



**CITY OF
TALLAHASSEE**

TALLAHASSEE MASTER PLAN – SURFACE WATER (TMaPS): VOLUME 3

LAKE MUNSON BASIN



Submitted by:
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July 2025

Geosyntec 
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TMaPS: VOLUME 3

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Prepared for

City of Tallahassee

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Tallahassee, Florida 32301

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Project Number: FW7714

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The engineering material and data contained within the enclosed report was prepared by Geosyntec Consultants, Inc. for sole use by the City of Tallahassee. This report was prepared under the supervision and direction of the respective undersigned, whose seal as a registered professional engineer is affixed below.

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Tallahassee Master Plan – Surface Water (TMaPS)

Volume 1: Executive Summary

Volume 2: Background & Approach

Volume 3: Lake Munson Basin

Volume 4: Lake Jackson Basin

Volume 5: Lake Lafayette Basin

Volume 6: Wakulla Springs and Lake Talquin

Volume 7: Non-Structural and Structural Project Development

Volume 8: Regulatory Review

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ACRONYMS AND ABBREVIATIONS

AGM	annual geometric mean
BMAP	basin management action plan
BMP	best management practice
BOD	biochemical oxygen demand
CDA	Concentrated Discharge Areas
cfs	cubic feet per second
Chl-a	chlorophyll a
CN	curve number
City	City of Tallahassee
DCIA	directly connected impervious area
DEM	digital elevation model
DO	dissolved oxygen
<i>E. coli</i>	<i>Escherichia coli</i>
EMC	event mean concentration
EPA	U.S. Environmental Protection Agency
ERP	Environmental Resource Permit
F.A.C.	Florida Administrative Code
FAMU	Florida Agricultural and Mechanical (A&M) University
FDEP	Florida Department of Environmental Protection
FDOH	Florida Department of Health
FDOT	Florida Department of Transportation
FGS	Florida Geologic Survey
FIB	Fecal Indicator Bacteria
FLUCCS	Florida Land Use Cover Classification System
FSQAH	Florida Stormwater Quality Applicants Handbook
FSU	Florida State University
ft	feet
FWC	Florida Fish and Wildlife Conservation Commission
GIS	geographic information system
HA	Habitat Assessment
HSG	hydrologic soil group

ID	identification
IWR	Impaired Waters Rule
lb/yr	pounds per year
LDI	Landscape Development Intensity
LVI	Lake Vegetation Index
MARC	mean annual runoff coefficient
MARS	Megginnis Arm Regional Stormwater
mg/L	milligrams per liter
MGD	million gallons per day
mL	milliliter
MPN	most probable number
NADP	National Atmospheric Deposition Program
NAVD88	North American Vertical Datum of 1988
NHD	National Hydrological Dataset
NNC	numeric nutrient criteria
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resource Conservation Service
NWFWMD	Northwest Florida Water Management District
OSTDS	onsite sewage treatment and disposal systems
PCB	polychlorinated biphenyl
PCU	platinum-cobalt units
QAPP	Quality Assurance Project Plan
SCI	Stream Condition Index
SIMPLE	Spatially Integrated Model for Pollutant Loading Estimates
SSO	sanitary sewer overflow
SWFWMD	Southwest Florida Water Management District
SWMF	Stormwater Management Facility
SWMM	Stormwater Management Model
TKN	total Kjeldahl nitrogen
TMaPS	Tallahassee Master Plan - Surface Water
TMDL	total maximum daily load
TN	total nitrogen

TP	total phosphorus
TSI	Trophic State Index
TSS	total suspended solids
µg/L	micrograms per liter
USDA	U.S. Department of Agriculture
USGS	U.S. Geological Survey
WBID	waterbody identification

3 Lake Munson Basin

3.1 Basin Overview and Project Waterbodies

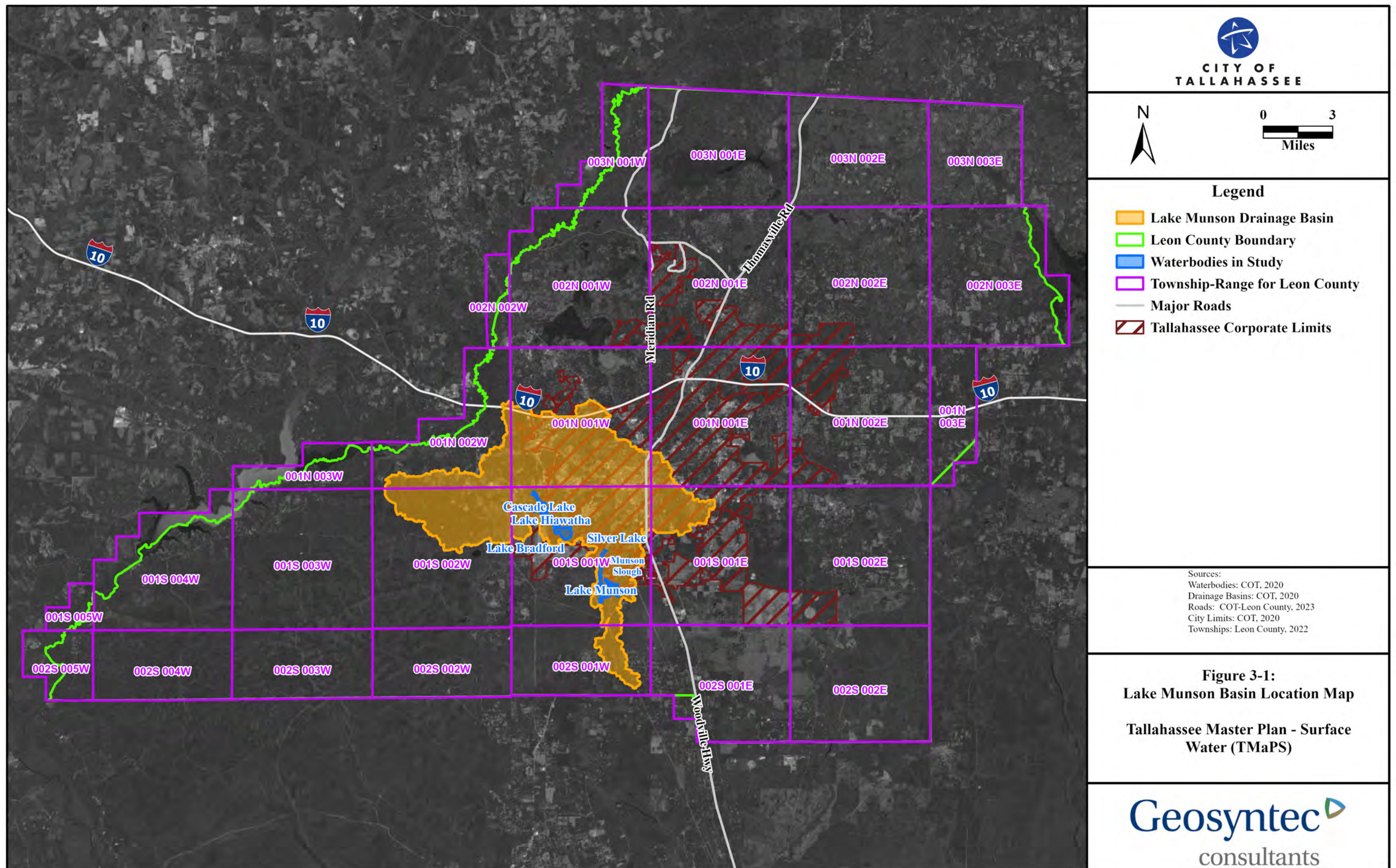
The Lake Munson basin is located in Leon County, FL north of Tallahassee and encompasses the township and ranges of: 001N 002W, 001N 001W, 001N 001E, 001S 002W, 001S 001W, 001S 001E, and 002S 001W. **Figure 3-1** shows the location of the Lake Munson basin in relation to the City of Tallahassee (City) limits and within the Leon County boundary. The basin covers approximately 42,500 acres (66.5 square miles), of which 95 percent (40,400 acres) is land cover and the remaining 5 percent (2,100 acres) is surface water. **Exhibit 3-1** presents a map showing basin boundaries, waterbodies that are part of this study (termed primary waterbodies), tributary inputs, the extents of the City incorporated area, and smaller watershed areas that drain to Lake Munson, which is the primary receiving waterbody in the basin.

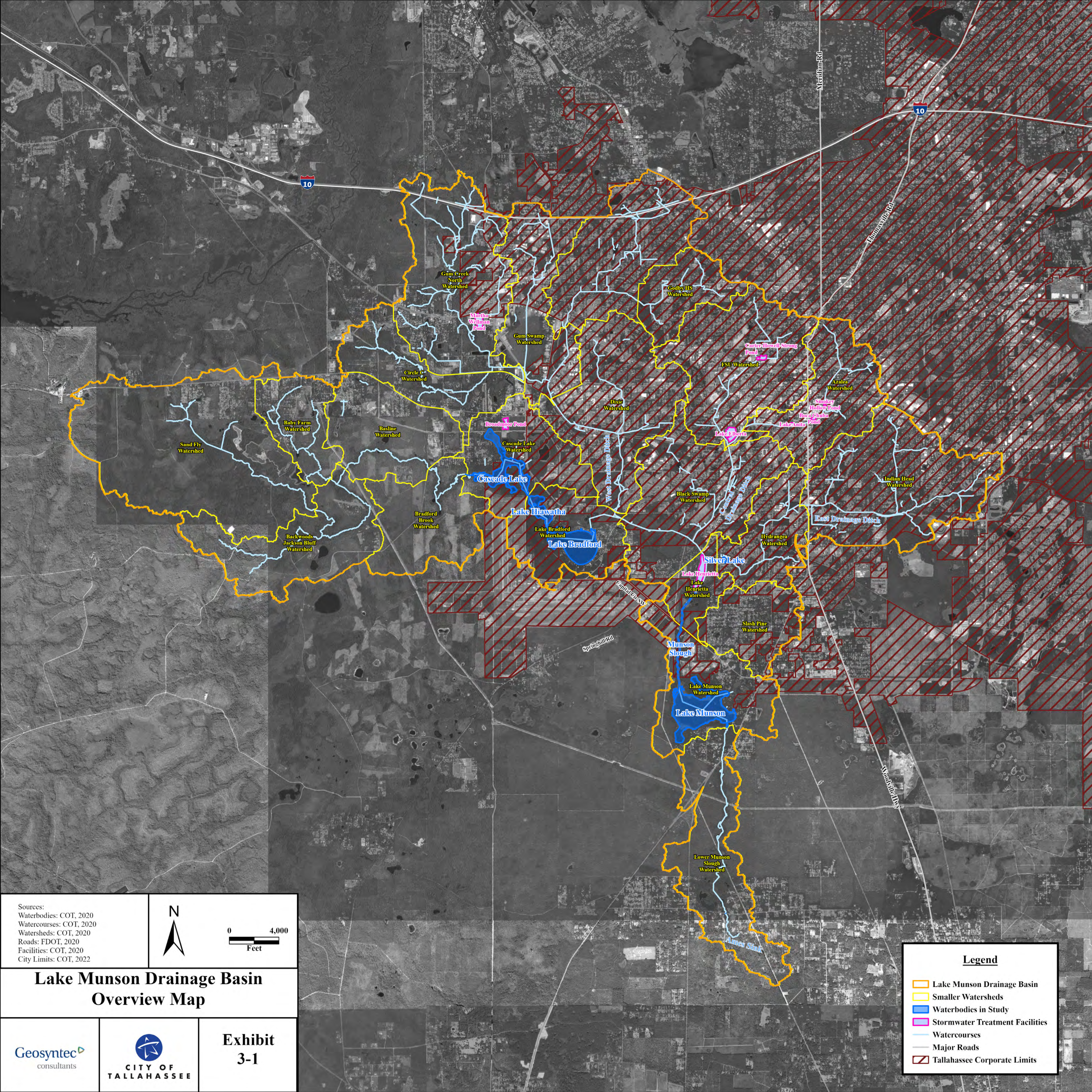
Major water features within the Lake Munson basin include West Drainage Ditch, East Drainage Ditch, Central Drainage Ditch, Bradford Chain of Lakes, Munson Slough, Lake Munson, and Ames Sink. Forty-five percent of the basin is within the City's incorporated area, approximately 19,000 acres (30 square miles). Looking at drainage to the lake (**Exhibit 3-1**), the entire basin drains into Lake Munson through the lower portion of Munson Slough [downstream of the Lake Henrietta Stormwater Management Facility (SWMF)]. To understand water quality aspects of Lake Munson, it is important to also understand Munson Slough. The slough and its heavily urbanized tributaries drain a large portion of the City. The slough flows south (through the Lake Henrietta SWMF) into and out of Lake Munson, then continues to Eight Mile Pond. After exiting Eight Mile Pond, the slough flows under Oak Ridge Road and enters Ames Sink, which is connected to Wakulla Spring.

For the Lake Munson basin, six primary waterbodies were identified for evaluation of potential pollutant loads and development of structural and non-structural projects to improve their water quality (as needed):

- Lake Munson and Munson Slough (downstream of Lake Henrietta SWMF)
- Bradford Chain of Lakes (Lake Bradford, Lake Hiawatha, and Cascade Lake)
- Silver Lake

These waterbodies are highlighted in **Exhibit 3-1** and are the focus of the analyses in the sections following this introduction.





Sources:
Waterbodies: COT, 2020
Watercourses: COT, 2020
Watersheds: COT, 2020
Roads: FDOT, 2020
Facilities: COT, 2020
City Limits: COT, 2022

N

0 4,000
Feet

Lake Munson Drainage Basin Overview Map

Geosyntec
consultants


CITY OF
TALLAHASSEE

Exhibit
3-1

Legend

- Lake Munson Drainage Basin
- Smaller Watersheds
- Waterbodies in Study
- Stormwater Treatment Facilities
- Watercourses
- Major Roads
- Tallahassee Corporate Limits

3.2 Report Review Summary

For the Lake Munson basin, a series of reports was reviewed that provided the history and background of the basin and its waterbodies, along with data and other information to support the identification of potential sources and structural and non-structural projects to improve water quality. **Table 3-1** presents a list of the reports and other information reviewed.

The reports/information range in time from the 1970s through the present and include water quality studies on the various lakes and causes of water quality degradation; analyses of measured hydrologic, water quality, and biological data; management plans to address restoration of Lake Munson and other waterbodies within the basin; lake sediment studies; fish and benthic studies; grant documents; National Pollutant Discharge Elimination System (NPDES) permits; and presentations on Lake Munson and other waterbodies within the basin.

Table 3-1: Lake Munson Basin Reference List

Report Name	Author	Year
Report on Lake Munson Leon County, Florida, EPA Region IV, Working Paper No. 268 (National Eutrophication Survey)	EPA	1977
Water Quality Evaluation of Lake Munson, Leon County, Florida Water Resources Assessment 88-1	NWFWMD	1988
Stormwater Management Plan Volume VI - Technical Report	NWFWMD	1991
City Of Tallahassee and Leon County Stormwater Management Plan Volume I: Executive Summary (Water Resources Assessment 91-1)	NWFWMD	1992
City of Tallahassee and Leon County Stormwater Management Plan, Volume II: Lake Munson Basin Plan. Water Resources Assessment 91-2	NWFWMD	1992
Figure 5. Lake Munson Basin Recommended Structural and Non-Structural Alternatives	Lake Munson Action Team	1993
1994 Lake Munson Management Plan	Map	1994
Lake Munson Restoration	Leon County Public Works	1997
Final Report - FY97 Section 319 Grant Program	Leon County Public Works	1997
Sediment Investigation: Lake Munson Enhancement Project	Leon County/ESG	2005
Correlation of Environmental Analysis - Lake Munson Sediment Samples	ESG	2007
Final TMDL Supplemental Information Report for Munson Slough/Lake Munson, WBIDs 807, 807C, and 807D	FDEP	2010

Table 3-1: Lake Munson Basin Reference List

Report Name	Author	Year
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)	FDEP	2013
Lake Munson: Spatial and Temporal Changes in Characteristics of Sediment Nutrients during an Extreme Drawdown Event (text)	DEAR	2013
Spatial and Temporal Changes in Nutrient Characteristics of Sediments during an Extreme Drawdown Event in Lake Munson, Florida, USA	FDEP	2014
Evaluation of the Feasibility of Sediment Nutrient Inactivation in Lake Munson. Final Report	ERD	2016
Lake Munson Seminar, June 9, 2016 [both PowerPoint (City LakeMunsonSeminar) and PDF (Heidecker Lake Munson Seminar) saved]	City	2016
Significance of Internal Recycling in Lake Munson and Feasibility of Sediment Inactivation Using Alum, Lake Munson Summit [both PPT (Harper_Lake MunsonSeminar) and PDF (Harper_LakeMunsonSeminar) saved]	ERD	2016
Recommendations for the Lake Munson Basin (Powerpoint) And text summary titled BMP Recommendations for the Lake Munson Basin	Theresa Heiker	2016
Conservation and Other Land Uses Within the Lake Munson Watershed	Leon County Planning Department)	2016
Discussion topics from the Lake Munson Meeting; June 9, 2016 with editorial notes from meeting	WML	2016
Lake Munson	Leon County Public Works	2016
Summary of Lake Munson Presentation 2016	Leon County Public Works	2016
Ames Sink Acquisition Proposal	Stevenson (florida_springs@comcast.net)	2016
Leon County Science Advisory Committee, Lake Munson Meeting (6/6/2016) Summary of the FWC Presentation	BJ Jamison (DFFM), Derek Fussell (IPM) and Megan Keserauskis & BJ Jamison (AHRE)	2016

Table 3-1: Lake Munson Basin Reference List

Report Name	Author	Year
Lake Munson: Spatial and Temporal Changes in Nutrient Characteristics of Sediments During a Drawdown Event (ppt)	DEAR	2016
Lake Munson	FWC: HSC, AHRE, IPM DFFM	2016
Lake Munson Meeting June 9, 2016	Science Advisory Committee	2016
Science Advisory Committee Meeting presentation	Charles Hargraves and Gary Phillips	2016
City of Tallahassee – Lake Munson Presentation Summary	City	2016
City of Tallahassee MS4 As it Relates to the DEP Assessment of Surface Waters & Strategic Monitoring	City	2017
Ground Penetrating Radar Survey of Lake Munson	FGS	2018
Lake Munson Sediment Sampling and Analysis Project	FGS	2019
Letter of Support to NFWFMD re: FDEP Office of Ecosystem Projects Harmful Algal Bloom Innovative Technology Grant for Lake Munson	City	2019
Project Information Proposal For Grant Funding Consideration: Intact Cellular Algae Harvesting with Simultaneous Nutrient Export in Lake Munson to Mitigate Harmful Algae Blooms and Reduce Direct Nutrient Enrichment of the Floridan Aquifer.	NFWFMD	2019
Toxicology Consult for Lake Munson	FDOH	2020
Approved Wastewater Discharge Permit Facility Project – Lake Munson Tallahassee FL. AECOM Permit # 20200507-003 for Lake Munson Tallahassee FL. / Gil Waters Preserve Park, 5800 Crawfordville Road (30.365140 84.302403)	City	2020
Conceptual Approval ERP Leon County Central Drainage Ditch ERP Permit No.: 0391181-001-EC/37	FDEP	2020
Lake Munson Sediment Sampling and Analysis Project Review	Terracon Consultants	2021
Waterbody Summary for Lake Munson	Leon County	2021

3.3 Volume Outline

The sections that follow present the results from the completion of work tasks to date including: an overview of available data; assessment of the water quality conditions in the primary waterbodies and the tributaries that drain into them; development of potential pollutant loads; identification of “hot spot” areas, by waterbody, to target for structural and non-structural projects within the Lake Munson basin; and recommendations for additional data collection or studies to fill data gaps and support assessment of specific stressors to the primary waterbodies. The specific tasks, with a description of the work, include the following.

- Task 1 – Data Collection
 - Collection and review of data for use in project analyses.
- Task 2 – Waterbody Data Review and Summary
 - Evaluation of existing water quality conditions and general health of target waterbodies using available data and studies.
 - Qualitative assessment for each waterbody to identify pollutant loading sources to focus on.
- Task 3 – Water Quality Assessment
 - Calculation of pollutant load estimates to the target waterbodies (where data allow) including stormwater runoff, groundwater impacted by onsite sewage treatment and disposal systems (OSTDS), point sources, lake inflow, internal recycling, and atmospheric deposition.
 - Identification of hotspots within each drainage basin and prioritization of waterbodies to target for restoration efforts.
- Task 4 – Water Quality Study Identification and Prioritization
 - Identification of potential data collection or water quality improvement studies needed to address data gaps.

Section 3.4 through **Section 3.6** present an overview and history for each of the primary waterbodies along with the findings and results from Tasks 1 through 3. **Section 3.7** presents a basin-wide assessment of hot spot areas as outlined in Task 3 to target for structural and non-structural projects based on the data and analyses presented in **Section 3.4** through **Section 3.6**. **Section 3.8** presents a summary of potential stressors within target waterbodies and recommendations on data collection or studies.

3.4 Lake Munson and Munson Slough Downstream of Lake Henrietta SWMF

This section presents the results from Tasks 1 through 3 for Lake Munson and Munson Slough downstream of Lake Henrietta SWMF. This includes an overview and history of the lake and basin, present impairment status of waterbodies in the basin, an overview of available data, a qualitative assessment of potential pollutant sources, and calculation of potential pollutant loads.

3.4.1 Overview and History

Lake Munson is a 255-acre shallow manmade lake that was a cypress swamp with pockets of open water prior to dam construction. The earliest documented use of Lake Munson was in 1704 by the Spanish Deputy Governor who ordered men to go up the St. Marks and Wakulla River by canoe up to a landing place near the Saint Luis Fort (Lake Munson Action Group, 1993). An 1840 map shows Munson's Mill Pond, and by 1883, maps show Munson Lake. In the 1900s, the lake was used as a hunting area for waterfowl and identified as a good Cracker fishing lake. In the 1950s, the swamp was impounded through the construction of a dam with several control structures to alleviate flooding downstream. It is noted that, according to the 1993 Lake Munson Action Group report, some form of structure to impound the lake may have been present as early as 1840.

In more recent times, a modern dam control structure was constructed to replace the 1950s dam. **Photo 3-1** through **Photo 3-8** present aerial photographs of Lake Munson from 1937 through 2020. The photos show that overall, the lake has retained its general shape and open water area. The introduction of the dam in the 1950s appears to create a larger permanent pool area than is seen in the 1930s photo. **Photo 3-9** and **Photo 3-10** show the lake and the control structure respectively in 2021. Lake Munson discharges to lower Munson Slough, Eight Mile Pond, and Ames Sink. Recharge from Ames Sink emerges at Wakulla Spring and flows to the Gulf of Mexico. Dye trace studies have confirmed a direct connection between Ames Sink and Wakulla Spring (Stevenson, 2016).

The lake receives the majority of its water from Munson Slough and its tributaries, which drain a significant portion of the City's incorporated area (**Exhibit 3-1**). There are four primary drainageways that flow together into Munson Slough prior to discharging (through Lake Henrietta SWMF) into Lake Munson. The East Drainage Ditch is located entirely within the City's incorporated boundaries and drains approximately 3,800 acres including the Hydrangea and Indian Head watersheds. The Central Drainage Ditch, also fully within the City's incorporated boundaries, drains approximately 4,800 acres including the Azalea, Florida State University (FSU) and Black Swamp watersheds. The Central Drainage Ditch is almost entirely located within the highly urbanized downtown areas of Tallahassee. The West Drainage Ditch, located within both incorporated and unincorporated areas, drains approximately 6,700 acres including the Dixie, Gum Swamp, Solstice, Gum Creek North, and Circle C watersheds. Finally, Bradford Brook, which passes through the Bradford Chain of Lakes, drains an area of approximately 12,600 acres, including the Lake Bradford, Cascade Lake, Bradford Brook, Baseline, Baby Farm, Sand Fly, and Backwoods Jackson Bluff watersheds, which are mostly within unincorporated Leon County and the bulk of the western portions within the Apalachicola National Forest.



Photo 3-1: Lake Munson Aerial – 1937

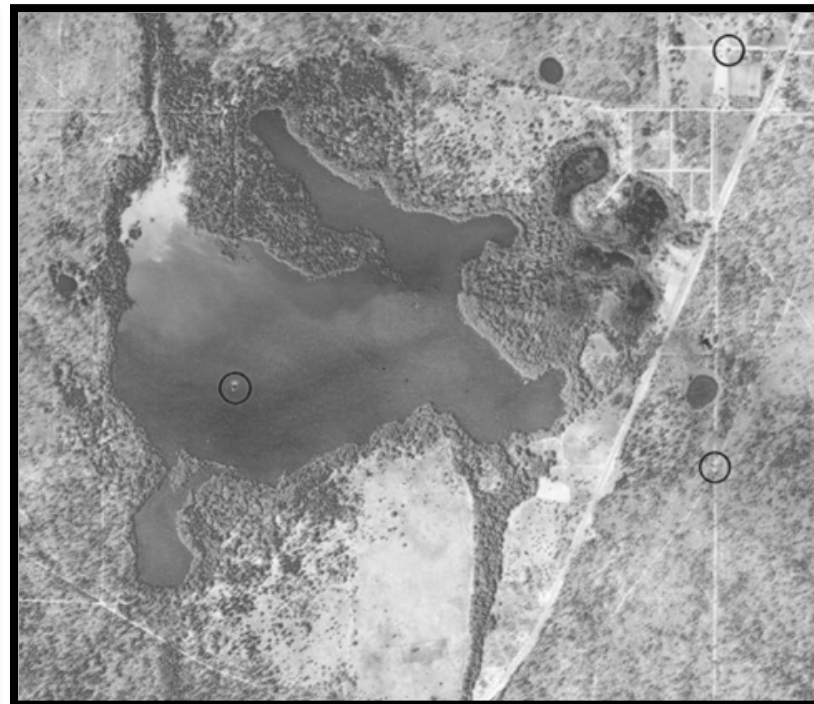


Photo 3-2: Lake Munson Aerial – 1949



Photo 3-3: Lake Munson Aerial – 1954



Photo 3-4: Lake Munson Aerial – 1970



Photo 3-5: Lake Munson Aerial – 1983

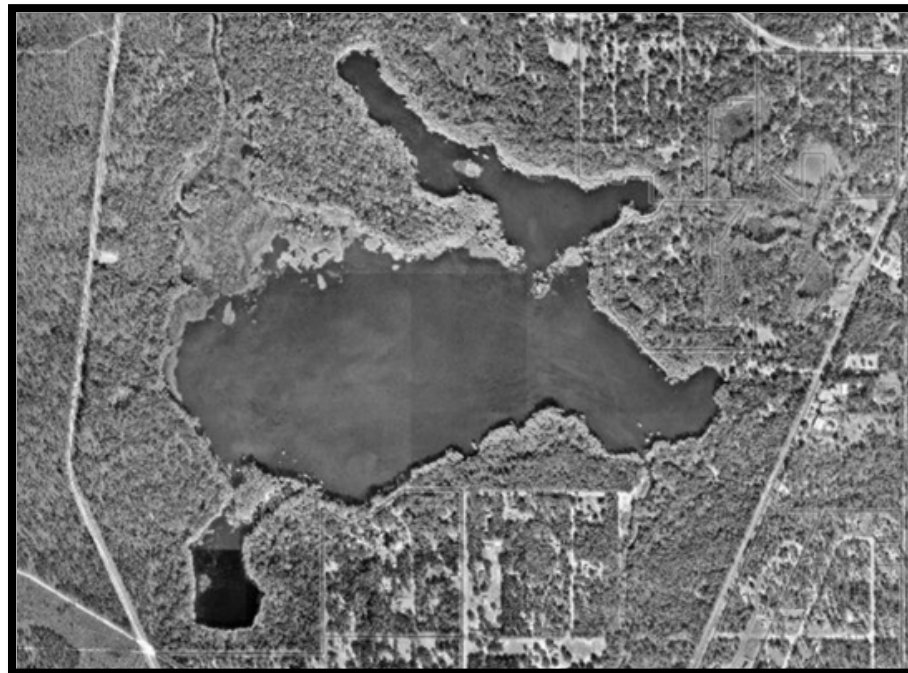


Photo 3-6: Lake Munson Aerial – 1996



Photo 3-7: Lake Munson Aerial – 2007



Photo 3-8: Lake Munson Aerial – 2020



Photo 3-9: Lake Munson (2021)

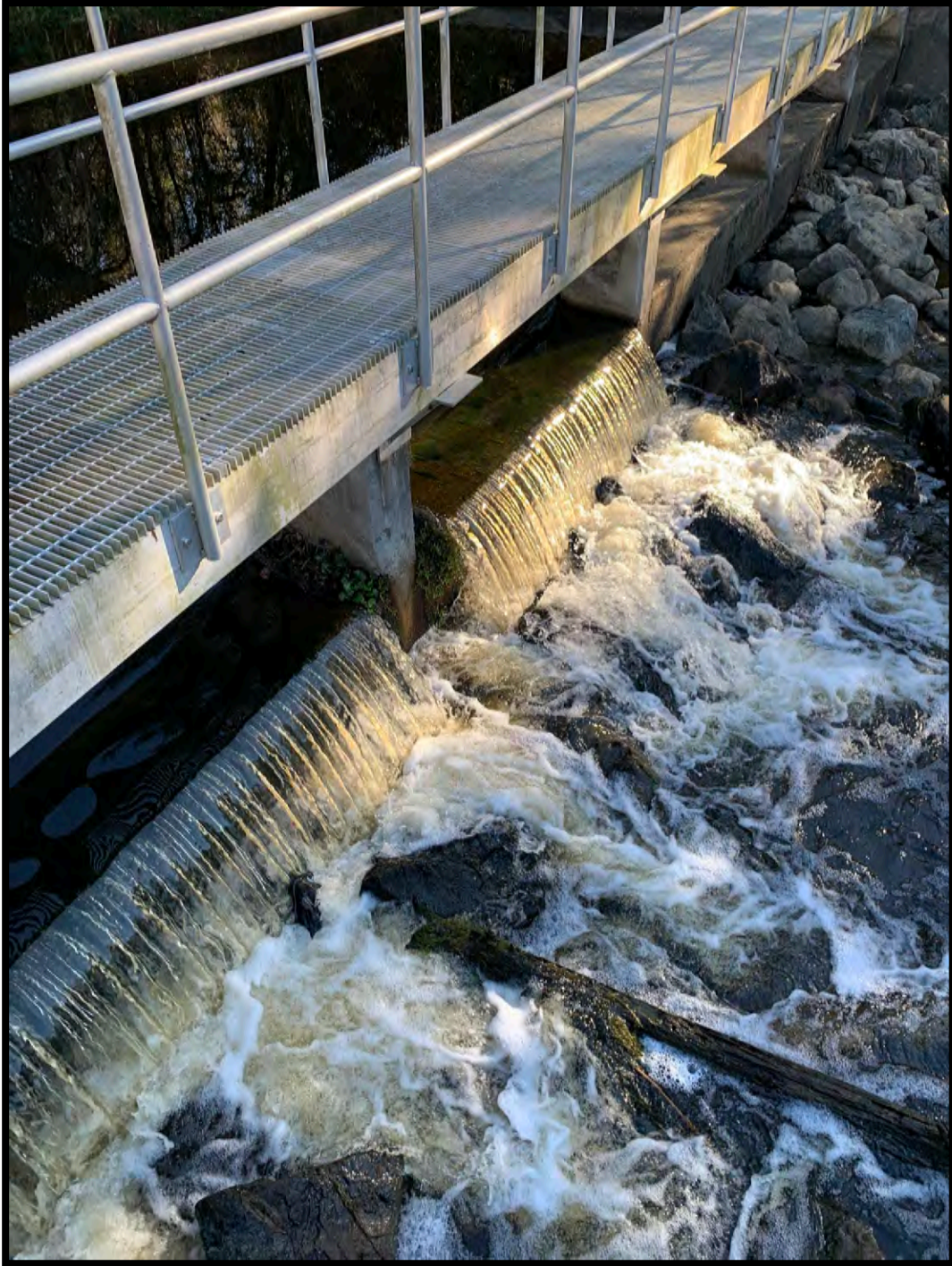


Photo 3-10: Lake Munson Dam Control Structure (2021)

The Dale Mabry wastewater treatment facility was built in the 1930s and discharged primary treated effluent to the Central Drainage Ditch upstream of Lake Munson. The Lake Bradford wastewater treatment facility was built in the 1950s and also discharged treated effluent upstream of the lake. Following the introduction of the wastewater discharges, Lake Munson, including Munson Slough, experienced nutrient enrichment, low dissolved oxygen (DO), algal blooms, high bacteria levels, and degraded sediment conditions. The first reports of massive algal blooms and fish kills in the lake date as early as 1956 [Northwest Florida Water Management District (NFWMD), 1988]. As part of the National Eutrophication Survey initiated in 1972, Lake Munson was ranked 39th out of 41 lakes for lake water quality in Florida [U.S. Environmental Protection Agency (EPA), 1977]. The EPA report identified that Lake Munson was nitrogen limited and calculated that 46 percent of the total phosphorus (TP) load and 44 percent of the total nitrogen (TN) load to the lake was from wastewater plants. The 1988 Water Quality Evaluation by the NFWMD noted that in 1982 Lake Munson was classified as hypereutrophic and ranked the seventh most degraded lake in the state. The City constructed a wastewater sprayfield in 1984, which resulted in removal of the direct discharges and improved water quality in the lake. Afterward, the lake was classified as eutrophic and ranked the fifty-second most degraded lake in the state.

While the removal of the direct wastewater discharges significantly decreased nutrient loads reaching the lake, the lake continued to receive nutrient loads from stormwater runoff primarily originating in urban areas and conveyed to the lake via Munson Slough and its tributaries. A study conducted by NFWMD (1988), following the removal of the direct discharges, identified significant loading of sediments, biochemical oxygen demand (BOD), TN and TP. Using inflow, in-lake, and outflow concentration data, NFWMD estimated that the lake retained 95 percent of the sediments, 20 percent of the BOD, 31 percent of the nitrogen, 64 percent of the phosphorus, and over 70 percent of various metals. Tests conducted in the lake indicated significant release of orthophosphate from the sediments and metal concentrations in the sediments 10 to 100 times higher than other lakes.

