**FLORIDA DEPARTMENT OF ENVIRONMENTAL PROTECTION**

Division of Environmental Assessment and Restoration, Bureau of Watershed Restoration

NORTHWEST DISTRICT • OCHLOCKONEE–ST. MARKS BASIN

# FINAL TMDL REPORT

## TMDLs for Munson Slough, WBID 807D (Dissolved Oxygen); Lake Munson, WBID 807C (Dissolved Oxygen, Nutrients [Trophic State Index], and Turbidity); and Munson Slough below Lake Munson, WBID 807 (Dissolved Oxygen and Un-ionized Ammonia)

**Douglas Gilbert,**
**Richard Wieckowicz, Ph.D., P.E.,**
**Woo-Jun Kang, Ph.D.,**
**Erin G. Wilcox, and Ben Ralys**

**June 7, 2013**

# Acknowledgments

This analysis could not have been accomplished without significant contributions from staff in the Florida Department of Environmental Protection's Watershed Evaluation and Total Maximum Daily Load Section. George Jackson and William Weatherspoon provided most of the recent flow and data logger collections. Tricia McClenahan provided the basin delineations and Florida land use aggregations. Many agencies were involved with field data collection over several years, including the Department's Watershed Evaluation and TMDL Section and its Biology Section (Nia Wellendorf), the Northwest Florida Water Management District, the Department's Invasive Plant Bureau (Jesse Van Dyke), Leon County (Theresa Heiker and Johnny Richardson), the city of Tallahassee (Geoffrey Watts and Katherine Bray), and McGlynn Labs (Sean McGlynn).

Editorial assistance was provided by Jan Mandrup-Poulsen and Linda Lord.

Map production assistance was provided by Erin G. Wilcox.

For information on the implementation of TMDLs through the Basin Management Action Plan process in the St. Marks–Wakulla River Basin, contact:

Stephen Cioccia
Florida Department of Environmental Protection
Bureau of Watershed Restoration
Watershed Planning and Coordination Section
2600 Blair Stone Road
Tallahassee, FL 32399-2400
Stephen.Cioccia@dep.state.fl.us
Phone: (850) 245–8513
Fax: (850) 245–8434

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

Douglas Gilbert
Florida Department of Environmental Protection
Bureau of Watershed Restoration
Watershed Evaluation and TMDL Section
2600 Blair Stone Road, Mail Station 3555
Tallahassee, FL 32399-2400
Douglas.Gilbert@dep.state.fl.us
Phone: (850) 245–8450
Fax: (850) 245–8434

# Contents

## *List of Tables*

## List of Figures

## 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**

http://www.dep.state.fl.us/legal/Rules/shared/62-303/62-303.pdf

**STORET Program**

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

**2012 Integrated Report**

http://www.dep.state.fl.us/water/docs/2012_integrated_report.pdf

**Criteria for Surface Water Quality Classifications**

http://www.dep.state.fl.us/water/wqssp/classes.htm

**Basin Status Report: Ochlockonee–St. Marks**

http://waterwebprod.dep.state.fl.us/basin411/stmarks/status/Ochlockonee_St_Marks.pdf

**Water Quality Assessment Report: Ochlockonee–St. Marks**

http://waterwebprod.dep.state.fl.us/basin411/stmarks/assessment/Ochlockonee-GP1AR-WEBX.pdf

### U.S. Environmental Protection Agency, National STORET Program

**STORET Program**

http://www.epa.gov/storet/

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

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

# Chapter 1: INTRODUCTION

## 1.1 Purpose of Report

This report presents the Total Maximum Daily Loads (TMDLs) for dissolved oxygen (DO), nutrients (Trophic State Index [TSI]), un-ionized ammonia (NH3-U), and turbidity for the Munson Slough/Lake Munson watershed in the St. Marks–Wakulla River Basin (which in turn is a part of the larger Ocklockonee–St. Marks Basin). Munson Slough upstream of the lake was verified as impaired for DO (linked to nutrients and five-day biological oxygen demand [$BOD_5$]), and fecal coliform;[1] Lake Munson was verified as impaired for nutrients (TSI), DO (linked to nutrients and $BOD_5$), and turbidity; and Munson Slough downstream of the lake was verified as impaired for DO (linked to $BOD_5$) and NH3-U. These waters are included on the Verified List of impaired waters adopted by Secretarial Order on June 3, 2008. The TMDLs establish the allowable loadings to Lake Munson and Munson Slough that would restore these waterbodies so that they meets the applicable water quality impairment thresholds for nutrients, DO, turbidity, and NH3-U.

During the development of the TMDLs, significant research, data analysis, modeling, and compilation of ancillary information were completed. Not all of this information was directly used in the development of the TMDLs. However, it is included in the report *TMDL Supplemental Information for Munson Slough/Lake Munson Watershed, WBIDs 807, 807C, and 807D* (Gilbert *et al.* 2008b) (*Supplemental Information* report). In particular, all information referenced in this document as being in the *Supplemental Information Appendices* is located in the separate *Supplemental Information* report.

## 1.2 Identification of Waterbody

The Munson Slough/Lake Munson watershed, located in Leon County, Florida, has a 53-square-mile ($mi^2$) drainage area (Bartel et al. 1992a), as shown in **Figure 1.1.** Lake Munson is about 255 acres in size. Major population centers in the watershed include parts of the western, central, and eastern sections of the city of Tallahassee (COT) and parts of Leon County.

For assessment purposes, the Department has divided the St. Marks–Wakulla River Basin into water assessment polygons with a unique **w**ater**b**ody **id**entification (WBID) number for each watershed or stream reach. **Figure 1.2** shows these numerous segments. This TMDL report addresses primarily the Munson Slough/Lake Munson watershed, including WBIDs 807D, 807C, and 807. **Figure 1.3** shows Lake Munson (WBID 807C)

Lake Munson is mainly fed by Munson Slough (WBID 807D) and its tributaries. The tributaries include the West Drainage Ditch (WDD) or Godby Ditch (WBIDs 807D and 820), Bradford Brook (WBID 878B), Cascade Lake (WBID 878D), Lake Hiawatha (WBID 878C), Lake Bradford (WBID 878A), Grassy Lake (WBID 878E), Central Drainage Ditch (CDD) (WBID 857), St. Augustine Branch (SAB) (WBID 865), and East Drainage Ditch (EDD)/Indianhead Creek (WBID 916). Lake Munson is impounded by a dam, which was built in about 1950 (Maristany 1988). Several control gates discharge to Lower Munson Slough (WBID 807), Eightmile Pond/Ames Sink (WBID 807A).

[1] A separate TMDL report has been published for fecal coliform (Wieckowicz, Wilcox, and Ralys 2008a).

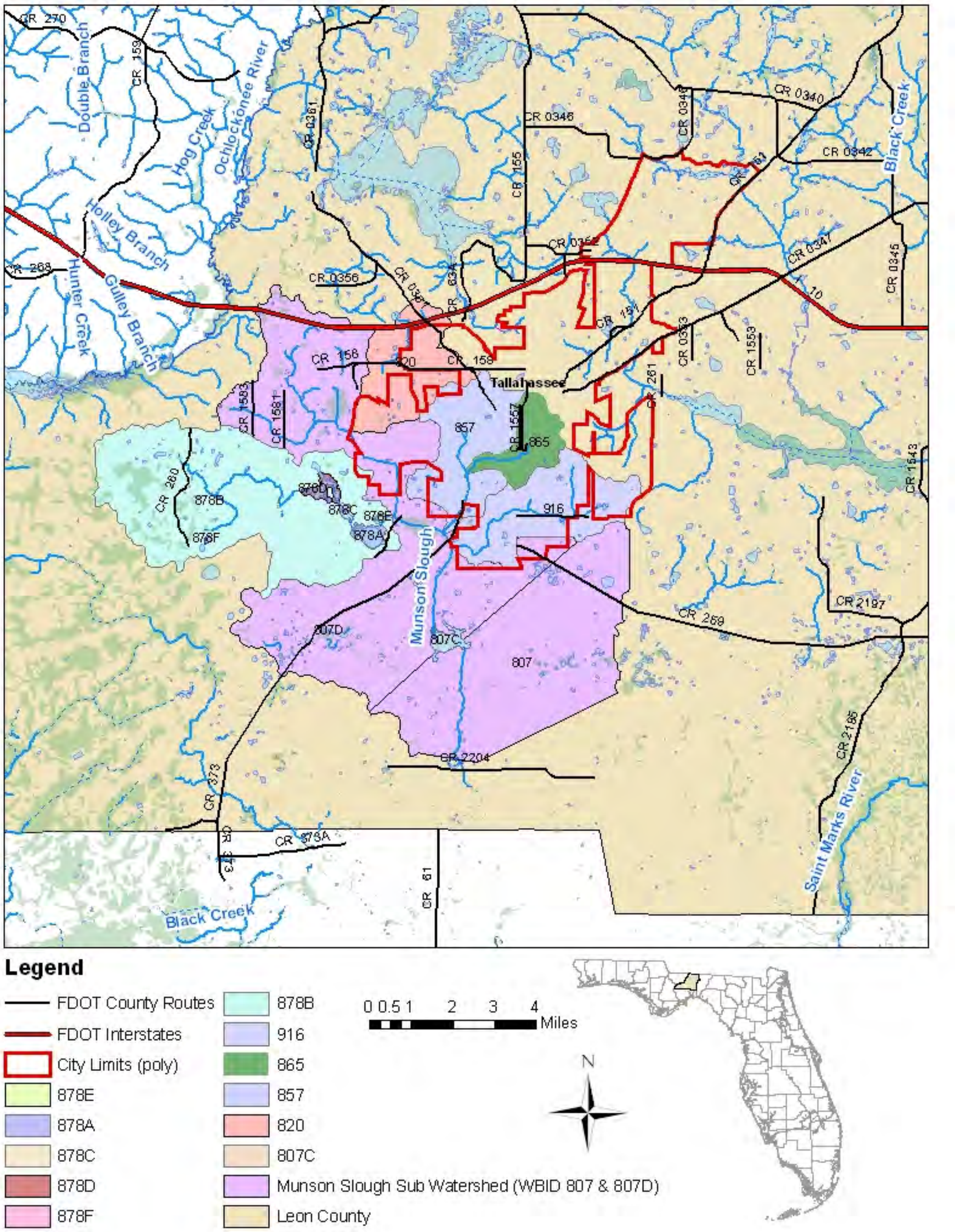
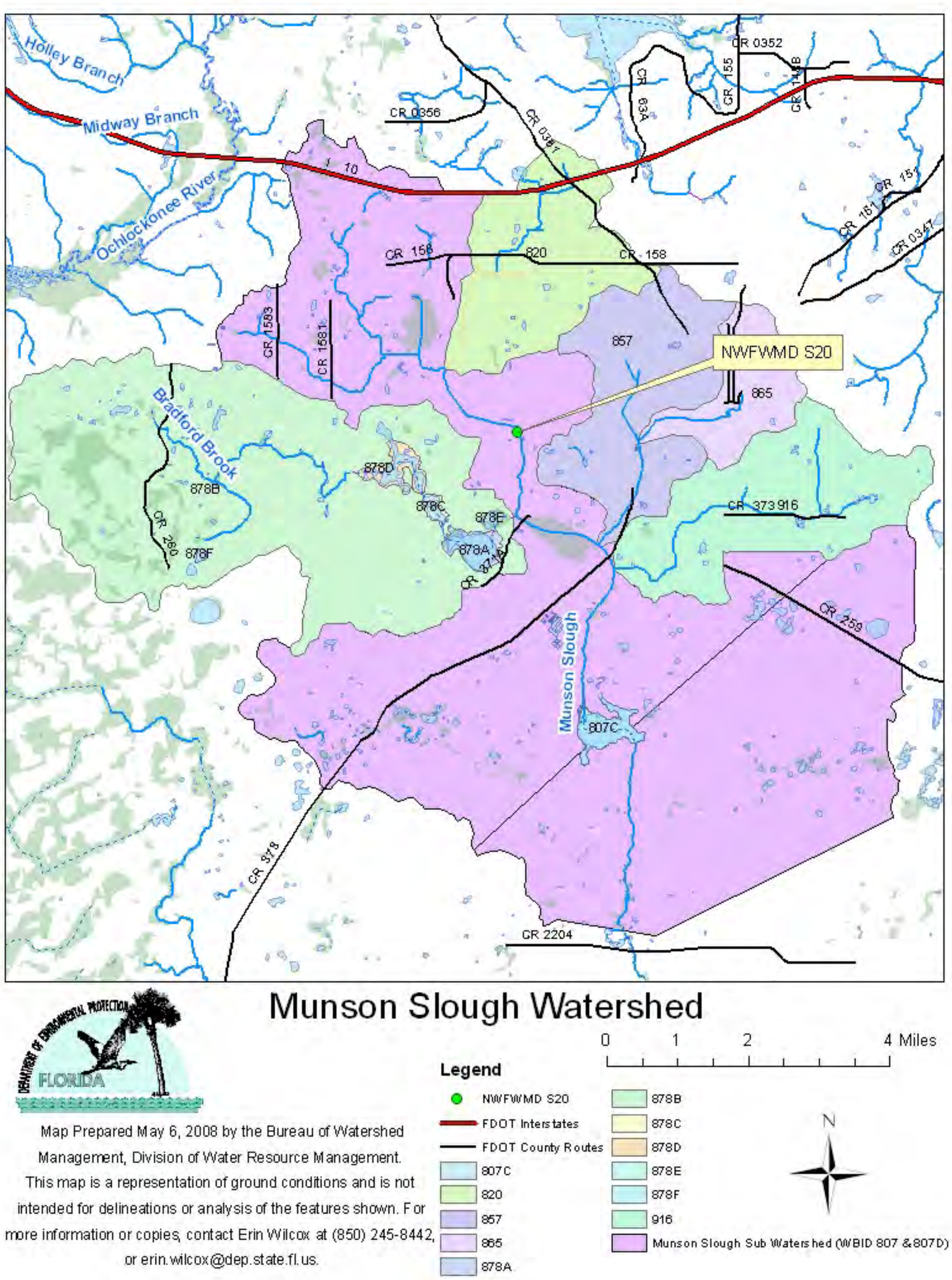



Figure 1.1 Major Geopolitical Features in the Munson Slough/Lake Munson Watershed in Florida

**Note:** Florida Department of Transportation (FDOT) routes are for illustration purposes only and are not meant to depict roadways for which FDOT is responsible.




## Figure 1.2 WBIDs in the Munson Slough/Lake Munson Watershed, Including WBID 807C

**Note:** FDOT routes are for illustration purposes only and are not meant to depict roadways for which FDOT is responsible.


Figure 1.3 Lake Munson, WBID 807C

Munson Slough is a fourth-order stream fed by the Floridan aquifer and urban runoff. Additional information about the stream and lake hydrology and geology are available in the Basin Status Report for Ochlockonee and St. Marks (Florida Department of Environmental Protection [Department] 2001b) and Northwest Florida Water Management District (NWFWMD) reports (Maristany *et al.* 1988; Bartel et al. 1992a).

## 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 five-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 to reduce the amount of nutrients, un-ionized ammonia, $BOD_5$, and turbidity and increase the DO levels causing the verified impairments of Lake Munson and Munson Slough. These activities will depend heavily on the active participation of the NWFWMD, 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 TMDLs for impaired waterbodies.

The problems of Lake Munson are well documented in the literature (see Chapter 3). This TMDL is also linked to the draft nutrient TMDL (Gilbert 2010) for the Upper Wakulla River (WBID 1006), as the Munson Slough/Lake Munson watershed lies within the springshed that is the primary source of water for the Upper Wakulla River. Public meetings on Florida springs, including Wakulla, were held quarterly at the Department (including two in 2008) to discuss data collection, stakeholder involvement, and future research. Another significant workshop on Wakulla Spring was held May 12 through 13, 2005. The meeting included the publication of a *Peer Review Committee Report* (Loper *et al.* 2005) that summarized current research (Hand 2007) and mitigation strategies for reducing nutrient loading.

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

Florida's 1998 303(d) list included 13 waterbodies in the St. Marks–Wakulla River Basin. However, the FWRA (Section 403.067, F.S.) stated that all previous Florida 303(d) lists were for planning purposes only and directed the Department to develop, and adopt by rule, a new science-based methodology to identify impaired waters. 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 IWR was modified in 2006 and 2007.

## 2.2 Information on Verified Impairment

The Department used the IWR to assess water quality impairments in the Munson Slough/Lake Munson watershed and has verified the impairments listed in **Table 2.1**. **Table 2.2** provides assessment results for the TSI for the period of record and the verified period for Lake Munson. The data for total nitrogen (TN) and total phosphorus (TP) are from the IWR Run 34 dataset. The data for chlorophyll *a* (Chla) for the period prior to the verified period include data from the Department's Statewide Biological (SBIO) database and Laboratory Information Management System (LIMS), as well as data transcribed from reports by the NWFWMD. Data for Chla from the verified period are corrected Chla (CChla) and are also from the IWR Run 34 dataset.

During the data analysis phase of TMDL development, some results were removed from the analysis. Data reported as less than detect were processed in accordance with Section 62-4.246, F.A.C., with several exceptions. For all naturally occurring constituents, data labeled as less than detect, given a result of zero, and labeled as no detection limit reported were flagged as not used and removed from the analysis. For data coded as less than detection, a detection limit was reported, and reported results that were over 10 times the detection limit were also flagged as not used and removed from the analysis. All data reported as less than detection with no detection limit provided were flagged as not used and removed from the analysis. All data reported as between the detection and quantification limits were included as reported. All of these data (data used and data not used) are available in electronic form upon request.

The historical data reflect changes in land use, water quality protection, and water quality over the last 30 years. It is the position of the Department and EPA that all available data be evaluated as part of the TMDL development process. The historical data are included and discussed in this context. Each table and figure in the report contain the period of record for the included data. For example, only data from the verified period (2000–07) were used to develop the Watershed Management Model (WMM) loadings. The empirical model used to relate the response of CChla to nitrogen and phosphorus was developed using data from 2003 through 2009. The verified period for the Group 1 basins is January 1, 2000, through June 30, 2007. As the year 2007 of the verified period contains only six months, the annual average TSI for this year was not considered in verifying TSI impairment for lakes.

Color was also compared with the requirements of Section 62-303.352, F.A.C., which states that for lakes with a mean color greater than 40 platinum cobalt units (PCUs), the annual TSI must not exceed 60. The lake and Munson Slough also have problems with low DO related to nutrients and high $BOD_5$, supersaturated DO, NH3-U, high turbidity, high-sediment nutrients and organics, aquatic vegetation, fish kills, and polychlorinated biphenyls (PCBs) in fish tissue (Richardson 2008). **Table 2.3** shows the number of exceedances for DO for WBIDs 807, 807C, and 807D. It should be noted that while all three waterbodies have many low DO values, Lake Munson has many in the supersaturated range (DOSAT>110% or DOSAT>150%).

**Table 2.4** also notes biological exceedances**.** Recent BioReconnnaissance (BioRecon) data were not available, but recent photos of the lake showing excessive macrophyte coverage (**Figure 2.1**) and algae blooms (**Figure 2.2**) suggest that the biological problems have continued to the present. *Appendix H* of the *Supplemental Information* report contains additional photos documenting recent algal blooms and fish kills. The high ammonia nitrogen (NH3-N) levels combined with high pH in the lake also contribute to in-lake and downstream exceedances of the NH3-U criterion of 0.02 milligrams per liter (mg/L). Macroalgae mats can produce human health problems, foul beaches and boat props, and reduce the aesthetic value of clear springs or stream runs. Ongoing research for many Florida springs, including Wakulla, is attempting to relate the threshold concentrations of nitrogen or phosphorus that cause nuisance macroalgae growth. Macroalgae may sequester ground water sources of nutrients or sediment nutrients, such as phosphorus, that are not routinely examined with surface water sampling.

Concerns were raised though public comments that the data used by the Department could be biased by excessive sampling during stormwater discharge events. Because of the generally high correlation of turbidity to stormwater events, the Department used turbidity as the best representative of stormwater sampling biases. Given that the median turbidity of the total dataset is 9.5 nephelometric turbidity units (NTU), it does not appear that the overall dataset is biased by stormwater sampling.

The following is a brief summary of the historical water quality problems in Lake Munson:

1. *Lake Munson was identified in historical maps dating from the 1800s (Heiker 2008).*

2. *The 255-acre lake was originally a cypress swamp that was impounded about 1950 (Maristany et al. 1988) to relieve flooding problems downstream. The shallow lake had a dam structure with control gates at its southern end. The current structure with control gates was built in 1968, about 100 feet west of its predecessor (Heiker 2008), with the flow continuing to Munson Slough below Lake Munson and then to Eightmile Pond.*

3. *The contributing area to Lake Munson has tripled since the 1930s from the construction of mosquito control and flood control ditches connecting Bradford Brook, WDD, and EDD to Munson Slough.*

4. *In 1956, the split-pea soup description of the lake was noted by the Florida State Board of Health (Beck 1963).*

5. *Limited diel water quality sampling (June 12 and 13, 1963) at 4 stations showed early morning DO near 0.0 mg/L and late afternoon values supersaturated (Beck 1963). The pH values were also extremely high (9.2 to 9.6 standard units [su]). The number of bottom organisms had increased by a factor of seven since 1956. A fish kill was also noted on June 10, 1963, and was attributed to an algae bloom.*

6. *In 1973, the EPA's National Eutrophication Survey (EPA 1975) analyzed 41 lakes in Florida that were suspected of being eutrophic. Lake Munson ranked as hypereutrophic (scored 39th highest out of the 41 analyzed) using a combination of six lake parameters. Limnologists also noted emergent and floating vegetation at all stations, heavy phytoplankton blooms, and clumps of filamentous blue-green algae at one station. Algal assay results showed that the lake was nitrogen limited. The three surveys (June 20, August 30, and November 5, 1973) included nutrient sampling. About one U.S. Geological Survey (USGS) stream flow estimate per month, for one year, was completed for the input via Munson Slough.*

7. *In September 1976, a "limited" drawdown of Lake Munson was proposed (Leseman 1977). Water quality sampling was performed monthly at six lake stations and one station on Munson Slough inflow from February 1976 to March 1977. Additional sampling was done for sediment nutrients and heavy metals and water quality in nearby residents' wells. The Florida Game and Fresh Water Fish Commission (GFC) also analyzed the fish species and populations in the lake. This report also showed the water quality trends for TN and orthophosphate (OPO4P) from 1966 to 1975 (*Appendix D, Supplemental Information *report). The loading from the three city sewage treatment plants (STPs) (T.P. Smith, Dale Mabry, and Lake Bradford) was also quantified (*Appendix A, Supplemental Information *report). In 1977, when the drawdown was attempted, a dense stand of weeds formed in the lake, but the bottom sediments were too soft to support equipment to remove the weeds.*

8. *Around 1978, a decision was made by the City of Tallahassee to phase out the STP discharges to Munson Slough and Lake Munson and utilize land spreading at two different sites. The USGS completed the sampling of sediment for PCBs, nutrients, pesticides, and heavy metals in August 1981. These samples were summarized for four area lakes, including Munson. The effluent discharges from T.P. Smith stopped in 1980, Dale Mabry STP discharges were discontinued in 1982, and Lake Bradford Rd. STP discharges stopped in 1984.*

9. *The Florida Department of Environmental Regulation (FDER) (1988) conducted a large study of the lake from November 1986 to October 1987. Algal growth potential (AGP) and nutrient-limiting assays were performed on water samples from seven lake stations. Nitrogen was found to be the limiting nutrient and AGP was still above the threshold level of 5.0 mg dry weight per liter (dwt/l) but much reduced from 1977 levels (62.61 mg dwt/l). This indicated that the lake was recovering from the cessation of STP discharges but was still receiving a large fraction of the stormwater from Tallahassee.*

10. *Aquatic plants have been a periodic problem in Lake Munson. The Florida Department of Natural Resources (FDNR) (Van Dyke 1986) noted that on October 17, 1986, the aquatic plant community consisted primarily of emersed species such as smartweed, willow, beggar-tick, and elephant ear. The most potentially harmful plant present was water hyacinth. This floating species only occupied 0.45 hectares (ha) (1.11 acres) but has the potential to expand rapidly. No dense phytoplankton coverage was found in the lake at that time. A summary of the annual plant coverage from 1983 to 2004, by species, is shown in* Appendix E *of the* Supplemental Information *report (Department 2008). Note that hyacinth (*Eichornia crassipes*) maximum coverage (15 acres) occurred in 1994. The submersed species hydrilla (*Hydrilla verticillata*) was found to cover 25 acres in 1993 and expanded to cover 200 acres by 1995. In 2003, hydrilla covered 180 acres, while filamentous algae covered 60 acres and American lotus (*Nelumbo lutea*) extended over 60 acres.* ***Figures 2.1*** *and* ***2.2*** *show excessive macrophytes and algal mats, respectively, in Lake Munson in 2000 and 2003.*

11. *The most recent invasive species in Lake Munson is the apple snail, which has decimated aquatic plants throughout the lake. Nutrient reductions called for by these TMDLs may not address the invasive snail issue.*

The Lake Vegetation Index (LVI) listed in **Table 2.5** shows that Lake Bradford, located upstream of Lake Munson, passed the LVI screening.

### Table 2.1 Verified Impairments Addressed by the TMDLs

| WBID | Waterbody Segment | Parameters Assessed using the IWR | Priority for TMDL Development | Projected Year of TMDL Development |
|---|---|---|---|---|
| 807 | Munson Slough (below Lake Munson) | DO, Un-ionized Ammonia | Medium | 2013 |
| 807C | Lake Munson | DO, Nutrients (TSI), Turbidity | Medium | 2008 |
| 807D | Munson Slough (above Lake Munson) | DO | Low | 2008 |

## Table 2.2 Annual Average TN, TP, CChla, TSI, and TN:TP Ratio, 1973–2007

- = Empty cell/no data
**Note:** Highlighting and boldface type indicate verified period data.
[1] Includes data from the Department's LIMS and SBIO databases not in the IWR database.

| Year | TN-IWR34 | TP-IWR34 | CChla-IWR34 | Chla[1] | TSI | Four Quarters | TN:TP ratio |
|---|---|---|---|---|---|---|---|
| 1973 | 6.05 | 2.063 | - | 140.32 | 93.1 | - | 2.9 |
| 1986 | 0.89 | 0.266 | - | 31.55 | 61.8 | - | 3.4 |
| 1987 | 0.88 | 0.259 | - | 34.59 | 62.4 | Yes | 3.4 |
| 1991 | 0.81 | 0.119 | - | 14.53 | 55.2 | - | 6.9 |
| 1992 | 1.18 | 0.068 | - | 13.36 | 56.9 | - | 17.5 |
| 1994 | 1.43 | 0.232 | - | 20.60 | 63.9 | - | 6.2 |
| 1995 | 0.98 | 0.112 | - | 41.33 | 64.8 | - | 8.8 |
| 1996 | 1.24 | 0.209 | - | 41.58 | 67.4 | Yes | 5.9 |
| 1997 | 2.28 | 0.217 | - | 8.58 | 62.4 | - | 10.5 |
| 1998 | 0.95 | 0.250 | - | 19.27 | 59.0 | - | 3.8 |
| 1999 | 1.07 | 0.163 | - | 23.42 | 61.7 | Yes | 6.6 |
| **2000** | **0.78** | **0.123** | **-** | **6.49** | **48.9** | **-** | **6.3** |
| **2001** | **0.71** | **0.087** | **-** | **23.85** | **57.3** | **Yes** | **8.1** |
| **2002** | **1.10** | **0.106** | **28.00** | **-** | **64.0** | **Yes** | **10.4** |
| **2003** | **0.51** | **0.028** | **15.34** | **-** | **49.5** | **Yes** | **18.3** |
| **2004** | **0.50** | **0.036** | **16.18** | **-** | **51.0** | **Yes** | **14.1** |
| **2005** | **0.73** | **0.152** | **31.98** | **-** | **59.7** | **Yes** | **4.8** |
| **2006** | **1.99** | **0.348** | **73.51** | **-** | **76.5** | **Yes** | **5.7** |
| 2007 | 1.55 | 0.279 | 30.61 | - | 67.6 | - | 5.6 |

## Table 2.3 DO Exceedances, DO%>110%, DO%>150%, and NH3U Exceedances During the Verified Period (2000–06)

| WBID | N DO | N DO < 5 | N DOSAT | N DOSAT >110 | N DOSAT >150 | N NH3NU | N NH3NU > 0.02 |
|---|---|---|---|---|---|---|---|
| 807 | 108 | 30 | 31 | 4 | 1 | 20 | 5 |
| 807C | 1,289 | 128 | 1,142 | 84 | 26 | 464 | 46 |
| 807D | 158 | 54 | 116 | 9 | 0 | 44 | 0 |

## Table 2.4 Summary of Biology Data Stream Condition Index (SCI) Surveys for Munson Slough

* The method of scoring SCIs changed on June 6, 2004. Please refer to the Department's Standard Operating Procedure (SOP) FS7420.
** A series of measurements was made on the same day.

| WBID | Date | Result | Impaired | Source |
|---|---|---|---|---|
| 807D | 9/14/1994 | 19 | Poor | SCI |
| 807D | 7/19/1995 | 15 | Poor | SCI |
| 807D | 2/6/1996 | 13 | Very Poor | SCI |
| 807D | 2/6/1996 | 0 | Impaired | BioRecon |
| 807D | 9/13/1995 | 0 | Impaired | BioRecon |
| 807D | 2/10/1997 | 17 | Poor | SCI |
| 807D | 3/17/1999 | 1 | Suspect | BioRecon |
| 807 | 5/1/2002 | 1 | Suspect** | BioRecon |

## Table 2.5 Summary of LVI Data for Lake Munson and Lake Bradford

| Waterbody Name | Date | LVI | Proposed Call |
|---|---|---|---|
| Lake Munson | 10/21/2003 | 23 | Failed |
| Lake Bradford | 10/19/2006 | 81 | Passed |
| Lake Bradford | 6/21/2007 | 78 | Passed |


Figure 2.1 Lake Munson Showing Excessive Macrophytes in 2000

Figure 2.2 Lake Munson Showing Algal Mats in 2003

# Chapter 3. DESCRIPTION OF APPLICABLE WATER QUALITY STANDARDS AND TARGETS

## 3.1 Classification of the Waterbody and Criteria Applicable to the TMDLs

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 Munson and Munson Slough are Class III fresh waterbodies (with a designated use of recreation, propagation and maintenance of a healthy, well-balanced population of fish and wildlife. The Class III fresh water quality criteria applicable to the impairment addressed by these TMDLs are nutrients and TSI, DO, un-ionized ammonia, and turbidity.

## 3.2 Applicable Water Quality Standards and Numeric Water Quality Targets

### *3.2.1 Munson Slough above Lake Munson (WBID 807D)*

#### DO Impairment

The DO criterion in Subsection 62-302.530(30), F.A.C., requires that DO shall not be less than 5.0 mg/L. Normal daily and seasonal fluctuations above these levels shall be maintained. Algae blooms can also cause DO supersaturation. Subsection 62-302.530(66), F.A.C., notes that total dissolved gases (TDG) shall not be greater than 110%. This translates into a requirement for the DO% portion of TDG to be less than about 150% (Kumar 1984). These exceedances are noted in **Table 2.3**. Additional recent data on diurnal DO are in *Appendix D* of the *Supplemental Information* report and **Chapter 5** of this document. The exceedances of the DO criterion were linked to elevated $BOD_5$ and nutrients.

#### Nutrient TMDL (addresses DO impairment)

In determining TMDLs for several WBIDs in the Munson Slough/Lake Munson watershed, the EPA (2006) used seven reference streams from this area to set nutrient targets of 0.72 mg/L for TN and 0.15 mg/L for TP (**Tables 3.1** and **3.2**) based on the 75$^{th}$ percentile values of the combined data. Based on a review of the data in WBID 807D, these values were selected as the target for the nutrient TMDL in Munson Slough above Lake Munson.

#### $BOD_5$ TMDL (addresses DO impairment)

As has been the case for over 20 years, the Department uses the 70$^{th}$ percentile concentrations of $BOD_5$ from STORET data collected from 1970 to 1987 as the target level below which $BOD_5$ values will not cause or contribute to low DO conditions in the water. The documentation for this analysis is contained in the report *Typical Water Quality Values for Florida's Lakes, Streams, and Estuaries* (Friedemann and Hand 1989). The 70$^{th}$ percentile level for BOD in streams (including slough systems) is 2.0 mg/L. The 70$^{th}$ percentile level for BOD in lakes is 2.9 mg/L. Given that Lake Munson (WBID 807C) is the headwaters of Munson Slough below Lake Munson (WBID 807), the $BOD_5$ TMDL for Lake Munson must also be protective of the downstream water in Munson Slough below the lake. For this reason, the level of 2.0 mg/L for streams was applied to both the lake and the stream. Based on the Department's experience assessing DO impairments in streams and lakes (Friedemann and Hand 1989), if the $BOD_5$ is less than 2.0 mg/L it is not considered as "causing or contributing" to low DO conditions in the water.

### Table 3.1 EPA Set of Reference Streams in North Florida

| Storet ID | Station Nickname | Station Description | Waterbody Name |
|---|---|---|---|
| 22030061 | LLOYDDREF | Lloyd Creek S.R. 158a Jefferson Co. | Lloyd Creek |
| 31010140 | NMOS REF | North Mosquito Ck | North Mosquito Creek |
| 22020062 | OKLREF | Oklawaha Ck | Oklawaha Creek |
| 31010050 | CRKREF | Crooked Creek @ Hwy 20 Gadsden Co. | Crooked Creek |
| 31010142 | FLTREF | Flat Creek @ Hwy 12 Gadsden Co. | Flat Creek |
| 22020049 | MULEREF | Mule Creek @ SR 12 Liberty Co. | Mule Creek |
| 31010051 | SETREF | Sweetwater Creek @ Hwy 270 Liberty Co. | Sweetwater Creek |

### Table 3.2 EPA Stream Nutrient Targets

| Parameter | Units | Number of Stations | Number of Data Points | 75$^{th}$ Percentile of All Reference Data | TMDL Target |
|---|---|---|---|---|---|
| TN | mg/L | 7 | 47 | 0.72 | 0.72 |
| TP | mg/L | 7 | 47 | 0.15 | 0.15 |

### *3.2.2 Lake Munson (WBID 807C)*

#### Turbidity Impairment

Lake Munson was verified as impaired by turbidity. This was based on assessing the in-lake turbidity data against a criterion of natural background plus 29 NTU. A natural background turbidity of 2.0 NTU was assigned based on the lower 25$^{th}$ percentile of 304 turbidity measurements taken during the planning and verified periods. Therefore, the target turbidity value for restoration is 31.0 NTU. There were 28 turbidity values greater than 31 NTUs out of 217 values during the verified period. The 12.7% exceedance rate was sufficient to result in the lake being listed as impaired for turbidity.

During the 1986–87 period, the NWFWMD conducted a comprehensive sampling of lake water quality (Maristany *et al.*1988) and found significant relationships among several water quality parameters. Part of the correlation matrix is included in *Appendix D* of the *Supplemental Information* report. Maristany *et al.* found that turbidity was positively correlated (R>0.2) with alkalinity (ALK), total solids (TS), total nonfiltrable residue or suspended solids (SS), nonfiltrable volatile residue (NVR), total Kjeldahl nitrogen (TKN), and TP. Turbidity was negatively correlated (R<0.2) with Secchi depth (SECI), dissolved TKN (DTKN), and total organic carbon (TOC), and very weakly correlated with chlorophyll a (CHLA). SECI was positively correlated with oxidized nitrogen (NO23N) (NO32), and negatively correlated with color (COLOR), SS, NVR, TN, TKN, TP, TOC, and CHLA.

### DO Impairment

The DO criterion in Subsection 62-302.530(30), F.A.C., requires that DO shall not be less than 5.0 mg/L in predominantly fresh waters. Normal daily and seasonal fluctuations above these levels shall be maintained. Algae blooms can also cause DO supersaturation. Subsection 62-302.530(66) F.A.C., notes that TDG shall not be greater than 110%. This translates into a requirement for the DO% portion of TDG to be less than about 150% (Kumar 1984). These exceedances are noted in **Table 2.3**. The exceedances for DO were linked to elevated $BOD_5$ and nutrients. Additional recent data on diurnal DO are in *Appendix D* of the *Supplemental Information* report and **Chapter 5** of this document**.**

### $BOD_5$ TMDL (addresses DO impairment)

As has been the case for over 20 years, the Department uses the 70$^{th}$ percentile concentrations of $BOD_5$ from STORET data collected from 1970 to 1987 as the target level below which $BOD_5$ values will not cause or contribute to low DO conditions in the water. The documentation for this analysis is contained in Friedemann and Hand (1989.) The 70$^{th}$ percentile level for BOD in streams (including slough systems) is 2.0 mg/L. The 70$^{th}$ percentile level for BOD in lakes is 2.9 mg/L. Given that Lake Munson (WBID 807C) is the headwaters of Munson Slough below Lake Munson (WBID 807), the $BOD_5$ TMDL for Lake Munson must also be protective of the downstream water in Munson Slough below the lake. For this reason the level of 2.0 mg/L for streams was applied to both the lake and the stream. Based on the Department's experience assessing DO impairments in streams and lakes (Friedemann and Hand 1989), if $BOD_5$ is less than 2.0 mg/L it is not considered as "causing or contributing" to low DO conditions in the water.

### Nutrient (Trophic State) Impairment (also addresses DO impairment)

Numeric criteria for nutrients such as TN and TP are not explicitly stated in Rule 62-302, F.A.C. However, Sections 62-303.350, 62-303.352, and 62-303.450, F.A.C. (Nutrients in Lakes), state that a lake with a mean color greater than 40 PCU is impaired when any annual mean TSI during the verified period exceeds 60, unless paleolimnological information indicates the lake was naturally greater than 60. Additionally, a lake can be impaired if data indicate that annual mean TSIs have increased over the assessment period, as indicated by a positive slope in the means plotted versus time, or the annual mean TSI has increased by more than 10 units over historical values. When evaluating the slope of mean TSIs over time, the Department shall require at least a 5-unit increase in TSI over the assessment period.

The IWR allows the use of additional information indicating an imbalance of flora or fauna due to nutrient enrichment. These imbalances include algal blooms, changes in algal species richness, excessive macrophyte growth, a decrease in the areal coverage or density of seagrasses or other submerged aquatic vegetation (SAV), and excessive diel oxygen variation. While routine water column sampling at the surface produced a TSI greater than 60 for only two years of the verified period (2002 and 2006), exceeding this threshold in any one year of the verified period would be sufficient for a waterbody to be listed as impaired for nutrients.

Additionally, benthic macroalgae mats were shown to be a significant problem (Richardson 2008). These mats cause a variety of ecological impairments, including, but not limited to, habitat smothering, the production of nutrition and habitat for pathogenic bacteria, the production of toxins that may affect biota, and the reduction of oxygen levels in the lake. As a part of the EPA review of the IWR, the EPA recognized that merely because a waterbody is below the IWR thresholds (including a TSI of 60 for lakes) does not demonstrate that the waterbody is achieving its water quality standard for nutrients. As depicted in **Table 2.2**, the Lake Munson TSI is frequently below 60, yet the lake contains nuisance levels of blue-green nitrogen-fixing cyanobacteria and bloom-forming phytoplankton. During the period when the Lake Munson TSI values were at the lowest, the lake was nearly 100% covered by nuisance aquatic macrophytes and exhibiting light limitation.

When most of a lake's surface area is covered by floating macrophytes, in-lake concentrations of nutrients may reach unreasonably high levels but result in very low water column Chla due to limitation by light. This results in a low TSI even with high nutrient concentrations. Thus even while the lake TSI was at the "level" sought as a target for restoration, the excessive degree of nutrient loading had already resulted in a lake potentially impaired by nuisance conditions and exhibiting an imbalance in flora and fauna.

### Lake Munson Nutrient Target Development

The Department determined that the use of a watershed loading model together with an empirical model to relate in-lake TN and TP to CChla was the preferred approach for establishing both the TMDL target and the reductions required to attain the target. First, the models are calibrated to existing conditions and then used to establish a background land use TSI for the lake (in this case background TSI=51). The only difference between the existing condition model and the background land use scenario is changing the more anthropogenic land uses to background land uses that mimic a more natural system. This background land use TSI is used in accordance with Rule 62-303, F.A.C., to establish an alternative TSI threshold that better represents specific conditions for Lake Munson than the IWR threshold of impairment, which is a TSI of 60. The existing highly extended watershed was used in both the existing and background model scenarios.

In accordance with Rule 62-303, F.A.C., once the alternative TSI is established (TSI=51); a 10-TSI unit increase over this level becomes the new threshold for assessing impairment (51 +10 = 61). If the waterbody is verified as impaired with the new threshold (as is the case for Lake Munson), then the target for TMDL development is the impairment threshold (61) minus 5 TSI units. For Lake Munson, the Department has used the background land use TSI of 51 (which resulted from modeling the lake without anthropogenic land uses) to establish a new threshold of impairment at a TSI of 61 (background plus 10 based on the IWR). The TMDL target of 56 is selected as a 5-TSI-unit reduction from the impairment threshold. Because the selection of the TMDL TSI target was 5 TSI units above the background TSI and the highly modified watershed was used in both scenarios, the Department's goal is not restoring these systems to a pre-human level of water quality. This 5-TSI-unit reduction from the impairment threshold creates assimilative capacity within the lake, allowing for future growth.

Additionally, as a restoration target, the background TN:TP ratio of 17 is part of the target for attaining water quality standards. It is the Department's understanding that only reducing nitrogen in lakes that have become dominated by cyanobacteria and bloom-forming algae (Lake Munson) without even greater corresponding reductions in phosphorus will only give the cyanobacteria and bloom-forming algae an even stronger position in the lake biota. The results of long-term nutrient dosing studies such as 37 years of lake studies by Schindler *et al.* (2008) indicate that the "focus of management must be on decreasing inputs of phosphorus." Quiros (2002) states that the largest body of "existing literature indicates that both N2-fixing cyanophytes and bloom forming algae usually dominate lakes with relatively low TN:TP ratios," as is the case for Lake Munson.

This research supports that of others who found an inverse relationship between the TN:TP ratio and the degree of eutrophication, indicating that the degree of eutrophication cannot be reversed without corresponding increases in the TN:TP ratio. During increasing levels of eutrophication, "the lake ecosystem reorganizes itself in order to sustain ecosystem integrity." The key change is suspected to be the reorganization of species structure. The results indicate that the "systematic response to TN:TP lowering may be supported by species pre-adaptations to nutrient and light conditions." The final conclusion is that "the TN:TP ratio for lakes is both a cause and a consequence of aquatic biology, in spite of involved mechanisms."

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

The WMM, developed by Camp Dresser and McKee (CDM) for the Department, is a land use pollutant loading model used to estimate annual or seasonal loading from nonpoint and point sources in a watershed or a subbasin (CDM 1998a; 1998b). The loading estimation using the WMM can be executed based on the event mean concentrations (EMCs) of pollutants, land use, percent impervious surface, and annual rainfall. The model also can address watershed management needs for identified nonpoint source pollutants as a part of best management practices (BMPs).

The goal of this TMDL development is to identify the maximum allowable TN and TP concentrations in the lake and the associated percent reductions from current conditions, so that Lake Munson will meet the narrative nutrient water quality, turbidity, and DO criteria and thus maintain its function and designated use as a Class III water. In order to achieve the goal, the Department selected the WMM to predict nutrient loadings from the watershed to the lake and a multivariable empirical equation developed from the lake data to predict annual CChla responses in the lake as a function of TN and TP concentrations. This allowed the Department to construct a multivariable regression equation used to establish the assimilative capacity of the lake.

This approach has a sound basis in the scientific literature. For example, Shannon and Brezonik (1972) found strong relationships between lake TSI (calculated from TN, TP, and Chla concentrations) and the supply (load) of nutrients entering the lake. The regression model was then used to predict concentrations of Chla from various combinations of in-lake concentrations of TN and TP. These two models were used to relate changes in watershed loadings (WMM) to changes in lake concentrations of nutrients (empirical equation). To be conservative, the changes in loadings between two different WMM scenarios were considered as proportional to changes in lake concentrations. The load reductions were obtained by applying the percent reduction in concentration (from current condition to TSI target) to the current condition loading estimates from WMM.

Using the WMM-based spreadsheet and the CChla predictive equation developed for existing conditions, all human land uses in the watershed were assigned a background land use category based on the current proportion of these land uses in the watershed, and the models were run for the background land use condition. **Table 5.10** shows the results for existing measured condition, existing calibrated models, and the background land use condition.

### Lake Comparisons

The Department examined several lakes in the Lake Munson watershed and the Tallahassee Red Hills Physiographic Province (TRPP) to determine if the trophic state and nutrient concentration TMDL targets developed for Lake Munson are appropriate and achievable. By appropriate, it is meant that the TMDL targets are not aimed at restoring the lake to pristine natural conditions, but rather at allowing for some utilization of assimilative capacity. The lakes located below the Cody Scarp include Cascade Lake, Lake Hiawatha, and Lake Bradford (Bradford Chain of Lakes [BCL]). Although these lakes are not pristine, they are currently minimally impacted by human activities (COT 2007; Wieckowicz *et al.* 2008b). The lakes are ringed by cypress trees and have developed high color levels similar to those of Lake Munson.

A significant portion of the Lake Munson drainage basin lies within the TRPP. As such, several lakes located in this area were also reviewed to gain insight into the appropriate conditions for Lake Munson. These lakes include Tom Brown Park Lake, A.J. Henry Park Lake, Lake Hall, Lake Overstreet, Lake Killarney, Lake Kanturk, Goose Pond, and Alford Arm. **Appendix C** provides summaries of the lake systems and associated water quality data for each of these lakes and how they compare with Lake Munson.

Lake Munson is a shallow, flow-through lake, with a maximum depth at normal pool elevations of about 2.84 feet and an average depth of 4.17 feet. The lake is 255 acres in size, with a 42,500-acre watershed (Leon County 2008). The drainage-area-to-lake-area ratio is 167:1. The lake receives drainage from the national forest and the TRPP. The main sources are Gum Swamp, CDD, St. Augustine Branch (SAB), EDD, Bradford Brook, and BCL. The lake discharges ultimately to Munson Slough. The shallow flow-through lakes located within the TRPP include A.J. Henry Park Lake, Lake Killarney, Lake Kanturk, Goose Pond, and Alford Arm.

Lake Hall and Lake Overstreet are both flow-through lakes in good to excellent condition, but are not suitable as reference lakes due to their low color, low alkalinity, and relatively deep nature. It is worth noting that these two lakes have median TN concentrations of 0.31 and 0.29 mg/L, TP of 0.012 and 0.013 mg/L, and Chla of 2.8 and 3.00 micrograms per liter (µg/L), respectively. Both lakes are co-limited by nitrogen and phosphorus. In fact, with the exception of Goose Pond (nitrogen limited and depicted by the COT as being “highly degraded” and having “some of the poorest water quality” of any lake in the area), all of the other lakes in the TRPP are co-limited. The BCL is phosphorus limited, high color, and low alkalinity.

The data for alkalinity, conductivity, and color from the shallow flow-through lakes were examined and ranked in terms of similarity to Lake Munson (**Table 3.3**). For alkalinity, the median of A.J. Henry Park Lake (24.5 mg/L) is most similar to that of Lake Munson (28.3 mg/L), followed by Goose Pond (38.0 mg/L), Lake Killarney (13.8 mg/L), Alford Arm (7.85 mg/L), Lake Kanturk (5.8 mg/L), and BCL (2.35 mg/L). For conductivity, the median of Goose Pond (106 micromohs per centimeter [µmhos/cm]) is most similar to that of Lake Munson (87 µmhos /cm), followed by A.J. Henry Park Lake (62 µmhos /cm), Lake Killarney (44 µmhos /cm), Lake Kanturk (40 µmhos/cm), BCL (31 µmhos/cm), and Alford Arm (30 µmhos/cm). For color, the median of

Alford Arm (43 PCU) is most similar to that of Lake Munson (75 PCU), followed by Lake Killarney (30 PCU), BCL (121.6 PCU), and Lake Kanturk (14.6 PCU). No color data were located for A.J. Henry Park Lake or Goose Pond. Based on the alkalinity and conductivity rankings (all lakes had data for these parameters), A.J. Henry Park Lake and Goose Pond are most similar to Lake Munson, followed by Lake Killarney, Alford Arm, Lake Kanturk, and BCL. For the four lakes that included color data, the rankings are Lake Killarney, Alford Arm, Lake Kanturk, and BCL.

### Table 3.3 Ranking of Lakes for Data after 1986 Compared with Lake Munson (lowest number is most similar)

N/A = Not available

| Lake | Alkalinity | Conductivity | Sum of Rank | Color | Sum of Rank |
|---|---|---|---|---|---|
| BCL | 6 | 5 | 11 | 3 | 14 |
| A.J. Henry Park Lake | 1 | 2 | 3 | N/A | N/A |
| Lake Killarney | 3 | 3 | 6 | 2 | 8 |
| Lake Kanturk | 5 | 4 | 9 | 4 | 13 |
| Goose Pond | 2 | 1 | 3 | N/A | N/A |
| Alford Arm | 4 | 6 | 10 | 1 | 11 |

All of the shallow flow-through lakes in the TRPP are located in watersheds that are moderately to heavily urbanized and as such, may not be suitable as reference lakes and are certainly not in a pristine natural condition. COT (2007) states that the A.J. Henry Park Lake watershed is heavily urbanized and that the lake is hypereutrophic. While the lake is not suitable as a reference lake, it is noteworthy that the median TN, TP, and Chla are 1.54 mg/L, 0.059 mg/L, and 48.3 µg/L, respectively. In this case, the median TP in this hypereutrophic waterbody is less than 0.06 mg/L. COT (2007) notes that Goose Pond receives drainage from a large urbanized watershed and is a “degraded eutrophic system” with “some of the poorest water quality found in any lake system in the area.” Based on this characterization, Goose Pond is not suitable as a reference lake. However, the median TN, TP, and Chla in this degraded system are 0.57 mg/L, 0.062 mg/L, and 10.1 µg/L, respectively. Alford Arm, while not a true "lake," is flow through and shallow, and has other characteristics similar to those of Lake Munson. Alford Arm has median concentrations for TN, TP, and Chla of 0.60 mg/L, 0.044 mg/L, and 8.3 µg/L, respectively. The TN:TP ratio for Alford Arm is 13.6. Lake Killarney, characterized by COT as eutrophic and surrounded by residential development, has a median TN, TP, and Chla of 0.73 mg/L, 0.033 mg/L, and 11.8 µg/L, respectively, with a TN:TP ratio of 22.

