitrogen loading in urban watersheds. The physical properties of an aquifer, such as thickness, sediment type (sand, silt, and clay), and location play a large part in determining whether contaminants from the land surface will reach the groundwater (USGS, 2010). Figure 4.2 displays the distribution of onsite sewage disposal systems (septic tanks) and sewer systems in the residential land use areas within and surrounding the Lake Ida WBID boundary. The risk of contamination is greater for unconfined (water-table) aquifers than for confined aquifers because they usually are nearer to land surface and lack an overlying confining layer to impede the movement of contaminants (USGS, 2010).

Sediment type (sand, silt, and clay) also determines the risk of contamination in a particular watershed. "Porosity, which is the proportion of a volume of rock or soil that consists of open spaces, tells us how much water rock or soil can retain. Permeability is a measure of how easily water can travel through porous soil or bedrock. Soil and loose sediments, such as sand and gravel, are porous and permeable. They can hold a lot of water, and it flows easily through them. Although clay and shale are porous and can hold a lot of water, the pores in these fine-grained materials are so small that water flows very slowly through them. Clay has a low permeability (USGS, 2010)." Septic tanks located in sand and gravel sediment have a higher risk of contamination than septic tanks located in clay sediment.

Also, the risk of contamination is increased for areas with a relatively high groundwater table. The drain field can be flooded during the rainy season, resulting in ponding and nitrogen pollution can pollute the surface water through stormwater runoff. Additionally, in these circumstances, a high water table can result in nitrogen pollution reaching the receiving waters through baseflow.

Septic tanks may also cause nitrogen pollution when they are built too close to irrigation wells. Any well that is installed in the surficial aquifer system will cause a drawdown. If the septic tank system is built too close to the well (e.g., less than 75 feet), the septic tank discharge will be within the cone of influence of the well. As a result, septic tank effluent may enter the well, and once the polluted water is used to irrigate lawns, nitrogen pollution may reach the land surface and wash into surface waters through stormwater runoff.

**Sanitary Sewer Overflows**

Sanitary sewer overflows (SSOs) can also be a potential source of nitrogen pollution. Human sewage can be introduced into surface waters even when storm and sanitary sewers are separated. Leaks and overflows are common in many older sanitary sewers where capacity is exceeded, high rates of infiltration and inflow occur (i.e., outside water gets into pipes, reducing capacity), frequent blockages occur, or sewers are simply falling apart due to poor joints or pipe materials. Power failures at pumping stations are also a common cause of SSOs. The greatest risk of an SSO occurs during storm events; however, few comprehensive data are available to quantify SSO frequency and nitrogen loads in most watersheds.

**Wildlife**

Wildlife is another possible source of nitrogen pollution within the Lake Ida WBID boundary. Areas that border the Lake Ida boundary serve as habitat for wildlife that has the potential to contribute nitrogen pollution to the canal. Wildlife specifically organisms with high levels of
nitrogen in their feces such as birds, deposit their feces directly into the water or onto land surfaces, where they can be transported during storm events to the lake. However, the nitrogen loading from naturally occurring wildlife is assumed to be background. However, as these represent natural inputs, no reductions are assigned to these sources by this TMDL.

4.3 SWMM Model

SWMM, Version 5.0, was used to simulate the Lake Worth Lagoon Canals and Lakes water quantity and quality, including Lake Ida and Lake Eden and the canals into and out of these lakes. The model can simulate individual storm events with a time step (time interval between computations) as low as a few seconds or minutes, or carry out a continuous simulation over an extended period (EPA, 1997). It includes the hydrologic processes of rainfall, surface and subsurface runoff, flow routing through a drainage network, storage, and treatment. SWMM is composed of three groups of elements: hydrologic, hydraulic, and quality. The hydrologic elements include rain gages, subcatchments, aquifers, and snow packs. The hydraulic elements include vehicles to move and store water and are grouped into links or nodes. Links (which handle flow mechanisms) include conduits (streams and pipes), pumps, orifices, weirs, and outlets. Nodes (which are turning points, storage points, and receiving or discharge points) include junctions, outfalls, dividers, and storage units.

SWMM requires the subcatchment properties of percent imperviousness, infiltration rate, depression storage, and surface roughness (EPA, 1988). It also requires other inputs such as stream or conduit geometry (shape, width, depth, side slopes), land uses, baseflow, baseflow concentrations, and EMCs by land use. These basic components were used to represent the Lake Worth Lagoon Canal and are shown (Figure 4.3) as they appear in the Windows-based SWMM (Rossman, 2004; EPA, 2005), with a backdrop transferred from GIS Arcmap.

The Lake Worth Lagoon watershed and surrounding area were divided into over 245 subcatchments (each with landuse breakdown), 544 nodes, data from 12 rain gages, and 635 conduits. Lake Ida, Lake Eden, and the flow into and out of these lakes are a part of this system and were represented by conduits and storage nodes of volume and dimensions consistent with the measured lake bathymetry and that used in the Bathtub model. The reason for the detailed basin representation is:

- **A greater number of subcatchments provides more opportunities to use internal mechanisms to create storage and delay flow in the modeled basin. This more accurately simulates long-term storm effects and gives width to the flow hydrograph.**

- **Instead of lumping and averaging all properties within larger subcatchments, for each smaller subcatchment one can specify such parameters as area, infiltration rate, percent impervious area, slope, point of entry into conduit (stream), ground water characteristics, and land uses.**

Given that SWMM lumps the properties of each subcatchment, the best way to model an individual subcatchment with different characteristics is to create a new subcatchment. Of course, there is a balance between making subcatchment divisions and the time required to define each subcatchment. The benefits are also proportional to the degree of detail that one can describe for the different parameters related to each subcatchment. Other data inputs include stream widths and depths (from information obtained during stream flow
measurements), surface slopes, areas, soils, land use (information obtained from GIS shape files and maps), and rainfall data.

![Diagram of Lake Worth Lagoon Canals feeding into Lake Eden and Lake Ida](image)

**Figure 4.3** Basic Components of SWMM applied to the Lake Worth Lagoon Canals feeding into Lake Eden and Lake Ida

**Data Required for Estimating TP and TN Loadings.** To estimate TN and BOD loadings from the Lake Worth Lagoon Canal watershed using SWMM, the following data were collected:

A. **Rain precipitation data** were obtained from the Lake Worth Drainage District (LWDD) Rain Gages 8, 9, and 11, which are located near Lakes Ida and Eden.

B. **Areas of different land use categories** impacting Lake Ida (WBID 3262A) include those in immediate area around Lake Ida as well as that of sub basins upstream of Lake Ida (basin C15) and waters from SFWMD control structures.

C. **Percent impervious area of each land use category** is a very important parameter in estimating surface runoff using SWMM. 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 land use (User’s Manual: Watershed Management Model, 1998). Ideally, the impervious area is the area that does not retain water and, therefore, 100 percent 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 percent. Impervious runoff coefficients lower than this range were observed in the literature, but usually the number should not be lower than 80 percent. For pervious area, the runoff coefficient usually ranges between 10 and 20 percent, although values lower than this range were also observed (User’s Manual: Watershed Management Model, 1998).

It should be noted that the impervious area percentages do not necessarily represent DCIA. Using a single-family residence as an example, rain falls on rooftops, sidewalks, and driveways. The sum of these areas may represent 30 percent of the total area of the residential 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 SWMM, DCIA was used to characterize imperviousness according to land use. To simulate infiltration, SWMM provides the user with the option of using either the Horton Equation or the Green-Ampt Equation. The Horton equation was selected for this simulation with the parameters required were more accessible.
Chapter 5: DETERMINATION OF ASSIMILATIVE CAPACITY

5.1 Determination of Loading Capacity

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

The goal of this TMDL development is to identify the maximum allowable TN and TP loadings from the watershed, so that Lake Ida will meet the narrative nutrient water quality criteria and thereby maintain its function and designated use as a Class III water. In order to achieve the goal, the Department selected the Bathtub model as the waterbody model. It was run through the 8-year period to simulate Chla responses in the lake to watershed nutrient loading and to ultimately estimate the assimilative capacity.

5.2 Water Quality Trends of Tributary Canals and Lake Ida

Water quality data for Lake Ida from September 2000 to June 2009 were recorded in Florida STORET and retrieved through IWR Run43. A total of 20 water quality sampling stations within the lake are listed for the period of observation, but there are no water quality data available during the period of 2003-2005 (Table 5.1). Based on a study done by ERD (2002) for Palm Beach County Chain of Lakes, major canals that contributed to the lake hydrologic and nutrient budgets are the Central E-4 and L-30 Canals. Figure 5.1 indicates the sampling locations within the lake and tributary inflow and outflow. Although insufficient to address annual water quality, some water quality data from these canals are also available for the water quality assessment (Table 5.1).