In the early 1990s, a Stormwater Management Plan was developed by the City and Leon County to evaluate stormwater treatment and flood reduction options (NFWMD, 1991). The plan identified a series of structural projects to treat the stormwater loads and reduce flooding as well as non-structural alternatives to support restoration of water quality and preservation of sensitive areas. Structural project recommendations included:

- East Drainage Ditch stormwater facilities,
- Jim Lee Road Pond on the East Drainage Ditch,
- Vega Drive Pond on the West Drainage Ditch,
- FSU Pond on the Central Drainage Ditch,
- Orange Avenue Pond on the East Drainage Ditch,
- Eisenhower Avenue facility on the West Drainage Ditch, and
- Culvert enlargements at various areas locations along the East and West Drainage Ditches.

Non-structural recommendations included:

- Acquisition and protection around Gum Swamp,
- Restoration of Lake Henrietta SWMF,
- Restrictions and preservation efforts around Black Swamp,

- Development restrictions in sensitive areas around Lake Bradford and Bradford Brook,
- Detailed studies to support direct efforts on Lake Munson restoration and monitoring,
- Development restrictions around Grassy Lake, and
- Restrictions on encroachment and development within sensitive wetland areas within the basin.

Following the development of the Stormwater Management Plan, the Lake Munson Action Team provided additional recommendations to support improved water quality in Lake Munson (Lake Munson Action Group, 1993). The recommendations included:

- Fully implement Lake Munson Projects in the Stormwater Management Plan;
- Repair the dam at the southern end of Lake Munson;
- Remove organic muck after stormwater projects completed;
- Routine winter drawdowns to oxidize and consolidate organic sediments;
- Increase protection of wetlands within the basin;
- Increase inspection and maintenance of all stormwater treatment facilities;
- Develop more stringent limits on impervious area within the basin;
- Continue to control exotic aquatic plants with the judicious use of herbicides;
- Address litter and trash through a combination of legislative programs, social programs, and structural best management practices (BMPs);
- Increase lake shore protection and public access through acquisition of lakefront property, coordination with lakefront property owners on restoration activities, and developing and managing facilities in an environmentally sensitive manner; and
- Acquire sensitive areas such as Blackwater Swamp.

In general, the planned approach to the restoration of Lake Munson included two phases. Phase one was to first reduce the loading of sediments, nutrients and other pollutants to the lake through Munson Slough to levels able to be naturally assimilated. And then, following completion of projects to reduce loads, phase two was to address legacy loads and internal recycling within the lake.

Phase one began immediately following the aforementioned planning efforts. Since the 1990s, more than 70 projects to reduce stormwater loads and alleviate flooding have been completed within the basin, at a cost of more than \$285 million dollars. Notable stormwater treatment facilities are identified in **Exhibit 3-1** and discussed below. Additional discussions on facilities located within the Bradford Chain of Lakes and Silver Lake watersheds are presented and discussed in **Section 3.5** and **Section 3.6**, respectively.

Due to its highly urbanized nature, the Central Drainage Ditch, and the historic St. Augustine Branch which flows into the Central Ditch, contain a number of larger regional facilities. The Carter-Howell-Strong Pond (**Photo 3-11**), located in the upper end of the Central Ditch is a 5-acre wet detention facility that receives drainage from portions of FSU and surrounding residential areas. Lake Elberta (**Photo 3-12**) is a 17-acre wet detention facility at the confluence of the Central and St. Augustine Branch. A series of treatment facilities is located along the historic St. Augustine Branch. These include the Cascade Park stormwater treatment facilities

including two wet detention ponds (1 acre and 2 acre) and other treatment components (**Photo 3-13**), Lake Anita (**Photo 3-14**) a 2-acre wet detention facility along FAMU Way, and a 1.2-acre wet pond near Railroad Square Park (**Photo 3-15**).



Photo 3-11: Carter-Howell-Strong Wet Detention Pond



Photo 3-12: Lake Elberta Wet Detention Pond



Photo 3-13: Boca Chuba Wet Detention Pond in Cascade Park



Photo 3-14: Lake Anita Wet Detention Pond



Photo 3-15: Wet Detention Pond near Railroad Square Park

Treatment facilities within the West Drainage Ditch are generally smaller stormwater treatment facilities constructed to support land development and are maintained by the City and the Florida Department of Transportation (FDOT). Numerous FDOT-maintained facilities are located around I-10 and Capital Circle in the upper portions of the West Drainage Ditch. One larger facility, maintained by Leon County, is Martha Wellman Pond, a 13-acre wet pond near the intersection of Capital Circle SW and West Tennessee (**Photo 3-16**).



Photo 3-16: Martha Wellman Wet Detention Pond

The largest stormwater facility within the Lake Munson basin is the Lake Henrietta SWMF, which was constructed in 2000 and is located at the confluence of Munson Slough and the East Drainage Ditch. Lake Henrietta was historically a wetland system that was altered through the construction of a mosquito control ditch and berm, and ongoing sedimentation and pollutant discharge from Munson Slough. As part of the Leon County Lake Munson restoration, the altered wetland system was converted to a 25-acre wet detention treatment facility with trash traps to reduce sediments, slow runoff, and reduce trash before water enters the restored and stabilized channel north of Lake Munson (**Photo 3-17** and **Photo 3-18**).

In addition to treatment facilities, projects have been constructed to stabilize channels to reduce erosion and the transport of sediments to downstream waterbodies. **Photo 3-19** shows a bank stabilization project along the Central Drainage Ditch. Ongoing erosion issues still exist at various locations throughout the drainage system. **Photo 3-20** shows a portion of the Central Drainage Ditch along Eppes Drive where bank erosion can be seen.

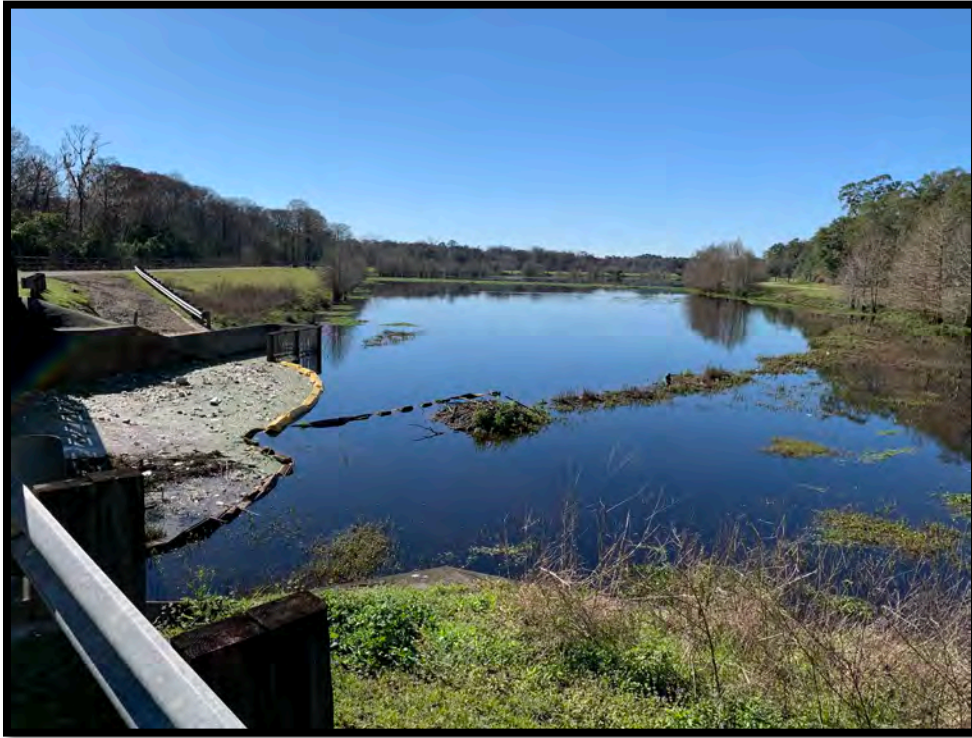


Photo 3-17: Lake Henrietta SWMF Regional Treatment Pond, North End Facing South



Photo 3-18: Lake Henrietta SWMF Regional Treatment Pond, Middle and South Sections Facing South



Photo 3-19: Channel Stabilization Project along Central Ditch



Photo 3-20: Central Ditch Bank Conditions near Epps Drive

Like previously mentioned, phase two of the Lake Munson restoration plan was to focus on internal recycling of nutrients and nutrient flux from sediments due to legacy loading. The buildup of in-lake nutrient loads has been identified in numerous studies as a significant loading source to the lake. Leon County conducted a sediment study in 2005 taking 125 borings throughout the lake (Leon County, 2005). They identified the natural soils as having relatively low organic content (1 to 3 percent), with other sediments found in the lake with organic contents upwards of 60 percent. An analysis of sediment data from 1997 and 2005 by Leon County and the Florida Fish and Wildlife Conservation Commission (FWC) evaluated the feasibility of disposal of sediments once removed (Leon County and FWC, 2007). The analyses determined that the sediments could be put in a nearby disposal facility so long as it was capped to prevent runoff of polychlorinated biphenyls (PCBs). A key consideration was the level of disturbance (suspension) of the sediments during removal and the transportation/dewatering.

To date, the main activities completed to address in-lake loads have been periodic drawdowns for the purpose of oxidizing and consolidating the sediments and reducing long-term fluxes. Drawdowns occurred in 1977 and 2010. The 2010 drawdown commenced on October 18, 2010, and continued until June 14, 2011 (**Photo 3-21**).

A 2014 Florida Department of Environmental Protection (FDEP) sediment biogeochemical study to quantify temporal and spatial changes in nutrient characteristics of the lake sediments in response to the 2010 drawdown indicated that significant removal of TN occurred but TP removal was not as significant (FDEP, 2014). The study identified that a combination of planting and harvesting could maximize TN and TP removal from the exposed lake sediments through proper management of the drawdown.



Photo 3-21: Lake Munson during Drawdown (2011)

A 2016 evaluation of the feasibility of sediment nutrient inactivation in Lake Munson determined that significant buildup of nutrients has occurred within the sediments due to 50 years of nutrient-rich inflows (ERD, 2016). Analyses of concentrations between the inflow and outflow of the lake indicated significant internal recycling. The study concluded that the 2010 drawdown appeared to have little impact on the in-lake water quality, and that sediment inactivation using alum could be successful in reducing internal recycling of phosphorus. To date, however, sediment inactivation has not been employed as a treatment strategy in Lake Munson.

In 2018, Leon County and the Florida Geologic Survey (FGS) initiated a sediment study where cores were collected and analyzed at 37 locations throughout Lake Munson, Munson Slough and Lake Henrietta SWMF (FDEP-FGS, 2019). The analyses focused primarily on contaminants in the sediments relative to removal and disposal. A 2021 review of the data collected in 2018 (Terracon, 2021), indicated that ongoing and continued contaminant releases into Lake Munson are not occurring because only the most persistent organic and inorganic contaminants are prevalent. The study identified that the compounds in the lake accumulated from activities prior to the mid-1990s and continue to persist due to their resistance to or inability to break down.

In addition to drawdowns, NFWFMD recently entered into a contract with AECOM for a pilot study of algae harvesting in Lake Munson for removal of in-lake nutrient loads. NFWFMD postulated that the root cause of the lake's continued water quality problems are legacy nutrients contained within the lake sediments and surrounding soils that release nutrients in the lake's water column. Algae harvesting can reduce in-lake nutrient concentrations by directly removing a nutrient sink and reducing the release of legacy nutrients by reducing oxygen demand. The

pilot algae harvesting system was established near the lake's control structure and operated from 2021 to 2022. It is noted that minimal algae harvesting occurred due to insufficient algae growth, so the pilot project location was moved to an alternative waterbody. No data was available at the time of this report to evaluate the effectiveness of the harvesting.

At present, the City and County plan for additional stormwater retrofit and improvement projects within the basin. Several future projects are described in a 2020 FDEP conceptual Environmental Resource Permit authorizing activities along the Central Drainage Ditch, specifically: Capital Cascades Trail Segment 4, Rerouting Untreated Stormwater to the Lake Elberta Regional Stormwater Facility, and Expansion of the Lakes Stormwater Management Facility. FWC also continues aquatic plant management on Lake Munson. Leon County has continued periodic drawdowns with a recent drawdown between November of 2022 to December of 2023.

3.4.2 Regulatory Status

EPA is authorized under Section 303(d) of the Clean Water Act to assist states in the identification of impaired waterbodies and the calculation of total maximum daily loads (TMDLs) to these waterbodies. FDEP administers the 303(d) program in Florida. A waterbody on the FDEP's 303(d) list falls into one of several categories:

Category 4a – The waterbody is impaired but does not require TMDL development because a TMDL has already been completed.

Category 4b – The waterbody is impaired but will not require a TMDL to be developed because the waterbody will attain standards due to existing or proposed measures.

Category 4c – The waterbody is impaired, but the impairment is not caused by a pollutant and therefore does not require a TMDL.

Category 4d – The waterbody is impaired but the pollutant causing impairment is not known. A TMDL cannot be calculated until the pollutant is identified.

Category 4e – The waterbody is impaired, but ongoing or recently completed restoration activities are underway to restore designated uses, so a TMDL calculation is not necessary.

Category 5 – The waterbody is impaired, and a TMDL will be calculated.

Waterbodies in Florida on the FDEP's 303(d) list are impaired. Waterbodies classified in Category 5 are placed on FDEP's comprehensive Verified List. When a waterbody is placed on the Verified List, FDEP is required by law to develop a TMDL. Waterbodies classified on Categories 4a through 4e are not on the comprehensive Verified List but are considered impaired. Generally, this means that more study is needed (4d) or FDEP has identified that local efforts are expected to restore the waterbody (4b and 4e).

FDEP has the option to develop basin management action plans (BMAPs) for waterbodies that have adopted TMDLs. A BMAP is a framework for water quality restoration in various forms containing commitments at local and state levels. These broad-based plans are developed with local stakeholders, including cities and counties. Once these plans are adopted by FDEP Secretarial Order, they are legally enforceable. FDEP also has a process by which local entities can initiate restoration activities in lieu of development of a TMDL. This type of activity fits

under the 4e and 4b categories. These are locally driven restoration efforts with a goal to meet water quality standards. This process is often favored because it puts control in the hands of the local stakeholders to determine what is needed to restore their waterbodies rather than FDEP dictating the terms of a load reduction. The process is also much faster than the traditional TMDL/BMAP pathway, which can take more than a decade.

FDEP finalized TMDLs for Lake Munson and Munson Slough upstream and downstream of Lake Munson in 2008 and 2013. The TMDLs were established for DO, nutrients/Trophic State Index (TSI) (for the lake), fecal coliform, and un-ionized ammonia. The specific impairments include:

- Munson Slough above Lake Munson [waterbody identification (WBID) 807D] – fecal coliform, DO.
- Lake Munson (WBID 807C) – DO, nutrients (TSI), and turbidity.
- Munson Slough below Lake Munson (WBID 807) – DO and un-ionized ammonia.

Exhibit 3-2 provides a map and table outlining the WBIDs and parameters. The TMDL completed in 2008 was for fecal coliform which is no longer the standard for bacteria. The TMDL completed in 2013 established in-lake and in-stream alternate numeric nutrient criteria (NNC) for Munson Slough above Lake Munson and Lake Munson. These TN and TP targets are discussed in more detail in **Section 3.4.3.7**. In the 2020-2022 Biennial Assessment, FDEP determined that the TMDL for Munson Slough is being met and placed that WBID in Category 2t. Lake Munson was also placed in Category 2t for turbidity.

In addition, there are multiple verified impairments within the Lake Munson basin at present. **Exhibit 3-2** displays the verified impaired WBIDs inside the Lake Munson Drainage Basin. The verified impairments are summarized below.

- Godby Ditch (WBID 820) and East Drainage Ditch (WBID 916) are verified impaired for fecal coliform. However, fecal coliform is no longer the applicable bacteria parameter for its waterbody classification. *Escherichia coli* (*E. coli*) will be included in the upcoming Strategic Monitoring Plan to collect the new applicable bacteria parameter data while the WBID remains on the Verified List for a fecal coliform impairment.
- Lake Munson (WBID 807C), Munson Slough downstream of Lake Munson (WBID 807), Munson Slough upstream of Lake Munson (WBID 807D), Lake Bradford (WBID 878A), and Cascade Lake (WBID 878D) are impaired for lead. In the most recent assessment, Munson Slough upstream of Lake Munson did not exceed the standard for lead but could not be delisted because there are not enough sample events meeting the standard to support delisting.

3.4.3 Waterbody Data Review and Summary

This section presents an overview of available data and data sources for Lake Munson and the Lake Munson basin including bathymetry, land use, soils, septic systems, hydrologic measurements, surface water quality, groundwater quality, biological, stormwater treatment facilities, and atmospheric deposition. Based on the timing of when data was acquired from the

City and/or downloaded and evaluated for this study, December 31, 2020, was the general cutoff date for data acquisition and presentation for this study.

3.4.3.1 Bathymetry

The best available bathymetric information for Lake Munson was developed from a survey completed for FWC in 2005 (**Figure 3-2**). The bathymetric map was developed by Environmental Geotechnical Consultants and may not fully reflect conditions in the lake today.

Based on the 2005 data, the average depth of Lake Munson is around 4 feet (ft) with the deepest portions at around 6 ft and shallow areas along the sides.

3.4.3.2 Land Use

Land use is the term used to describe the general purpose or function of a given area of land. It can represent economic and cultural activities, or it can depict the physical nature of the land (known as land cover). Land use categorization is used for planning and regulation purposes and assists agencies in keeping track of geographic areas for their respective organization purposes, such as zoning or environmental management. Impacts to waterbodies from watershed loading are evaluated, in part, as a function of land use. Event mean concentrations (EMCs) are utilized for simulating water quality concentrations in stormwater runoff. Pollutant loads are a function of pollutant concentration and volume of runoff. Land use types are used to determine appropriate EMCs when assessing water quality impacts from stormwater.

For the purpose of this study, the Level 2 Florida Land Use Cover Classification System (FLUCCS) codes were used to be consistent with classifications used to generate EMC values, which dictate pollutant loading with respect to precipitation and land use types. **Exhibit 3-3** presents a map of the Level 2 land uses within the Lake Munson basin. Tables are provided for both the Level 2 and grouped Level 1 land uses including overall acreages and percent cover. The largest land use types within the Lake Munson Drainage Basin per the grouped Level 1 categories are Urban and Built Up (45 percent) and Upland Forest (31 percent). Within the Urban Built Up category, Medium-Density Residential is the most common. In general, anthropogenic land uses are clustered within the City's incorporated area and along primary roadway corridors on the western side.

3.4.3.3 Soils

Soil classifications for the study were determined from the area's hydrologic soil group category. Hydrologic soil groups are based on estimates of runoff and infiltration potential. The Natural Resource Conservation Service (NRCS), an agency of the U.S. Department of Agriculture (USDA), delineates four primary soil groups (A, B, C, and D) as well as three dual classes (A/D, B/D, and C/D). Group A soils are characterized as having high infiltration rates with low runoff potential, and each subsequent group is characterized by an iteratively lower infiltration rate and higher runoff potential, ending with Group D soils being designated as having very low infiltration rates with high runoff potential. The dual classes represent conditions where infiltration rates under dry conditions would be per the primary soil type, but due to high groundwater levels in these areas, infiltration is low.

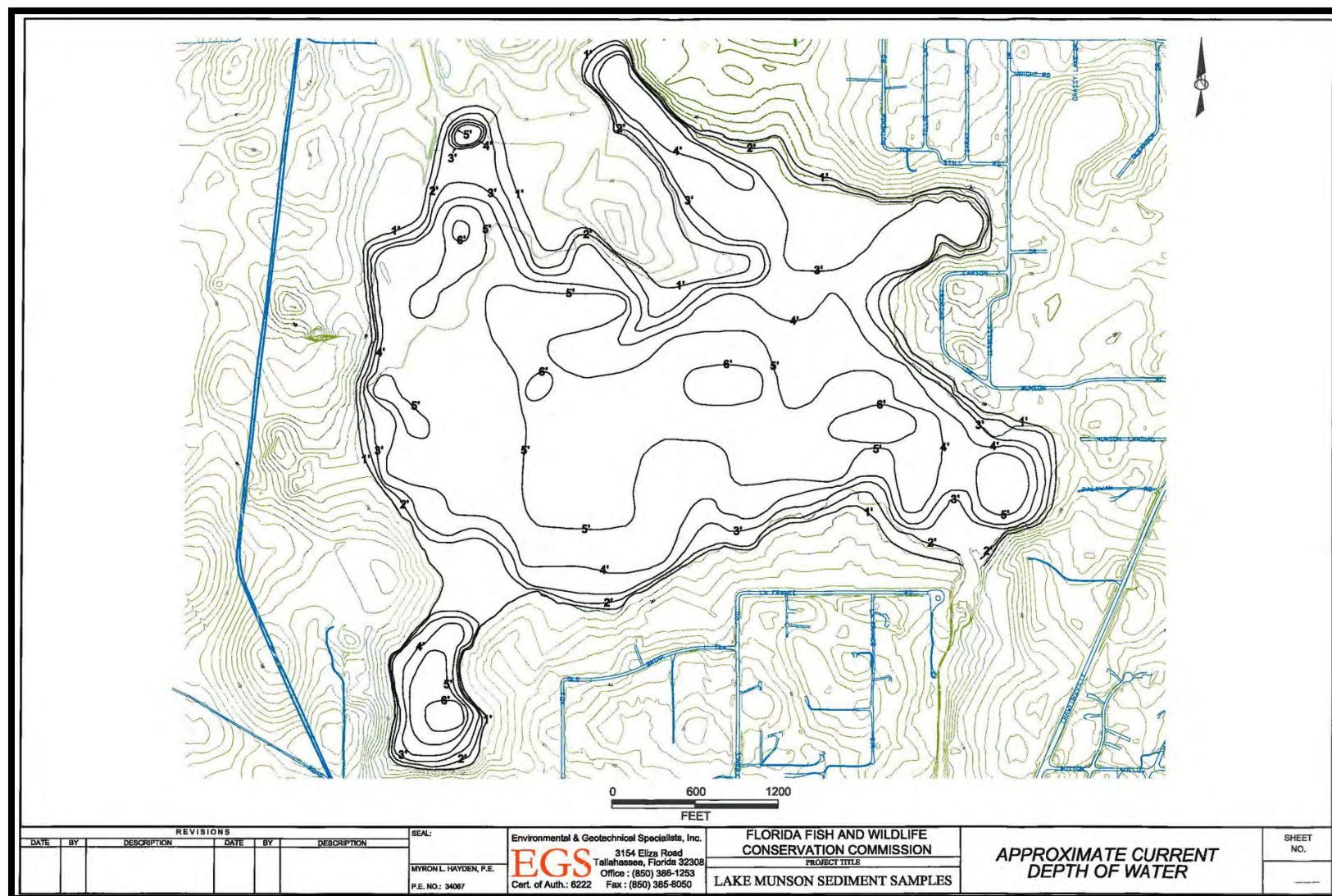


Figure 3-2: Bathymetry in Lake Munson

The most prevalent soil group in the Lake Munson Drainage Basin is Group A (41 percent) and is almost entirely on the western and southern sides of the basin (**Exhibit 3-4**). Group A soils have a high rate of infiltration. The urbanized areas within the City boundaries are predominantly B soils (20 percent). Group B soils have moderate rates of infiltration. Some clusters of A/D or B/D soils are found within low lying tributary sections throughout the basin. These soil groups have high to moderate infiltration potential, but due to elevated groundwater table conditions, will act more similarly to soils with low infiltration potential.

3.4.3.4 Septic Systems

An estimated 4,123 septic tank units are within the boundaries of the Lake Munson Drainage Basin based on the Florida Department of Health (FDOH) septic tank layer (**Exhibit 3-5**). Effluent from septic tanks that are in good condition should be comparable to secondarily treated wastewater effluent from sewage treatment plants. However, septic systems can be a source of pollutants, pathogens, and nutrients and are identified by FDEP as a potential source of bacteria and nutrients to waterbodies in its assessment processes. Within the Lake Munson basin, septic systems are generally clustered within neighborhoods outside of the City's incorporated area (**Exhibit 3-5**) but some are found within the City's incorporated areas.

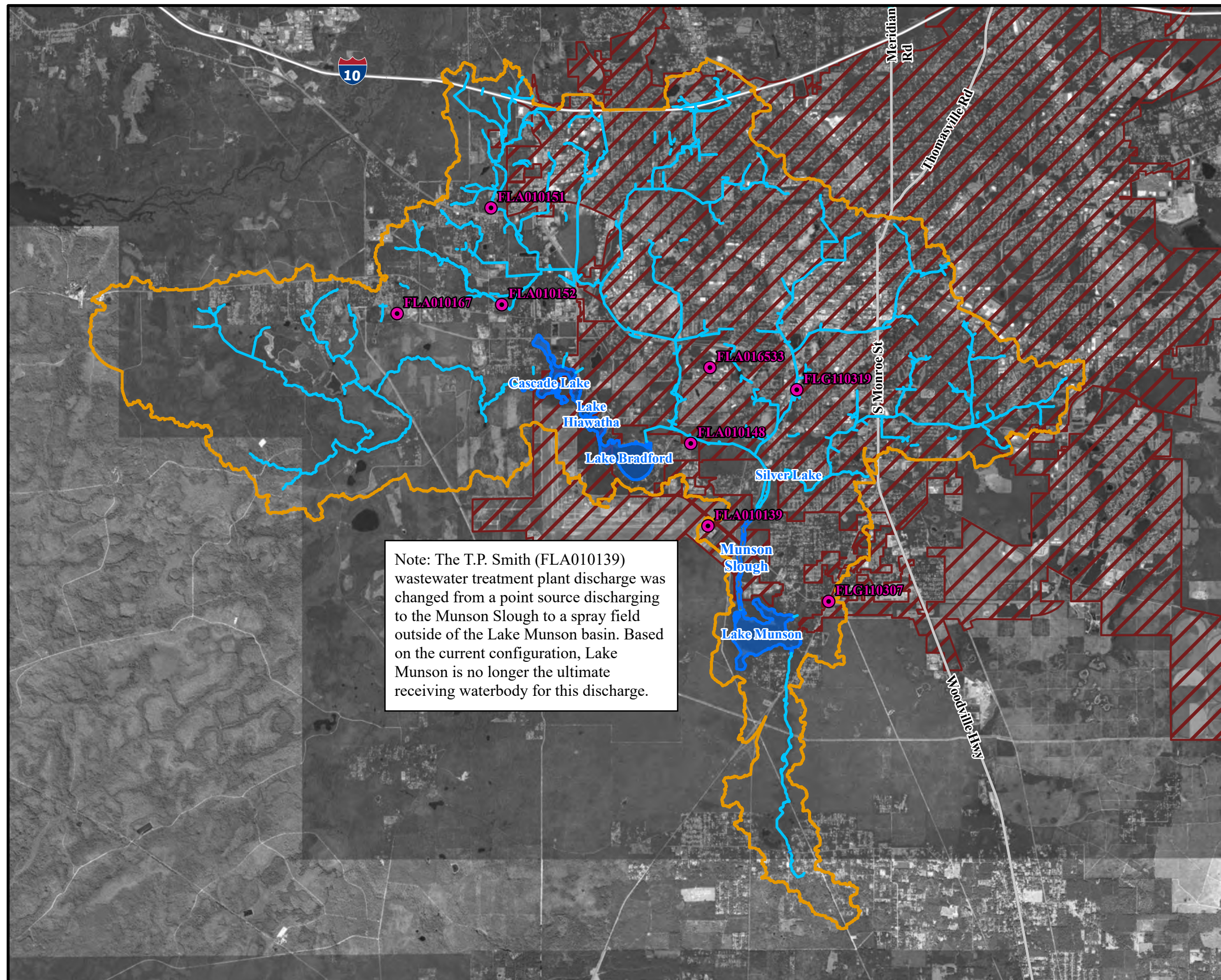
Nutrient loads to a waterbody are a function of the number of septic units, the number of people per household, the soil conditions in the area, groundwater table conditions, and if the systems are working properly. As discussed in **Section 3.4.3.3**, the predominant soil types within the areas where septic systems are clustered are Type A which have high infiltration potential. However, there are approximately 360 septic systems in areas of A/D or B/D soils which have low infiltration potential due to high groundwater tables.

3.4.3.5 Point Sources

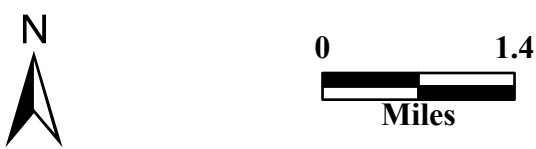
Permitted facilities within the Lake Munson basin were identified based on a facilities list provided by the City and information from FDEP's Oculus platform. **Figure 3-3** presents the locations of active permitted facilities identified within the Lake Munson basin. **Table 3-2** outlines the key facility attributes, including facility name, permit number, and the type of discharge (point discharge or land application). While the City's Thomas P. Smith Water Reclamation Facility is identified on the map due to its proximity to the Lake Munson basin, the associated sprayfield discharge is not within the basin and does not contribute to Lake Munson.

Table 3-2: Summary Table of Active Point Source Facilities within the Lake Munson Basin

Site Name	Permit Number	Discharge Type
Grand Village Mobile Home Park WWTP	FLA010151	Land
Lake Bradford Estates MHP WWTP	FLA010148	Land
National High Magnetic Field Lab FSU	FLA016533	Land
Sandstone Ranch WWTF	FLA010167	Land
Smyrna Ready Mix Concrete LLC SRM Plant 103	FLG110319	Point
Smyrna Ready Mix Concrete LLC SRM Plant 104	FLG110307	Point
TP Smith Water Reclamation Facility	FLA010139	Land
Western Estates MHP WWTP	FLA010152	Land



Note: The T.P. Smith (FLA010139) wastewater treatment plant discharge was changed from a point source discharging to the Munson Slough to a spray field outside of the Lake Munson basin. Based on the current configuration, Lake Munson is no longer the ultimate receiving waterbody for this discharge.



- Legend**
- Lake Munson Drainage Basin
 - Waterbodies in Study
 - Watercourses
 - Tallahassee Corporate Limits
 - Point Source Facilities

Sources:
Waterbodies: COT, 2020
Drainage Basins: COT, 2020
Roads: COT-Leon County, 2023
City Limits: COT, 2020
Point Source Facilities: COT, 2020

Figure 3-3:
Active Point Source Facilities within the Lake Munson Basin

Tallahassee Master Plan - Surface Water (TMaPS)



3.4.3.6 Hydrologic Data

Exhibit 3-6 presents the locations of hydrologic data stations utilized for this study within the Lake Munson basin per the NFWMD database. The exhibit shows the types of data available for each location, i.e. precipitation, stage, and/or flow. A table is provided on the exhibit that lists the station number, station name, type of data, and the start and end of the available record. For any station, there may be data gaps in the period of record identified.

There are four stations within the boundaries of the Lake Munson Drainage Basin that were utilized for precipitation data from the NFWMD database (**Exhibit 3-6**). The station with the longest record of available data is Station 011284, which is located in the immediate vicinity of Munson Slough and Lake Munson (**Exhibit 3-6**). While other stations in the area have a longer record (airport), the period of record for this station was of sufficient length for the purposes of this report.

Figure 3-4 presents the annual precipitation from 1987 through 2020 for Station 011284. Where gaps in the data at this station were found, they were filled in with data from the other stations where available. The data show that annual precipitation ranged from lows around 40 inches in various years up to a maximum of more than 80 inches in 2003. The average precipitation over this period was 59.5 inches.

There are eight stations within the Lake Munson basin that were utilized for this study from the NFWMD database (**Exhibit 3-6**). Of those eight stations, six are located along tributaries and two are located within lakes (Lake Munson, Lake Bradford). For the purposes of this report, stage data are only presented and discussed for the lakes. Flow data from the tributaries (calculated from measured stage) are presented and discussed below and in later sections.

The Lake Bradford stage data are presented and discussed in **Section 3.5.3.5**. Stage data for Lake Munson were available after 2013. **Figure 3-5** presents the measured water levels in the lake from 2013 through 2020. The influence of the control structure [shown as red line at 26.1 ft referenced to the North American Vertical Datum of 1988 (NAVD88)] can be seen in **Figure 3-5**, which shows levels relatively stable between 26 and 27 ft-NAVD88.

Dry-down periods can be seen in the latter part of 2015 and 2016 lasting between 2 and 3 months. Dry-down periods are defined as periods of time where the water elevation experienced a significant decrease below typical levels that are not intentional drawdown events. Typically, these are a result of periods of lower-than-normal rainfall or other environmental factors. Another dry-down period appears in 2020 but the data for that event is incomplete. In addition to periods of dry-down, at times the lake has been intentionally drawn down to oxidize sediments for the purpose of reducing internal loads to the lake. One such drawdown occurred around 2011 although data were not available for lake stage during that time period. Drawdown events typically bring water levels down to around 20.5 ft-NAVD88, well below the dry-down period levels shown in **Figure 3-5**.