The trophic state target for developing a nutrient TMDL for Lake Munson is a long-term average TSI of less than 56. Based on the evaluation of similar lakes in the TRPP, achieving co-limitation of TN and TP should also be factored into the lake restoration. Based on the condition of all the lakes evaluated in the TRPP (except Goose Pond, which is slightly n-limited with a ratio of 9.3), co-limitation is a reasonable target for Lake Munson. The average TN:TP ratio for the co-limited lakes in the TRPP is 21.8.

### *3.2.3 Munson Slough Below Lake Munson (WBID 807)*

#### DO Impairment

The DO criterion in Subsection 62-302.530(30), F.A.C., requires that DO shall not be less than 5.0 mg/L. Normal daily and seasonal fluctuations above these levels shall be maintained. Algae blooms can also cause DO supersaturation. Paragraph 62-302.530(x), F.A.C., notes that TDG shall not be greater than 110%. This translates into a requirement for the DO% portion of TDG to be less than about 150% (Kumar 1984). These exceedances are noted in **Table 2.3**. The exceedances for DO were linked to elevated $BOD_5$. Additional recent data on diurnal DO are in *Appendix D* of the *Supplemental Information* report and **Chapter 5** of this document.

#### $BOD_5$ TMDL (addresses DO impairment)

As has been the case for over 20 years, the Department has used the 70$^{th}$ percentile concentrations of $BOD_5$ from STORET data collected from 1970 to 1987 as the target level below which $BOD_5$ values will not cause or contribute to low DO conditions in the water. The documentation for this analysis is contained in Friedemann and Hand (1989). The 70$^{th}$ percentile level for BOD in streams (including slough systems) is 2.0 mg/L. Based on the Department's experience assessing DO impairments in streams (Friedemann and Hand 1989), if $BOD_5$ is less than 2.0 mg/L it is not considered as "causing or contributing" to low DO conditions in the water.

#### Un-ionized Ammonia Impairment

Florida's un-ionized ammonia criterion for Class III freshwater bodies states that the un-ionized ammonia shall be less than or equal to 0.02 mg/L, as ammonia. This criterion has been adopted by the state to protect aquatic life from the toxic effects of un-ionized ammonia and is not a nutrient-related criterion. A regression approach based on equations provided in Chapra (1997) was used to establish the TMDL target. Since there are an infinite number of combinations of pH and temperature (TEMP) to use for design conditions, a statistical or Monte Carlo approach was used (EPA 1999). Using the mean and standard deviation for pH and TEMP in WBID 807, random normal distributions of 1,000 pairs of pH and TEMP were generated using Excel. Given a mean value for NH3-N, random normal distributions of NH3-N were also generated for each pair of pH and TEMP. The NH3-U was then calculated for each set of 1,000 values using an equation provided by Chapra (1997). The number of exceedances (NGSTD) of the 0.02 mg/L criterion was then tabulated for each mean NH3-N. A regression line was used to estimate the concentration of total ammonia that would not result in an impairment for un-ionized ammonia in Munson Slough (Chapra 1997).

# 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 nutrients in the watershed and the amount of pollutant loading contributed by each of these sources. Sources are broadly classified as either "point sources" or "nonpoint sources." Historically, the term "point sources" has meant discharges to surface waters that typically have a continuous flow via a discernible, 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, such as 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 in the Munson Slough/Lake Munson Watershed

### *4.2.1 Point Sources*

In Leon County, 15 permitted WWTFs are currently located in the Munson Slough/Lake Munson watershed. Of these, 5 do not have a direct surface discharge, and 10 permittees potentially do. These facilities are permitted through the NPDES Program in Florida. During the past decade, several treatment plants have changed their discharge points and or treatment processes (**Table 4.1**). **Figure 4.1** shows the locations of the wastewater facilities in the watershed.

The following 10 permittees have a potential discharge: Ready Mix USA – Mosely Street Plant (FLG11358), Florida Rock – Tallahassee (FLG110319), Trinity Materials Plant 32 (FLG110307), Lake Bradford Estates STP (FLA010148), Sandstone Ranch WWTF (FLA010167), National High Magnetic Field Laboratory – Florida State University (NHMFL – FSU) (FLA01633), Southern Bell Trailer Park (FLA010151), Western Estates Mobile Home Park (MHP)

(FLA010152), Lake Bradford Road Wastewater Treatment Plant (WWTP) (FLA010140), and T.P. Smith Water Reclamation Facility (WRF) (FLA010139).

Ready Mix USA – Mosely Street Plant, Florida Rock – Tallahassee, and Trinity Materials Plant 32 are considered general industrial waste permits and discharge to a Type I pond. No monitoring is required for these ponds, and they only discharge during wet weather events. The Department does not consider nutrients from these facilities to be a source to the impaired waters. The Ready Mix USA – Mosely Street Plant was permitted on May 7, 2007, and is not due for permit renewal until May 6, 2012. Florida Rock – Tallahassee was originally permitted on February 5, 2001, with a current status of active and is not due for renewal until February 5, 2011. Trinity Materials Plant 32 was originally permitted on December 28,1995, with a current status of active . None of these facilities is considered a source of nutrients.

NHMFL – FSU is located south of Roberts Ave. and east of WDD/Munson Slough. It develops and operates high magnetic field facilities that are used for several scientific research projects. NHMFL buildings produce wastewater from air-conditioning condensate and cooling tower blowdown water. This wastewater is then land applied by a timed and zone irrigation system to the public area surrounding the NHMFL facilities. NHMFL is not considered a source of nutrients.

Sandstone Ranch WWTF is located south of Blountstown Highway and north of Bradford Brook. Sandstone is a 0.0707-million-gallons-per-day (MGD) annual average daily flow (AADF) WWTF with a rapid infiltration basin system consisting of two percolation ponds. This system currently contains surge tanks, influent screening, aeration, and anoxic zone, a reaeration zone clarification, and disinfection. Sandstone Ranch WWTF will be undergoing construction to expand the existing WWTP from 0.070 to 0.25 MGD AADF. The proposed headworks will consist of a mechanical screen unit, two-basin aerobic Sequential Batch Reactor (SBR) system to be operated on a four-cycle per day per basin schedule, two chlorine contact chambers, two sludge digesters, and two sludge-drying beds. Residuals are aerobically digested on beds and transported to the Lake Jackson WWTP. The Sandstone Ranch facility is not considered a significant source of nutrients.

Southern Bell Trailer Park is located north of U.S. Highway 90 and to the west of North Gum Branch Creek. It is a 0.025-MGD AADF activated sludge WWTF with a slow-rate public access system and a surface drip irrigation system consisting of two half-acre fields. Southern Bell Trailer Park contains a grease trap, a wet well, a surge tank, an anoxic tank, five aeration tanks, two clarifiers, two pyradeck polishing clarifiers, two chlorine contact chambers, two digestor tanks, a microaeration tank, and a reclaimed water pump tank. Recently, the facility has had a number of compliance issues, ranging from the failure to have a certified operator to not complying with the monitoring requirements of the permit. Southern Bell Trailer Park recently also had a sewage leak, which is believed to be due to a lack of maintenance. This facility is not considered a significant source of nutrients.

Lake Bradford Estates MHP is located east of Lake Bradford Rd. and west of Black Swamp. It is a 0.043-MGD AADF activated sludge WWTF with an absorption field and land application system. The system consists of three absorption beds with a capacity of 0.043 MGD. Lake Bradford Estates MHP contains equalization, nitrification/denitrification, reaeration, secondary clarification, chlorination, and digester. Residuals are transported to the T.P. Smith WRF for treatment and disposal. In the past, Lake Bradford Estates MHP has had a compliance issue. This facility is not considered to be a significant source of nutrients.

Western Estates MHP is located north of Blountstown Highway and to the south of West Gum Branch Creek. It is a 0.02-MGD AADF activated sludge WWTF. The system contains a Part IV rapid-rate land application system, consisting of two dual absorption beds. Western Estates MHP operates an extended aeration mode. The treatment facility has provisions for nitrification, denitrification, reaeration, secondary clarification, filter, disinfection, dozing tank, and aerobic digestion of residuals. Residuals are transported to a Class I or II landfill or a residual management facility for further treatment and disposal. In the past, Western Estates MHP has had a number of compliance issues due to a lack of maintenance on the system. At one point, it was trying to tie into COT sewer service. This facility is not considered a significant source of nutrients.

The Lake Bradford Road WWTF is located between Lake Bradford Road and the CDD. The WWTF is a 4.5-MGD AADF but will be modified to a membrane bioreactor process advanced wastewater treatment (AWT) plant producing reclaimed water. The system currently contains reclaimed water that is pumped to an existing slow-rate restricted public access facility outside the Munson Slough/Lake Munson watershed. Southeast Farm Spray Field is operated and monitored by the T.P. Smith WRF and is regulated under Permit Number FLA010139.

Along with the Southeast Farm Spray Field, a new 4.5-MGD AADF slow-rate public access system will be built. The construction date will be determined after a feasibility study is conducted. The modified treatment process will include coarse screening, grit removal, a flow equalization tank, primary clarification, fine screening, four-stage Bardenpho nitrogen removal process, membrane filtration, high-level disinfection using sodium hypochlorite, and a 1.0-million-gallon reclaimed water storage tank. All or part of the influent flow can be redirected to the T.P. Smith WRF for treatment. Residuals are not treated at this facility; primary sludge from the primary clarifiers and waste-activated sludge from the Bardenpho process are transferred via the COT sewage collection system to the T.P. Smith WRF for further treatment. As of February 3, 2008, the Lake Bradford Road WWTF discontinued processing flows. This is due to the upgrades that are occurring to the plant. The WWTF is unlikely to be a source of nutrients to the watershed, and this facility is not considered a source.

The T.P. Smith WRF is located at the corner of Capital Circle and Springhill Road and to the west of Munson Slough. The facility is a modified 26.5-MGD AADF existing treatment system but will be modified to a four-stage Bardenpho-type activated-sludge process, AWT plant producing reclaimed water. The T.P Smith WRF consists of a 23.25-MDG AADF and a 7.31-MGD AADF slow-rate restricted public access system, located outside the Munson Slough/Lake Munson watershed at the Southeast Farm Spray Field. Another 0.8-MDG AADF slow-rate restricted public access system is located in the Munson Slough/Lake Munson watershed at the T.P. Smith WRF.

A new 1.2-MGD AADF slow-rate public access system is the planning stages and will consist of reclaimed water. The modified treatment system consists of new headworks and three substantially modified treatment trains: Train 2 (6.9 MGD), Train 3 (6.9 MGD), and Train 4 (12.7 MGD). Pretreatment at the new headworks consists of coarse screening, grit removal, odor mitigation, and flow equalization. Flow equalization is used if storm flows exceed 53 MGD peak hourly flow; it consists of a diversion structure and a 30-MGD flow equalization basin. The modified treatment process at each of the three trains includes primary clarification, primary effluent pumping, four-stage Bardenpho nitrogen removal process, secondary clarification, tertiary filtration with deep-bed sand filters, high-level disinfection using chlorine, and 97 million gallons of reclaimed water storage in six effluent storage ponds at the T.P. Smith WRF. The facility is not considered a source of nutrients.

**Tables 4.4a** through **4.4d** contain a summary of annual point source loads to Munson Slough as of 1975. *Appendix A* of the *Supplemental Information* report contains annual summaries for 1970 to 1984. A comprehensive summary of wastewater loading to the St. Marks–Wakulla River Basin was also compiled by the NWFWMD (Chellette *et al.* 2002).

### Table 4.1 Potential Point Sources in the Munson Slough/Lake Munson Watershed

- = Empty cell/no data

| NPDES Permit Number | Facility Name | City Mailing Address | Type of Facility | Facility Status | Design Capacity (MGD) | Watershed | WBID |
|---|---|---|---|---|---|---|---|
| FLA010148 | Lake Bradford Estates MHP WWTF | Tallahassee | Domestic | Active | 0.043 | Munson Slough | 807D |
| FLA010151 | Southern Bell Trailer Park WWTP | Tallahassee | Domestic | Active | 0.025 | Munson Slough | 807D |
| FLA016533 | NHMFL – FSU | Tallahassee | Industrial | Active | 0.075 | Munson Slough | 857 |
| FLA010167 | Sandstone Ranch WWTF | Tallahassee | Domestic | Active | 0.0707 | Munson Slough | 878B |
| FLA010152 | Western Estates MHP WWTP | Tallahassee | Domestic | Active | 0.02 | Munson Slough | 807D |
| FLA010139 | T.P. Smith WRF | Tallahassee | Domestic | Active | 27.5 | Munson Slough and Wakulla River | 807D |
| FLA010140 | Lake Bradford Road WWTP | Tallahassee | Domestic | Active | 4.5 | Wakulla River | 857 |
| FLA470759 | Woodville Hwy. Sand Mine | Tallahassee | Industrial | Active | - | Munson Slough | 807 |
| FLG110726 | Superior Redi-Mix – Plant #2 | Tallahassee | Industrial | Active | - | Munson Slough | 807 |
| FLA188590 | Neff Rental | Tallahassee | Industrial | Active | - | Munson Slough | 807 |
| FLA010163 | Dollar Rent A Car | Tallahassee | Industrial | Active | - | Munson Slough | 878B |
| FLA010160 | Flint Equipment Company | Tallahassee | Industrial | Active | - | Munson Slough | 807D |
| FLG110319 | Florida Rock – Tallahassee Plant | Tallahassee | Industrial | Active | Only during wet weather | Munson Slough | 857 |
| FLG110358 | Ready Mix USA – Mosley St. Plant | Tallahassee | Industrial | Active | Only during wet weather | Munson Slough | 857 |
| FLG110307 | AMGI Plant #21 | Tallahassee | Industrial | Active | Only during wet weather | Munson Slough | 807 |

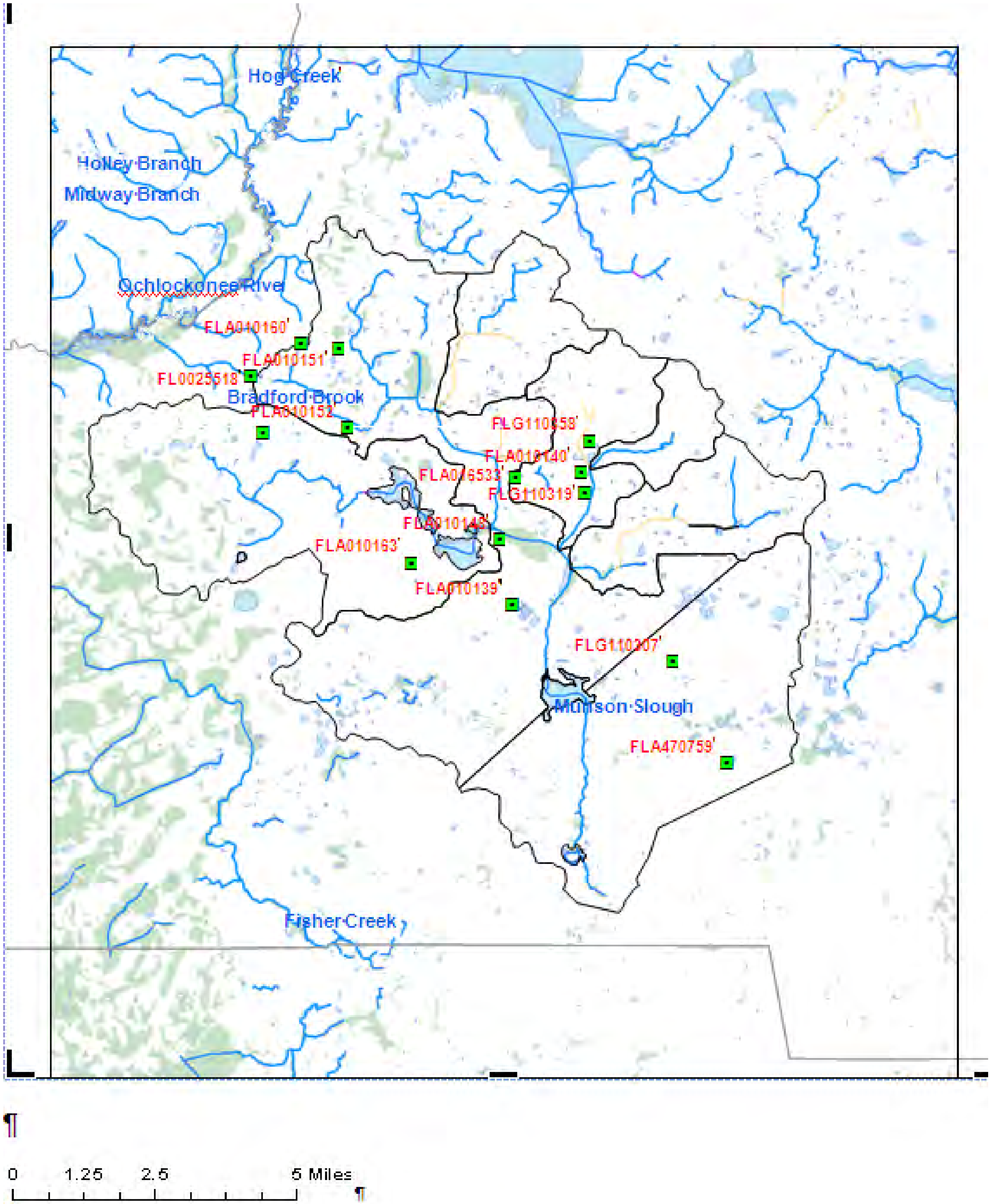



Figure 4.1 Wastewater Facilities in the Lake Munson Watershed

### Municipal Separate Storm Sewer System Permittees

Within the Munson Slough/Lake Munson watershed, the stormwater collection systems owned and operated by Leon County, COT, and Florida Department of Transportation (FDOT) District 3 in Leon County are covered by Phase I NPDES municipal separate storm sewer system (MS4) permits. Leon County and FDOT are co-permittees (FLS000033), while COT (FLS000034) is the other major permit holder. Phase II permits are held by FSU (FLR04E051), Florida Agricultural and Mechanical University (FAMU) (FLR04E095), and the Federal Correctional Institution (FLR04E096). The pollutant loadings calculated for the Munson Slough/Lake Munson watershed by each NPDES permit holder are included in *Appendix A* of the *Supplemental Information* report.

## *4.2.2 Land Uses and Nonpoint Sources*

Nutrient loadings to the Munson Slough/Lake Munson watershed are primarily generated from nonpoint sources in the watershed. Additional loadings to Lake Munson may come from internal nutrient sediment release or nutrient cycling from aquatic plants and aquatic life. Potential nonpoint sources of nutrients can be characterized by their pathway or delivery to the river, tributary runoff, ground water, sediment nutrient release, and atmospheric deposition. Nonpoint sources can also be described by the type of land use where the sources are generated.

A comprehensive summary of nonpoint source loading (by category) to the St. Marks–Wakulla River Basin was compiled by the NWFWMD (Chellette *et al.* 2002). The TP and TSS loadings based on land use were also determined by the NWFWMD (Bartel et al.1992a) as part of a countywide stormwater management plan.

### Land Uses

The spatial distribution and acreage of different land use categories in Florida were identified using the 1997 land use coverage (scale 1:40,000) contained in the Department's Geographic Information System (GIS) library. Land use categories in the watersheds (Leon County) were aggregated using the simplified Level 1/Level 3 codes tabulated in **Table 4.2a**. The spatial distribution and acreage of different land use categories were identified using COT land use and Leon County land use information (COT 2007; Leon County 2007). Land use categories in the watershed were aggregated using the simplified Level 1 codes tabulated in **Table 4.2b-1** through **4.2b-3** (totals are to Capital Circle). **Figure 4.2a** shows the acreage of the principal land uses in Leon County, while **Figure 4.2b** shows the principal land uses in the watershed.

## Table 4.2a Classification of Land Use Categories in Leon County

- = Empty cell/no data

| Code | Land Use | Acreage | Square Miles | % of Watershed |
|---|---|---|---|---|
| 1000 | Urban Open | 15,013 | 23.458 | 3.3% |
| 1100 | Low-Density Residential | 18,875 | 29.492 | 4.2% |
| 1200 | Medium-Density Residential | 16,540 | 25.844 | 3.7% |
| 1300 | High-Density Residential | 27,457 | 42.903 | 6.1% |
| 2000 | Agriculture | 35,515 | 55.492 | 7.9% |
| 3000+7000 | Rangeland | 4,427 | 6.9172 | 1.0% |
| 4000 | Forest/Rural Open | 242,830 | 379.42 | 54.1% |
| 5000 | Water | 13,574 | 21.210 | 3.0% |
| 6000 | Wetlands | 70,572 | 110.27 | 15.7% |
| 8000 | Communication and Transportation | 4,305.7 | 6.7276 | 1.0% |
| - | **Total** | **449,110** | **701.73** | **100.0%** |

## Table 4.2b-1 Classification of Land Use Categories in the Munson Slough/Lake Munson Watershed (COT)

- = Empty cell/no data

| Code | Land Use | Acreage | Square Miles | % of COT |
|---|---|---|---|---|
| 1000 | Urban and Built-Up | 8,060.45 | 12.5904 | 81.1854% |
| 2000 | Agriculture | 0.0000 | 0.0000 | 0.0000% |
| 3000 | Rangeland | 0.0000 | 0.0000 | 0.0000% |
| 4000 | Upland Forests | 0.0000 | 0.0000 | 0.0000% |
| 5000 | Water | 6.5696 | 0.0103 | 0.0662% |
| 6000 | Wetlands | 0.0000 | 0.0000 | 0.0000% |
| 7000 | Barren Land | 0.0000 | 0.0000 | 0.0000% |
| 8000 | Transportation, Communication and Utilities | 1,861.4210 | 2.9075 | 18.7484% |
| **-** | **Total** | **9,928.4356** | **15.5082** | **100.0000%** |

## Table 4.2b-2 Classification of Land Use Categories in the Munson Slough/Lake Munson Watershed (Leon County)

- = Empty cell/no data

| Code | Land Use | Acreage | Square Miles | % of Leon County |
|---|---|---|---|---|
| 1000 | Urban and Built-Up | 5,624.10 | 8.7848 | 26.6071% |
| 2000 | Agriculture | 56.7000 | 0.0886 | 0.2682% |
| 3000 | Rangeland | 5,591.2000 | 8.7335 | 26.4514% |
| 4000 | Upland Forests | 6,461.9000 | 10.0935 | 30.5706% |
| 5000 | Water | 0.0000 | 0.0000 | 0.0000% |
| 6000 | Wetlands | 2,507.1000 | 3.9161 | 11.8609% |
| 7000 | Barren Land | 0.0000 | 0.0000 | 0.0000% |
| 8000 | Transportation, Communication, and Utilities | 896.6000 | 1.4005 | 4.2417% |
| **-** | **Total** | **21,137.6000** | **33.0169** | **100.0000%** |

## Table 4.2b-3 Classification of Land Use Categories in the Munson Slough/Lake Munson Watershed (COT Plus Leon County)

- = Empty cell/no data

| Code | Land Use | Acreage | Square Miles | % of COT Plus Leon County |
|---|---|---|---|---|
| 1000 | Urban and Built-Up | 13,684.55 | 21.38 | 44.0499% |
| 2000 | Agriculture | 56.70 | 0.09 | 0.1825% |
| 3000 | Rangeland | 5,591.20 | 8.73 | 17.9978% |
| 4000 | Upland Forests | 6,461.90 | 10.09 | 20.8005% |
| 5000 | Water | 6.57 | 0.01 | 0.0211% |
| 6000 | Wetlands | 2,507.10 | 3.92 | 8.0702% |
| 7000 | Barren Land | 0.00 | 0.00 | 0.0000% |
| 8000 | Transportation, Communication, and Utilities | 2,758.02 | 4.31 | 8.8779% |
| **-** | **Total** | **31,066.0356** | **48.5251** | **100.0000%** |

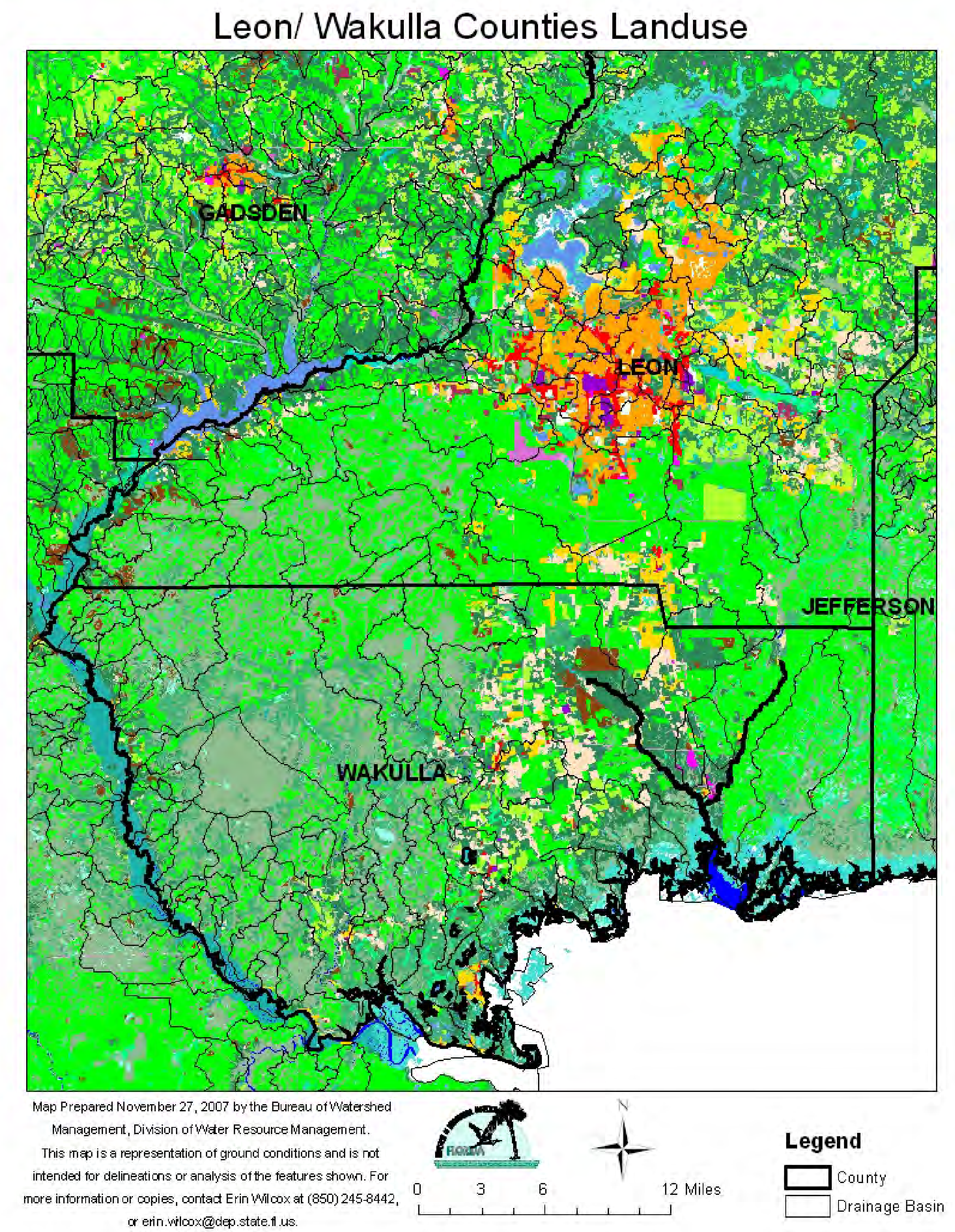



Figure 4.2a Principal Land Uses in the St. Marks–Wakulla River Basin in 2007

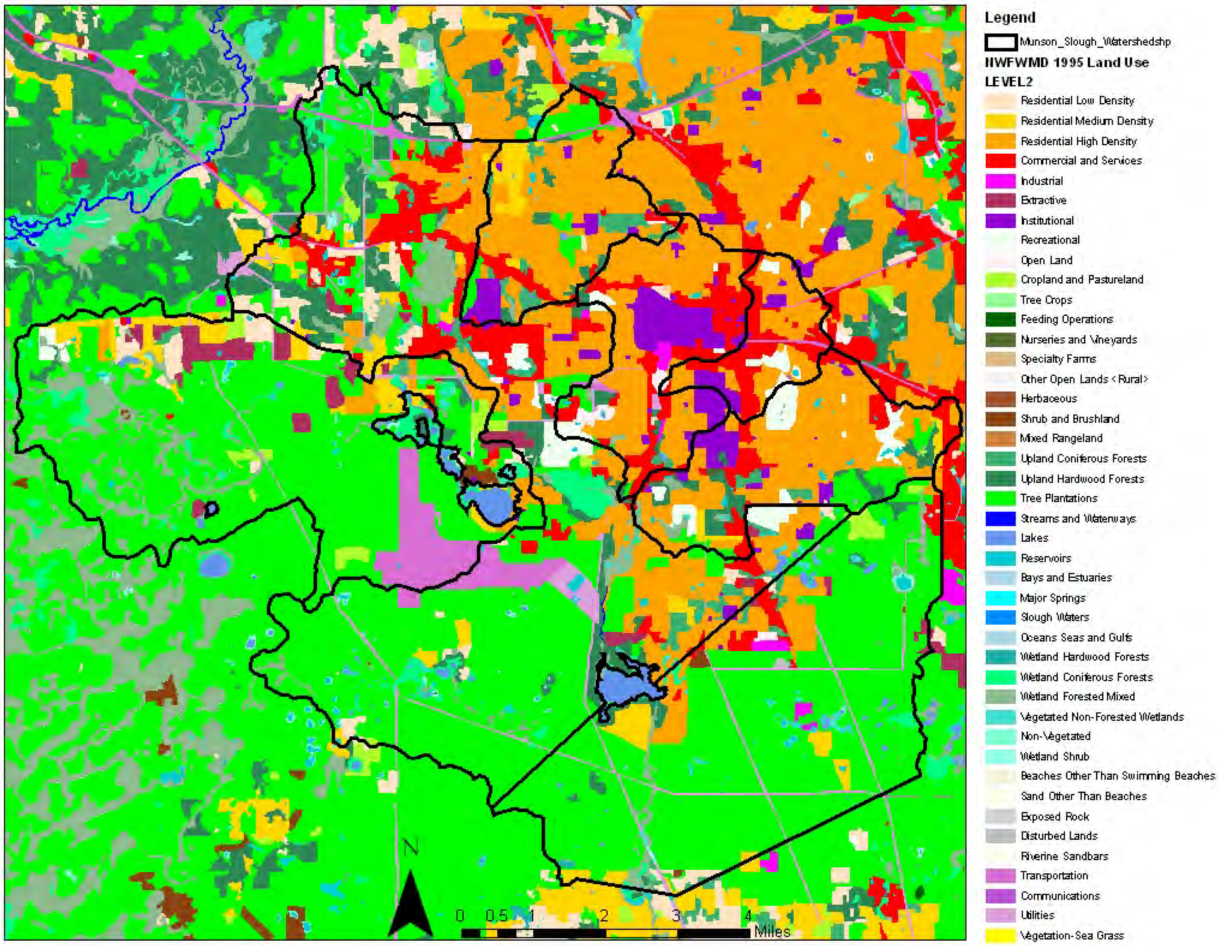



Figure 4.2b Principal Land Uses in the Munson Slough/Lake Munson Watershed in 1995

## Septic Tanks

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

As of 2006, Leon County had roughly 38,530 septic systems (Florida Department of Health [FDOH] website 2008). Data for septic tanks are based on 1970 to 2007 FDOH Census results, with year-by-year additions based on new septic tank construction. The data do not reflect septic tanks that have been removed going back to 1970. From 1991 to 2005, 5,849 permits (389.9 per year) for repairs were issued (FDOH website 2008). Based on the number (81,325) of housing units (HU) located in the county (U.S. Census Bureau 1990), approximately 58,881

(72.40%) of the HU are connected to a WWTF, with the remaining 22,090 (27.16%) utilizing septic tanks or cesspools, and 354 (0.44%) using other systems. Information on the distribution of septic tanks in the county was obtained from the FDOH website, as shown in **Appendix B.**

To estimate the TN and TP loading per septic system, the EPA methodology was used. The mean household use in Tampa, FL, is 65.8 gallons per capita per day (gal/cap/day) (EPA 2002). The Department used a value of:

Qseptic = 70 gal/cap/day* 2.6 persons /household*0.1337 (cuft/gal)*(1 day/(24*3600 sec)

Qseptic = 2.8164E-04 cfs/tank

To represent the water quality exiting the septic tank, the mean values of TN=50.5 mg/L and TP=9.0 mg/L were used (EPA 2002). **Appendix B** shows the estimates from 1970 to 2006 for Leon County. **Tables 4.4a** through **4.4d** list the loads for 1997.

### Agriculture

The USGS (Ruddy *et al.* 2006) has estimated nutrient inputs to the land surface at the county level from livestock, fertilizer use, and atmospheric deposition. **Appendix B** shows the estimates from 1987 to 2001 for Leon County. **Tables 4.4a** through **4.4d** list the loads for 1997.

### Livestock

The USGS (Goolsby 1999) developed methods to estimate the nitrogen (TN) and phosphorus (TP) content of manure generated by various types of livestock. The method accounts for the different life cycles of the animals on an annual basis and whether the animals were in confined or unconfined conditions. Losses of nitrogen due to storage, handling, and volatilization have also been determined. **Appendix B** shows the estimates from 1987 to 2001 for Leon County**.** **Tables 4.4a** through **4.4d** list the loads for 1997.

### Fertilizer

Several methods have been used to allocate state fertilizer data to counties. State fertilizer sales data, in tons, were compiled by the U.S. Census of Agriculture from 1945 through 1985. The USGS (Alexander and Smith 1990) used county fertilized-acreage data from the Census to allocate the state-level sales to fertilizer use in individual counties. The USGS also compiled additional data from 1985 to 2001 (Battaglin and Goolsby 1995). It was assumed that fertilizer sold in the county was used in the same year. Fertilizer in tons of product was converted to tons of nitrogen and phosphorus based on the chemical composition data for each product. In addition, fertilizer was divided into farm (agricultural) and nonfarm (urban) land use. **Appendix B** shows the estimates from 1987 to 2001 for Leon and Wakulla Counties**.** **Tables 4.4a** through **4.4d** list the loads for 1997.

### Atmospheric Deposition

The USGS obtained annual summaries of wet deposition in kilograms per hectare (kg/ha) from the National Atmospheric Deposition Program (NADP) website (NADP 2002). Nationwide wet deposition sites were utilized and developed into 1-kilometer (km) resolution grid cells. Annual wet deposition for each county by year was then developed from the grid cells in each county. **Appendix B** contains tables of TN (kilograms per year [kg/yr]). No TP data were developed, because concentrations were not considered significant and samples were subject to contamination.

The wet and dry atmospheric deposition rates (kg/ha/yr) for Leon and Wakulla Counties were calculated separately from the USGS, as noted in **Tables 4.4a** through **4.4d**. NADP data from 1984 to 2006 for the Quincy, FL site (FL14) were used and applied to the Leon County areas with values converted to pounds per year (lb/yr). These data are included in **Appendix B**. Dry deposition was assumed equal to wet deposition (wet:dry ratio=1.00) based on studies in Tampa Bay area (Poor *et al.* 2001; Pribble and Janicki 1999). There are some monitoring sites (Pollman 2003) where the wet:dry ratio is much lower (Sumatra, FL wet:dry ratio=1:0.19). However, the wet deposition data at the Sumatra, FL site (SUM156, CASTNET website 2007) were comparable to the Quincy site (FL14).

Additional studies from air pollution files at the Department (Rogers 2006) have compiled nitrogen oxides emissions (tons/yr) by county for various source categories. These categories include stationary point, stationary area, on-road mobile, nonroad mobile, and total sources. TP deposition data from early studies in Florida (Brezonik *et al.* 1983) show that wet+dry deposition of TP=59 milligrams per square meter per year (mg/sqm/yr). However, the Brezonik analysis showed that dry deposition accounted for 80% of the total. Concentration ranges for Florida studies from 1955 to 1975 ranged from 26 to 50 µg/L. The USGS (Irwin and Kirkland 1980) monitored TP in bulk precipitation (1977–78) at a site in Leon County near the Ochlockonee River and U.S. Highway 27. Results for five samples gave a mean TP of 0.03 mg/L (30 µg/L) and a range of 0.01 to 0.05 mg/L.

### Domesticated Animals

Domesticated animals can also be a source of nutrients to the Munson Slough watershed. The number of households (HH) can be used to estimate the numbers of dogs, cats, and horses in each county. Using nationwide figures from the American Veterinary Medical Association (AVMA) website (available: www.avma.org), the numbers are as follows:

NDOGS = 0.58* HH
NCATS = 0.66* HH
NHORSES = 0.05*HH

The fecal loading rates from a variety of farm and domestic animals are well documented in the literature (EPA 2001). However, the nutrient loading rates for dogs and cats were much more difficult to find. Warden (2007) of the Lahontan Regional Water Quality Control Board estimated that an average 45-pound dog will produce TN=13 lb/yr and TP=2 lb/yr. Using household census figures from 1990 and 2000, linear interpolation was used to estimate the number of dogs (NDOGS) for each year from 1970 to 2006 and the corresponding load. Domestic cats are not considered equivalent to dogs, because many use a litter box. However, the number of feral or wild cats (NFERALCATS) can be quite large.

Veterinary research in Canada (Funaba 2005) tested a variety of cat foods and measured the input and output of TN, TP, and other nutrients based on the body weight of an average cat (BW=4 kg). Domestic horses and ponies have the same loading rates as agricultural horses (Ruddy 2006). **Appendix B** shows the estimates from 1970 to 2005 for Leon County**. Tables 4.4a** through **4.4d** list the loads for 1997.

#### Wildlife

Another possible source of nutrients to Lake Munson could be wild animals. The Florida Department of Agriculture and Consumer Services (FDACS) notes that there are major wildlife areas along much of the lower Pine Barren Creek watershed in Escambia County. It was assumed that the deer density data are transferable to other areas until better data become available. The white-tailed deer population has been estimated at various densities); however, the Department used a deer density of 1 per 50 acres or 12.8/mi$^2$. **Appendix B** shows the estimated deer population for the St. Marks–Wakulla River Basin. Using the average TN and TP loading per animal (USDA Website 2007), the annual TN and TP loads to the watershed can be calculated.

Migratory waterfowl and other wild bird populations have been estimated annually from 1998 to 2006 (Birdsource 2007), as shown in **Appendix B**. The numbers of waterfowl and other birds are compiled annually through the Christmas bird count. Some birds may frequent wetland areas, while others may congregate near landfills.

Studies of nutrient loading from migratory waterfowl showed that median TN=3.15 grams per day per bird (g/day/bird) and TP=0.45 g/day/bird (Post *et al.* 1998). USGS summaries (Ruddy *et al.* 2006) of livestock nutrient loading show values for chickens and hens and tom and hen turkeys similar to these numbers,

The most recent TMDL work (Benham 2007) quantifying wildlife contributions to fecal coliform divides the load among eight categories of wildlife: deer, raccoons, muskrats, beavers, geese, ducks, wild turkeys, and other. **Appendix B** shows the estimates for Leon County. **Tables 4.4a** through **4.4d** list the loads for 1997.

#### Population

The U.S. Census Bureau reports that, in Leon County the total population for 2000 was 239,452 with 96,521 HH and 119,420 HU. For all of Leon County (**Figure 4.3**), the Bureau reported a housing density of 144.8 HH per square mile (155.9 HU per square mile). This places Leon County among the highest in housing densities in Florida (U.S. Census Bureau 2007). This conclusion is also supported by the data showing that 17.342% of the land use in Leon County is dedicated to urban and residential land uses.

### *4.2.3 Previous Nonpoint Source Runoff Loading Models Used To Assess Sources in the Munson Slough/Lake Munson Watershed*

#### NWFWMD 1992 Methods

The Storm Water Management Model (SWMM) (Bartel et al. 1992a) was calibrated based on long-term rainfall (1958–87) and limited hydrologic records for some of the 55 subbasins in the Munson Slough/Lake Munson watershed. The average annual and peak flow was computed at various cross-section locations measured from a zero mile point (Munson Slough at Oak Ridge Road). The average annual pollutant loads for TSS and TP (lb/ac/yr) were computed for each of the 55 subbasins.

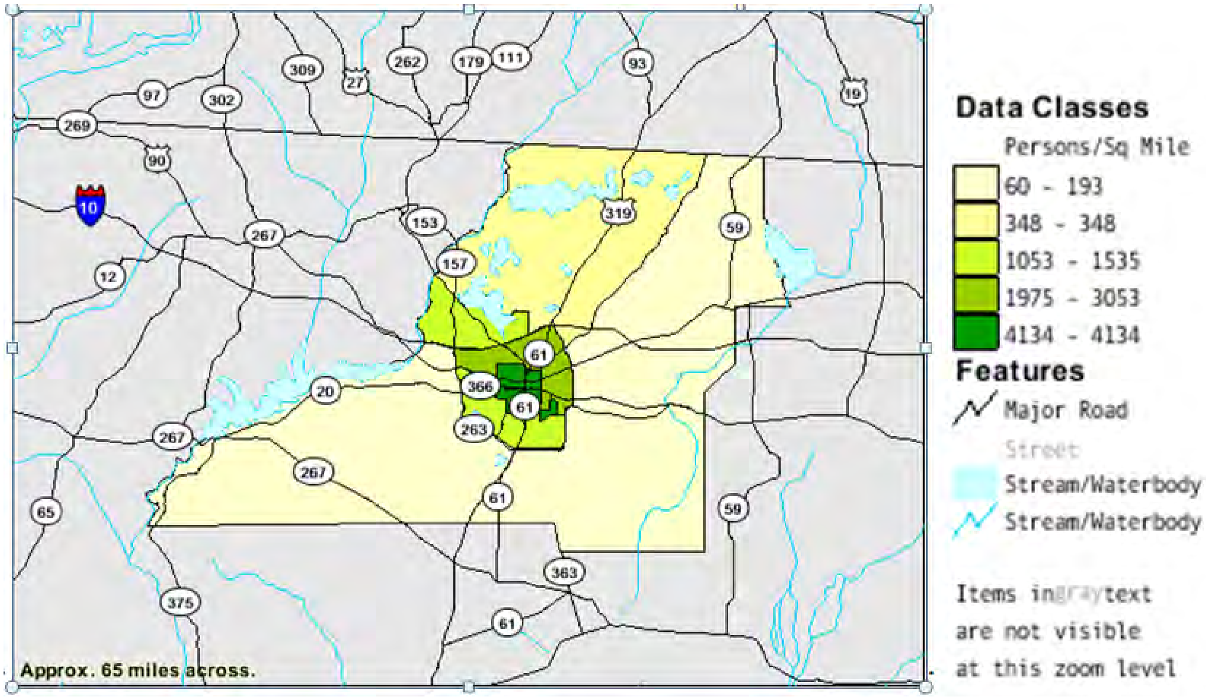



Figure 4.3 Population Density in Leon County, FL, in 2007

### COT 2002 Methods

COT and its consultants (Environmental Research and Design [ERD] 2000) developed a spreadsheet flow and loading model for each lake basin in Tallahassee and surrounding Leon County. The City of Tallahassee Nonpoint Source Loading and Management Model (CoTNSLMM) used a different approach than SWMM by extrapolating monitoring results from statewide event mean concentrations (EMCs) and locally measured storm events from four test watersheds. **Table 4.3** shows the annual loadings of TN, TP, BOD, and TSS (lb/yr) generated by each of 36 subbasins. Not all of the pollutants generated in each subbasin are actually delivered to Munson Slough and Lake Munson. COT incorporated pollutant removal in the watershed by existing dry detention, dry retention, and wet detention facilities. The pollutant loads along stream channels were also reduced by utilizing a delivery system reduction factor of 0.517 for the annual runoff volume for all subbasins. **Table 4.3** shows the results of the reduction in loads to Lake Munson.

### COT 2007 Methods

The COT method used in the 2007 NPDES MS4 permit submittal (COT 2007) was based on a different model than noted above. This current model is the WMM (CDM 1998a; 1998b). The COT portion of the Munson Slough/Lake Munson watershed was subdivided into 64 subbasins with labels defined by Outfall IDs. The total drainage area covered was 9,897.46 acres, which yielded a runoff of 26,801.84 acre-feet per year (ac-ft/yr). For example, the TP load was computed as 22,508 lb/yr. **Tables 4.4a** through **4.4d** provide a summary for an average year (1948–2005).

### Leon County 2007 Methods

Leon County and its consultants (CDM) developed pollutant load estimates using the WMM for portions of 19 watersheds in unincorporated Leon County. The Leon County portion of the Munson Slough/Lake Munson watershed included 21,137.7 acres. Annual load estimates for flow (29,540 ac-ft/yr), BOD, chemical oxygen demand (COD), total suspended solids (TSS), total dissolved solids (TDS), TKN, NO23N, dissolved phosphorus (DP), TP, cadmium (Cd), copper (Cu), lead (Pb), and zinc (Zn) (lb/yr) were computed as shown in **Appendix A, Tables A.2, A.3,** and **A.4**, both with and without BMPs. For example, the TP load without BMPs was 16,956 lb/yr and was only slightly reduced (5.2%) to 16,073 lb/yr with BMPs implemented. It should be noted that the loads did not include baseflow. **Tables 4.4a** through **4.4d** provide a summary for an average-year rainfall of 61.8 inches (1948–2005).

### Department Load Estimator (LOADEST) Model

The Department completed a regression analysis of loads for Munson Slough upstream of Lake Munson at Capital Circle SW (State Road 263). This site corresponds to NWFWMD Station 3 and the Department's Watershed Assessment Section (WAS) Station 955. The concentrations of nutrients were compiled from several agencies that collected data near these gage sites. The final regression equation is:

$$Ln (L) = A_0 + A_1 * Ln(Q) + A_2 * [ Ln (Q) ]^2 + A_3 * \sin(2\pi\ t/T) + A_4 * \cos(2\pi\ t/T)$$

Where:
L = instantaneous load,
t = decimal time (yr),
T = 1.0 yr,
Q (cfs) = average daily discharge or flow,
Ln = natural logarithm, and
$A_n$ = regression coefficients.

The five-parameter regression fit the data very well over the entire period analyzed (1987–2000). The $R^2$ values ranged from 0.92 for the TN data and 0.87 for the TP data. *Appendix B* in the *Supplemental Information* report contains the semilog plots of predicted and measured daily loads (lb/day) of long-term nitrogen (LTN) and long-term phosphorus (LTP) for each year from 1987 to 2000. Annual loads were the sum of daily loads. This analysis was repeated for parameters such as long-term $BOD_5$ ($LBOD_5$).