Prior to whole lake water quality assessment, spatial variations in concentrations of water quality parameters were examined using the data obtained from Lake Ida versus Lake Eden. Results of mean comparison analyses using Tukey-Kramer HSD for corrected Chla (Chlac), TN and TP between the two waterbodies indicated that spatial variations of Chlac, TN and TP concentrations within the waterbodies are insignificant as presented in Appendix 1. Therefore, observed water quality data from all the stations of Lake Ida and Lake Eden were aggregated as a daily average under the assumption that the lake is a well-mixed single waterbody.
Table 5.1 Water Quality Stations in Lake Ida and Its Tributary Canals during the Period of 2000 to 2009.

<table>
<thead>
<tr>
<th>Waterbody</th>
<th>STA</th>
<th>LAT</th>
<th>LONG</th>
<th>NOBS</th>
<th>BD</th>
<th>ED</th>
</tr>
</thead>
<tbody>
<tr>
<td>In-lake</td>
<td>21FLERDIERD-001</td>
<td>26.479</td>
<td>-80.083</td>
<td>537</td>
<td>2000</td>
<td>2001</td>
</tr>
<tr>
<td></td>
<td>21FLERDIERD-007</td>
<td>26.489</td>
<td>-80.077</td>
<td>577</td>
<td>2000</td>
<td>2001</td>
</tr>
<tr>
<td></td>
<td>21FLERDIERD-021</td>
<td>26.492</td>
<td>-80.081</td>
<td>144</td>
<td>2000</td>
<td>2001</td>
</tr>
<tr>
<td></td>
<td>21FLERDIERD-022</td>
<td>26.486</td>
<td>-80.079</td>
<td>144</td>
<td>2000</td>
<td>2001</td>
</tr>
<tr>
<td></td>
<td>21FLERDIERD-023</td>
<td>26.486</td>
<td>-80.078</td>
<td>144</td>
<td>2000</td>
<td>2001</td>
</tr>
<tr>
<td></td>
<td>21FLERDIERD-024</td>
<td>26.495</td>
<td>-80.078</td>
<td>144</td>
<td>2000</td>
<td>2001</td>
</tr>
<tr>
<td></td>
<td>21FLPBCH64</td>
<td>26.489</td>
<td>-80.077</td>
<td>175</td>
<td>2006</td>
<td>2009</td>
</tr>
<tr>
<td></td>
<td>21FLWBP 28010539</td>
<td>26.481</td>
<td>-80.083</td>
<td>150</td>
<td>2002</td>
<td>2003</td>
</tr>
<tr>
<td></td>
<td>21FLERDIERD-019</td>
<td>26.484</td>
<td>-80.086</td>
<td>144</td>
<td>2000</td>
<td>2001</td>
</tr>
</tbody>
</table>

Temporal trends of Chlac, TN and TP concentrations, and TN/TP ratios were shown in Figure 5.2. A long-term average of TN was about 1.27 ± 0.42 mg/L (n = 43) during the period of 2000-2009, with coefficient variation of 33% (Table 5.2). Similarly, TP concentrations averaged about 0.115 ± 0.068 mg/L (n = 45) with coefficient variation of 59%. Although the peak concentrations of TN and TP appeared in December 2000 and October 2000, respectively, in-lake concentrations of TN and TP have remained constant over the 9-yr period of observation. As a result, the TN/TP ratios were found to be constant over the period (n = 42), with an average of 12.7 ± 5.6 and coefficient variation of 44%. The TN/TP ratio indicated that the lake may have been alternating between nitrogen-limiting and co-limiting during the period of the observation, with a greater tendency of co-limiting. Concentrations of Chlac in Lake Ida ranged from 2.0 µg/L to 80.5 µg/L, with an average of 31.7 ± 19.7 µg/L (n = 42) and coefficient variation of 62% (Table 5.2). Figure 5.2 also indicated that there are some monthly or seasonal fluctuations in the Chlac concentrations.
Figure 5.1 Water Quality Stations in Lake Ida and Central E-4 and L-30 canals.
Figure 5.2  Daily concentrations of Chlac, TN and TP and TN/TP Ratios for Lake Ida between 2000 and 2009.

Table 5.2  Long-term Averages of Water Quality Parameters in Lake Ida Observed from 2000 to 2009

<table>
<thead>
<tr>
<th>Water Quality Variables</th>
<th>Unit</th>
<th>Number of Observation</th>
<th>Median</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Min</th>
<th>Max</th>
<th>Coefficient Variation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corrected Chla</td>
<td>μg/L</td>
<td>42</td>
<td>25.9</td>
<td>31.7</td>
<td>19.7</td>
<td>2.0</td>
<td>80.5</td>
<td>62%</td>
</tr>
<tr>
<td>Total Nitrogen</td>
<td>mg/L</td>
<td>43</td>
<td>1.20</td>
<td>1.27</td>
<td>0.420</td>
<td>0.762</td>
<td>3.081</td>
<td>33%</td>
</tr>
<tr>
<td>Total Phosphorus</td>
<td>mg/L</td>
<td>45</td>
<td>0.102</td>
<td>0.115</td>
<td>0.068</td>
<td>0.036</td>
<td>0.450</td>
<td>59%</td>
</tr>
<tr>
<td>DO</td>
<td>mg/L</td>
<td>43</td>
<td>7.7</td>
<td>7.4</td>
<td>2.1</td>
<td>0.3</td>
<td>10.8</td>
<td>29%</td>
</tr>
<tr>
<td>TSS</td>
<td>mg/L</td>
<td>39</td>
<td>5.46</td>
<td>7.44</td>
<td>12.39</td>
<td>2.00</td>
<td>81.65</td>
<td>167%</td>
</tr>
<tr>
<td>Color</td>
<td>Pt-Co</td>
<td>25</td>
<td>50</td>
<td>52</td>
<td>12.7</td>
<td>27</td>
<td>75</td>
<td>24%</td>
</tr>
<tr>
<td>TN/TP Ratio</td>
<td>no units</td>
<td>42</td>
<td>11.7</td>
<td>12.7</td>
<td>5.6</td>
<td>2.6</td>
<td>34.5</td>
<td>44%</td>
</tr>
</tbody>
</table>
Table 5.3 Annual Means ($\pm$ 1-σ Standard Deviation) of Chlac, TN, TP, TN/TP and TSI of Lake Ida from 2000 to 2009. NOBS Represents the Number of Observation for Each Year.

<table>
<thead>
<tr>
<th>Year</th>
<th>Chlac (μg/L)</th>
<th>TN (mg/L)</th>
<th>TP (mg/L)</th>
<th>TN/TP Ratio</th>
<th>TSI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>NOBS</td>
<td>NOBS</td>
<td>NOBS</td>
<td>NOBS</td>
<td>NOBS</td>
</tr>
<tr>
<td>2000</td>
<td>31.4 ± 28.6</td>
<td>1.57 ± 1.11</td>
<td>0.127 ± 0.083</td>
<td>9.2 ± 3.7</td>
<td>68</td>
</tr>
<tr>
<td></td>
<td>(n=6)</td>
<td>(n=7)</td>
<td>(n=7)</td>
<td>(n=7)</td>
<td>(n=7)</td>
</tr>
<tr>
<td>2001</td>
<td>14.4 ± 43.6</td>
<td>0.26 ± 1.29</td>
<td>0.030 ± 0.112</td>
<td>8.7 ± 11.7</td>
<td>65</td>
</tr>
<tr>
<td></td>
<td>(n=7)</td>
<td>(n=9)</td>
<td>(n=9)</td>
<td>(n=9)</td>
<td>(n=9)</td>
</tr>
<tr>
<td>2002</td>
<td>20.6 ± 30.8</td>
<td>0.07 ± 1.07</td>
<td>0.021 ± 0.101</td>
<td>2.4 ± 11.1</td>
<td>68</td>
</tr>
<tr>
<td></td>
<td>(n=6)</td>
<td>(n=5)</td>
<td>(n=6)</td>
<td>(n=6)</td>
<td>(n=5)</td>
</tr>
<tr>
<td>2006</td>
<td>19.8 ± 16.6</td>
<td>0.22 ± 1.08</td>
<td>0.023 ± 0.080</td>
<td>3.3 ± 13.5</td>
<td>64</td>
</tr>
<tr>
<td></td>
<td>(n=6)</td>
<td>(n=6)</td>
<td>(n=6)</td>
<td>(n=6)</td>
<td>(n=6)</td>
</tr>
<tr>
<td>2007</td>
<td>16.9 ± 34.8</td>
<td>0.08 ± 1.29</td>
<td>0.016 ± 0.104</td>
<td>2.4 ± 13.6</td>
<td>59</td>
</tr>
<tr>
<td></td>
<td>(n=5)</td>
<td>(n=10)</td>
<td>(n=5)</td>
<td>(n=10)</td>
<td>(n=10)</td>
</tr>
<tr>
<td>2008</td>
<td>16.3 ± 16.7</td>
<td>0.36 ± 1.67</td>
<td>0.043 ± 0.132</td>
<td>5.5</td>
<td>66</td>
</tr>
<tr>
<td></td>
<td>(n=9)</td>
<td>(n=2)</td>
<td>(n=2)</td>
<td>(n=2)</td>
<td>(n=1)</td>
</tr>
<tr>
<td>2009</td>
<td>14.0 ± 3.4</td>
<td>0.67</td>
<td>0.038</td>
<td>11.5</td>
<td>62</td>
</tr>
<tr>
<td></td>
<td>(n=3)</td>
<td>(n=2)</td>
<td>(n=2)</td>
<td>(n=2)</td>
<td>(n=1)</td>
</tr>
</tbody>
</table>
Figure 5.3  Monthly Variations of Chlac, TN, TP and TN/TP Ratio for Lake Ida during 2000-2009. Error Bars Represent 1-σ Standard Deviation.