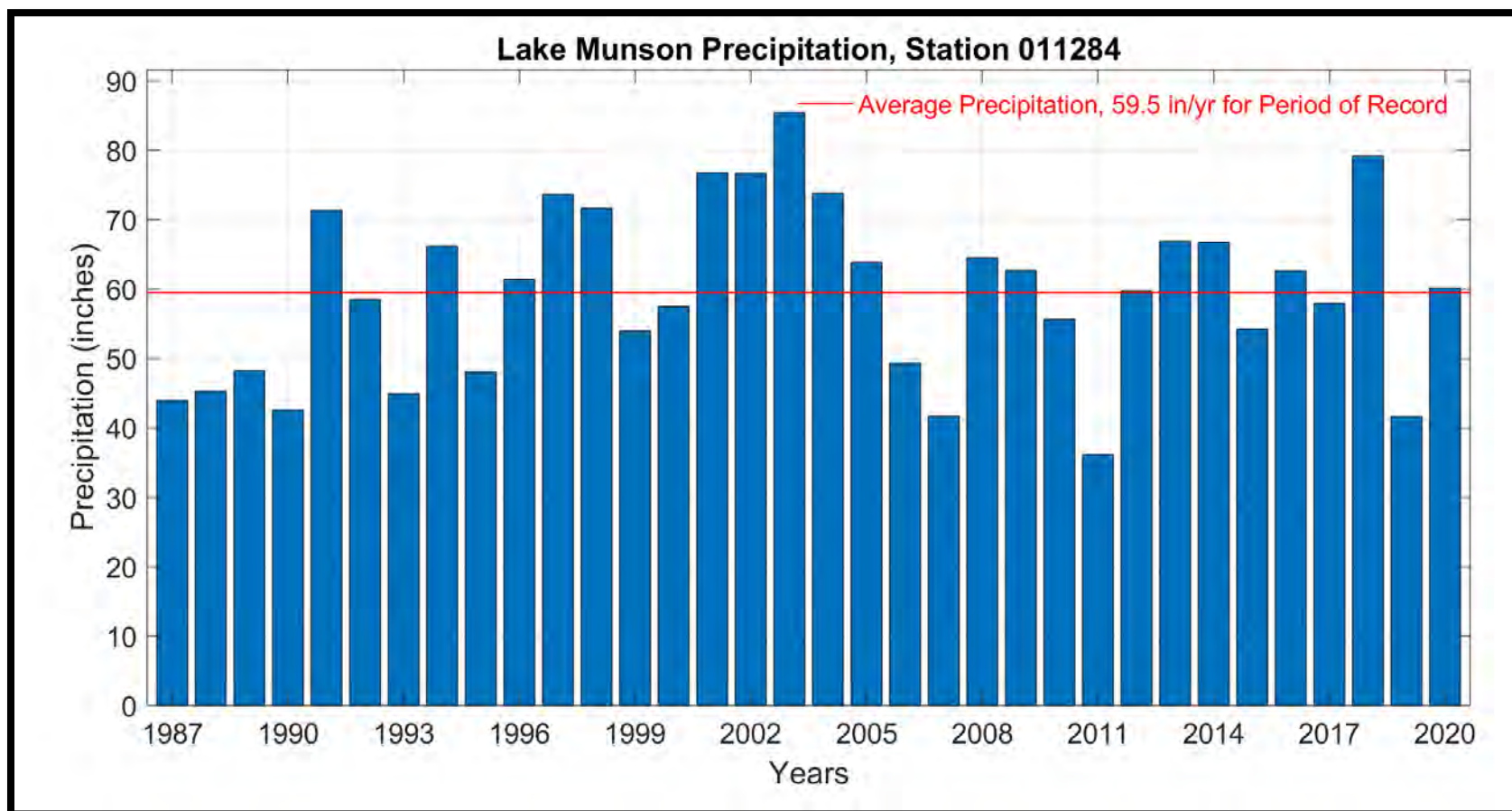


Figure 3-4: Annual Precipitation from Lake Munson Stations (1987 to 2020)

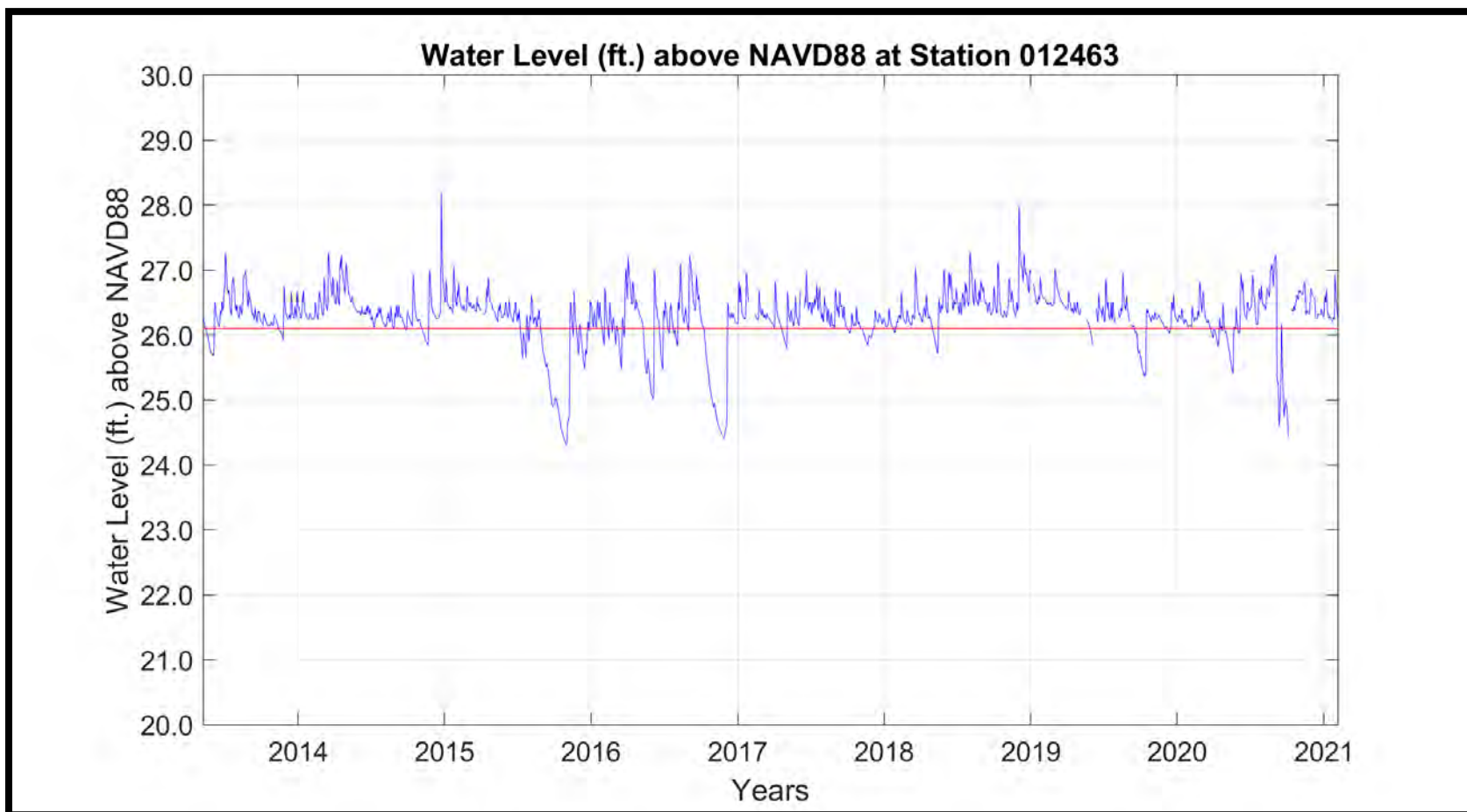


Figure 3-5: Measured Water Levels in Lake Munson (2013 to 2020) (Control Structure Elevation as Red Line)

Continuous flow data, calculated from measured stage and rating curves, were utilized from the NFWFMD database at six locations (**Exhibit 3-6**):

- Bradford Brook upstream of Cascade Lake along Aenon Church Road (008445),
- West Ditch at US 90 (008449),
- West Ditch at Rockerts Ave (008466),
- East Drainage Ditch at Adams St (008481),
- Munson Slough at Capitol Circle (008434), and
- Munson Slough at Oak Ridge Road (007736).

Flow data for these stations ranges from as early as 1987 up to the present. Some stations have significant data gaps over their period of record. Bradford Brook (008445) and East Drainage Ditch (008481) flows are presented and discussed in **Section 3.5.3.5** and **Section 3.6.3.5**, respectively. For the purposes of this section, flow data are presented for the stations upstream of Lake Munson along Munson Slough and within the West Ditch (008449, 008466, and 008434).

Figure 3-6 through **Figure 3-8** present plots of the calculated daily average flows at the three stations upstream of Lake Munson. The rapid hydrologic response of the basin (“flashiness”) is immediately evident in the flow data for the stations. However, with such a large basin and the large amount of hydraulic storage available within manmade stormwater facilities (like Lake Henrietta SWMF) and natural depression areas (like Black Swamp), flow responses can vary widely from gauge to gauge. Examination of the calculated flows on Munson Slough downstream of Lake Henrietta shows flows as high as 1800 cubic feet per second (cfs), with peak flows generally ranging between 200 cfs and 600 cfs. On the West Ditch at the downstream station, peak flows are as high as 1,000 cfs, with peak flows generally ranging between 200 cfs to 600 cfs. Upstream peak flows are proportionally similar.

The provided gauged flows are estimated from stage recordings and single-value (stage-flow) rating curves, which are unable to account for hysteresis. Due to the nature of the watershed, significant hysteresis is often present in flow response from a single storm event, meaning multiple flow rates are likely to occur at any given stage. These characteristics of the data development limit the accuracy of the flow data. Determinations made using the flow data must consider these known limitations.

3.4.3.7 Surface Water Quality Data

The water quality data used for this study were retrieved from the FDEP Impaired Waters Rule (IWR) and City databases. The IWR outlines FDEP’s methodology to identify waters that will be included in the 303(d) list. The IWR database is a collection of stations that are used to assess ambient water quality of surface waterbodies. The stations are not necessarily managed by FDEP, but any relevant data from various agencies are included for the purpose of collecting pertinent information for a given body of water.

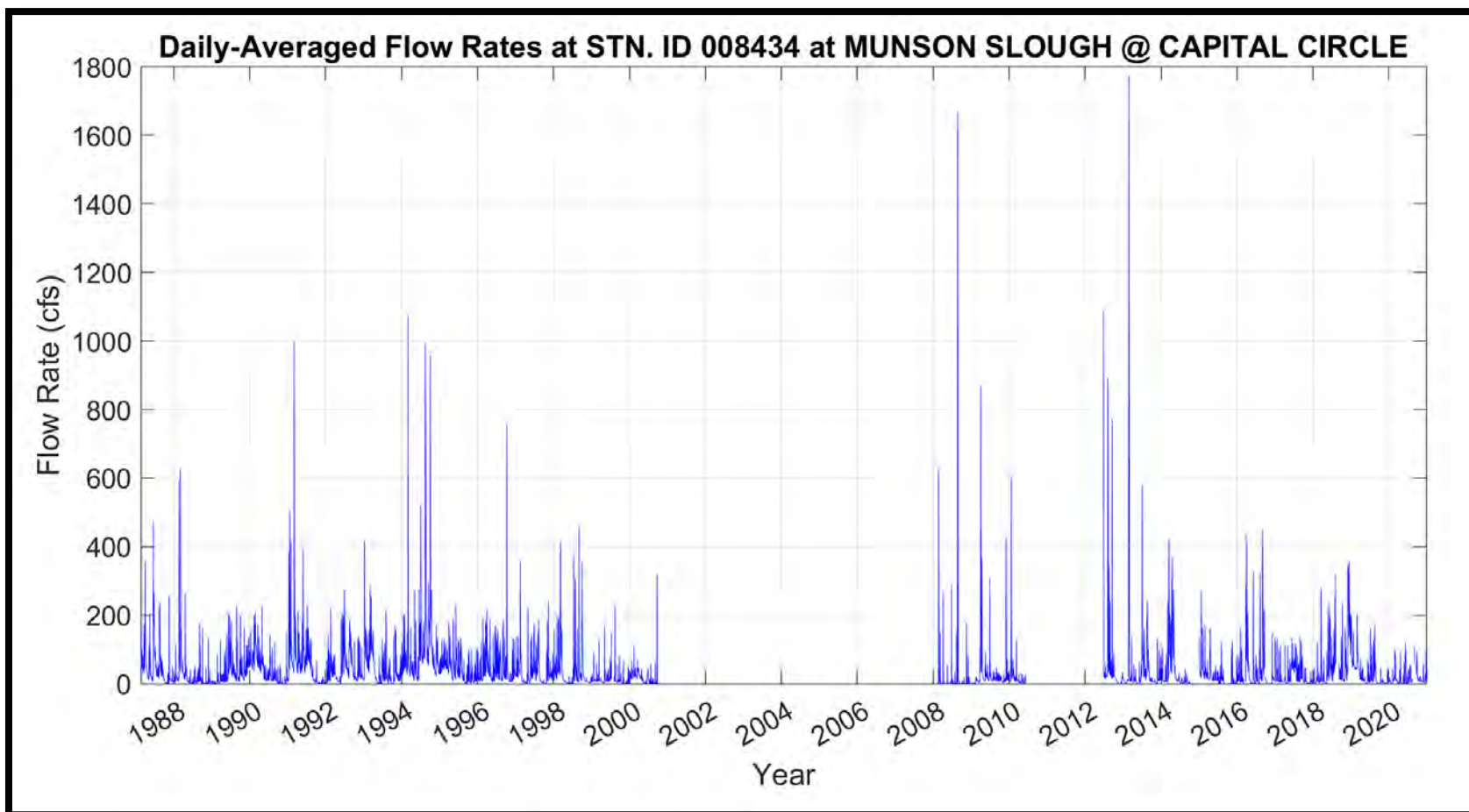


Figure 3-6: Daily Average Flows in Munson Slough Above Lake Munson (Station 008434) (1987 to 2020)

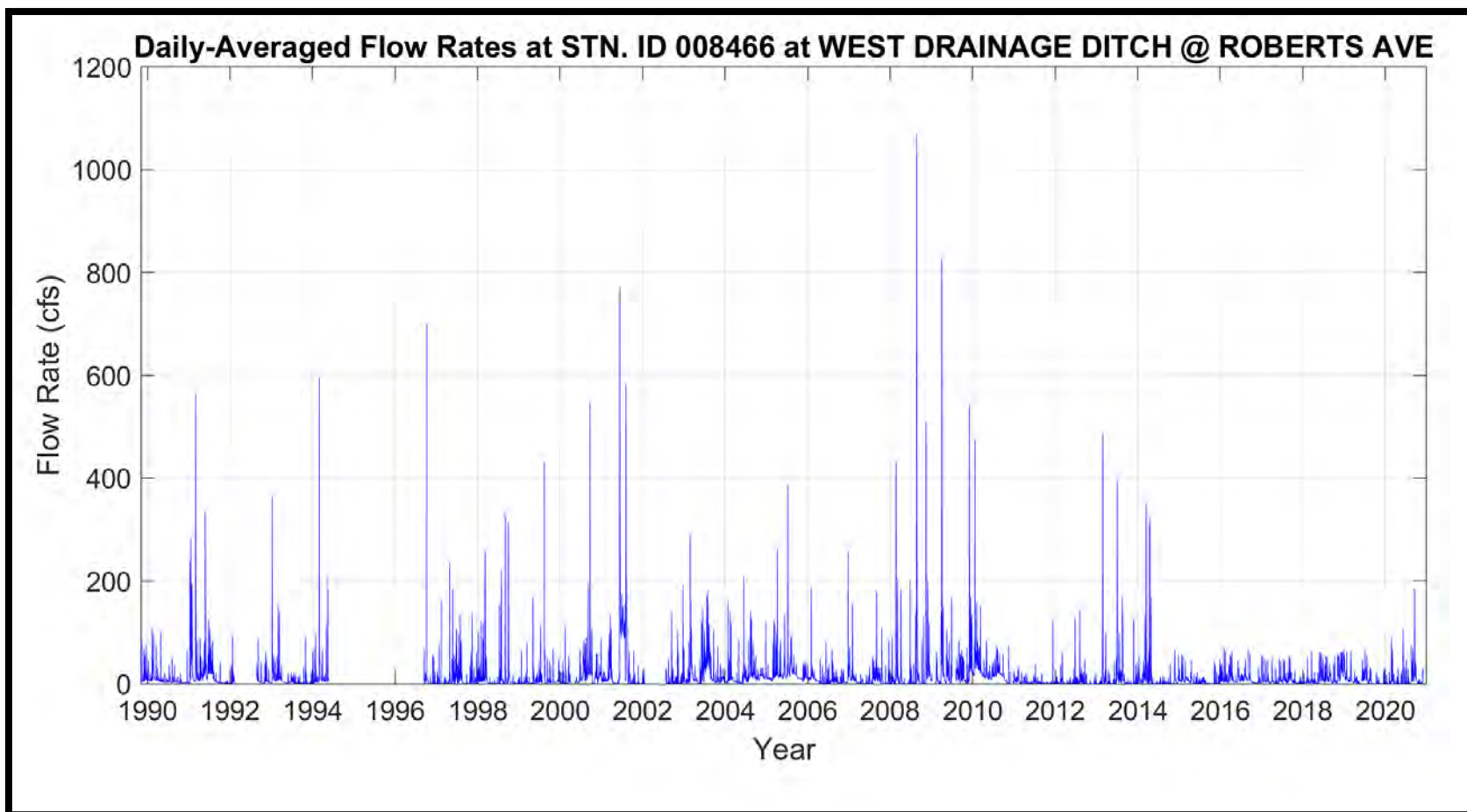


Figure 3-7: Daily Average Flows in West Drainage Ditch (Station 008466) (1990 to 2020)

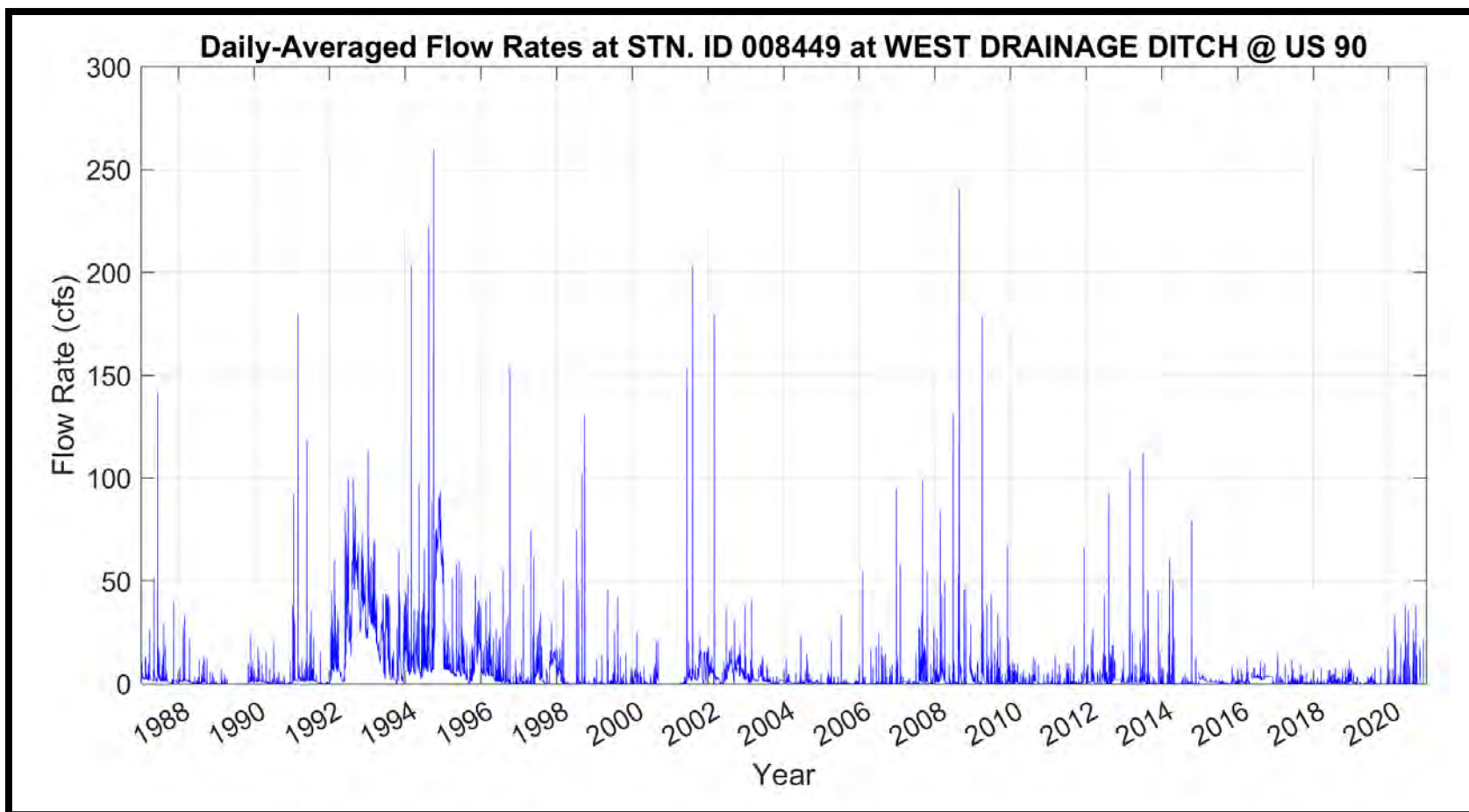


Figure 3-8: Daily Average Flows in West Drainage Ditch (Station 008449) (1987 to 2020)

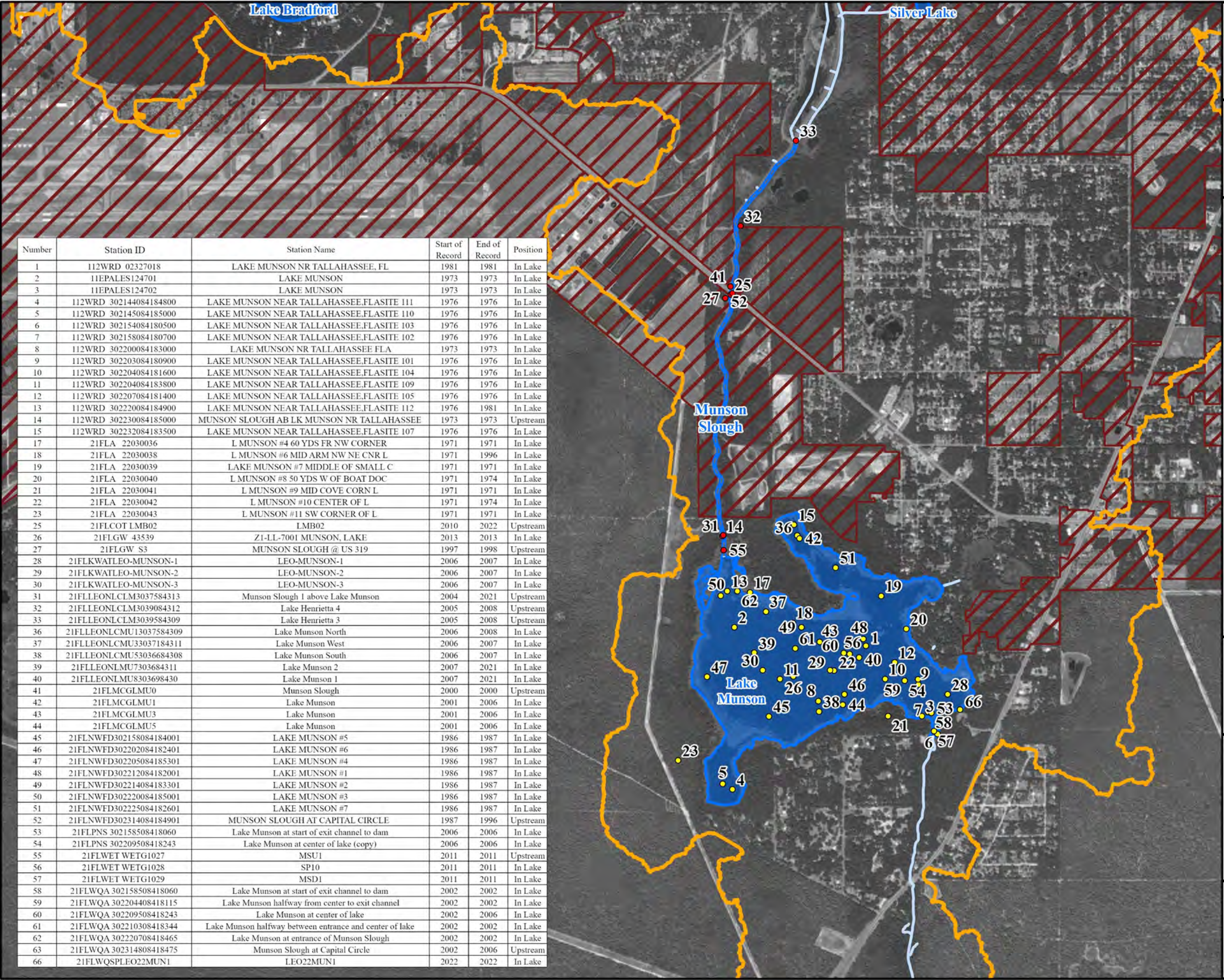
The water quality dataset for Lake Munson (WBID 807C) and Munson Slough (downstream of Lake Henrietta SWMF, part of WBID 807D) spans from 1971 to 2022 and includes contributions from local, state, and national agencies. The IWR contains multiple parameters that are monitored. For the purposes of this study, the primary parameters will be nutrients (and nutrient-related parameters) and fecal indicator bacteria (FIB). **Figure 3-9** presents the locations of in-lake water quality monitoring stations for Lake Munson (yellow), along with stations that provide water quality data along Munson Slough downstream of Lake Henrietta SWMF (red). A table is provided in **Figure 3-9** that shows the station identification (ID), station name, period of record, sample count, data source, and if the station represents in-lake or inflowing tributary data (upstream of the lake). The station locations are based on the latitude and longitude within the IWR database and at times are not fully accurate (see lake stations located on land in **Figure 3-9**).

Based on the number of stations and the length of the station IDs, station IDs were not provided directly on the figure, rather each of the stations is given a number and the numbers correspond to stations in the table. Stations within or upstream of other waterbodies in the Lake Munson basin that are targeted for evaluation in this study (**Exhibit 3-1**) are not shown in **Figure 3-9** (i.e., stations related to the Bradford Chain of Lakes or Silver Lake). These stations will be presented along with the discussions for the individual waterbodies in the sections to follow. Additionally, data upstream of Lake Henrietta SWMF are not presented because the target waterbodies (Munson Slough downstream of Lake Henrietta SWMF and Lake Munson) are downstream of the Lake Henrietta SWMF.

Figure 3-9 shows that there are stations located throughout Lake Munson from near the Munson Slough inflow on the northwestern side down to near the outfall on the southeast side. There are a few stations within the lobe on the northern side of the lake. Within Munson Slough (downstream of Lake Henrietta SWMF) there are a group of stations just upstream of where the slough flows into the lake with other stations downstream of Lake Henrietta SWMF down to the Capital Circle SW crossing. However, much of the data are older. Of the 56 in-lake stations only 4 (station numbers 26, 39, 40, 66) have data after 2010, and these are located in the west-central and east-central parts of the lake. No lake data after 2010 are available at the outfall or near the inflow of Munson Slough. In Munson Slough, data after 2010 are available at the Capital Circle SW crossing and just upstream of where the slough enters the lake.

For the surface water quality data plots and analyses, only data after 2010 are presented and analyzed since the focus of this master plan is present conditions. Therefore, only data from January 1, 2010, to December 31, 2020, were considered to best represent the waterbodies as they exist today and in the immediate past. Some discussions of the historical measurements are provided in the text that follows where significant changes have occurred.

Initial plots of the available data in Lake Munson and Munson Slough (downstream of Lake Henrietta SWMF) are provided below. This includes plots of the data and analyses of annual geometric means (AGM) against NNC criteria for both the lake and stream segments. As nutrients are the primary constituent of interest relative to water quality conditions in Lake Munson and Munson Slough (downstream of Lake Henrietta SWMF), plots are provided for the key parameters related to potential nutrient impairment. These include TN, TP, chlorophyll a (Chl-a), and TSI for Lake Munson and TP and TN for Munson Slough (downstream of Lake Henrietta SWMF).



Number	Station ID	Station Name	Start of Record	End of Record	Position
1	112WRD 02327018	LAKE MUNSON NR TALLAHASSEE, FL	1981	1981	In Lake
2	11EPALES124701	LAKE MUNSON	1973	1973	In Lake
3	11EPALES124702	LAKE MUNSON	1973	1973	In Lake
4	112WRD 302144084184800	LAKE MUNSON NEAR TALLAHASSEE,FLASITE 111	1976	1976	In Lake
5	112WRD 302145084185000	LAKE MUNSON NEAR TALLAHASSEE,FLASITE 110	1976	1976	In Lake
6	112WRD 302154084180500	LAKE MUNSON NEAR TALLAHASSEE,FLASITE 103	1976	1976	In Lake
7	112WRD 302158084180700	LAKE MUNSON NEAR TALLAHASSEE,FLASITE 102	1976	1976	In Lake
8	112WRD 302200084183000	LAKE MUNSON NR TALLAHASSEE FLA	1973	1973	In Lake
9	112WRD 302203084180900	LAKE MUNSON NEAR TALLAHASSEE,FLASITE 101	1976	1976	In Lake
10	112WRD 302204084181600	LAKE MUNSON NEAR TALLAHASSEE,FLASITE 104	1976	1976	In Lake
11	112WRD 302204084183800	LAKE MUNSON NEAR TALLAHASSEE,FLASITE 109	1976	1976	In Lake
12	112WRD 302207084181400	LAKE MUNSON NEAR TALLAHASSEE,FLASITE 105	1976	1976	In Lake
13	112WRD 302220084184900	LAKE MUNSON NEAR TALLAHASSEE,FLASITE 112	1976	1981	In Lake
14	112WRD 302230084185000	MUNSON SLOUGH AB LK MUNSON NR TALLAHASSEE	1973	1973	Upstream
15	112WRD 302232084183500	LAKE MUNSON NEAR TALLAHASSEE,FLASITE 107	1976	1976	In Lake
17	21FLA 22030036	L MUNSON #4 60 YDS FR NW CORNER	1971	1971	In Lake
18	21FLA 22030038	L MUNSON #6 MID ARM NW NE CNR L	1971	1996	In Lake
19	21FLA 22030039	LAKE MUNSON #7 MIDDLE OF SMALL C	1971	1971	In Lake
20	21FLA 22030040	L MUNSON #8 50 YDS W OF BOAT DOC	1971	1974	In Lake
21	21FLA 22030041	L MUNSON #9 MID COVE CORN L	1971	1971	In Lake
22	21FLA 22030042	L MUNSON #10 CENTER OF L	1971	1974	In Lake
23	21FLA 22030043	L MUNSON #11 SW CORNER OF L	1971	1971	In Lake
25	21FLCOT LMB02	LMB02	2010	2022	Upstream
26	21FLGW 43539	Z1-LL-7001 MUNSON, LAKE	2013	2013	In Lake
27	21FLGW S3	MUNSON SLOUGH @ US 319	1997	1998	Upstream
28	21FLKWATLEO-MUNSON-1	LEO-MUNSON-1	2006	2007	In Lake
29	21FLKWATLEO-MUNSON-2	LEO-MUNSON-2	2006	2007	In Lake
30	21FLKWATLEO-MUNSON-3	LEO-MUNSON-3	2006	2007	In Lake
31	21FLLEONCLM3037584313	Munson Slough 1 above Lake Munson	2004	2021	Upstream
32	21FLLEONCLM3039084312	Lake Henrietta 4	2005	2008	Upstream
33	21FLLEONCLM3039584309	Lake Henrietta 3	2005	2008	Upstream
36	21FLLEONLCMU13037584309	Lake Munson North	2006	2008	In Lake
37	21FLLEONLCMU33037184311	Lake Munson West	2006	2007	In Lake
38	21FLLEONLCMU53036684308	Lake Munson South	2006	2007	In Lake
39	21FLLEONLMU7303684311	Lake Munson 2	2007	2021	In Lake
40	21FLLEONLMU8303698430	Lake Munson 1	2007	2021	In Lake
41	21FLMCGLMU0	Munson Slough	2000	2000	Upstream
42	21FLMCGLMU1	Lake Munson	2001	2006	In Lake
43	21FLMCGLMU3	Lake Munson	2001	2006	In Lake
44	21FLMCGLMU5	Lake Munson	2001	2006	In Lake
45	21FLNWFD302158084184001	LAKE MUNSON #5	1986	1987	In Lake
46	21FLNWFD302202084182401	LAKE MUNSON #6	1986	1987	In Lake
47	21FLNWFD302205084185301	LAKE MUNSON #4	1986	1987	In Lake
48	21FLNWFD302212084182001	LAKE MUNSON #1	1986	1987	In Lake
49	21FLNWFD302214084183301	LAKE MUNSON #2	1986	1987	In Lake
50	21FLNWFD302220084185001	LAKE MUNSON #3	1986	1987	In Lake
51	21FLNWFD302225084182601	LAKE MUNSON #7	1986	1987	In Lake
52	21FLNWFD302314084184901	MUNSON SLOUGH AT CAPITAL CIRCLE	1987	1996	Upstream
53	21FLPNS 302158508418060	Lake Munson at start of exit channel to dam	2006	2006	In Lake
54	21FLPNS 302209508418243	Lake Munson at center of lake (copy)	2006	2006	In Lake
55	21FLWET WETG1027	MSU1	2011	2011	Upstream
56	21FLWET WETG1028	SP10	2011	2011	In Lake
57	21FLWET WETG1029	MSD1	2011	2011	In Lake
58	21FLWQA 302158508418060	Lake Munson at start of exit channel to dam	2002	2002	In Lake
59	21FLWQA 302204408418115	Lake Munson halfway from center to exit channel	2002	2002	In Lake
60	21FLWQA 302209508418243	Lake Munson at center of lake	2002	2006	In Lake
61	21FLWQA 302210308418344	Lake Munson halfway between entrance and center of lake	2002	2002	In Lake
62	21FLWQA 302220708418465	Lake Munson at entrance of Munson Slough	2002	2002	In Lake
63	21FLWQA 302314808418475	Munson Slough at Capital Circle	2002	2006	Upstream
66	21FLWQSPLEO22MUN1	LFO22MUN1	2022	2022	In Lake



Legend

Lake Munson Major Drainage Basin

Waterbodies in Study

Watercourses

Tallahassee Corporate Limits

Water Quality Stations

Position

In-Lake

Upstream of Lake

Sources:
Waterbodies: COT, 2020
Watercourses: COT, 2020
Drainage Basins: COT, 2020
Roads: COT-Leon County, 2023
City Limits: COT, 2020
WQ Stations: FDEP, 2022

Figure 3-9:
Lake Munson and Munson Slough (below
Lake Henrietta) Water Quality Station
Location Map

Tallahassee Master Plan - Surface
Water (TMaPS)



Additionally, based on interest in the area relative to septic systems and other sources, FIB, specifically *E. coli*, are included. Through the analysis of the TN data for this study, issues were identified relative to how certain total Kjeldahl nitrogen (TKN) data were used in the calculation of TN. **Appendix A** presents a short write up of the issues encountered and how they were rectified to get the TN levels utilized in the analyses below. Additional data plots and analyses are also provided as part of the qualitative assessment of sources in **Section 3.4.4**.