Flow measurements at NWFWMD gaging stations at the CDD at Orange Avenue (Station S19) and Munson Slough at State Road 263 (Station S3) were unfortunately discontinued in mid-2000. This data loss occurred at a critical time during the Leon County project to dredge and

## Table 4.3 COT 2002 Model Loads

- = Empty cell/no data

| Watershed | Basin Area (ac) | Volume (ac-ft/yr) | Mass Loading TN (lb/yr) | Mass Loading TP (lb/yr) | Mass Loading BOD (lb/yr) | Mass Loading TSS (lb/yr) |
|---|---|---|---|---|---|---|
| Airport | 576 | 776 | 4,360 | 580 | 36,560 | 39,389 |
| Alumni Village | 583 | 425 | 1,311 | 307 | 8,579 | 36,925 |
| Astoria Park | 1,126 | 646 | 2,191 | 531 | 10,317 | 85,818 |
| Balkin Road | 241 | 49 | 181 | 52 | 1,101 | 6,801 |
| Baseline | 232 | 32 | 116 | 46 | 665 | 3,561 |
| Bethel Church | 32 | 6 | 24 | 7 | 134 | 684 |
| Big Dog | 627 | 529 | 3,086 | 413 | 26,055 | 25,055 |
| Black Swamp | 875 | 343 | 1,135 | 422 | 5,554 | 33,487 |
| Bradford Brook | 10,384 | 2,345 | 7,462 | 2,710 | 41,528 | 190,365 |
| Campground | 145 | 17 | 68 | 23 | 424 | 1,685 |
| Eight Mile Pond | 3,200 | 822 | 2,512 | 651 | 16,443 | 79,433 |
| Empty | 137 | 1 | 4 | 2 | 15 | 68 |
| FSU | 2,984 | 2551 | 8,019 | 1,607 | 49,723 | 217,796 |
| Forbes | 892 | 11 | 35 | 18 | 147 | 677 |
| Forest Square | 47 | 16 | 48 | 14 | 412 | 1,561 |
| Godby High | 1,067 | 679 | 2,418 | 653 | 13,325 | 86,254 |
| Gum Creek North | 1,735 | 659 | 2,071 | 603 | 8,701 | 69,191 |
| Gum Creek West | 1,631 | 728 | 2,226 | 688 | 14,239 | 62,512 |
| Gum Swamp | 1,648 | 1,029 | 2,831 | 692 | 15,320 | 70,362 |
| Indian Head | 2,933 | 1,863 | 6,050 | 1,555 | 41,856 | 188,508 |
| Innovation Park | 130 | 72 | 184 | 33 | 1,498 | 2,869 |
| Koger | 936 | 499 | 1717 | 462 | 8,746 | 52,905 |
| Leon High | 1,494 | 1,272 | 3,878 | 762 | 24,006 | 96,453 |
| Monday Street | 53 | 15 | 54 | 18 | 356 | 1,519 |
| Moore Lake | 286 | 19 | 61 | 30 | 253 | 1,163 |
| North Munson Slough | 520 | 191 | 612 | 158 | 2,670 | 7,824 |
| North Tennessee | 323 | 225 | 730 | 191 | 4,226 | 23,768 |
| Ocala Road | 45 | 31 | 93 | 18 | 594 | 2,758 |
| Poodle | 271 | 423 | 2,474 | 329 | 20,916 | 20,021 |
| Ruth | 36 | 8 | 27 | 12 | 128 | 537 |
| South Tennessee | 78 | 66 | 185 | 39 | 1,098 | 5,661 |
| Sylvan Lake | 69 | 37 | 127 | 40 | 935 | 5,052 |
| Trimble Road | 196 | 54 | 183 | 44 | 949 | 6,426 |
| West Ditch | 1,132 | 1,001 | 2,932 | 632 | 17,601 | 78,910 |
| West Tennessee | 1,559 | 1,216 | 4,754 | 1,027 | 30,423 | 111,030 |
| West Tharpe | 509 | 341 | 1,028 | 206 | 6,509 | 24,445 |
| Tables 5.4a and 5.4b | - | - | - | - | - | - |
| **Sum to Mouth Munson Dam–Generated** | **38,732** | **18,997** | **65,187** | **15,575** | **412,006** | **1,641,473** |
| **Table 5.11–Delivered** | **38,732** | **17,632** | **34,925** | **3,521** | **100,275** | **176,466** |

reconfigure Lake Henrietta and Munson Slough downstream of Springhill Road. The Department made miscellaneous flow measurements (*Appendix F* in the *Supplemental Information* report) for Munson Slough and tributaries during the 1997 to 2008 period, but these data were insufficient to reconstruct a daily flow record from daily stage data. Several techniques used to calculate daily flow are summarized below and in *Appendix F* in the *Supplemental Information* report:

1. *The Station S3 stage and flow data were correlated annually for 1987 to 2000 as well as individual years. The correlation equations were then applied to the Station S3 stage data beyond 2000. Since Munson Slough was reconfigured into a somewhat uniform trapezoidal channel, the older relationships yielded flow values that were too high. The construction of a weir upstream of State Road 263 and backwater effects from Lake Munson also complicated the analysis.*

2. *The WDD at Roberts Ave. (Station S20) flows were correlated with the flow at Munson Slough for the period from 1987 to 2000. Although there is a reasonable correlation, the intervening hydrology makes this relationship tenuous. During high flows, a significant part of the flow from the WDD is diverted into Grassy Lake and Lake Bradford, depending on the relative elevations of water levels in these waterbodies (Wieckowicz et al. 2008b). The Bradford Brook/Lake Bradford system becomes a storage system instead of a tributary to Munson Slough. The Black Swamp portion of Munson Slough, downstream of the WDD/Bradford Brook system, also acts a reservoir affecting the timing and magnitude of flows to Munson Slough.*

3. *Using a combination of Q and drainage area (DA) ratios for the WDD, SAB, and EDD, the daily flows were also estimated for Munson Slough at State Road 263 for the period from 1987 to 2007. The correlation between predicted and measured flows shows that peak flows were too high. Part of the problem is that the large stormwater storage facilities along the CDD and EDD, and the reconfiguration of the EDD, were not incorporated into the analysis.*

4. *Another methodology used the Manning Equation for the Munson Slough trapezoidal channel upstream and downstream of State Road 263. Daily stream elevations were available for NWFWMD Stations 645, 3, 646, and 647 during a three-year period. Stream slopes were computed from several combinations of these stations, and a range of Manning "n" values was used to compute daily flows.*

5. *Flows at Station S3 were also correlated with rainfall at the Tallahassee Regional Airport for the previous 3-, 10-, and 30-day periods, as shown in* Appendix F *of the* Supplemental Information *report. None of these correlations was very successful in predicting daily flows. The annual average flow at Station S3 was also compared with annual average rainfall, as shown in* Appendix F *of the* Supplemental Information *report. The correlation between flow (Q3) and rainfall (x) is approximated by:*
   $Q3 = 0.0137\, x^2 - 0.1039\, x$ *(RSQ= 0.7817).*

## 4.3 Source Summary

### *4.3.1 Summary of the Nutrient Loadings in Leon County and Lake Munson from Various Sources*

**Table 4.4a** summarizes the annual average $BOD_5$ loadings for 1997 from point sources and each of the nonpoint source categories detailed above generated in Leon County and/or the Munson Slough/Lake Munson watershed. Missing data are shown as a zero load. **Tables 4.4b, 4.4c,** and **4.4d** summarize the average daily TKN, TN, and TP loads, respectively, to the Munson Slough/Lake Munson watershed for the categories noted above. **Appendix B** gives a detailed breakdown for each category.

## 4.4 Lake Munson TMDLs (WBID 807C)

### *4.4.1 Surface Water Runoff*

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

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

The WMM, developed by CDM for the Department, is a land use pollutant loading model to estimate annual or seasonal pollutant loading from pollution sources (i.e., nonpoint and point source) in a watershed or a subbasin (CDM 1998a; 1998b). The loading estimation using the WMM can be executed based on the EMCs of pollutants, land use, percent impervious, and annual rainfall. The model also can address watershed management needs for identified nonpoint source pollution as a part of BMPs.

## Table 4.4a Summary of $BOD_5$ Loads to the Munson Slough/Lake Munson Watershed, 1997

- = Empty cell/no data

| Estimated Annual Loading | Year(s) | Flow (MGD) | Leon County $BOD_5$ (lb/yr) | Munson Basin $BOD_5$ (lb/yr) |
|---|---|---|---|---|
| POINT SOURCES | - | - | - | - |
| COT TP SMITH | 1975 | - | 4.6538E+05 | 4.6538E+05 |
| COT LAKE BRADFORD | 1975 | - | 7.2197E+05 | 7.2197E+05 |
| COT DALE MABRY | 1975 | - | 1.9345E+04 | 1.9345E+04 |
| TOTAL POINT SOURCE LOAD | 1975 | - | 1.2067E+06 | 1.2067E+06 |
| COT TP SMITH (FLA010139) R-001 | 2008 | 23.2500 | 9.6953E+02 | - |
| COT TP SMITH (FLA010139) R-002 | 2008 | 0.8000 | 3.3360E+01 | 3.3360E+01 |
| COT TP SMITH (FLA010139) R-003 | 2008 | 4.2600 | 1.7764E+02 | - |
| COT TP SMITH (FLA010139) R-004 | 2008 | - | - | - |
| SANDSTONE RANCH WWTF (FLA010167) R-001 | 2007 | 0.0707 | 1.1793E+01 | 1.1793E+01 |
| WESTERN ESTATES MHP (FLA010152) R-001 | 2007 | 0.0200 | 3.3360E+00 | 3.3360E+00 |
| SOUTHERN BELL TRAILER PARK (FLA010151) R-002 | 2007 | 0.0250 | 4.1700E+00 | 4.1700E+00 |
| LAKE BRADFORD ESTATES (FLA010148) R-001 | 2005 | 0.0430 | 7.1724E+00 | 7.1724E+00 |
| LAKE BRADFORD ROAD WWTP (FLA010140) R-001/R-003 | 2008 | - | - | 0.0000E+00 |
| LAKE BRADFORD ROAD WWTP (FLA010140) R-005 | 2008 | 4.5000 | 1.8765E+02 | 1.8765E+02 |
| NONPOINT SOURCES | - | - | - | - |
| DEPARTMENT ATMOSPHERIC DEPOSITION WET+DRY | 1997 | - | - | - |
| USGS ATMOSPHERIC DEPOSITION | 1997 | - | - | - |
| USGS NONFARM FERTILIZER USE | 1997 | - | - | - |
| USGS FARM FERTILIZER USE | 1997 | - | - | - |
| USGS UNCONFINED LIVESTOCK | 1997 | - | - | - |
| USGS CONFINED LIVESTOCK | 1997 | - | - | - |
| TOTAL USGS AGRICULTURE | 1997 | - | - | - |
| TOTAL BASEFLOW | 1997 | - | - | - |
| TOTAL GROUND WATER SEEPAGE LOSS | 1997 | - | - | - |
| TOTAL SEPTIC TANKS | 1997 | - | 4.3284E+06 | 7.6042E+05 |
| TOTAL SPILLS SEWAGE | 1997 | - | - | - |
| TOTAL LEAKS SEWAGE | 1997 | - | 1.2176E+06 | 2.1391E+05 |
| TOTAL SLUDGE/RESIDUALS LOADING | 1997 | - | - | - |
| SURFACE RUNOFF WMM MODEL | - | - | - | - |
| COT NPDES MS4 | - | - | - | 6.5655E+05 |
| LEON CO NPDES MS4 | - | - | - | 6.4300E+05 |
| TOTAL SURFACE RUNOFF WMM MODEL | - | - | - | 1.2996E+06 |
| TOTAL WILDLIFE | 1997 | - | - | - |
| TOTAL DOMESTIC ANIMALS | 1997 | - | - | - |
| TOTAL NONPOINT SOURCE LOAD | 1997 | - | - | - |
| TOTAL MEASURED REGRESSION LOADS LOADEST | 1997 | - | - | 4.6259E+05 |
| TOTAL NUTRIENT WATER COLUMN IN LAKE | 1997 | - | - | - |
| TOTAL MACROPHYTE NUTRIENT STORED IN LAKE | 1997 | - | - | - |
| TOTAL SEDIMENT NUTRIENT RELEASE | 1997 | - | - | - |
| TOTAL SEDIMENT NUTRIENT STORED IN LAKE | 1997 | - | - | - |
| TOTAL SEDIMENT NUTRIENT DREDGED FROM LAKE | 2000 | - | - | - |

## Table 4.4b Summary of TKN Loads to the Munson Slough/Lake Munson Watershed, 1997

- = Empty cell/no data

| Estimated Annual Loading | Year(s) | Flow (MGD) | Leon County TKN (lb/yr) | Munson Basin (lb/yr) |
|---|---|---|---|---|
| **POINT SOURCES** | - | - | - | - |
| COT TP SMITH | 1975 | - | - | - |
| COT LAKE BRADFORD | 1975 | - | - | - |
| COT DALE MABRY | 1975 | - | - | - |
| TOTAL POINT SOURCE LOAD | 1975 | - | - | - |
| COT TP SMITH (FLA010139) R-001 | 2008 | 23.2500 | - | - |
| COT TP SMITH (FLA010139) R-002 | 2008 | 0.8000 | - | - |
| COT TP SMITH (FLA010139) R-003 | 2008 | 4.2600 | - | - |
| COT TP SMITH (FLA010139) R-004 | 2008 | - | - | - |
| SANDSTONE RANCH WWTF (FLA010167) R-001 | 2007 | 0.0707 | - | - |
| WESTERN ESTATES MHP (FLA010152) R-001 | 2007 | 0.0200 | - | - |
| SOUTHERN BELL TRAILER PARK (FLA010151) R-002 | 2007 | 0.0250 | - | - |
| LAKE BRADFORD ESTATES (FLA010148) R-001 | 2005 | 0.0430 | - | - |
| LAKE BRADFORD ROAD WWTP (FLA010140) R-001/R-003 | 2008 | - | - | - |
| LAKE BRADFORD ROAD WWTP (FLA010140) R-005 | 2008 | 4.5000 | - | - |
| NONPOINT SOURCES | - | - | - | - |
| DEPARTMENT ATMOSPHERIC DEPOSITION WET+DRY | 1997 | - | - | - |
| USGS ATMOSPHERIC DEPOSITION | 1997 | - | - | - |
| USGS NONFARM FERTILIZER USE | 1997 | - | - | - |
| USGS FARM FERTILIZER USE | 1997 | - | - | - |
| USGS UNCONFINED LIVESTOCK | 1997 | - | - | - |
| USGS CONFINED LIVESTOCK | 1997 | - | - | - |
| TOTAL USGS AGRICULTURE | 1997 | - | - | - |
| TOTAL BASEFLOW | 1997 | - | - | - |
| TOTAL GROUND WATER SEEPAGE LOSS | 1997 | - | - | - |
| TOTAL SEPTIC TANKS | 1997 | - | 9.7169E+05 | 1.7071E+05 |
| TOTAL SPILLS SEWAGE | 1997 | - | - | - |
| TOTAL LEAKS SEWAGE | 1997 | - | 2.4352E+05 | 4.2781E+04 |
| TOTAL SLUDGE/RESIDUALS LOADING | 1997 | - | - | - |
| SURFACE RUNOFF WMM MODEL | - | - | - | - |
| COT NPDES MS4 | - | - | - | 8.3174E+04 |
| LEON CO NPDES MS4 | - | - | - | 8.1814E+04 |
| TOTAL SURFACE RUNOFF WMM MODEL | - | - | - | 1.6499E+05 |
| TOTAL WILDLIFE | 1997 | - | - | - |
| TOTAL DOMESTIC ANIMALS | 1997 | - | - | - |
| TOTAL NONPOINT SOURCE LOAD | 1997 | - | - | - |
| TOTAL MEASURED REGRESSION LOADS LOADEST | 1997 | - | - | - |
| TOTAL NUTRIENT WATER COLUMN IN LAKE | 1997 | - | - | - |
| TOTAL MACROPHYTE NUTRIENT STORED IN LAKE | 1997 | - | - | - |
| TOTAL SEDIMENT NUTRIENT RELEASE | 1997 | - | - | - |
| TOTAL SEDIMENT NUTRIENT STORED IN LAKE | 1997 | - | - | - |
| TOTAL SEDIMENT NUTRIENT DREDGED FROM LAKE | 2000 | - | - | - |

## Table 4.4c Summary of TN Loads to the Munson Slough/Lake Munson Watershed, 1997

= Empty cell/no data

| Estimated Annual Loading | Year(s) | Flow (MGD) | Leon County TN (lb/yr) | Munson Basin TN (lb/yr) |
|---|---|---|---|---|
| POINT SOURCES | - | - | - | - |
| COT TP SMITH | 1975 | - | 5.0188E+05 | 5.0188E+05 |
| COT LAKE BRADFORD | 1975 | - | 2.4966E+05 | 2.4966E+05 |
| COT DALE MABRY | 1975 | - | 8.7600E+03 | 8.7600E+03 |
| TOTAL POINT SOURCE LOAD | 1975 | - | 7.6030E+05 | 7.6030E+05 |
| COT TP SMITH (FLA010139) R-001 | 2008 | 23.2500 | 5.8172E+02 | - |
| COT TP SMITH (FLA010139) R-002 | 2008 | 0.8000 | 2.0016E+01 | 2.0016E+01 |
| COT TP SMITH (FLA010139) R-003 | 2008 | 4.2600 | 1.0659E+02 | - |
| COT TP SMITH (FLA010139) R-004 | 2008 | - | - | - |
| SANDSTONE RANCH WWTF (FLA010167) R-001 | 2007 | 0.0707 | 2.3586E+00 | 2.3586E+00 |
| WESTERN ESTATES MHP (FLA010152) R-001 | 2007 | 0.0200 | 6.6720E-01 | 6.6720E-01 |
| SOUTHERN BELL TRAILER PARK (FLA010151) R-002 | 2007 | 0.0250 | 8.3400E-01 | 8.3400E-01 |
| LAKE BRADFORD ESTATES (FLA010148) R-001 | 2005 | 0.0430 | 1.4345E+01 | 1.4345E+01 |
| LAKE BRADFORD ROAD WWTP (FLA010140) R-001/R-003 | 2008 | - | - | 0.0000E+00 |
| LAKE BRADFORD ROAD WWTP (FLA010140) R-005 | 2008 | 4.5000 | 1.1259E+02 | 1.1259E+02 |
| NONPOINT SOURCES | - | - | - | - |
| DEPARTMENT ATMOSPHERIC DEPOSITION WET+DRY | 1997 | - | 2.6676E+06 | 1.9428E+05 |
| USGS ATMOSPHERIC DEPOSITION | 1997 | - | 1.3313E+06 | 9.6956E+04 |
| USGS NONFARM FERTILIZER USE | 1997 | - | 9.3787E+05 | 1.4974E+03 |
| USGS FARM FERTILIZER USE | 1997 | - | 2.2947E+05 | 3.6637E+02 |
| USGS UNCONFINED LIVESTOCK | 1997 | - | 5.1036E+05 | 8.1485E+02 |
| USGS CONFINED LIVESTOCK | 1997 | - | 2.4140E+05 | 3.8543E+02 |
| TOTAL USGS AGRICULTURE | 1997 | - | 1.9191E+06 | 3.0641E+03 |
| TOTAL BASEFLOW | 1997 | - | - | - |
| TOTAL GROUND WATER SEEPAGE LOSS | 1997 | - | - | - |
| TOTAL SEPTIC TANKS | 1997 | - | 9.9132E+05 | 1.7416E+05 |
| TOTAL SPILLS SEWAGE | 1997 | - | - | - |
| TOTAL LEAKS SEWAGE | 1997 | - | 2.4352E+05 | 4.2781E+04 |
| TOTAL SLUDGE/RESIDUALS LOADING | 1997 | - | 2.0000E+03 | - |
| SURFACE RUNOFF WMM MODEL | - | - | - | - |
| COT NPDES MS4 | - | - | - | 1.1323E+05 |
| LEON CO NPDES MS4 | - | - | - | 1.1084E+05 |
| TOTAL SURFACE RUNOFF WMM MODEL | - | - | - | 2.2407E+05 |
| TOTAL WILDLIFE | 1997 | - | - | 1.5723E+05 |
| TOTAL DOMESTIC ANIMALS | 1997 | - | - | 2.0004E+05 |
| TOTAL NONPOINT SOURCE LOAD | 1997 | - | - | - |
| TOTAL MEASURED REGRESSION LOADS LOADEST | 1997 | - | - | 6.9938E+04 |
| TOTAL NUTRIENT WATER COLUMN IN LAKE | 1997 | - | - | 1.7064E+03 |
| TOTAL MACROPHYTE NUTRIENT STORED IN LAKE | 1997 | - | - | 4.8884E+03 |
| TOTAL SEDIMENT NUTRIENT RELEASE | 1997 | - | - | 1.2921E+04 |
| TOTAL SEDIMENT NUTRIENT STORED IN LAKE | 1997 | - | - | - |
| TOTAL SEDIMENT NUTRIENT DREDGED FROM LAKE | 2000 | - | - | 3.8714E+06 |

## Table 4.4d Summary of TP Loads to Munson Slough/Lake Munson Watershed, 1997

- = Empty cell/no data

| Estimated Annual Loading | Year(s) | Flow (MGD) | Leon County TP (lb/yr) | Munson Basin TP (lb/yr) |
|---|---|---|---|---|
| POINT SOURCES | - | - | - | - |
| COT TP SMITH | 1975 | - | 1.6717E+05 | 1.6717E+05 |
| COT LAKE BRADFORD | 1975 | - | 7.4825E+04 | 7.4825E+04 |
| COT DALE MABRY | 1975 | - | 1.3870E+04 | 1.3870E+04 |
| TOTAL POINT SOURCE LOAD | 1975 | - | 2.5587E+05 | 2.5587E+05 |
| COT TP SMITH (FLA010139) R-001 | 2008 | 23.2500 | 4.8476E+02 | - |
| COT TP SMITH (FLA010139) R-002 | 2008 | 0.8000 | 1.6680E+01 | 1.6680E+01 |
| COT TP SMITH (FLA010139) R-003 | 2008 | 4.2600 | 8.8821E+01 | - |
| COT TP SMITH (FLA010139) R-004 | 2008 | - | - | - |
| SANDSTONE RANCH WWTF (FLA010167) R-001 | 2007 | 0.0707 | - | - |
| WESTERN ESTATES MHP (FLA010152) R-001 | 2007 | 0.0200 | - | - |
| SOUTHERN BELL TRAILER PARK (FLA010151) R-002 | 2007 | 0.0250 | - | - |
| LAKE BRADFORD ESTATES (FLA010148) R-001 | 2005 | 0.0430 | - | - |
| LAKE BRADFORD ROAD WWTP (FLA010140) R-001/R-003 | 2008 | - | - | - |
| LAKE BRADFORD ROAD WWTP (FLA010140) R-005 | 2008 | 4.5000 | 9.3825E+01 | - |
| NONPOINT SOURCES | - | - | - | - |
| DEPARTMENT ATMOSPHERIC DEPOSITION WET+DRY | 1997 | - | 2.8450E+04 | 2.0720E+03 |
| USGS ATMOSPHERIC DEPOSITION | 1997 | - | - | - |
| USGS NONFARM FERTILIZER USE | 1997 | - | 1.3710E+05 | 2.1890E+02 |
| USGS FARM FERTILIZER USE | 1997 | - | 4.1006E+04 | 6.5471E+01 |
| USGS UNCONFINED LIVESTOCK | 1997 | - | 1.2200E+05 | 1.9478E+02 |
| USGS CONFINED LIVESTOCK | 1997 | - | 5.5463E+04 | 8.8554E+01 |
| TOTAL USGS AGRICULTURE | 1997 | - | 3.5557E+05 | 5.6771E+02 |
| TOTAL BASEFLOW | 1997 | - | - | - |
| TOTAL GROUND WATER SEEPAGE LOSS | 1997 | - | - | - |
| TOTAL SEPTIC TANKS | 1997 | - | 1.7667E+05 | 3.1038E+04 |
| TOTAL SPILLS SEWAGE | 1997 | - | | |
| TOTAL LEAKS SEWAGE | 1997 | - | 6.0879E+04 | 1.0695E+04 |
| TOTAL SLUDGE/RESIDUALS LOADING | 1997 | - | 1.0000E+03 | - |
| SURFACE RUNOFF WMM MODEL | - | - | - | - |
| COT NPDES MS4 | - | - | - | 2.2508E+04 |
| LEON CO NPDES MS4 | - | - | - | 1.6956E+04 |
| TOTAL SURFACE RUNOFF WMM MODEL | - | - | - | 3.9464E+04 |
| TOTAL WILDLIFE | 1997 | - | - | 8.6660E+01 |
| TOTAL DOMESTIC ANIMALS | 1997 | - | - | 3.2341E+04 |
| TOTAL NONPOINT SOURCE LOAD | 1997 | - | - | |
| TOTAL MEASURED REGRESSION LOADS LOADEST | 1997 | - | - | 2.4101E+04 |
| TOTAL NUTRIENT WATER COLUMN IN LAKE | 1997 | - | - | 5.6879E+02 |
| TOTAL MACROPHYTE NUTRIENT STORED IN LAKE | 1997 | - | - | 1.1006E+03 |
| TOTAL SEDIMENT NUTRIENT RELEASE | 1997 | - | - | 9.0931E+02 |
| TOTAL SEDIMENT NUTRIENT STORED IN LAKE | 1997 | - | - | - |
| TOTAL SEDIMENT NUTRIENT DREDGED FROM LAKE | 2000 | - | - | 5.5912E+06 |

The WMM estimates annual pollution loads for each land use based on EMCs for different pollutants and average annual surface runoff from land use. **Table 4.5** lists the EMCs used for this analysis. The pollutant loading ($M_L$ in the unit of lbs/ac/yr) is then computed for each land use by the following equation:

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

Where:

- $M_L$ = loading factor for land use L (lbs/ac/yr),
- $EMC_L$ = event mean concentration of runoff from land use L (mg/L); EMC varies by land use and pollutant,
- $R_L$ = total average annual surface runoff from land use L (in/yr), and
- K = 0.2266, a unit conversion constant.

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

$$(2) \qquad R_L = [C_p + (C_I – C_p) IMP_L] * I$$

Where:

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

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

Additionally, **Table 4.5** shows the relationship between the TN:TP ratios in runoff (EMCs) from various land uses. From these data, it appears that the loadings from residential, commercial and services, cropland and pasture, and transportation land uses are contributing to nitrogen limitation, while the loadings from upland forest/rural open, water, and wetland land uses are contributing to co-limitation. **Table 4.6** contains the percent imperviousness used (as directly connected impervious area [DCIA]) for each land use in the model and runoff coefficients, respectively. Runoff coefficients (**Table 4.7**) are important parameters to estimate runoff volume. Typically, a runoff coefficient of 0.20 can be used for pervious areas, while a coefficient of 0.90 is used for impervious areas (WMM 1998).

For use in the Lake Munson watershed, the governing equations from the WMM were incorporated into an Excel spreadsheet. To model the Lake Munson watershed, a drainage basin for Munson Slough Flow Station S20 was created, as shown in **Figure 4.4**. Runoff coefficients for the new basin were first adjusted to calibrate to the measured flow upstream of Flow Station S20, and then the calibrated coefficients were applied to the entire Lake Munson watershed.

## Table 4.5 WMM EMC Input Parameters

[a] Values for the EMCs are obtained from Harper and Baker (2003)
[b] Values for the EMCs are obtained from Harper and Baker (2007).

| Land Use Category | TN (mg/L) | TP (mg/L) | TN:TP |
|---|---|---|---|
| Low-Density Residential | 1.61[b] | 0.191[b] | 8.4 |
| Medium-Density Residential | 1.29[b] | 0.505[b] | 2.5 |
| High-Density Residential | 1.22[b] | 0.380[b] | 3.2 |
| Commercial and Services | 1.12[a] | 0.180[a] | 6.2 |
| Cropland and Pastureland | 2.79[a] | 0.431[a] | 6.5 |
| Upland Forests/Rural Open | 1.09[a] | 0.046[a] | 23.7 |
| Water | 1.60[a] | 0.067[a] | 23.9 |
| Wetlands | 1.01[a] | 0.090[a] | 11.2 |
| Transportation and Communication | 1.10[b] | 0.166[a] | 6.6 |

## Table 4.6 Percentage of DCIA Used in the WMM

[a] Percent DCIA referred to Harper and Baker (2003)
[b] Percent DCIA referred to Brown (1995)
[c] Percent DCIA referred to CDM (1998a; 1998b)
[d] Percent DCIA referred to Harper and Livingston (1999)

| Florida Land Use, Cover, and Form Classification System (FLUCCS) Code | Land Use Category | Lake Munson Basin (acres) | Munson Slough Subbasin for Station S20 (acres) | % DCIA |
|---|---|---|---|---|
| 1100 | Low-Density Residential | 3,790 | 1,321 | 14.7%[a] |
| 1200 | Medium-Density Residential | 3,675 | 1,281 | 18.7%[b] |
| 1300 | High-Density Residential | 4,,020 | 1401 | 29.6%[b] |
| 1400 | Commercial and Services | 7048 | 2,135 | 44.38%[c] |
| 2100 | Cropland and Pastureland | 335 | 80 | 0.0%[a] |
| 4000 | Upland Forests/Rural Open | 11,664 | 2,888 | 0.5%[a] |
| 5000 | Water | 730 | 85 | 30.0%[d] |
| 6000 | Wetlands | 2,780 | 737 | 30.0%[d] |
| 8200 | Transportation/Communication/Utility | 755 | 334 | 36.2%[b] |

### Table 4.7 Runoff Coefficients by Year Used in the WMM

[1] Runoff coefficients are a fractional percentage of 1.

| Year | Impervious[1] | Pervious[1] |
|---|---|---|
| 2000 | 0.99 | 0.17 |
| 2001 | 0.99 | 0.30 |
| 2002 | 0.80 | 0.01 |
| 2003 | 0.99 | 0.13 |
| 2004 | 0.95 | 0.07 |
| 2005 | 0.96 | 0.10 |
| 2006 | 0.80 | 0.01 |
| 2007 | 0.90 | 0.02 |

For the Lake Munson TMDL, all nonpoint sources were evaluated by the use of a watershed model and a regression model for the lake. Land use coverages for the watershed were aggregated using FLUCCS (1999) into nine different land use categories: cropland/pastureland, upland forests/rural open, commercial/industrial, transportation, high-density residential (HDR), low-density residential (LDR), medium-density residential (MDR), water, and wetlands.

**Figure 4.5** shows the area of the various land use categories in the Lake Munson/Munson Slough watersheds in 1999. **Figure 4.6** indicates the percent acreage of various land uses for the Lake Munson watershed, and **Figure 4.7** shows the percent acreage of land uses for the Munson Slough subbasin at Station S20. Based on information from COT (2010) and as shown in **Figure 4.6**, the predominant land coverages for the Lake Munson watershed include upland forest/rural open (33.5%), HDR (12.0%), and commercial/industrial (20.3%). Other uses include MDR (10.6%), LDR (10.9%), wetlands (8.0%), transportation (2.2%), water (not including Lake Munson) (2.1%), and cropland/pastureland (1.0 %).

## 4.5 Estimating Point and Nonpoint Source Loadings to Lake Munson

### *4.5.1 Model Approach*

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


Figure 4.4 Lake Munson Watershed and Calibration Subbasin

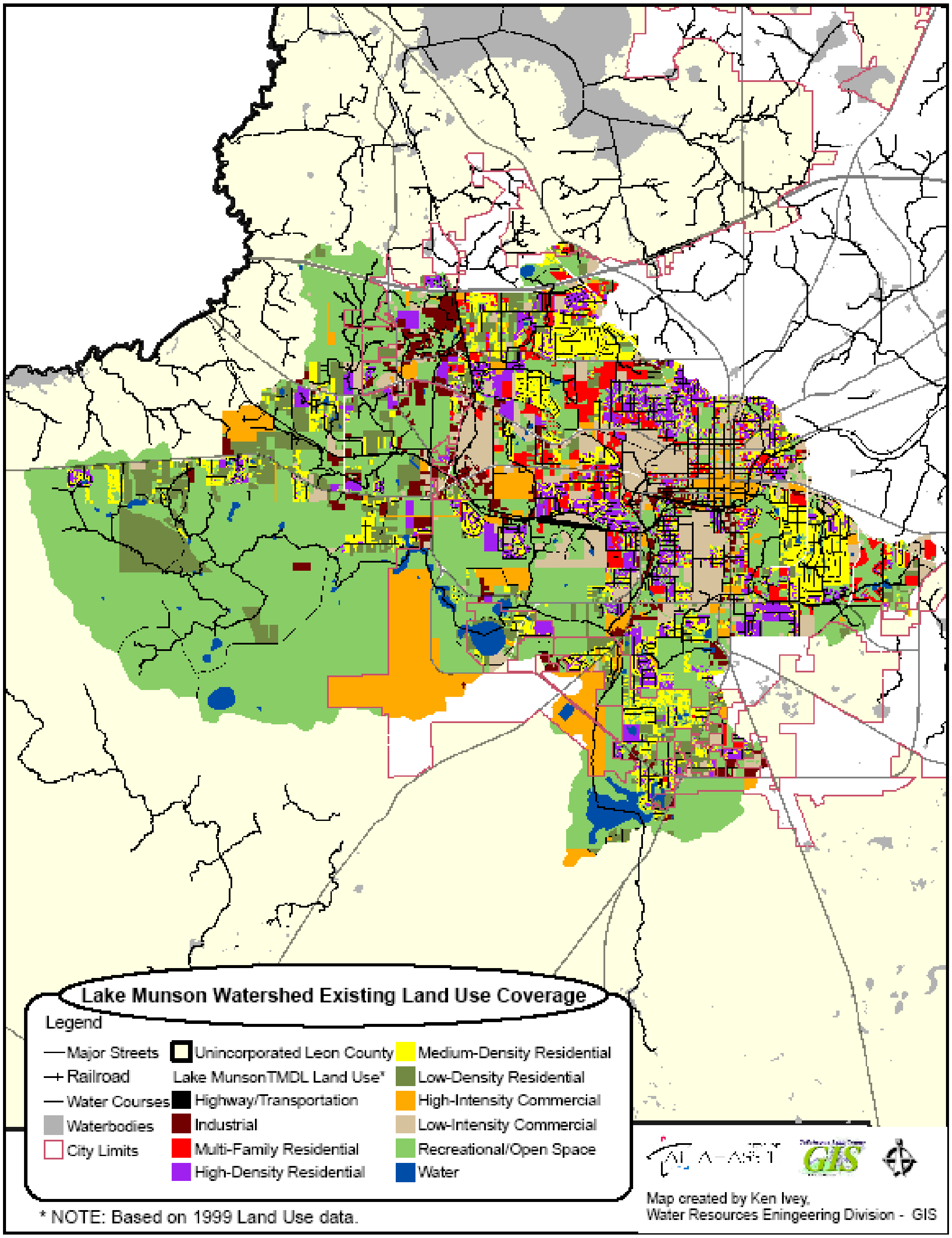



Figure 4.5 Lake Munson Watershed Existing Land Use Coverage in 1999

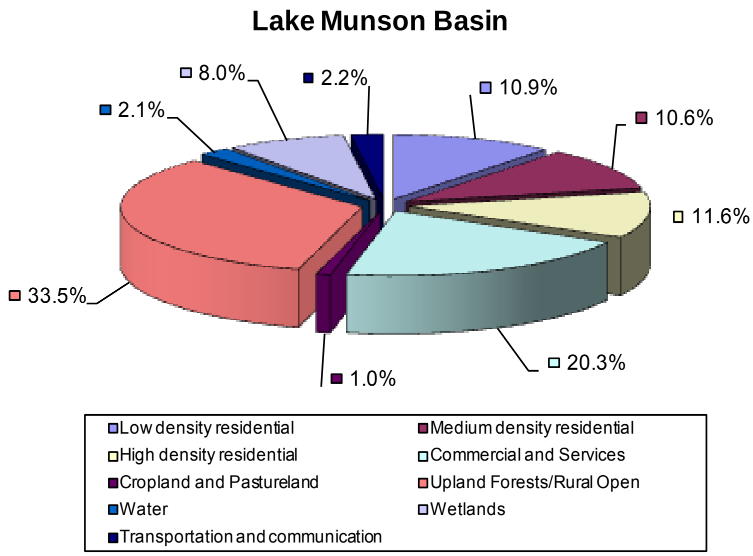



Figure 4.6 Percent Acreage of the Various Land Use Categories in the Lake Munson Watershed

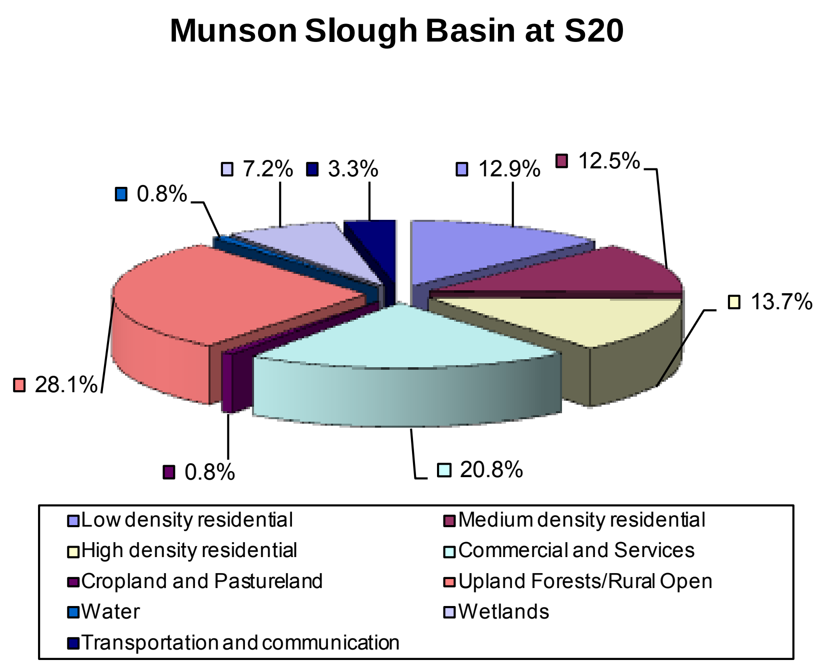



Figure 4.7 Percent Acreage of the Various Land Use Categories in the Munson Slough Subbasin

# Chapter 5: DETERMINATION OF ASSIMILATIVE CAPACITY

## 5.1 Determination of Loading Capacity

Munson Slough DO levels depend on the loading of $BOD_5$ and nutrients from the many tributary systems represented by Godby Ditch, SAB, CDD, and EDD. DO also is highly temperature, flow, and light dependent. **Figure 5.1** shows the sampling locations in the Munson Slough/Lake Munson watershed, and **Figure 5.2** shows the sampling locations in Lake Munson. **Table 5.1** lists the organizations that sample in the Munson Slough/Lake Munson watershed. **Tables 5.2** and **5.3** contain statistical annual averages for Lake Munson (WBID 807C). **Tables 5.4a** and **5.4b** show statistical annual averages for Munson Slough above and below Lake Munson (WBIDs 807D and 807), respectively. **Figures 5.3, 5.4, 5.5,** and **5.6** depict annual average scatter plots for TN, TP, Chla, and TSI, respectively, for Lake Munson. **Tables 5.5, 5.6,** and **5.7** provide statistical summaries for the Munson Slough/Lake Munson watershed.

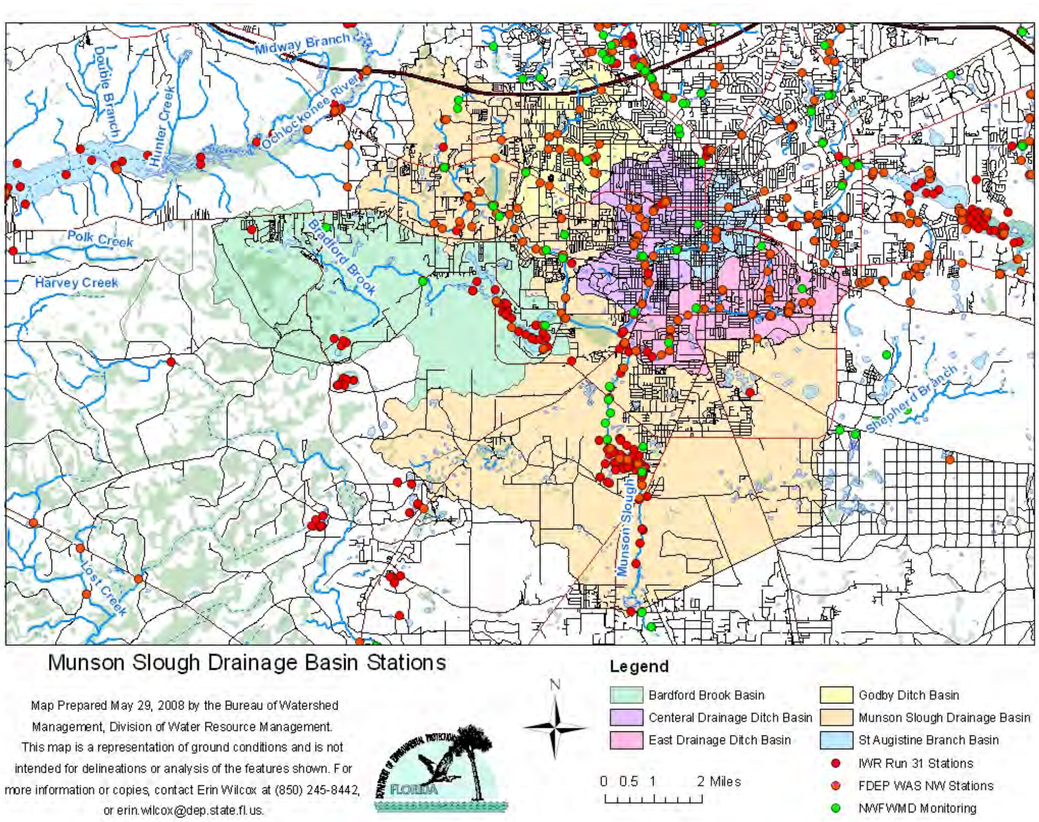



Figure 5.1 Monitoring Sites in the Munson Slough/Lake Munson Watershed

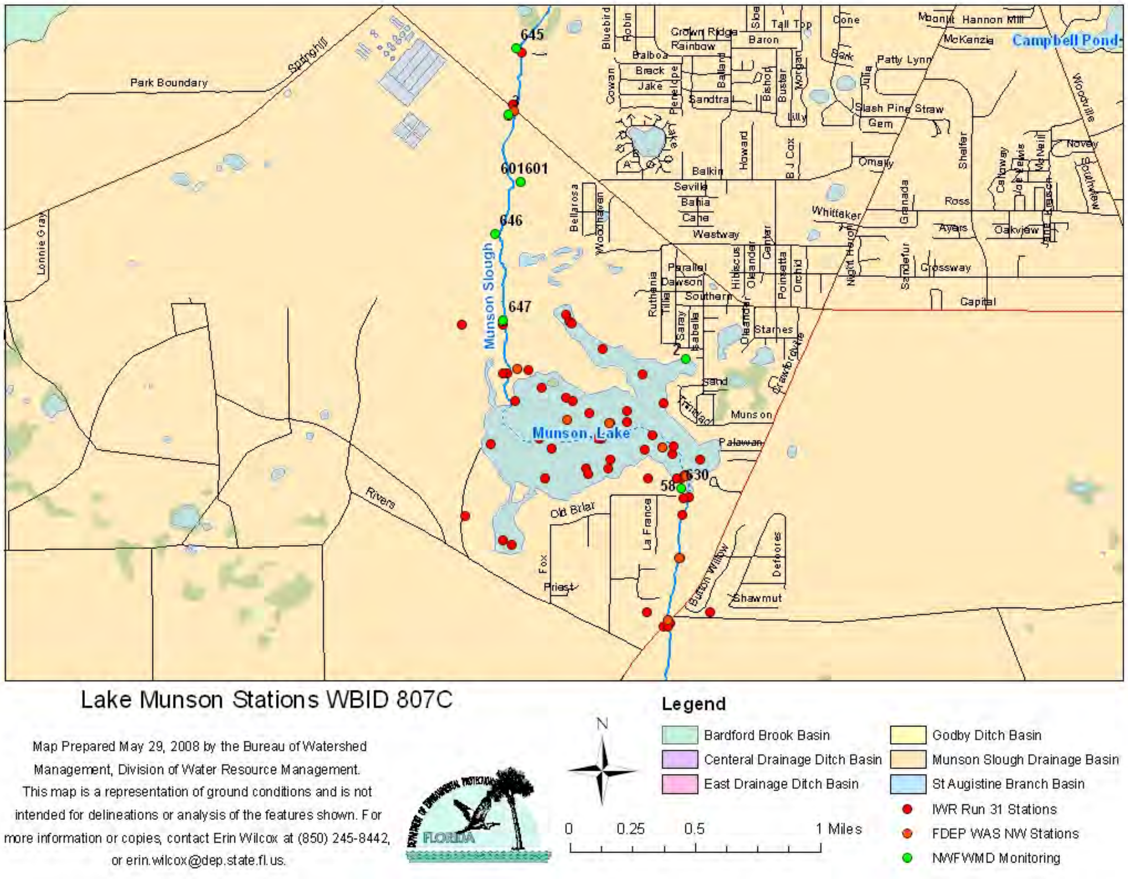



Figure 5.2 Monitoring Sites in WBID 807C

Table 5.1 Organizations Sampling in the Munson Slough/Lake Munson Watershed

| Organization |
|---|
| Florida Department of Environmental Protection |
| Florida Department of Environmental Protection, Biology |
| Florida Department of Environmental Protection, Northeast District |
| Florida Department of Environmental Protection, Northwest District |
| Florida Department of Environmental Protection, Watershed Assessment Section |
| LakeWatch |
| Leon County |
| McGlynn Labs |
| Northwest Florida Water Management District |
| U.S. Geological Survey |
| U.S. Environmental Protection Agency |

## Table 5.2 Statistical Table of Observed Annual Data for Lake Munson, WBID 807C

\- = Empty cell/no data
[1] Includes data from the Department's LIMS and SBIO databases not in the IWR database
**Note:** Rows with highlighting and boldface type indicate verified period data

| Year | TN-(mg/L) IWR34 | TP-(mg/L) IWR34 | CChla-(µg/L) IWR34 | Chla[1] (µg/L) | TSI | Four Quarters | TN:TP ratio |
|---|---|---|---|---|---|---|---|
| 1973 | 6.05 | 2.063 | - | 140.32 | 93.1 | - | 2.9 |
| 1986 | 0.89 | 0.266 | - | 31.55 | 61.8 | - | 3.4 |
| 1987 | 0.88 | 0.259 | - | 34.59 | 62.4 | Yes | 3.4 |
| 1991 | 0.81 | 0.119 | - | 14.53 | 55.2 | - | 6.9 |
| 1992 | 1.18 | 0.068 | - | 13.36 | 56.9 | - | 17.5 |
| 1994 | 1.43 | 0.232 | - | 20.60 | 63.9 | - | 6.2 |
| 1995 | 0.98 | 0.112 | - | 41.33 | 64.8 | - | 8.8 |
| 1996 | 1.24 | 0.209 | - | 41.58 | 67.4 | Yes | 5.9 |
| 1997 | 2.28 | 0.217 | - | 8.58 | 62.4 | - | 10.5 |
| 1998 | 0.95 | 0.250 | - | 19.27 | 59.0 | - | 3.8 |
| 1999 | 1.07 | 0.163 | - | 23.42 | 61.7 | Yes | 6.6 |
| **2000** | **0.78** | **0.123** | **-** | **6.49** | **48.9** | **-** | **6.3** |
| **2001** | **0.71** | **0.087** | **-** | **23.85** | **57.3** | **Yes** | **8.1** |
| **2002** | **1.10** | **0.106** | **28.00** | **-** | **64.0** | **Yes** | **10.4** |
| **2003** | **0.51** | **0.028** | **15.34** | **-** | **49.5** | **Yes** | **18.3** |
| **2004** | **0.50** | **0.036** | **16.18** | **-** | **51.0** | **Yes** | **14.1** |
| **2005** | **0.73** | **0.152** | **31.98** | **-** | **59.7** | **Yes** | **4.8** |
| **2006** | **1.99** | **0.348** | **73.51** | **-** | **76.5** | **Yes** | **5.7** |
| 2007 | 1.55 | 0.279 | 30.61 | - | 67.6 | - | 5.6 |

## Table 5.3 Statistical Table of Observed Annual Data for Lake Munson, WBID 807C

- = Empty cell/no data
UNNH4 = unionized ammonia

| Year | DO (mg/L) | BOD (mg/L) | UNNH4 (mg/L) |
|---|---|---|---|
| 1971 | 19.83 | 12.23 | - |
| 1973 | 11.26 | 8.40 | 0.35 |
| 1974 | 9.79 | 12.98 | 0.23 |
| 1981 | 10.70 | - | 0.09 |
| 1986 | 7.07 | 6.28 | 0.00 |
| 1987 | 6.28 | 5.74 | 0.00 |
| 1991 | 6.97 | - | - |
| 1992 | 8.85 | - | - |
| 1993 | 7.95 | - | 0.00 |
| 1994 | 6.31 | - | 0.01 |
| 1995 | 7.84 | - | 0.03 |
| 1996 | 8.72 | - | 0.00 |
| 1997 | 6.71 | - | 0.01 |
| 1998 | 7.92 | - | 0.08 |
| 1999 | 6.07 | - | 0.01 |
| 2000 | 8.07 | | 0.00 |
| 2001 | 5.94 | | 0.00 |
| 2002 | 6.50 | 3.00 | 0.01 |
| 2003 | 5.79 | 1.60 | 0.00 |
| 2004 | 5.95 | 2.55 | 0.00 |
| 2005 | 5.97 | 3.08 | 0.00 |
| 2006 | 9.17 | 7.28 | 0.01 |
| 2007 | 7.77 | 5.69 | - |

## Table 5.4a Statistical Table of Observed Annual Data for Munson Slough, WBID 807D

- = Empty cell/no data

| Year | TN (mg/L) | TP (mg/L) | Chla (µg/L) | DO (mg/L) | BOD (mg/L) | UNNH4 (mg/L) |
|---|---|---|---|---|---|---|
| 1971 | - | 7.97 | - | 6.40 | 129.15 | - |
| 1972 | - | 8.82 | - | - | 210.00 | - |
| 1973 | 5.09 | 2.02 | - | - | 159.53 | - |
| 1974 | 3.45 | 1.68 | - | - | 112.40 | - |
| 1975 | - |  | - | - | 152.50 | - |
| 1976 | 8.41 | 3.03 | - | - | - | - |
| 1987 | 0.98 | 0.48 | - | - | 6.87 | - |
| 1988 | 0.96 | 0.66 | - | - | 4.86 | - |
| 1992 | 1.20 | 0.65 | - | 5.90 | - | 0.00 |
| 1993 | 0.62 | 0.12 | - | 2.80 | - | - |
| 1995 | 0.82 | 0.14 | - | 2.88 | - | 0.00 |
| 1996 | 1.02 | 0.19 | - | 4.33 | - | 0.00 |
| 1997 | 0.68 | 0.08 | - | 3.00 | - | 0.00 |
| 1998 | 0.62 | 0.12 | - | 5.22 | - | 0.00 |
| 1999 | 0.70 | 0.13 | - | 7.89 | - | - |
| 2000 | 0.91 | 0.21 | - | 5.27 | - | 0.00 |
| 2001 | - | - | - | 6.49 | - | - |
| 2002 | 1.00 | 0.51 | - | 6.10 | 0.47 | 0.00 |
| 2004 | - | - | - | 8.56 | - | - |
| 2005 | 1.06 | 0.04 | - | - | 2.73 | - |
| 2006 | 1.19 | 0.18 | - | 6.37 | 4.52 | 0.00 |
| 2007 | 1.40 | 0.18 | - | 6.94 | 4.59 | 0.00 |