Figure 5.4  Temporal Variations of TN Concentrations Observed from Tributary Canals and Lake Ida during September 2000-August 2001.
Figure 5.5  Mean Comparisons of TN Concentrations Observed from Tributary Canals and Lake Ida during September 2000-August 2001.

Figure 5.6  Temporal Variations of TP Concentrations Observed from Tributary Canals and Lake Ida during September 2000-August 2001.
Figure 5.7 Mean Comparisons of TP Concentrations Observed from Tributary Canals and Lake Ida during September 2000-August 2001.

Monthly TN, TP, and Chlac concentrations observed for Lake Ida from 2000 through 2009 were shown in Figure 5.3. As expected, there were no seasonal trends observed for TN and TP concentrations or TN/TP ratios during the 9-year period. However, monthly Chlac concentrations indicated that the concentrations elevated in May through November compared to those in December through April, showing a peak concentration in June. This seasonal trend seems typical in subtrophic regions, indicating more algae production occurs in May through November. An average concentration of Chlac during the growing season is about 39.9 ± 10.3 µg/L (n = 7) while the concentrations during the non-growing season averaged about 17.4 ± 7.0 µg/L (n = 5). The concentration difference between growing versus non-growing seasons was about 22.5 µg/L.

Annual concentrations of Chlac, TN and TP collected between 2000 and 2009 were summarized in Table 5.3. Annual concentrations of TN and TP ranged from 1.07 mg/L in 2006 to 1.67 mg/L in 2009 and from 0.080 mg/L in 2007 to 0.206 mg/L in 2000, respectively. Annual Chlac concentrations ranged from 14 µg/L in 2009 to 43.6 µg/L in 2002, and showed the concentrations similar over most of the years except for 2007 and 2009. Multivariable analysis indicated that there were poor relationships between annual Chlac and annual TN (r = -0.267) and annual TP (r = 0.010), while annual TN was strongly correlated with TP (r = 0.776, n = 7).

Annual TSI values were calculated using the observed Chlac, TN and TP concentrations during the period of 2000-2009. It should be noted that only two or three data points of each parameter were available for the year 2009 to obtain annual TSI. Due to insufficient quarterly
data of Chlac, TN and TP for each year, it was not possible to obtain a quarterly mean value of TSI to calculate an annual mean TSI value from the four quarterly values for each year (except for 2006 and 2008). Therefore, annual TSI values shown in Table 5.3 were calculated based on annual averages of Chla, TN and TP obtained from daily values of each year so that more annual TSI values can be compared to those predicted from the model. Calculated annual TSI values ranged from 59 to 68, with an average of 65. The lowest TSI value (59) appeared in 2007 when TN, TP and Chlac were lowest; however, the values in the rest of years exceeded annual TSI 60, indicating the lake has been eutrophic, exceeding the IWR TSI threshold.

Water quality data (especially Chlac, TN and TP) collected from tributary canals, as shown in Table 5.1 and Figure 5.1, were retrieved and compared with those obtained from in-lake water quality stations. The TN and TP data between September 2000 and August 2001 were only available at the stations, 21FLERDIERD-020 and 21FLERDIERD-019, but no Chlac data were available during this period. For the station, 21FLWPB 28010743, only six measurements for Chlac were made from January 2008 to October 2008, but no TN and TP data were available for the comparison.

The temporal trends of TN observed from the canals during the period were much similar to those obtained from the lake (Figure 5.4). Mean concentrations of TN in tributary canals were $1.24 \pm 0.37$ mg/L at the station, 21FLERDIERD-019, and $1.21 \pm 0.43$ mg/L at the station, 21FLERDIERD-020, similar to the mean concentration ($1.31 \pm 0.57$ mg/L) of TN observed from the lake at the same period of observation (Figure 5.5). Moreover, mean comparisons using a Tukey-Kramer analysis (JMP, version 8) indicated that TN concentrations in the lake versus canals were not significantly different.

Similarly, TP concentrations in the lake versus canals also showed no differences in a temporal fluctuation and a concentration distribution analysis (Figure 5.6 and Figure 5.7). Although the median TP concentration ($0.131$ mg/L) at the station, 21FLERDIERD-019, was slightly higher than the median TP ($0.099$ mg/L) observed from the lake, similarities in both TN and TP concentrations and their patterns between lake and canal may be a result of a short residence time of the lake. This observation can be supported by an intensive study (ERD, 2002) showing that the residence time of the Lake Ida was estimated to be 15 days. Although limited, quarterly Chlac data collected at Canal E-4 at Boynton Beach were available only for 2008 to assess a temporal trend of Chlac. A quarterly mean Chlac concentration ($n = 4$) from this location was also similar to that from the lake ($23 \pm 18$ µg/L for the canals versus $30 \pm 10$ µg/L for the lake). Based on the assessment, the lake water quality seems to be strongly influenced by the canal water quality due to a short residence time. In order to evaluate lake responses in terms of the trophic status to watershed TN and TP loads, BATHTUB was used to predict in-lake TN, TP and Chla concentrations and thereby obtain trophic responses as TSI values for the lake.

In order to establish a nutrient TMDL for Lake Ida, tributary inflow and outflow in the Lake Ida watershed, which are mainly Central E-4 and L-30 canals, were modeled and calibrated using the SWMM. The calibrated daily flows from tributary canals were then aggregated to annual flows for the BATHTUB modeling. Daily TN and TP concentrations from various point and nonpoint sources in the watershed were also calibrated using SWMM and then aggregated for annual inputs for the BATHTUB eutrophication model.
5.3 Lake Water Quality Modeling

5.3.1 BATHTUB Overview

The U.S. Corps of Engineers’ BATHTUB was used to assess in-lake water quality responses to the watershed TN and TP loads. BATHTUB is a series of empirical eutrophication models for morphologically complex lakes and reservoirs. The model performs steady-state water and nutrient balance calculations in a spatially segmented hydraulic network, which accounts for advective and diffusive transport, and nutrient sedimentation (Walker, 1996). BATHTUB is often used to simulate the fate and transport of nutrients and water quality conditions and responses to the nutrients load into a lake or similar water body. BATHTUB is composed of three major components that include water balance, nutrient sedimentation, and eutrophication response models (expressed in terms of total N, total P, Chlac, transparency, organic N, and organic P). In order to simulate water quality conditions, BATHTUB requires as input information on various lake characteristics such as length, width, mean depth, and nutrient loads from various sources in the surrounding watershed. These data are then used to evaluate key in-lake water quality parameters such as nutrient concentrations, turbidity and aquatic plant growth. One major advantage of BATHTUB over other lake models is its use of simple steady-state calculations to address eutrophication processes, which reduces data demands. Particularly where data are limited, BATHTUB has been cited as an effective tool for lake and reservoir water quality assessment and management (US EPA, 1999 and 2010).

The net accumulation of nutrients in a lake is a result of nutrient mass balance between incoming flow to the lake and outgoing flow from the lake and decays of nutrient in the lake. BATHTUB provided several sub-models depending on the inorganic/organic nutrient partitioning coefficient and reaction kinetics. The major pathway for TN and TP to be removed from the water columns, in these simplified empirical equations, is through sedimentation to the bottom of the lake. Prediction of Chla concentrations 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. Scenarios that include algal communities limited by light intensity or controlled by the lake flushing rate are also included in the suit of models. The variety of models available in BATHTUB allows the user to choose specific models based on the particular condition of the lake.