Figure 3-10 through **Figure 3-12** presents plots of the measured TN, TP, and Chl-a data. Examination of the plots shows that the lake saw a significant shift in nutrient and Chl-a concentrations after 2016. For all three parameters, the data after 2016 show significant reductions and downward trends, with the lowest values generally seen in the latter years up to 2020.

Figure 3-13 and **Figure 3-14** present plots of the measured TN and TP data for Munson Slough downstream of Lake Henrietta SWMF. Examination of the plots shows that like the lake data, there are clear downward trends in the TN and TP coming into the lake after 2016. The changes are not as pronounced as those seen in the lake, and the changes tend to be seen after 2017.

Under FDEP's NNC, Lake Munson is defined as a high color system with a long-term geomean true color above 40 platinum-cobalt units (PCUs). Based on this designation, the AGM threshold for Chl-a is 20 micrograms per liter ($\mu\text{g/L}$). For TN and TP, a range of concentrations are allowed, based on maintaining Chl-a concentrations below 20 $\mu\text{g/L}$. For TN, the range is 1.27 milligram per liter (mg/L) to 2.23 mg/L . For TP, the range is 0.05 mg/L to 0.16 mg/L . If Lake Munson did not have site-specific alternative nutrient criteria (see discussion below), TN or TP levels below the minimum indicate the system is not impaired for either parameter, levels above the maximum would indicate impairment, measurements in between would be allowable so long as the Chl-a levels that coincide with the nutrient concentrations are below the 20 $\mu\text{g/L}$ threshold.

If Munson Slough did not have site-specific alternative nutrient criteria (see discussion below), the NNC criteria for a stream segment within the Panhandle East Nutrient Region would apply. These are TN below 1.03 mg/L and TP below 0.18 mg/L . It should also be noted that for a stream segment to be deemed impaired, biological data [Stream Condition Index (SCI)] would also need to indicate the system is imbalanced.

Historically, FDEP utilized TSI as a metric for determination of lake impairment due to nutrients. TSI is a classification system designed to "rate" lakes based on the amount of biological productivity occurring in the waterbody, with higher TSI values indicative of more productive lakes. The calculations are based on a scale from 1 to 100. Lakes with TSI values less than 60 were considered good, lakes with values between 60 and 69 were considered fair, and lakes with values greater than 70 were considered poor. While no longer utilized for assessment of impairment, the TSI index remains a tool for evaluating potential nutrient enrichment and biological productivity. Therefore, data on TSI are presented against the thresholds listed above.

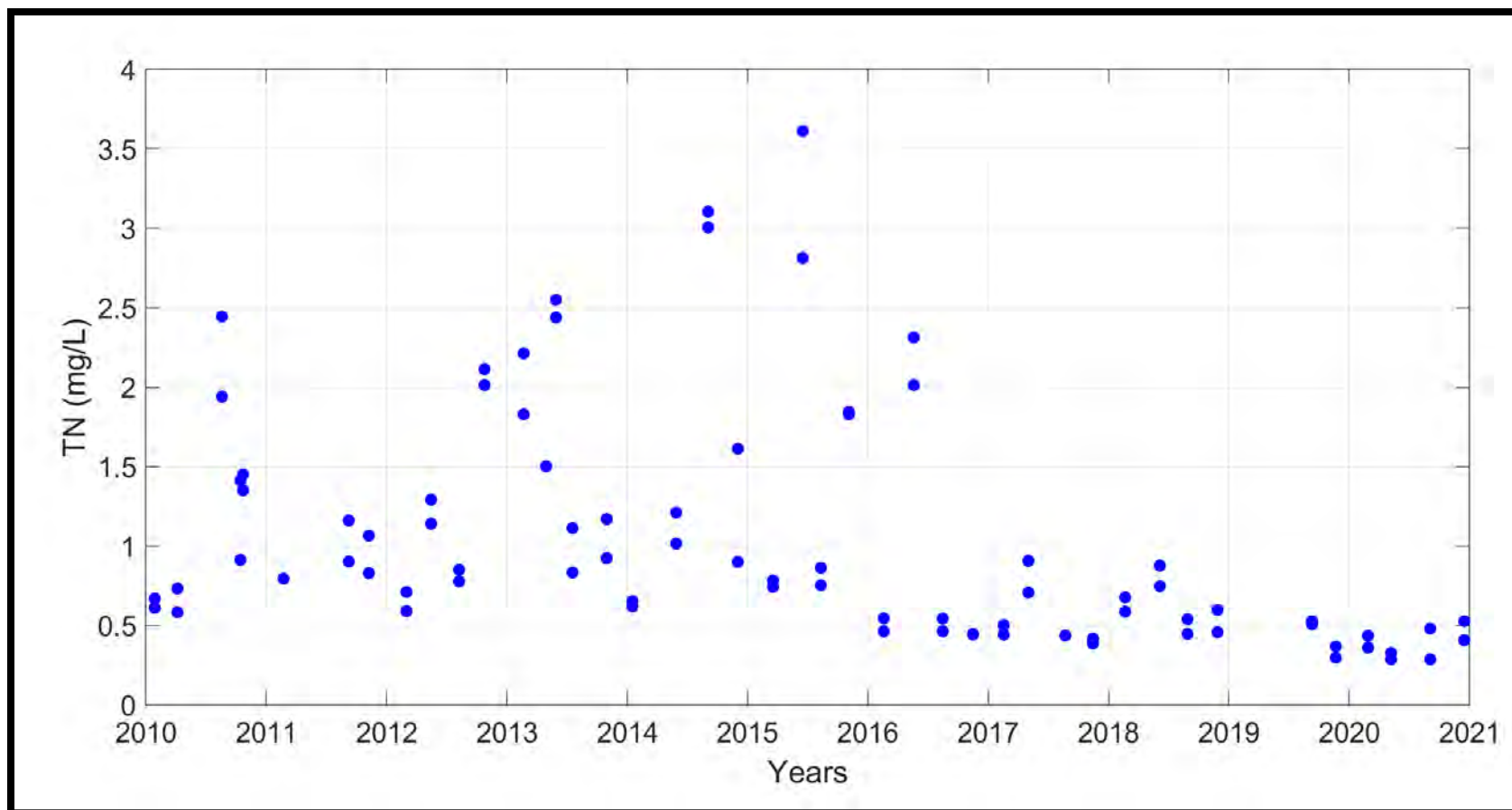


Figure 3-10: Plot of Measured TN in Lake Munson

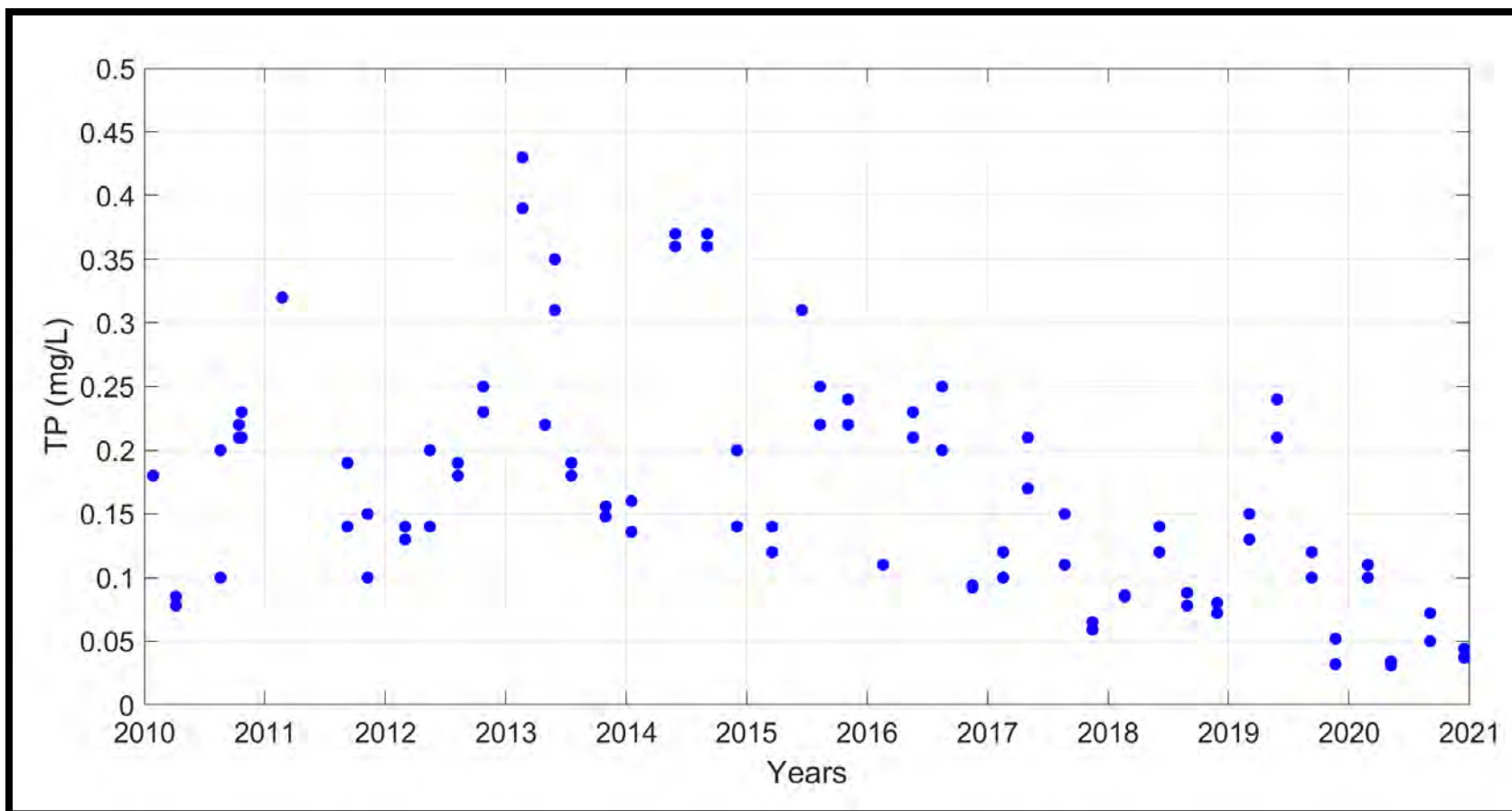


Figure 3-11: Plot of Measured TP in Lake Munson

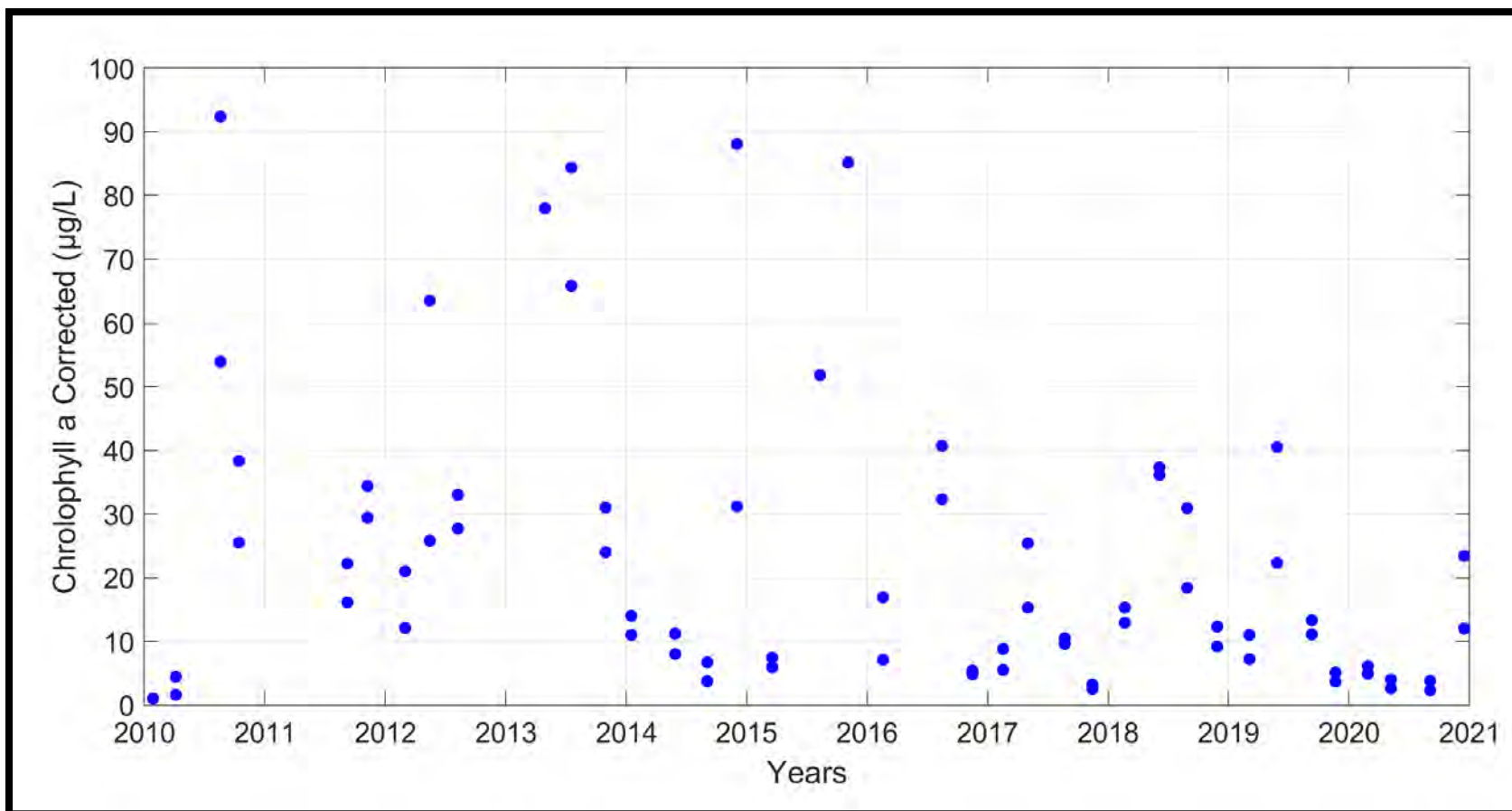


Figure 3-12: Plot of Measured Chl-a Lake Munson

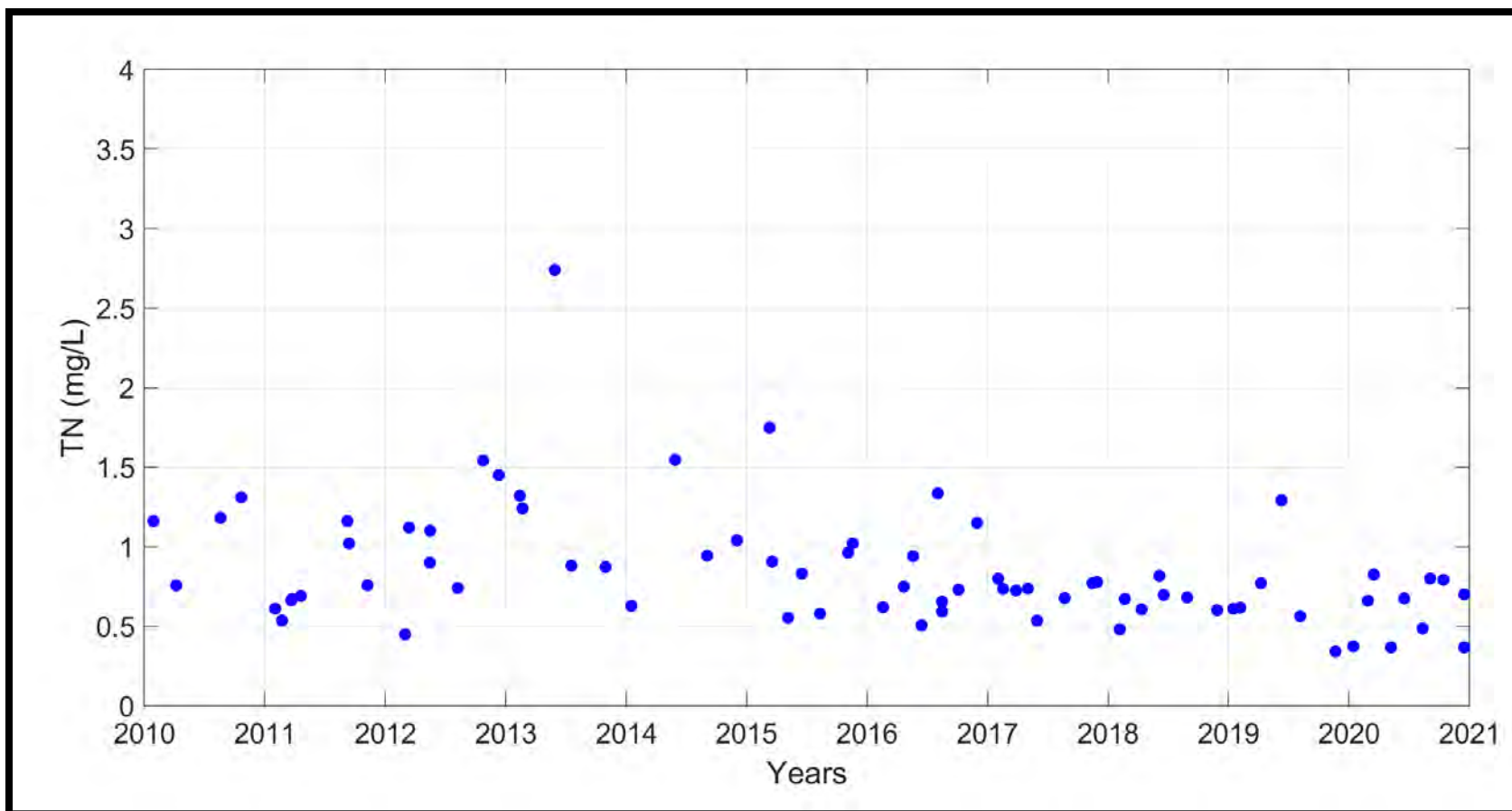


Figure 3-13: Plot of Measured TN in Munson Slough downstream of Lake Henrietta SWMF

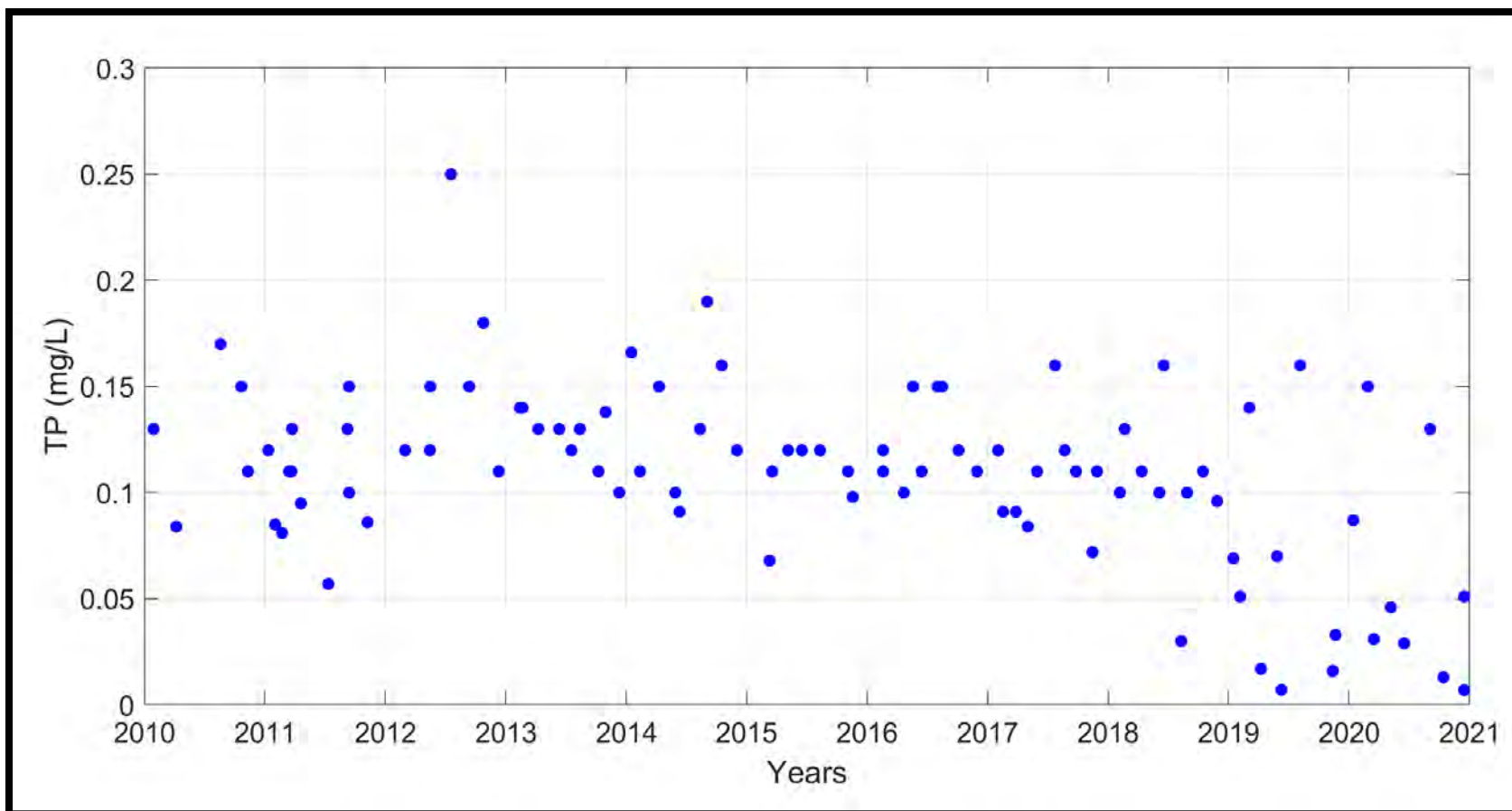


Figure 3-14: Plot of Measured TP in Munson Slough downstream of Lake Henrietta SWMF

As identified above, NNC criteria can be replaced by site-specific criteria developed in a TMDL. This is the case for Lake Munson and Munson Slough. The TMDLs for Lake Munson (WBID 807C) and Munson Slough (above and below Lake Munson, WBID 807D and WBID 807) (FDEP 2013) targeted DO in Munson Slough above Lake Munson, DO, nutrients (TSI), and turbidity in Lake Munson, and DO and un-ionized ammonia for Munson Slough below Lake Munson. The TMDLs within Munson Slough utilized EPA reference stream targets for TN and TP. The TMDL targets for Munson Slough above Lake Munson were 0.72 mg/L TN and 0.15 mg/L TP (**Table 3-3**). For the TMDL for Lake Munson, relationships were developed between TN, TP and Chl-a based on observed data from 2004 to 2008 along with loading from a spreadsheet model of the basin between 2000 and 2007. Based on achieving a targeted TSI of 56 and a TN:TP ratio of 17, the targets for in-lake concentrations for the TMDL were 0.044 mg/L TP, 0.76 mg/L TN and 21.7 µg/L Chl-a (**Table 3-3**). The targeted TSI for the lake was 56, which is just below the TSI threshold of 60 discussed above. The TMDL targets for TN and TP are below the presently defined minimums under the NNC for Lake Munson (0.05 mg/L TP and 1.27 mg/L TN).

Table 3-3: Comparison of TMDL and NNC Targets and Basis for Munson Slough and Lake Munson

Parameter	Waterbody	TMDL Target/Basis	NNC Targets
TN	Munson Slough	0.72 mg/L	1.03 mg/L
TP	Munson Slough	0.15 mg/L	0.18 mg/L
TN	Lake Munson	0.76 mg/L	1.27 – 2.23 mg/L
TP	Lake Munson	0.044 mg/L	0.05 – 0.16 mg/L
Chl-a	Lake Munson	21.7 µg/L (basis)	20 µg/L
TSI	Lake Munson	56 (basis)	<60 (old rule)

For *E. coli*, the criteria are monthly geometric means below 126 colonies per 100 milliliters (mL) of water and less than 10 percent of samples above 410 colonies per 100 mL of water in any 30-day period. Generally, insufficient samples are available to assess the monthly geometric means, therefore, the criteria most used for assessing *E. coli* is the 410 colonies per 100 mL. For the purposes of this report, the *E. coli* are presented against the 410 threshold to see if more than 10 percent of the available data are above it.

TN, TP, and Chl-a AGMs for Lake Munson and Munson Slough are plotted in **Figure 3-15** through **Figure 3-19**. For Munson Slough, only TN and TP are provided as they are the primary constituents for assessing loading to Lake Munson. Where sufficient data are available (based generally on the IWR rule requirements) to assess the AGMs, the levels are provided. The Chl-a threshold and the minimum and maximum thresholds for TN and TP relative to the NNC are provided on each of the graphs as pink dashed lines and listed in **Table 3-3**. Additional threshold lines are provided for the TMDL targets.

Examination of the TN plot for Lake Munson (**Figure 3-15**) shows that between 2010 and 2015, the AGM values were just above or below the minimum NNC criteria but above the TMDL target. After 2015, the TN levels in the lake drop significantly such that all of the calculated AGMs were below the TMDL threshold. Historically, prior to removal of the wastewater treatment facility discharges (around 1980), TN levels were significantly higher than the levels shown in **Figure 3-15**. Following removal, the levels dropped down to between the minimum and maximum NNC thresholds.

TP AGMs (**Figure 3-16**) show a similar pattern, with values from 2010 to 2015 at or above the NNC maximum threshold (0.16 mg/L). After 2015, the levels drop steadily, with values between the minimum and maximum NNC threshold up to 2020, where the levels were right around the minimum NNC threshold (0.05 mg/L) and the TMDL target (0.044 mg/L). As with the TN levels, prior to the removal of wastewater discharges, TP levels were well above the NNC maximum threshold and have been dropping since, although levels were somewhat steady between 1996 and 2015 before continuing to decrease.

The corrected Chl-a plot (**Figure 3-17**) shows that since 2010, the Chl-a AGMs have fluctuated significantly, with levels well above the 20 µg/L threshold to values below the threshold. Since 2015, the levels have remained lower, with the values from 2017 to 2020 below the 20 µg/L such that in the recent years, the 20 µg/L target has been met despite the TP TMDL threshold of 0.044 mg/L not being met. This conflict in meeting thresholds might suggest that Lake Munson is nitrogen limited, which is discussed further with the TSI plots below. It is noted that in a 2016 study of Lake Munson performed by ERD, the TN/TP ratios at the time were within the range that favors cyanobacteria growth, which is a nitrogen fixer. The study noted that due to the significantly elevated TP concentrations, nitrogen limited conditions are unlikely to occur.

The TN plot for Munson Slough downstream of Lake Henrietta SWMF (**Figure 3-18**) shows that between 2010 and 2016, the AGMs were above the TMDL threshold of 0.72 mg/L, while above and below the NNC threshold of 1.03 mg/L. Between 2017 and 2020, all the AGMs were below the TMDL threshold. As discussed in **Section 3.4.2**, based on the AGM values below the TMDL threshold, Munson Slough was placed in Category 2t as meeting the TMDL.

Historically, following the removal of the wastewater discharges, the TN levels in Munson Slough have been low (generally below the maximum NNC threshold and at times below the minimum).

The TP plot for Munson Slough downstream of Lake Henrietta SWMF (**Figure 3-19**) shows that TP AGMs in Munson Slough (downstream of Lake Henrietta SWMF) have in all but one year been below the TMDL threshold of 0.15 mg/L. All AGMs are below the NNC stream threshold (0.18 mg/L). In 2019 and 2020, the AGMs have been near the lake TMDL target and NNC minimum threshold of 0.044 mg/L and 0.05 mg/L, respectively. Historically, following the removal of the wastewater discharges, the TP levels in Munson Slough dropped significantly. Since that time (after 1990), levels have generally been dropping (with some low years), with levels after 2000 below the NNC threshold.