## Table 5.4b Statistical Table of Observed Annual Data for Munson Slough, WBID 807

- = Empty cell/no data

| Year | TN (mg/L) | TP (mg/L) | Chla (µg/L) | DO (mg/L) | BOD (mg/L) | UNNH4 (mg/L) |
|---|---|---|---|---|---|---|
| 1971 | - | 0.98 | - | 13.00 | 0.13 | - |
| 1973 | 5.79 | 1.92 | - | - | 9.20 | - |
| 1974 | 6.67 | 2.87 | - | 5.58 | 7.90 | 0.04 |
| 1976 | 4.13 | 1.34 | - | 4.30 | - | - |
| 1987 | 0.86 | 0.25 | - | - | 5.50 | - |
| 1992 | 0.66 | 0.11 | - | 7.80 | - | 0.00 |
| 1993 | 0.63 | 0.11 | - | 6.67 | - | - |
| 1996 | - | - | - | 4.47 | - | - |
| 1997 | - | - | - | 6.94 | - | - |
| 2000 | 1.84 | 0.51 | - | 5.98 | - | 0.02 |
| 2001 | - | - | - | 7.78 | - | - |
| 2002 | 0.80 | 0.24 | - | 7.54 | 1.10 | 0.00 |
| 2004 | - | - | - | 10.69 | - | - |
| 2005 | 0.92 | 0.10 | - | 6.94 | 2.64 | 0.00 |
| 2006 | 1.97 | 0.23 | 60.81 | 5.93 | 5.92 | 0.03 |
| 2007 | 2.01 | 0.45 | - | 7.47 | 8.88 | 0.00 |

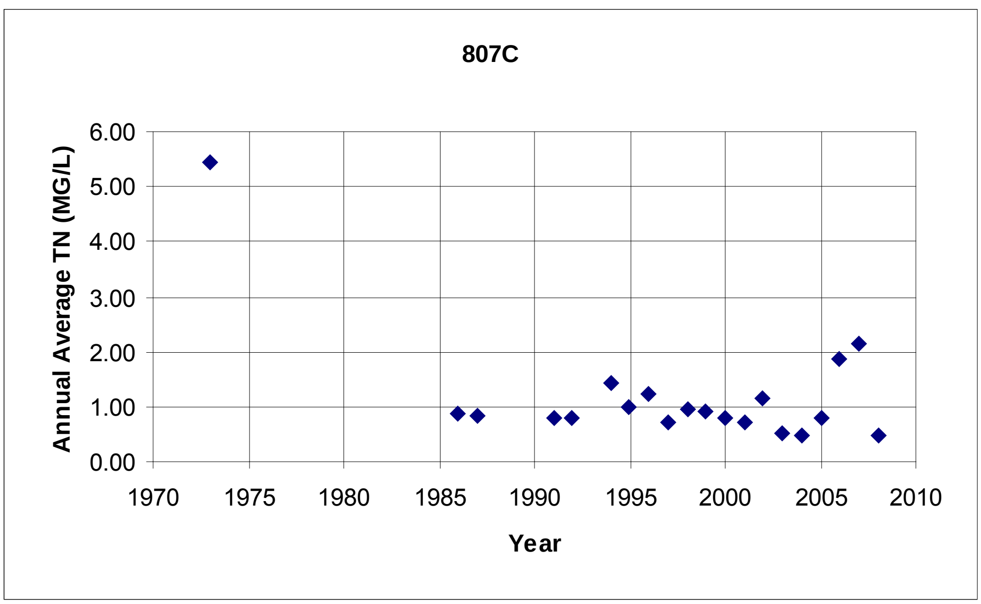



Figure 5.3 Chart of Annual TN Observations for Lake Munson, WBID 807C

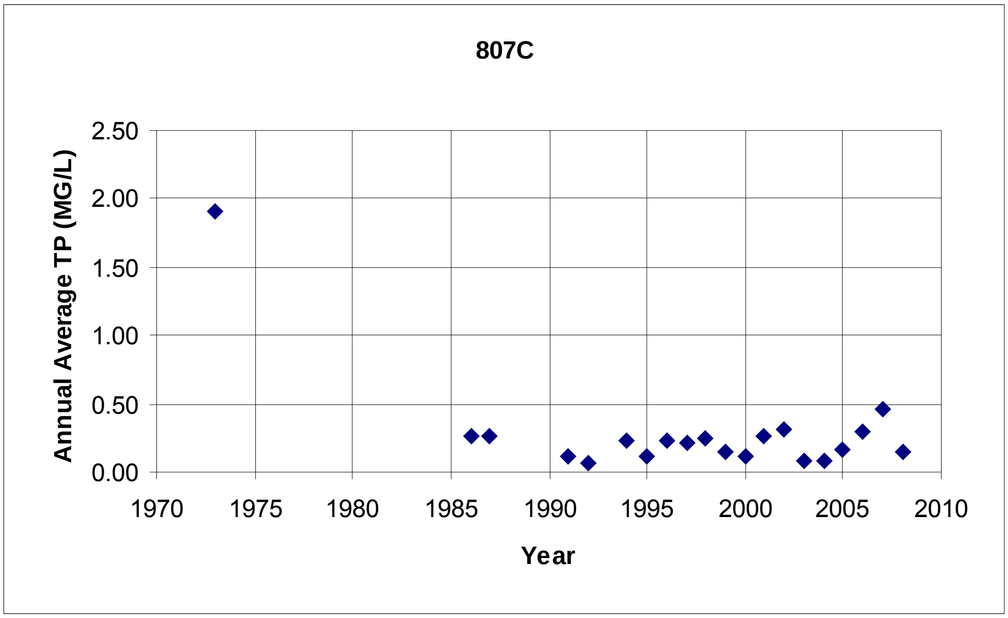



Figure 5.4 Chart of Annual Historical TP Observations for Lake Munson, WBID 807C

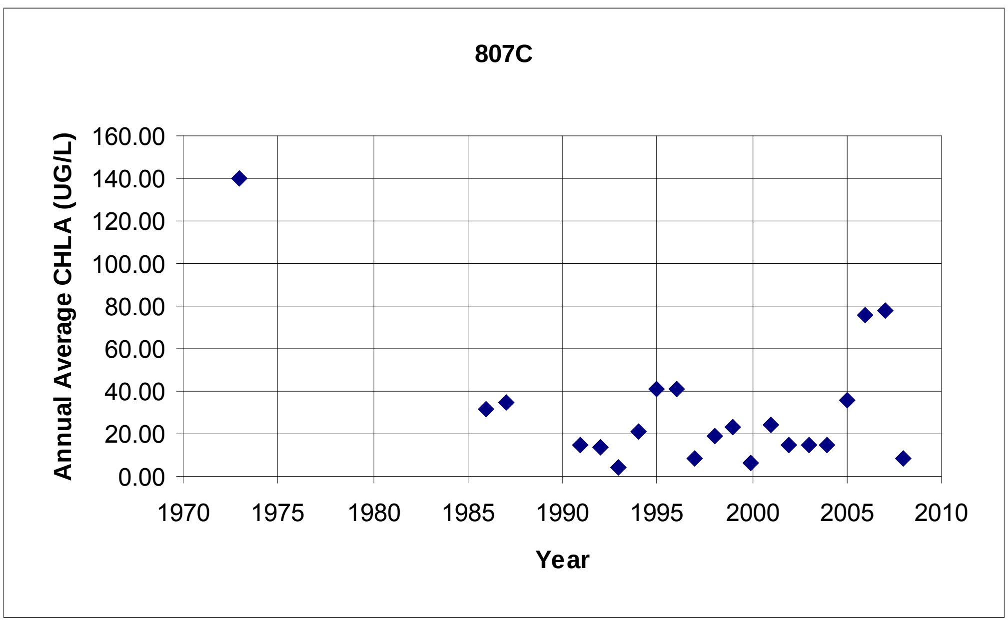



Figure 5.5 Chart of Annual Historical Chla Observations for Lake Munson, WBID 807C

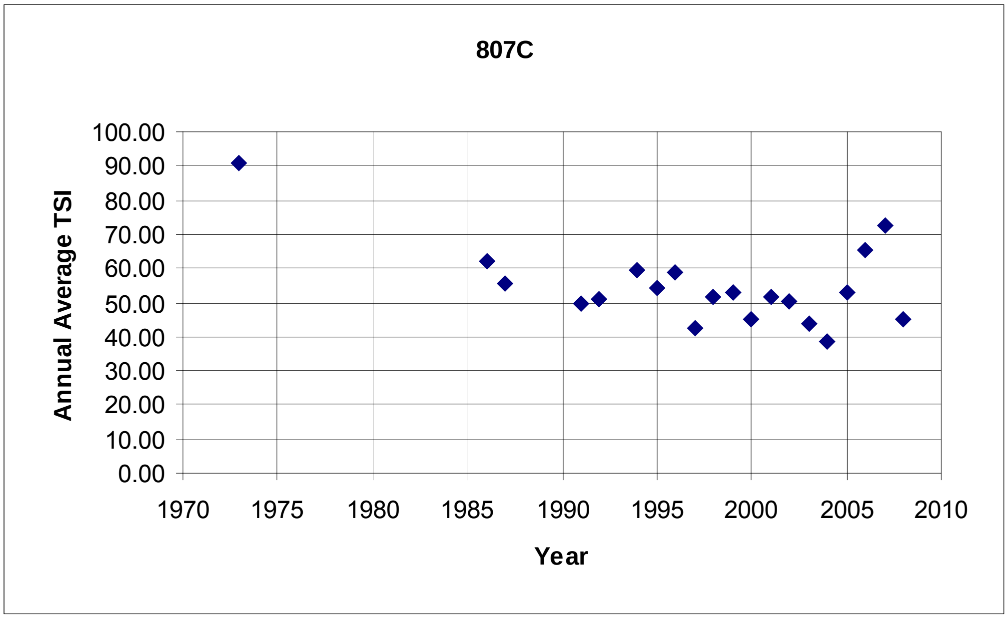



Figure 5.6 Chart of Annual Historical TSI Observations for Lake Munson, WBID 807C

## Table 5.5 Statistical Summary of Observed Data from Lake Munson (WBID 807C) in the Munson Slough/Lake Munson Watershed, 1971–2007

N/A = Not applicable

| WBID | Parameter | Code | Units | N | Minimum | Maximum | Mean | Median | 70% | 75% |
|---|---|---|---|---|---|---|---|---|---|---|
| 807C | TEMP | 10 | DEGC | 1297 | 4.9060E-01 | 3.5020E+01 | 2.1945E+01 | 2.2500E+01 | 2.6826E+01 | 2.7000E+01 |
| 807C | TURB | 76 | NTU | 188 | 2.7000E+00 | 3.7000E+01 | 1.0501E+01 | 9.5000E+00 | 1.2000E+01 | 1.3000E+01 |
| 807C | SECCHI | 77 | INCHES | 189 | 2.5000E-01 | 1.2000E+00 | 6.7157E-01 | 6.6000E-01 | 7.5000E-01 | 8.1000E-01 |
| 807C | COLOR | 80 | PTCO | 539 | 0.0000E+00 | 3.2000E+02 | 8.3527E+01 | 7.5000E+01 | 1.0000E+02 | 1.0850E+02 |
| 807C | FCOND | 94 | US/CM | 495 | 4.3000E+01 | 3.4900E+02 | 9.7012E+01 | 8.7000E+01 | 9.8000E+01 | 1.0500E+02 |
| 807C | LCOND | 95 | US/CM | 141 | 4.9000E+01 | 1.2000E+03 | 1.3687E+02 | 1.0300E+02 | 1.1400E+02 | 1.1700E+02 |
| 807C | DO | 299 | MG/L | 435 | 9.0000E-02 | 1.7800E+01 | 7.1770E+00 | 7.3000E+00 | 8.9360E+00 | 9.3350E+00 |
| 807C | DO | 300 | MG/L | 854 | 1.0000E-01 | 2.8400E+01 | 6.5812E+00 | 6.9000E+00 | 7.6000E+00 | 7.8000E+00 |
| 807C | DO | 301 | % | 1142 | 1.2000E+00 | 3.6426E+02 | 7.3361E+01 | 7.3747E+01 | 8.2407E+01 | 8.6957E+01 |
| 807C | BOD5 | 310 | MG/L | 340 | 2.0000E-01 | 2.3500E+01 | 5.5849E+00 | 4.7750E+00 | 7.0000E+00 | 8.0000E+00 |
| 807C | COD | 340 | MG/L | 199 | 8.0000E+00 | 1.2100E+02 | 4.1717E+01 | 3.8000E+01 | 4.3600E+01 | 4.5000E+01 |
| 807C | PH | 400 | SU | 681 | 2.3400E+00 | 1.1810E+01 | 7.2844E+00 | 6.9300E+00 | 7.3500E+00 | 7.5600E+00 |
| 807C | ALK CACO3 | 410 | MG/L | 475 | 0.0000E+00 | 1.2770E+02 | 3.1448E+01 | 2.8333E+01 | 3.5900E+01 | 3.9000E+01 |
| 807C | TS | 500 | MG/L | 194 | 5.3000E+01 | 3.5900E+02 | 8.9969E+01 | 7.7000E+01 | 8.9000E+01 | 9.0000E+01 |
| 807C | TSS | 530 | MG/L | 440 | 0.0000E+00 | 1.7200E+02 | 1.0615E+01 | 6.0000E+00 | 1.0000E+01 | 1.2000E+01 |
| 807C | TN | 600 | MG/L | 545 | 0.0000E+00 | 1.0460E+01 | 1.0724E+00 | 7.3000E-01 | 9.8500E-01 | 1.1500E+00 |
| 807C | ORGN | 605 | MG/L | N/A | N/A | N/A | 8.1820E-01 | 6.4516E-01 | 8.3318E-01 | 9.6372E-01 |
| 807C | NH3NDISS | 608 | MG/L | 2 | 6.0000E-02 | 2.2000E-01 | 1.4000E-01 | 1.4000E-01 | 1.7200E-01 | 1.8000E-01 |
| 807C | NH3N | 610 | MG/L | 551 | 0.0000E+00 | 5.1930E+00 | 1.8732E-01 | 6.4841E-02 | 1.0182E-01 | 1.2629E-01 |
| 807C | NO2N | 615 | MG/L | 337 | 0.0000E+00 | 1.1000E-01 | 4.8050E-03 | 0.0000E+00 | 3.4540E-03 | 5.0200E-03 |
| 807C | TKNDISS | 623 | MG/L | 2 | 6.8000E-01 | 9.4000E-01 | 8.1000E-01 | 8.1000E-01 | 8.6200E-01 | 8.7500E-01 |
| 807C | TKN | 625 | MG/L | N/A | N/A | N/A | 1.0055E+00 | 7.1000E-01 | 9.3500E-01 | 1.0900E+00 |
| 807C | NO23N | 630 | MG/L | 427 | -4.5000E-03 | 1.5400E+00 | 6.6908E-02 | 2.0000E-02 | 5.0000E-02 | 6.0000E-02 |
| 807C | TP | 665 | MG/L | 453 | 0.0000E+00 | 7.3000E+00 | 3.1994E-01 | 2.0000E-01 | 2.8000E-01 | 3.0700E-01 |
| 807C | OP04P | 671 | MG/L | 315 | 2.0000E-03 | 2.0900E+00 | 1.4450E-01 | 1.2000E-01 | 1.5000E-01 | 1.6000E-01 |
| 807C | TOC | 680 | MG/L | 242 | 1.7000E-01 | 8.2000E+01 | 1.6258E+01 | 1.6650E+01 | 1.8840E+01 | 1.9275E+01 |
| 807C | TOTCOLI | 31501 | N/100ML | 309 | 0.0000E+00 | 2.6200E+04 | 8.2042E+02 | 3.4000E+02 | 6.1867E+02 | 7.2000E+02 |
| 807C | FCOLI | 31625 | N/100ML | 184 | 0.0000E+00 | 8.0000E+02 | 7.1201E+01 | 2.4000E+01 | 6.4000E+01 | 1.0000E+02 |
| 807C | CHLA | 32211 | µG/L | 87 | 1.0000E+00 | 2.0140E+02 | 3.3553E+01 | 1.3485E+01 | 2.8283E+01 | 4.5077E+01 |
| 807C | PHAEOP | 32218 | µG/L | 32 | 0.0000E+00 | 2.0359E+01 | 5.0185E+00 | 3.8070E+00 | 7.0122E+00 | 7.5000E+00 |
| 807C | LAKEDEPTH | 72025 | FT | 188 | 1.8000E+00 | 5.4000E+00 | 4.1723E+00 | 4.4000E+00 | 4.6000E+00 | 4.6000E+00 |

## Table 5.6 Statistical Summary of Observed Data from Munson Slough above Lake Munson (WBID 807D) in the Munson Slough/Lake Munson Watershed, 1971–2007

N/A = Not applicable

| WBID | Parameter | Code | Units | N | Minimum | Maximum | Mean | Median | 70% | 75% |
|---|---|---|---|---|---|---|---|---|---|---|
| 807D | TEMP | 10 | DEGC | 165 | 6.9800E+00 | 3.1450E+01 | 2.0892E+01 | 2.1400E+01 | 2.4408E+01 | 2.5700E+01 |
| 807D | TURB | 76 | NTU | 95 | 2.7000E+00 | 6.3700E+02 | 6.4133E+01 | 3.1000E+01 | 5.4720E+01 | 6.1000E+01 |
| 807D | SECCHI | 77 | INCHES | 0 | 0.0000E+00 | 0.0000E+00 | 0.0000E+00 | 0.0000E+00 | 0.0000E+00 | 0.0000E+00 |
| 807D | COLOR | 80 | PTCO | 202 | 1.5800E+01 | 4.0900E+02 | 1.0735E+02 | 9.1100E+01 | 1.2000E+02 | 1.3900E+02 |
| 807D | FCOND | 94 | US/CM | 55 | 3.8300E+01 | 4.7900E+02 | 1.9357E+02 | 1.6200E+02 | 2.5800E+02 | 2.9200E+02 |
| 807D | LCOND | 95 | US/CM | 193 | 3.0000E+01 | 5.8500E+02 | 1.0912E+02 | 8.5000E+01 | 1.0680E+02 | 1.1400E+02 |
| 807D | DO | 299 | MG/L | 157 | 0.2 | 14.46 | 6.077579618 | 6.2900E+00 | 7.5460E+00 | 8.1200E+00 |
| 807D | DO | 300 | MG/L | 1 | 6.4000E+00 | 6.4000E+00 | 6.4000E+00 | 6.4000E+00 | 6.4000E+00 | 6.4000E+00 |
| 807D | DO | 301 | % | 116 | 1.9000E+00 | 1.4400E+02 | 6.5372E+01 | 6.4267E+01 | 8.1750E+01 | 8.8050E+01 |
| 807D | BOD5 | 310 | MG/L | 198 | 6.0000E-01 | 2.9000E+02 | 2.6088E+01 | 5.0000E+00 | 7.8100E+00 | 9.0000E+00 |
| 807D | COD | 340 | MG/L | 91 | 1.9000E+01 | 5.1900E+02 | 6.7462E+01 | 4.0000E+01 | 5.3000E+01 | 5.8000E+01 |
| 807D | PH | 400 | SU | 123 | 5.5300E+00 | 9.9500E+00 | 7.3970E+00 | 7.2400E+00 | 7.5400E+00 | 7.6600E+00 |
| 807D | ALK CACO3 | 410 | MG/L | 173 | 2.6000E+00 | 1.9000E+02 | 4.1067E+01 | 3.2800E+01 | 4.4400E+01 | 4.9000E+01 |
| 807D | TS | 500 | MG/L | 90 | 4.5000E+01 | 2.7310E+03 | 2.2462E+02 | 1.3500E+02 | 1.8820E+02 | 2.2125E+02 |
| 807D | TSS | 530 | MG/L | 234 | 1.3000E+00 | 2.8700E+03 | 6.6002E+01 | 1.7500E+01 | 4.4200E+01 | 6.1750E+01 |
| 807D | TN | 600 | MG/L | 221 | 1.5200E-01 | 1.9987E+01 | 1.2855E+00 | 8.3000E-01 | 1.1300E+00 | 1.2600E+00 |
| 807D | ORGN | 605 | MG/L | N/A | N/A | N/A | 9.7202E-01 | 7.0450E-01 | 9.0530E-01 | 9.9250E-01 |
| 807D | NH3NDISS | 608 | MG/L | 0 | 0.0000E+00 | 0.0000E+00 | 0.0000E+00 | 0.0000E+00 | 0.0000E+00 | 0.0000E+00 |
| 807D | NH3N | 610 | MG/L | 218 | 0.0000E+00 | 3.3000E+00 | 1.6111E-01 | 8.3500E-02 | 1.4000E-01 | 1.6000E-01 |
| 807D | NO2N | 615 | MG/L | 154 | 0.0000E+00 | 2.2000E+00 | 4.1536E-02 | 1.0000E-02 | 1.2000E-02 | 1.4750E-02 |
| 807D | TKNDISS | 623 | MG/L | 0 | 0.0000E+00 | 0.0000E+00 | 0.0000E+00 | 0.0000E+00 | 0.0000E+00 | 0.0000E+00 |
| 807D | TKN | 625 | MG/L | N/A | N/A | N/A | 1.1331E+00 | 7.8800E-01 | 1.0453E+00 | 1.1525E+00 |
| 807D | NO23N | 630 | MG/L | 178 | 0.0000E+00 | 7.6000E+00 | 1.5238E-01 | 4.2000E-02 | 8.4700E-02 | 1.0750E-01 |
| 807D | TP | 665 | MG/L | 224 | 0.0000E+00 | 1.1760E+01 | 6.1214E-01 | 1.8000E-01 | 3.5100E-01 | 4.4000E-01 |
| 807D | OP04P | 671 | MG/L | 118 | 0.0000E+00 | 2.2000E+00 | 1.8676E-01 | 8.0000E-02 | 1.1980E-01 | 1.2750E-01 |
| 807D | TOC | 680 | MG/L | 148 | 4.2000E+00 | 4.5300E+01 | 1.5750E+01 | 1.5000E+01 | 1.8180E+01 | 1.9575E+01 |
| 807D | TOTCOLI | 31501 | N/100ML | 100 | 0.0000E+00 | 1.3000E+07 | 3.4021E+05 | 1.8500E+03 | 1.9300E+04 | 2.5000E+04 |
| 807D | FCOLI | 31625 | N/100ML | 1 | 1.6000E+02 | 1.6000E+02 | 1.6000E+02 | 1.6000E+02 | 1.6000E+02 | 1.6000E+02 |
| 807D | CHLA | 32211 | µG/L | 17 | 1.0000E+00 | 1.9000E+02 | 1.8976E+01 | 8.0000E+00 | 1.1000E+01 | 1.1000E+01 |
| 807D | PHAEOP | 32218 | µG/L | 18 | 0.0000E+00 | 2.2428E+01 | 3.5849E+00 | 1.9500E+00 | 2.9737E+00 | 3.0000E+00 |
| 807D | LAKEDEPTH | 72025 | FT | 0 | 0.0000E+00 | 0.0000E+00 | 0.0000E+00 | 0.0000E+00 | 0.0000E+00 | 0.0000E+00 |

## Table 5.7 Statistical Summary of Observed Data from Munson Slough below Lake Munson (WBID 807) in the Munson Slough/Lake Munson Watershed, 1971–2007

N/A = Not applicable

| WBID | Parameter | Code | Units | N | Minimum | Maximum | Mean | Median | 70% | 75% |
|---|---|---|---|---|---|---|---|---|---|---|
| 807 | TEMP | 10 | DEGC | 115 | 9.5800E+00 | 3.1540E+01 | 2.2534E+01 | 2.3170E+01 | 2.7122E+01 | 2.8010E+01 |
| 807 | TURB | 76 | NTU | 22 | 3.1000E+00 | 3.9200E+01 | 8.5682E+00 | 4.9500E+00 | 6.0800E+00 | 6.8000E+00 |
| 807 | SECCHI | 77 | INCHES | 0 | 0.0000E+00 | 0.0000E+00 | 0.0000E+00 | 0.0000E+00 | 0.0000E+00 | 0.0000E+00 |
| 807 | COLOR | 80 | PTCO | 77 | 1.0000E+01 | 2.0000E+02 | 6.1664E+01 | 5.0000E+01 | 7.7152E+01 | 8.0000E+01 |
| 807 | FCOND | 94 | US/CM | 82 | 1.1000E+01 | 3.6000E+02 | 6.0332E+01 | 1.3000E+01 | 9.3400E+01 | 1.0698E+02 |
| 807 | LCOND | 95 | US/CM | 46 | 6.7000E+01 | 1.2000E+03 | 1.7115E+02 | 1.1750E+02 | 1.3150E+02 | 1.5100E+02 |
| 807 | DO | 299 | MG/L | 103 | 1.6500E+00 | 1.8360E+01 | 6.7777E+00 | 6.7400E+00 | 8.4960E+00 | 8.6950E+00 |
| 807 | DO | 300 | MG/L | 5 | 3.8000E+00 | 1.3000E+01 | 6.8080E+00 | 4.3000E+00 | 8.0120E+00 | 8.9400E+00 |
| 807 | DO | 301 | % | 31 | 2.5900E+01 | 1.5860E+02 | 7.8436E+01 | 8.0300E+01 | 8.6539E+01 | 9.1450E+01 |
| 807 | BOD5 | 310 | MG/L | 64 | 1.3000E-01 | 1.2000E+01 | 5.3873E+00 | 4.9000E+00 | 7.0100E+00 | 7.3000E+00 |
| 807 | COD | 340 | MG/L | 19 | 2.5000E+01 | 1.1600E+02 | 4.0305E+01 | 3.2000E+01 | 3.6200E+01 | 3.7500E+01 |
| 807 | PH | 400 | SU | 88 | 4.9800E+00 | 1.0350E+01 | 6.6945E+00 | 6.4650E+00 | 7.3360E+00 | 7.4275E+00 |
| 807 | ALK CACO3 | 410 | MG/L | 64 | 9.0398E+00 | 1.4700E+02 | 4.2279E+01 | 3.5000E+01 | 4.4100E+01 | 4.7125E+01 |
| 807 | TS | 500 | MG/L | 18 | 6.6000E+01 | 2.8200E+02 | 1.0317E+02 | 8.6500E+01 | 9.0000E+01 | 9.1500E+01 |
| 807 | TSS | 530 | MG/L | 75 | 1.4286E+00 | 2.0350E+02 | 1.8824E+01 | 1.0000E+01 | 1.3800E+01 | 1.9300E+01 |
| 807 | TN | 600 | MG/L | 90 | 2.0700E-01 | 1.0930E+01 | 2.1043E+00 | 1.0600E+00 | 2.4931E+00 | 2.7920E+00 |
| 807 | ORGN | 605 | MG/L | N/A | N/A | N/A | 1.3684E+00 | 8.7258E-01 | 1.9796E+00 | 1.8570E+00 |
| 807 | NH3NDISS | 608 | MG/L | 0 | 0.0000E+00 | 0.0000E+00 | 0.0000E+00 | 0.0000E+00 | 0.0000E+00 | 0.0000E+00 |
| 807 | NH3N | 610 | MG/L | 72 | 4.0000E-03 | 2.7600E+00 | 4.7887E-01 | 1.0742E-01 | 3.4350E-01 | 6.5500E-01 |
| 807 | NO2N | 615 | MG/L | 52 | 0.0000E+00 | 3.6000E-01 | 7.5115E-02 | 1.3500E-02 | 7.4200E-02 | 9.8000E-02 |
| 807 | TKNDISS | 623 | MG/L | 0 | 0.0000E+00 | 0.0000E+00 | 0.0000E+00 | 0.0000E+00 | 0.0000E+00 | 0.0000E+00 |
| 807 | TKN | 625 | MG/L | N/A | N/A | N/A | 1.8473E+00 | 9.8000E-01 | 2.3231E+00 | 2.5120E+00 |
| 807 | NO23N | 630 | MG/L | 77 | 0.0000E+00 | 2.3000E+00 | 2.5699E-01 | 8.0000E-02 | 1.7000E-01 | 2.8000E-01 |
| 807 | TP | 665 | MG/L | 96 | 6.5000E-03 | 4.1000E+00 | 6.0449E-01 | 2.6000E-01 | 4.2200E-01 | 5.8500E-01 |
| 807 | OP04P | 671 | MG/L | 37 | 6.7000E-02 | 2.7000E+00 | 6.0724E-01 | 1.8000E-01 | 5.4900E-01 | 8.5000E-01 |
| 807 | TOC | 680 | MG/L | 51 | 6.7000E+00 | 2.6000E+01 | 1.2201E+01 | 1.1700E+01 | 1.4100E+01 | 1.5550E+01 |
| 807 | TOTCOLI | 31501 | N/100ML | 44 | 4.9000E+01 | 3.2000E+05 | 2.3570E+04 | 1.8500E+03 | 1.3300E+04 | 1.7250E+04 |
| 807 | FCOLI | 31625 | N/100ML | 0 | 0.0000E+00 | 0.0000E+00 | 0.0000E+00 | 0.0000E+00 | 0.0000E+00 | 0.0000E+00 |
| 807 | CHLA | 32211 | µG/L | 4 | 1.0000E+00 | 8.5000E+01 | 2.5075E+01 | 7.1500E+00 | 1.9300E+01 | 3.0250E+01 |
| 807 | PHAEOP | 32218 | µG/L | 24 | 0.0000E+00 | 3.2000E+02 | 6.3635E+01 | 2.5000E+01 | 6.4100E+01 | 7.0644E+01 |
| 807 | LAKEDEPTH | 72025 | FT | 0 | 0.0000E+00 | 0.0000E+00 | 0.0000E+00 | 0.0000E+00 | 0.0000E+00 | 0.0000E+00 |

## 5.2 TMDL Development Process

The approaches used to develop the nutrient TMDLs are described below.

### *5.2.1 Develop Reference Stream Nutrient Target Concentrations from Similar Streams (addresses DO impairment)*

The EPA developed nutrient TMDLs (EPA 2006) for several tributary streams to Munson Slough based on nutrient concentrations for reference streams in North Florida. **Tables 3.1** and **3.2** list the seven reference streams used, along with the nutrient concentrations based on the 75$^{th}$ percentile values ($TN_{sref}$, $TP_{sref}$) for TN and TP. Comparing the median values for TN and TP at the Munson Slough inlet (NWFWMD Station S3) with the EPA reference stream values results in the needed percent reductions (**Table 5.8**).

TN% Reduction= 100% * (TN median- $TN_{sref}$)/ TN median

TP% Reduction= 100% * (TP median- $TP_{sref}$)/ TP median

Table 5.8 Summary of Nutrient Reduction Needed for Munson Slough (WBID 807D) Using EPA Reference Streams

| Years | TN Median (mg/L) | EPA TMDL 75% | Difference | % Reduction | TP Median (mg/L) | EPA TMDL 75% | Difference | % Reduction |
|---|---|---|---|---|---|---|---|---|
| 1971–2007 | 0.79 | 0.72 | 0.07 | 8.35% | 0.18 | 0.15 | 0.03 | 17.53% |

### *5.2.2 Develop Lake Nutrient (TSI) TMDL*

#### Determination of Loading Capacity

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

The goal of this TMDL development analysis is to identify the maximum allowable TN and TP loadings from the watershed, so that Lake Munson will meet the narrative nutrient water quality and dissolved oxygen criteria and thus maintain its function and designated use as a Class III water. To achieve the goal, the Department selected the WMM to predict nutrient loadings from the watershed to the lake. A multivariable empirical equation was then developed from the measured in-lake concentrations of Chla, TN, and TP to predict annual Chla responses in the lake as a function of TN and TP concentrations. These two models were used to relate changes in watershed loadings to changes in lake concentrations of nutrients. To be conservative, the changes in load between two different WMM scenarios were considered as proportional to changes in lake concentrations. The load reductions were obtained by applying the percent reduction in concentration (from current condition to TSI target) to the current condition loading estimates from WMM.

### Meteorological and Stage Data

Daily rainfall data for Lake Munson were obtained from the Tallahassee Regional Airport station (**Table 5.9**) in the vicinity of Lake Munson. **Figure 5.7** shows the annual average rainfall for each year of the verified period. The annual average rainfall contained in **Table 5.10** was used in the model.

Table 5.9 General Information on the Weather Station for Lake Munson

| Location Name | Start Date | End Date | Frequency | Facility | County |
|---|---|---|---|---|---|
| Tallahassee Regional Airport | 01/01/2000 | 12/31/2007 | Daily | National Oceanographic and Atmospheric Administration (NOAA) | Leon |

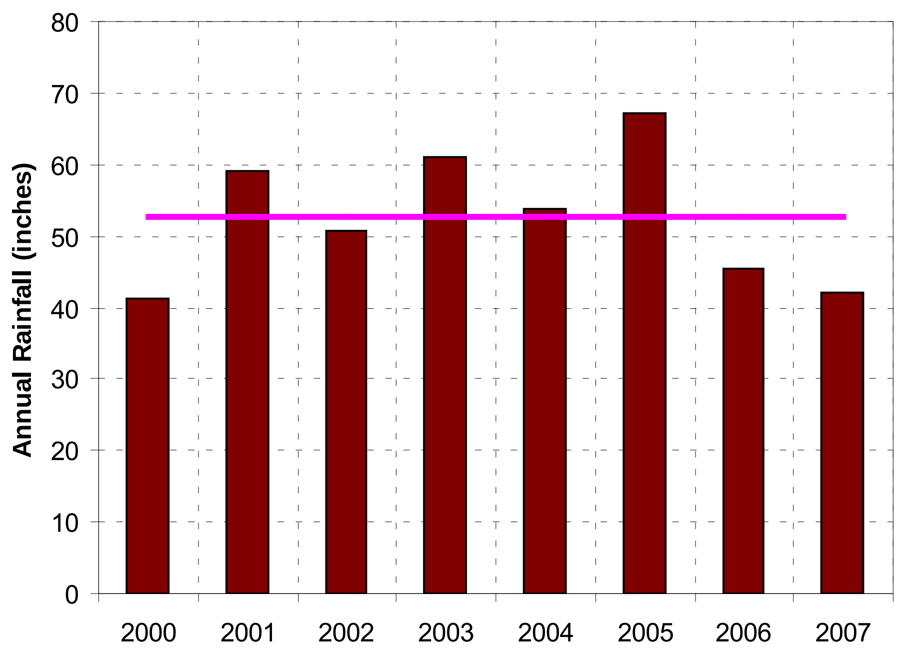



Figure 5.7 Total Annual Rainfall (inches) Observed during the Verified Period, 2000–07. Solid Line Indicates the Eight-Year Average Annual Rainfall of 52.6 Inches.

Table 5.10 Annual Rainfall Used in the Model

| Year | Rainfall (inches) |
|---|---|
| 2000 | 41.3 |
| 2001 | 59.1 |
| 2002 | 50.6 |
| 2003 | 61.1 |
| 2004 | 53.9 |
| 2005 | 67.3 |
| 2006 | 45.5 |
| 2007 | 42.1 |
| **Average** | **52.6** |
| **Standard Deviation** | **9.4** |

## Model Calibration

Using the annual rainfall data, the WMM spreadsheet model was used to estimate the volume of water and the loading of TN and TP from the watershed. First, the annual runoff volume from the Munson Slough subbasin was modeled for the verified period (2000–07). Observed flow data were available for the Munson Slough subbasin at Station S20 operated by the NWFWMD during the verified period. The measured annual runoff volumes varied significantly over the observed period, ranging from 6,998 ac-ft/yr to 25,058 ac-ft/yr (**Table 5.11**). The difference between the observed and simulated runoff volumes over the verified period is about 331 ac-ft/yr with 2.5% standard error, indicating that the simulated runoff volumes are in good agreement with the measured volumes (**Table 5.11**).

For the calibration, the calibrated runoff coefficients ranging from 0.80 to 0.99 for impervious areas and from 0.01 to 0.30 for pervious areas were used for the Munson Slough subbasin. Subsequent to the calibration of flows from the Munson Slough subbasin, the same DCIA and runoff coefficients (per each land use) were applied to the entire Lake Munson watershed to produce runoff volumes and TN and TP loads, as shown in **Table 5.12**.

## Table 5.11 Measured and Simulated Flows for the Munson Slough Subbasin

- = Empty cell/no data

| Year | Munson Slough @ S20 Measured Total (surface plus base) Flow (ac-ft/yr) | Munson Slough @ S20 Simulated Total (surface plus base) Runoff (ac-ft/yr) | Difference (ac/ft/yr) | % Error |
|---|---|---|---|---|
| 2000 | 12,276 | 12,147 | 129.1 | 1.05 |
| 2001 | 25,058 | 22,562 | 2496.4 | 9.96 |
| 2002 | 7,014 | 7,687 | -673.3 | 9.60 |
| 2003 | 16,523 | 16,320 | 203.2 | 1.23 |
| 2004 | 11,967 | 11,828 | 139.4 | 1.17 |
| 2005 | 16,582 | 16,261 | 320.8 | 1.93 |
| 2006 | 6,998 | 6,917 | 81.5 | 1.16 |
| 2007 | 7,395 | 7,442 | -46.6 | 0.63 |
| **Average** | **12,977** | **12,645** | **331.3** | **2.55** |
| **Standard Deviation** | **6,273** | **5,481** | **-** | **-** |

## Table 5.12 Simulated Flows and Nutrient Loads for the Lake Munson Watershed

- = Empty cell/no data

| Year | Munson Slough @ S20 Measured Total (surface plus base) flow (ac-ft/yr) | Munson Slough @ S20 Simulated Total (surface plus base) Runoff (ac-ft/yr) | TN (lbs/yr) | TP (lbs/yr) |
|---|---|---|---|---|
| 2000 | 12,147 | 39,953 | 130,931 | 22,674 |
| 2001 | 22,562 | 75,017 | 246,436 | 40,963 |
| 2002 | 7,687 | 24,607 | 80,142 | 15,315 |
| 2003 | 16,320 | 53,423 | 174,886 | 30,830 |
| 2004 | 11,828 | 38,376 | 125,375 | 22,830 |
| 2005 | 16,261 | 53,026 | 173,437 | 31,008 |
| 2006 | 6,917 | 22,141 | 72,112 | 13,781 |
| 2007 | 7,442 | 23,881 | 77,826 | 14,740 |
| Average | 12,645 | 41,303 | 135,143 | 24,018 |
| Standard Deviation | 5,481 | 18,442 | 60,744 | 9,653 |
| **-** | **-** | **COT and Leon County NPDES MS4 (1997)** | **224,070** | **39,464** |

The long-term (2000–07) average TN and TP loads were estimated to be about 135,143 and 24,018 lbs/yr, respectively (**Table 5.12**). During 2001 and 2003, when annual rainfall was similar to that in 1997, the averaged loads of TN and TP were 210,661 and 35,896 lbs/yr, respectively. These loading estimates are fairly comparable to the NPDES MS4 TN and TP loadings (224,070 lbs/yr for TN and 39,464 lbs/yr for TP) in 1997 reported by COT and Leon County. It should be noted that TN and TP loads were significantly lower in 2002, 2006, and 2007, possibly due to low rainfall.

Given the flows and loads calculated above, a separate empirical multivariable equation was developed to predict the assimilative capacity of the lake, using the water quality data during the verified period of 2003 to 2009. During the review of the data, several results were identified as possible outliers. In the process, daily values were carefully examined with professional tools such as method detection limits, practical quantitative limits, standard deviation, coefficient variance, and other quality control procedures (laboratory flag or code). **Table 5.13** shows examples of the data that were removed from the overall dataset. Daily results obtained from several different locations per each sampling event were aggregated into an averaged value to represent daily concentrations for CChla, TN, and TP. The values were then aggregated to an averaged quarterly value used to develop the multivariable equation.

**Figures 5.8** and **5.9** depict strong relationships between CChla and TN and between CChla and TP in the lake during the period from 2004 to 2008 (2003 and 2009 did not have data in all four calendar quarters), indicating that CChla positively corresponds to in-lake TN and TP concentrations with a linear response. During these years, CChla data for the full fours quarter were available for the assessment. The multivariable equation was derived from the CChla to TN to TP relationships, showing that CChla is well correlated to TN and TP. Based on the equation below, CChla (µg/L) can be predicted (as well as TSI) as a function of the TN and TP concentrations (mg/L) proportional to the TN and TP loadings to the lake.

$$\text{CChla} = 32.88 \cdot \text{TN} + 18.71 \cdot \text{TP} - 4.26 \quad (r = 0.779,\ n = 20) \qquad (1)$$

Where CChla, TN and TP are observed concentrations of CChla in µg/L and TN and TP in mg/L during the period from 2004 to 2008.

**Figure 5.10** compares the results from predicting CChla with the measured CChla concentration. This graph supports the conclusion that the equation is well calibrated. **Figure 5.11** shows observed CChla concentrations as a function of TN:TP ratios (by weight), indicating that the lake has been N-limited in most cases over the period of observation, especially during periods with elevated Chla concentrations. Moreover, the relationship between CChla and TN:TP ratio also indicates that the lake trophic state would be improved with co-limiting conditions of TN:TP ratios greater than 10.

## Table 5.13 Data Not Used In the Development of the Multivariable Regression Equation

- = Empty cell/no data
[1] Rcode: A = mean of 2 or more results; I = value is between MDL and PQL; T = reported value is less than MDL

| Parameter | Station | Year | Month | Day | Time | Depth | Result | Units | Rcode[1] |
|---|---|---|---|---|---|---|---|---|---|
| TP | 21FLPNS 302209508418243 | 2006 | 3 | 27 | 1245 | 0.15 | 7 | mg/L | - |
| TP | 21FLPNS 302158508418060 | 2006 | 3 | 27 | 1230 | 0.15 | 7.3 | mg/L | A |
| TP | 21FLMCGLMU5 | 2004 | 12 | 27 | 155 | - | 0.00464 | mg/L | T |
| TP | 21FLMCGLMU5 | 2004 | 11 | 29 | 825 | - | 0.00612 | mg/L | I |
| TP | 21FLMCGLMU3 | 2004 | 11 | 29 | 847 | - | 0.00077 | mg/L | T |
| TP | 21FLMCGLMU1 | 2004 | 11 | 29 | 928 | - | 0.00256 | mg/L | T |
| TP | 21FLMCGLMU3 | 2005 | 5 | 4 | 937 | - | 0.00535 | mg/L | T |
| TP | 21FLMCGLMU1 | 2005 | 5 | 4 | 948 | - | 0.00535 | mg/L | T |

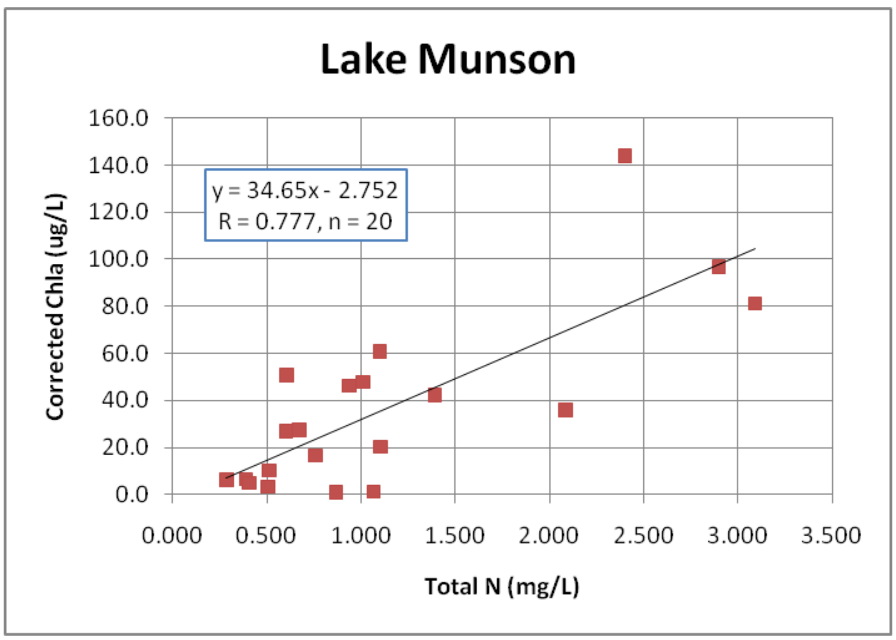



Figure 5.8 Relationship between Chla and TN Observed in Lake Munson, 2004–08

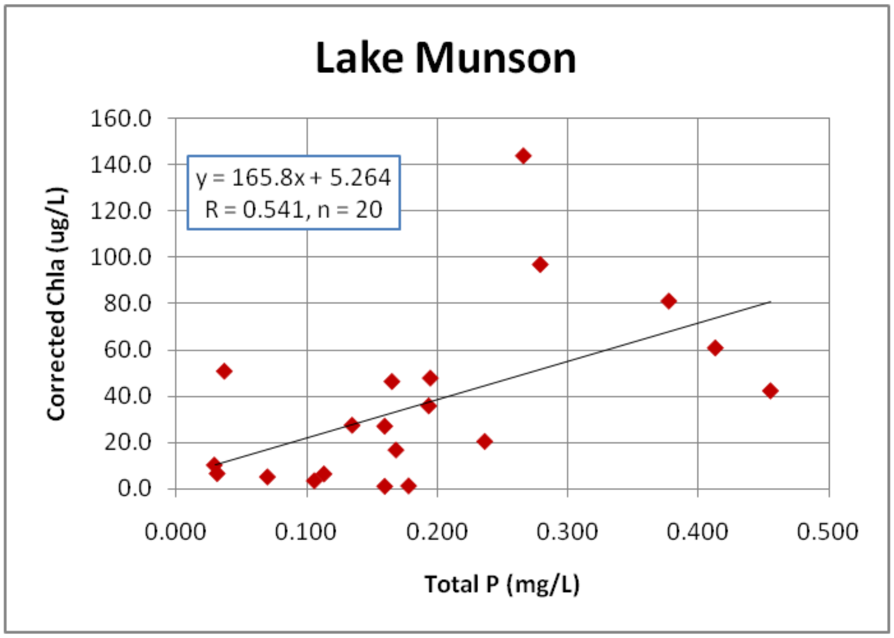



Figure 5.9 Relationship between Chla and TP Observed in Lake Munson, November 1986–December 2007

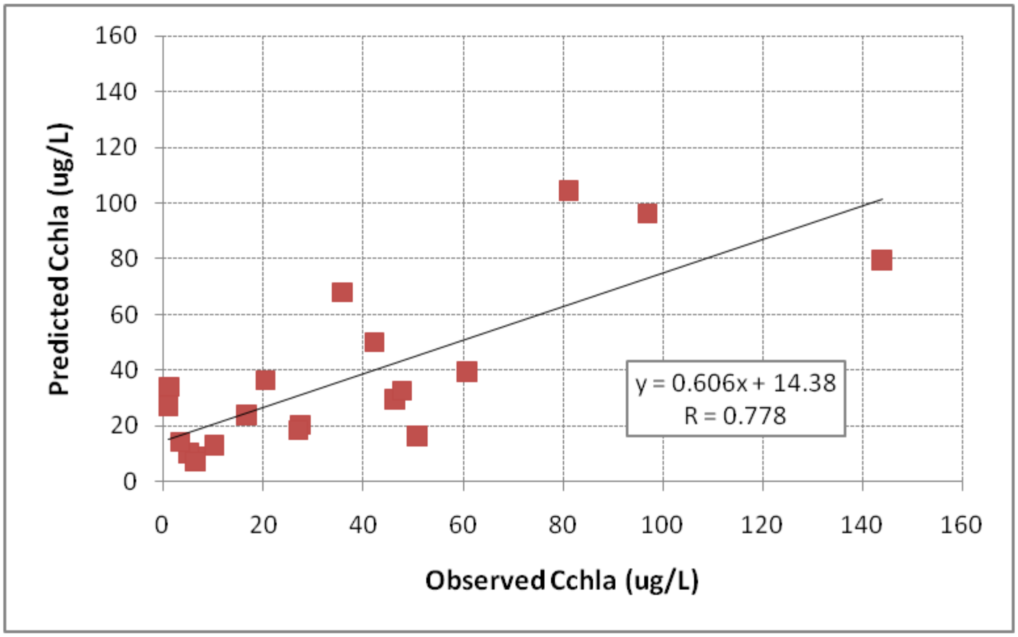



Figure 5.10 Predicted Chla Versus Daily Averaged Chla Observed in Lake Munson, 1986–2007

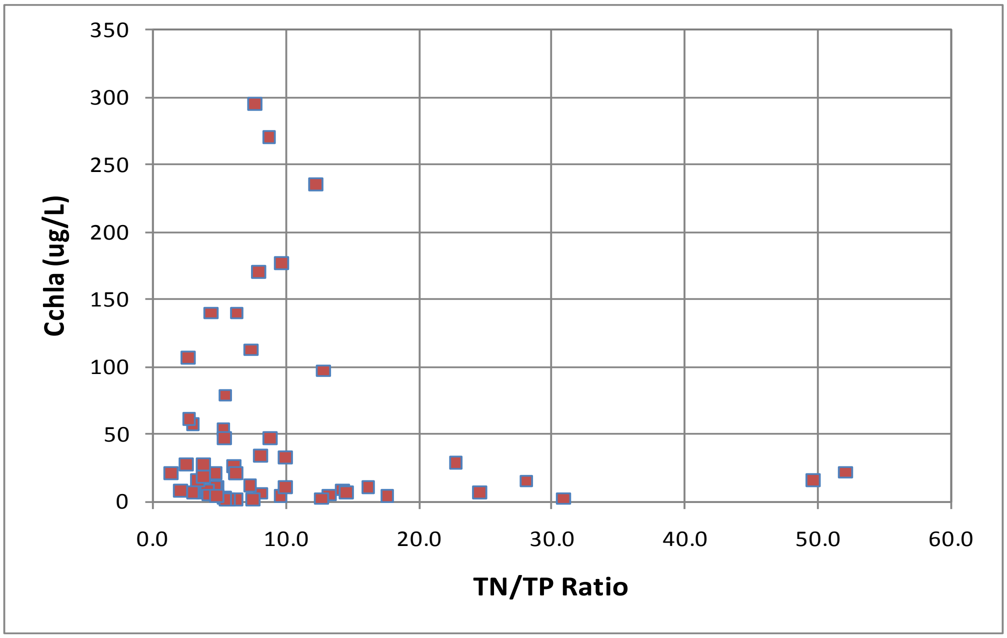



Figure 5.11 CChla Concentration Versus TN:TP Ratio Observed in Lake Munson, October 2003–August 2009

## Selection of Lake TMDL Target

Using the WMM-based spreadsheet model for load estimates and the CChla predictive equation developed for existing conditions to predict nutrient concentrations, all human land uses in the watershed were assigned a background land use category based on the current proportion of those land uses in the watershed, and the models were run for the background land use condition. The same highly extended (enlarged) watershed that exists today was also used as the watershed for the background land use scenario. **Table 5.14** shows the results for the existing measured condition, existing calibrated models, and background land use condition. The background land use scenario was developed to ensure that the final TMDL target concentrations were not aimed at restoring the lake to a pristine natural condition.