5.3.2 BATHTUB Inputs

5.3.2.1 Morphologic Characteristics of Lake Ida

Bathymetric surveys of Lake Ida and Lake Eden were conducted by Palm Beach County in the summer of 1995 (Palm Beach County, 1997). These surveys were performed using an electronic echosounder that was moved across each lake along transects at constant speed. Continuous depth profiles obtained by the underwater fathometer and satellite-based positioning
information determined by a global positioning system were used to develop bathymetric contour maps and morphologic characteristics for each of the lakes. These bathymetric maps (Palm Beach County, 1997) were reproduced using DesignCad Pro 2000 to obtain relations of lake surface area versus depth for use in the model development. A depth-surface area relationship was then computed using the reproduced bathymetric maps and surface area as a function of stage was obtained using a best-fit equation based on the relationship. Lake volumes were calculated using surface area and depth within each contour and computing 2-ft layers. The water volume contained between the shoreline and 2-ft interval was calculated using the truncated cone method (Wetzel, 1983). The calculation was completed for all layers, and best-fit equations were established to provide estimates of lake volume as a function of water depth. This method was used by Environmental Consulting & Technology for bathymetric analysis of Lake Apopka (ECT, 1989).

Figure 5.8 represents relationships between water depth and surface area and between water depth and cumulative volume for WBID 3262A. For the TMDL development purposes, estimated surface areas and volume for Lake Ida and Lake Eden were summed up to represent surface area and lake volume for a single impaired WBID. The best-fit equations were obtained from the relationships to calculate annual surface area and lake volume. Based on the relationships, calculated surface area and lake volume at the depth of 6.05 m for the WBID corresponded to those reported by ERD (2002). Annual averaged water depth simulated by SWMM for Lake Ida was applied to obtain annual surface area and lake volume for the WBID (Table 5.4).
Figure 5.8 Relationships of Depth versus Surface Area (Top) and Depth versus Cumulative Volume (Bottom). Solid line is a best-fit line.
Lake surface area varied as a function of changing lake levels during the period of 2001-2008, ranging from 0.562 km² in 2001 to 0.398 km² in 2007, with an average of 0.449 km². Similarly, the peak of lake volume was estimated to be 1,223,867 m³ in 2001 while the lowest volume of 81,9492 m³ was estimated in 2007. Mean depth was calculated by lake surface area and lake volume. Because Lake Ida is a shallow, elongated lake, with the assumption of a well mixed lake for modeling purposes, the mixed layer depth was assumed to be equal to the mean depth of the lake.

### Table 5.4 Annual Means of Morphologic Characteristics of Lake Ida from 2001 to 2008.

<table>
<thead>
<tr>
<th>Year</th>
<th>Simulated Depth (ft)</th>
<th>Lake Surface Area (km²)</th>
<th>Lake Volume (m³)</th>
<th>Mean Depth (m)</th>
<th>Mixed layer depth (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001</td>
<td>18.6</td>
<td>0.562</td>
<td>1,223,867</td>
<td>2.18</td>
<td>2.18</td>
</tr>
<tr>
<td>2002</td>
<td>17.5</td>
<td>0.485</td>
<td>1,045,734</td>
<td>2.16</td>
<td>2.16</td>
</tr>
<tr>
<td>2003</td>
<td>16.9</td>
<td>0.453</td>
<td>965,887</td>
<td>2.13</td>
<td>2.13</td>
</tr>
<tr>
<td>2004</td>
<td>16.8</td>
<td>0.448</td>
<td>954,491</td>
<td>2.13</td>
<td>2.13</td>
</tr>
<tr>
<td>2005</td>
<td>16.1</td>
<td>0.410</td>
<td>852,604</td>
<td>2.08</td>
<td>2.08</td>
</tr>
<tr>
<td>2006</td>
<td>16.4</td>
<td>0.424</td>
<td>891,094</td>
<td>2.10</td>
<td>2.10</td>
</tr>
<tr>
<td>2007</td>
<td>15.8</td>
<td>0.398</td>
<td>819,492</td>
<td>2.06</td>
<td>2.06</td>
</tr>
<tr>
<td>2008</td>
<td>16.2</td>
<td>0.414</td>
<td>864,472</td>
<td>2.09</td>
<td>2.09</td>
</tr>
<tr>
<td>Average</td>
<td>16.8</td>
<td>0.449</td>
<td>952,205</td>
<td>2.12</td>
<td>2.12</td>
</tr>
</tbody>
</table>

### 5.3.2.2 Meteorological Data

Precipitation data collected at station LW 11, located close to Lake Ida, were used as an input for BATHTUB. Precipitation data were expressed as an annual total based on the unit of m/year for the model. Pan-evaporation is also an important parameter for simulating direct evaporation from the surface of the lake. Free water-surface evaporation is different from pan-evaporation, which can be computed by using methods to correct for the difference in heat storage capabilities of water in a pan versus in a lake (Lee and Swancar, 1997). Free water-surface evaporation is a function of many factors including barometric pressure, wind speed, the amount of solar radiation, and temperature. The energy-budget method is known to be the
most accurate way to measure lake evaporation (Winter, 1981) and requires a large amount of
data collection. Lee and Swancar (1997) derived pan coefficients for lakes in central Florida,
ranging from 0.70 to 0.77 for Lake Lucerne and 0.71 to 0.75 for Lake Alfred. On an annual
basis, the long-term annual average coefficient of 0.74 was derived by Farnsworth et al (1982).
Trommer et al (1999) also used a coefficient of 0.75 applied to pan evaporation data from the
Bradenton 5 ESE weather station to estimate evaporation for Ward Lake in Manatee County,
Florida. Given the range in Florida values of 0.70 to 0.77, a pan coefficient of 0.75 was used for
this TMDL modeling. The pan evaporation data obtained from the weather stations of Ft.
Pier_E and S65_E were used for the modeling. Several pan evaporation data gaps were
identified for the Ft. Pier station within the available period of record; however, the data from the
S65_E station were used to fill in and complete the dataset as a model input. The input data
were expressed as an annual total (m/year) for BATHTUB. Actual inputs of rainfall and direct
evaporation for the model were shown in Table 5.5.

Table 5.5 Lake Evaporation and Precipitation for Lake Ida from 2000 to 2010.

<table>
<thead>
<tr>
<th>Year</th>
<th>Lake evaporation (m)</th>
<th>Precipitation (m)</th>
<th>Difference (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>1.54</td>
<td>1.75</td>
<td>0.21</td>
</tr>
<tr>
<td>2001</td>
<td>1.38</td>
<td>2.03</td>
<td>0.65</td>
</tr>
<tr>
<td>2002</td>
<td>1.28</td>
<td>1.49</td>
<td>0.21</td>
</tr>
<tr>
<td>2003</td>
<td>1.17</td>
<td>1.38</td>
<td>0.21</td>
</tr>
<tr>
<td>2004</td>
<td>1.27</td>
<td>1.33</td>
<td>0.05</td>
</tr>
<tr>
<td>2005</td>
<td>1.26</td>
<td>1.69</td>
<td>0.43</td>
</tr>
<tr>
<td>2006</td>
<td>1.43</td>
<td>1.42</td>
<td>-0.01</td>
</tr>
<tr>
<td>2007</td>
<td>1.50</td>
<td>1.40</td>
<td>-0.10</td>
</tr>
<tr>
<td>2008</td>
<td>1.34</td>
<td>1.70</td>
<td>0.36</td>
</tr>
<tr>
<td>2009</td>
<td>1.40</td>
<td>1.52</td>
<td>0.12</td>
</tr>
<tr>
<td>2010</td>
<td>1.28</td>
<td>1.51</td>
<td>0.23</td>
</tr>
<tr>
<td>Average</td>
<td>1.35</td>
<td>1.57</td>
<td>0.22</td>
</tr>
</tbody>
</table>

Direct atmospheric TN depositions for Lake Ida were estimated using the atmospheric N data
(2000-2010) from the National Atmospheric Deposition Program (NADP). These annual
inorganic N data as precipitation weight concentrations were retrieved from one of the NADP
stations located in Everglades National Park (FL11). Table 5.6 showed direct atmospheric TN
loads to Lake Ida that was obtained by multiplying the precipitation-weighted N concentrations
by the total precipitation amount for each year. Estimated atmospheric TN loads during the period of 2000 to 2010 ranged from 834 mg/m²/yr in 2004 to 1341 mg/m²/yr in 2006, with a long-term average of 1033 mg/m²/yr. The average of atmospheric TN load for Lake Ida was similar to atmospheric total deposition rates of 1032 mg/m²/yr (or 506 kg N/yr) observed by ERD for Chain of Lakes in Palm Beach County (ERD, 2002) and 840 mg/m²/yr estimated by Poor (2006) for Tampa Bay. Atmospheric TP concentrations for the station FL11 were not available in the database of NADP; however, an atmospheric TN/TP ratio of 14.8 observed by ERD in the Central and South Florida areas (ERD, 1993) was used to calculate atmospheric TP concentrations. Direct atmospheric TP deposition rates were also estimated for Lake Ida, ranging from 56 mg/m²/yr to 90 mg/m²/yr, with an average of 69 mg/m²/yr that corresponds to the value (68 mg/m²/yr) estimated by ERD (2002) for Lake Ida.