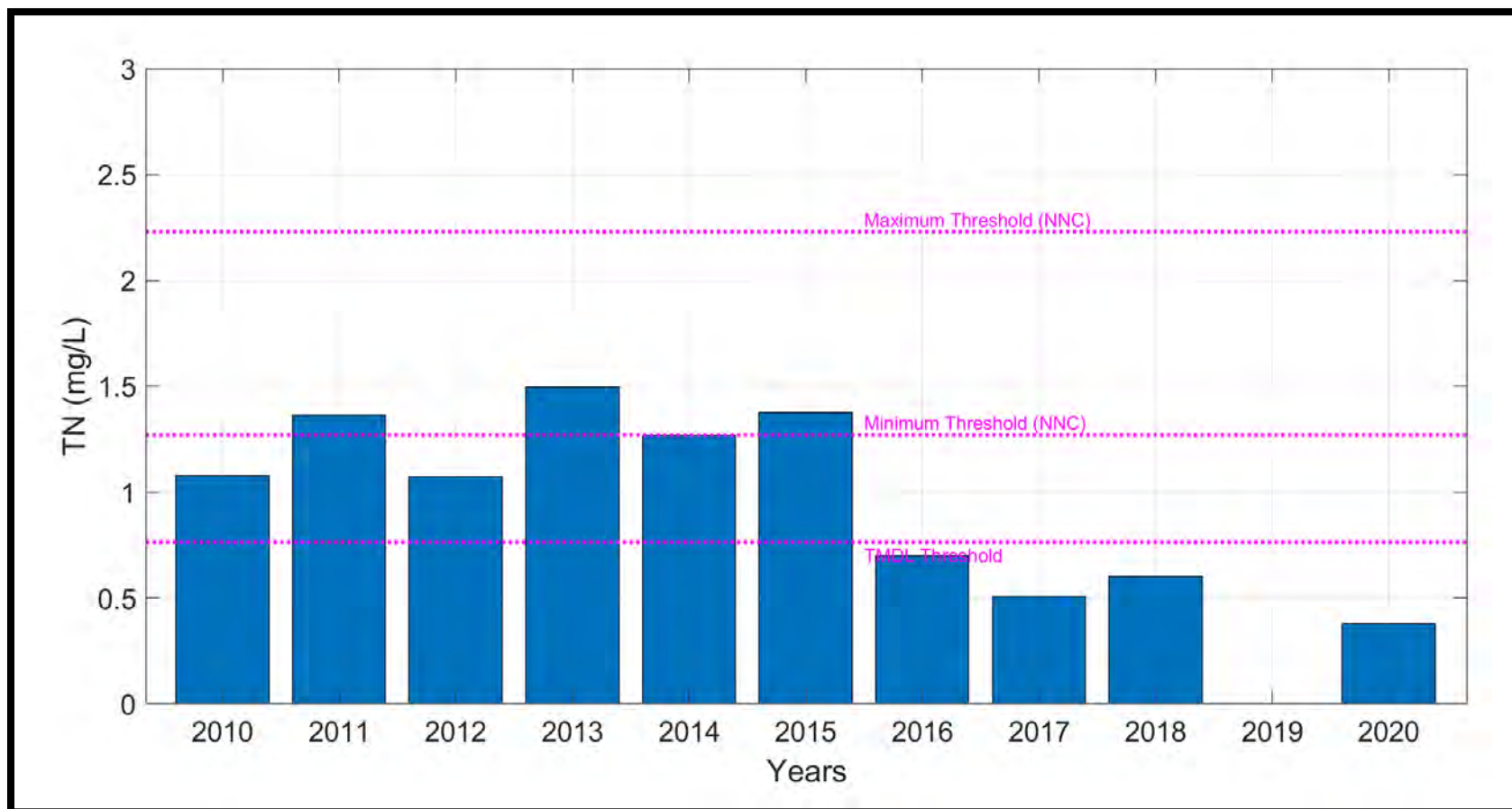


Figure 3-15: Plot of Annual Geometric Means for TN with NNC Criteria for Lake Munson

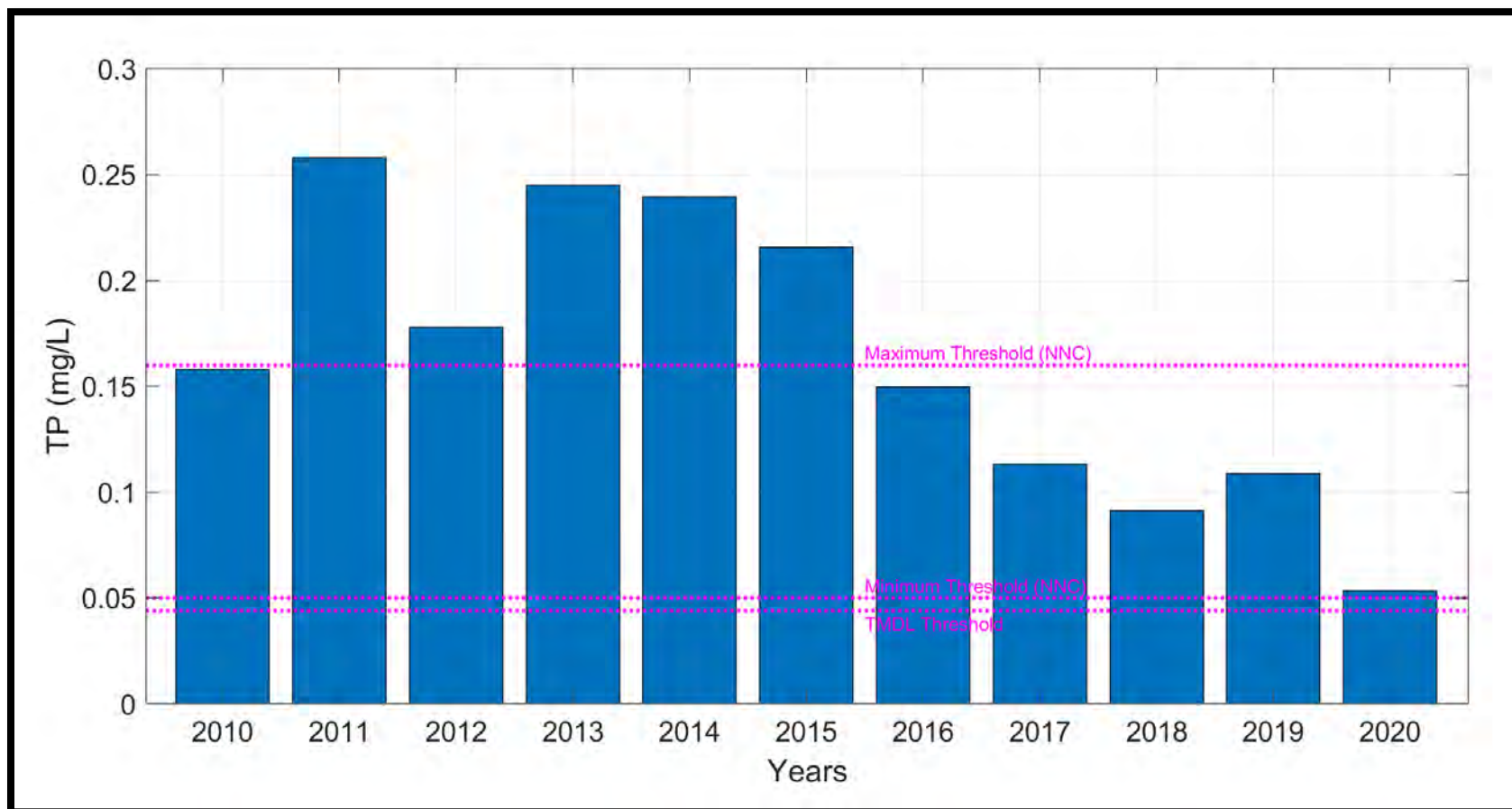


Figure 3-16: Plot of Annual Geometric Means for TP with NNC Criteria for Lake Munson

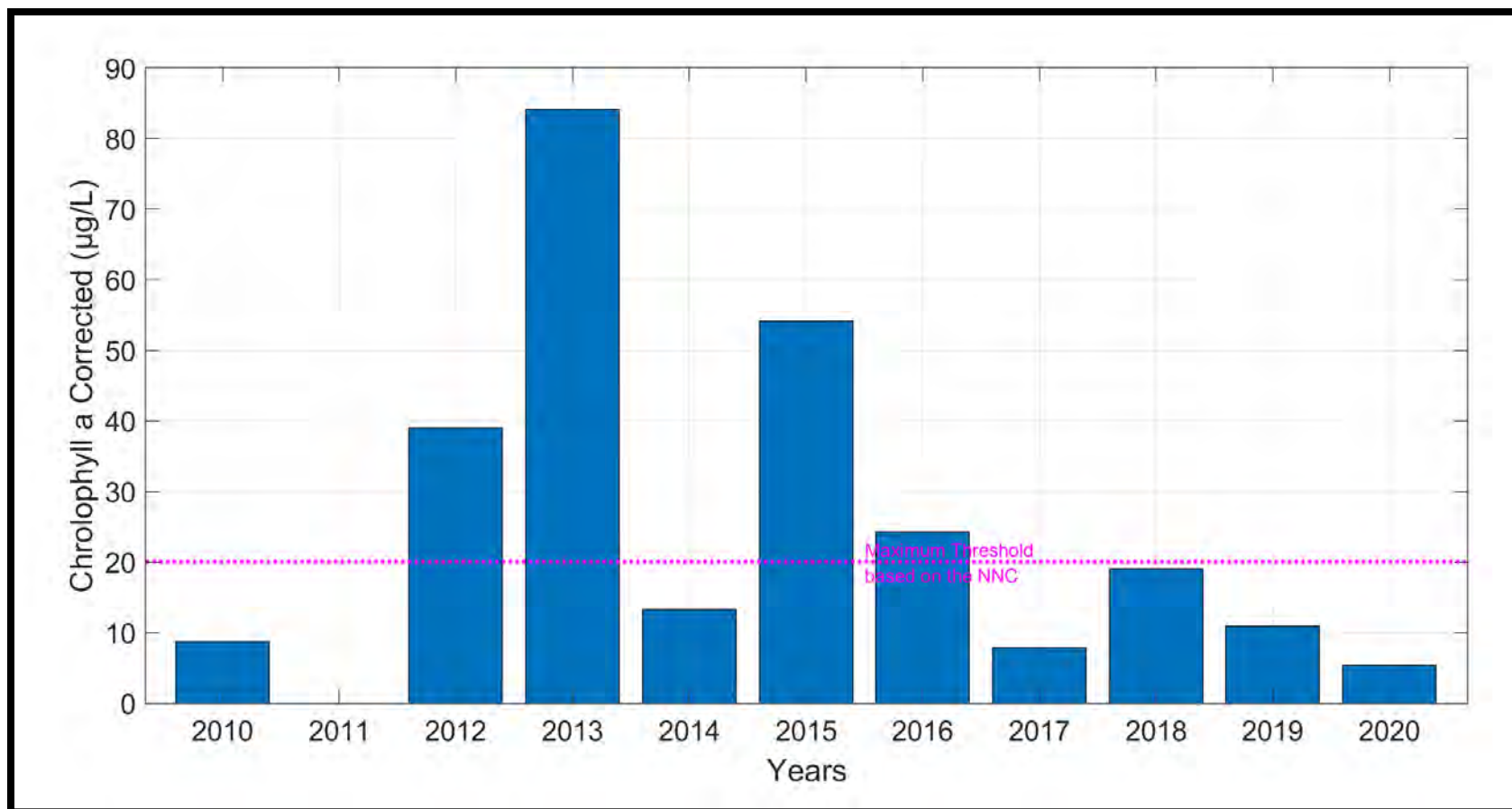


Figure 3-17: Plot of Annual Geometric Means for Chl-a with NNC Criteria for Lake Munson

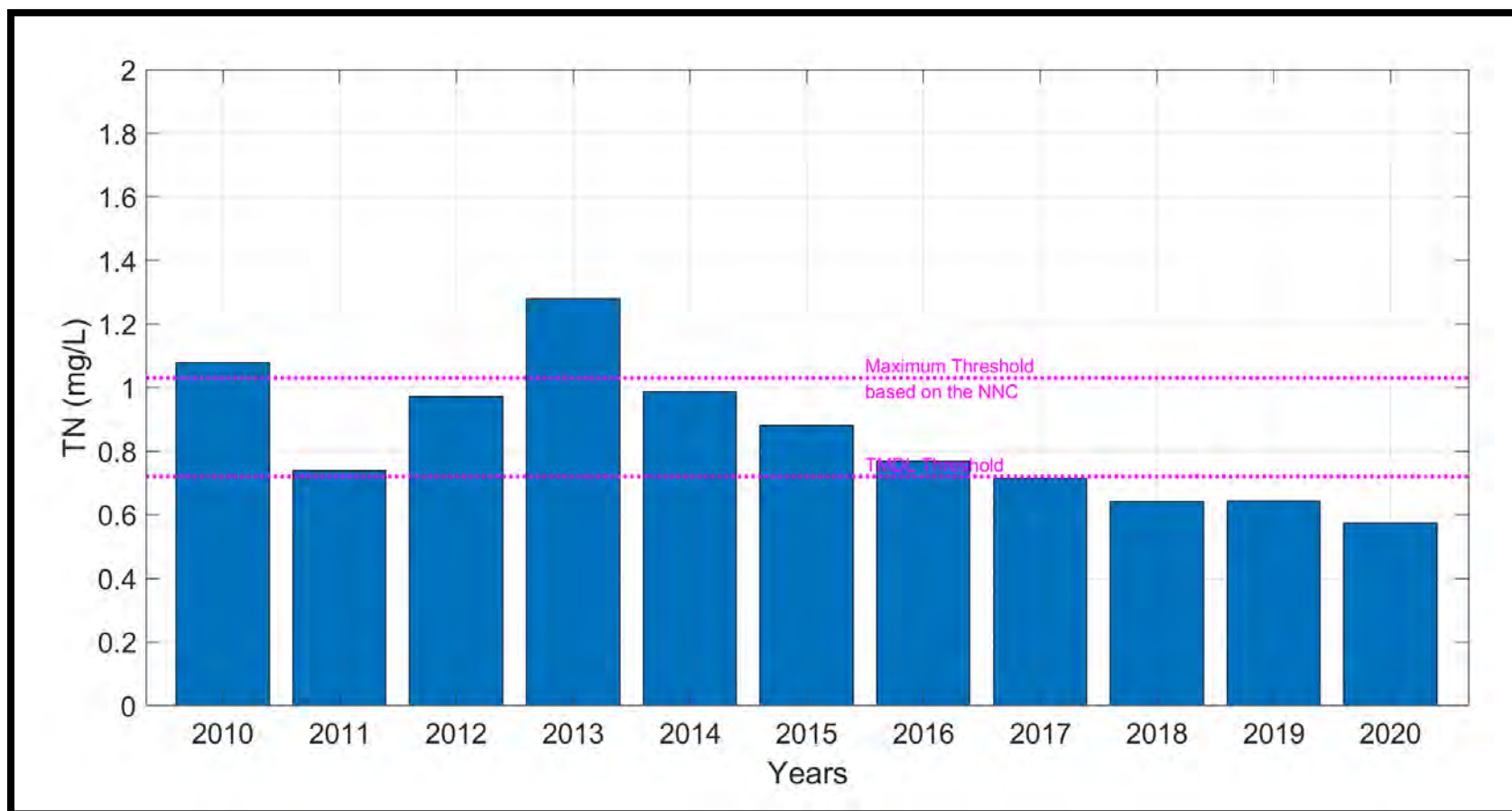


Figure 3-18: Plot of Annual Geometric Means for TN with NNC Criteria for Munson Slough downstream of Lake Henrietta SWMF

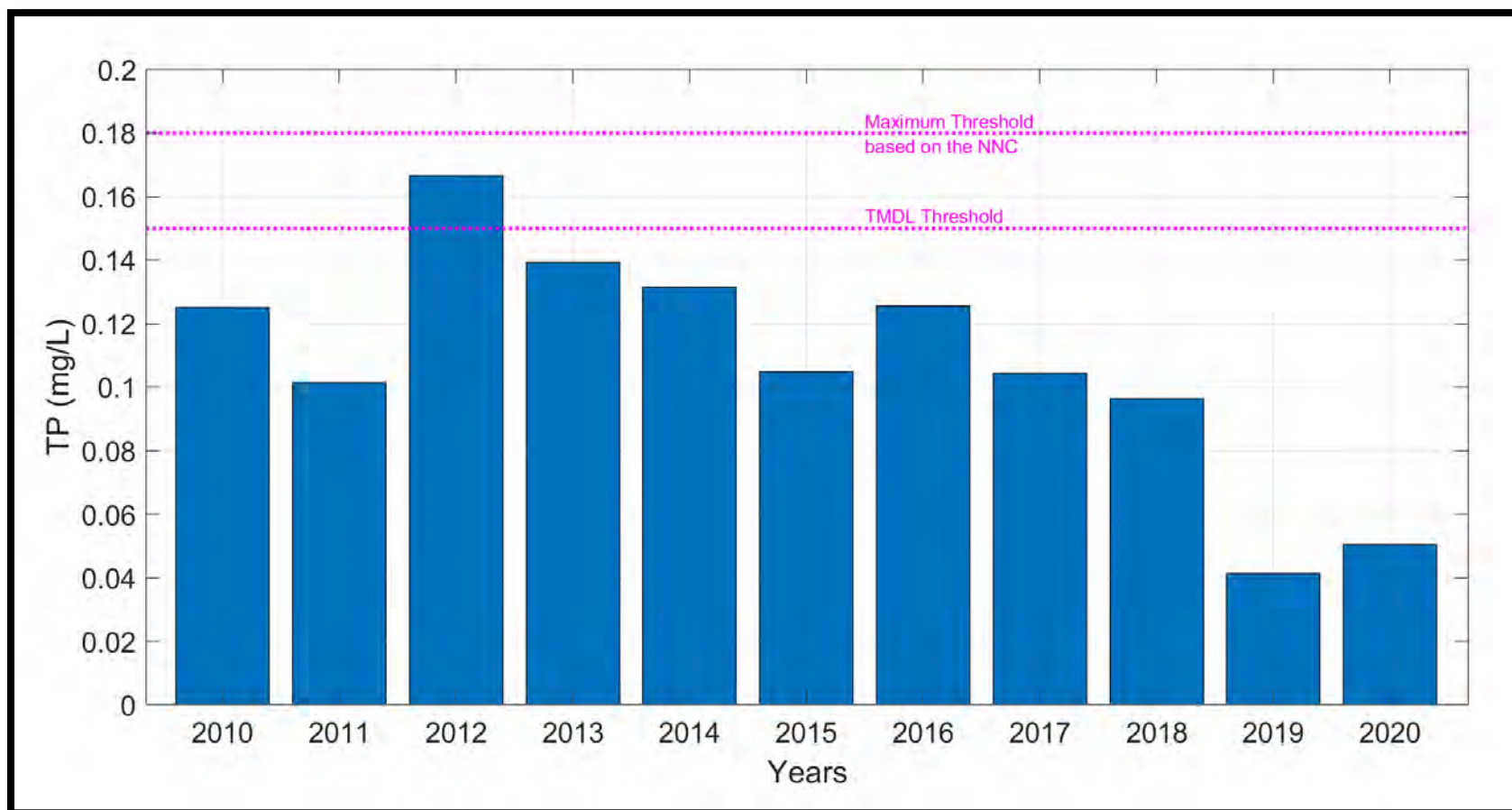


Figure 3-19: Plot of Annual Geometric Means for TP with NNC Criteria for Munson Slough downstream of Lake Henrietta SWMF

Figure 3-20 presents a plot of calculated TSI values in the lake. Examination of the TSI plot shows that between 2010 and 2016, the TSI levels fluctuated between good to poor, with some levels up as high as over 90. Between 2016 through 2020 (as was seen in the nutrient and Chl-a levels), the TSI values have steadily dropped to where after mid-2018, all values are good. The data indicate nitrogen limited conditions in the lake as constant over time, with only a few times where it moved into the area of nutrient balanced. At no time from 2010 through 2020 do the TSI data indicate TP limitation. The nitrogen limited determinations based on TSI may not be representative of the in-lake nutrient dynamics due to the identification of nitrogen fixing bacteria in the lake.

Figure 3-21 presents a plot of *E. coli* data for the available period of record (2014 to 2020) for Lake Munson. The *E. coli* plot shows that no measurements exceeded the less than 10 percent of samples above 410 colonies per 100 mL criteria for Class III freshwaters, and values within the lake are generally low. **Figure 3-22** presents a plot of *E. coli* data for the available period of record (2014 to 2020) for Munson Slough downstream of Lake Henrietta SWMF. The plot shows that only a few measurements from 2014 to 2020 exceeded the 410 colonies per 100 mL threshold, and values within Munson Slough are generally low.

The basis for the TMDL in Lake Munson comes from relationships between Chl-a and TN, TP using data from 2004 to 2008. Two concerns are identified relative to the application of these targets today. First, the data used for those relationships reflects conditions in the lake between 2004 and 2008. Examination of the TN, TP, and Chl-a AGM and raw data plots discussed above shows that conditions in the lake have changed significantly. Secondly, examination of the graphs provided in the TMDL and the calculations of correlation coefficients shows that the data in the analyses had significant variation, and the significance of the relationships was somewhat limited (especially for TP). Comparatively, when focused on the present conditions, the lake is meeting the Chl-a target of 20 µg/L relative to the in-lake TP levels. Given the TMDL targets were developed from prior conditions and the supporting analyses' weak correlation to TP, statewide NNC may be a more appropriate water quality target for Lake Munson. Moreover, given that the present levels of TP and TN in the lake meet respective NNC targets (based on Chl-a levels below 20 µg/L), the current water quality characteristics may prove to be supportive of Lake Munson's designated use in the coming years.

3.4.3.8 Groundwater Data

Groundwater is water that has infiltrated to fill spaces between sediments and cracks in rock. Groundwater is fed by precipitation and eventually resurfaces to replenish surface water, including lakes through seepage from the surficial aquifer and, at times, from inputs from the Floridan aquifer. For Lake Munson and Munson Slough downstream of Lake Henrietta SWMF, the surficial aquifer could be a source of water and/or nutrients through direct seepage into the lake or slough. Therefore, analysis of surficial groundwater data can be beneficial in evaluating potential seepage into the lake and its impacts on water quality.

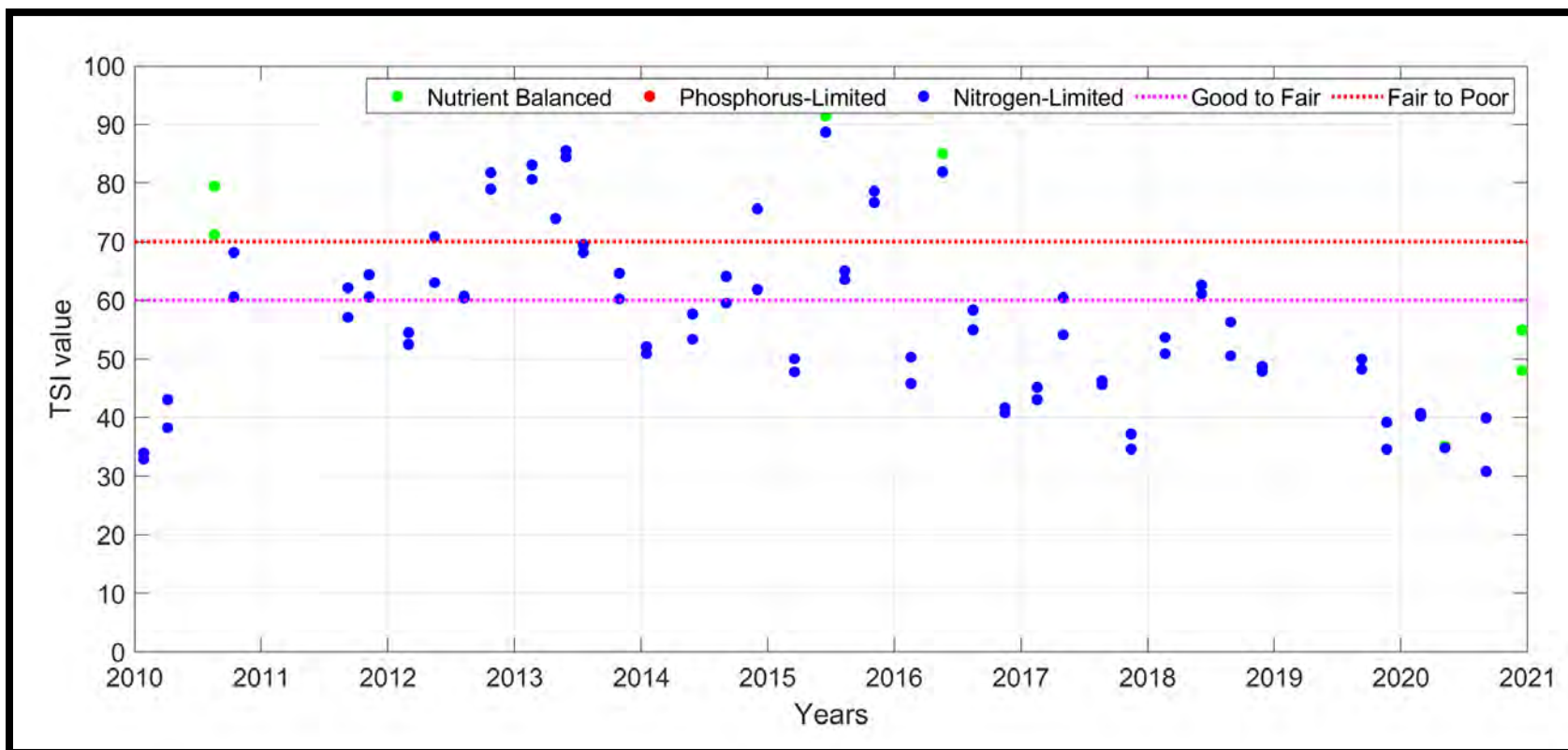


Figure 3-20: Trophic State Index for Lake Munson

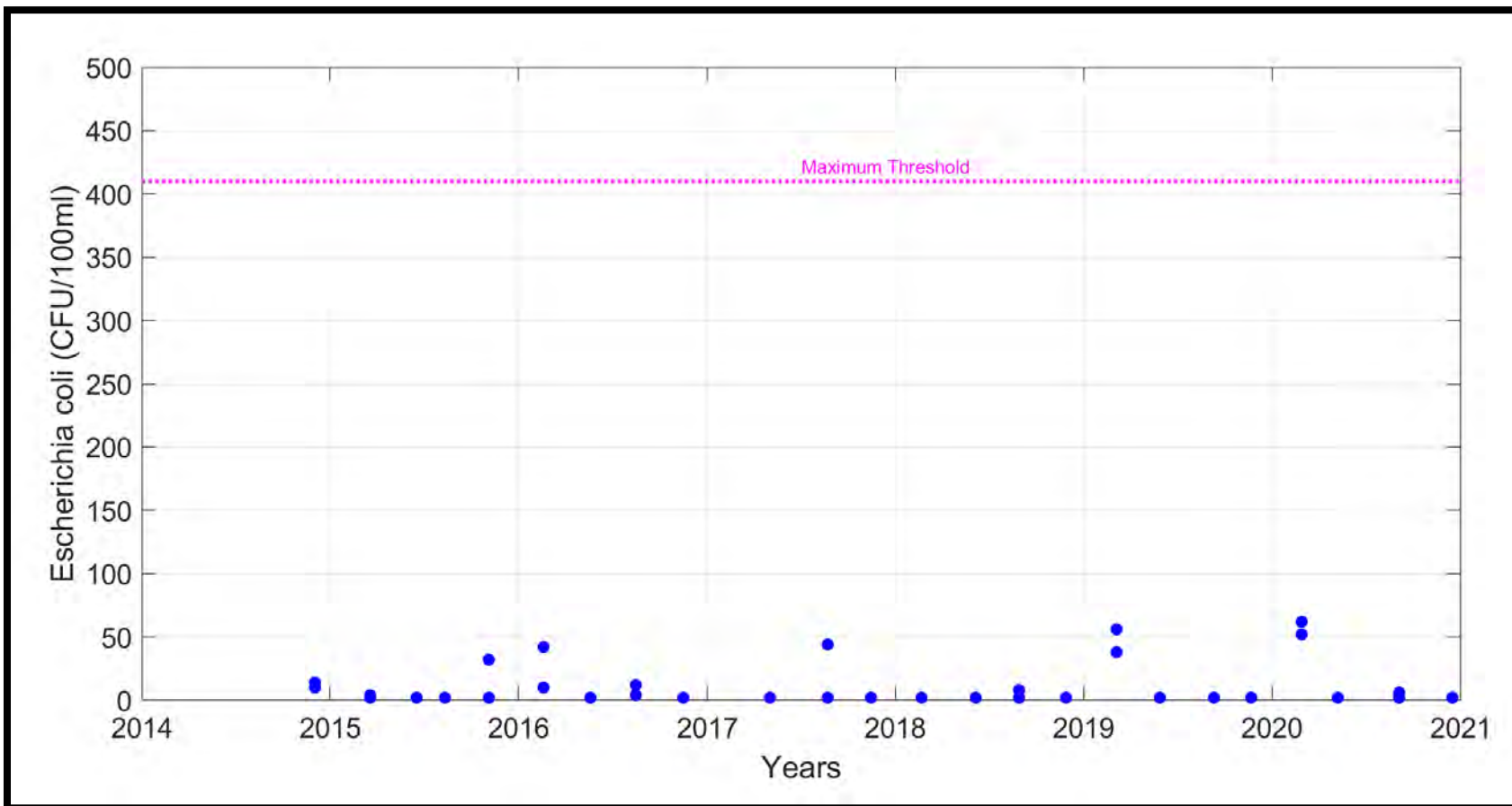


Figure 3-21: Plot of *E. coli* for Lake Munson

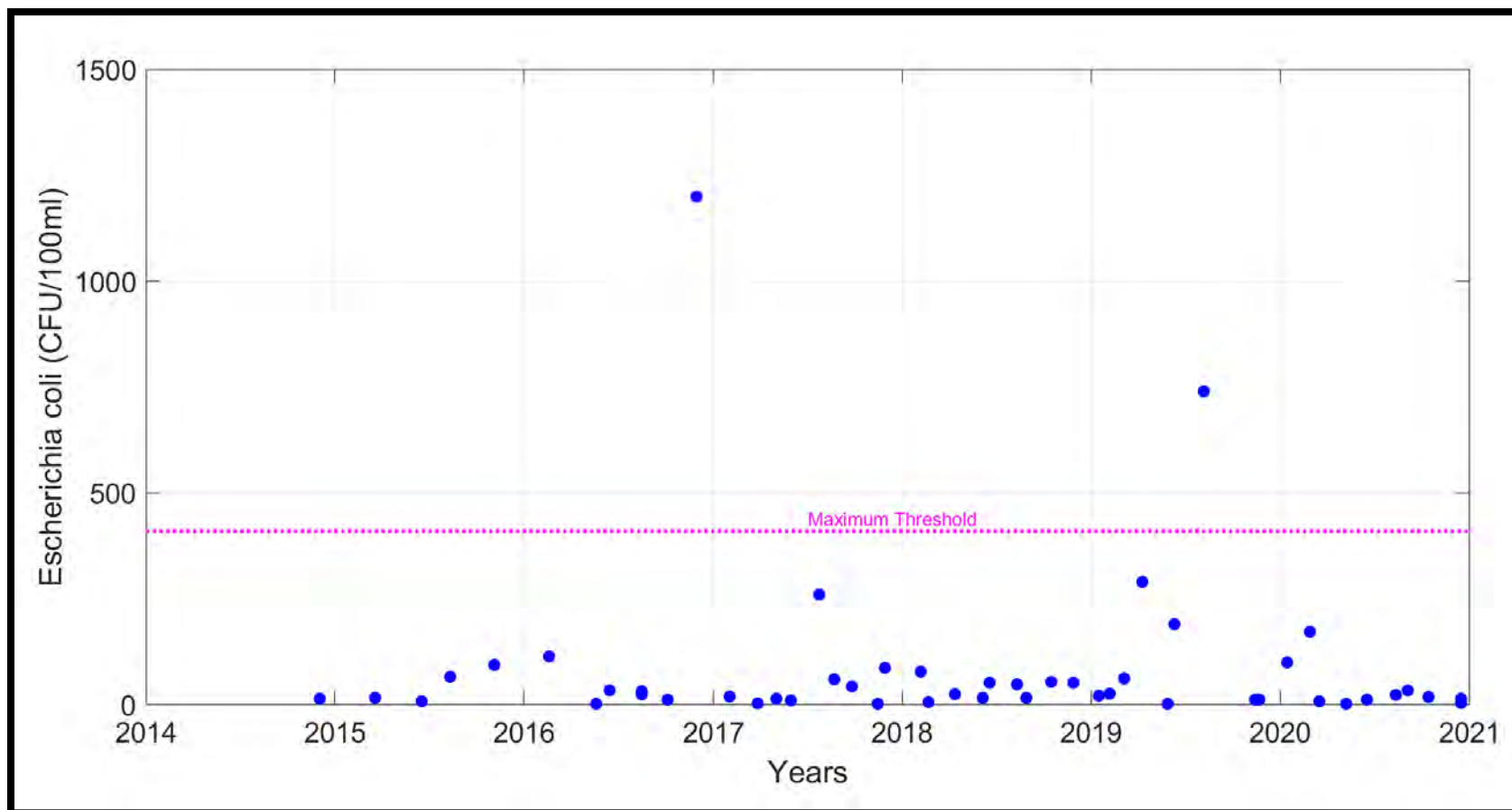


Figure 3-22: Plot of *E. coli* for Munson Slough

Two surficial aquifer groundwater sampling wells are within the boundaries of the Lake Munson Drainage Basin, Station AAA0291 and Station AAD5312 (**Figure 3-23**). These wells are located on the far western side of the basin within the Apalachicola National Forest (AAA0291) and within Lake Bradford Estates a mobile home community to the east of Lake Bradford (AAD5312). As shown in the figure, data are available from 1993 to 1999 for the station in the Apalachicola National Forest. For the station near Lake Bradford Estates, data only from 2000 is available. The available groundwater quality data in the area limits the assessment of potential seepage issues into Lake Munson under present conditions.

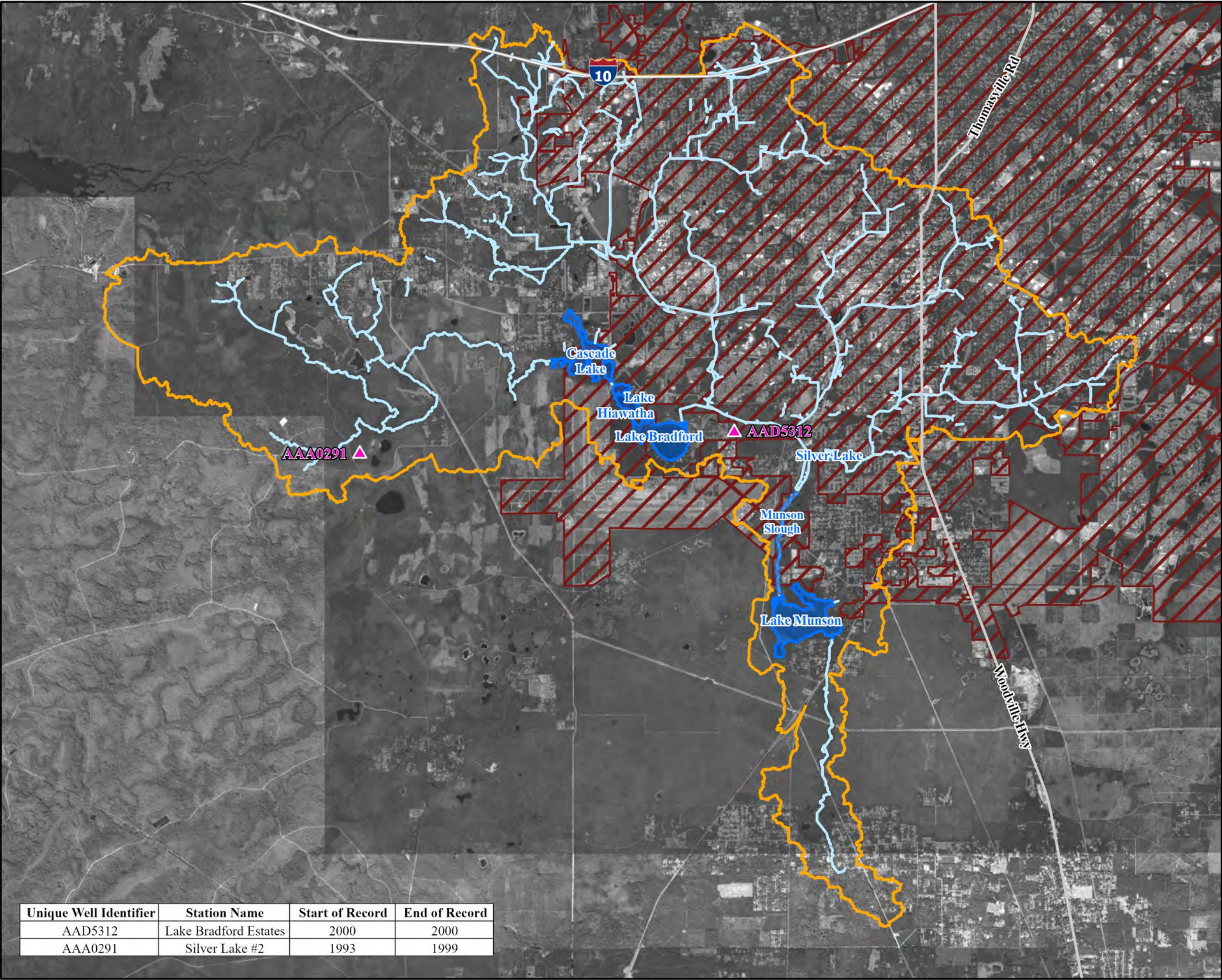
3.4.3.9 Biological Data

The Lake Vegetation Index (LVI) is a bioassessment procedure that analyzes the health of the plant communities in freshwater surface waterbodies. FDEP performs sampling and calculations for waterbodies to interpret LVI values with respect to how closely they resemble the levels of a lake under conditions of minimal human disturbance. The LVI methodology was developed in 2005 in the pursuit of relating plant metrics to human disturbance. The LVI assesses factors such as the presence of exotic species and their ratio to native plant species, lakeshore alterations, and chemical disturbances such as excessive nutrients from surrounding land uses.