Table 5.14 Quarterly Measured Data, Regression Model, Background Land Use, CChla, TN, TP, and TSI, 2004–08 (n = 20)

| Scenario | Chla (µg/L) | TN (mg/L) | TP (mg/L) | TSI | TN:TP |
|---|---|---|---|---|---|
| Existing Measured Data | 36.50 | 1.13 | 0.189 | 65.4 | 6.0 |
| Existing Model Predicted | 36.56 | 1.134 | 0.189 | 65.5 | 6.0 |
| Background Land Use | 15.86 | 0.593 | 0.033 | 51.4 | 17.7 |

**Table 5.15** contains the acreages of background land uses incorporated into the background loading analysis. **Table 5.16** contains the estimated TN and TP loadings to Lake Munson under background land use conditions.

## Table 5.15 Background Land Use

[1] Acreage of water does not include the area of Lake Munson.

| Land Use Category | Area (acres) |
|---|---|
| Upland Forest/Open | 26,753 |
| Water[1] | 1,673 |
| Wetland | 6,370 |

## Table 5.16 Background Annual TN and TP loads

* Std = standard deviation

| Year | TN (lbs/yr) | TP (lbs/yr) |
|---|---|---|
| 2000 | 82,965 | 4,673 |
| 2001 | 180,370 | 9,655 |
| 2002 | 30,467 | 2,138 |
| 2003 | 103,117 | 5,967 |
| 2004 | 63,631 | 3,912 |
| 2005 | 96,141 | 5,700 |
| 2006 | 27,415 | 1,924 |
| 2007 | 31,465 | 2,143 |
| **Average** | **76,946** | **4,514** |
| **Standard Deviation** | **51,611** | **2,627** |

### Simulations for Nutrient TMDL Load Reduction for Lake Munson (WBID 807C)

As discussed in the section on calibration, rainfall data from 2000 to 2007 were retrieved from the Tallahassee Regional Airport Weather Station to create a complete daily rainfall dataset that matched the verified period of the impairment. Since the observed flow measurements were available from Flow Station S20 (upstream of Lake Munson) operated by the NWFWMD, the model calibration was made at this point of the delivery of water and mass. Then, the calibrated parameters (e.g., DCIA and runoff coefficients) of the WMM were used to model the entire Lake Munson watershed. The model outputs included annual flows (ac-ft/yr) and TN and TP loads (lbs/yr) from the watershed to the lake. Under the current conditions, the long-term (2000–07) annual average of TN and TP loads are about 135,143 and 24,018 lbs/yr, respectively (**Table 5.12**).

**Table 5.17** summarizes the water quality parameters and TSI under existing and background land uses and percent load reductions. For the background condition, TN, TP, and CChla concentrations were 0.593 mg/L, 0.033 mg/L, and 15.86 µg/L, respectively, with a TN:TP ratio of 17.7. These values result in a background TSI of 51.4.

Table 5.17 TN, TP, Chla, TSI, and TN:TP Results for Measured, Predicted, Background, and TMDL Condition

| Result | Chla (µg/L) | TN (mg/L) | TP (mg/L) | TSI | TN:TP Ratio |
|---|---|---|---|---|---|
| **Existing Measured** | 36.5 | 1.134 | 0.189 | 65.45 | 6.0 |
| **Existing Predicted** | 36.56 | 1.134 | 0.189 | 65.46 | 6.0 |
| **Background Predicted** | 15.86 | 0.593 | 0.033 | 51.44 | 17.7 |
| **32.5%TN/76.7%TP Reductions** | 21.71 | 0.765 | 0.044 | 56.23 | 17.4 |

The percent reduction in loads from WMM estimates of current condition and background land use condition was applied to the regression equation to derive estimates of the background concentrations. The background land use scenario was run to ensure that the target for impairment was correct and that the final TMDLs developed by the Department were not aimed at restoring pristine predevelopment conditions.

Based on the requirements of the IWR, a new TSI threshold for impairment of 61 (background TSI of 51 plus 10) was established and the water quality data were reevaluated to determine if the waterbody was still impaired. The IWR specifies that a lake is impaired if a single year exceeds the impairment threshold (TSI 61) during the verified period. The Lake Munson threshold target TSI of 61 was exceeded in 2002 (64), 2006 (76), and 2007 (68), resulting in the lake remaining as impaired. The 10 TSI unit increase over the background condition represents 100% of the allowable assimilative capacity of the lake (the IWR states that a 10 TSI unit increase over background results in verified impairment). In these cases, the Department allows an increase in TSI above the background condition, representative of 50% of the assimilative capacity condition, resulting in a TMDL target TSI of 56 (51 +5).

The TMDL load reductions were obtained by iteratively reducing the concentrations in the regression model, until a TSI of 56 and TN:TP ratio of 17 were achieved. The load reductions were obtained by applying the percent reduction in concentration (from current condition to TSI target) to the current condition loading estimates from the WMM. The in-lake concentrations for CChla, TN, and TP that result in attaining the target TSI and maintaining a TN:TP ratio of 17 are 21.7 µg/L, 0.76 mg/L, and 0.044 mg/L, respectively. The load reduction required to achieve the TSI target of 56.0 (assuming that the loading is proportional to the in-lake concentrations of TN and TP) is 32.5% for TN and 76.7% for TP. The existing annual average load for TN is 135,143 lbs/year. A 32.5% reduction of TN is 43,921 lbs/year, resulting in an annual average allowable TN load of 91,221 lbs/year, or an average annual daily load of 249.9 lbs/day. The existing annual average load for TP is 24,018 lbs/yr. A 76.7% reduction of TP is 18,422 lbs/year, resulting in an annual average allowable TP load of 5,596 lbs/yr, or an average annual daily load of 15.3 lbs/day. The Department has determined that expressing the nutrient TMDLs for Lake Munson as concentrations and percent reductions is appropriate and will result in the lake meeting standards.

### Lake Munson Sediment Nutrient Release (SNR)

Nutrients stored in lake sediments as a result of historical loadings from wastewater and stormwater discharges can be released to the water column under a variety of conditions. Estimates of allowable external nutrient loadings under the TMDL for Lake Munson will not necessarily result in the lake attaining standards if the internal recycling of these historical nutrient loads is a significant source. Addressing the impact on the lake from these internally stored nutrients is not a part of this TMDL, but should be addressed as a part of implementation activities under the Basin Management Action Plan (BMAP). These include both maintenance dredging and physical/chemical/biological processes.

## 5.3 Turbidity TMDL Percent Reduction for Lake Munson (WBID 807C)

Lake Munson was verified as impaired by turbidity. This was based on assessing the in-lake turbidity data against a criterion of 29 plus natural background. In this case, a natural background turbidity of 2 NTU was determined as representing a natural background condition. Therefore, the target turbidity value for restoration is 31.0 NTU. The median turbidity of all the results greater than 31 NTU is 45.5 NTU. In order for the lake to attain standards for turbidity, the in-lake concentration must be reduced by 31.9%. Based on the Department's understanding of the source of the high turbidity (excessive algae in the lake), attaining standards for nutrients will restore the algal community and reduce turbidity in the lake to within 29 NTUs of the natural condition.

## 5.4 Total Ammonia Reductions To Address Un-ionized Ammonia for Munson Slough Below Lake Munson

Munson Slough (WBID 807) below Lake Munson is listed as impaired for un-ionized ammonia (NH3U).

The calculation for the un-ionized ammonia is after Chapra (1997):

$$NH3U = (17/14) * (NH3N) * (f(pH, TEMP)) <= 0.02 \text{ mg/l}$$

Since there are an infinite number of combinations of pH and TEMP to use for design conditions, a statistical or Monte Carlo approach was used (EPA 1999). Using the mean and standard deviation for pH and TEMP (WBID 807), random normal distributions of 1,000 pairs of pH and TEMP were generated using Excel. Given a mean value for NH3-N, random normal distributions of NH3-N were also generated for each pair of pH and TEMP. The NH3-U concentrations were then calculated for each set of 1,000 values. The number of exceedances (NGSTD) of the 0.02 mg/L criterion was then tabulated for each mean NH3-N. A regression line (**Figure 5.12**) was used to estimate NH3-N=0.32 mg/l as the mean value corresponding to a 10% exceedance rate. **Table 5.18** shows the percent reduction needed for WBID 807 to meet the NH3-U criterion.

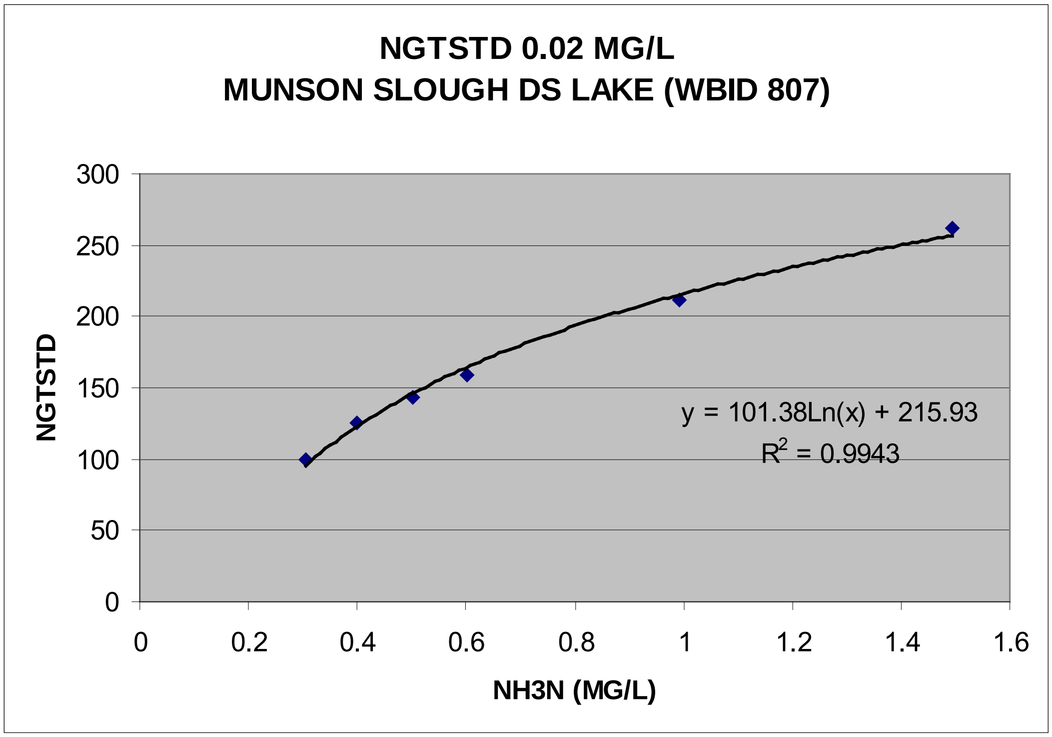



Figure 5.12 Chart of Number of NH3-U Exceedances (NGTSTD) Versus NH3-N for WBID 807

Table 5.18 Summary of Total Ammonia Reduction Needed for Munson Slough (WBID 807) To Meet the NH3-U Criterion

| | Munson Slough Mean NH3-N (mg/L) | Monte Carlo Mean NH3-N (mg/L) | Difference | % Reduction |
|---|---|---|---|---|
| 1971–2007 | 0.48 | 0.32 | 0.16 | 33.3% |

## 5.5 Develop $BOD_5$ TMDL (addresses DO impairment)

The Department has examined simple linear responses of DO to various nutrient and $BOD_5$ pollutants for WBIDs 807D, 807C, and 807. No significant correlation was found between DO grab samples and grab samples for these individual pollutants (*Appendix D* of the *Supplemental Information* report). The 1986–87 NWFWMD study (Maristany *et al.* 1988) looked at a narrow time window dataset for Lake Munson. For example, the correlation analysis showed that DO at the surface, one-foot, and two-foot levels was negatively correlated with NH3N and COLOR, but not correlated with $BOD_5$. However, DO levels depend on a complex nonlinear relationship among: individual pollutants, decay rates for these pollutants, temperature, reaeration, sediment oxygen demand, aquatic plants, light, flow, stratification, etc. Currently, the Department has not completed a calibrated/verified model that includes the processes that control the DO in the lake and could be used to answer the question of what improvements in the DO regime of the lake can be expected from reducing nutrients and Chla.

However, the Department has collected recent additional DO data that illustrate the complexity of this system. These data are described in *Appendix D* of the *Supplemental Information* report.

### 5.5.1 BOD Summary

As has been the case for over 20 years, the Department uses the 70$^{th}$ percentile concentrations of $BOD_5$ from STORET data collected from 1970 to 1987 as the target level, where $BOD_5$ values below these concentrations will not cause or contribute to low DO conditions in the water. The documentation for this analysis is contained in Friedemann and Hand (1989). The 70$^{th}$ percentile level for BOD in streams (including slough systems) is 2.0 mg/L. The 70$^{th}$ percentile level for BOD in lakes is 2.9 mg/L. Given that Lake Munson (WBID 807C) is the headwaters of Munson Slough below Lake Munson (WBID 807), the $BOD_5$ TMDL for Lake Munson must also be protective of the downstream water in Munson Slough below the lake. For this reason, the level of 2.0 mg/L for streams was applied to both the lake and the stream. Based on the Department's experience assessing DO impairments in streams and lakes (Friedemann and Hand 1989), if $BOD_5$ is less than 2.0 mg/L it is not considered as "causing or contributing" to low DO conditions in the water. **Tables 5.19a** and **5.19b** contain the recommended percent reductions.

Table 5.19a Summary of $BOD_5$ Reduction Needed for Lake Munson (WBID 807C) To Meet the DO Target

| Waterbody (WBID) | Year | Median $BOD_5$ (mg/L) | Lake $BOD_5$ Target Level (mg/L) | Difference | % Reduction |
|---|---|---|---|---|---|
| WBID 807C (Lake Munson) | 1986–2007 | 4.00 | 2.0 | 2.0 | 50.0% |

Table 5.19b Summary of $BOD_5$ Reduction Needed for Munson Slough (WBIDs 807, 807D) To Meet the DO Target

| Waterbody (WBID) | Year | Median $BOD_5$ (mg/L) | Stream $BOD_5$ Target Level (mg/L) | Difference | % Reduction |
|---|---|---|---|---|---|
| WBID 807D (Upstream) | 1986–2007 | 4.00 | 2.0 | 2.0 | 50.0% |
| WBID 807 (Downstream) | 1986–2007 | 4.25 | 2.0 | 2.9 | 53.0% |

## 5.6 Critical Conditions for Chla and DO/Seasonality

The critical condition for Chla in a given watershed depends on many factors, including the presence of point sources and the land use pattern in the watershed. Typically, the critical condition for nonpoint sources is an extended dry period followed by a rainfall runoff event. During the wet weather period, rainfall washes off nutrients that have built up on the land surface under dry conditions. However, significant nonpoint source contributions can also appear under dry conditions without any major surface runoff event. This may happen when nonpoint sources contaminate the surficial aquifer and nutrients are brought into the receiving waters through baseflow. In addition, sediments that have accumulated for months may provide a flux of nutrients to the water column under certain weather or DO conditions. The critical condition for point source loading typically occurs during periods of low stream flow, when dilution is minimized.

The Department examined both DO and TSI for Lake Munson, by quarter, from 1973 to 2007, as shown in *Appendix D* of the *Supplemental Information* report. The data show that the DO was subject to extremes of anaerobic (<2.0 mg/L) and supersaturated conditions (>15.0 mg/L) for all seasons of the year. The TSI was very high (>60) in 1973 during the time that effluent was discharged to Munson Slough. The most recent data, from 2006 to 2007 show quarterly TSI values above 60 for all seasons.

## 5.7 Meeting Downstream Water Quality Needs

Dye studies have linked water draining from Munson Slough through Ames Sink to water discharged from Wakulla Spring. The Department has proposed a nitrate concentration of 0.35 mg/L as protective of Florida springs. The nutrient TMDL for Lake Munson will reduce the concentrations within the lake for TN to 0.76 mg/L (a 32.5% reduction in current levels) and phosphorus to 0.044 mg/L (a 76.7% reduction). The current median verified period nitrate-nitrite concentration for Munson Slough below Lake Munson is 0.06 mg/L, and the median total ammonia is 0.087 mg/L. The sum of these (assuming a 100% conversion of ammonia to nitrate-nitrite) is 0.147 mg/L, substantially less than the proposed nitrate target of 0.35 mg/L for Florida springs.

The TKN concentrations below the lake are about 0.84 mg/L. The organic and ammonia nitrogen that make up the TKN can oxidize to yield NO23-N. However, insufficient information is available in lower Munson Slough and Ames Sink to determine if this oxidation process is taking place. These current concentrations will be substantially reduced through the implementation of the TMDL.

Nutrient loadings for several sinking streams in the Woodville Karst Plain were evaluated by Chelette *et al.* (2002). These streams include Munson Slough, Fisher Creek, Black Creek, and Lost Creek. The combined 10-year average TN load from these streams was estimated at 72,000 kg/yr, or about 3% of the total estimated load to the watershed.

# 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:

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

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

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

It should be noted that the various components of the revised TMDL equation may not sum up to the value of the TMDL because (1) 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 (2) TMDL components can be expressed in different terms (for example, the WLA for stormwater is typically expressed as a percent reduction, and the WLA for wastewater is typically expressed as mass per day).

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

This approach is consistent with federal regulations (40 CFR § 130.2[I]), which state that TMDLs can be expressed in terms of mass per time (e.g., pounds per day), toxicity, or **other appropriate measure**. TMDLs for the Munson Slough/Lake Munson watershed are expressed in terms of concentration of nutrients (**Tables 6.1a** through **6.1d**). **Table 6.1a** contains the percent reduction for WBID 807D needed to achieve water quality standards and the in-stream concentrations required to maintain standards for the tributaries to Lake Munson. **Table 6.1b** contains the percent reductions required in the Lake Munson watershed to achieve water quality standards for nutrients (TSI) and DO in Lake Munson and the allowable in-lake concentrations required to maintain standards in the lake. **Table 6.1c** contains the percent reduction for turbidity required for Lake Munson (WBID 807C) to attain standards. **Table 6.1d** contains the percent reductions for $BOD_5$ (DO impairment) and un-ionized ammonia for WBID 807.

## Table 6.1a TMDL Components for Munson Slough and Streams above Lake Munson (WBID 807D). Addresses DO impairment.

N/A = Not applicable

| WBID | Parameter | TMDL (mg/L) | TMDL (% reduction) | WLA for Wastewater | WLA for NPDES Stormwater (% reduction) | LA (% reduction) | MOS |
|---|---|---|---|---|---|---|---|
| 807D | $BOD_5$ | 2.00 | 50.0% | N/A | 50.0% | 50.0% | Implicit |
| 807D | TN | 0.72 | 8.35% | N/A | 8.35% | 8.35% | Implicit |
| 807D | TP | 0.15 | 17.53% | N/A | 17.53% | 17.53% | Implicit |

## Table 6.1b Nutrient (TSI) and $BOD_5$ TMDL Components for the Munson Slough/Lake Munson Watershed (WBID 807C) Required To Restore Lake Munson. Addresses nutrient (TSI) and DO impairments.

N/A = Not applicable

**Note:** The percent reductions of TN and TP will correct the impairments for nutrients and DO. Achieving a long-term TSI of 56.0 results in an average CChla of 21.7 µg/L, TN of 0.765 mg/L, and TP of 0.044 mg/L, and a TN:TP ratio of 17.

| WBID | Parameter | TMDL (mg/L) | WLA for Wastewater (lb/yr) | WLA for Stormwater (% reduction) | LA (% reduction) | MOS | TMDL (lb/yr) | % Reduction |
|---|---|---|---|---|---|---|---|---|
| 807C | $BOD_5$ | 2.00 | N/A | 50% | 50% | Implicit | N/A | 50% |
| 807C | TN | 0.765 | N/A | 32.5% | 32.5% | Implicit | N/A | 32.5% |
| 807C | TP | 0.044 | N/A | 76.7% | 76.7% | Implicit | N/A | 76.7% |

## Table 6.1c Turbidity TMDL Components for Lake Munson (WBID 807C)

N/A - Not applicable

| WBID | Parameter | TMDL | TMDL (% reduction) | WLA for Wastewater | WLA for NPDES Stormwater (% reduction | LA (% reduction) | MOS |
|---|---|---|---|---|---|---|---|
| 807C | Turbidity (NTU) | 31 | 31.9% | N/A | 31.9% | 31.9% | Implicit |

Table 6.1d TMDL Components for Munson Slough below Lake Munson (WBID 807)

N/A - Not applicable

| WBID | Parameter | TMDL (mg/L) | TMDL (% reduction) | WLA for Wastewater | WLA for NPDES Stormwater (% reduction) | LA (% reduction) | MOS |
|---|---|---|---|---|---|---|---|
| 807 | $BOD_5$ | 2.00 | 52.9% | N/A | 52.9% | 52.9% | Implicit |
| 807 | $NH_3N$ | 0.32 | 33.3% | N/A | 33.3% | 33.3% | Implicit |

## 6.2 Load Allocation (LA)

Based on the approach in this document, a $BOD_5$ reduction of 50% is needed in WBID 807D, 50% in WBID 807C, and 53% in WBID 807. A reduction in TN of 8.35% and in TP of 17.53% is needed in WBID 807D in order to attain water quality standards in streams. Collectively, reductions of TN and TP from the Lake Munson watershed of 32.5 and 76.7%, respectively, are required for Lake Munson to attain water quality standards. For the lake to attain standards for turbidity, the in-lake concentration must be reduced by 31.9%.

Based on the Department's evaluation of the sources of turbidity (excessive algal production in the lake), attaining standards for nutrients will restore the range of turbidity in the lake to within 29 NTUs of the natural condition. A NH3-N percent reduction of 33.3% is needed in WBID 807. 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 (WLA)

Currently 10 permittees have potential discharge sites in the Munson Slough watershed: Ready Mix USA – Mosely Street Plant (FLG11358), Florida Rock – Tallahassee (FLG110319), Trinity Materials Plant 32 (FLG110307), Lake Bradford Estates STP (FLA010148), Sandstone Ranch WWTF (FLA010167), NHMFL – FSU (FLA01633), Southern Bell Trailer Park (FLA010151), Western Estates MHP (FLA010152), Lake Bradford Road WWTP (FLA010140, and T.P. Smith WRF (FLA010139). As none of these facilities discharges directly into waters of the state, they are not expected to contribute a significant amount of nutrients to the Munson Slough or Lake Munson. Any new potential discharger is expected to comply with the Class III criterion for DO, with limits on $BOD_5$, TN, TP, and NH3-N consistent with the TMDL.

### *6.3.1 NPDES Wastewater Discharges*

Point source facilities are permitted through the Clean Water Act NPDES Program. There is no continuous discharge of NPDES-permitted point sources in the Lake Munson watershed. Therefore, no specific allocations are assigned to NPDES wastewater facilities as part of this TMDL. Any new potential discharger is expected to comply with the Class III criterion for DO, with limits on $BOD_5$, TN, TP, and NH3-N consistent with the TMDL.

### *6.3.2 NPDES Stormwater Discharges*

The Munson Slough watershed, located in Leon County, falls under the Leon County & Co. App. – MS4 permit (FLS000033) and COT (MS4) permit (FLS000034) (Phase I MS4 permits), as well as FSU (FLR04E051), and FAMU (FLR04E095) (Phase II NPDES MS4 permits).

The wasteload allocations for these MS4 permits are a $BOD_5$ reduction of 50% needed in WBID 807D, 50% in WBID 807C, and 53% in WBID 807. A reduction in TN of 8.35% and in TP of 17.53% is needed in WBID 807D in order to attain water quality standards in streams. Collectively, reductions of TN and TP from the Lake Munson watershed of 36.5 and 76.7%, respectively, are required for Lake Munson to attain water quality standards. For the lake to attain standards for turbidity, the in-lake concentration must be reduced by 31.9%. It is the Department's position that attaining standards for nutrients will restore the range of turbidity in the lake to within 29 NTUs of the natural condition. A NH3-N percent reduction of 33.3% is needed in WBID 807. It should be noted that any MS4 permittee is only responsible for reducing the loads associated with stormwater outfalls that it owns or otherwise has responsible control over, and it is not responsible for reducing other nonpoint source loads in its jurisdiction.

## 6.4 Margin of Safety (MOS)

TMDLs shall include an MOS that takes into account any lack of knowledge about the pollutant loading and in-stream water quality. There are two methods for incorporating an MOS in the analysis: (1) implicitly incorporate the MOS using conservative model assumptions to develop allocations; or (2) explicitly specify a portion of the TMDL as the MOS and use the remainder for allocations. Consistent with the recommendations of the Allocation Technical Advisory Committee (Department 2001), an implicit MOS was used in the development of each of these TMDLs because of the conservative assumptions used in the water quality model for the lake and the TMDLs for nutrients in the stream, in order to take into account the uncertainty associated with instream processes, limited data, and the use of median values.

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

## 7.1 Basin Management Action Plan

Following the adoption of these TMDLs by rule, the Department will determine the best course of action regarding their implementation. Depending on 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. BMAPs 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.

The Department has determined that a BMAP is needed to support the implementation of these TMDLs, 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 the following:

- *Water quality goals (based directly on the TMDLs);*
- *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 TMDLs;*
- *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 the obligations of wastewater point source, MS4, and non-MS4 stakeholders in TMDL implementation; enhanced transparency in the Department's decision making; and built strong relationships between the Department and local stakeholders that have benefited other program areas.

# References

Alexander, R.B., and R.A. Smith. 1990. *County level estimates of nitrogen and phosphorus fertilizer use in the United States, 1945 to 1985.* U.S. Geological Survey Open-File Report 90-130.

Ambrose, R.B., T.A. Wool, J.P. Connolly, and R.W.Schanz. 1988. *WASP4, A hydrodynamic and water quality model—Model theory, user's manual, and programmer's guide.* EPA/600/3-87/039. Washington, DC: U.S. Environmental Protection Agency.

American Veterinary Medical Association website. 2004. Available: http://www.avma.org.

Arnold, J.G., P.M. Allen, R. Muttiah, and G. Bernhardt. 1995. Automated base flow separation and recession analysis techniques. *Ground Water* 33(6): 1010–1018.

Arnold, J.G., and P.M. Allen. 1999. Automated methods for estimating baseflow and ground water recharge from streamflow records. *Journal of the American Water Resources Association* 35(2): 411–424.

Bartel, R.L., and F.B. Ard. 1992. *U.S. Environmental Protection Agency Clean Lakes Program, Phase I, Diagnostic feasibility report for Lake Munson.* Northwest Florida Water Management District Water Resources Special Report 92-4.

Bartel, R.L., R. Arteaga, N. Wooten, F.B. Ard, and A.T. Benoit. Revised September 1992. *City of Tallahassee and Leon County stormwater management plan, Vol. II: Lake Munson basin management plan.* Northwest Florida Water Management District Water Resources Assessment 91-2.

Battaglin, W.A., and D.A. Goolsby. 1995. *Spatial data in geographic information system format on agricultural chemical use, land use, and cropping practices in the United States.* U.S. Geological Survey Water-Resources Investigations Report 95-4176. Available: http://water.usgs.gov/pubs/wri/wri944176.

Beck 1963 Florida State Board of Health, Annual Report

Benham 2007 TMDL Implementation: Lessions Learned, Virgina Tech.

Birdsource Website 2007 http://www.birdsource.org/gbbc

Blackburn, R.D., L.W. Weldon, R.R. Yeo, and T.M. Taylor. 1969. Identification and distribution of certain similar-appearing submersed aquatic weeds in Florida. *JAPM* 8: 17–21.

Brezonik, P.L., C.D. Hendry, Jr., E.S. Edgerton, R.L. Schulze, and T.L. Crisman. 1983. *Acidity, nutrients, and minerals in atmospheric precipitation over Florida: Deposition patterns, mechanisms, and ecological effects.* EPA-600/3-83-004. Washington, DC: U.S. Environmental Protection Agency.

Brezonik, P.L., and T.H. Stadelmann. 2002. Analysis and predictive models of stormwater runoff volumes, loads, and pollutant concentrations from watersheds in the Twin Cities metropolitan area, Minnesota, USA. *Water Research* 36: 1743–1757.

Brown, M.T. 1995. *South Dade watershed project.* University of Miami and the Southwest Florida Water Management District.

Brown, M., K.C. Reiss, M.J. Cohen, J.M. Evans, and K.R. Reddy *et al.* April 28, 2008. *Summary and synthesis of the available literature on the effects of nutrients on spring organisms and systems*. Gainesville, FL: University of Florida Water Institute. Available: http://www.dep.state.fl.us/springs/reports/files/UF_SpringsNutrients_Report.pdf.

Camp Dresser McKee. 1998a. *Rouge River National Wet Weather Demonstration Project, Wayne County, Michigan. Technical memorandum. User's manual: Watershed management model, Version 4.0.* RPO-NPS-TM27.01.

———. 1998b. *Rouge River National Wet Weather Demonstration Project, Wayne County, Michigan. User's manual: Watershed management model, Version 4.1.* PRO-NPS-TM27.02.

Canfield, D.E., Jr., K.A. Langeland, and M.J. Maceina. 1983. Trophic state classifications of lakes with aquatic macrophytes, *Can. J. Fish Aquatic Sci.* 40:1713–1718.

Chapra, S. 1997. *Surface water-quality modeling.* McGraw Hill Science/Engineering/Math.

Chelette, A., T.R. Pratt, and B.G. Katz. April 2002. *Nitrate loading as an indicator of nonpoint source pollution in the lower St. Marks-Wakulla Rivers watershed.* Northwest Florida Water Management District Water Resources Special Report 02-1.

City of Tallahassee. September 2007. *A water quality and biological assessment of selected lakes.* Tallahassee, FL: City of Tallahassee Stormwater Management Division.

Environmental Research and Design, Inc. 2000. *Winter Park Chain-of-Lakes groundwater/sediment study.* Final report prepared for the city of Winter Park, FL.

Florida Administrative Code. *Chapter 62-302, Surface water quality standards*.

———. *Chapter 62-303, Identification of impaired surface waters*.

Florida Department of Environmental Protection. 2001a. *A report to the governor and the legislature on the allocation of total maximum daily loads in Florida.* Tallahassee, FL: Bureau of Watershed Management, Division of Water Resource Management.

———. 2001b. *Basin status report: Ochlockonee and St. Marks.* Tallahassee, FL: Bureau of Watershed Management, Division of Water Resource Management.

———. 2008. *Aquatic plant database*.

Florida Department of Environmental Regulation. 1988. *Lake Munson, Leon County*.

Florida Department of Health website. 2008. Available: http://www.doh.state.fl.us/.

Florida Department of Transportation. 1999*. Florida land use, cover, and forms classification system (FLUCCS)*. Thematic Mapping Section.

Friedeman, M., and J. Hand. 1989. *Typical water quality values for Florida's lakes, streams, and estuaries.* Tallahassee, FL.

Funaba 2005 *Evaluation of meat meal, chicken meal, and corn gluten meal as dietary sources of protein in dry cat food*. Can J Vet Res. 2005 October; 69(4): 299–304.

Gilbert, D. 2010. *Nutrient (biology) TMDL for the Upper Wakulla River.* Tallahassee, FL: Division of Environmental Assessment and Restoration, Bureau of Watershed Restoration.

Gilbert ,D., R. Wieckowicz, E. Wilcox, W.J. Kang, and B. Ralys. 2008. *TMDL supplemental information for Munson Slough/Lake Munson watershed, WBIDs 807, 807C, and 807D.* Tallahassee, FL: Florida Department of Environmental Protection.

Goolsby 1999 *Nitrogen in the Mississippi Basin-Estimating Sources and Predicting Flux to the Gulf of Mexico.* USGS Fact Sheet 135-00

Hand, J. 2007. Health Aquatic Plant Index (HAPI) surveys, personal communication.

Harper, H.H., and E.H. Livingston. 1999. *Everything you always wanted to know about stormwater management practices but were afraid to ask.* Biennial Stormwater Research Conference, Tampa, FL.

Harper, H.H., and D.M. Baker. 2003. *Evaluation of alternative stormwater regulations for southwest Florida.* Report prepared by Environmental Research and Design, Inc. for the Water Enhancement and Restoration Coalition, Inc.

———. 2007. *Evaluation of current stormwater design criteria within the state of Florida.* Final Report prepared by Environmental Research and Design, Inc. for the Florida Department of Environmental Protection.

Heiker, T., 2008. *Lake Munson restoration project.* Leon County Public Works.

———. 2008. *Final report FY97 Section 319 Grant Program.* Florida Department of Environmental Protection Contract WM682.

Irwin, G.A., and R.T. Kirkland. 1980. *Chemical and physical characteristics of precipitation at selected sites in Florida.* U.S. Geological Survey Water-Resources Investigations Report 80-81.

Kohler 1959 . Weather Bureau Technical Paper 37.

Kumar, N. 1984. U.S. Environmental Protection Agency Region 4, personal communication.

Leon County 2008. City of Tallahassee Lakes Report 2008.

Leseman 1977 Lake Munson Study; unpublished report, City of Tallahassee Water Quality Laboratory.

Loper, D., W.M. Landing, C.D. Pollman, and A.B.C. Hilton. 2005. *Degradation of water quality at Wakulla Springs, Florida: Assessment and recommendations.* Report of the Peer Review Committee on the Workshop "Solving Water Pollution Problems in the Wakulla Springshed of North Florida, May 12-13, 2005, Tallahassee, FL.

Maristany, A.E., R.L. Bartel, and D. Wiley. 1988. *Water quality evaluation of Lake Munson, Florida.* Northwest Florida Water Management District Water Resources Assessment 88-1.

National Atmospheric Deposition Program 2002. Website http://nadp.sws.uiuc.edu/data/

Nicol, J.P., and S. McClelland. February 1984. *Automated water quality analysis report development (AWQARD).* Florida Department of Environmental Regulation Water Quality Technical Series Vol. 3, No. 13.

Northwest Florida Water Management District website. 2008. Available: http://www.nwfwmd.state.fl.us/.

USDA Website 2007
http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs143_013181.pdf

Pollman, C.D., and S. Roy. August 20, 2003*. Examination of atmospheric deposition chemistry and its potential effects on the Lower St. Johns Estuary, Tasks 1 through 4.* Tetra Tech Final report submitted to the St. Johns River Water Management District.

Poor, N., R. Pribble, and H. Greening, 2001. Direct wet and dry deposition of ammonia, nitric acid, ammonium, and nitrate to Tampa Bay Estuary, FL, USA. *Atmos. Environ.* 35:3947–3955.

Post, D.M., J.P. Taylor, J.F. Kitchell, M.H. Olson, D.E. Schindler, and B.R. Herwig. 1998. The role of migratory waterfowl as nutrient vectors in a managed wetland. *Conservation Biology* 12:910–920.

Potts, R.R. April 25, 1997. *Characterization of existing sediments environmentally through a literature search, Lake Munson sediments.* Prepared for Camp Dresser and McKee, Inc., by Environmental and Geotechnical Specialists, Inc.

Pribble, R., and A. Janicki. 1999. *Atmospheric deposition contributions to nitrogen and phosphorus loadings in Tampa Bay: Intensive wet and dry deposition data collection and analysis, August, 1996–July 1998.* Interim data report. Tampa Bay Estuary Program Technical Publication 05-99.

Quiros, R. 2002. The nitrogen to phosphorus ratio for lakes: A cause or a consequence of aquatic biology. In: A.Fernandez Cirelli and G. Chalar Marquisa (Eds.), *El aqua en Iberoamerica: De la limnologia a la gestion en Sudamerica* (Buenos Aires, Argentina: CYTED XVII, Centro de Estudios Transdiciplinarios del Aqua, Facultad de Veterinaria, Universidad de Buenos Aires, pp. 11–26).

Richardson, J. 2008. *Lake Munson: Past, present, and future.* Powerpoint presentation. Available: http://www.leoncountyfl.gov/pubworks/engineering/Stormwater_Management/Lake%20Munson%20Update%2010.1.07.pdf.

Rogers, T. 2006. Nitrogen oxides emissions for Florida counties 2002, personal communication.

Ruddy, B.C., D.L. Lorenz, and D.K. Mueller. 2006. *County-level estimates of nutrient inputs to the land surface of the conterminous United States, 1982–2001.* U.S. Geological Survey Scientific Investigations Report 2006-5012.

Runkel, R.L., C.G. Crawford, and T.A. Cohn. 2004. *Load estimator (LOADEST): A FORTRAN program for estimating constituent loads in streams and rivers, USGS Techniques and Methods, Book 4, Chapter A5.*

Schindler, D,W., R.E. Hecky, D.L. Findlay, M.P. Stainton, and B.R. Parker *et al.* August 2008. Eutrophication of lakes cannot be controlled by reducing nitrogen input: Results of a 37-year whole-ecosystem experiment. *Proceedings of the National Academy of Sciences* 0805108105.

Schmitz, D.C., J.D. Schardt, A.J. Leslie, F.A. Dray, Jr., J.A. Osborne, and B.V. Nelson. 1991. The ecological impact and management history of three invasive alien aquatic plant species in Florida. In: B.N. McKnight (Ed.), *Biological pollution: The control and impact of invasive exotic species, Proceedings of a Symposium held at the University Place Conference Center, Indiana Univ.–Purdue Univ. at Indianapolis, October 25 and 26, 1991* (Indianapolis, IN: Indiana Academy of Science, pp. 173–194).

Shannon, E.E. and P.L. Brezonik. 1972. Eutrophication analysis: a multi-variate approach. *J. Sanit. Eng. Div.Amer. Soc. Civil Eng.* **98:** 37-57.

Thomann, R.V., and J.A. Mueller. 1987. *Principles of surface water quality modeling and control.* New York: Harper & Row.

Thorpe, P. August 1996. *Evaluation of alternatives for the control of invasive exotic plants in Lake Jackson, Florida.* Northwest Florida Water Management District Water Resources Special Report 96-3.

U.S. Census Bureau. *Census data.* 1990, 2003, 2007. Available: http://www.census.gov/.

U.S. Department of Agriculture. 2002. *National Agricultural Statistics Service.* Available: http://www.nass.usda.gov/.

U.S. Environmental Protection Agency. 1975. Nation Eutrophication Survey, EPA-600/4-75-015, November 1975.

———. May 1997. *Compendium of tools for watershed assessment and TMDL development.* EPA841-B-97-006. Washington, DC: Office of Water.

———. 1999. *Protocol for developing nutrient TMDLs.* First edition. EPA 841-B-99-007.

———. 2001. U.S. Environmental Protection Agency. 2001. *Protocol for determining pathogen TMDLs.*EPA 841-R-00-002. Washington, DC: Office of Water. Available: http://www.epa.gov/owow/tmdl/pathogen_all.pdf

———. 2002. Onsite Wastewater Treatment Systems Manual, EPA/625/R-00/008, February 2002.

———. October 2006. *Total maximum daily load (TMDL) for Ochlockonee and St. Marks River Basins, Florida (WBIDs 459,746,820,857,865,916), nutrients, fecal and total coliforms.* Prepared by the U.S. Environmental Protection Agency, Region 4.

———. 2008. *WASP7.2 manual.* Available: www.epa.gov/athens/wwqtsc/html/wasp.html.

U.S. Geological Survey website. 2005. Available: http://www.usgs.gov/.

Van Dyke, J. 1986. Letter to John Outland, November 26, 1986, shown as Appendix III of Bartel 1992.

Voss, D. August 31, 1975. Hydrilla: Even experts aren't sure if the mysterious plant is really dangerous. *Tallahassee Democrat*.

Wanielista, M.P., and Y.A. Yousef. 1993. *Stormwater management.* New York: John Wiley & Sons, Inc.

Warden 2007 California Regional Water Quality Control Board Lahontan Region Meeting July 13-14, 2007

Wellendorf, N. 2008. Florida Department of Environmental Protection Biology, personal communication.

Wieckowicz, R., T. Sanders, and E. Wilcox. 2008. *Hydrilla summary report.*

Wieckowicz, R., E.G. Wilcox, and B. Ralys. 2008a. *Fecal coliforms TMDL for Munson Slough Watershed, WBID 807D.* TMDL Report. Tallahassee, FL: Florida Department of Environmental Protection, Bureau of Watershed Management.

———. 2008b. *Lake Bradford Listing Category 4C.*

Ziegmont, C. 2007. Florida Department of Environmental Protection permitting, personal communication regarding data sources for spills. Referred to website http://www.eoconline.org.

## Appendix A: Background Information on Federal and State Stormwater Programs—NPDES MS4 Data

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 state's water management districts, along with wetland protection requirements, into the Environmental Resource Permit (ERP)regulations.

Rule 62-40, F.A.C., also requires the 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, they have been established for Tampa Bay, Lake Thonotosassa, the Winter Haven Chain of Lakes, the Everglades, Lake Okeechobee, and Lake Apopka. No PLRG had been developed for Lake Munson when this report was published.

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 the master drainage systems of local governments with a population above 100,000, which are better known as MS4s. However, because the master drainage systems of most local governments in Florida are interconnected, the EPA implemented Phase I of the MS4 permitting program on a countywide basis, which brought in all cities (incorporated areas), Chapter 298 urban water control districts, and the FDOT throughout the 15 counties meeting the population criteria. The Department received authorization to implement the NPDES stormwater program in 2000.

An important difference between the federal NPDES and the state's stormwater permitting/ERP programs is that the NPDES Program covers both new and existing discharges, while the state's program focuses 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.

## Table A.1 COT NPDES MS4 Year 3 Report

| Outfall ID | Area (acres) | (2) Runoff (ac-ft/yr) | Tot N | TKN | N3+N2 | Tot P | Tot Diss P | BOD | COD | TSS | TDS | Cd | Cu | Pb | Zn |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| M-01-06-A | 64.27 | 187.42 | 825.86 | 577.82 | 193.9 | 152.6 | 72.6 | 4,950.18 | 29,730.11 | 30,437.79 | 33,898.62 | 0.2581 | 3.5329 | 2.7882 | 34.2116 |
| M-02-13-A | 627.26 | 1,780.24 | 7,846.43 | 5,842.57 | 1,805.16 | 1,474.50 | 574.83 | 43,060.10 | 249,632.26 | 317,960.74 | 313,749.56 | 2.6217 | 42.8789 | 29.8444 | 404.311 |
| M-04-14-A | 42.74 | 133.07 | 336.39 | 262.82 | 77.15 | 26.06 | 18.27 | 2,850.29 | 23,751.62 | 5,617.89 | 26,441.09 | 0.0039 | 0.7293 | 0.5186 | 11.7349 |
| M-05-02-A | 77.94 | 213.06 | 955.84 | 728.16 | 215.83 | 169.26 | 61.98 | 4,976.59 | 27,906.89 | 39,017.40 | 35,789.29 | 0.3127 | 6.0383 | 3.6048 | 53.895 |
| M-05-06-A | 301.61 | 884.55 | 3,503.34 | 2,529.71 | 889.06 | 659.71 | 264.38 | 21,271.51 | 137,817.70 | 126,444.97 | 135,816.12 | 0.9043 | 22.8076 | 15.4686 | 188.4442 |
| M-05-06-B | 75.78 | 204.79 | 884.94 | 657.38 | 208.36 | 159.61 | 63.18 | 4,907.16 | 28,801.93 | 34,271.63 | 34,632.78 | 0.2791 | 5.1456 | 3.3648 | 46.7523 |
| M-05-06-C | 35.6 | 111.97 | 517.54 | 364.04 | 117.96 | 94.84 | 45.51 | 3,007.93 | 17,395.13 | 19,674.50 | 21,166.90 | 0.1733 | 2.0539 | 1.6148 | 20.941 |
| M-05-07-A | 38.16 | 119.44 | 497.53 | 365.92 | 121.28 | 82.9 | 34 | 2,889.81 | 17,155.12 | 18,030.78 | 22,789.10 | 0.1712 | 2.1194 | 1.6387 | 23.5388 |
| M-05-07-B | 2.63 | 8.45 | 28.81 | 20.23 | 8.75 | 5.31 | 1.88 | 195.8 | 1,395.30 | 880.91 | 1,155.64 | 0.0059 | 0.2194 | 0.158 | 1.7422 |
| M-05-11-A | 28.79 | 53.69 | 174.52 | 126.73 | 47.92 | 29.98 | 11.5 | 1,174.44 | 8,144.84 | 5,037.17 | 8,039.11 | 0.035 | 1.1204 | 0.8438 | 9.4015 |
| M-05-11-B | 1.33 | 5.03 | 19.25 | 13.66 | 5.67 | 3.21 | 1.16 | 120.08 | 759.84 | 617.22 | 845.45 | 0.0063 | 0.1045 | 0.083 | 1.0464 |
| M-05-11-C | 1.05 | 3.86 | 14.37 | 10.17 | 4.27 | 2.45 | 0.88 | 91.47 | 596.62 | 456.25 | 618.13 | 0.0043 | 0.0852 | 0.0658 | 0.8019 |
| M-05-11-D | 1.27 | 4.39 | 17.28 | 12.84 | 4.53 | 3.2 | 1.08 | 101.14 | 662.25 | 649.45 | 617.3 | 0.0043 | 0.1377 | 0.0848 | 1.0959 |
| M-05-11-E | 7.23 | 22.78 | 88.18 | 63.17 | 25.21 | 14.34 | 5.25 | 537.89 | 3,288.76 | 2,840.34 | 3,993.76 | 0.0306 | 0.4337 | 0.3551 | 4.6138 |
| M-05-11-F | 1.68 | 6.42 | 24.79 | 17.6 | 7.28 | 4.1 | 1.48 | 153.46 | 959.55 | 797.86 | 1,097.32 | 0.0084 | 0.1299 | 0.1044 | 1.3341 |
| M-05-11-G | 3.69 | 13.41 | 50.09 | 35.47 | 14.84 | 8.52 | 3.06 | 317.83 | 2,063.23 | 1,591.52 | 2,164.01 | 0.0152 | 0.2928 | 0.2273 | 2.7808 |
| M-05-11-H | 1.25 | 2.15 | 8.57 | 6.36 | 2.16 | 1.23 | 0.49 | 48.13 | 247.69 | 271.83 | 448.71 | 0.0036 | 0.0215 | 0.024 | 0.3634 |
| M-05-11-I | 2.3 | 8.02 | 30.93 | 22.03 | 8.99 | 5.08 | 1.85 | 190.68 | 1,183.30 | 992.63 | 1,384.22 | 0.0105 | 0.1579 | 0.1281 | 1.6437 |
| M-05-11-J | 3.01 | 9.71 | 33.46 | 23.48 | 10.18 | 6.13 | 2.17 | 226.15 | 1,600.78 | 1,029.47 | 1,345.58 | 0.0072 | 0.2504 | 0.1811 | 2.0165 |
| M-05-11-K | 1.26 | 4.66 | 18.16 | 14.15 | 4.09 | 3.92 | 1.29 | 95.85 | 604.9 | 659.03 | 780.89 | 0.0052 | 0.1488 | 0.082 | 1.0473 |
| M-05-12-A | 19.7 | 57.01 | 278.18 | 195.66 | 55.81 | 54.65 | 27.88 | 1,593.55 | 9,277.27 | 11,341.25 | 10,457.38 | 0.083 | 1.1926 | 0.8416 | 10.5438 |
| M-05-12-B | 0.94 | 1.94 | 8.58 | 6.95 | 1.64 | 1.66 | 0.53 | 40.88 | 239.2 | 394.55 | 253.39 | 0.002 | 0.0801 | 0.0391 | 0.585 |
| M-05-12-D | 73.69 | 211.28 | 999.13 | 750.27 | 197.81 | 208.56 | 86.18 | 5,307.35 | 31,158.79 | 45,191.16 | 35,283.29 | 0.294 | 6.172 | 3.8718 | 50.858 |
| M-05-12-E | 33.03 | 79.95 | 401.11 | 280.56 | 74.92 | 79.19 | 42.87 | 2,288.29 | 12,968.59 | 16,450.37 | 15,474.77 | 0.1222 | 1.4235 | 1.0675 | 13.1595 |
| M-05-13-A | 20.72 | 73.71 | 305.25 | 226.33 | 79.96 | 52.73 | 18.17 | 1,725.22 | 10,410.20 | 11,334.66 | 12,031.96 | 0.0986 | 1.9466 | 1.2831 | 17.8142 |
| M-05-13-B | 31.81 | 103.72 | 365.91 | 263.42 | 101.75 | 57.59 | 23 | 2,421.69 | 16,441.49 | 10,978.91 | 17,736.34 | 0.0952 | 1.8705 | 1.4458 | 18.5842 |
| M-05-13-C | 1,950.32 | 5,908.56 | 24,694.39 | 18,172.45 | 5,994.23 | 4,751.84 | 1,915.70 | 142,738.70 | 889,984.12 | 949,393.94 | 947,119.09 | 7.011 | 154.8285 | 102.9865 | 1,334.24 |