Table 5.6 Direct Atmospheric Deposition of TN and TP to Lake Ida from 2000 to 2010.

<table>
<thead>
<tr>
<th>Year</th>
<th>TN (mg/m²/yr)</th>
<th>TP (mg/m²/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>1065</td>
<td>71</td>
</tr>
<tr>
<td>2001</td>
<td>1293</td>
<td>87</td>
</tr>
<tr>
<td>2002</td>
<td>1024</td>
<td>69</td>
</tr>
<tr>
<td>2003</td>
<td>917</td>
<td>62</td>
</tr>
<tr>
<td>2004</td>
<td>834</td>
<td>56</td>
</tr>
<tr>
<td>2005</td>
<td>975</td>
<td>65</td>
</tr>
<tr>
<td>2006</td>
<td>1341</td>
<td>90</td>
</tr>
<tr>
<td>2007</td>
<td>874</td>
<td>59</td>
</tr>
<tr>
<td>2008</td>
<td>1002</td>
<td>67</td>
</tr>
<tr>
<td>2009</td>
<td>1024</td>
<td>69</td>
</tr>
<tr>
<td>2010</td>
<td>1011</td>
<td>68</td>
</tr>
<tr>
<td>Average</td>
<td>1033</td>
<td>69</td>
</tr>
</tbody>
</table>

5.3.2.3 Tributary Inflows and Concentrations

Multiple of external inflows can be specified for any modeled segment in BATHTUB. For this study, tributary inflows and nutrient concentrations from two major canals were classified as a type of monitored inflow (Code 1) in BATHTUB. This type inflow required monitored tributary volume and nutrient concentrations as inputs to the model. Tributary flows and concentrations associated with any nonpoint and point sources of TN and TP in the watershed were simulated.
by SWMM and converted to hm$^3$/year for the BATHTUB modeling. Table 5.7 and 5.8 showed annual flow and TN and TP concentrations obtained by SWMM from 2001 to 2008. Internal loads of TN and TP from bottom sediment of the lake were not measured for the TMDL development purposes. However, an intensive study done by ERD (2002) to estimate mass loadings of TN and TP from ground water seepage into the chain-of-lakes indicated that mass loadings of TN and TP to Lake Ida were 14.4 mg/m$^2$/day and 3.83 mg/m$^2$/day, respectively. These values were utilized as inputs of TN and TP internal loads for BATHTUB.
Table 5.7 Inflow Rates and TN and TP Concentrations from North E-4 Canal to Lake Ida Simulated by SWMM from 2001 to 2008.

<table>
<thead>
<tr>
<th>Year</th>
<th>Inflow from north E-4 Canal (hm3/yr)</th>
<th>TN from north E-4 Canal (ug/L)</th>
<th>TP from north E-4 Canal (ug/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001</td>
<td>13.23</td>
<td>1152</td>
<td>134</td>
</tr>
<tr>
<td>2002</td>
<td>9.44</td>
<td>1050</td>
<td>130</td>
</tr>
<tr>
<td>2003</td>
<td>8.56</td>
<td>1108</td>
<td>134</td>
</tr>
<tr>
<td>2004</td>
<td>8.10</td>
<td>1049</td>
<td>122</td>
</tr>
<tr>
<td>2005</td>
<td>6.73</td>
<td>1189</td>
<td>132</td>
</tr>
<tr>
<td>2006</td>
<td>4.73</td>
<td>1072</td>
<td>120</td>
</tr>
<tr>
<td>2007</td>
<td>-2.84</td>
<td>1112</td>
<td>117</td>
</tr>
<tr>
<td>2008</td>
<td>3.63</td>
<td>1207</td>
<td>132</td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td>1117</td>
<td>128</td>
</tr>
</tbody>
</table>

Table 5.8 Inflow Rates and TN and TP Concentrations from L-30 Canal to Lake Ida Simulated by SWMM from 2001 to 2008.

<table>
<thead>
<tr>
<th>Year</th>
<th>Inflow from L-30 Canal (hm3/yr)</th>
<th>TN from L-30 Canal (ug/L)</th>
<th>TP from L-30 Canal (ug/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001</td>
<td>13.25</td>
<td>1153</td>
<td>107</td>
</tr>
<tr>
<td>2002</td>
<td>10.34</td>
<td>1058</td>
<td>100</td>
</tr>
<tr>
<td>2003</td>
<td>8.30</td>
<td>1070</td>
<td>108</td>
</tr>
<tr>
<td>2004</td>
<td>8.74</td>
<td>1014</td>
<td>103</td>
</tr>
<tr>
<td>2005</td>
<td>7.83</td>
<td>1150</td>
<td>126</td>
</tr>
<tr>
<td>2006</td>
<td>7.44</td>
<td>1029</td>
<td>112</td>
</tr>
<tr>
<td>2007</td>
<td>7.00</td>
<td>1052</td>
<td>116</td>
</tr>
<tr>
<td>2008</td>
<td>7.87</td>
<td>1131</td>
<td>126</td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td>1082</td>
<td>112</td>
</tr>
</tbody>
</table>
5.3.3 BATHTUB Calibration

For TN and TP prediction, subroutines of nutrient sedimentation models in BATHTUB were used to estimate net removal of TN and TP in the waterbody. Although a second-order decay model in BATHTUB is the most generally applicable formulation for representing TP and TN sedimentation in reservoirs (Walker 1987), a second-order nutrient available model (Model 1) performed better in predicting in-lake TN and TP concentrations for Lake Ida. Therefore, the Department selected TN and TP sedimentation Model 1 which performs mass balance calculations on available P and TP concentrations from tributary inflow, in-lake and outflow from the lake. Inflow nutrient partitioning by adjusting the inflow nutrient concentrations was taken into account in the model, which may be an important process for TP mass balance in Lake Ida with a short residence time and dominant tributary inflow. It should be noted that calibration factors were not applied to fit model prediction to the observed data of Chla, TN and TP.

The prediction of Chla concentrations can be based on one of the five sub-models in BATHTUB. Observed N/P ratios in Lake Ida indicated that the lake was co-limited by both N and P for algae growth. Chla Models 1 and 3 in BATHTUB accounted for the effects of both TN and TP limitations on Chla levels. These two models are also applicable to prediction of Chla that is influenced by not only nutrient limitations but also light intensity and flushing rate. Model 1 requires estimates of non-algal turbidity for each waterbody whereas non-algal turbidity in Model 3 may not be specified or less than 0.9. Sensitivity analyses on Chla concentrations using these two models indicated that Model 3 predicted Chla concentrations closer to observed Chla concentrations in Lake Ida with an exception for 2007, implying that light limitation interfered by color and inorganic solids may not be a major factor controlling in-lake Chla concentrations in most of the years. For 2007, prediction of Chla was better performed with Model 1 with non-algal turbidity of 3.0, implying that algal growth in the lake was most likely influenced by color or inorganic solids during the driest year. Considering TN limitation on algal responses, N fixation of atmospheric nitrogen by bluegreen algae for Lake Ida were not considered because of positive retention coefficients for TN (i.e., tributary inflow TN is similar to or greater than outflow TN) and co-limitation by both TN and TP in both inflows and the lake, as described in the previous section.

Predicted versus observed concentrations of TN, TP and Chla were shown in Table 5.9 through Table 5.11. Long-term averages of TN and TP were predicted to be 1030 ± 35 ppb and 95 ± 3 ppb, respectively. The predicted 8-year averages were similar to those of the observed TN (1167 ± 111 ppb) and TP (96 ± 14 ppb). The predicted Chla concentrations were also consistent with the observed Chla concentrations. The long-term average of Chla was predicted to be 30 ± 6.0 ppb, comparable to the observed value of 32 ± 10 ppb. Overall, although no observed TN, TP and Chla data from 2003 to 2005 were available for the model calibration, annual mean concentrations of TN, TP and Chla predicted by BATHTUB were comparable to the annual concentrations observed for Lake Ida, within the coefficient of variation. Therefore, it was decided that the BATHTUB model was considered calibrated for Lake Ida.
Table 5.9 Predicted TN versus Observed TN Concentrations in Lake Ida from 2001 to 2008. CV represents the Coefficient of Variation.