For lakes in Florida, an LVI range of 79 to 100 is considered exceptional, a range of 43 to 78 is considered healthy, and any values below 42 are deemed impaired. **Table 3-4** presents LVI data for Lake Munson from 2010 to the present. Based on the data presented, there have been no instances in which the LVI assessments were at or below the 42 threshold, meaning overall, per the plant community distribution, lake conditions are healthy. However, the LVI measurements do exhibit a somewhat decreasing trend over time.

Table 3-4: Summary of LVI Results for Lake Munson

Date	Station ID	LVI	Aquatic Life Use Category
5/21/2010	21FLLEONLEONLVI008	61	Healthy
9/14/2012	21FLLEONLEONLVI008	68	Exceptional
6/17/2013	21FLGW 43539	60	Healthy
7/25/2013	21FLLEONLEONLVI008	61	Healthy
5/8/2014	21FLLEONLEONLVI008	57	Healthy
7/31/2015	21FLLEONLEONLVI008	58	Healthy
8/25/2016	21FLLEONLEONLVI008	54	Healthy
7/24/2018	21FLLEONLEONLVI008	57	Healthy
7/24/2019	21FLLEONLEONLVI008	56	Healthy
9/22/2020	21FLLEONLEONLVI008	53	Healthy



Legend

- Lake Munson Drainage Basin
- Waterbodies in Study
- Watercourses
- Major Roads
- Tallahassee Corporate Limits
- Groundwater Sampling Sites

Sources:
Waterbodies: COT, 2020
Wells: Leon County, 2020
Drainage Basins: COT, 2020
Roads: COT-Leon County, 2023
City Limits: COT, 2020

Figure 3-23:
Surficial Ground Water Sampling Wells

Tallahassee Master Plan - Surface Water (TMaPS)

Unique Well Identifier	Station Name	Start of Record	End of Record
AAD5312	Lake Bradford Estates	2000	2000
AAA0291	Silver Lake #2	1993	1999



Biological assessment methods for stream segments include Habitat Assessment (HA) and SCI. Some historical biological assessments on Munson Slough were conducted in the upstream reaches around Gum Swamp. In 2020, HA and SCI assessments were performed on Munson Slough below Lake Henrietta just upstream of the confluence with Lake Munson. The HA scores reflected marginal to poor conditions based on issues related to riparian width and vegetation quality, smothering, velocity and substrate availability. The SCI score for that evaluation was 44, which is at the low end of healthy conditions.

3.4.3.10 Stormwater Treatment Facilities

In assessing potential sources of pollutants to Lake Munson, and ultimately for targeting nutrient reduction projects, it is important to identify existing treatment facilities adjacent to and along tributaries flowing into the downstream waterbodies. In **Section 3.4.1** some discussion of larger regional facilities within the Lake Munson basin was provided.

Exhibit 3-7 presents a map of stormwater treatment facilities (ponds) within the Lake Munson basin boundaries, based on available data from the City, Leon County, and FDOT. As the exhibit shows, there are extensive treatment facilities located throughout the urbanized areas of the East Ditch, Central Ditch and West Ditch. Facilities in the western side of the basin within the more natural areas are generally limited to neighborhoods and significant roadways.

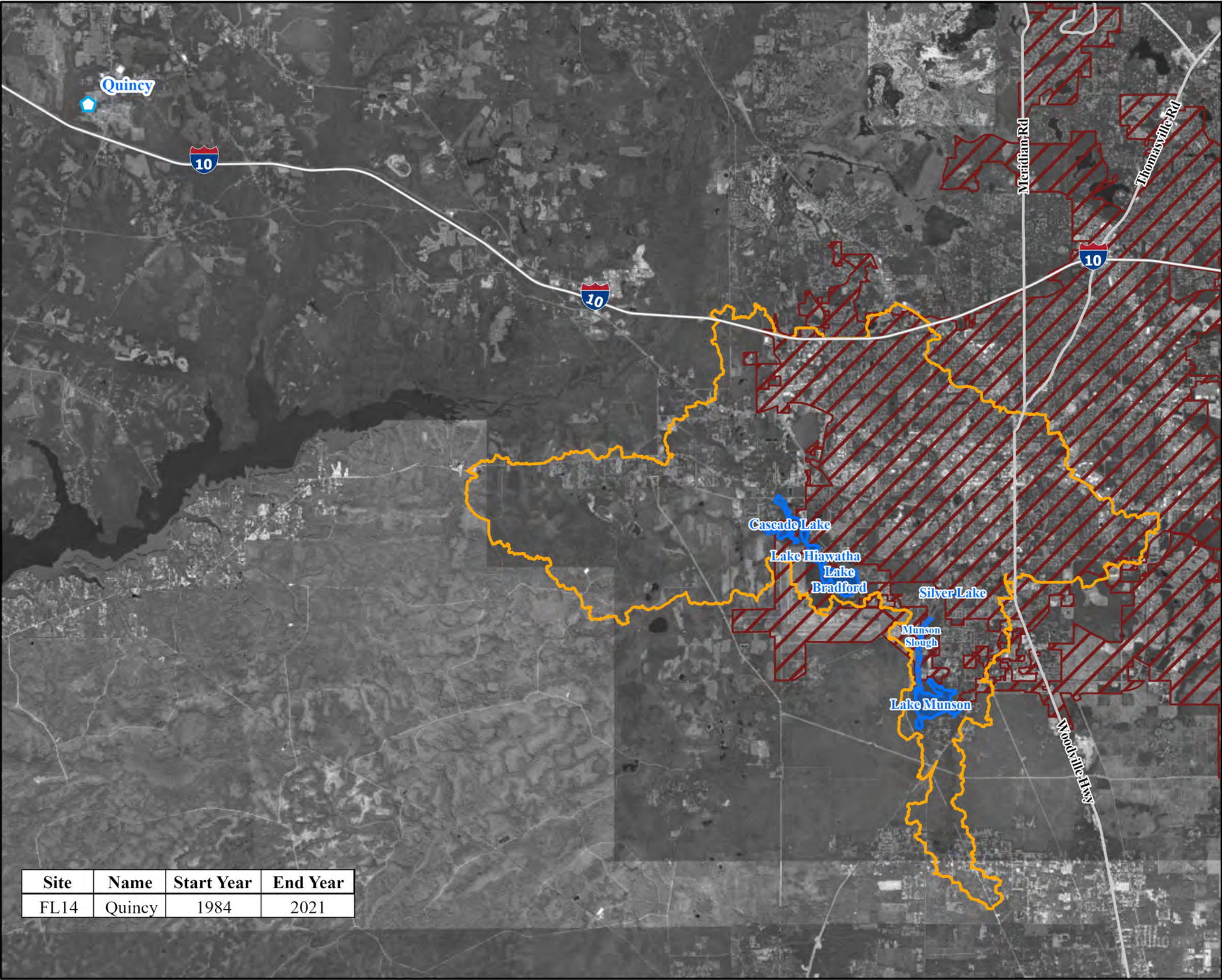
3.4.3.11 Atmospheric Deposition Data

Atmospheric deposition is the loading contained in rainfall that falls directly onto the open water lake surface or that falls onto the surface as dry deposition. Stations are maintained throughout Florida that collect atmospheric deposition data. **Figure 3-24** shows the location of the nearest atmospheric deposition station to Lake Munson. The station is in Quincy (FL14) and has been collecting data since 1984.

3.4.3.12 Data Summary

For the purposes of the qualitative analysis of sources of pollutants to Lake Munson and Munson Slough downstream of Lake Henrietta SWMF (**Section 3.4.4**), the available data are reasonable. There are sufficient active surface water quality stations within the lake and along Munson Slough downstream of Lake Henrietta SWMF to support the qualitative assessment. The following outlines limitations in the available data. Specific recommendations on additional data collection efforts are provided in **Section 3.8**.

- There are limited data to evaluate the potential for seepage of pollutants to the lake from the surficial aquifer, i.e., surficial groundwater sampling stations around the lake and along the slough.
- The measured water quality data in Munson Slough are generally collected during baseflow conditions rather than during storm events, which bring the bulk of the flow and potential load into the lake.
- The data reflecting the conditions within the lake at the location of the inflow from Munson Slough and directly at the outfall are old, with no data since 2010 at these locations.



Legend

- Lake Munson Drainage Basin
- Waterbodies in Study
- Major Roads
- Tallahassee Corporate Limits
- Atmospheric Deposition Station

Sources:
Waterbodies: COT, 2020
Station: NADP, 2022
Drainage Basin: COT, 2020
Roads: COT-Leon County, 2023
City Limits: COT, 2022

Figure 3-24:
Location of Atmospheric Deposition Station
Relative to Lake Munson

Tallahassee Master Plan - Surface
Water (TMaPS)



Site	Name	Start Year	End Year
FL14	Quincy	1984	2021

- No direct measurements of internal nutrient flux within Lake Munson have been completed that reflect the internal loading conditions that exist today.

3.4.4 Qualitative Assessment of Sources

Prior to performing loading calculations and other analyses to quantify existing pollutant sources to Lake Munson and Munson Slough downstream of Lake Henrietta SWMF, it is important to analyze available data and summarize findings from historical studies to support identification of the pathway and magnitude of potential sources. This aids in the determination of sources by providing a more complete understanding of the lake's water quality response and (where data and historical studies are available) highlights the degree to which inflow from Munson Slough and other inputs contribute as sources. Additionally, the determination of potential sources must take into account existing water quality treatment infrastructure and how their location and function mitigate conditions prior to discharge to the lake and slough.

For Lake Munson and Munson Slough downstream of Lake Henrietta SWMF, the sources that were evaluated include the following:

- Stormwater runoff
- Septic systems
- Internal recycling and seepage
- Wastewater
- Atmospheric deposition
- Interconnected flows (inflows from other connected lakes)

An overview of the analyses and findings for each of the sources listed above is provided in the following sections. Prior to the discussions of each of the potential sources, analyses examining the spatial variation of the parameters of interest within the lake and the slough downstream of Lake Henrietta SWMF are provided to support determination of key sources to focus on. Following the discussions for each source type, a summary of findings for the qualitative assessment is provided.

3.4.4.1 In-Lake and Munson Slough (Downstream of Lake Henrietta SWMF) Water Quality

In-lake spatial variation was evaluated for the following parameters:

- Color
- Alkalinity
- Total Phosphorus
- Total Nitrogen
- Chl-a

- Trophic State Index
- *E. coli*

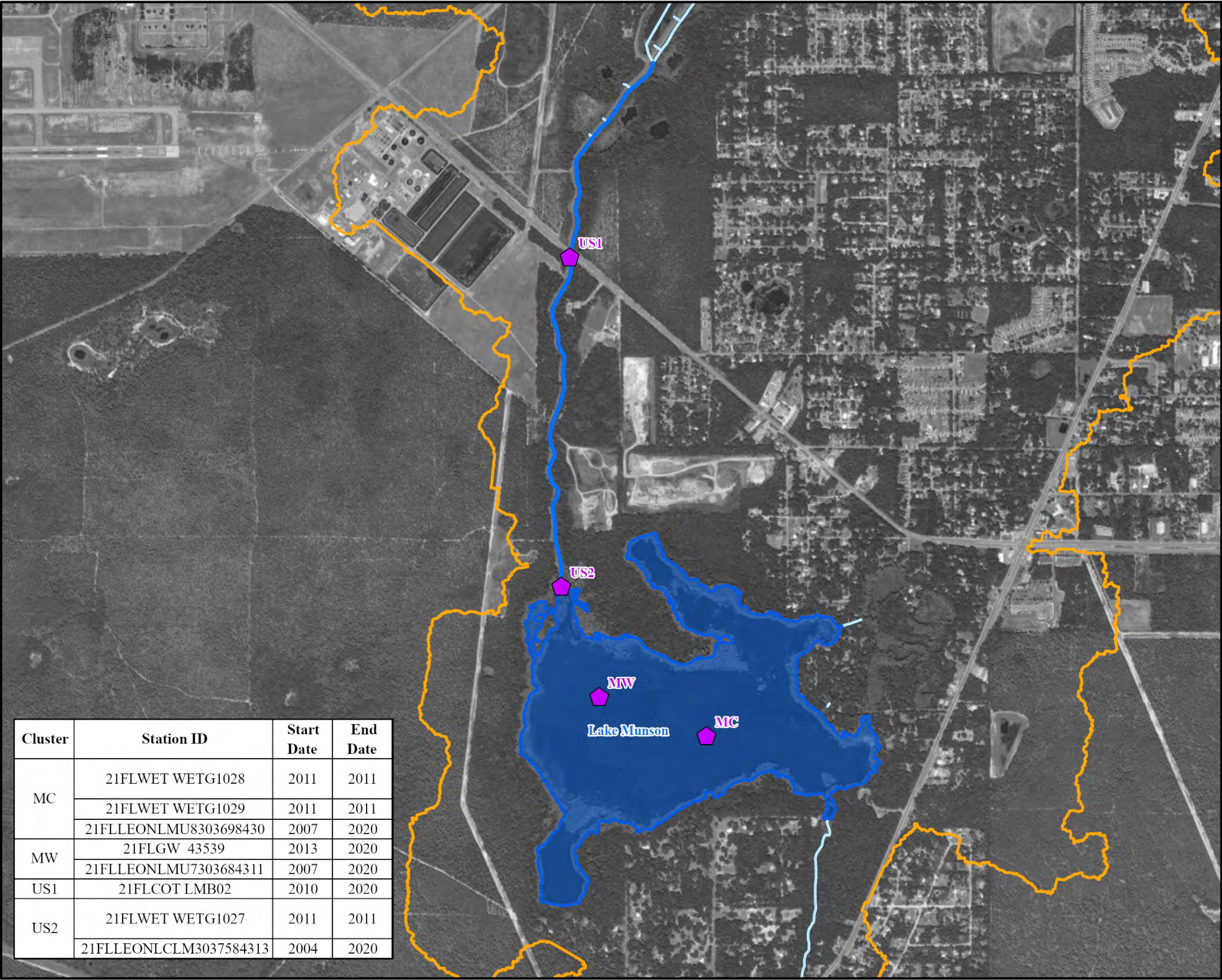
Spatial variation within Munson Slough (downstream of Lake Henrietta SWMF) was evaluated for the following parameters:

- Total Nitrogen
- Total Phosphorus
- Total Suspended Solids
- *E. coli*

To maximize available data for use in the spatial analyses, data stations were clustered to represent general areas of the lake such as stations nearer to the inflow and outflow. Additionally, stations were clustered along Munson Slough downstream of Lake Henrietta SWMF to identify any changes moving downstream from the treatment at Lake Henrietta SWMF and to provide comparisons with in-lake data. Analyses were then performed on the collective data for those general locations. **Figure 3-25** presents the data clustering locations and the specific water quality stations where data were pulled for that specific cluster for Lake Munson and Munson Slough downstream of Lake Henrietta SWMF. A total of two clusters were identified in Lake Munson and two along Munson Slough.

The spatial analyses were performed using data only after 2010 to represent recent conditions. Any station that had data after 2010 was assigned one of the cluster locations and a collective data set developed for that cluster. As such, all data available within the lake and the slough (downstream of Lake Henrietta SWMF) after 2010 were utilized in the spatial analyses. As discussed in **Section 3.4.3.7**, while historically data have been collected throughout the lake, including in the immediate area of the inflow and at the outflow structure, data since 2010 have been collected primarily within two areas more central to the lake. The two clusters (**Figure 3-25**) are MW closer to the inflow and MC closer to the outflow, but both are generally located within the lake center. Having clusters that are generally only within the center of the lake does limit some of the effectiveness of the spatial evaluation. Along Munson Slough downstream of Lake Henrietta SWMF, data are available at a station downstream of Lake Henrietta SWMF, where the slough crosses Capital Circle (US1) and just prior to flowing into the lake (US2), providing a more robust evaluation of changes in concentrations following discharge from Lake Henrietta SWMF.

Figure 3-26 through **Figure 3-33** present the results of the spatial analyses. For all parameters (other than *E. coli*), the annual geomeans for the period of record from 2010 to 2020 were averaged to calculate the cluster values. For *E. coli*, the 90th percentile of the data was calculated. Each of the clusters had data that spanned the full period from 2010 to 2020, providing greater confidence in the comparisons between stations.



Cluster	Station ID	Start Date	End Date
MC	21FLWET WETG1028	2011	2011
	21FLWET WETG1029	2011	2011
	21FLLEONLMU8303698430	2007	2020
MW	21FLGW 43539	2013	2020
	21FLLEONLMU7303684311	2007	2020
US1	21FLCOT LMB02	2010	2020
US2	21FLWET WETG1027	2011	2011
	21FLLEONLCLM3037584313	2004	2020



0 0.2
Miles

Legend

- Lake Munson Drainage Basin
- Waterbodies in Study
- Watercourses
- Station Clusters

Sources:
Waterbodies: COT, 2020
Watercourses: COT, 2020
Drainage Basins: COT, 2020
Roads: COT-Leon County, 2023

Figure 3-25:
Station Clustering for Spatial
Analyses to Lake Munson

Tallahassee Master Plan - Surface
Water (TMaPS)



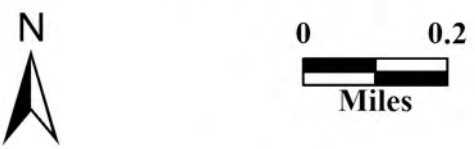
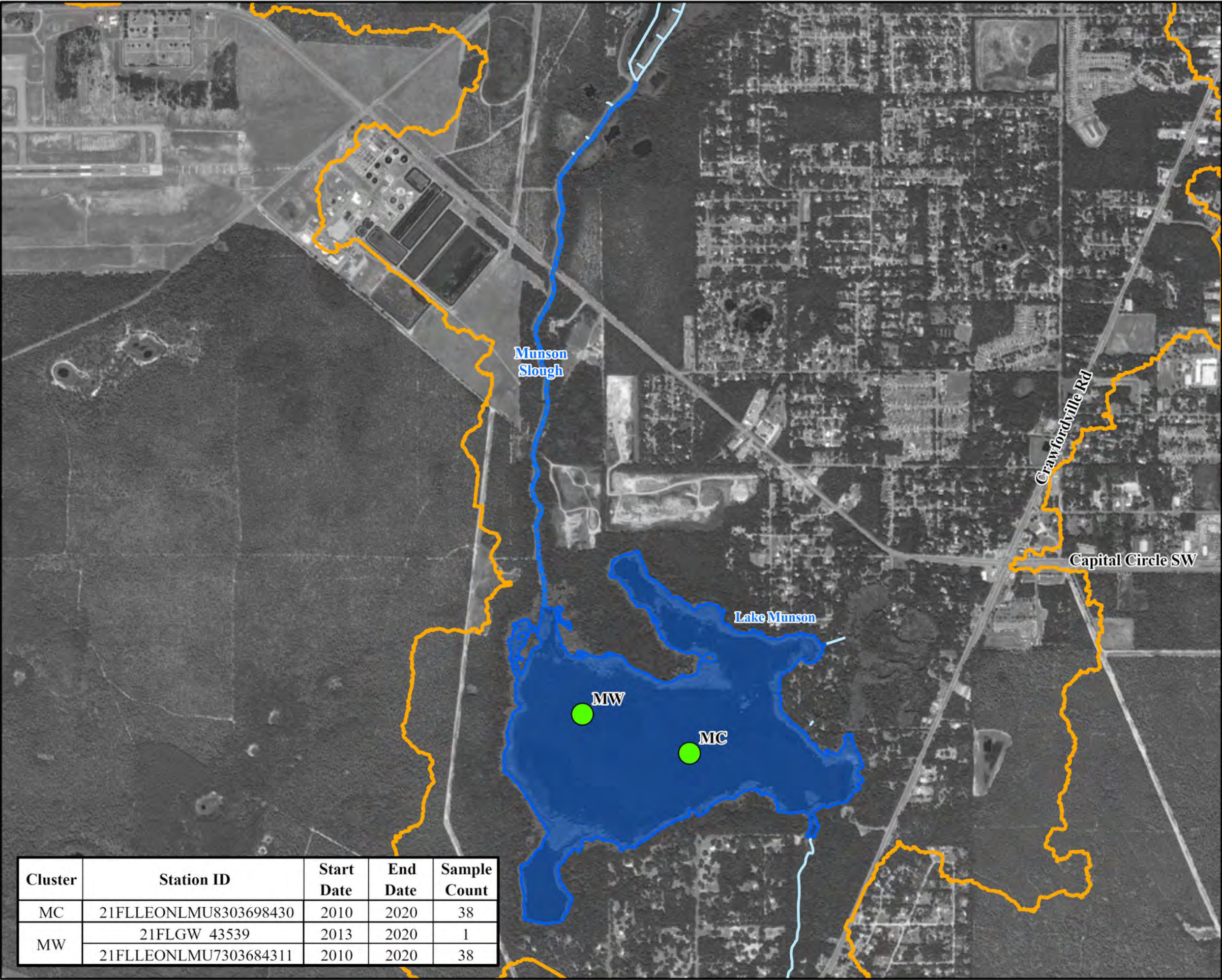
The results at each cluster of stations are presented as colored symbols representing ranges of calculated values. For nutrients and Chl-a, analyses the TMDL criteria/thresholds were used to define breakpoints for the color transitions. For color and alkalinity in the lake, the NNC thresholds defining lake type were utilized. For *E. coli*, the stream and lake criteria were utilized.

For all parameters with maximum thresholds, the transition from orange to red was set at the criteria/threshold. The other four levels were then evenly divided down from the maximum to 0.

- For Lake Munson alkalinity, the cutoff from orange into red was set to 20 mg/L based on the NNC threshold for lake type.
- For Lake Munson color, the cutoff from blue to green was set at 40 PCUs based on the NNC threshold for lake type.
- For Lake Munson TN and TP, cutoffs were set for orange to red at the TMDL targets of 0.76 mg/L and 0.044 mg/L respectively.
- For Munson Slough TN and TP, cutoffs were set for orange to red at the TMDL targets of 0.72 mg/L and 0.15 mg/L respectively.
- For Chl-a, the cutoff from orange to red was set at the criteria for Lake Munson (20 µg/L).
- For TSI, the cutoff was set to 60 from orange to red, based on the transition from mesotrophic to eutrophic conditions.
- For *E. coli*, the transition from orange to red was set at 410 most probable number (MPN)/100 mL.

The analyses presented herein are not meant to indicate conditions of impairment or non-impairment per FDEP rules and criteria. The criteria/thresholds are to aid in assessing general conditions in the lake and spatial variation, and the thresholds provide baselines to evaluate against and to aid in defining potential target areas for water quality improvement projects. Additionally, the analyses represent average conditions from 2010 through 2020 and do not account for trends or changes during that time period. This is important relative to Lake Munson and Munson Slough due to the changes seen in the data after 2016, as discussed in **Section 3.4.3.7**.

Figure 3-26 and **Figure 3-27** present the variations in color and alkalinity. The color data show similar levels between the two lake clusters, with average color values just above the 40 PCU NNC threshold for lake type (MW=41 PCU, MC=45 PCU). Alkalinity also does not show significant variation between the two clusters, with values well above the 20 mg/L NNC threshold (MW=37 mg/L, MC=39 mg/L).



Legend

- Lake Munson Major Drainage Basin
- Waterbodies in Study
- Watercourses
- Color Average 2010-2020
- PCU
 - 0-40
 - 40-80
 - 80-120
 - 120-160
 - >160

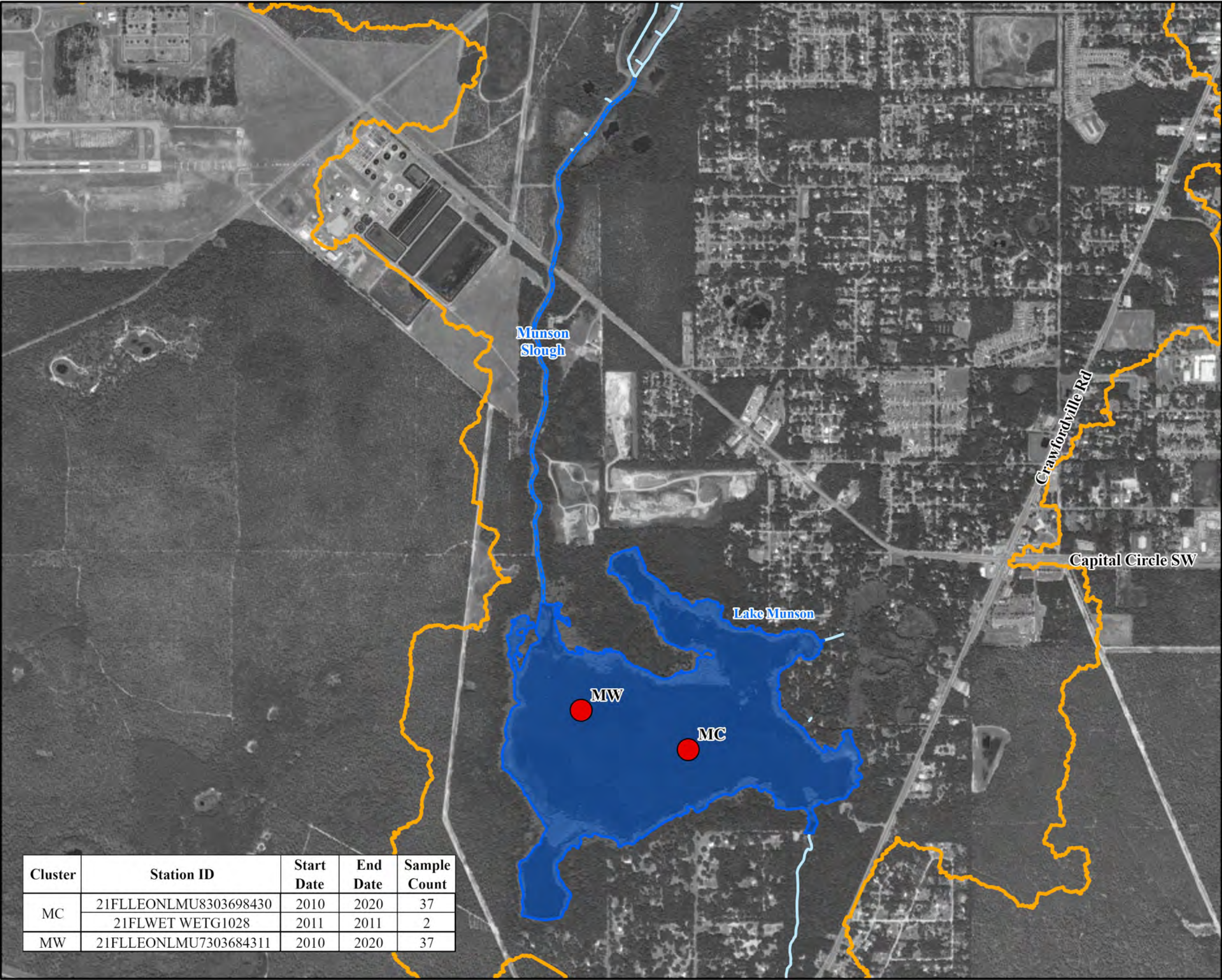
Sources:
Waterbodies: COT, 2020
Watercourses: COT, 2020
Drainage Basins: COT, 2020
Roads: COT-Leon County, 2023
Station Data: FDEP, 2021

Figure 3-26:
Spatial Assessment of Color in Lake
Munson

Tallahassee Master Plan - Surface
Water (TMaPS)



Cluster	Station ID	Start Date	End Date	Sample Count
MC	21FLLEONLMU8303698430	2010	2020	38
MW	21FLGW 43539	2013	2020	1
	21FLLEONLMU7303684311	2010	2020	38



Cluster	Station ID	Start Date	End Date	Sample Count
MC	21FLLEONLMU8303698430	2010	2020	37
	21FLWET WETG1028	2011	2011	2
MW	21FLLEONLMU7303684311	2010	2020	37



Legend

- Lake Munson Major Drainage Basin
- Waterbodies in Study
- Watercourses
- Alkalinity Average 2010-2020
mg/L
 - 0-5
 - 5-10
 - 10-15
 - 15-20
 - >20

Sources:
Waterbodies: COT, 2020
Watercourses: COT, 2020
Drainage Basins: COT, 2020
Roads: COT-Leon County, 2023
Station Data: FDEP, 2021

Figure 3-27:
Spatial Assessment of Alkalinity in Lake
Munson

Tallahassee Master Plan - Surface
Water (TMaPS)



Figure 3-28 and **Figure 3-29** present the variations in TN and TP, respectively, within Lake Munson and Munson Slough downstream of Lake Henrietta SWMF. The TN averages are all above the TMDL thresholds of 0.72 mg/L for the lake and 0.76 mg/L for the slough. The high averages are primarily due to the data prior to 2016. The TN averages looking from upstream in the slough down through the lake (US1=0.79 mg/L, US2=0.74 mg/L, MW=0.84 mg/L, MC=0.87 mg/L) do not show significant spatial variation, with the inflowing concentrations slightly lower than the lake values.

The TP averages are above the TMDL threshold of 0.044 mg/L for the lake but below the TMDL threshold for the slough (0.16 mg/L). As with TN, the high averages are primarily due to the data prior to 2016. The TP averages looking from upstream in the slough down through the lake (US1=0.10 mg/L, US2=0.12 mg/L, MW=0.16 mg/L, MC=0.19 mg/L) show a general increase moving down the slough through the lake. The lake averages are higher than those seen coming in from the slough. The higher values in the lake indicate internal sources are likely contributing to the load, based on the data from 2010 to 2020. Again, this result is driven by the data prior to 2016.

Figure 3-30 and **Figure 3-31** present the variations in Chl-a and TSI within the lake. These parameters represent the biological response to nutrient loading. The Chl-a data show similar levels between the two lake clusters, with both stations showing averages above the 20 µg/L threshold (MW=29 µg/L, MC=28 µg/L). TSI also does not show significant variation between the two clusters, with values right around the 60 threshold from good to fair (MW=62 mg/L, MC=58 mg/L).

Figure 3-32 and **Figure 3-33** present the variations in *E. coli* within the lake and slough and total suspended solids (TSS) within the slough. The *E. coli* 90th percentiles are all well below the 410 MPN/100 mL threshold in both the slough and lake (US1=48 MPN/100 mL, US2=16 MPN/100 mL, MW=6 MPN/100 mL, MC=4 MPN/100 mL), decreasing moving from upstream in the slough through the lake. TSS averages in the slough are also low, both upstream and downstream (US1=5.4 mg/L, US2=6.5 mg/L).

3.4.4.2 Stormwater Runoff

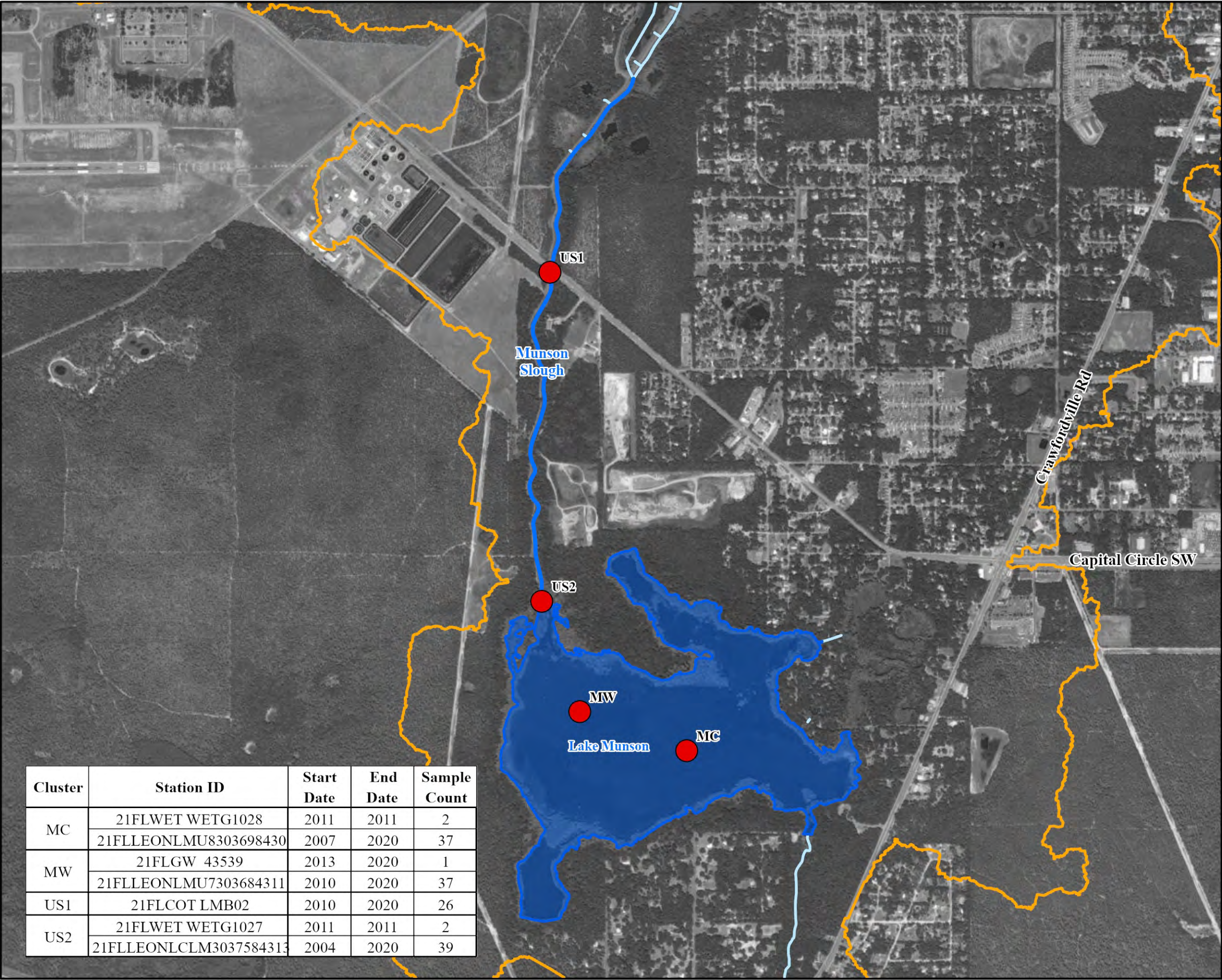
To assess stormwater runoff as a potential source of pollutant loads to Lake Munson, a number of analyses were conducted. First, calculations of Landscape Development Intensity (LDI) Index by sub-watershed were performed. LDI is an estimate of the intensity of human land use based on nonrenewable energy flow (Brown and Vivas, 2005). The LDI is calculated as the percentage area within a catchment of particular types of land use, multiplied by the coefficient of energy associated with that land use, summed over all land use types in the catchment.

$$LDI = \sum (LDI_i * \%LU_i)$$

Where:

LDI_i = the nonrenewable energy land use for land use i, and

%LU_i = the percentage of land area in the catchment with land use i.