| Outfall ID | Area (acres) | (2) Runoff (ac-ft/yr) | Tot N | TKN | N3+N2 | Tot P | Tot Diss P | BOD | COD | TSS | TDS | Cd | Cu | Pb | Zn |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| M-06-01-C | 523.92 | 1,327.76 | 6,177.98 | 4,537.21 | 1,158.14 | 1,409.85 | 630.48 | 34,547.23 | 208,559.85 | 281,457.75 | 239,020.94 | 1.8143 | 31.1036 | 23.4423 | 262.3201 |
| M-06-06-A | 621.49 | 1,696.87 | 7,814.31 | 5,768.14 | 1,564.45 | 1,652.66 | 717.41 | 43,306.52 | 262,621.66 | 343,526.32 | 279,691.07 | 2.1488 | 46.7776 | 30.5061 | 377.6435 |
| M-09-09-A | 417.74 | 1,139.69 | 4,640.74 | 3,446.10 | 1,056.87 | 878.22 | 359.01 | 27,312.75 | 171,152.58 | 181,053.39 | 203,395.76 | 1.3722 | 23.5219 | 17.5929 | 224.872 |
| M-09-11-A | 297.35 | 659.57 | 2,271.54 | 1,647.72 | 618.87 | 459.88 | 169.88 | 14,944.10 | 103,331.42 | 77,782.20 | 101,780.14 | 0.5463 | 14.2602 | 11.778 | 123.7904 |
| M-10-07-B | 30.09 | 85.39 | 311.57 | 221.59 | 89.6 | 54.93 | 20.29 | 1,998.66 | 13,185.80 | 9,969.37 | 13,470.59 | 0.0871 | 1.8722 | 1.453 | 17.0527 |
| M-10-08-B | 23.81 | 66.86 | 337.98 | 235.54 | 67.73 | 64.82 | 34.79 | 1,924.21 | 10,655.17 | 13,544.35 | 13,691.55 | 0.1153 | 1.0168 | 0.8545 | 11.0881 |
| M-10-10-B | 16.62 | 63.89 | 262.68 | 191.08 | 72.26 | 44.87 | 16.75 | 1,531.70 | 9,135.60 | 9,179.04 | 11,369.41 | 0.094 | 1.3368 | 1.0232 | 14.0955 |
| M-10-11-A | 188.9 | 548.2 | 1,980.18 | 1,401.54 | 538.41 | 397.97 | 160.48 | 13,091.56 | 92,890.55 | 67,375.08 | 73,686.20 | 0.3592 | 15.1541 | 10.357 | 113.2494 |
| M-10-12-B | 10.58 | 33.09 | 126.71 | 90.45 | 35.45 | 22.71 | 8.49 | 789.14 | 5,015.91 | 4,292.31 | 5,619.78 | 0.0406 | 0.6651 | 0.5518 | 6.609 |
| M-10-13-A | 82.38 | 158.52 | 616.19 | 444.42 | 150.47 | 108.66 | 47.17 | 3,749.60 | 22,822.13 | 20,906.81 | 27,889.45 | 0.1874 | 2.758 | 2.297 | 27.5425 |
| M-10-15-F | 46.93 | 119.56 | 554.09 | 435.32 | 109.71 | 106.47 | 37.95 | 2,724.03 | 15,677.52 | 25,049.48 | 17,221.37 | 0.1475 | 4.5246 | 2.3111 | 34.5365 |
| M-10-15-K | 48.9 | 129.68 | 650.52 | 470.97 | 121.38 | 154.05 | 86.87 | 3,683.27 | 21,428.71 | 27,651.69 | 26,497.98 | 0.2007 | 1.9716 | 1.7226 | 21.8036 |
| M-10-16-C | 271.75 | 378.78 | 1,323.19 | 997.87 | 318.13 | 215.76 | 85.04 | 7,960.74 | 48,220.45 | 41,254.90 | 63,878.94 | 0.371 | 6.6137 | 5.2184 | 64.1938 |
| M-10-17-A | 341.9 | 582.58 | 2,687.38 | 2,053.93 | 495.43 | 725.67 | 368.2 | 14,977.05 | 93,207.23 | 123,946.58 | 108,759.07 | 0.7447 | 11.9187 | 9.7234 | 115.0759 |
| M-10-21-A | 116.81 | 310.99 | 1,565.42 | 1,090.39 | 293.58 | 328.3 | 173.74 | 9,033.32 | 51,721.94 | 66,507.27 | 62,855.65 | 0.5043 | 4.8463 | 4.3561 | 48.907 |
| M-10-23-A | 111.85 | 315.31 | 1,449.09 | 1,015.72 | 312.09 | 288.31 | 141.3 | 8,573.95 | 51,215.60 | 57,445.85 | 58,414.89 | 0.4473 | 5.8653 | 4.77 | 55.6774 |
| M-11-08-A | 396.16 | 897.77 | 3,668.17 | 2,784.51 | 768.16 | 831.75 | 314.81 | 20,901.46 | 135,866.82 | 163,749.66 | 136,793.37 | 0.9009 | 25.8679 | 17.8531 | 202.262 |
| M-12-05-C | 21.93 | 70.58 | 229.92 | 160.31 | 71.29 | 44.38 | 15.57 | 1,624.85 | 12,145.24 | 6,905.52 | 8,723.34 | 0.0341 | 2.0043 | 1.3956 | 14.6693 |
| M-12-05-D | 8.16 | 28.16 | 102.03 | 72.09 | 30.42 | 17.86 | 6.39 | 662.11 | 4,439.14 | 3,208.94 | 4,312.34 | 0.0278 | 0.6534 | 0.4942 | 5.821 |
| M-12-07-B | 2.51 | 8.54 | 32.02 | 22.79 | 9.36 | 5.44 | 1.96 | 201.54 | 1,299.33 | 1,025.17 | 1,385.50 | 0.0098 | 0.1862 | 0.1436 | 1.771 |
| M-12-08-A | 69.89 | 223.99 | 862.78 | 619.64 | 236.64 | 153.29 | 57.32 | 5,318.36 | 34,373.67 | 29,505.35 | 35,069.02 | 0.243 | 5.4312 | 3.8788 | 47.8976 |
| M-12-08-B | 20.47 | 75.95 | 299.38 | 213.14 | 87.2 | 48.89 | 17.83 | 1,825.20 | 11,148.70 | 9,722.22 | 13,444.45 | 0.107 | 1.4584 | 1.202 | 15.7832 |
| M-12-08-C | 22.84 | 78.55 | 305.22 | 217.56 | 88.62 | 50.02 | 18.14 | 1,872.27 | 11,558.28 | 9,859.48 | 13,636.40 | 0.1054 | 1.5475 | 1.2542 | 16.2253 |
| M-12-11-A | 131.97 | 388.19 | 1,661.06 | 1,204.63 | 399.27 | 316.6 | 134.34 | 9,666.23 | 58,902.36 | 63,494.61 | 66,443.73 | 0.5095 | 8.9045 | 6.4043 | 82.0111 |
| M-12-14-C | 890.41 | 2,663.14 | 11,403.73 | 8,283.73 | 2,689.49 | 2,190.18 | 945.92 | 66,496.61 | 406,192.11 | 438,769.15 | 462,449.97 | 3.4726 | 59.1748 | 43.0348 | 550.1055 |
| M-13-04-F | 14.07 | 11.64 | 37.51 | 30.27 | 6.54 | 5.55 | 2.53 | 211.57 | 1,118.93 | 1,091.62 | 2,150.25 | 0.0104 | 0.1156 | 0.1098 | 1.3707 |
| M-13-04-J | 25.98 | 28.25 | 105.23 | 85.96 | 18.37 | 18.47 | 6.92 | 540.58 | 3,048.67 | 4,075.52 | 4,360.19 | 0.0243 | 0.7255 | 0.4133 | 5.7503 |
| M-13-04-L | 247.78 | 717.12 | 3,227.49 | 2,356.61 | 653.78 | 650.27 | 297.64 | 18,478.00 | 115,693.91 | 134,556.31 | 115,125.00 | 0.7871 | 19.701 | 12.0374 | 153.0251 |
| M-13-04-N | 28.66 | 66.77 | 243.48 | 177.25 | 66.25 | 45.6 | 18.77 | 1,533.62 | 9,976.18 | 7,873.62 | 10,906.64 | 0.0674 | 1.3398 | 1.0657 | 12.7416 |

| Outfall ID | Area (acres) | (2) Runoff (ac-ft/yr) | Tot N | TKN | N3+N2 | Tot P | Tot Diss P | BOD | COD | TSS | TDS | Cd | Cu | Pb | Zn |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| M-13-07-D | 1,214.18 | 3,333.93 | 13,839.89 | 10,174.55 | 3,269.69 | 2,748.36 | 1,110.90 | 80,640.47 | 506,177.15 | 544,487.58 | 539,872.67 | 3.8885 | 84.3178 | 58.654 | 724.8274 |
| M-14-01-A | 1.27 | 4.5 | 16.04 | 11.63 | 4.47 | 3.12 | 1.1 | 99.01 | 651.05 | 471.1 | 781.72 | 0.005 | 0.1001 | 0.0725 | 0.829 |
| M-14-01-B | 2.48 | 9.71 | 38.45 | 28.3 | 10.22 | 4.84 | 2.03 | 231 | 1,335.74 | 1,171.66 | 2,168.22 | 0.0158 | 0.0754 | 0.0863 | 1.6174 |
| M-14-01-C | 1.23 | 4.11 | 11.99 | 9.17 | 2.92 | 1.14 | 0.64 | 90.82 | 689.71 | 261.06 | 844.88 | 0.0019 | 0.0251 | 0.0216 | 0.4507 |
| M-14-01-D | 48.49 | 148.81 | 601.21 | 433.55 | 152.72 | 101.87 | 44.54 | 3,643.15 | 22,299.59 | 20,441.29 | 27,799.46 | 0.1969 | 2.4959 | 2.0279 | 27.4713 |
| M-14-12-A | 25.53 | 44.28 | 197.48 | 153.31 | 28.66 | 67.91 | 29.32 | 1,129.26 | 7,606.44 | 11,714.33 | 8,678.63 | 0.0571 | 0.8374 | 1.0137 | 7.8179 |
| M-17-02-A | 58.78 | 100.17 | 341.62 | 248.72 | 89.88 | 58.93 | 23.35 | 2,201.61 | 14,434.34 | 10,300.33 | 15,688.14 | 0.0824 | 1.9675 | 1.5393 | 17.3507 |
| M-17-10-A | 64.62 | 67.65 | 309.57 | 248.53 | 40.56 | 117.68 | 63.21 | 1,757.03 | 11,808.44 | 17,158.73 | 14,230.47 | 0.0776 | 0.8548 | 1.2155 | 10.2875 |
| Grand Total | 9,897.46 | 26,801.84 | 113,232.66 | 83,174.20 | 26,005.79 | 22,508.44 | 9,452.23 | 656,554.77 | 4,075,785.42 | 4,483,149.85 | 4,477,236.96 | 32.3719 | 647.9127 | 454.5906 | 5,676.05 |

## Table A.2 Leon County NPDES MS4 Loadings to Its Portion of the Lake Munson Watershed without BMPs

Leon County NPDES Permit No. FLS000033. Year 3 Pollutant Load Estimates. Annual Pollutant Loads w/o BMPs

| Basin Name | Drainage Area (acres) | DCIA Drainage Area(acres) | %DCIA | Flow (ac-ft/yr) | BOD (lbs/yr) | COD (lbs/yr) | TSS (lbs/yr) | TDS (lbs/yr) | TKN (lbs/yr) | N02+3 (lbs/yr) | DP (lbs/yr) | TP (lbs/yr) | Cd (lbs/yr) | Cu (lbs/yr) | Pb (lbs/yr) | Zn (lbs/yr) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Airport Vicinity | 1,652 | 75 | 4.5 | 1,585 | 15,871 | 232,000 | 92,545 | 494,000 | 4,080 | 1,294 | 363 | 564 | 3 | 63 | 124 | 197 |
| Bird Sink | 13,619 | 1,451 | 10.7 | 16,512 | 394,000 | 2,720,000 | 1,760,000 | 5,260,000 | 41,565 | 13,091 | 5,550 | 9,451 | 51 | 1,154 | 2,239 | 3,742 |
| Coastal Areas | 738 | 44 | 5.9 | 751 | 12,266 | 102,000 | 46,375 | 314,000 | 1,615 | 411 | 225 | 405 | 1 | 52 | 9 | 109 |
| Copeland Sink | 2,120 | 292 | 13.8 | 2,842 | 74,601 | 489,000 | 347,000 | 757,000 | 7,380 | 2,453 | 901 | 1,583 | 10 | 207 | 487 | 734 |
| Fred George | 1,777 | 385 | 21.7 | 2,962 | 86,595 | 583,000 | 436,000 | 719,000 | 9,613 | 3,672 | 1,375 | 2,120 | 18 | 180 | 901 | 943 |
| Hammock Sink | 4,684 | 292 | 6.2 | 4,823 | 103,000 | 743,000 | 407,000 | 1,790,000 | 11,127 | 3,144 | 1,448 | 2,515 | 8 | 273 | 227 | 706 |
| Lake Drain sink | 1,668 | 194 | 11.6 | 2,090 | 58,037 | 392,000 | 272,000 | 603,000 | 5,877 | 2,015 | 767 | 1,229 | 9 | 107 | 422 | 482 |
| Lake lamonia | 50,944 | 5,021 | 9.9 | 60,079 | 1,150,000 | 8,780,000 | 5,260,000 | 21,100,000 | 144,000 | 43,829 | 20,769 | 34,218 | 151 | 4771 | 66023 | 13406 |
| Lake Jackson | 21,181 | 3169 | 15.0 | 29,436 | 625,000 | 4,490,000 | 3,140,000 | 8,630,000 | 76,894 | 25,916 | 10,589 | 17,532 | 95 | 2,385 | 4.486 | 7,789 |
| Lake Lafayette | 26,249 | 4,068 | 15.5 | 37,062 | 1,050,000 | 6,790,000 | 5,000,000 | 9,590,000 | 107,000 | 38,265 | 13,458 | 22,860 | 157 | 2,058 | 7,504 | 9,133 |
| Lake Miccosukee | 21,346 | 1,151 | 5.4 | 21,247 | 440,000 | 3,380,000 | 1,770,000 | 7,910,000 | 51,064 | 14,757 | 8,646 | 10,908 | 43 | 1,058 | 1,372 | 2,993 |
| Lake Munson | 21,138 | 3,202 | 15.1 | 29,540 | 643,000 | 4,708,000 | 3,350,000 | 8,290,000 | 81,814 | 29,029 | 10,269 | 16,956 | 107 | 1,715 | 4,736 | 6,753 |
| National Forest | 68,676 | 6,537 | 9.5 | 80,035 | 1,250,000 | 9,900,000 | 5,600,000 | 30,300,000 | 169,000 | 46,388 | 24,913 | 43,353 | 113 | 7,665 | 3,071 | 17,484 |
| Ochlockonee | 64,673 | 8,318 | 12.9 | 84,286 | 1,440,000 | 10,700,000 | 7,120,000 | 28,500,000 | 186,000 | 56,836 | 27,124 | 46,389 | 161 | 8,519 | 6,303 | 21,575 |
| Patty Sink | 11,664 | 817 | 7.0 | 12,383 | 289,000 | 2,000,000 | 1,150,000 | 4,650,000 | 29,566 | 8,559 | 4,089 | 7,003 | 29 | 703 | 918 | 2,009 |
| St. Marks | 37,286 | 4,191 | 11.2 | 46,100 | 858,000 | 6,330,000 | 4,050,000 | 15,300,000 | 105,000 | 31,808 | 14,406 | 24,737 | 94 | 4,142 | 3,836 | 10,932 |
| Upper Moccasin Gap | 1,363 | 94 | 6.9 | 1,442 | 40,280 | 280,000 | 163,000 | 474,000 | 3,931 | 1,231 | 471 | 813 | 5 | 46 | 220 | 226 |
| Wood Sink | 735 | 67 | 9.1 | 845 | 18,914 | 143,000 | 83,504 | 304,000 | 2,214 | 679 | 332 | 528 | 3 | 57 | 137 | 194 |
| Woodville Recharge | 33,052 | 2,045 | 6.2 | 33,982 | 756,000 | 5,700,000 | 2,940,000 | 13,500,000 | 85,938 | 25,171 | 11,068 | 19,818 | 89 | 1,222 | 2,435 | 3,964 |

## Table A.3 Leon County NPDES MS4 Loadings to Its Portion of the Lake Munson Watershed with BMPs

Leon County NPDES Permit No. FLS000033
Year 3 Pollutant Load Estimates

Annual Pollutant Loads w/BMPs

| Basin Name | Drainage Area (acres) | DCIA Drainage Area( acres) | % DCIA | Flow (ac-ft/yr) | BOD (lbs/yr) | COD (lbs/yr) | TSS (lbs/yr) | TDS (lbs/yr) | TKN (lbs/yr) | N02+3 (lbs/yr) | DP (lbs/yr) | TP (lbs/yr) | Cd (lbs/yr) | Cu (lbs/yr) | Pb (lbs/yr) | Zn (lbs/yr) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Airport Vicinity | 1,652 | 75 | 4.5 | 1,585 | 15,871 | 232,000 | 92,545 | 494,000 | 4,080 | 1,294 | 363 | 564 | 3 | 63 | 124 | 197 |
| Bird Sink | 13,619 | 1,451 | 10.7 | 16,512 | 370,000 | 2,610,000 | 1,570,000 | 5,210,000 | 40,174 | 12,796 | 5,413 | 9,045 | 44 | 1,118 | 1,950 | 3,420 |
| Coastal Areas | 738 | 44 | 5.9 | 751 | 12,266 | 102,000 | 46,375 | 314,000 | 1,615 | 411 | 225 | 405 | 1 | 52 | 9 | 109 |
| Copeland Sink | 2,120 | 292 | 13.8 | 2,842 | 61,880 | 435,000 | 255,0000 | 703,000 | 6,419 | 2,126 | 796 | 1,346 | 8 | 188 | 370 | 611 |
| Fred George | 1,777 | 385 | 21.7 | 2,962 | 78,135 | 539,000 | 371,000 | 694,000 | 8,969 | 3,512 | 1,360 | 1,979 | 15 | 168 | 799 | 828 |
| Hammock Sink | 4,684 | 292 | 6.2 | 4,823 | 84,048 | 650,000 | 306,000 | 1,620000 | 9,840 | 2,764 | 1,270 | 2,235 | 7 | 257 | 206 | 635 |
| Lake Drain sink | 1,668 | 194 | 11.6 | 2,090 | 56,288 | 387,000 | 262,000 | 596,000 | 5,812 | 1,994 | 763 | 1,207 | 9 | 106 | 421 | 477 |
| Lake Iamonia | 50,944 | 5,021 | 9.9 | 60,079 | 1,070,000 | 8,420,000 | 4,800,000 | 20,800,000 | 137,000 | 41,446 | 19,628 | 32,024 | 125 | 4,601 | 4,773 | 12,139 |
| Lake Jackson | 21,181 | 3169 | 15.0 | 29,436 | 568,000 | 4,180,000 | 2,690,000 | 8,370,000 | 71,031 | 24,007 | 10,066 | 16,100 | 79 | 2,286 | 3,750 | 7,000 |
| Lake Lafayette | 26,249 | 4,068 | 15.5 | 37,062 | 946,000 | 6,270,000 | 4,110,000 | 9,150,000 | 98,918 | 35,964 | 12,635 | 20,590 | 126 | 1,873 | 6,309 | 7,585 |
| Lake Miccosukee | 21,346 | 1,151 | 5.4 | 21,247 | 440,000 | 3,380,000 | 1,770,000 | 7,910,000 | 51,048 | 14,753 | 6,648 | 10,904 | 43 | 1,058 | 1,372 | 2,993 |
| Lake Munson | 21,138 | 3,202 | 15.1 | 29,540 | 609,000 | 4,600,000 | 3,080,000 | 8,040,000 | 78,278 | 27,710 | 9,848 | 16,073 | 100 | 1,635 | 4,495 | 6,280 |
| National Forest | 68,676 | 6,537 | 9.5 | 80,035 | 1,240,000 | 9,890,000 | 5,580,000 | 30,300,000 | 168,000 | 46,350 | 24,909 | 43,301 | 112 | 7,659 | 3,001 | 17,428 |
| Ochlockne e | 64,673 | 8,318 | 12.9 | 84,286 | 1,370,000 | 10,400,000 | 6,590,000 | 28,200,000 | 182,000 | 55,703 | 26,788 | 45,204 | 149 | 8,440 | 5,795 | 20,930 |
| Patty Sink | 11,664 | 817 | 7.0 | 12,383 | 281,000 | 1,970,000 | 1,080,000 | 4,600,000 | 29,159 | 8,430 | 3,998 | 6,881 | 28 | 697 | 813 | 1,979 |
| St. Marks | 37,286 | 4,191 | 11.2 | 46,100 | 826,000 | 6,190,000 | 3,780,000 | 15,200,000 | 103,000 | 31,389 | 14,232 | 24,149 | 86 | 4,082 | 3,467 | 10,493 |
| Upper Moccasin Gap | 1,363 | 94 | 6.9 | 1,442 | 38,598 | 272,000 | 151,000 | 463,000 | 3,781 | 1,178 | 444 | 769 | 5 | 41 | 195 | 187 |
| Wood Sink | 735 | 67 | 9.1 | 845 | 18,914 | 143,000 | 83,504 | 304,000 | 2,214 | 679 | 332 | 528 | 3 | 57 | 137 | 194 |
| Woodville Recharge | 33,052 | 2,045 | 8.2 | 33,982 | 738,000 | 5,810,000 | 2,810,000 | 13,400,000 | 84,514 | 24,802 | 10,946 | 18,480 | 85 | 1,200 | 2,284 | 3,753 |

## Table A.4 Leon County NPDES MS4 Loadings to Its Portion of the Lake Munson Watershed Percent Reduction from BMPs

Annual Pollutant Loads –Percent Reduction Due to BMPS

| Basin Name | Drainage Area (acres) | DCIA Drainage Area(acres) | %DCIA | Flow (ac-ft/yr) | BOD (lbs/yr) | COD (lbs/yr) | TSS (lbs/yr) | TDS (lbs/yr) | TKN (lbs/yr) | N02+3 (lbs/yr) | DP (lbs/yr) | TP (lbs/yr) | Cd (lbs/yr) | Cu (lbs/yr) | Pb (lbs/yr) | Zn (lbs/yr) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Airport Vicinity | 1,652 | 75 | 4.5 | 1,585 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Bird Sink | 13,619 | 1,451 | 10.7 | 16,512 | 6.1 | 4.0 | 10.7 | 1.0 | 3.3 | 2.3 | 2.5 | 4.3 | 13.1 | 3.1 | 12.9 | 8.6 |
| Coastal Areas | 738 | 44 | 5.9 | 751 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Copeland Sink | 2,120 | 292 | 13.8 | 2,842 | 17.3 | 11.1 | 26.3 | 7.1 | 12.8 | 13.3 | 11.7 | 15.0 | 22.9 | 9.2 | 24.1 | 16.8 |
| Fred George | 1,777 | 385 | 21.7 | 2,962 | 9.8 | 7.8 | 15.0 | 3.5 | 6.7 | 4.4 | 1.1 | 6.7 | 13.5 | 6.5 | 11.3 | 12.2 |
| Hammock Sink | 4,684 | 292 | 6.2 | 4,823 | 18.4 | 12.5 | 24.7 | 9.7 | 11.6 | 12.1 | 12.3 | 11.1 | 11.1 | 5.8 | 9.2 | 10.1 |
| Lake Drain sink | 1,668 | 194 | 11.6 | 2,090 | 3.0 | 1.3 | 3.7 | 1.2 | 1.1 | 1.0 | 0.5 | 1.8 | 0.6 | 0.5 | 0.2 | 1.0 |
| Lake Iamonia | 50,944 | 5,021 | 9.9 | 60,079 | 6.8 | 4.1 | 12.7 | 1.7 | 4.8 | 5.4 | 5.5 | 6.4 | 18.8 | 3.6 | 20.7 | 9.5 |
| Lake Jackson | 21,181 | 3169 | 15.0 | 29,436 | 9.1 | 7.0 | 14.5 | 3.0 | 7.6 | 7.4 | 4.9 | 8.2 | 17.0 | 4.1 | 16.4 | 10.1 |
| Lake Lafayette | 26,249 | 4,068 | 15.5 | 37,062 | 10.1 | 7.7 | 17.8 | 4.6 | 7.6 | 6.0 | 6.1 | 9.9 | 19.5 | 9.0 | 15.9 | 16.9 |
| Lake Miccosukee | 21,346 | 1,151 | 5.4 | 21,247 | 0.1 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 |
| Lake Munson | 21,138 | 3,202 | 15.1 | 29,540 | 5.4 | 3.8 | 8.1 | 3.0 | 4.3 | 4.5 | 4.1 | 5.2 | 6.4 | 4.7 | 5.1 | 7.0 |
| National Forest | 68,676 | 6,537 | 9.5 | 80,035 | 0.2 | 0.1 | 0.5 | 0.0 | 0.1 | 0.1 | 0.0 | 0.1 | 1.2 | 0.1 | 2.3 | 0.3 |
| Ochlocknee | 64,673 | 8,318 | 12.9 | 84,286 | 5.0 | 2.7 | 7.5 | 0.9 | 2.2 | 2.0 | 1.2 | 2.6 | 7.7 | 0.9 | 8.1 | 3.0 |
| Patty Sink | 11,664 | 817 | 7.0 | 12,383 | 3.1 | 1.5 | 5.1 | 1.1 | 1.4 | 1.5 | 2.2 | 1.7 | 1.2 | 0.8 | 0.6 | 1.5 |
| St. Marks | 37,286 | 4,191 | 11.2 | 46,100 | 3.7 | 2.2 | 6.5 | 0.5 | 1.8 | 1.3 | 1.2 | 2.4 | 9.1 | 1.4 | 9.6 | 4.0 |
| Upper Moccasin Gap | 1,363 | 94 | 6.9 | 1,442 | 4.2 | 2.8 | 7.7 | 2.3 | 3.8 | 4.3 | 5.9 | 5.3 | 8.8 | 11.2 | 11.1 | 12.8 |
| Wood Sink | 735 | 67 | 9.1 | 845 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Woodville Recharge | 33,052 | 2,045 | 6.2 | 33,982 | 2.4 | 1.8 | 4.5 | 0.6 | 1.7 | 1.6 | 1.1 | 1.7 | 4.5 | 1.8 | 6.2 | 5.3 |

# Appendix B: Summary of Land Use Loads and Trends by Category

## Table B.1a Lake Munson Basin Basics

- = Empty cell/no data

| Watershed Area | Acres | Ft**2 | Sqmi | SqM | Ha |
|---|---|---|---|---|---|
| TOTAL | 4.4000E+04 | 1.9140E+09 | 6.8750E+01 | 1.7806E+08 | 1.7806E+04 |
| CONTRIBUTING | 3.3929E+04 | 1.4759E+09 | 5.3014E+01 | 1.3731E+08 | 1.3731E+04 |
| NONCONTRIBUTING | 1.0071E+04 | 4.3809E+08 | 1.5736E+01 | 4.0756E+07 | 4.0756E+03 |
| COT NPDES MS4 | 9.8975E+03 | 4.3054E+08 | 1.5465E+01 | 4.0054E+07 | 4.0054E+03 |
| LEON CO NPDES MS4 | 2.1345E+04 | 9.2850E+08 | 3.3351E+01 | 8.6380E+07 | 8.6380E+03 |
| TOTAL MS4 | 3.1242E+04 | 1.3590E+09 | 4.8816E+01 | 1.2643E+08 | 1.2643E+04 |
| **MUNSON SLOUGH AT** | **-** | **-** | **-** | **-** | **-** |
| SPRINGHILL RD | 2.6628E+04 | 1.1583E+09 | 4.1606E+01 | 1.0776E+08 | 1.0776E+04 |
| CAPITAL CIRCLE SR 263 | 3.1081E+04 | 1.3520E+09 | 4.8564E+01 | 1.2578E+08 | 1.2578E+04 |
| DAM | 3.2711E+04 | 1.4229E+09 | 5.1111E+01 | 1.3238E+08 | 1.3238E+04 |
| US 319 | 3.2941E+04 | 1.4329E+09 | 5.1470E+01 | 1.3331E+08 | 1.3331E+04 |
| UPS EIGHTMILE POND | 3.4125E+04 | 1.4844E+09 | 5.3320E+01 | 1.3810E+08 | 1.3810E+04 |
| LAKE AREA | 2.5500E+02 | 1.1093E+07 | 3.9844E-01 | 1.0320E+06 | 1.0320E+02 |
| **LAKE MUNSON** | **IN** | **-** | **FT** | **M** | **-** |
| LAKE ELEVATION AVE | - | - | 2.6000E+01 | 7.9248E+00 | - |
| LAKE DEPTH AVE | - | - | 3.0000E+00 | 9.1440E-01 | - |
| SEDIMENT DEPTH AVE. | - | - | 2.3500E+00 | | - |
| RAINFALL AVE 1959-1976 | 6.4600E+01 | - | 5.3833E+00 | 1.6408E+00 | - |
| LAKE EVAPOTRANSPIRATION | 4.7000E+01 | - | 3.9167E+00 | 1.1938E+00 | - |
| **LAKE MUNSON** | **-** | **-** | **FT**3** | **M**3** | **-** |
| LAKE VOLUME | - | - | 3.3263E+07 | 9.4202E+05 | - |
| SEDIMENT VOLUME | - | - | 2.6067E+07 | | - |
| SEDIMENT MASS | - | - | - | - | - |
| LAKE LATITUDE | 302207 | | - | - | - |

| Watershed Area | Acres | Ft**2 | Sqmi | SqM | Ha |
|---|---|---|---|---|---|
| LAKE LONGITUDE | 841837 | | - | - | - |
| LAKE AREA DREDGED 2000-2002 | 2.9000E+01 | - | - | - | - |
| SEDIMENT VOLUME DREDGED (DRY) | - | - | - | - | - |
| SEDIMENT MASS DREDGED | ASSUME 2.65 GM/CM^3 | - | - | - | - |
| TKN CONTENT INFLOW TO LAKE = | 4.1510E+03 | (MG/KG)* | 4.2297E+08 | (KG)= | - |
| TP CONTENT INFLOW TO LAKE = | 5.9950E+03 | (MG/KG)* | 4.2297E+08 | (KG)= | - |
| TN IN LAKE 1987 MEAN | 7.8520E+03 | MG/KG | 4.2297E+08 | (KG)= | - |
| TP IN LAKE 1987 MEAN | 1.0382E+04 | MG/KG | 4.2297E+08 | (KG)= | - |
| TN 1997 (MG/L) | 0.75 | - | - | - | - |
| TP 1997 (MG/L) | 0.25 | - | - | - | - |

## Table B.1b References for Lake Munson Basin Basics

- - Empty cell/no data

| Watershed Area | - | - | - | - | Reference |
|---|---|---|---|---|---|
| TOTAL | - | - | - | - | BARTEL AND ARD 1992. NWFWMD SPECIAL REPORT 92-4 |
| CONTRIBUTING | - | - | - | - | BARTEL AND ARD 1992. NWFWMD SPECIAL REPORT 92-4 |
| NONCONTRIBUTING | - | - | - | - | BARTEL AND ARD 1992. NWFWMD SPECIAL REPORT 92-4 |
| COT NPDES MS4 | - | - | - | - | - |
| LEON CO NPDES MS4 | - | - | - | - | - |
| TOTAL MS4 | - | - | - | - | - |
| **MUNSON SLOUGH AT** | **-** | **-** | **-** | **-** | **-** |
| SPRINGHILL RD | - | - | - | - | BARTEL *ET AL.* 1992. NWFWMD WATER RESOURCES ASSESSMENT 91-2 |
| CAPITAL CIRCLE SR 263 | - | - | - | - | BARTEL *ET AL.* 1992. NWFWMD WATER RESOURCES ASSESSMENT 91-2 |
| DAM | - | - | - | - | BARTEL *ET AL.* 1992. NWFWMD WATER RESOURCES ASSESSMENT 91-2 |
| US 319 | - | - | - | - | BARTEL *ET AL.* 1992. NWFWMD WATER RESOURCES ASSESSMENT 91-2 |
| UPS EIGHTMILE POND | - | - | - | - | BARTEL *ET AL.* 1992. NWFWMD WATER RESOURCES ASSESSMENT 91-2 |
| LAKE AREA | - | - | - | - | BARTEL AND ARD 1992. NWFWMD SPECIAL REPORT 92-4 |
| **LAKE MUNSON** | **-** | **-** | **-** | **-** | **-** |
| LAKE ELEVATION AVE | - | - | - | - | BARTEL AND ARD 1992. NWFWMD SPECIAL REPORT 92-4 |
| LAKE DEPTH AVE | - | - | - | - | - |
| SEDIMENT DEPTH AVE. | - | - | - | - | MARISTANY *ET AL.* 1988 |
| RAINFALL AVE 1959-1976 | - | - | - | - | - |
| LAKE EVAPOTRANSPIRATION | - | - | - | - | KOHLER 1959 |

| Watershed Area | - | - | - | - | Reference |
|---|---|---|---|---|---|
| **LAKE MUNSON** | - | - | - | - | - |
| LAKE VOLUME | - | - | - | - | BARTEL AND ARD 1992.<br>NWFWMD SPECIAL REPORT 92-4 |
| SEDIMENT VOLUME | - | - | - | - | - |
| SEDIMENT MASS | - | - | - | - | - |
| LAKE LATITUDE | - | - | - | - | - |
| LAKE LONGITUDE | - | - | - | - | - |
| LAKE AREA DREDGED 2000-2002 | - | - | - | - | HEIKER 2008. PERSONAL COMMUNICATION 319 H |
| SEDIMENT VOLUME DREDGED (DRY) | 2.0875E+05 | (CY)= | - | M^3 | HEIKER 2008. PERSONAL COMMUNICATION 319 H |
| SEDIMENT MASS DREDGED | 4.2297E+08 | (KG) | - | - | - |
| TKN CONTENT INFLOW TO LAKE= | 1.7557E+12 | (MG)= | 3.8714E+06 | (LB) | POTTS 1997. 11/30/1995 SAMPLES |
| TP CONTENT INFLOW TO LAKE= | 2.5357E+12 | (MG)= | 5.5912E+06 | (LB) | POTTS 1997. 11/30/1995 SAMPLES |
| TN IN LAKE 1987 MEAN | 3.3211E+12 | (MG) | 7.3231E+06 | - | MARISTANY *ET AL.*1988 |
| TP IN LAKE 1987 MEAN | 4.3912E+12 | (MG) | 9.6826E+06 | - | MARISTANY *ET AL* 1988 |
| TN 1997 (MG/L) | - | - | -- | - | - |
| TP 1997 (MG/L) | - | - | | - | - |

## Table B.2 Leon County Septic Tanks

* MEAN HOUSEHOLD USE TAMPA, FL = 65.8 GALLONS/CAP/DAY (EPA ONSITE WWTS MANUAL TABLE 3-2)
** MEAN USE = 70 GAL/CAP/DAY WITH 2.6 PERSONS/HOUSEHOLD (EPA -841-R-00-002)
** Q (CFS) = 70 (GAL/CAP/DAY) *2.6 (CAP) * 0.1337 (CUFT/GAL) * (1 DAY/(24*3600 SEC)= 2.8164E-04 CFS/TANK
LEON PORTION WAKULLA RIVER WATERSHED URBAN RATIO TO COUNTY = 1.0000E+00
$BOD_5$ = 220.5, MEAN OF RANGE 155-286 MG/L (EPA ONSITE WWTS MANUAL TABLE 3-2)
NH3N = 8.5 MG/L, MEAN OF RANGE 4-13 MG/L (EPA ONSITE WWTS MANUAL TABLE 3-2)
NO23N = 1.0 MG/L, MEAN OF RANGE < 1 MG/L (EPA ONSITE WWTS MANUAL TABLE 3-2)
ORGN = 41.0 MG/L, ESTIMATED MEAN (EPA ONSITE WWTS MANUAL TABLE 3-2)
TKN = 49.5 MG/L, ESTIMATED MEAN (EPA ONSITE WWTS MANUAL TABLE 3-2)
DA = 7.0178E+02 (SQMI)

| Date | Year | Leon County (ntanks new) | Leon County (ntanks cum) | Wakulla River Watershed (ntanks) | Wakulla River Watershed (gal/cap/day*) | Wakulla River Watershed (q cfs/tank**) | 80% Q (cfs) | $BOD_5$ (mg/L) | $BOD_5$ (lb/day) | $BOD_5$ (lb/yr) |
|---|---|---|---|---|---|---|---|---|---|---|
| 1/1/1970 | 1970 | 9,921 | 9,921 | 9.9210E+03 | 70 | 2.82E-04 | 2.7942E+00 | 2.2050E+02 | 3.3208E+03 | 1.2121E+06 |
| 1/1/1971 | 1971 | 629 | 10,550 | 1.0550E+04 | 70 | 2.82E-04 | 2.9713E+00 | 2.2050E+02 | 3.5314E+03 | 1.2890E+06 |
| 1/1/1972 | 1972 | 396 | 10,946 | 1.0946E+04 | 70 | 2.82E-04 | 3.0828E+00 | 2.2050E+02 | 3.6639E+03 | 1.3373E+06 |
| 1/1/1973 | 1973 | 342 | 11,288 | 1.1288E+04 | 70 | 2.82E-04 | 3.1792E+00 | 2.2050E+02 | 3.7784E+03 | 1.3791E+06 |
| 1/1/1974 | 1974 | 578 | 11,866 | 1.1866E+04 | 70 | 2.82E-04 | 3.3419E+00 | 2.2050E+02 | 3.9719E+03 | 1.4497E+06 |
| 1/1/1975 | 1975 | 447 | 12,313 | 1.2313E+04 | 70 | 2.82E-04 | 3.4678E+00 | 2.2050E+02 | 4.1215E+03 | 1.5043E+06 |
| 1/1/1977 | 1976 | 725 | 13,038 | 1.3038E+04 | 70 | 2.82E-04 | 3.6720E+00 | 2.2050E+02 | 4.3642E+03 | 1.5929E+06 |
| 1/1/1978 | 1977 | 976 | 14,014 | 1.4014E+04 | 70 | 2.82E-04 | 3.9469E+00 | 2.2050E+02 | 4.6909E+03 | 1.7122E+06 |
| 1/1/1979 | 1978 | 1,293 | 15,307 | 1.5307E+04 | 70 | 2.82E-04 | 4.3111E+00 | 2.2050E+02 | 5.1237E+03 | 1.8701E+06 |
| 1/1/1980 | 1979 | 1,652 | 16,959 | 1.6959E+04 | 70 | 2.82E-04 | 4.7763E+00 | 2.2050E+02 | 5.6766E+03 | 2.0720E+06 |
| 1/1/1981 | 1980 | 991 | 17,950 | 1.7950E+04 | 70 | 2.82E-04 | 5.0554E+00 | 2.2050E+02 | 6.0084E+03 | 2.1931E+06 |
| 1/1/1982 | 19 81 | 952 | 18,902 | 1.8902E+04 | 70 | 2.82E-04 | 5.3236E+00 | 2.2050E+02 | 6.3270E+03 | 2.3094E+06 |
| 1/1/1984 | 1982 | 819 | 19,721 | 1.9721E+04 | 70 | 2.82E-04 | 5.5542E+00 | 2.2050E+02 | 6.6012E+03 | 2.4094E+06 |
| 1/1/1983 | 1983 | 1,450 | 21,171 | 2.1171E+04 | 70 | 2.82E-04 | 5.9626E+00 | 2.2050E+02 | 7.0865E+03 | 2.5866E+06 |
| 1/1/1984 | 1984 | 1,206 | 22,377 | 2.2377E+04 | 70 | 2.82E-04 | 6.3023E+00 | 2.2050E+02 | 7.4902E+03 | 2.7339E+06 |
| 1/1/1985 | 1985 | 1,237 | 23,614 | 2.3614E+04 | 70 | 2.82E-04 | 6.6506E+00 | 2.2050E+02 | 7.9043E+03 | 2.8851E+06 |
| 1/1/1986 | 1986 | 1,084 | 24,698 | 2.4698E+04 | 70 | 2.82E-04 | 6.9559E+00 | 2.2050E+02 | 8.2671E+03 | 3.0175E+06 |
| 1/1/1987 | 1987 | 1,130 | 25,828 | 2.5828E+04 | 70 | 2.82E-04 | 7.2742E+00 | 2.2050E+02 | 8.6453E+03 | 3.1556E+06 |
| 1/1/1988 | 1988 | 1,171 | 26,999 | 2.6999E+04 | 70 | 2.82E-04 | 7.6040E+00 | 2.2050E+02 | 9.0373E+03 | 3.2986E+06 |
| 1/1/1989 | 1989 | 1,055 | 28,054 | 2.8054E+04 | 70 | 2.82E-04 | 7.9011E+00 | 2.2050E+02 | 9.3905E+03 | 3.4275E+06 |
| 1/1/1990 | 1990 | 1,194 | 29,248 | 2.9248E+04 | 70 | 2.82E-04 | 8.2374E+00 | 2.2050E+02 | 9.7901E+03 | 3.5734E+06 |

| Date | Year | Leon County (ntanks new) | Leon County (ntanks cum) | Wakulla River Watershed (ntanks) | Wakulla River Watershed (gal/cap/day*) | Wakulla River Watershed (q cfs/tank**) | 80% Q (cfs) | $BOD_5$ (mg/L) | $BOD_5$ (lb/day) | $BOD_5$ (lb/yr) |
|---|---|---|---|---|---|---|---|---|---|---|
| 1/1/1991 | 1991 | 1,136 | 30,384 | 3.0384E+04 | 70 | 2.82E-04 | 8.5573E+00 | 2.2050E+02 | 1.0170E+04 | 3.7122E+06 |
| 1/1/1992 | 1992 | 772 | 31,156 | 3.1156E+04 | 70 | 2.82E-04 | 8.7748E+00 | 2.2050E+02 | 1.0429E+04 | 3.8065E+06 |
| 1/1/1993 | 1993 | 783 | 31,939 | 3.1939E+04 | 70 | 2.82E-04 | 8.9953E+00 | 2.2050E+02 | 1.0691E+04 | 3.9022E+06 |
| 1/1/1994 | 1994 | 727 | 32,666 | 3.2666E+04 | 70 | 2.82E-04 | 9.2001E+00 | 2.2050E+02 | 1.0934E+04 | 3.9910E+06 |
| 1/1/1995 | 1995 | 979 | 33,645 | 3.3645E+04 | 70 | 2.82E-04 | 9.4758E+00 | 2.2050E+02 | 1.1262E+04 | 4.1106E+06 |
| 1/1/1996 | 1996 | 984 | 34,629 | 3.4629E+04 | 70 | 2.82E-04 | 9.7529E+00 | 2.2050E+02 | 1.1591E+04 | 4.2308E+06 |
| 1/1/1997 | 1997 | 799 | 35,428 | 3.5428E+04 | 70 | 2.82E-04 | 9.9779E+00 | 2.2050E+02 | 1.1859E+04 | 4.3284E+06 |
| 1/1/1998 | 1998 | 576 | 36,004 | 3.6004E+04 | 70 | 2.82E-04 | 1.0140E+01 | 2.2050E+02 | 1.2052E+04 | 4.3988E+06 |
| 1/1/1999 | 1999 | 266 | 36,270 | 3.6270E+04 | 70 | 2.82E-04 | 1.0215E+01 | 2.2050E+02 | 1.2141E+04 | 4.4313E+06 |
| 1/1/2000 | 2000 | 318 | 36,588 | 3.6588E+04 | 70 | 2.82E-04 | 1.0305E+01 | 2.2050E+02 | 1.2247E+04 | 4.4702E+06 |
| 1/1/2001 | 2001 | 342 | 36,930 | 3.6930E+04 | 70 | 2.82E-04 | 1.0401E+01 | 2.2050E+02 | 1.2361E+04 | 4.5119E+06 |
| 1/1/2002 | 2002 | 297 | 37,227 | 3.7227E+04 | 70 | 2.82E-04 | 1.0485E+01 | 2.2050E+02 | 1.2461E+04 | 4.5482E+06 |
| 1/1/2003 | 2003 | 344 | 37,571 | 3.7571E+04 | 70 | 2.82E-04 | 1.0581E+01 | 2.2050E+02 | 1.2576E+04 | 4.5903E+06 |
| 1/1/2004 | 2004 | 296 | 37,867 | 3.7867E+04 | 70 | 2.82E-04 | 1.0665E+01 | 2.2050E+02 | 1.2675E+04 | 4.6264E+06 |
| 1/1/2005 | 2005 | 291 | 38,158 | 3.8158E+04 | 70 | 2.82E-04 | 1.0747E+01 | 2.2050E+02 | 1.2773E+04 | 4.6620E+06 |
| 1/1/2006 | 2006 | 372 | 38,530 | 3.8530E+04 | 70 | 2.82E-04 | 1.0852E+01 | 2.2050E+02 | 1.2897E+04 | 4.7074E+06 |