<table>
<thead>
<tr>
<th>Year</th>
<th>Predicted TN (ppb)</th>
<th>CV</th>
<th>Observed TN (ppb)</th>
<th>CV</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001</td>
<td>1070</td>
<td>0.55</td>
<td>1110</td>
<td>0.23</td>
</tr>
<tr>
<td>2002</td>
<td>1000</td>
<td>0.55</td>
<td>1290</td>
<td>0.05</td>
</tr>
<tr>
<td>2003</td>
<td>1023</td>
<td>0.55</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>2004</td>
<td>984</td>
<td>0.55</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>2005</td>
<td>1076</td>
<td>0.55</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>2006</td>
<td>1008</td>
<td>0.55</td>
<td>1074</td>
<td>0.21</td>
</tr>
<tr>
<td>2007</td>
<td>1018</td>
<td>0.55</td>
<td>1077</td>
<td>0.07</td>
</tr>
<tr>
<td>2008</td>
<td>1062</td>
<td>0.55</td>
<td>1286</td>
<td>0.28</td>
</tr>
<tr>
<td>Average</td>
<td>1030</td>
<td>0.03</td>
<td>1167</td>
<td>0.10</td>
</tr>
</tbody>
</table>

Table 5.10 Predicted TP versus Observed TP Concentrations in Lake Ida from 2001 to 2008. CV represents the Coefficient of Variation.

<table>
<thead>
<tr>
<th>Year</th>
<th>Predicted TP (ppb)</th>
<th>CV</th>
<th>Observed TP (ppb)</th>
<th>CV</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001</td>
<td>95</td>
<td>0.45</td>
<td>83</td>
<td>0.36</td>
</tr>
<tr>
<td>2002</td>
<td>92</td>
<td>0.45</td>
<td>112</td>
<td>0.19</td>
</tr>
<tr>
<td>2003</td>
<td>95</td>
<td>0.45</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>2004</td>
<td>91</td>
<td>0.45</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>2005</td>
<td>98</td>
<td>0.45</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>2006</td>
<td>93</td>
<td>0.45</td>
<td>101</td>
<td>0.23</td>
</tr>
<tr>
<td>2007</td>
<td>96</td>
<td>0.45</td>
<td>80</td>
<td>0.20</td>
</tr>
<tr>
<td>2008</td>
<td>97</td>
<td>0.45</td>
<td>104</td>
<td>0.41</td>
</tr>
<tr>
<td>Average</td>
<td>95</td>
<td>0.03</td>
<td>96</td>
<td>0.15</td>
</tr>
</tbody>
</table>
Table 5.11 Predicted Chla versus Observed TP Concentrations in Lake Ida from 2001 to 2008. CV represents the Coefficient of Variation.

<table>
<thead>
<tr>
<th>Year</th>
<th>Predicted Chla (ppb)</th>
<th>CV</th>
<th>Observed Chla (ppb)</th>
<th>CV</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001</td>
<td>33</td>
<td>0.58</td>
<td>37</td>
<td>0.39</td>
</tr>
<tr>
<td>2002</td>
<td>31</td>
<td>0.60</td>
<td>44</td>
<td>0.47</td>
</tr>
<tr>
<td>2003</td>
<td>32</td>
<td>0.60</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>2004</td>
<td>30</td>
<td>0.60</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>2005</td>
<td>34</td>
<td>0.59</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>2006</td>
<td>31</td>
<td>0.60</td>
<td>31</td>
<td>0.64</td>
</tr>
<tr>
<td>2007</td>
<td>17</td>
<td>0.47</td>
<td>17</td>
<td>1.01</td>
</tr>
<tr>
<td>2008</td>
<td>33</td>
<td>0.59</td>
<td>35</td>
<td>0.46</td>
</tr>
<tr>
<td>Average</td>
<td>30</td>
<td>0.18</td>
<td>32</td>
<td>0.31</td>
</tr>
</tbody>
</table>

Figure 5.9  Predicted versus Observed Annual TSI Values from 2001 to 2008. Solid line is for a TSI of 60.
Annual TSI for Lake Ida was calculated based on TN, TP and Chla concentrations predicted by BATHTUB from 2001 to 2008. As shown in Figure 5.9, the predicted TSI values were very similar to the TSI values calculated based on measured TN, TP, and Chla concentrations. The predicted TSI ranged from 59.5 in 2007 to 64.9 in 2005, with an 8-yr average of 63 ± 2. Both predicted and observed TSI values in 2007 were below the threshold of 60, while the TSI values in most of the years did not meet the TSI threshold. The year 2007 was recorded as a dry year and as a result, TN and TP loadings to Lake Ida from north of Canal E-4 were much reduced by about 50%, compared to those in normal years.

Current watershed loads of TN and TP were estimated from 2001 to 2008 as shown in Tables 5.12 through 5.13. Contribution of tributary TN loads via E-4 and L-30 Canals was predominant, ranging from 0 kg/year in 2007 to 15,241 kg/year in 2001 from E-4 Canal and from 7,364 kg/year in 2007 to 15,277 kg/year in 2001 from L-30 Canal during the period of prediction. The estimated annual TN loads from the canals accounted for 86% of the total TN loads to Lake Ida (Figure 5.10). Ground water seepage was the second largest contributor delivering 12% of the total TN loads to Lake Ida. Only a small portion of the incoming TN was retained in Lake Ida, accounting for 16-26%, while a majority of the incoming TN (about 76-84%) was removed out of the lake via outgoing flows. For example, tributary canal loads of TN in 2001 were the largest during the prediction period; at the same time, discharges of TN in 2001 from the lake to downstream were estimated to be the largest compared to those in other normal years. Interestingly, in-lake TN concentrations in 2001 (see Table 5.9) remained comparable with those in other years. This means that an increase of watershed loading of TN may not be necessary to increase in-lake TN concentrations. This is possibly because increased inflow rates resulted in a shorter residence time and created a proportional increase of outgoing flow.

Watershed TP loads via tributary canals ranged from 0 kg/year in 2007 to 1773 kg/year in 2001 for E-4 Canal and from 812 kg/year in 2007 to 1418 kg/year in 2001 for L-30 Canal. The estimated loads indicated that TP contributions to the lake via the canals were dominant (Table 5.13), accounting for about average 74% of the total loads of TP over the prediction period (Figure 5.10). A long-term average of TP loads to the lake was estimated to be 1868 kg/year from the canals, 628 kg/year from ground water seepage and 30 kg/year from direct precipitation. Overall, our estimates of TN and TP loads in 2001 agreed to those reported by ERD (2002) for Lake Ida as shown in Tables 5.12 and 5.13.
Table 5.12 TN Mass Balance of Lake Ida from 2001 to 2008. Results by ERD (2002) were referenced for Comparison Purposes.

<table>
<thead>
<tr>
<th>Year</th>
<th>TN Loads from E-4 Canal (kg/yr)</th>
<th>TN Loads from L-30 Canal (kg/yr)</th>
<th>TN Loads from Precipitation (kg/yr)</th>
<th>TN Groundwater Seepage (kg/yr)</th>
<th>TN Retention (kg/yr)</th>
<th>TN Outflow (kg/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001</td>
<td>15241</td>
<td>15277</td>
<td>727</td>
<td>2950</td>
<td>5481</td>
<td>28714</td>
</tr>
<tr>
<td>2002</td>
<td>9912</td>
<td>10940</td>
<td>497</td>
<td>2546</td>
<td>4011</td>
<td>19883</td>
</tr>
<tr>
<td>2003</td>
<td>9484</td>
<td>8881</td>
<td>415</td>
<td>2378</td>
<td>3811</td>
<td>17347</td>
</tr>
<tr>
<td>2004</td>
<td>8497</td>
<td>8862</td>
<td>374</td>
<td>2351</td>
<td>3490</td>
<td>16594</td>
</tr>
<tr>
<td>2005</td>
<td>8002</td>
<td>9005</td>
<td>400</td>
<td>2152</td>
<td>3702</td>
<td>15856</td>
</tr>
<tr>
<td>2006</td>
<td>5071</td>
<td>7656</td>
<td>569</td>
<td>2225</td>
<td>3255</td>
<td>12265</td>
</tr>
<tr>
<td>2007</td>
<td>0</td>
<td>7364</td>
<td>348</td>
<td>2892</td>
<td>2711</td>
<td>7090</td>
</tr>
<tr>
<td>2008</td>
<td>4381</td>
<td>8901</td>
<td>415</td>
<td>2173</td>
<td>3497</td>
<td>12373</td>
</tr>
</tbody>
</table>

Average (2001-2008)  
7574 9611 468 2458 3745 16265

ERD (Sep 2000-Aug 2001)  
15084 10575 506 2570 N/A 24670

Table 5.13 TP Mass Balance of Lake Ida from 2001 to 2008. Results by ERD (2002) were referenced for Comparison Purposes.