Legend

Lake Munson Drainage Basin

Waterbodies in Study

Watercourses

In-Lake TN Average 2010-2020

mg/L

0-0.43

0.43-0.53

0.53-0.63

0.63-0.76

>0.76

Stream TN Average 2010-2020

mg/L

0-0.41

0.41-0.50

0.50-0.59

0.59-0.72

>0.72

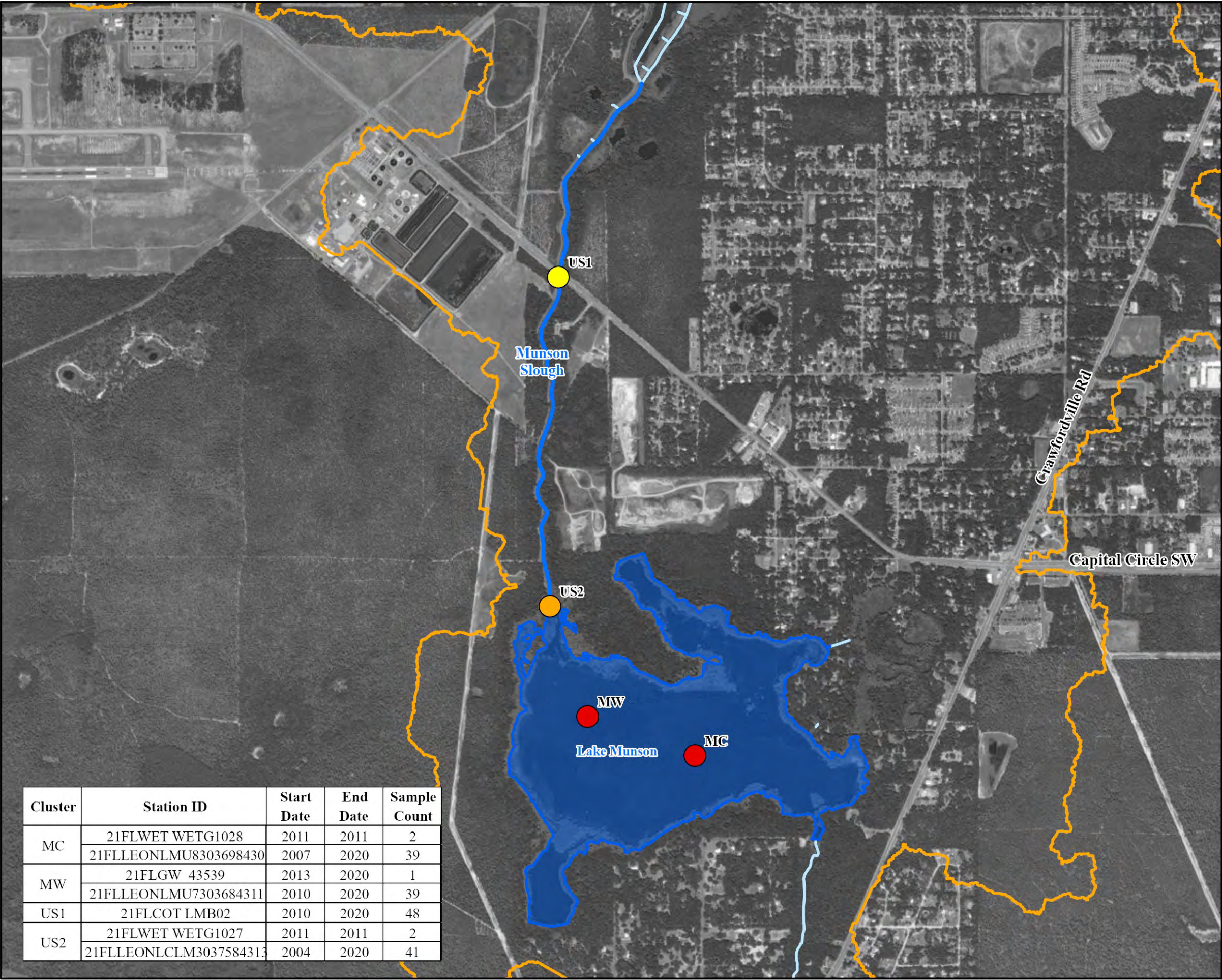
Sources:
Waterbodies: COT, 2020
Watercourses: COT, 2020
Drainage Basins: COT, 2020
Roads: COT-Leon County, 2023
Station Data: FDEP, 2021

Figure 3-28:
Spatial Assessment of TN in Lake Munson
and Munson Slough Below Lake Henrietta

Tallahassee Master Plan - Surface
Water (TMaPS)



Cluster	Station ID	Start Date	End Date	Sample Count
MC	21FLWET WETG1028	2011	2011	2
	21FLLEONLMU8303698430	2007	2020	37
MW	21FLGW 43539	2013	2020	1
	21FLLEONLMU7303684311	2010	2020	37
US1	21FLCOT LMB02	2010	2020	26
US2	21FLWET WETG1027	2011	2011	2
	21FLLEONLCLM3037584313	2004	2020	39



Cluster	Station ID	Start Date	End Date	Sample Count
MC	21FLWET WETG1028	2011	2011	2
	21FLLEONLMU8303698430	2007	2020	39
MW	21FLGW 43539	2013	2020	1
	21FLLEONLMU7303684311	2010	2020	39
US1	21FLCOT LMB02	2010	2020	48
US2	21FLWET WETG1027	2011	2011	2
	21FLLEONLCLM3037584313	2004	2020	41



Legend

- Lake Munson Drainage Basin
- Munson Slough
- Waterbodies in Study
- Watercourses

In-Lake TP Average 2010-2020
mg/L

- 0-0.014
- 0.014-0.025
- 0.025-0.036
- 0.036-0.044
- >0.044

Stream TP Average 2010-2020
mg/L

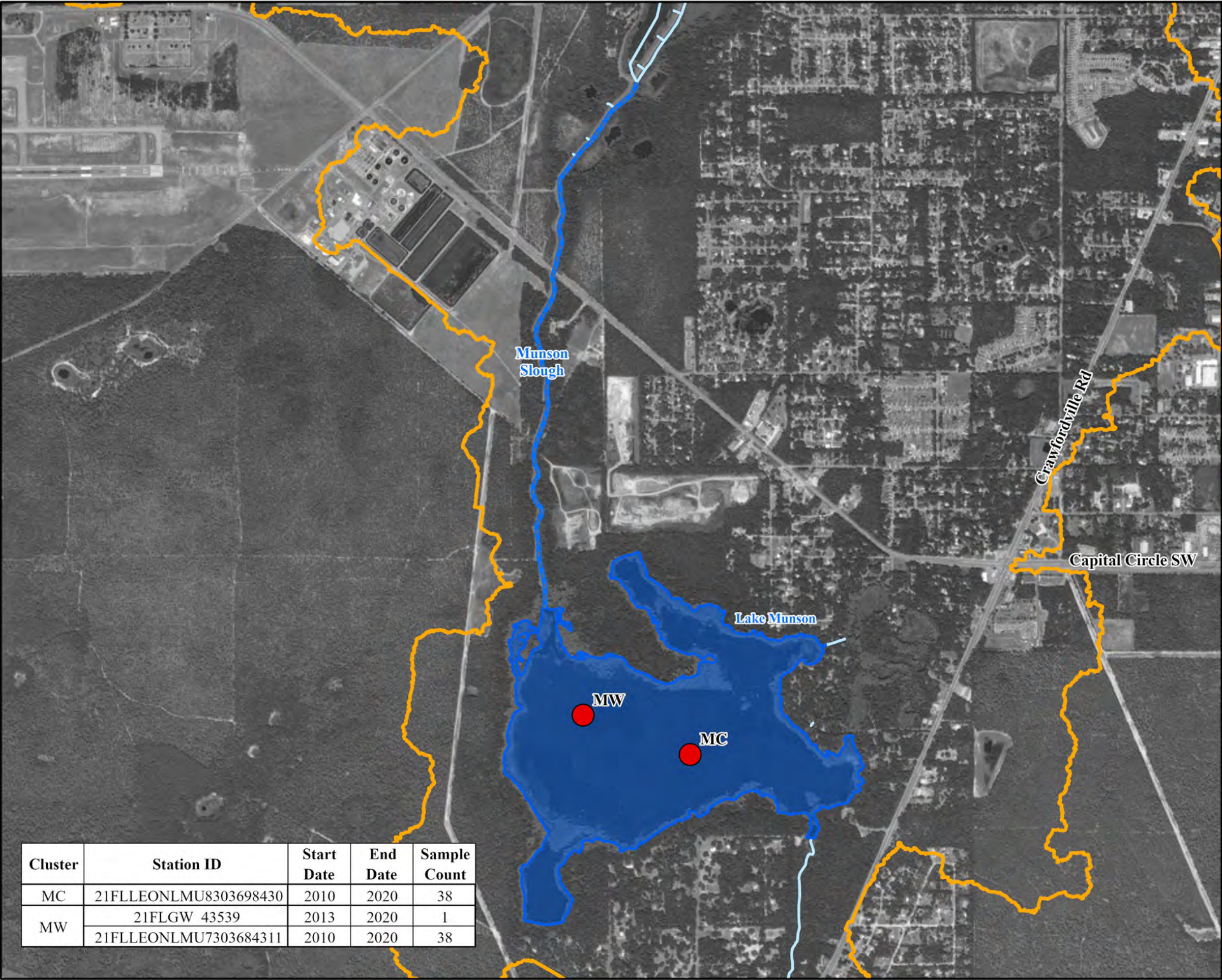
- 0-0.05
- 0.05-0.8
- 0.08-0.12
- 0.12-0.15
- >0.15

Sources:
Waterbodies: COT, 2020
Watercourses: COT, 2020
Drainage Basins: COT, 2020
Roads: COT-Leon County, 2023
Station Data: FDEP, 2021

Figure 3-29:
Spatial Assessment of TP in Lake Munson
and Munson Slough Below Lake Henrietta

Tallahassee Master Plan - Surface
Water (TMaPS)





Legend

Lake Munson Major Drainage Basin

Waterbodies in Study

Watercourses

Chl a Average 2010-2020

µg/L

0-5

5-10

10-15

15-20

>20

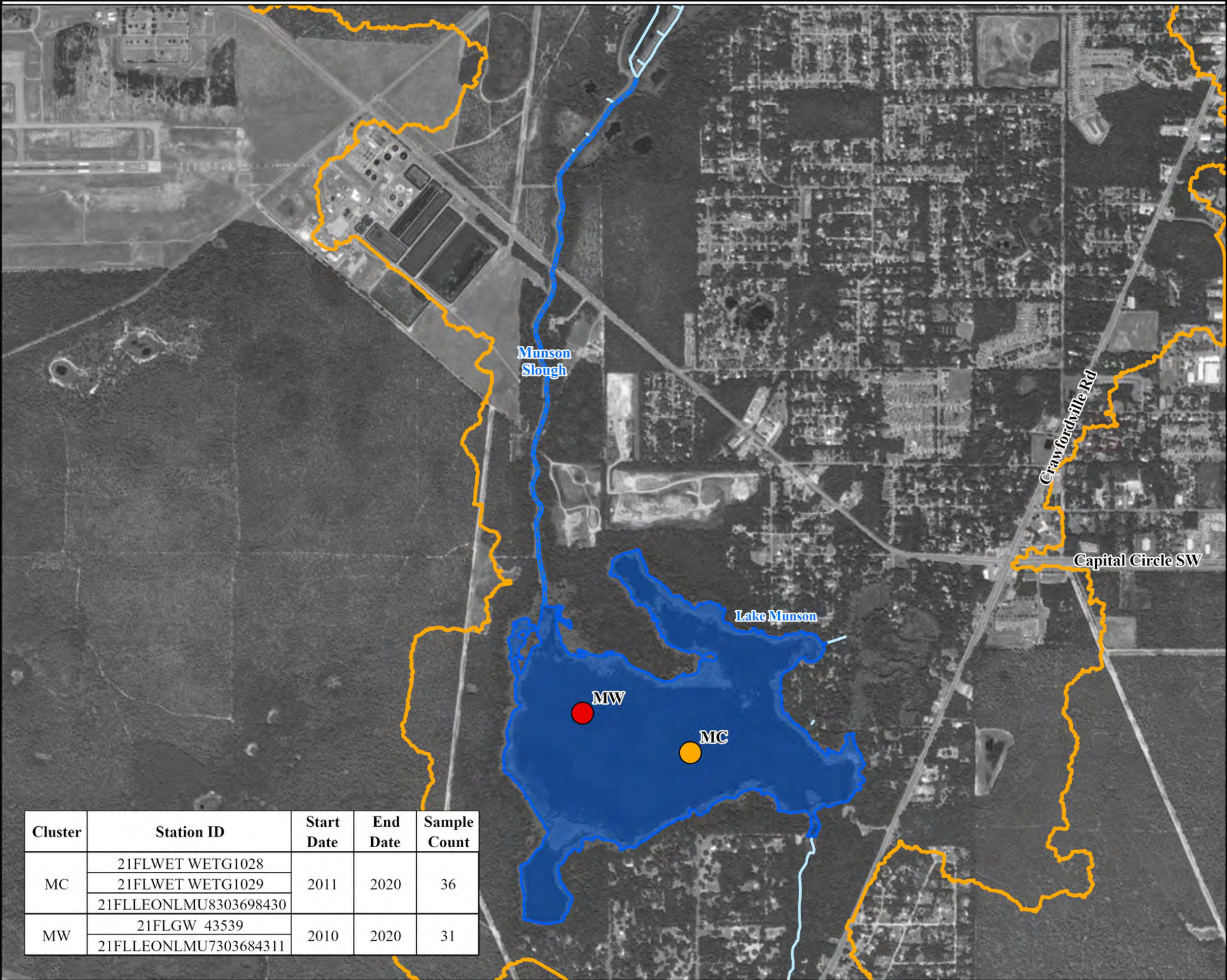
Sources:
Waterbodies: COT, 2020
Watercourses: COT, 2020
Drainage Basins: COT, 2020
Roads: COT-Leon County, 2023
Station Data: FDEP, 2021

Figure 3-30:
Spatial Assessment for Chl a in Lake Munson

Tallahassee Master Plan - Surface Water (TMaPS)

Cluster	Station ID	Start Date	End Date	Sample Count
MC	21FLLEONLMU8303698430	2010	2020	38
	21FLGW 43539	2013	2020	1
MW	21FLLEONLMU7303684311	2010	2020	38





Legend

- Lake Munson Major Drainage Basin
- Waterbodies in Study
- Watercourses
- TSI Average 2010-2020
- TSI Score
 - 0-15
 - 15-30
 - 30-45
 - 45-60
 - >60

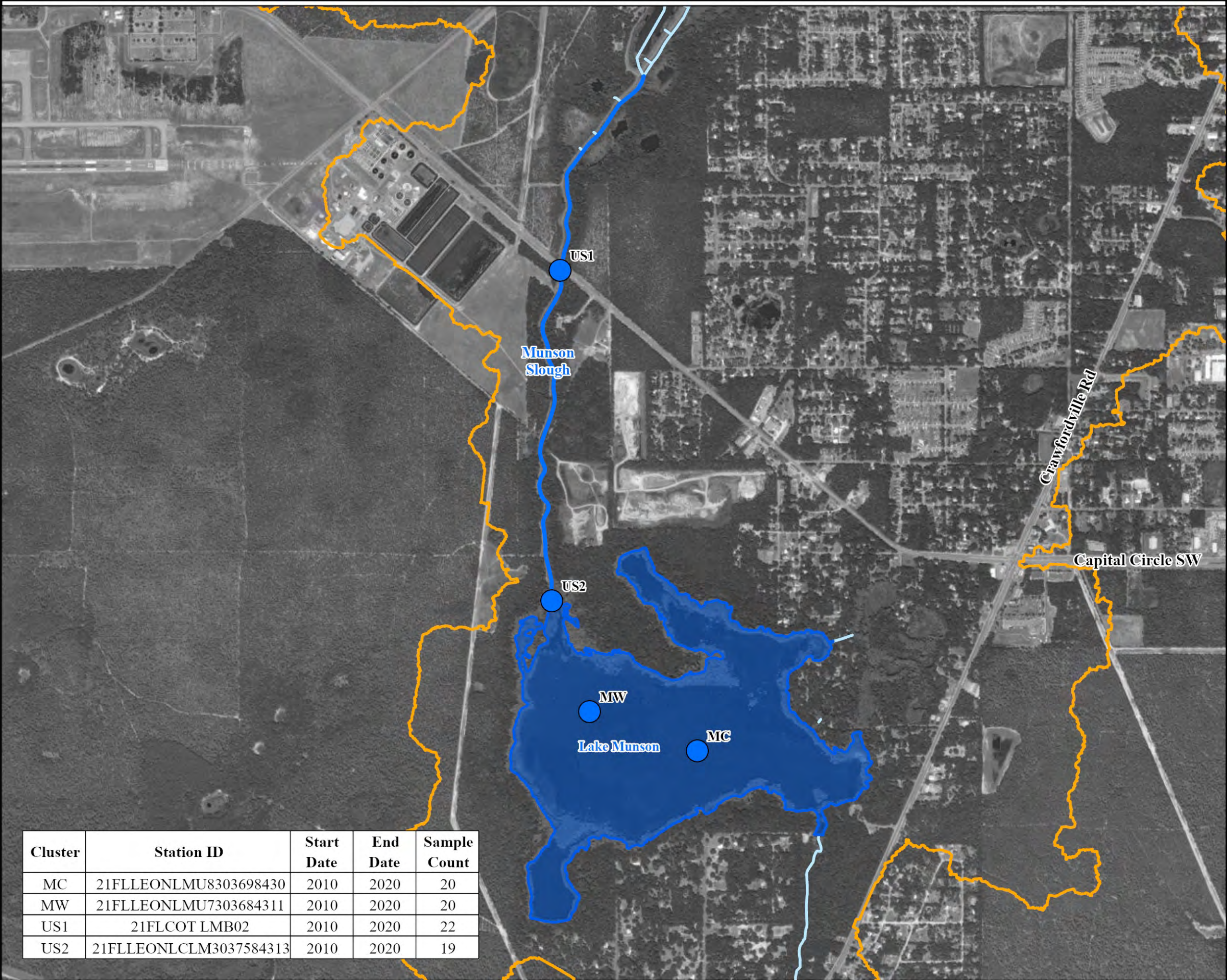
Sources:
Waterbodies: COT, 2020
Watercourses: COT, 2020
Drainage Basins: COT, 2020
Roads: COT-Leon County, 2023
Station Data: FDEP, 2021

Figure 3-31:
Spatial Assessment of TSI in Lake Munson

Tallahassee Master Plan - Surface
Water (TMaPS)



Cluster	Station ID	Start Date	End Date	Sample Count
MC	21FLWET WETG1028	2011	2020	36
	21FLWET WETG1029			
	21FLLEONLMU8303698430			
MW	21FLGW 43539	2010	2020	31
	21FLLEONLMU7303684311			



Cluster	Station ID	Start Date	End Date	Sample Count
MC	21FLLEONLMU8303698430	2010	2020	20
MW	21FLLEONLMU7303684311	2010	2020	20
US1	21FLCOT LMB02	2010	2020	22
US2	21FLLEONLCLM3037584313	2010	2020	19



Legend

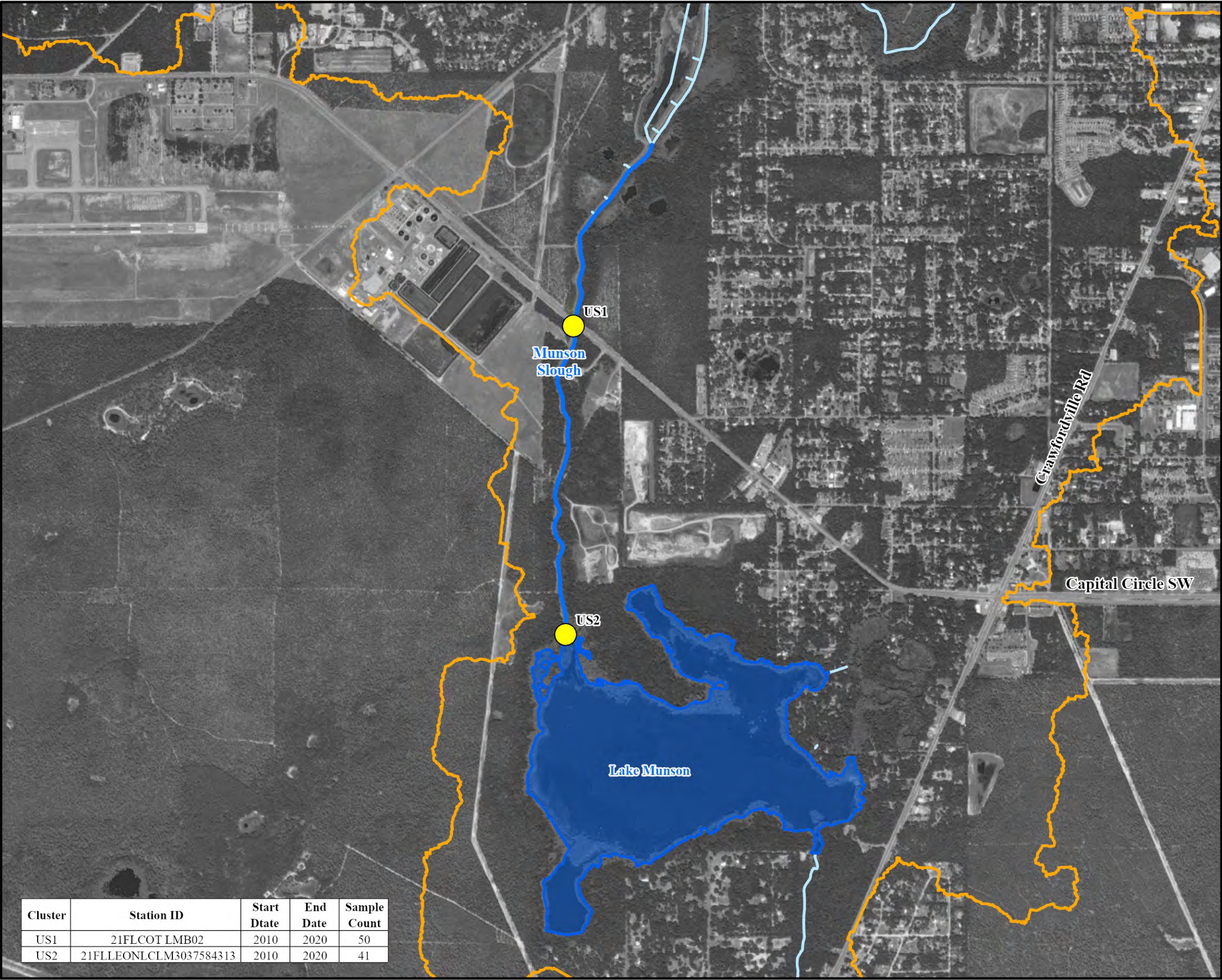
- Lake Munson Drainage Basin
- Munson Slough
- Waterbodies in Study
- Watercourses
- E. coli 90th Percentile 2010-2020 MPN/100mL
 - 0-100
 - 100-200
 - 200-300
 - 300-410
 - >410

Sources:
Waterbodies: COT, 2020
Watercourses: COT, 2020
Drainage Basins: COT, 2020
Roads: COT-Leon County, 2023
Station Data: FDEP, 2021

Figure 3-32:
Spatial Assessment of E. coli in Lake Munson and Munson Slough Below Lake Henrietta

Tallahassee Master Plan - Surface Water (TMaPS)





Legend

- Lake Munson Drainage Basin
- Waterbodies in Study
- Watercourses
- TSS Average 2010-2020
mg/L
 - 0-2.5
 - 2.5-5.0
 - 5.0-7.5
 - 7.5-10.0
 - >10.0

Sources:
Waterbodies: COT, 2020
Watercourses: COT, 2020
Drainage Basins: COT, 2020
Roads: COT-Leon County, 2023
Station Data: FDEP, 2021

Figure 3-33:
Spatial Assessment of TSS in Munson Slough Below Lake Henrietta

Tallahassee Master Plan - Surface Water (TMaPS)



Cluster	Station ID	Start Ddate	End Date	Sample Count
US1	21FLCOT LMB02	2010	2020	50
US2	21FLLEONLCMLM3037584313	2010	2020	41

The LDI coefficients are provided in **Table 3-5**.

Table 3-5: Landscape Development Intensity Index Coefficients

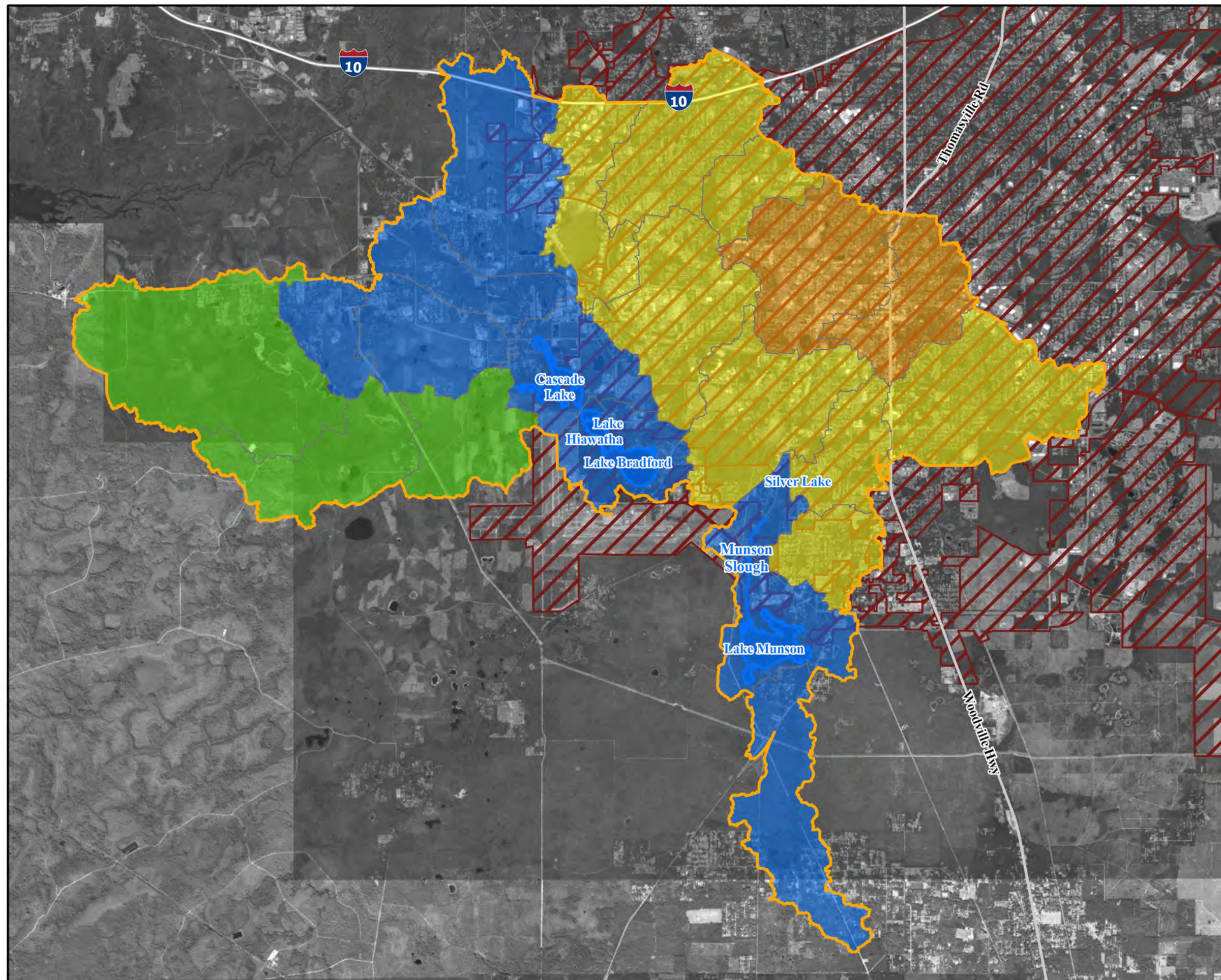
Category	Coefficient
Natural System	1
Pine Plantation	1.6
Pasture	3.4
Row Crops	4.5
Residential (low)	6.8
Residential (high)	7.6
Commercial	8.0
Industrial	8.3
Commercial (high)	9.2
Business District	10.0

FDEP uses the LDI as a tool to estimate potential adverse human effects from various land uses on adjacent waterbodies, such as streams, lakes, and wetlands. Based on the LDI score, the catchment area is rated as excellent (1 to 2), good (3 to 4), moderate (5 to 6), poor (7 to 8), or very poor (9 to 10) in relation to its potential for adverse impacts or loadings to waterbodies that receive runoff (FDEP, 2020).

Figure 3-34 presents the calculated LDIs by sub-watershed throughout the Lake Munson basin. The boundaries of the watersheds evaluated are thin grey lines in the figure. The results show the distinct spatial differences in land use and runoff loading potential in the basin. The LDI analyses do not account for treatment that occurs within the various watersheds but rather reflect the potential for pollutant load in stormwater runoff from the various land uses.

The eastern side of the basin reflects conditions within the City's incorporated area with LDIs ranging from moderate to poor. These areas drain to Silver Lake (via the East Drainage Ditch) and Munson Slough (via the Central Drainage Ditch and portions of the West Drainage Ditch). Moving west, LDI values are good for areas draining to Munson Slough (via the upper portion of the West Drainage Ditch), the Bradford Chain of Lakes, and areas downstream of Lake Henrietta SWMF along Munson Slough. In the westernmost parts of the basin, within the Apalachicola National Forest, LDI values are excellent.

The second analysis was based on data presented in **Section 3.4.3.7** and **Section 3.4.4.1**, which quantified the concentrations coming into Munson Slough out of Lake Henrietta SWMF. As the Lake Henrietta SWMF takes in flows from 95 percent of the major drainages upstream of Lake Munson, these data reflect the stormwater runoff entering Lake Munson under ambient and low flow conditions.



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Miles

Legend

- Lake Munson Drainage Basin
- Waterbodies in Study
- Tallahassee Corporate Limits
- Land Development Index**
- Excellent
- Good
- Moderate
- Poor
- Very Poor

Sources:
Waterbodies: COT, 2020
Drainage Basins: COT, 2020
Roads: COT-Leon County, 2023
City Limits: COT, 2020

Figure 3-34:
Land Development Index by Sub-
Watershed within Lake Munson Drainage
Basin

Tallahassee Master Plan - Surface
Water (TMaPS)

Geosyntec
consultants

The analyses showed that TN and TP concentrations coming out of Lake Henrietta SWMF and flowing into Lake Munson (especially in recent years) are at levels below the TMDL targets established for the slough and lake, which indicates that for present conditions, stormwater loading, while likely the largest load to the lake, is not creating conditions that would degrade lake quality and designated uses. However, again, the data utilized in this analysis were generally collected under non-storm event conditions and may not fully reflect the concentrations during less frequent discharges from large rain events.

3.4.4.3 Septic Systems

Figure 3-35 presents a map showing the septic tank densities by watershed to aid in identifying the areas more likely to be sources of loading to Lake Munson and Munson Slough downstream of Lake Henrietta SWMF as well as other waterbodies targeted in this study. Septic densities around the basin are low, with the bulk of the basin having less than 1 unit per 5 acres. This low density is due to the extent of the City's incorporated area, where most residences are connected to central sewer, and the extent of undeveloped area in the western portion of the basin.