## Table B.3 Leon County Septic Tanks

| Date | Year | Orgn (mg/L) | Orgn (lb/day) | Orgn (lb/yr) | NH3N (mg/L) | NH3N (lb/day) | NH3N (lb/yr) | TKN (mg/L) | TKN (lb/day) | TKN (lb/yr) |
|---|---|---|---|---|---|---|---|---|---|---|
| 1/1/1970 | 1970 | 4.1000E+01 | 6.1748E+02 | 2.2538E+05 | 8.5000E+00 | 1.2801E+02 | 4.6725E+04 | 4.9500E+01 | 7.4549E+02 | 2.7211E+05 |
| 1/1/1971 | 1971 | 4.1000E+01 | 6.5663E+02 | 2.3967E+05 | 8.5000E+00 | 1.3613E+02 | 4.9688E+04 | 4.9500E+01 | 7.9276E+02 | 2.8936E+05 |
| 1/1/1972 | 1972 | 4.1000E+01 | 6.8127E+02 | 2.4867E+05 | 8.5000E+00 | 1.4124E+02 | 5.1553E+04 | 4.9500E+01 | 8.2251E+02 | 3.0022E+05 |
| 1/1/1973 | 1973 | 4.1000E+01 | 7.0256E+02 | 2.5643E+05 | 8.5000E+00 | 1.4565E+02 | 5.3163E+04 | 4.9500E+01 | 8.4821E+02 | 3.0960E+05 |
| 1/1/1974 | 1974 | 4.1000E+01 | 7.3854E+02 | 2.6957E+05 | 8.5000E+00 | 1.5311E+02 | 5.5886E+04 | 4.9500E+01 | 8.9165E+02 | 3.2545E+05 |
| 1/1/1975 | 1975 | 4.1000E+01 | 7.6636E+02 | 2.7972E+05 | 8.5000E+00 | 1.5888E+02 | 5.7991E+04 | 4.9500E+01 | 9.2524E+02 | 3.3771E+05 |
| 1/1/1977 | 1976 | 4.1000E+01 | 8.1148E+02 | 2.9619E+05 | 8.5000E+00 | 1.6823E+02 | 6.1405E+04 | 4.9500E+01 | 9.7971E+02 | 3.5760E+05 |
| 1/1/1978 | 1977 | 4.1000E+01 | 8.7223E+02 | 3.1836E+05 | 8.5000E+00 | 1.8083E+02 | 6.6002E+04 | 4.9500E+01 | 1.0531E+03 | 3.8436E+05 |
| 1/1/1979 | 1978 | 4.1000E+01 | 9.5270E+02 | 3.4774E+05 | 8.5000E+00 | 1.9751E+02 | 7.2092E+04 | 4.9500E+01 | 1.1502E+03 | 4.1983E+05 |
| 1/1/1980 | 1979 | 4.1000E+01 | 1.0555E+03 | 3.8527E+05 | 8.5000E+00 | 2.1883E+02 | 7.9872E+04 | 4.9500E+01 | 1.2743E+03 | 4.6514E+05 |
| 1/1/1981 | 1980 | 4.1000E+01 | 1.1172E+03 | 4.0778E+05 | 8.5000E+00 | 2.3161E+02 | 8.4539E+04 | 4.9500E+01 | 1.3488E+03 | 4.9232E+05 |
| 1/1/1982 | 1981 | 4.1000E+01 | 1.1765E+03 | 4.2941E+05 | 8.5000E+00 | 2.4390E+02 | 8.9023E+04 | 4.9500E+01 | 1.4204E+03 | 5.1843E+05 |
| 1/1/1984 | 1982 | 4.1000E+01 | 1.2274E+03 | 4.4801E+05 | 8.5000E+00 | 2.5447E+02 | 9.2880E+04 | 4.9500E+01 | 1.4819E+03 | 5.4089E+05 |
| 1/1/1983 | 1983 | 4.1000E+01 | 1.3177E+03 | 4.8095E+05 | 8.5000E+00 | 2.7318E+02 | 9.9709E+04 | 4.9500E+01 | 1.5909E+03 | 5.8066E+05 |
| 1/1/1984 | 1984 | 4.1000E+01 | 1.3927E+03 | 5.0835E+05 | 8.5000E+00 | 2.8874E+02 | 1.0539E+05 | 4.9500E+01 | 1.6815E+03 | 6.1374E+05 |
| 1/1/1985 | 1985 | 4.1000E+01 | 1.4697E+03 | 5.3645E+05 | 8.5000E+00 | 3.0470E+02 | 1.1122E+05 | 4.9500E+01 | 1.7744E+03 | 6.4767E+05 |
| 1/1/1986 | 1986 | 4.1000E+01 | 1.5372E+03 | 5.6108E+05 | 8.5000E+00 | 3.1869E+02 | 1.1632E+05 | 4.9500E+01 | 1.8559E+03 | 6.7740E+05 |
| 1/1/1987 | 1987 | 4.1000E+01 | 1.6075E+03 | 5.8675E+05 | 8.5000E+00 | 3.3327E+02 | 1.2164E+05 | 4.9500E+01 | 1.9408E+03 | 7.0839E+05 |
| 1/1/1988 | 1988 | 4.1000E+01 | 1.6804E+03 | 6.1335E+05 | 8.5000E+00 | 3.4838E+02 | 1.2716E+05 | 4.9500E+01 | 2.0288E+03 | 7.4051E+05 |
| 1/1/1989 | 1989 | 4.1000E+01 | 1.7461E+03 | 6.3732E+05 | 8.5000E+00 | 3.6199E+02 | 1.3213E+05 | 4.9500E+01 | 2.1081E+03 | 7.6944E+05 |
| 1/1/1990 | 1990 | 4.1000E+01 | 1.8204E+03 | 6.6444E+05 | 8.5000E+00 | 3.7740E+02 | 1.3775E+05 | 4.9500E+01 | 2.1978E+03 | 8.0219E+05 |
| 1/1/1991 | 1991 | 4.1000E+01 | 1.8911E+03 | 6.9025E+05 | 8.5000E+00 | 3.9205E+02 | 1.4310E+05 | 4.9500E+01 | 2.2831E+03 | 8.3335E+05 |
| 1/1/1992 | 1992 | 4.1000E+01 | 1.9391E+03 | 7.0779E+05 | 8.5000E+00 | 4.0202E+02 | 1.4674E+05 | 4.9500E+01 | 2.3412E+03 | 8.5452E+05 |
| 1/1/1993 | 1993 | 4.1000E+01 | 1.9879E+03 | 7.2557E+05 | 8.5000E+00 | 4.1212E+02 | 1.5042E+05 | 4.9500E+01 | 2.4000E+03 | 8.7600E+05 |
| 1/1/1994 | 1994 | 4.1000E+01 | 2.0331E+03 | 7.4209E+05 | 8.5000E+00 | 4.2150E+02 | 1.5385E+05 | 4.9500E+01 | 2.4546E+03 | 8.9594E+05 |
| 1/1/1995 | 1995 | 4.1000E+01 | 2.0941E+03 | 7.6433E+05 | 8.5000E+00 | 4.3413E+02 | 1.5846E+05 | 4.9500E+01 | 2.5282E+03 | 9.2279E+05 |
| 1/1/1996 | 1996 | 4.1000E+01 | 2.1553E+03 | 7.8668E+05 | 8.5000E+00 | 4.4683E+02 | 1.6309E+05 | 4.9500E+01 | 2.6021E+03 | 9.4978E+05 |
| 1/1/1997 | 1997 | 4.1000E+01 | 2.2050E+03 | 8.0483E+05 | 8.5000E+00 | 4.5714E+02 | 1.6686E+05 | 4.9500E+01 | 2.6622E+03 | 9.7169E+05 |

| Date | Year | Orgn (mg/L) | Orgn (lb/day) | Orgn (lb/yr) | NH3N (mg/L) | NH3N (lb/day) | NH3N (lb/yr) | TKN (mg/L) | TKN (lb/day) | TKN (lb/yr) |
|---|---|---|---|---|---|---|---|---|---|---|
| 1/1/1998 | 1998 | 4.1000E+01 | 2.2409E+03 | 8.1792E+05 | 8.5000E+00 | 4.6457E+02 | 1.6957E+05 | 4.9500E+01 | 2.7054E+03 | 9.8749E+05 |
| 1/1/1999 | 1999 | 4.1000E+01 | 2.2574E+03 | 8.2396E+05 | 8.5000E+00 | 4.6800E+02 | 1.7082E+05 | 4.9500E+01 | 2.7254E+03 | 9.9478E+05 |
| 1/1/2000 | 2000 | 4.1000E+01 | 2.2772E+03 | 8.3119E+05 | 8.5000E+00 | 4.7211E+02 | 1.7232E+05 | 4.9500E+01 | 2.7493E+03 | 1.0035E+06 |
| 1/1/2001 | 2001 | 4.1000E+01 | 2.2985E+03 | 8.3896E+05 | 8.5000E+00 | 4.7652E+02 | 1.7393E+05 | 4.9500E+01 | 2.7750E+03 | 1.0129E+06 |
| 1/1/2002 | 2002 | 4.1000E+01 | 2.3170E+03 | 8.4570E+05 | 8.5000E+00 | 4.8035E+02 | 1.7533E+05 | 4.9500E+01 | 2.7973E+03 | 1.0210E+06 |
| 1/1/2003 | 2003 | 4.1000E+01 | 2.3384E+03 | 8.5352E+05 | 8.5000E+00 | 4.8479E+02 | 1.7695E+05 | 4.9500E+01 | 2.8232E+03 | 1.0305E+06 |
| 1/1/2004 | 2004 | 4.1000E+01 | 2.3568E+03 | 8.6024E+05 | 8.5000E+00 | 4.8861E+02 | 1.7834E+05 | 4.9500E+01 | 2.8454E+03 | 1.0386E+06 |
| 1/1/2005 | 2005 | 4.1000E+01 | 2.3749E+03 | 8.6685E+05 | 8.5000E+00 | 4.9237E+02 | 1.7971E+05 | 4.9500E+01 | 2.8673E+03 | 1.0466E+06 |
| 1/1/2006 | 2006 | 4.1000E+01 | 2.3981E+03 | 8.7530E+05 | 8.5000E+00 | 4.9717E+02 | 1.8147E+05 | 4.9500E+01 | 2.8953E+03 | 1.0568E+06 |

## Table B.4 Leon County Septic Tanks

LEON PORTION WAKULLA RIVER WATERSHED URBAN RATIO TO COUNTY = 1.0000E+00
BOD5 = 220.5 , MEAN OF RANGE 155-286 MG/L (EPA ONSITE WWTS MANUAL TABLE 3-2)
NH3N =8.5 MG/L, MEAN OF RANGE 4-13 MG/L (EPA ONSITE WWTS MANUAL TABLE 3-2)
NO23N = 1.0 MG/L, MEAN OF RANGE < 1 MG/L (EPA ONSITE WWTS MANUAL TABLE 3-2)
ORGN = 41.0 MG/L, ESTIMATED MEAN (EPA ONSITE WWTS MANUAL TABLE 3-2)
TKN = 49.5 MG/L, ESTIMATED MEAN (EPA ONSITE WWTS MANUAL TABLE 3-2)
DA = 7.0178E+02 (SQMI)

| Date | Year | NO23N (mg/L) | NO23N (lb/day) | NO23N (lb/yr) | TN (mg /L ***) | TN (lb/day) | TN (lb/yr) | TP (mg /L) | TP (lb/day) | TP (lb/yr) |
|---|---|---|---|---|---|---|---|---|---|---|
| 1/1/1970 | 1970 | 1.0000E+00 | 1.5060E+01 | 5.4971E+03 | 5.0500E+01 | 7.6055E+02 | 2.7760E+05 | 9.0000E+00 | 1.3554E+02 | 4.9474E+04 |
| 1/1/1971 | 1971 | 1.0000E+00 | 1.6015E+01 | 5.8456E+03 | 5.0500E+01 | 8.0877E+02 | 2.9520E+05 | 9.0000E+00 | 1.4414E+02 | 5.2610E+04 |
| 1/1/1972 | 1972 | 1.0000E+00 | 1.6616E+01 | 6.0650E+03 | 5.0500E+01 | 8.3913E+02 | 3.0628E+05 | 9.0000E+00 | 1.4955E+02 | 5.4585E+04 |
| 1/1/1973 | 1973 | 1.0000E+00 | 1.7136E+01 | 6.2545E+03 | 5.0500E+01 | 8.6535E+02 | 3.1585E+05 | 9.0000E+00 | 1.5422E+02 | 5.6291E+04 |
| 1/1/1974 | 1974 | 1.0000E+00 | 1.8013E+01 | 6.5748E+03 | 5.0500E+01 | 9.0966E+02 | 3.3203E+05 | 9.0000E+00 | 1.6212E+02 | 5.9173E+04 |
| 1/1/1975 | 1975 | 1.0000E+00 | 1.8692E+01 | 6.8224E+03 | 5.0500E+01 | 9.4393E+02 | 3.4453E+05 | 9.0000E+00 | 1.6822E+02 | 6.1402E+04 |
| 1/1/1977 | 1976 | 1.0000E+00 | 1.9792E+01 | 7.2242E+03 | 5.0500E+01 | 9.9951E+02 | 3.6482E+05 | 9.0000E+00 | 1.7813E+02 | 6.5017E+04 |
| 1/1/1978 | 1977 | 1.0000E+00 | 2.1274E+01 | 7.7649E+03 | 5.0500E+01 | 1.0743E+03 | 3.9213E+05 | 9.0000E+00 | 1.9146E+02 | 6.9884E+04 |
| 1/1/1979 | 1978 | 1.0000E+00 | 2.3237E+01 | 8.4814E+03 | 5.0500E+01 | 1.1734E+03 | 4.2831E+05 | 9.0000E+00 | 2.0913E+02 | 7.6332E+04 |
| 1/1/1980 | 1979 | 1.0000E+00 | 2.5744E+01 | 9.3967E+03 | 5.0500E+01 | 1.3001E+03 | 4.7453E+05 | 9.0000E+00 | 2.3170E+02 | 8.4570E+04 |
| 1/1/1981 | 1980 | 1.0000E+00 | 2.7249E+01 | 9.9458E+03 | 5.0500E+01 | 1.3761E+03 | 5.0226E+05 | 9.0000E+00 | 2.4524E+02 | 8.9512E+04 |
| 1/1/1982 | 1981 | 1.0000E+00 | 2.8694E+01 | 1.0473E+04 | 5.0500E+01 | 1.4490E+03 | 5.2890E+05 | 9.0000E+00 | 2.5825E+02 | 9.4260E+04 |
| 1/1/1984 | 1982 | 1.0000E+00 | 2.9937E+01 | 1.0927E+04 | 5.0500E+01 | 1.5118E+03 | 5.5182E+05 | 9.0000E+00 | 2.6944E+02 | 9.8344E+04 |
| 1/1/1983 | 1983 | 1.0000E+00 | 3.2138E+01 | 1.1731E+04 | 5.0500E+01 | 1.6230E+03 | 5.9239E+05 | 9.0000E+00 | 2.8925E+02 | 1.0557E+05 |
| 1/1/1984 | 1984 | 1.0000E+00 | 3.3969E+01 | 1.2399E+04 | 5.0500E+01 | 1.7154E+03 | 6.2614E+05 | 9.0000E+00 | 3.0572E+02 | 1.1159E+05 |
| 1/1/1985 | 1985 | 1.0000E+00 | 3.5847E+01 | 1.3084E+04 | 5.0500E+01 | 1.8103E+03 | 6.6075E+05 | 9.0000E+00 | 3.2262E+02 | 1.1776E+05 |
| 1/1/1986 | 1986 | 1.0000E+00 | 3.7493E+01 | 1.3685E+04 | 5.0500E+01 | 1.8934E+03 | 6.9108E+05 | 9.0000E+00 | 3.3743E+02 | 1.2316E+05 |
| 1/1/1987 | 1987 | 1.0000E+00 | 3.9208E+01 | 1.4311E+04 | 5.0500E+01 | 1.9800E+03 | 7.2270E+05 | 9.0000E+00 | 3.5287E+02 | 1.2880E+05 |
| 1/1/1988 | 1988 | 1.0000E+00 | 4.0986E+01 | 1.4960E+04 | 5.0500E+01 | 2.0698E+03 | 7.5547E+05 | 9.0000E+00 | 3.6887E+02 | 1.3464E+05 |
| 1/1/1989 | 1989 | 1.0000E+00 | 4.2587E+01 | 1.5544E+04 | 5.0500E+01 | 2.1506E+03 | 7.8499E+05 | 9.0000E+00 | 3.8328E+02 | 1.3990E+05 |
| 1/1/1990 | 1990 | 1.0000E+00 | 4.4400E+01 | 1.6206E+04 | 5.0500E+01 | 2.2422E+03 | 8.1840E+05 | 9.0000E+00 | 3.9960E+02 | 1.4585E+05 |
| 1/1/1991 | 1991 | 1.0000E+00 | 4.6124E+01 | 1.6835E+04 | 5.0500E+01 | 2.3293E+03 | 8.5018E+05 | 9.0000E+00 | 4.1512E+02 | 1.5152E+05 |
| 1/1/1992 | 1992 | 1.0000E+00 | 4.7296E+01 | 1.7263E+04 | 5.0500E+01 | 2.3885E+03 | 8.7178E+05 | 9.0000E+00 | 4.2566E+02 | 1.5537E+05 |

| Date | Year | NO23N (mg/L) | NO23N (lb/day) | NO23N (lb/yr) | TN (mg /L ***) | TN (lb/day) | TN (lb/yr) | TP (mg /L) | TP (lb/day) | TP (lb/yr) |
|---|---|---|---|---|---|---|---|---|---|---|
| 1/1/1993 | 1993 | 1.0000E+00 | 4.8485E+01 | 1.7697E+04 | 5.0500E+01 | 2.4485E+03 | 8.9369E+05 | 9.0000E+00 | 4.3636E+02 | 1.5927E+05 |
| 1/1/1994 | 1994 | 1.0000E+00 | 4.9588E+01 | 1.8100E+04 | 5.0500E+01 | 2.5042E+03 | 9.1404E+05 | 9.0000E+00 | 4.4629E+02 | 1.6290E+05 |
| 1/1/1995 | 1995 | 1.0000E+00 | 5.1074E+01 | 1.8642E+04 | 5.0500E+01 | 2.5793E+03 | 9.4143E+05 | 9.0000E+00 | 4.5967E+02 | 1.6778E+05 |
| 1/1/1996 | 1996 | 1.0000E+00 | 5.2568E+01 | 1.9187E+04 | 5.0500E+01 | 2.6547E+03 | 9.6896E+05 | 9.0000E+00 | 4.7311E+02 | 1.7269E+05 |
| 1/1/1997 | 1997 | 1.0000E+00 | 5.3781E+01 | 1.9630E+04 | 5.0500E+01 | 2.7159E+03 | 9.9132E+05 | 9.0000E+00 | 4.8403E+02 | 1.7667E+05 |
| 1/1/1998 | 1998 | 1.0000E+00 | 5.4655E+01 | 1.9949E+04 | 5.0500E+01 | 2.7601E+03 | 1.0074E+06 | 9.0000E+00 | 4.9190E+02 | 1.7954E+05 |
| 1/1/1999 | 1999 | 1.0000E+00 | 5.5059E+01 | 2.0097E+04 | 5.0500E+01 | 2.7805E+03 | 1.0149E+06 | 9.0000E+00 | 4.9553E+02 | 1.8087E+05 |
| 1/1/2000 | 2000 | 1.0000E+00 | 5.5542E+01 | 2.0273E+04 | 5.0500E+01 | 2.8049E+03 | 1.0238E+06 | 9.0000E+00 | 4.9988E+02 | 1.8246E+05 |
| 1/1/2001 | 2001 | 1.0000E+00 | 5.6061E+01 | 2.0462E+04 | 5.0500E+01 | 2.8311E+03 | 1.0333E+06 | 9.0000E+00 | 5.0455E+02 | 1.8416E+05 |
| 1/1/2002 | 2002 | 1.0000E+00 | 5.6512E+01 | 2.0627E+04 | 5.0500E+01 | 2.8539E+03 | 1.0417E+06 | 9.0000E+00 | 5.0861E+02 | 1.8564E+05 |
| 1/1/2003 | 2003 | 1.0000E+00 | 5.7034E+01 | 2.0818E+04 | 5.0500E+01 | 2.8802E+03 | 1.0513E+06 | 9.0000E+00 | 5.1331E+02 | 1.8736E+05 |
| 1/1/2004 | 2004 | 1.0000E+00 | 5.7484E+01 | 2.0982E+04 | 5.0500E+01 | 2.9029E+03 | 1.0596E+06 | 9.0000E+00 | 5.1735E+02 | 1.8883E+05 |
| 1/1/2005 | 2005 | 1.0000E+00 | 5.7925E+01 | 2.1143E+04 | 5.0500E+01 | 2.9252E+03 | 1.0677E+06 | 9.0000E+00 | 5.2133E+02 | 1.9028E+05 |
| 1/1/2006 | 2006 | 1.0000E+00 | 5.8490E+01 | 2.1349E+04 | 5.0500E+01 | 2.9537E+03 | 1.0781E+06 | 9.0000E+00 | 5.2641E+02 | 1.9214E+05 |

## Table B.5 Munson Slough Watershed Septic Tanks

| Date | Year | Leon County (ntanks new) | Leon County (ntanks cum) | Lake Munson Watershed (ntanks) | Lake Munson Watershed (gal/cap/day) | Lake Munson Watershed (q cfs/tank) | 80% Q (cfs) | $BOD_5$ (mg/L) | $BOD_5$ (lb/day) | $BOD_5$ (lb/yr) |
|---|---|---|---|---|---|---|---|---|---|---|
| 1/1/1970 | 1970 | 9,921 | 9,921 | 1.7429E+03 | 70 | 2.82E-04 | 4.9088E-01 | 2.2050E+02 | 5.8340E+02 | 2.1294E+05 |
| 1/1/1971 | 1971 | 629 | 10,550 | 1.8534E+03 | 70 | 2.82E-04 | 5.2200E-01 | 2.2050E+02 | 6.2039E+02 | 2.2644E+05 |
| 1/1/1972 | 1972 | 396 | 10,946 | 1.9230E+03 | 70 | 2.82E-04 | 5.4159E-01 | 2.2050E+02 | 6.4368E+02 | 2.3494E+05 |
| 1/1/1973 | 1973 | 342 | 11,288 | 1.9831E+03 | 70 | 2.82E-04 | 5.5851E-01 | 2.2050E+02 | 6.6379E+02 | 2.4228E+05 |
| 1/1/1974 | 1974 | 578 | 11,866 | 2.0846E+03 | 70 | 2.82E-04 | 5.8711E-01 | 2.2050E+02 | 6.9778E+02 | 2.5469E+05 |
| 1/1/1975 | 1975 | 447 | 12,313 | 2.1631E+03 | 70 | 2.82E-04 | 6.0923E-01 | 2.2050E+02 | 7.2407E+02 | 2.6428E+05 |
| 1/1/1977 | 1976 | 725 | 13,038 | 2.2905E+03 | 70 | 2.82E-04 | 6.4510E-01 | 2.2050E+02 | 7.6670E+02 | 2.7985E+05 |
| 1/1/1978 | 1977 | 976 | 14,014 | 2.4620E+03 | 70 | 2.82E-04 | 6.9339E-01 | 2.2050E+02 | 8.2409E+02 | 3.0079E+05 |
| 1/1/1979 | 1978 | 1,293 | 15,307 | 2.6891E+03 | 70 | 2.82E-04 | 7.5737E-01 | 2.2050E+02 | 9.0013E+02 | 3.2855E+05 |
| 1/1/1980 | 1979 | 1,652 | 16,959 | 2.9794E+03 | 70 | 2.82E-04 | 8.3911E-01 | 2.2050E+02 | 9.9727E+02 | 3.6400E+05 |
| 1/1/1981 | 1980 | 991 | 17,950 | 3.1535E+03 | 70 | 2.82E-04 | 8.8814E-01 | 2.2050E+02 | 1.0555E+03 | 3.8528E+05 |
| 1/1/1982 | 1981 | 952 | 18,902 | 3.3207E+03 | 70 | 2.82E-04 | 9.3524E-01 | 2.2050E+02 | 1.1115E+03 | 4.0571E+05 |
| 1/1/1984 | 1982 | 819 | 19,721 | 3.4646E+03 | 70 | 2.82E-04 | 9.7577E-01 | 2.2050E+02 | 1.1597E+03 | 4.2329E+05 |
| 1/1/1983 | 1983 | 1,450 | 21,171 | 3.7193E+03 | 70 | 2.82E-04 | 1.0475E+00 | 2.2050E+02 | 1.2450E+03 | 4.5441E+05 |
| 1/1/1984 | 1984 | 1,206 | 22,377 | 3.9312E+03 | 70 | 2.82E-04 | 1.1072E+00 | 2.2050E+02 | 1.3159E+03 | 4.8030E+05 |
| 1/1/1985 | 1985 | 1,237 | 23,614 | 4.1485E+03 | 70 | 2.82E-04 | 1.1684E+00 | 2.2050E+02 | 1.3886E+03 | 5.0685E+05 |
| 1/1/1986 | 1986 | 1,084 | 24,698 | 4.3389E+03 | 70 | 2.82E-04 | 1.2220E+00 | 2.2050E+02 | 1.4524E+03 | 5.3011E+05 |
| 1/1/1987 | 1987 | 1,130 | 25,828 | 4.5375E+03 | 70 | 2.82E-04 | 1.2779E+00 | 2.2050E+02 | 1.5188E+03 | 5.5437E+05 |
| 1/1/1988 | 1988 | 1,,171 | 26,999 | 4.7432E+03 | 70 | 2.82E-04 | 1.3359E+00 | 2.2050E+02 | 1.5877E+03 | 5.7950E+05 |
| 1/1/1989 | 1989 | 1,055 | 28,054 | 4.9285E+03 | 70 | 2.82E-04 | 1.3881E+00 | 2.2050E+02 | 1.6497E+03 | 6.0215E+05 |
| 1/1/1990 | 1990 | 1,194 | 29,248 | 5.1383E+03 | 70 | 2.82E-04 | 1.4471E+00 | 2.2050E+02 | 1.7199E+03 | 6.2777E+05 |
| 1/1/1991 | 1991 | 1136 | 30,384 | 5.3379E+03 | 70 | 2.82E-04 | 1.5034E+00 | 2.2050E+02 | 1.7867E+03 | 6.5216E+05 |
| 1/1/1992 | 1992 | 772 | 31,156 | 5.4735E+03 | 70 | 2.82E-04 | 1.5416E+00 | 2.2050E+02 | 1.8321E+03 | 6.6873E+05 |
| 1/1/1993 | 1993 | 783 | 31,939 | 5.6110E+03 | 70 | 2.82E-04 | 1.5803E+00 | 2.2050E+02 | 1.8782E+03 | 6.8553E+05 |
| 1/1/1994 | 1994 | 727 | 32,666 | 5.7388E+03 | 70 | 2.82E-04 | 1.6163E+00 | 2.2050E+02 | 1.9209E+03 | 7.0114E+05 |
| 1/1/1995 | 1995 | 979 | 33,645 | 5.9108E+03 | 70 | 2.82E-04 | 1.6647E+00 | 2.2050E+02 | 1.9785E+03 | 7.2215E+05 |
| 1/1/1996 | 1996 | 984 | 34,629 | 6.0836E+03 | 70 | 2.82E-04 | 1.7134E+00 | 2.2050E+02 | 2.0364E+03 | 7.4327E+05 |

| Date | Year | Leon County (ntanks new) | Leon County (ntanks cum) | Lake Munson Watershed (ntanks) | Lake Munson Watershed (gal/cap/day) | Lake Munson Watershed (q cfs/tank) | 80% Q (cfs) | $BOD_5$ (mg/L) | $BOD_5$ (lb/day) | $BOD_5$ (lb/yr) |
|---|---|---|---|---|---|---|---|---|---|---|
| 1/1/1997 | 1997 | 799 | 35,428 | 6.2240E+03 | 70 | 2.82E-04 | 1.7529E+00 | 2.2050E+02 | 2.0833E+03 | 7.6042E+05 |
| 1/1/1998 | 1998 | 576 | 36,004 | 6.3252E+03 | 70 | 2.82E-04 | 1.7814E+00 | 2.2050E+02 | 2.1172E+03 | 7.7278E+05 |
| 1/1/1999 | 1999 | 266 | 36,270 | 6.3719E+03 | 70 | 2.82E-04 | 1.7946E+00 | 2.2050E+02 | 2.1329E+03 | 7.7849E+05 |
| 1/1/2000 | 2000 | 318 | 36,588 | 6.4278E+03 | 70 | 2.82E-04 | 1.8103E+00 | 2.2050E+02 | 2.1516E+03 | 7.8532E+05 |
| 1/1/2001 | 2001 | 342 | 36,930 | 6.4879E+03 | 70 | 2.82E-04 | 1.8272E+00 | 2.2050E+02 | 2.1717E+03 | 7.9266E+05 |
| 1/1/2002 | 2002 | 297 | 37,227 | 6.5400E+03 | 70 | 2.82E-04 | 1.8419E+00 | 2.2050E+02 | 2.1891E+03 | 7.9903E+05 |
| 1/1/2003 | 2003 | 344 | 37,571 | 6.6005E+03 | 70 | 2.82E-04 | 1.8590E+00 | 2.2050E+02 | 2.2094E+03 | 8.0642E+05 |
| 1/1/2004 | 2004 | 296 | 37,867 | 6.6525E+03 | 70 | 2.82E-04 | 1.8736E+00 | 2.2050E+02 | 2.2268E+03 | 8.1277E+05 |
| 1/1/2005 | 2005 | 291 | 38,158 | 6.7036E+03 | 70 | 2.82E-04 | 1.8880E+00 | 2.2050E+02 | 2.2439E+03 | 8.1902E+05 |
| 1/1/2006 | 2006 | 372 | 38,530 | 6.7690E+03 | 70 | 2.82E-04 | 1.9064E+00 | 2.2050E+02 | 2.2658E+03 | 8.2700E+05 |

## Table B.6 Munson Slough Watershed Septic Tanks

| Date | Year | ORGN (mg/L) | ORGN (lb/day) | ORGN (LB/YR) | NH3N (mg/L) | NH3N (lb/day) | NH3N (lb/yr) | TKN (mg/L) | TKN (lb/day) | TKN (lb/yr) |
|---|---|---|---|---|---|---|---|---|---|---|
| 1/1/1971 | 1971 | 4.1000E+01 | 1.1536E+02 | 4.2105E+04 | 8.5000E+00 | 2.3915E+01 | 8.7291E+03 | 4.9500E+01 | 1.3927E+02 | 5.0834E+04 |
| 1/1/1972 | 1972 | 4.1000E+01 | 1.1969E+02 | 4.3686E+04 | 8.5000E+00 | 2.4813E+01 | 9.0568E+03 | 4.9500E+01 | 1.4450E+02 | 5.2742E+04 |
| 1/1/1973 | 1973 | 4.1000E+01 | 1.2343E+02 | 4.5050E+04 | 8.5000E+00 | 2.5588E+01 | 9.3397E+03 | 4.9500E+01 | 1.4901E+02 | 5.4390E+04 |
| 1/1/1974 | 1974 | 4.1000E+01 | 1.2975E+02 | 4.7357E+04 | 8.5000E+00 | 2.6899E+01 | 9.8180E+03 | 4.9500E+01 | 1.5664E+02 | 5.7175E+04 |
| 1/1/1975 | 1975 | 4.1000E+01 | 1.3463E+02 | 4.9141E+04 | 8.5000E+00 | 2.7912E+01 | 1.0188E+04 | 4.9500E+01 | 1.6255E+02 | 5.9329E+04 |
| 1/1/1977 | 1976 | 4.1000E+01 | 1.4256E+02 | 5.2035E+04 | 8.5000E+00 | 2.9555E+01 | 1.0788E+04 | 4.9500E+01 | 1.7212E+02 | 6.2822E+04 |
| 1/1/1978 | 1977 | 4.1000E+01 | 1.5323E+02 | 5.5930E+04 | 8.5000E+00 | 3.1768E+01 | 1.1595E+04 | 4.9500E+01 | 1.8500E+02 | 6.7525E+04 |
| 1/1/1979 | 1978 | 4.1000E+01 | 1.6737E+02 | 6.1090E+04 | 8.5000E+00 | 3.4699E+01 | 1.2665E+04 | 4.9500E+01 | 2.0207E+02 | 7.3755E+04 |
| 1/1/1980 | 1979 | 4.1000E+01 | 1.8543E+02 | 6.7683E+04 | 8.5000E+00 | 3.8444E+01 | 1.4032E+04 | 4.9500E+01 | 2.2388E+02 | 8.1715E+04 |
| 1/1/1981 | 1980 | 4.1000E+01 | 1.9627E+02 | 7.1639E+04 | 8.5000E+00 | 4.0690E+01 | 1.4852E+04 | 4.9500E+01 | 2.3696E+02 | 8.6490E+04 |
| 1/1/1982 | 1981 | 4.1000E+01 | 2.0668E+02 | 7.5438E+04 | 8.5000E+00 | 4.2848E+01 | 1.5640E+04 | 4.9500E+01 | 2.4953E+02 | 9.1078E+04 |
| 1/1/1984 | 1982 | 4.1000E+01 | 2.1563E+02 | 7.8707E+04 | 8.5000E+00 | 4.4705E+01 | 1.6317E+04 | 4.9500E+01 | 2.6034E+02 | 9.5024E+04 |
| 1/1/1983 | 1983 | 4.1000E+01 | 2.3149E+02 | 8.4494E+04 | 8.5000E+00 | 4.7992E+01 | 1.7517E+04 | 4.9500E+01 | 2.7948E+02 | 1.0201E+05 |
| 1/1/1984 | 1984 | 4.1000E+01 | 2.4468E+02 | 8.9307E+04 | 8.5000E+00 | 5.0725E+01 | 1.8515E+04 | 4.9500E+01 | 2.9540E+02 | 1.0782E+05 |
| 1/1/1985 | 1985 | 4.1000E+01 | 2.5820E+02 | 9.4244E+04 | 8.5000E+00 | 5.3530E+01 | 1.9538E+04 | 4.9500E+01 | 3.1173E+02 | 1.1378E+05 |
| 1/1/1986 | 1986 | 4.1000E+01 | 2.7005E+02 | 9.8570E+04 | 8.5000E+00 | 5.5987E+01 | 2.0435E+04 | 4.9500E+01 | 3.2604E+02 | 1.1901E+05 |
| 1/1/1987 | 1987 | 4.1000E+01 | 2.8241E+02 | 1.0308E+05 | 8.5000E+00 | 5.8548E+01 | 2.1370E+04 | 4.9500E+01 | 3.4096E+02 | 1.2445E+05 |
| 1/1/1988 | 1988 | 4.1000E+01 | 2.9521E+02 | 1.0775E+05 | 8.5000E+00 | 6.1203E+01 | 2.2339E+04 | 4.9500E+01 | 3.5642E+02 | 1.3009E+05 |
| 1/1/1989 | 1989 | 4.1000E+01 | 3.0675E+02 | 1.1196E+05 | 8.5000E+00 | 6.3594E+01 | 2.3212E+04 | 4.9500E+01 | 3.7034E+02 | 1.3518E+05 |
| 1/1/1990 | 1990 | 4.1000E+01 | 3.1981E+02 | 1.1673E+05 | 8.5000E+00 | 6.6301E+01 | 2.4200E+04 | 4.9500E+01 | 3.8611E+02 | 1.4093E+05 |
| 1/1/1991 | 1991 | 4.1000E+01 | 3.3223E+02 | 1.2126E+05 | 8.5000E+00 | 6.8876E+01 | 2.5140E+04 | 4.9500E+01 | 4.0110E+02 | 1.4640E+05 |
| 1/1/1992 | 1992 | 4.1000E+01 | 3.4067E+02 | 1.2434E+05 | 8.5000E+00 | 7.0626E+01 | 2.5779E+04 | 4.9500E+01 | 4.1129E+02 | 1.5012E+05 |
| 1/1/1993 | 1993 | 4.1000E+01 | 3.4923E+02 | 1.2747E+05 | 8.5000E+00 | 7.2401E+01 | 2.6426E+04 | 4.9500E+01 | 4.2163E+02 | 1.5390E+05 |
| 1/1/1994 | 1994 | 4.1000E+01 | 3.5718E+02 | 1.3037E+05 | 8.5000E+00 | 7.4049E+01 | 2.7028E+04 | 4.9500E+01 | 4.3123E+02 | 1.5740E+05 |
| 1/1/1995 | 1995 | 4.1000E+01 | 3.6788E+02 | 1.3428E+05 | 8.5000E+00 | 7.6268E+01 | 2.7838E+04 | 4.9500E+01 | 4.4415E+02 | 1.6212E+05 |
| 1/1/1996 | 1996 | 4.1000E+01 | 3.7864E+02 | 1.3820E+05 | 8.5000E+00 | 7.8499E+01 | 2.8652E+04 | 4.9500E+01 | 4.5714E+02 | 1.6686E+05 |
| 1/1/1997 | 1997 | 4.1000E+01 | 3.8738E+02 | 1.4139E+05 | 8.5000E+00 | 8.0310E+01 | 2.9313E+04 | 4.9500E+01 | 4.6769E+02 | 1.7071E+05 |
| 1/1/1998 | 1998 | 4.1000E+01 | 3.9368E+02 | 1.4369E+05 | 8.5000E+00 | 8.1616E+01 | 2.9790E+04 | 4.9500E+01 | 4.7529E+02 | 1.7348E+05 |

| Date | Year | ORGN (mg/L) | ORGN (lb/day) | ORGN (LB/YR) | NH3N (mg/L) | NH3N (lb/day) | NH3N (lb/yr) | TKN (mg/L) | TKN (lb/day) | TKN (lb/yr) |
|---|---|---|---|---|---|---|---|---|---|---|
| 1/1/1999 | 1999 | 4.1000E+01 | 3.9659E+02 | 1.4475E+05 | 8.5000E+00 | 8.2219E+01 | 3.0010E+04 | 4.9500E+01 | 4.7880E+02 | 1.7476E+05 |
| 1/1/2000 | 2000 | 4.1000E+01 | 4.0006E+02 | 1.4602E+05 | 8.5000E+00 | 8.2940E+01 | 3.0273E+04 | 4.9500E+01 | 4.8300E+02 | 1.7630E+05 |
| 1/1/2001 | 2001 | 4.1000E+01 | 4.0380E+02 | 1.4739E+05 | 8.5000E+00 | 8.3715E+01 | 3.0556E+04 | 4.9500E+01 | 4.8752E+02 | 1.7794E+05 |
| 1/1/2002 | 2002 | 4.1000E+01 | 4.0705E+02 | 1.4857E+05 | 8.5000E+00 | 8.4388E+01 | 3.0802E+04 | 4.9500E+01 | 4.9144E+02 | 1.7937E+05 |
| 1/1/2003 | 2003 | 4.1000E+01 | 4.1081E+02 | 1.4995E+05 | 8.5000E+00 | 8.5168E+01 | 3.1086E+04 | 4.9500E+01 | 4.9598E+02 | 1.8103E+05 |
| 1/1/2004 | 2004 | 4.1000E+01 | 4.1405E+02 | 1.5113E+05 | 8.5000E+00 | 8.5839E+01 | 3.1331E+04 | 4.9500E+01 | 4.9989E+02 | 1.8246E+05 |
| 1/1/2005 | 2005 | 4.1000E+01 | 4.1723E+02 | 1.5229E+05 | 8.5000E+00 | 8.6499E+01 | 3.1572E+04 | 4.9500E+01 | 5.0373E+02 | 1.8386E+05 |
| 1/1/2006 | 2006 | 4.1000E+01 | 4.2130E+02 | 1.5377E+05 | 8.5000E+00 | 8.7342E+01 | 3.1880E+04 | 4.9500E+01 | 5.0864E+02 | 1.8565E+05 |

## Table B.7 Munson Slough Watershed Septic Tanks

LEON PORTION WAKULLA RIVER WATERSHED URBAN RATIO TO COUNTY = 1.7568E-01
$BOD_5$= 220.5 , MEAN OF RANGE 155-286 MG/L (EPA ONSITE WWTS MANUAL TABLE 3-2)
NH3N=8.5 MG/L, MEAN OF RANGE 4-13 MG/L (EPA ONSITE WWTS MANUAL TABLE 3-2)
NO23N= 1.0 MG/L, MEAN OF RANGE < 1 MG/L (EPA ONSITE WWTS MANUAL TABLE 3-2)
ORGN= 41.0 MG/L, ESTIMATED MEAN (EPA ONSITE WWTS MANUAL TABLE 3-2)
TKN= 49.5 MG/L , ESTIMATED MEAN (EPA ONSITE WWTS MANUAL TABLE 3-2)
*** TN= 50.5 MG/L , MEAN OF RANGE 26-75 MG/L (EPA ONSITE WWTS MANUAL TABLE 3-2)
*** TP=9 MG/L, MEAN OF RANGE 6-12 MG/L (EPA ONSITE WWTS MANUAL TABLE 3-2)
DA= 7.0178E+02 (SQMI)

| Date | Year | NO23N (mg/L) | NO23N (lb/day) | NO23N (lb/yr) | TN (mg/L***) | TN (lb/day) | TN (lb/yr) | TP (mg/L) | TP (lb/day) | TP (lb/yr) |
|---|---|---|---|---|---|---|---|---|---|---|
| 1/1/1970 | 1970 | 1.0000E+00 | 2.6458E+00 | 9.6573E+02 | 5.0500E+01 | 1.3361E+02 | 4.8769E+04 | 9.0000E+00 | 2.3812E+01 | 8.6915E+03 |
| 1/1/1971 | 1971 | 1.0000E+00 | 2.8136E+00 | 1.0270E+03 | 5.0500E+01 | 1.4209E+02 | 5.1861E+04 | 9.0000E+00 | 2.5322E+01 | 9.2426E+03 |
| 1/1/1972 | 1972 | 1.0000E+00 | 2.9192E+00 | 1.0655E+03 | 5.0500E+01 | 1.4742E+02 | 5.3808E+04 | 9.0000E+00 | 2.6273E+01 | 9.5895E+03 |
| 1/1/1973 | 1973 | 1.0000E+00 | 3.0104E+00 | 1.0988E+03 | 5.0500E+01 | 1.5202E+02 | 5.5489E+04 | 9.0000E+00 | 2.7093E+01 | 9.8891E+03 |
| 1/1/1974 | 1974 | 1.0000E+00 | 3.1645E+00 | 1.1551E+03 | 5.0500E+01 | 1.5981E+02 | 5.8330E+04 | 9.0000E+00 | 2.8481E+01 | 1.0395E+04 |
| 1/1/1975 | 1975 | 1.0000E+00 | 3.2837E+00 | 1.1986E+03 | 5.0500E+01 | 1.6583E+02 | 6.0528E+04 | 9.0000E+00 | 2.9554E+01 | 1.0787E+04 |
| 1/1/1977 | 1976 | 1.0000E+00 | 3.4771E+00 | 1.2691E+03 | 5.0500E+01 | 1.7559E+02 | 6.4092E+04 | 9.0000E+00 | 3.1294E+01 | 1.1422E+04 |
| 1/1/1978 | 1977 | 1.0000E+00 | 3.7374E+00 | 1.3641E+03 | 5.0500E+01 | 1.8874E+02 | 6.8889E+04 | 9.0000E+00 | 3.3636E+01 | 1.2277E+04 |
| 1/1/1979 | 1978 | 1.0000E+00 | 4.0822E+00 | 1.4900E+03 | 5.0500E+01 | 2.0615E+02 | 7.5245E+04 | 9.0000E+00 | 3.6740E+01 | 1.3410E+04 |
| 1/1/1980 | 1979 | 1.0000E+00 | 4.5228E+00 | 1.6508E+03 | 5.0500E+01 | 2.2840E+02 | 8.3366E+04 | 9.0000E+00 | 4.0705E+01 | 1.4857E+04 |
| 1/1/1981 | 1980 | 1.0000E+00 | 4.7871E+00 | 1.7473E+03 | 5.0500E+01 | 2.4175E+02 | 8.8238E+04 | 9.0000E+00 | 4.3084E+01 | 1.5726E+04 |
| 1/1/1982 | 1981 | 1.0000E+00 | 5.0410E+00 | 1.8400E+03 | 5.0500E+01 | 2.5457E+02 | 9.2917E+04 | 9.0000E+00 | 4.5369E+01 | 1.6560E+04 |
| 1/1/1984 | 1982 | 1.0000E+00 | 5.2594E+00 | 1.9197E+03 | 5.0500E+01 | 2.6560E+02 | 9.6943E+04 | 9.0000E+00 | 4.7334E+01 | 1.7277E+04 |
| 1/1/1983 | 1983 | 1.0000E+00 | 5.6461E+00 | 2.0608E+03 | 5.0500E+01 | 2.8513E+02 | 1.0407E+05 | 9.0000E+00 | 5.0815E+01 | 1.8547E+04 |
| 1/1/1984 | 1984 | 1.0000E+00 | 5.9677E+00 | 2.1782E+03 | 5.0500E+01 | 3.0137E+02 | 1.1000E+05 | 9.0000E+00 | 5.3709E+01 | 1.9604E+04 |
| 1/1/1985 | 1985 | 1.0000E+00 | 6.2976E+00 | 2.2986E+03 | 5.0500E+01 | 3.1803E+02 | 1.1608E+05 | 9.0000E+00 | 5.6678E+01 | 2.0688E+04 |
| 1/1/1986 | 1986 | 1.0000E+00 | 6.5867E+00 | 2.4041E+03 | 5.0500E+01 | 3.3263E+02 | 1.2141E+05 | 9.0000E+00 | 5.9280E+01 | 2.1637E+04 |
| 1/1/1987 | 1987 | 1.0000E+00 | 6.8880E+00 | 2.5141E+03 | 5.0500E+01 | 3.4785E+02 | 1.2696E+05 | 9.0000E+00 | 6.1992E+01 | 2.2627E+04 |
| 1/1/1988 | 1988 | 1.0000E+00 | 7.2003E+00 | 2.6281E+03 | 5.0500E+01 | 3.6362E+02 | 1.3272E+05 | 9.0000E+00 | 6.4803E+01 | 2.3653E+04 |
| 1/1/1989 | 1989 | 1.0000E+00 | 7.4817E+00 | 2.7308E+03 | 5.0500E+01 | 3.7783E+02 | 1.3791E+05 | 9.0000E+00 | 6.7335E+01 | 2.4577E+04 |
| 1/1/1990 | 1990 | 1.0000E+00 | 7.8001E+00 | 2.8470E+03 | 5.0500E+01 | 3.9391E+02 | 1.4378E+05 | 9.0000E+00 | 7.0201E+01 | 2.5623E+04 |
| 1/1/1991 | 1991 | 1.0000E+00 | 8.1031E+00 | 2.9576E+03 | 5.0500E+01 | 4.0921E+02 | 1.4936E+05 | 9.0000E+00 | 7.2928E+01 | 2.6619E+04 |

| Date | Year | NO23N (mg/L) | NO23N (lb/day) | NO23N (lb/yr) | TN (mg/L***) | TN (lb/day) | TN (lb/yr) | TP (mg/L) | TP (lb/day) | TP (lb/yr) |
|---|---|---|---|---|---|---|---|---|---|---|
| 1/1/1992 | 1992 | 1.0000E+00 | 8.3090E+00 | 3.0328E+03 | 5.0500E+01 | 4.1960E+02 | 1.5316E+05 | 9.0000E+00 | 7.4781E+01 | 2.7295E+04 |
| 1/1/1993 | 1993 | 1.0000E+00 | 8.5178E+00 | 3.1090E+03 | 5.0500E+01 | 4.3015E+02 | 1.5700E+05 | 9.0000E+00 | 7.6660E+01 | 2.7981E+04 |
| 1/1/1994 | 1994 | 1.0000E+00 | 8.7117E+00 | 3.1798E+03 | 5.0500E+01 | 4.3994E+02 | 1.6058E+05 | 9.0000E+00 | 7.8405E+01 | 2.8618E+04 |
| 1/1/1995 | 1995 | 1.0000E+00 | 8.9728E+00 | 3.2751E+03 | 5.0500E+01 | 4.5312E+02 | 1.6539E+05 | 9.0000E+00 | 8.0755E+01 | 2.9476E+04 |
| 1/1/1996 | 1996 | 1.0000E+00 | 9.2352E+00 | 3.3708E+03 | 5.0500E+01 | 4.6638E+02 | 1.7023E+05 | 9.0000E+00 | 8.3117E+01 | 3.0338E+04 |
| 1/1/1997 | 1997 | 1.0000E+00 | 9.4483E+00 | 3.4486E+03 | 5.0500E+01 | 4.7714E+02 | 1.7416E+05 | 9.0000E+00 | 8.5034E+01 | 3.1038E+04 |
| 1/1/1998 | 1998 | 1.0000E+00 | 9.6019E+00 | 3.5047E+03 | 5.0500E+01 | 4.8489E+02 | 1.7699E+05 | 9.0000E+00 | 8.6417E+01 | 3.1542E+04 |
| 1/1/1999 | 1999 | 1.0000E+00 | 9.6728E+00 | 3.5306E+03 | 5.0500E+01 | 4.8848E+02 | 1.7829E+05 | 9.0000E+00 | 8.7055E+01 | 3.1775E+04 |
| 1/1/2000 | 2000 | 1.0000E+00 | 9.7576E+00 | 3.5615E+03 | 5.0500E+01 | 4.9276E+02 | 1.7986E+05 | 9.0000E+00 | 8.7819E+01 | 3.2054E+04 |
| 1/1/2001 | 2001 | 1.0000E+00 | 9.8488E+00 | 3.5948E+03 | 5.0500E+01 | 4.9737E+02 | 1.8154E+05 | 9.0000E+00 | 8.8639E+01 | 3.2353E+04 |
| 1/1/2002 | 2002 | 1.0000E+00 | 9.9280E+00 | 3.6237E+03 | 5.0500E+01 | 5.0137E+02 | 1.8300E+05 | 9.0000E+00 | 8.9352E+01 | 3.2614E+04 |
| 1/1/2003 | 2003 | 1.0000E+00 | 1.0020E+01 | 3.6572E+03 | 5.0500E+01 | 5.0600E+02 | 1.8469E+05 | 9.0000E+00 | 9.0178E+01 | 3.2915E+04 |
| 1/1/2004 | 2004 | 1.0000E+00 | 1.0099E+01 | 3.6860E+03 | 5.0500E+01 | 5.0999E+02 | 1.8614E+05 | 9.0000E+00 | 9.0888E+01 | 3.3174E+04 |
| 1/1/2005 | 2005 | 1.0000E+00 | 1.0176E+01 | 3.7144E+03 | 5.0500E+01 | 5.1390E+02 | 1.8758E+05 | 9.0000E+00 | 9.1587E+01 | 3.3429E+04 |
| 1/1/2006 | 2006 | 1.0000E+00 | 1.0276E+01 | 3.7506E+03 | 5.0500E+01 | 5.1891E+02 | 1.8940E+05 | 9.0000E+00 | 9.2480E+01 | 3.3755E+04 |

## Table B.8 Leon County Atmospheric Deposition

- = Empty cell/no data

| Date | Year | NADP14 Quincy (annual rain cm) | NADP14 Quincy (annual rain in) | NWS Tallahassee (annual rain in) | NADP14 Precip Wt Conc (NH4 mg/L) | NO3 (mg/L) | TN (mg/L) | NADP14 Wet Deposition Rate (NH4 kg/ha/yr) | NO3 (kg/ha/yr) | TN (kg/ha/yr) | NADP14 Wet Deposition (area sq mi) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1/1/1983 | 1983 | - | - | - | - | - | - | - | - | - | - |
| 1/1/1984 | 1984 | 111.7500 | 43.9961 | 56.2000 | 0.1200 | 0.6220 | 0.2338 | 1.3400 | 6.9500 | 2.6116 | 701.7800 |
| 1/1/1985 | 1985 | 135.7200 | 53.4331 | 62.9300 | 0.0730 | 0.4100 | 0.1494 | 0.9900 | 5.5600 | 2.0255 | 701.7800 |
| 1/1/1986 | 1986 | 147.7800 | 58.1811 | 71.7800 | 0.0440 | 0.5150 | 0.1505 | 0.6500 | 7.6100 | 2.2239 | 701.7800 |
| 1/1/1987 | 1987 | 113.6000 | 44.7244 | 67.8200 | 0.0770 | 0.5490 | 0.1839 | 0.8700 | 6.2400 | 2.0857 | 701.7800 |
| 1/1/1988 | 1988 | 118.6900 | 46.7283 | 48.4600 | 0.0640 | 0.7470 | 0.2185 | 0.7600 | 8.8700 | 2.5940 | 701.7800 |
| 1/1/1989 | 1989 | 153.3000 | 60.3543 | 63.5900 | 0.1440 | 0.6360 | 0.2556 | 2.2100 | 9.7500 | 3.9205 | 701.7800 |
| 1/1/1990 | 1990 | 93.1900 | 36.6890 | 45.7300 | 0.1530 | 0.7300 | 0.2838 | 1.4300 | 6.8000 | 2.6477 | 701.7800 |
| 1/1/1991 | 1991 | 202.1500 | 79.5866 | 72.2500 | 0.0680 | 0.5380 | 0.1744 | 1.3700 | 10.8800 | 3.5223 | 701.7800 |
| 1/1/1992 | 1992 | 147.6300 | 58.1220 | 62.7800 | 0.0740 | 0.5440 | 0.1804 | 1.0900 | 8.0300 | 2.6610 | 701.7800 |
| 1/1/1993 | 1993 | 142.0500 | 55.9252 | 51.9300 | 0.1140 | 0.7110 | 0.2492 | 1.6200 | 10.1000 | 3.5406 | 701.7800 |
| 1/1/1994 | 1994 | 210.4900 | 82.8701 | 89.8900 | 0.0620 | 0.4570 | 0.1514 | 1.3100 | 9.6200 | 3.1911 | 701.7800 |
| 1/1/1995 | 1995 | 141.3500 | 55.6496 | 52.4000 | 0.1660 | 0.6140 | 0.2678 | 2.3500 | 8.6800 | 3.7878 | 701.7800 |
| 1/1/1996 | 1996 | 125.3200 | 49.3386 | 56.7200 | 0.1090 | 0.5650 | 0.2124 | 1.3700 | 7.0800 | 2.6643 | 701.7800 |
| 1/1/1997 | 1997 | 156.3600 | 61.5591 | 64.2500 | 0.0910 | 0.6300 | 0.2130 | 1.4200 | 9.8500 | 3.3286 | 701.7800 |
| 1/1/1998 | 1998 | 134.3100 | 52.8780 | 58.8300 | 0.0960 | 0.5990 | 0.2099 | 1.2900 | 8.0500 | 2.8211 | 701.7800 |
| 1/1/1999 | 1999 | 102.8500 | 40.4921 | 50.0700 | 0.0950 | 0.6900 | 0.2297 | 0.9800 | 7.1000 | 2.3654 | 701.7800 |
| 1/1/2000 | 2000 | 101.6300 | 40.0118 | 44.5100 | 0.1230 | 0.7680 | 0.2691 | 1.2500 | 7.8000 | 2.7335 | 701.7800 |
| 1/1/2001 | 2001 | 132.2100 | 52.0512 | 63.4500 | 0.1010 | 0.6110 | 0.2165 | 1.3400 | 8.0800 | 2.8667 | 701.7800 |
| 1/1/2002 | 2002 | 136.6700 | 53.8071 | 56.4000 | 0.0850 | 0.5390 | 0.1878 | 1.1600 | 7.3700 | 2.5664 | 701.7800 |
| 1/1/2003 | 2003 | 136.8100 | 53.8622 | 65.3000 | 0.1130 | 0.6280 | 0.2297 | 1.5500 | 8.5900 | 3.1452 | 701.7800 |
| 1/1/2004 | 2004 | 149.1400 | 58.7165 | 56.8300 | 0.0820 | 0.5640 | 0.1911 | 1.2200 | 8.4100 | 2.8479 | 701.7800 |
| 1/1/2005 | 2005 | 152.0700 | 59.8701 | 68.2800 | 0.1100 | 0.5510 | 0.2100 | 1.6700 | 8.3800 | 3.1911 | 701.7800 |
| 1/1/2006 | 2006 | 111.4400 | 43.8740 | 49.3400 | 0.1510 | 0.6810 | 0.2712 | 1.6800 | 7.5900 | 3.0205 | 701.7800 |