<table>
<thead>
<tr>
<th>Year</th>
<th>TP Loads from E-4 Canal (kg/yr)</th>
<th>TP Loads from L-30 Canal (kg/yr)</th>
<th>TP Loads from Precipitation (kg/yr)</th>
<th>TP Groundwater Seepage (kg/yr)</th>
<th>TP Retention (kg/yr)</th>
<th>TP Outflow (kg/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001</td>
<td>1773</td>
<td>1418</td>
<td>49</td>
<td>786</td>
<td>1473</td>
<td>2553</td>
</tr>
<tr>
<td>2002</td>
<td>1227</td>
<td>1034</td>
<td>33</td>
<td>678</td>
<td>1141</td>
<td>1832</td>
</tr>
<tr>
<td>2003</td>
<td>1147</td>
<td>896</td>
<td>28</td>
<td>634</td>
<td>1093</td>
<td>1612</td>
</tr>
<tr>
<td>2004</td>
<td>988</td>
<td>900</td>
<td>25</td>
<td>627</td>
<td>1000</td>
<td>1540</td>
</tr>
<tr>
<td>2005</td>
<td>888</td>
<td>987</td>
<td>27</td>
<td>574</td>
<td>1025</td>
<td>1450</td>
</tr>
<tr>
<td>2006</td>
<td>568</td>
<td>833</td>
<td>25</td>
<td>593</td>
<td>891</td>
<td>1129</td>
</tr>
<tr>
<td>2007</td>
<td>0</td>
<td>812</td>
<td>23</td>
<td>557</td>
<td>726</td>
<td>666</td>
</tr>
<tr>
<td>2008</td>
<td>479</td>
<td>992</td>
<td>28</td>
<td>579</td>
<td>945</td>
<td>1133</td>
</tr>
</tbody>
</table>

Average (2001-2008)  
884 984 30 628 1037 1489
Table 5.12 ERD (Sep 2000-Aug 2001)

| ERD (Sep 2000-Aug 2001) | 1155 | 1245 | 34 | 685 | N/A | 2938 |

**Percent TN loads**

- E-4 Canal: 38%
- L-30 Canal: 48%
- Groundwater Seepage: 12%
- Precipitation: 2%

**Percent TP loads**

- E-4 Canal: 35%
- L-30 Canal: 39%
- Groundwater Seepage: 25%
- Precipitation: 1%

*Figure 5.10 Percent Contribution of Annual Average TN Loads from Various Pathways to Lake Ida from 2001 to 2008.*
Figure 5.11  Percent Contribution of Annual Average TP Loads from Various Pathways to Lake Ida from 2001 to 2008.

Table 5.14 In-lake Concentrations of TN, TP and Chla, TN/TP Ratios, and Annual TSI of Lake Ida under the TMDL Conditions from 2001 to 2008.

<table>
<thead>
<tr>
<th>Year</th>
<th>TMDL TN (ppb)</th>
<th>TMDL TP (ppb)</th>
<th>TMDL Chla (ppb)</th>
<th>TN/TP Ratio</th>
<th>TMDL TSI</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001</td>
<td>885</td>
<td>60.7</td>
<td>22.1</td>
<td>14.6</td>
<td>59</td>
</tr>
<tr>
<td>2002</td>
<td>828</td>
<td>59.2</td>
<td>20.7</td>
<td>14.0</td>
<td>58</td>
</tr>
<tr>
<td>2003</td>
<td>848</td>
<td>61.6</td>
<td>21.6</td>
<td>13.8</td>
<td>58</td>
</tr>
<tr>
<td>2004</td>
<td>815</td>
<td>58.8</td>
<td>20.3</td>
<td>13.9</td>
<td>57</td>
</tr>
<tr>
<td>2005</td>
<td>894</td>
<td>63.9</td>
<td>23.0</td>
<td>14.0</td>
<td>59</td>
</tr>
<tr>
<td>2006</td>
<td>843</td>
<td>60.8</td>
<td>21.3</td>
<td>13.9</td>
<td>58</td>
</tr>
<tr>
<td>2007</td>
<td>859</td>
<td>64.3</td>
<td>12.9</td>
<td>13.4</td>
<td>55</td>
</tr>
<tr>
<td>2008</td>
<td>888</td>
<td>64.4</td>
<td>23.0</td>
<td>13.8</td>
<td>59</td>
</tr>
<tr>
<td>Average (2001-2008)</td>
<td>857</td>
<td>61.7</td>
<td>20.6</td>
<td>13.9</td>
<td>58</td>
</tr>
</tbody>
</table>
5.3.4 TMDL Development

Carlson and Simpson (1996) noted that trophic state is not synonymous with the concept of water quality. While trophic state is an absolute scale that describes the biological condition of a water body, water quality is used to describe the condition of a water body in relation to human needs or values, relative to the use of the water and the expectations of the user. Water quality targets for TMDL development are created to protect the designated uses of water bodies. In the case of Florida lakes, the designated uses are for the protection of healthy, well balanced populations of fish and wildlife, and for recreation in and on the water. TMDL targets must provide protection for these sometimes competing interests.


EPA found that correlations between nitrogen/phosphorus and biological response parameters in the different types of lakes in Florida were specific, significant, and documentable, and when considered in combination with additional lines of evidence, support a stressor-response approach to criteria development for Florida’s lakes. EPA’s results show a significant relationship between concentrations of nitrogen and phosphorus in lakes and algal growth. EPA proposed the use of chlorophyll a concentration as an indicator of a healthy biological condition, supportive of natural balanced populations of aquatic flora and fauna in each of the classes of Florida’s lakes. EPA has found that by using stressor-response approach to estimate the relationship between nitrogen/phosphorus concentrations and a response measure that is either directly or indirectly related to the designated use (in this case, chlorophyll a as a measure of attaining a balanced natural population of aquatic flora and fauna) can be used to determine the concentrations of nutrients that support the designated use.

The DEP TSD summarizes several lines of evidence that can be used to establish TMDL targets for nutrients. Among these lines of evidence are:

- Paleolimnologic studies, where pre-human disturbance chlorophyll a values are inferred from an analysis of diatom communities in deep sediment cores;
- Expert elicitation, or best professional judgment, for the determination of protective TSI or chlorophyll a values;
- Fisheries responses to chlorophyll a or TSI levels, dependent upon type of fisheries which are in turn adapted to associated dissolved oxygen conditions (i.e., cold water vs. warm water fisheries);
- Associating lake user visual perceptions (for swimming and aesthetics) with simultaneously measured chlorophyll a;
• Setting the criterion to maintain the existing condition (protection strategy).

Paleolimnological studies conducted in Florida lakes with a color of 40 PCU or greater suggest that the average chlorophyll $a$ in these lakes would naturally range between 14 to 48 $\mu$g/L. Studies at lakes that were naturally eutrophic suggest even higher Chla concentrations in these lakes.

Expert opinions based on Best Professional Judgment (BPJ) suggest TMDL targets that would protect against excessive eutrophication, expressed as annual or summertime averages, ranging from 20 to 33 $\mu$g/L of chlorophyll $a$.

Reviews of information from other states on fisheries end points for TMDL development were conducted. For example, the state of Virginia conducted an analysis to determine the effect of chlorophyll $a$ levels on the health of fisheries, and concluded that summer average chlorophyll $a$ concentrations of 35-60 $\mu$g/L in warmwater lakes were protective of fish health (Gregory 2007).

Texas conducted a study of lake user perceptions that indicated that in reservoirs, chlorophyll $a$ levels below approximately 20-25 $\mu$g/L still support full immersion recreational uses, as well as aesthetics (Glass 2006).

The State of Alabama’s approach to establishing lake or reservoir chlorophyll $a$ targets may be described as a method designed to “maintain the existing condition” (Macindoe 2006). Alabama’s chlorophyll $a$ targets for specific lakes or reservoirs range from 5 $\mu$g/L to 27 $\mu$g/L.

After reviewing these multiple lines of evidence, consideration of the competing designated uses for Lake Ida, and use of BPJ, the DEP is recommending an annual average Chla TMDL target of $\sim$ 20 $\mu$g/L as protective of designated uses in Lake Ida. The models (SWMM and Bathtub) were used to determine the concentrations of TN and TP that would result in an in-lake annual average Chla concentration of $\sim$ 20 $\mu$g/L.