## Table B.9 Leon County Atmospheric Deposition

**Notes:** NH3N = (14/18)*NH4 = (14/18)*0.12 = 0.0933
NO3N = (14/62)*NO3 = (14/62)*0.62201.67 = 0.1405
INORGN = NH3N+NO3N = 0.2338
ASSUME TN = INORGN = 0.2338
LEON CO WATERSHED SQMI = 701.7800
AREA (HA) = (259.01 HA/SQMI)* AREA (SQMI)
* ASSUME DRY PRECIPITATION = WET PRECIP
TOTAL PRECIP = WET + DRY = 2.0*WET
JANICKI, 2003. USED SAME FORMULA FOR TN AND TP
DRY PRECIP = 1.20*WET (NOVEMBER TO JUNE)
DRY PRECIP = 0.55*WET (JULY TO OCTOBER)
TP = WET PRECIP JAX AIRPORT

| Date | Year | TN (kg/yr) | TN (lb/yr) | NADP14 Total Deposition (TN lb/yr*) | Jax Airport Wet Deposition (TP kg/sqkm/yr) | TP (kg/ha/yr) | TP (kg/yr) | TP (lb/yr) |
|---|---|---|---|---|---|---|---|---|
| 1/1/1983 | 1983 | - | - | - | - | - | - | - |
| 1/1/1984 | 1984 | 4.7468E+05 | 1.0465E+06 | 2.0930E+06 | - | - | - | - |
| 1/1/1985 | 1985 | 3.6815E+05 | 8.1163E+05 | 1.6233E+06 | - | - | - | - |
| 1/1/1986 | 1986 | 4.0423E+05 | 8.9116E+05 | 1.7823E+06 | - | - | - | - |
| 1/1/1987 | 1987 | 3.7910E+05 | 8.3576E+05 | 1.6715E+06 | - | - | - | - |
| 1/1/1988 | 1988 | 4.7149E+05 | 1.0394E+06 | 2.0789E+06 | - | - | - | - |
| 1/1/1989 | 1989 | 7.1259E+05 | 1.5710E+06 | 3.1420E+06 | - | - | - | - |
| 1/1/1990 | 1990 | 4.8125E+05 | 1.0610E+06 | 2.1219E+06 | - | - | - | - |
| 1/1/1991 | 1991 | 6.4022E+05 | 1.4114E+06 | 2.8229E+06 | - | - | - | - |
| 1/1/1992 | 1992 | 4.8367E+05 | 1.0663E+06 | 2.1326E+06 | - | - | - | - |
| 1/1/1993 | 1993 | 6.4355E+05 | 1.4188E+06 | 2.8375E+06 | - | - | - | - |
| 1/1/1994 | 1994 | 5.8003E+05 | 1.2787E+06 | 2.5575E+06 | 8.7000E+00 | 8.7000E-02 | 1.5813E+04 | 3.4862E+04 |
| 1/1/1995 | 1995 | 6.8847E+05 | 1.5178E+06 | 3.0356E+06 | 7.4000E+00 | 7.4000E-02 | 1.3450E+04 | 2.9653E+04 |
| 1/1/1996 | 1996 | 4.8426E+05 | 1.0676E+06 | 2.1352E+06 | 8.5000E+00 | 8.5000E-02 | 1.5450E+04 | 3.4060E+04 |
| 1/1/1997 | 1997 | 6.0502E+05 | 1.3338E+06 | 2.6676E+06 | 7.1000E+00 | 7.1000E-02 | 1.2905E+04 | 2.8450E+04 |
| 1/1/1998 | 1998 | 5.1276E+05 | 1.1304E+06 | 2.2609E+06 | 1.0900E+01 | 1.0900E-01 | 1.9812E+04 | 4.3677E+04 |
| 1/1/1999 | 1999 | 4.2995E+05 | 9.4786E+05 | 1.8957E+06 | 5.3000E+00 | 5.3000E-02 | 9.6333E+03 | 2.1238E+04 |
| 1/1/2000 | 2000 | 4.9685E+05 | 1.0953E+06 | 2.1907E+06 | - | - | - | - |
| 1/1/2001 | 2001 | 5.2106E+05 | 1.1487E+06 | 2.2975E+06 | - | - | - | - |
| 1/1/2002 | 2002 | 4.6647E+05 | 1.0284E+06 | 2.0568E+06 | - | - | - | - |
| 1/1/2003 | 2003 | 5.7168E+05 | 1.2603E+06 | 2.5207E+06 | - | - | - | - |
| 1/1/2004 | 2004 | 5.1764E+05 | 1.1412E+06 | 2.2824E+06 | - | - | - | - |
| 1/1/2005 | 2005 | 5.8003E+05 | 1.2787E+06 | 2.5575E+06 | - | - | - | - |
| 1/1/2006 | 2006 | 5.4902E+05 | 1.2104E+06 | 2.4207E+06 | - | - | - | - |
| - | - | - | - | - | - | AVE | - | AVE |
| - | - | - | - | - | - | 7.9833E-02 | - | 3.1990E+04 |

## Table B.10 Munson Slough Watershed Atmospheric Deposition

- = Empty cell/no data

| Date | Year | NADP14 Quincy (annual rain cm) | NADP14 Quincy (annual rain in) | NWS Tallahassee (annual rain in) | NADP14 Precip-Wt Conc (NH4 mg/L) | NO3 (mg/L) | TN (mg/L) | NADP14 Wet Deposition Rate (NH4 kg/ha/yr) | NO3 (kg/ha/yr) | TN (kg/ha/yr) | NADP14 Wet Deposition (area sqmi) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1/1/1983 | 1983 | - | - | - | - | - | - | - | - | - | - |
| 1/1/1984 | 1984 | 111.7500 | 43.9961 | 56.2000 | 0.1200 | 0.6220 | 0.2338 | 1.3400 | 6.9500 | 2.6116 | 51.1100 |
| 1/1/1985 | 1985 | 135.7200 | 53.4331 | 62.9300 | 0.0730 | 0.4100 | 0.1494 | 0.9900 | 5.5600 | 2.0255 | 51.1100 |
| 1/1/1986 | 1986 | 147.7800 | 58.1811 | 71.7800 | 0.0440 | 0.5150 | 0.1505 | 0.6500 | 7.6100 | 2.2239 | 51.1100 |
| 1/1/1987 | 1987 | 113.6000 | 44.7244 | 67.8200 | 0.0770 | 0.5490 | 0.1839 | 0.8700 | 6.2400 | 2.0857 | 51.1100 |
| 1/1/1988 | 1988 | 118.6900 | 46.7283 | 48.4600 | 0.0640 | 0.7470 | 0.2185 | 0.7600 | 8.8700 | 2.5940 | 51.1100 |
| 1/1/1989 | 1989 | 153.3000 | 60.3543 | 63.5900 | 0.1440 | 0.6360 | 0.2556 | 2.2100 | 9.7500 | 3.9205 | 51.1100 |
| 1/1/1990 | 1990 | 93.1900 | 36.6890 | 45.7300 | 0.1530 | 0.7300 | 0.2838 | 1.4300 | 6.8000 | 2.6477 | 51.1100 |
| 1/1/1991 | 1991 | 202.1500 | 79.5866 | 72.2500 | 0.0680 | 0.5380 | 0.1744 | 1.3700 | 10.8800 | 3.5223 | 51.1100 |
| 1/1/1992 | 1992 | 147.6300 | 58.1220 | 62.7800 | 0.0740 | 0.5440 | 0.1804 | 1.0900 | 8.0300 | 2.6610 | 51.1100 |
| 1/1/1993 | 1993 | 142.0500 | 55.9252 | 51.9300 | 0.1140 | 0.7110 | 0.2492 | 1.6200 | 10.1000 | 3.5406 | 51.1100 |
| 1/1/1994 | 1994 | 210.4900 | 82.8701 | 89.8900 | 0.0620 | 0.4570 | 0.1514 | 1.3100 | 9.6200 | 3.1911 | 51.1100 |
| 1/1/1995 | 1995 | 141.3500 | 55.6496 | 52.4000 | 0.1660 | 0.6140 | 0.2678 | 2.3500 | 8.6800 | 3.7878 | 51.1100 |
| 1/1/1996 | 1996 | 125.3200 | 49.3386 | 56.7200 | 0.1090 | 0.5650 | 0.2124 | 1.3700 | 7.0800 | 2.6643 | 51.1100 |
| 1/1/1997 | 1997 | 156.3600 | 61.5591 | 64.2500 | 0.0910 | 0.6300 | 0.2130 | 1.4200 | 9.8500 | 3.3286 | 51.1100 |
| 1/1/1998 | 1998 | 134.3100 | 52.8780 | 58.8300 | 0.0960 | 0.5990 | 0.2099 | 1.2900 | 8.0500 | 2.8211 | 51.1100 |
| 1/1/1999 | 1999 | 102.8500 | 40.4921 | 50.0700 | 0.0950 | 0.6900 | 0.2297 | 0.9800 | 7.1000 | 2.3654 | 51.1100 |
| 1/1/2000 | 2000 | 101.6300 | 40.0118 | 44.5100 | 0.1230 | 0.7680 | 0.2691 | 1.2500 | 7.8000 | 2.7335 | 51.1100 |
| 1/1/2001 | 2001 | 132.2100 | 52.0512 | 63.4500 | 0.1010 | 0.6110 | 0.2165 | 1.3400 | 8.0800 | 2.8667 | 51.1100 |
| 1/1/2002 | 2002 | 136.6700 | 53.8071 | 56.4000 | 0.0850 | 0.5390 | 0.1878 | 1.1600 | 7.3700 | 2.5664 | 51.1100 |
| 1/1/2003 | 2003 | 136.8100 | 53.8622 | 65.3000 | 0.1130 | 0.6280 | 0.2297 | 1.5500 | 8.5900 | 3.1452 | 51.1100 |
| 1/1/2004 | 2004 | 149.1400 | 58.7165 | 56.8300 | 0.0820 | 0.5640 | 0.1911 | 1.2200 | 8.4100 | 2.8479 | 51.1100 |
| 1/1/2005 | 2005 | 152.0700 | 59.8701 | 68.2800 | 0.1100 | 0.5510 | 0.2100 | 1.6700 | 8.3800 | 3.1911 | 51.1100 |
| 1/1/2006 | 2006 | 111.4400 | 43.8740 | 49.3400 | 0.1510 | 0.6810 | 0.2712 | 1.6800 | 7.5900 | 3.0205 | 51.1100 |

## Table B.11 Munson Slough Watershed Atmospheric Deposition

- = Empty cell/no data

**NOTES:**

NH3N = (14/18)*NH4 = (14/18)*0.12 = 0.0933
NO3N = (14/62)*NO3 = (14/62)*0.62201.67= 0.1405
INORGN= NH3N+NO3N= 0.2338
ASSUME TN = INORGN = 0.2338
LAKE MUNSON WATERSHED SQMI 51.1100
AREA (HA) = (259.01 HA/SQMI)* AREA (SQMI)
* ASSUME DRY PRECIPITATION=WET PRECIP
TOTAL PRECIP = WET+DRY = 2.0*WET
JANICKI, 2003. USED SAME FORMULA FOR TN AND TP
DRY PRECIP = 1.20*WET (NOVEMBER TO JUNE)
DRY PRECIP = 0.55*WET (JULY TO OCTOBER)
TP = WET PRECIP JAX AIRPORT

| Date | Year | TN (kg/yr) | TN (lb/yr) | NADP14 Total Deposition (TN lb/yr)* | JAX Airport Wet Deposition (TP kg/sqkm/yr) | TP (kg/ha/yr) | TP (kg/yr) | TP (lb/yr) |
|---|---|---|---|---|---|---|---|---|
| 1/1/1983 | 1983 | - | - | - | - | - | - | - |
| 1/1/1984 | 1984 | 3.4571E+04 | 7.6215E+04 | 1.5243E+05 | - | - | - | - |
| 1/1/1985 | 1985 | 2.6812E+04 | 5.9110E+04 | 1.1822E+05 | - | - | - | - |
| 1/1/1986 | 1986 | 2.9439E+04 | 6.4902E+04 | 1.2980E+05 | - | - | - | - |
| 1/1/1987 | 1987 | 2.7609E+04 | 6.0868E+04 | 1.2174E+05 | - | - | - | - |
| 1/1/1988 | 1988 | 3.4338E+04 | 7.5702E+04 | 1.5140E+05 | - | - | - | - |
| 1/1/1989 | 1989 | 5.1898E+04 | 1.1441E+05 | 2.2883E+05 | - | - | - | - |
| 1/1/1990 | 1990 | 3.5049E+04 | 7.7269E+04 | 1.5454E+05 | - | - | - | - |
| 1/1/1991 | 1991 | 4.6627E+04 | 1.0279E+05 | 2.0559E+05 | - | - | - | - |
| 1/1/1992 | 1992 | 3.5225E+04 | 7.7657E+04 | 1.5531E+05 | - | - | - | - |
| 1/1/1993 | 1993 | 4.6869E+04 | 1.0333E+05 | 2.0666E+05 | - | - | - | - |
| 1/1/1994 | 1994 | 4.2243E+04 | 9.3128E+04 | 1.8626E+05 | 8.7000E+00 | 8.7000E-02 | 1.1517E+03 | 2.5390E+03 |
| 1/1/1995 | 1995 | 5.0141E+04 | 1.1054E+05 | 2.2108E+05 | 7.4000E+00 | 7.4000E-02 | 9.7957E+02 | 2.1596E+03 |
| 1/1/1996 | 1996 | 3.5268E+04 | 7.7752E+04 | 1.5550E+05 | 8.5000E+00 | 8.5000E-02 | 1.1252E+03 | 2.4806E+03 |
| 1/1/1997 | 1997 | 4.4063E+04 | 9.7141E+04 | 1.9428E+05 | 7.1000E+00 | 7.1000E-02 | 9.3986E+02 | 2.0720E+03 |
| 1/1/1998 | 1998 | 3.7344E+04 | 8.2328E+04 | 1.6466E+05 | 1.0900E+01 | 1.0900E-01 | 1.4429E+03 | 3.1810E+03 |
| 1/1/1999 | 1999 | 3.1313E+04 | 6.9032E+04 | 1.3806E+05 | 5.3000E+00 | 5.3000E-02 | 7.0159E+02 | 1.5467E+03 |
| 1/1/2000 | 2000 | 3.6185E+04 | 7.9773E+04 | 1.5955E+05 | - | - | - | - |
| 1/1/2001 | 2001 | 3.7948E+04 | 8.3661E+04 | 1.6732E+05 | - | - | - | - |
| 1/1/2002 | 2002 | 3.3973E+04 | 7.4897E+04 | 1.4979E+05 | - | - | - | - |
| 1/1/2003 | 2003 | 4.1635E+04 | 9.1788E+04 | 1.8358E+05 | - | - | - | - |
| 1/1/2004 | 2004 | 3.7699E+04 | 8.3112E+04 | 1.6622E+05 | - | - | - | - |
| 1/1/2005 | 2005 | 4.2243E+04 | 9.3128E+04 | 1.8626E+05 | - | - | - | - |
| 1/1/2006 | 2006 | 3.9984E+04 | 8.8149E+04 | 1.7630E+05 | - | - | - | - |

| Date | Year | TN (kg/yr) | TN (lb/yr) | NADP14 Total Deposition (TN lb/yr)* | JAX Airport Wet Deposition (TP kg/sqkm/yr) | TP (kg/ha/yr) | TP (kg/yr) | TP (lb/yr) |
|---|---|---|---|---|---|---|---|---|
| - | - | - | - | | - | AVE | - | AVE |
| - | - | - | - | 1.6841E+05 | - | 7.9833E-02 | - | 2.3298E+03 |

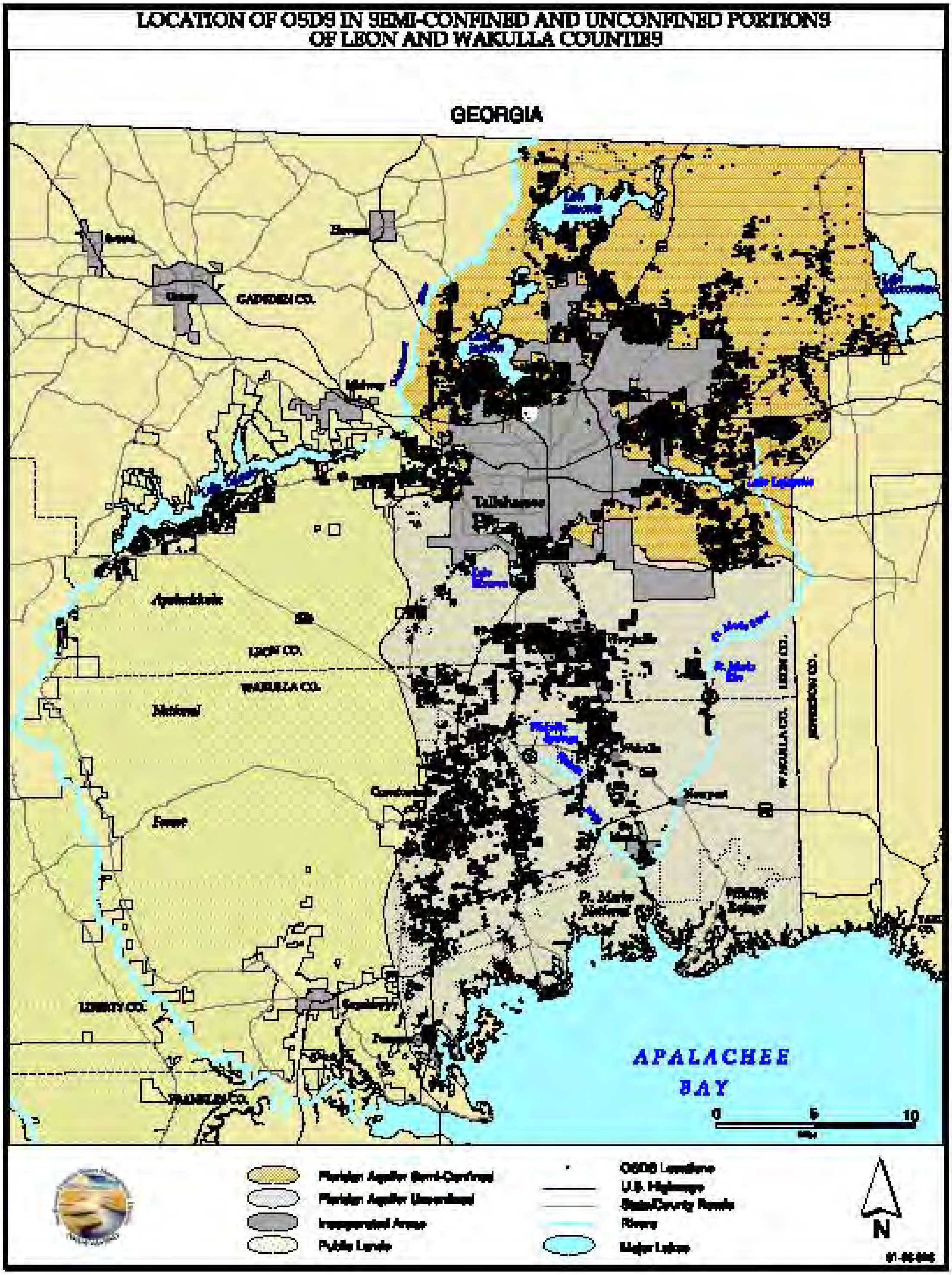



Figure B.1 Septic Tanks in Semiconfined and Unconfined Areas of Leon and Wakulla Counties

## Appendix C:  Other Lakes with Watersheds Located in the Tallahassee Redhills Physiographic Province

The lake classification system in **Table C11** was selected by COT in 2007 to assess concentrations of TN, TP, and Chla relative to trophic state.

### Table C.1 TN, TP, and Chla Concentrations and Trophic State

| Concentration | Trophic State |
|---|---|
| TP ≥ 0.1 mg/L = | hypereutrophic |
| TP ≥ 0.025 and < 0.1 mg/L= | eutrophic |
| TP ≥ 0.015 and < 0.025 mg/L= | mesotrophic |
| TP < 0.015 mg/L = | oligotrophic |
| TN ≥ 1.5 mg/L = | hypereutrophic |
| TN ≥ 0.601 mg/L and < 1.5 mg/L = | eutrophic |
| TN ≥ 0.4 mg/L and < 0.6 mg/L = | mesotrophic |
| TN < 0.4 mg/L = | oligotrophic |
| Chla ≥ 40 µg/L = | hypereutrophic |
| Chla ≥ 7.0 µg/L and < 40 µg/L= | eutrophic |
| Chla ≥ 4.0 µg/L and < 7.0 µg/L= | mesotrophic |
| Chla < 4.0 µg/L = | oligotrophic |

Given the data for the lakes located within the TRPP, the 75$^{th}$ percentile of BCL, data for Lake Munson, and the thresholds selected by COT for lakes, it appears reasonable to incorporate these thresholds developed by COT into the information used to establish the TMDL targets. Taken together with the median TSI (49.2), TN (0.68 mg/L), TP (0.033 mg/L), CChla (11.8 µg/L), and TN:TP ratio (23.5) for the moderately impacted (not pristine or in a natural condition) COT lakes most like Lake Munson (Tom Brown Park Lake, A.J. Henry Park Lake, Lake Killarney, Lake Kanturk, and Goose Pond) suggests that the targets for Lake Munson of TSI (56), in-lake concentrations for TN (0.765 mg/L), TP (0.044 mg/L), CChla (21.7 µg/L), and TN:TP ratio of 17 are reasonable and achievable values and not reflective of natural pristine conditions.

**Lakes in the Lake Munson Watershed**

***Bradford Chain of Lakes (BCL)***

This is a 519.6-acre lake system with a 12,500-acre drainage basin (GIS coverage 1997) located within the TRPP.  The drainage-area-to-lake-area ratio is 24:1.  BCL receives drainage from the national forest.  The main source is Bradford Brook.  BCL discharges ultimately to Munson Slough.  It has a maximum depth of 2.80 feet, with an average depth of 1.33 feet.  The physical, chemical, and trophic state of this lake system compared with that of Lake Munson is contained in the tables below.

**Lakes of the Tallahassee Redhills Physiographic Province (TRPP)**

The descriptions and information for all lakes marked with * were taken from COT (2007).

***Tom Brown Park Lake**

This park contains a 6-acre lake with a 180-acre drainage basin, and is located within the TRPP. The drainage-area-to-lake-area ratio is 30:1. The lake drains some undeveloped park lands, a mixture of ball parks, recreational areas, a museum, and the Federal Correctional Facility. COT (2007) notes that stormwater is directly routed into the lake and that algal blooms are frequent, and characterizes the trophic state as "expectedly eutrophic." The lake has a maximum depth of 11 feet, with an average depth of 6 feet. The physical, chemical, and trophic state of the lake is compared with that of Lake Munson and BCL in the tables below.

***A.J. Henry Park Lake**

This is a 14.3-acre lake with a 275-acre drainage basin, located within the TRPP. The drainage-area-to-lake-area ratio is 20:1. The lake drains heavily urbanized areas. It is a flow-through lake, ultimately draining to Alfred Arm. COT (2007) suggests that the lake is hypereutrophic, "a condition resulting from stormwater inflows with excessive concentrations of nutrients." It has a maximum depth of 10 feet, with an average depth of 5 feet. The physical, chemical, and trophic state of the lake is compared with that of Lake Munson and BCL in the tables below.

***Lake Hall**

This is a 160-acre lake with a 1,000-acre drainage basin, located within the TRPP. The drainage-area-to-lake-area ratio is 6.2:1. The lake is located north of Interstate 10, with a portion of the lake within Maclay Gardens State Park. The lake is heavily used for recreation, and the watershed is moderately developed. The lake is a flow-through lake, ultimately draining into Lake Overstreet. COT (2007) suggests that the lake TSI is declining over time, following declines in nitrogen. The data suggest that the lake is in excellent condition. It has a maximum depth of 30 feet, with an average depth of 14 feet. The physical, chemical, and trophic state of the lake is compared with that of Lake Munson and BCL in the tables below.

***Lake Overstreet**

This is a 140-acre lake with a 640-acre drainage basin, located within the TRPP. The drainage-area-to-lake-area ratio is 4.6:1. The lake, located north of Interstate 10, is within Maclay Gardens State Park. It is used for recreation, and the watershed is mostly undeveloped. The lake receives water from Lake Hall. COT (2007) suggests that the lake trophic state as measured by Chla would be considered oligotrophic. However, if production is measured by the biomass of macrophytes, the lake could be considered to be between eutrophic and hypereutrophic. The overall data suggest that the lake is in good condition. It has a maximum depth of 26 feet, with an average depth of 20 feet. The physical, chemical, and trophic state of the lake is compared with that of Lake Munson and BCL in the tables below.

***Lake Killarney**

This is an 80-acre lake with a 1,100-acre drainage basin, located within the TRPP. The drainage-area-to-lake-area ratio is 13.7:1. The lake is located in northeastern Tallahassee. Its shoreline is developed and the watershed contains residential subdivisions. The lake is a shallow flow-through reservoir that drains to Lake Kanturk. COT (2007) suggests that the lake is eutrophic. The overall data suggest that this lake is not in good condition. It has a maximum depth of 8 feet, with an average depth of 4 feet. The physical, chemical, and trophic state of the lake is compared with that of Lake Munson and BCL in the tables below.

### **Lake Kanturk*

This is a 70-acre lake with an 8,200-acre drainage basin, located within the TRPP. The drainage-area-to-lake-area ratio is 110:1. The lake is located in northeastern Tallahassee downstream from Lake Killarney and drains ultimately to the St. Marks River through Alford Arm. It is surrounded by residential subdivisions, with about 90% of the shoreline developed. It is a shallow flow-through reservoir. COT (2007) suggests that the lake is eutrophic and notes that the presence of macrophytes and filamentous algae may result in lowered Chla concentrations and an underestimation of the actual trophic state. This condition is also present in Lake Munson. The lake has a maximum depth of 7 feet, with an average depth of 4 feet. The physical, chemical, and trophic state of the lake is compared with that of Lake Munson and BCL in the tables below.

### **Goose Pond*

This is a 34-acre shallow, elongated, flow-through lake with a 2,545-acre drainage basin, located just north of Centerville Road within the TRPP. The drainage-area-to-lake-area ratio is 75:1. The lake receives drainage from a large urbanized area. There are four sources: NDD, Wednesday Street Pond, Woodgate Subdivision, and Goose Pond Tributary. The lake discharges ultimately to Upper Lake Lafayette. It has been accumulating sediment due to turbid inflows and decaying vegetation in the lake. COT (2007) suggests that the lake is a "degraded eutrophic system" and states in part that the lake is "a neglected reservoir/wetland that exhibits some of the poorest water quality found in any lake system in this area." It has a maximum depth of 5 feet, with an average depth of 3 feet. The physical, chemical, and trophic state of the lake is compared with that of Lake Munson and BCL in the tables below.

### *Alford Arm (WBID 647)*

Due to the configuration of Alford Arm, calculating a surface area is problematic. It has a 23,240.24-acre drainage basin (GIS coverage 1997) and is located within the TRPP. The drainage-area-to-lake-area ratio is currently not available. The lake receives drainage from a large urbanized area. The main sources are lakes located in Killearn Lake Estates (Lake Kinsale, Lake Killarney, and Lake Kanturk). Alford Arm discharges ultimately to Lake Lafayette. It has a maximum depth of 3.54 feet, with an average depth of 1.56 feet. The physical, chemical, and trophic state of the lake is compared with that of Lake Munson and BCL in the tables below.

## Table C.2 Chla Comparison of Lakes and Munson Slough for Data after 1986

N/A = Not applicable

| Waterbody | Parameter | Units | N | Minimum | Maximum | Mean | Median | 75% |
|---|---|---|---|---|---|---|---|---|
| Munson Slough above Lake Munson | Chla | µg/L | 156 | 1.00 | 190.0 | 10.37 | 3.27 | 10.55 |
| Munson Slough below Lake Munson | Chla | µg/L | 35 | 1.00 | 85.00 | 35.00 | 2.30 | 5.85 |
| Lake Munson | Chla | µg/L | 160 | 0.04 | 331.1 | 39.45 | 11.29 | 32.04 |
| BCL | Chla | µg/L | 446 | 1.00 | 148.4 | 5.84 | 4.45 | 6.90 |
| *Lake Bradford | Chla | µg/L | N/A | N/A | N/A | N/A | 5.8 | N/A |
| *Tom Brown Park Lake | Chla | µg/L | N/A | 1.20 | 114.00 | N/A | 14.00 | N/A |
| *A.J. Henry Park Lake | Chla | µg/L | N/A | N/A | N/A | N/A | 48.30 | N/A |
| *Lake Hall | Chla | µg/L | 220 | 0.00 | 24.10 | N/A | 2.80 | N/A |
| *Lake Overstreet | Chla | µg/L | N/A | N/A | N/A | N/A | 3.00 | N/A |
| *Lake Killarney | Chla | µg/L | N/A | N/A | 127.60 | N/A | 11.80 | N/A |
| *Lake Kanturk | Chla | µg/L | N/A | N/A | 150.00 | N/A | 9.90 | N/A |
| *Goose Pond | Chla | µg/L | N/A | N/A | N/A | N/A | 10.10 | N/A |
| Alford Arm | Chla | µg/L | 149 | 1.00 | 227.00 | 17.50 | 8.30 | 15.00 |

## Table C.3 TN Comparison of Lakes and Munson Slough for Data after 1986

~ Data inferred from graphs in COT 2007

| Waterbody | Parameter | Units | N | Minimum | Maximum | Mean | Median | 75% |
|---|---|---|---|---|---|---|---|---|
| Munson Slough above Lake Munson | TN | mg/L | 279 | 0.152 | 12.18 | 1.015 | 0.763 | 1.13 |
| Munson Slough below Lake Munson | TN | mg/L | 85 | 0.207 | 5.37 | 1.34 | 0.90 | 1.69 |
| Lake Munson | TN | mg/L | 539 | 0.079 | 6.90 | 0.981 | 0.73 | 1.10 |
| BCL | TN | mg/L | 1,480 | 0.015 | 2.56 | 0.55 | 0.54 | 0.65 |
| *Lake Bradford | TN | mg/L | N/A | ~0.39 | ~0.68 | N/A | 0.53 | N/A |
| *Tom Brown Park Lake | TN | mg/L | N/A | ~0.39 | ~0.83 | N/A | 0.54 | N/A |
| *A.J. Henry Park Lake | TN | mg/L | N/A | N/A | N/A | N/A | 1.54 | N/A |
| *Lake Hall | TN | mg/L | N/A | ~0.24 | ~0.39 | N/A | 0.31 | N/A |
| *Lake Overstreet | TN | mg/L | N/A | ~.21 | ~.33 | N/A | 0.29 | N/A |
| *Lake Killarney | TN | mg/L | N/A | ~0.47 | ~0.98 | N/A | 0.73 | N/A |
| *Lake Kanturk | TN | mg/L | N/A | ~0.47 | ~1.5 | N/A | 0.68 | N/A |
| *Goose Pond | TN | mg/L | N/A | ~0.47 | ~1.1 | N/A | 0.57 | N/A |
| Alford Arm | TN | mg/L | 235 | 0.03 | 4.50 | 0.74 | 0.60 | 0.85 |

## Table C.4 TP Comparison of Lakes and Munson Slough for Data after 1986

~ Data inferred from graphs in COT 2007

| Waterbody | Parameter | Units | N | Minimum | Maximum | Mean | Median | 75% |
|---|---|---|---|---|---|---|---|---|
| Munson Slough above Lake Munson | TP | mg/L | 219 | 0.003 | 2.37 | 0.291 | 0.160 | 0.335 |
| Munson Slough below Lake Munson | TP | mg/L | 76 | 0.01 | 1.097 | 0.242 | 0.22 | 0.300 |
| Lake Munson | TP | mg/L | 551 | 0.001 | 7.300 | 0.207 | 0.170 | 0.260 |
| BCL | TP | mg/L | 1106 | 0.002 | 0.340 | 0.012 | 0.016 | 0.021 |
| *Lake Bradford | TP | mg/L | N/A | ~0.006 | ~0.027 | N/A | 0.016 | N/A |
| *Tom Brown Park Lake | TP | mg/L | N/A | <0.01 | 0.043 | N/A | 0.023 | N/A |
| *A.J. Henry Park Lake | TP | mg/L | N/A | N/A | N/A | N/A | 0.059 | N/A |
| *Lake Hall | TP | mg/L | N/A | <.01 | ~0.016 | N/A | 0.012 | N/A |
| *Lake Overstreet | TP | mg/L | N/A | ~.012 | ~0.016 | N/A | 0.013 | N/A |
| *Lake Killarney | TP | mg/L | N/A | ~0.019 | ~0.042 | N/A | 0.033 | N/A |
| * Lake Kanturk | TP | mg/L | N/A | ~0.02 | ~0.85 | N/A | 0.037 | N/A |
| *Goose Pond | TP | mg/L | N/A | ~0.033 | ~0.1 | N/A | 0.062 | N/A |
| Alford Arm | TP | mg/L | 178 | 0.003 | 0.640 | 0.780 | 0.044 | 0.096 |

## Table C.5 TN:TP Ratio Comparison of Lakes and Munson Slough for Data after 1986

| Waterbody | Parameter | Units | N | Minimum | Maximum | Mean | Median | 75% |
|---|---|---|---|---|---|---|---|---|
| Munson Slough above Lake Munson | TN:TP | None | Long-term average | N/A | N/A | 3.5 | 4.8 | 3.4 |
| Munson Slough below Lake Munson | TN:TP | None | Long-term average | N/A | N/A | 5.5 | 4.1 | 5.6 |
| Lake Munson | TN:TP | None | Long-term average | N/A | N/A | 4.7 | 4.3 | 4.2 |
| BCL | TN:TP | None | Long-term average | N/A | N/A | 29.7 | 33.8 | 31.0 |
| *Lake Bradford | TN:TP | None | Long-term average | N/A | N/A | N/A | 34 | N/A |
| *Tom Brown Park Lake | TN:TP | None | Long-term average | N/A | N/A | 21.8 | 23.5 | N/A |
| *A.J. Henry Park Lake | TN:TP | None | Long-term average | N/A | N/A | 17.2 | 26.1 | N/A |
| *Lake Hall | TN:TP | None | Long-term average | N/A | N/A | N/A | 25.8 | N/A |
| *Lake Overstreet | TN:TP | None | Long-term average | N/A | N/A | N/A | 21.5 | N/A |
| *Lake Killarney | TN:TP | None | Long-term average | N/A | N/A | N/A | 23.7 | N/A |
| * Lake Kanturk | TN:TP | None | Long-term average | N/A | N/A | N/A | 18.4 | N/A |
| *Goose Pond | TN:TP | None | Long-term average | N/A | N/A | N/A | 9.3 | N/A |
| Alford Arm | TN:TP | None | Long-term average | N/A | N/A | N/A | 13.6 | N/A |

## Table C.6 Conductivity Comparison of Lakes and Munson Slough for Data after 1986

| Waterbody | Parameter | Units | N | Minimum | Maximum | Mean | Median | 0.75 |
|---|---|---|---|---|---|---|---|---|
| Munson Slough above Lake Munson | COND | µs/cm | 366 | 1.1 | 479.0 | 99.3 | 78.0 | 116.0 |
| Munson Slough below Lake Munson | COND | µs/cm | 130 | 11.0 | 360.0 | 77.4 | 89.0 | 116.0 |
| Lake Munson | COND | µs/cm | 640 | 43.0 | 290.0 | 95.9 | 89.0 | 107.0 |
| BCL | COND | µs/cm | 755 | 3.0 | 670.0 | 29.5 | 26.0 | 34.0 |
| *Lake Bradford | COND | µs/cm | N/A | N/A | N/A | N/A | 24.0 | N/A |
| *Tom Brown Park Lake | COND | µs/cm | N/A | N/A | N/A | N/A | 67.0 | N/A |
| *A.J. Henry Park Lake | COND | µs/cm | N/A | 33.0 | 101.0 | N/A | 64.0 | N/A |
| *Lake Hall | COND | µs/cm | N/A | N/A | N/A | N/A | 24.0 | N/A |
| *Lake Overstreet | COND | µs/cm | N/A | N/A | N/A | N/A | 19.0 | N/A |
| *Lake Killarney | COND | µs/cm | N/A | 26.0 | 88.0 | N/A | 44.0 | N/A |
| *Lake Kanturk | COND | µs/cm | N/A | 15.0 | 84.0 | N/A | 40.0 | N/A |
| *Goose Pond | COND | µs/cm | N/A | 32.0 | 320.0 | N/A | 106.0 | N/A |
| Alford Arm | COND | µs/cm | 385 | 12.8 | 440.0 | 39.2 | 30.0 | 44.0 |

## Table C.7 Turbidity Comparison of Lakes and Munson Slough for Data after 1986

| Waterbody | Parameter | Units | N | Minimum | Maximum | Mean | Median | 75% |
|---|---|---|---|---|---|---|---|---|
| Munson Slough above Lake Munson | TURB | NTU | 276 | 0.05 | 637.0 | 31.1 | 10.0 | 29.0 |
| Munson Slough below Lake Munson | TURB | NTU | 82 | 0.92 | 110.0 | 12.72 | 5.70 | 14.6 |
| Lake Munson | TURB | NTU | 556 | 0.13 | 118.0 | 10.1 | 6.8 | 12.0 |
| BCL | TURB | NTU | 502 | 0.1 | 23.6 | 1.72 | 1.30 | 2.00 |
| *Lake Bradford | TURB | NTU | N/A | N/A | 33.9 | N/A | 1.5 | N/A |
| *Tom Brown Park Lake | TURB | NTU | N/A | 1.70 | 35.40 | N/A | 7.00 | N/A |
| *A.J. Henry Park Lake | TURB | NTU | N/A | 0.70 | 273.00 | N/A | 21.20 | N/A |
| *Lake Hall | TURB | NTU | 216 | 0.10 | 12.20 | N/A | 0.80 | N/A |
| *Lake Overstreet | TURB | NTU | N/A | 0.00 | 2.00 | N/A | 0.70 | N/A |
| *Lake Killarney | TURB | NTU | N/A | N/A | N/A | N/A | 6.50 | N/A |
| *Lake Kanturk | TURB | NTU | N/A | 0.70 | 34.20 | N/A | 5.80 | N/A |
| *Goose Pond | TURB | NTU | N/A | N/A | N/A | N/A | 7.90 | N/A |
| Alford Arm | TURB | NTU | 193 | 0.20 | 86.00 | 7.00 | 2.80 | 6.00 |

## Table C.8 Alkalinity Comparison of Lakes and Munson Slough for Data after 1986

~ Data inferred from graphs in COT 2007

| Waterbody | Parameter | Units | N | Minimum | Maximum | Mean | Median | 75% |
|---|---|---|---|---|---|---|---|---|
| Munson Slough above Lake Munson | ALK CACO3 | mg/L | 209 | 2.60 | 138.50 | 35.76 | 30.00 | 45.40 |
| Munson Slough below Lake Munson | ALK CACO3 | mg/L | 68 | 9.04 | 106.5 | 36.41 | 33.00 | 44.00 |
| Lake Munson | ALK CACO3 | mg/L | 465 | 0.08 | 100.00 | 29.06 | 27.50 | 36.00 |
| BCL | ALK CACO3 | mg/L | 301 | 0.07 | 150.00 | 2.83 | 1.50 | 4.25 |
| *Lake Bradford | ALK CACO3 | mg/L | N/A | N/A | N/A | N/A | 2.6 | N/A |
| *Tom Brown Park Lake | ALK CACO3 | mg/L | N/A | ~8 | ~73 | N/A | 24.90 | N/A |
| *A.J. Henry Park Lake | ALK CACO3 | mg/L | N/A | 14.20 | 38.60 | N/A | 24.50 | N/A |
| *Lake Hall | ALK CACO3 | mg/L | N/A | N/A | N/A | N/A | 4.80 | N/A |
| *Lake Overstreet | ALK CACO3 | mg/L | N/A | N/A | N/A | N/A | 3.70 | N/A |
| *Lake Killarney | ALK CACO3 | mg/L | N/A | 4.40 | 38.00 | N/A | 13.80 | N/A |
| *Lake Kanturk | ALK CACO3 | mg/L | N/A | 0.60 | 34.20 | N/A | 5.80 | N/A |
| *Goose Pond | ALK CACO3 | mg/L | N/A | N/A | N/A | N/A | 38.00 | N/A |
| Alford Arm | ALK CACO3 | mg/L | 174 | 1.00 | 75.00 | 9.40 | 7.85 | 12.20 |

## Table C.9 TSI Comparison of Lakes and Munson Slough for Data after 1986

- = Empty cell/no data
~ Data inferred from graphs in COT 2007

| Waterbody | Parameter | Units | N | Minimum | Maximum | Mean | Median | 75% |
|---|---|---|---|---|---|---|---|---|
| Munson Slough above Lake Munson | Not a lake | - | - | - | - | - | - | - |
| Munson Slough below Lake Munson | Not a lake | - | - | - | - | - | - | - |
| Lake Munson | TSI | - | - | 38.60 | 62.20 | 51.90 | 51.30 | 58.70 |
| BCL | TSI | - | - | 32.30 | 50.70 | 42.30 | 42.70 | 46.50 |
| *Lake Bradford | TSI | - | - | ~32 | ~47 | N/A | 38.7 | N/A |
| *Tom Brown Park Lake | TSI | - | - | ~38 | ~50.2 | ~43.5 | 43.50 | ~45.8 |
| A.J. Henry Park Lake | TSI | - | - | ~50 | ~73 | N/A | 65.70 | N/A |
| *Lake Hall | TSI | - | - | ~26 | ~38 | ~31.4 | ~30 | ~34 |
| *Lake Overstreet | TSI | - | - | ~24 | ~34 | N/A | 30.60 | N/A |
| *Lake Killarney | TSI | - | - | ~48 | ~58 | N/A | 56.80 | N/A |
| *Lake Kanturk | TSI | - | - | 59.00 | 64.00 | N/A | 48.90 | N/A |
| *Goose Pond | TSI | - | - | ~47 | ~57 | N/A | 49.20 | N/A |
| Alford Arm | Not a lake | - | - | - | - | - | - | - |

## Table C.10 Color Comparison of Lakes and Munson Slough for Data after 1986

| Waterbody | Parameter | Units | N | Minimum | Maximum | Mean | Median | 75% |
|---|---|---|---|---|---|---|---|---|
| Munson Slough above Lake Munson | Color | PCU | 257 | 12.0 | 620.0 | 104.9 | 81.3 | 120.0 |
| Munson Slough below Lake Munson | Color | PCU | 85 | 10.0 | 200.0 | 60.6 | 50.0 | 80.0 |
| Lake Munson | Color | PCU | 519 | 2.5 | 320.0 | 84.0 | 75.0 | 109.7 |
| BCL | Color | PCU | 297 | 3.0 | 900.0 | 175.0 | 142.3 | 230.0 |
| *Lake Bradford | Color | PCU | N/A | N/A | N/A | N/A | 120.0 | N/A |
| *Tom Brown Park Lake | Color | PCU | N/A | N/A | N/A | N/A | N/A | N/A |
| *A.J. Henry Park Lake | Color | PCU | N/A | N/A | N/A | N/A | N/A | N/A |
| *Lake Hall | Color | PCU | N/A | N/A | N/A | <40 | N/A | N/A |
| *Lake Overstreet | Color | PCU | N/A | N/A | N/A | N/A | 13.0 | N/A |
| *Lake Killarney | Color | PCU | 53 | 4.0 | 100.0 | 36.2 | 30.0 | 50.0 |
| *Lake Kanturk | Color | PCU | N/A | N/A | N/A | N/A | N/A | N/A |
| *Goose Pond | Color | PCU | N/A | N/A | N/A | N/A | N/A | N/A |
| Alford Arm | Color | PCU | 198 | 1.6 | 267.0 | 48.0 | 43.0 | 60.0 |

## Table C.11 pH Comparison of Lakes and Munson Slough for Data after 1986

| Waterbody | Parameter | Units | N | Minimum | Maximum | Mean | Median | 75% |
|---|---|---|---|---|---|---|---|---|
| Munson Slough above Lake Munson | pH | SU | 284 | 4.77 | 9.95 | 7.03 | 7.01 | 7.35 |
| Munson Slough below Lake Munson | pH | SU | 115 | 4.98 | 9.57 | 6.80 | 6.97 | 7.43 |
| Lake Munson | pH | SU | 784 | 2.34 | 11.81 | 7.26 | 6.96 | 7.48 |
| BCL | pH | SU | 844 | 3.18 | 8.86 | 5.06 | 5.05 | 5.66 |
| *Lake Bradford | pH | SU | N/A | 3.5 | 8.1 | N/A | 5.2 | N/A |
| *Tom Brown Park Lake | pH | SU | N/A | 5.30 | 10.10 | N/A | 7.40 | N/A |
| *A.J. Henry Park Lake | pH | SU | N/A | 5.50 | 9.40 | N/A | 7.40 | N/A |
| *Lake Hall | pH | SU | N/A | N/A | N/A | N/A | 6.10 | N/A |
| *Lake Overstreet | pH | SU | N/A | N/A | N/A | N/A | 5.40 | N/A |
| *Lake Killarney | pH | SU | N/A | 5.50 | 9.80 | N/A | 7.80 | N/A |
| *Lake Kanturk | pH | SU | N/A | N/A | N/A | N/A | 7.40 | N/A |
| *Goose Pond | pH | SU | N/A | 5.30 | 8.30 | N/A | ~7.2 | N/A |
| Alford Arm | pH | SU | 391 | 3.70 | 9.60 | 6.30 | 6.13 | 6.59 |

## Table C.12 Munson Slough and Lake Munson $BOD_5$, DO, and Un-ionized Ammonia Comparison of Data after 1986

| Waterbody | WBID | Parameter | Units | Period of Record | N | Minimum | Maximum | Mean | Median | 75th |
|---|---|---|---|---|---|---|---|---|---|---|
| BCL | 878A,C,D | $BOD_5$ | mg/L | 12/2003–11/2007 | 166 | 0.01 | 9.9 | 1.02 | 0.9 | 1.03 |
| Munson Slough above Lake Munson | 807D | $BOD_5$ | mg/L | 2/1987–3/2008 | 196 | 0.2 | 42 | 4.72 | 4 | 6 |
| Lake Munson | 807C | $BOD_5$ | mg/L | 11/1986–2/2008 | 334 | 0.56 | 20 | 5.19 | 4 | 7.58 |
| Munson Slough below Lake Munson | 807 | $BOD_5$ | mg/L | 9/1987–3/2008 | 64 | 0.79 | 12 | 5.07 | 4.25 | 6.93 |
| BCL | 878A,C,D | DO | mg/L | 8/1990–3/2008 | 848 | 0.04 | 13.49 | 6.48 | 6.65 | 8.46 |
| Munson Slough above Lake Munson | 807D | DO | mg/L | 7/1992–3/2008 | 279 | 0.2 | 14.46 | 5.85 | 5.84 | 8.07 |
| Lake Munson | 807C | DO | mg/L | 11/1986–2/2008 | 1303 | 0.09 | 17.8 | 6.67 | 6.97 | 8.2 |
| Munson Slough below Lake Munson | 807 | DO | mg/L | 11/1992–3/2008 | 110 | 1.65 | 18.36 | 6.73 | 6.65 | 8.65 |
| BCL | 878A,C,D | UNNH4* | mg/L | 10/1988–3/2007 | 444 | 0.00000001 | 0.01172900 | 0.00004204 | 0.00000089 | 0.00000379 |
| Munson Slough above Lake Munson | 807D | UNNH4* | mg/L | 7/1992–2/2008 | 103 | 0.00000074 | 0.01180400 | 0.00095795 | 0.00012900 | 0.00103150 |
| Lake Munson | 807C | UNNH4* | mg/L | 11/1986–11/2006 | 435 | 0.00000002 | 0.69963900 | 0.00693224 | 0.00022400 | 0.00084800 |
| Munson Slough below Lake Munson | 807 | UNNH4* | mg/L | 11/1992–2/2008 | 28 | 0.00000186 | 0.16162300 | 0.01170054 | 0.00093250 | 0.00570500 |

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