The TMDL condition for the impaired lake was established by lowering watershed loads of TN and TP until the in-lake concentration approached 20 $\mu$g/L. TMDLs for Lake Ida were then expressed as in-lake target concentrations of TN and TP. When the current watershed loads of TN and TP were reduced by 20% and 45%, respectively, the long-term annual average Chla concentration was approximately 20 $\mu$g/L, (i.e., 20.6 $\mu$g/L). Under the TMDL reductions, long-term average in-lake concentrations of TN and TP were 0.857 mg/L and 0.062 mg/L, respectively, resulting in algal responses with a Chla concentration of 20.6 $\mu$g/L.
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, or WLAs), nonpoint source loads (Load Allocations, or LAs), and an appropriate margin of safety (MOS), which takes into account any uncertainty concerning the relationship between effluent limitations and water quality:

\[
\text{TMDL} = \sum \text{WLAs} + \sum \text{LAs} + \text{MOS}
\]

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

\[
\text{TMDL} \approx \sum \text{WLAs}_{\text{wastewater}} + \sum \text{WLAs}_{\text{NPDES Stormwater}} + \sum \text{LAs} + \text{MOS}
\]

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

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

This approach is consistent with federal regulations (40 CFR § 130.2[l]), which state that TMDLs can be expressed in terms of mass per time (e.g., pounds per day), toxicity, or other appropriate measure. The TMDL for Lake Ida is expressed in terms of percent reductions from watershed TN and TP loads and in-lake target TN and TP concentrations that represent the long-term annual average load of TN and TP the waterbody can assimilate and maintain the Class III narrative nutrient criterion (see Table 6.1).
### Table 6.1. TMDL Components for Nutrients in Lake Ida (WBID 3262A)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>TMDL</th>
<th>WLA</th>
<th>NPDES Stormwater (% reduction)</th>
<th>LA (% reduction)</th>
<th>MOS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Wastewater</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TN</td>
<td>0.857 mg/L</td>
<td>N/A</td>
<td>20%</td>
<td>20%</td>
<td>Implicit</td>
</tr>
<tr>
<td>TP</td>
<td>0.062 mg/L</td>
<td>N/A</td>
<td>45%</td>
<td>45%</td>
<td>Implicit</td>
</tr>
</tbody>
</table>

N/A Not Applicable

### 6.2 Load Allocation

Reductions from the existing loadings of 20% for TN and 45% for TP correspond to annual in-lake target concentrations of 0.857 mg/L for TN and 0.062 mg/L for TP in Lake Ida. 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).

### 6.3 Wasteload Allocation

#### 6.3.1 NPDES Wastewater Discharges

No NPDES-permitted wastewater facilities were permitted to discharge within the Lake Ida WBID boundary.

#### 6.3.2 NPDES Stormwater Discharges

The WLA for stormwater discharges with an MS4 permit is a 20% reduction in current loading for TN and a 45% reduction in current loading for TP. One NPDES municipal separate storm sewer system (MS4) permit cover the Lake Ida (WBID 3262A) watershed, which is held by Palm Beach County & Co Permittees (Phase I FLS000018), which includes FDOT Turnpike District/District 4. It should be noted that any MS4 permittee is only responsible for reducing the anthropogenic 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 MOS can either be implicitly accounted for by choosing conservative assumptions about loading or water quality response, or explicitly accounted for during the allocation of loadings. Consistent with the recommendations of the Allocation Technical Advisory Committee (Department, 2001), an implicit MOS was used in the development of this TMDL. The MOS is a required component of a TMDL and accounts for the uncertainty about the relationship between pollutant loads and the quality of the receiving waterbody [Clean Water Act, Section 303(d)(1)(c)]. Considerable uncertainty is usually inherent in estimating nutrient loading from nonpoint sources, as well as predicting water quality response. The effectiveness of management activities (e.g., stormwater management plans) in reducing loading is also subject to uncertainty. An implicit MOS was used because the TMDL was based on the conservative
decisions associated with a number of the modeling assumptions and selecting a TMDL target for Chla towards to lower end of the range suggested by the various lines of evidence.
Chapter 7: TMDL IMPLEMENTATION

7 TMDL Implementation

Following the adoption of this TMDL by rule, the Department will determine the best course of action regarding its implementation. Depending upon the pollutant(s) causing the waterbody impairment and the significance of the waterbody, the Department will select the best course of action leading to the development of a plan to restore the waterbody. Often this will be accomplished cooperatively with stakeholders by creating a Basin Management Action Plan, referred to as the BMAP. Basin Management Action Plans are the primary mechanism through which TMDLs are implemented in Florida [see Subsection 403.067(7) F.S.]. A single BMAP may provide the conceptual plan for the restoration of one or many impaired waterbodies.

If the Department determines a BMAP is needed to support the implementation of this TMDL, a BMAP will be developed through a transparent stakeholder-driven process intended to result in a plan that is cost-effective, technically feasible, and meets the restoration needs of the applicable waterbodies. Once adopted by order of the Department Secretary, BMAPs are enforceable through wastewater and municipal stormwater permits for point sources and through BMP implementation for nonpoint sources. Among other components, BMAPs typically include:

- Water quality goals (based directly on the TMDL);
- Refined source identification;
- Load reduction requirements for stakeholders (quantitative detailed allocations, if technically feasible);
- 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;
- Implementation funding mechanisms;
- An evaluation of future increases in pollutant loading due to population growth;
- Implementation milestones, project tracking, water quality monitoring, and adaptive management procedures; and
- Stakeholder statements of commitment (typically a local government resolution).

BMAPs are updated through annual meetings and may be officially revised every five years. Completed BMAPs in the state have improved communication and cooperation among local stakeholders and state agencies, improved internal communication within local governments, applied high-quality science and local information in managing water resources, clarified obligations of wastewater point source, MS4 and non-MS4 stakeholders in TMDL implementation, enhanced transparency in DEP decision-making, and built strong relationships between DEP and local stakeholders that have benefited other program areas.
However, in some basins, and for some parameters, particularly those with Nutrients (TSI) impairments, the development of a BMAP using the process described above will not be the most efficient way to restore a waterbody, such that it meets its designated uses. Why? Because Nutrients (TSI) impairments result from the cumulative effects of a multitude of potential sources, both natural and anthropogenic. Addressing these problems requires good old fashioned detective work that is best done by those in the area. There are a multitude of assessment tools that are available to assist local governments and interested stakeholders in this detective work. The tools range from the simple – such as Walk the WBIDs and GIS mapping - to the complex such as source tracking. Department staff will provide technical assistance, guidance, and oversight of local efforts to identify and minimize Nutrients (TSI) sources of pollution. Based on work in the Lower St Johns River tributaries and the Hillsborough River basin, the Department and local stakeholders have developed a logical process and tools to serve as a foundation for this detective work. In the near future, the Department will be releasing these tools to assist local stakeholders with the development of local implementation plans to address Nutrients (TSI) impairments. In such cases, the Department will rely on these local initiatives as a more cost-effective and simplified approach to identify the actions needed to put in place a roadmap for restoration activities, while still meeting the requirements of Chapter 403.067(7), F.S.
References


Appendices

Appendix A: Background Information on Federal and State Stormwater Programs

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

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

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

An important difference between the federal NPDES and the state’s stormwater/environmental resource permitting programs is that the NPDES Program covers both new and existing discharges, while the state’s program focus on new discharges only. Additionally, Phase II of the NPDES Program, implemented in 2003, expands the need for these permits to construction sites between 1 and 5 acres, and to local governments with as few as 1,000 people. 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. It should be noted that all MS4 permits issued in Florida include a reopener clause that allows permit revisions to implement TMDLs when the implementation plan is formally adopted.
Appendix B:

Oneway Analysis of Result By Waterbody Parameter=CHLAC

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<thead>
<tr>
<th>Quantiles</th>
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</thead>
<tbody>
<tr>
<td>Level</td>
</tr>
<tr>
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</tr>
<tr>
<td>Ida</td>
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<table>
<thead>
<tr>
<th>Means and Std Deviations</th>
</tr>
</thead>
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<tr>
<td>Level</td>
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<tr>
<td>Eden</td>
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<tr>
<td>Ida</td>
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<table>
<thead>
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<th>Means Comparisons</th>
</tr>
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<tbody>
<tr>
<td>Comparisons for all pairs using Tukey-Kramer HSD</td>
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Abs(Dif)-LSD

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Positive values show pairs of means that are significantly different.

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Levels not connected by same letter are significantly different.
Oneway Analysis of Result By Waterbody Parameter=TN

Quantiles

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<th>75%</th>
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Means and Std Deviations

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Means Comparisons

Comparisons for all pairs using Tukey-Kramer HSD

Abs(Dif)-LSD

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Positive values show pairs of means that are significantly different.

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Levels not connected by same letter are significantly different.
Oneway Analysis of Result By Waterbody Parameter=TP

Quantiles

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Means and Std Deviations

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Means Comparisons

Comparisons for all pairs using Tukey-Kramer HSD

\[ q^* \] Alp ha

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Positive values show pairs of means that are significantly different.

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Levels not connected by same letter are significantly different.