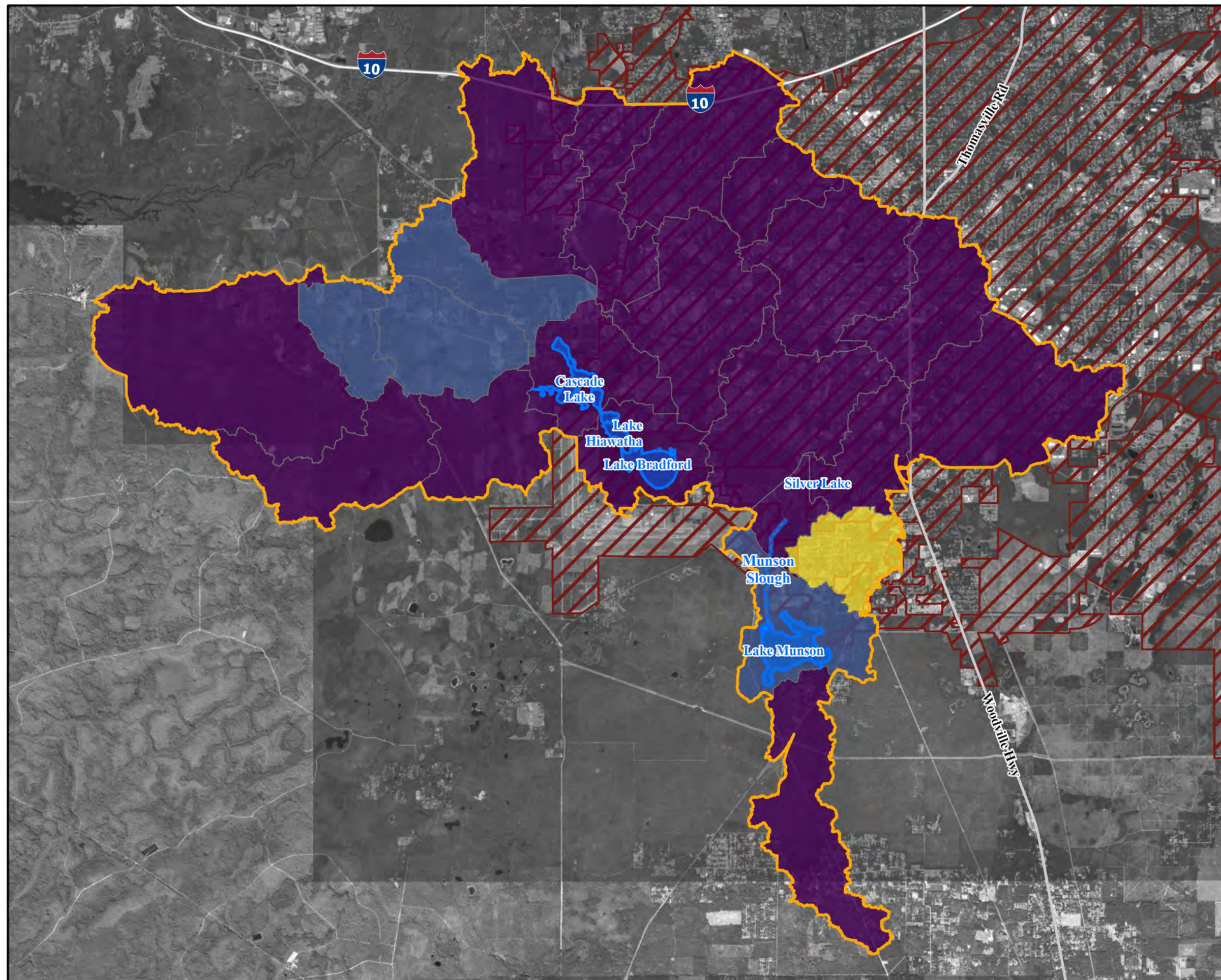
Only a few areas stand out as having higher densities. The highest density is found within a watershed to the east of Munson Slough downstream of Lake Henrietta SWMF. A significant portion of this basin has been identified as closed and not directly connected to Munson Slough or Lake Munson. Based on this, and the distance between this basin and the slough or lake, this area would not be deemed a significant source. The other areas of somewhat higher densities include the western portion of the basin in watersheds that include neighborhoods along State Road 20 and areas directly surrounding Lake Munson. Two of the watersheds shown drain through the Bradford Chain of Lakes, and their potential septic loads will be addressed as part of the Bradford Chain of Lakes evaluation (**Section 3.5.4.3**). The remaining watershed drains to Munson Slough (via the upper portions of the West Drainage Ditch). However, based on the distance from this watershed to Lake Munson, and the treatment from the Lake Henrietta SWMF, this watershed is not deemed a significant source to Lake Munson or Munson Slough downstream of Lake Henrietta SWMF. Furthermore, bacteria data within the slough and lake are not indicative of a wastewater source. Overall, the qualitative analyses indicate that septic loads are not a significant source. Given the readily available data, this determination will be substantiated through calculation of septic loads in **Section 3.4.5.2**.

3.4.4.4 Internal Recycling and Seepage

Internal Recycling

Section 3.4.1 presented an overview of studies conducted in Lake Munson to characterize sediments and assess the degree to which internal recycling, or nutrient flux, plays a role in the nutrient budget of the lake. Key studies and their findings are detailed in the following list.

- A NFWFMD study in 1988 showed that significant percentages of the sediment load, nutrients, and other contaminants were retained in the lake sediments. The study also identified a significant release of ortho-phosphorus from the sediments.



Legend

- Lake Munson Drainage Basin
- Waterbodies in Study
- Tallahassee Corporate Limits
- Septic Tank Density
Units/Acre
 - 0 - 0.15
 - 0.15 - 0.30
 - 0.30 - 0.50
 - 0.50 - 0.75
 - >0.75

Sources:
Waterbodies: COT, 2020
Drainage Basins: COT, 2020
Roads: COT-Leon County, 2023
City Limits: COT, 2020
Septic Tanks: COT, 2020

Figure 3-35:
Septic Tank Density by Sub-Basin within
Lake Munson Drainage Basin

Tallahassee Master Plan - Surface
Water (TMaPS)

- In 2005, Leon County conducted borings throughout the lake and identified extensive areas of high organic content soils, with upwards of 60 percent organic content in some areas.
- A 2014 FDEP sediment biogeochemical study to quantify temporal and spatial changes in nutrient characteristics of the lake sediments in response to the 2010 drawdown indicated that significant removal of TN occurred, but TP removal was not as significant.
- A 2016 evaluation of the feasibility of sediment nutrient inactivation in Lake Munson determined that significant internal recycling was occurring based on analyses of concentrations between the inflow and outflow of the lake. The study also identified that the drawdown that occurred in 2010 did not appear to have a significant impact on TP concentrations in the lake.

Based on these studies and other work conducted on the lake, it is clear that internal nutrient flux has played a significant role in the nutrient budget. However, to date, the studies conducted have not directly quantified the rate of nutrient flux. Recent data collection efforts and analyses of soils by FGS have been focused more on characterization of the sediments for disposal, if sediments were removed.

The 2016 ERD study identified that significant internal recycling was occurring based on analyses of concentrations between the inflow and outflow of the lake. To assess conditions today, a similar evaluation was performed, including more recent data. The analyses looked at TN and TP annual geomeans from three locations, Munson Slough downstream of the Lake Henrietta SWMF (representing inflowing TN and TP), in Lake Munson (representing in-lake TN and TP concentrations), and from the Leon County station located below the dam (representing outflowing TN and TP concentrations). **Figure 3-36** and **Figure 3-37** present graphs comparing the TN and TP AGMs from the three locations from 2010 to 2021, respectively. The graphs show that prior to 2016 (the time period of the ERD assessment), the in-lake and outflowing TN and TP concentrations exceed the inflow concentrations, supporting the assertion at that time that internal loading was a significant source. Examination of the data after 2016 presents a different story. For both TN and TP, the outflowing concentrations are at (for TP) or below (for TN) the inflowing concentrations. This would indicate that in the more recent years, internal loading has decreased. This is supported by the recent in-lake Chl-a responses, which are below the TMDL and NNC target AGM of 20 µg/L.

Seepage

As outlined in the data summary (**Section 3.4.3.9**), there are very few surficial sampling wells in the area that might provide direct data on the potential for seepage as a source to Lake Munson or Munson Slough downstream of Lake Henrietta SWMF. **Figure 3-23** identified two surficial sampling wells in the Lake Munson basin. Both stations are within the Bradford Chain of Lakes watersheds and do not have data after 2000. Based on the data analyses in the lake and slough (**Section 3.4.3.7** and **Section 3.4.4.1**), along with the analyses presented above for internal flux, baseflow driven by seepage does not appear to be a significant source of nutrients or bacteria.

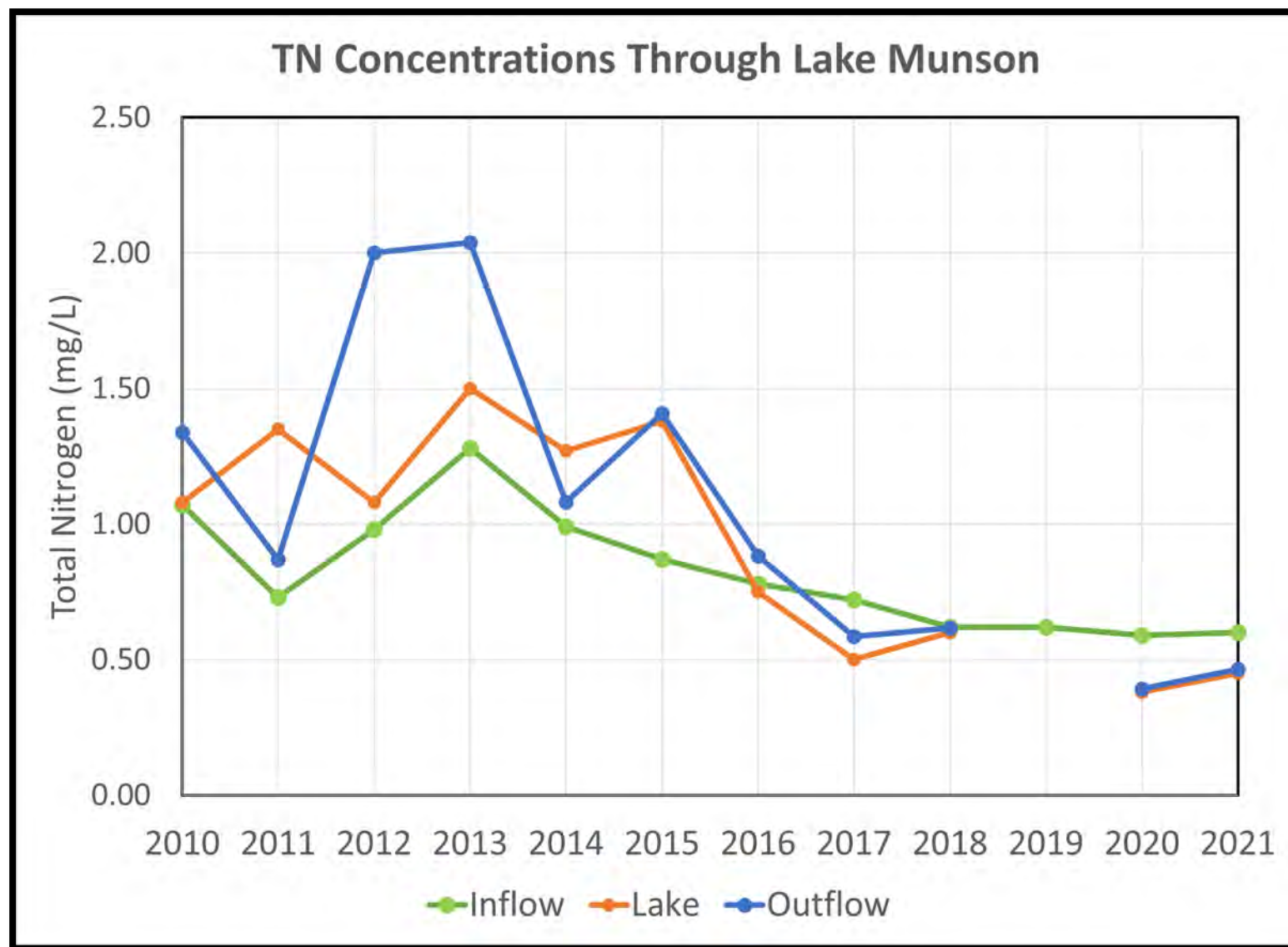


Figure 3-36: Comparison of TN AGMs Moving through Lake Munson (2010 to 2021)

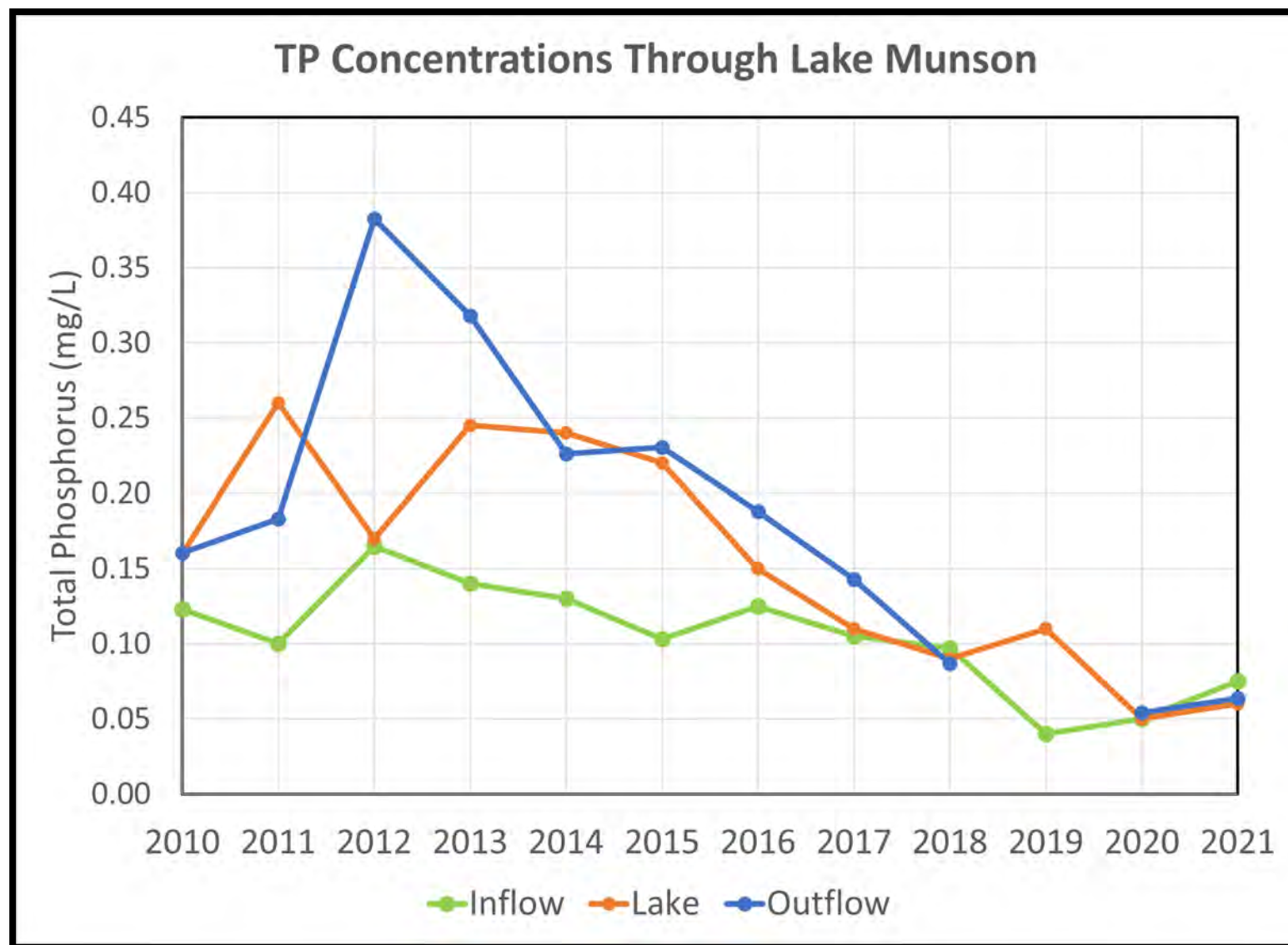


Figure 3-37: Comparison of TP AGMs Moving through Lake Munson (2010 to 2021)

3.4.4.5 Wastewater

A source of pollution that is discretely identifiable and from which pollutants are discharged is known as a “point source.” Common types of point sources include facilities like factories, paper/pulp mills, and water treatment plants. Effluent from these facilities can be discharged either directly to a waterbody or via land application on designated sprayfields. In either case, these discharges pose the potential to be a source of pollutants to waterbodies in the basin. This section of the report focuses on known point sources within the Lake Munson basin and reviews their potential for impacting water quality within the study waterbodies as a function of loading, with a focus on TN and TP.

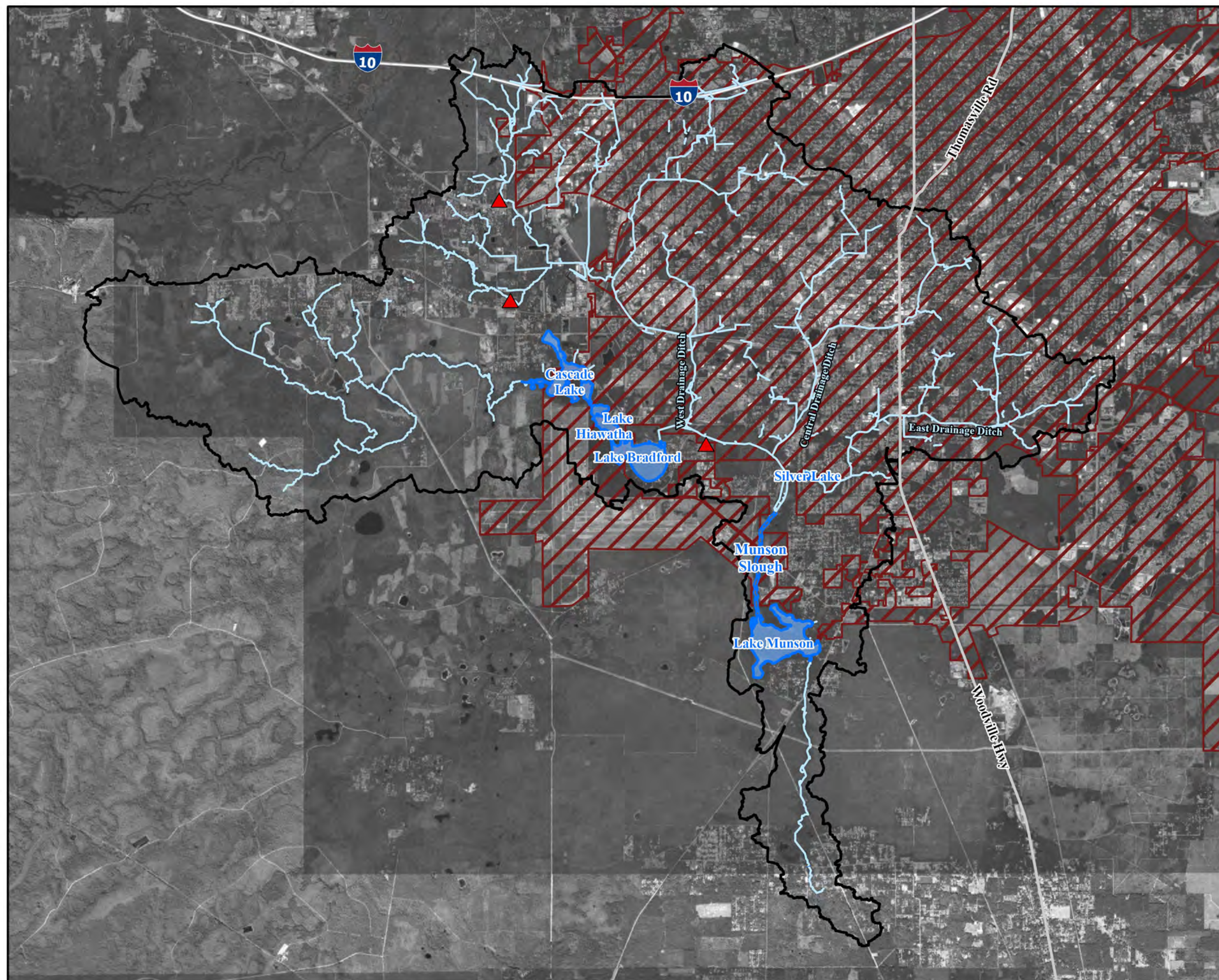
Figure 3-3 in **Section 3.4.3.5** identified active permitted point source discharges in the Lake Munson basin. A total of seven facilities are wholly or partially located within the basin boundaries. Of these seven facilities, only one is located downstream of the Lake Henrietta SWMF. That facility is the TP Smith Water Reclamation Facility. As discussed in **Section 3.4.3.5**, the sprayfield for the TP Smith facility is not within the basin and does not contribute to Lake Munson. The remaining six facilities discharge to sprayfields in areas draining to Munson Slough (upstream of the Lake Henrietta SWMF).

Section 3.4.3.5 presented a map of the active point source discharges within the Lake Munson basin, and **Table 3-2** provided descriptions of the discharges. For each of the facilities, the location of land application was referenced against proximity to stream segments as was done for the septic load calculations presented earlier. If the discharge was greater than 200 meters from a watercourse, it was not considered for load evaluation purposes.

Figure 3-38 presents the remaining facilities following the screening process outlined above. The three facilities include Grand Village wastewater treatment plant (WWTP), Western Estates WWTP, and Lake Bradford Estates WWTP. These facilities are all located upstream of Lake Henrietta SWMF. Therefore, their loads are treated by the facility prior to entering the designated portion of Munson Slough (downstream of Lake Henrietta SWMF). As such, their load is included in the loading calculated for the outflow from Lake Henrietta SWMF (**Section 3.4.5.1**). However, for completeness, brief descriptions of the three facilities are presented below.

Grand Village is the farthest upstream of the point sources. It is a privately owned facility that lies roughly 7.6 miles upstream of the Lake Henrietta SWMF. The WWTP has a flowrate of 0.025 million gallons per day (MGD) and has an associated land application area of approximately 1.12 acres. The facility recently underwent permit renewal in 2022, which included an Operations and Maintenance Performance Report detailing the state of the facility and its activities in keeping pollutant levels low.

Western Estates Mobile Home Park WWTP is located approximately 6.6 miles upstream of the Lake Henrietta SWMF. The WWTP has a flowrate of 0.02 MGD and has an associated land application area of approximately 0.13 acre. As of the latest evaluation in February 2022, the WWTP at Western Estates is in full compliance per FDEP’s Compliance Assurance Program.



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Miles

Legend

- Lake Munson Drainage Basin
- Waterbodies in Study
- Watercourses
- Major Roads
- Tallahassee Corporate Limits
- Point Sources

Sources:
Waterbodies: COT, 2020
Watercourses: COT, 2020
Drainage Basins: COT, 2020
Roads: COT-Leon County, 2023
City Limits: COT, 2020
Point Sources: COT, 2020

Figure 3-38:
Point Source Loads to Munson Slough and
the West Drainage Ditch

Tallahassee Master Plan - Surface
Water (TMaPS)

Geosyntec
consultants

Lake Bradford Estates is the nearest to the designated reach of Munson Slough, at roughly 1.3 miles upstream of the Lake Henrietta SWMF. The WWTP has a flowrate of 0.043 MGD and has three associated absorption beds with each at an area of roughly 0.14 acre (0.41 acre total). As of the latest evaluation in November 2021, the WWTP at Lake Bradford Estates is in full compliance per FDEP's Compliance Assurance Program.

Based on the permitted flow rates, their location upstream of treatment, and method of discharge (sprayfields), point sources are not identified as significant sources to Lake Munson or Munson Slough downstream of the Lake Henrietta SWMF, and the loads are not calculated in **Section 3.4.5**.

Figure 3-39 presents a map of the Lake Munson basin boundaries in relation to sewer service areas. Sewer infrastructure within the basin is located throughout the central and eastern portions of the basin and nearly all the drainage areas to Silver Lake (via the East Ditch) and Munson Slough (via the Central Ditch and West Ditch).

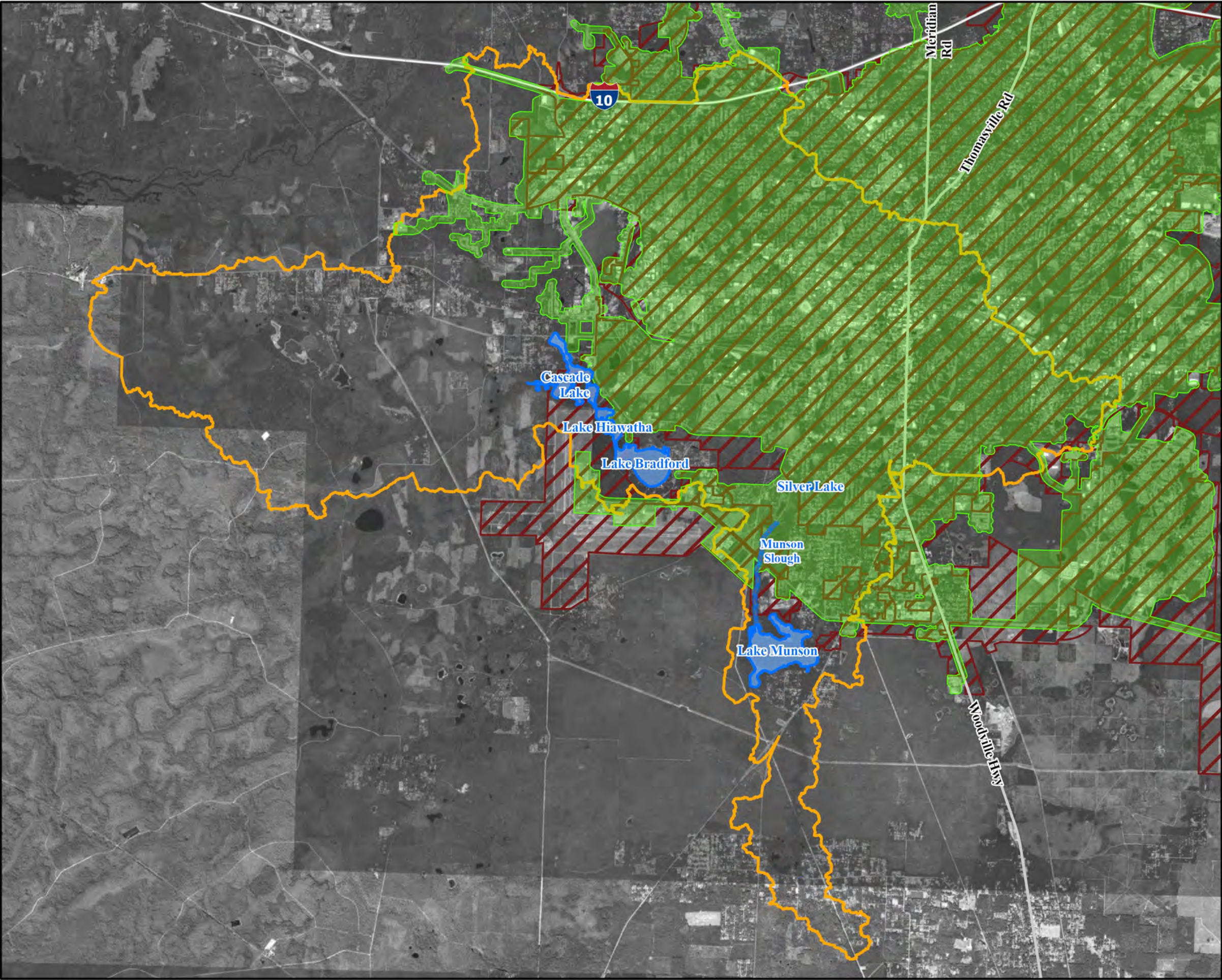
Within Munson Slough downstream of the Lake Henrietta SWMF, the available data from the tributaries did not show elevated nutrient or bacteria levels, indicating that there is not a persistent source of wastewater leakage in this area that reaches these waterbodies. While sanitary sewer overflows (SSOs) occur from time to time, SSOs are acute events with impacts lasting for relatively short periods of time (hours to several days), depending on magnitude and environmental conditions. The mechanism for abatement would not be treatment projects but rather any needed maintenance to sewer infrastructure. The City presently tracks, reports, and addresses these issues as they arise.

3.4.4.6 Atmospheric Deposition

Atmospheric deposition is the load that falls directly onto the earth's surface. For this and future analyses, atmospheric deposition will be accounted for both indirectly within stormwater runoff and directly as a load to the lake surface. In watersheds with a larger ratio of watershed to lake area (such as Lake Munson), atmospheric deposition directly to the lake does not play a significant role in overall loading. As such, while it will be considered in the assessment of loads to the lake, and given the readily available data will be calculated, it is not deemed a significant source of load to Lake Munson. It is important to note that project-specific recommendations made within this report will not address direct deposition on the lake surface as a source, but its quantification relative to other sources is important.

As outlined in **Section 3.4.3.11**, there is an atmospheric deposition station in the vicinity of Tallahassee. This station is the Quincy station (FL14). Data from this station is utilized to calculate the atmospheric deposition to Lake Munson and other lakes within the basin.

Atmospheric deposition is a function of air quality that is able to be improved through regulation and public outreach. Analysis of reductions in atmospheric deposition is outside of the project scope and, therefore, is not assessed in this report.



Legend

-  Lake Munson Drainage Basin
-  Waterbodies in Study
-  Tallahassee Corporate Limits
-  Sewer Service Areas

Sources:
Waterbodies: COT, 2020
Drainage Basins: COT, 2020
Roads: COT-Leon County, 2023
City Limits: COT, 2020
Waste Water: COT, 2020

Figure 3-39:
City of Tallahassee Wastewater Service
Areas within Lake Munson Drainage Basin

Tallahassee Master Plan - Surface
Water (TMaPS)



3.4.4.7 Interconnected Flows

For Lake Munson, there is one primary interconnected flow (flows coming in from other lakes) downstream of the Lake Henrietta SWMF, which is the flow from Cypress Lake into Lake Munson. Cypress Lake has a surface area of about 28 acres and is mostly surrounded by residential land use. Water from Cypress Lake discharges from the western portion of the waterbody and travels through a ditch less than 350 ft long before entering Lake Munson from the northeastern part of the lake. There is no current water quality data within Cypress Lake or the discharge ditch, so pollutant loads cannot be calculated for the inflow. Based on the size of the contributing area, general land use conditions surrounding Cypress Lake, the nature of the lake, and the connection to Lake Munson, Cypress Lake is not likely a potential significant contributor of anthropogenic nutrient or bacteria loading, so interconnected flows are not further evaluated.

3.4.4.8 Summary of Findings for Qualitative Assessment of Sources

Based on the discussions above, and data and information presented in **Section 3.4.3**, no sources of load have been identified as targets for load reduction for Lake Munson or Munson Slough. This is based on the system meeting the TMDL target for Chl-a in recent years, the discussions presented earlier on shortcomings of the TMDL relative to application today (**Section 3.4.3.7**), Munson Slough being below both the TMDL and NNC targets for TN and TP, and assessments of changes in TN and TP concentrations through the lake that indicate internal loads are no longer significant. The following outlines the findings for each of the potential pollutant sources discussed above.

- Stormwater Runoff – Stormwater runoff as assessed for Munson Slough downstream of Lake Henrietta SWMF meets TMDL targets and, therefore, likely is not a source to target for reduction. Due to availability of models and data, the load is quantified in **Section 3.4.5.1** to provide comparison with other loads.
- Septic Systems – Loads from septic system are not identified as a significant potential source of pollutants to Lake Munson. Based on availability of data, loads are calculated in **Section 3.4.5.2** to support this determination.
- Interconnected Flows – Loads from the adjacent lake (Cypress) that drains to Lake Munson are not deemed a significant source to Lake Munson.
- Internal Recycling – Based on recent data presented in **Section 3.4.4.4 (Figure 3-36 and Figure 3-37)** internal recycling in Lake Munson has decreased in recent years. At this time, no direct measurements of internal load that reflect present conditions have been conducted. Internal recycling is identified as a potential load, but direct measurements are needed to quantify the significance of the impacts and need for additional remediation.
- Seepage – While no data on seepage into the lake is available, it is assumed that the primary source of seepage loads would be septic systems, which are assessed separately.
- Wastewater – The permitted point sources presently located within the Lake Munson basin are not deemed a significant source of load to the lake based on location (upstream

of treatment) and method of discharge (sprayfields). SSOs can contribute to loading but are short-term events that are typically addressed fairly quickly. Based on the available data and locations of sewer infrastructure, SSOs were not identified as a potential significant source.

- Atmospheric Deposition – Based on the relatively high ratio of the direct watershed discharge to Lake Munson area, atmospheric deposition is not identified as a potentially significant load. While this load is quantified for comparison to other loads in **Section 3.4.5.6**, no recommendations will be made relative to potential reductions.

3.4.5 Calculation of Potential Nutrient Loads

This section presents calculations of potential nutrient (TN and TP) loads to Lake Munson and Munson Slough downstream of the Lake Henrietta SWMF for the sources identified for calculation in **Section 3.4.4.8**. These include stormwater runoff, septic systems, and atmospheric deposition. Where loads were not calculated, the following sections provide brief discussions. The load calculations are for the purpose of comparing the potential magnitudes of each source relative to one another.

3.4.5.1 Stormwater Pollutant Load

To calculate the potential stormwater TN and TP loads to Lake Munson, Munson Slough downstream of Lake Henrietta SWMF, and other waterbodies within the Lake Munson basin, average annual pollutant load modeling was performed. The goal was to identify areas that are contributing higher TN and TP loads relative to others within the drainage area to the waterbody and estimate a potential total load for comparison to other loading sources. TN and TP loads were calculated using the Spatially Integrated Model for Pollutant Loading Estimates (SIMPLE-Seasonal) model. The approach described below was used for all project waterbodies within the Lake Munson basin. Pollutant load models, such as the SIMPLE model, calculate loads by determining a volume of runoff from a specified area and then multiplying the runoff volume by EMCs. EMCs are concentrations of constituents (TN and TP in this case) that are found in runoff based on specified land uses.

SIMPLE-Seasonal Model Methodology

Pollutant loads from direct runoff for each subbasin are calculated using the SIMPLE-Seasonal model, originally developed by Jones Edmunds and Associates (Jones Edmunds) for Sarasota County and the Southwest Florida Water Management District (SWFWMD). The complete model development is documented in *Sarasota County County-Wide Non-Point Source Pollutant Loading Model* prepared by Jones Edmunds in August 2005. The model operates within a geographic information system (GIS) framework and calculates pollutant loading over large areas with spatially variable characteristics, leveraging the runoff excess estimation methods described by Harper and Baker, 2007.

For the purposes of this project, the model was set up following the procedure outlined in the Hernando County guidance document developed by Jones Edmunds (Hernando County, 2013). It should be noted that when running the SIMPLE-Seasonal model, Geosyntec utilized default model values to account for seasonal variability of rainfall. The model includes BMP, EMC,

runoff, basins, septic, and point source feature classes. For the purposes of this project, the septic and point source feature classes were not utilized since those loads are quantified separately. TN and TP reductions due to the different types of BMPs are assigned in the BMP shapefile. The EMC shapefile includes the TN and TP EMCs based on the land use types. The runoff shapefile includes the land use, hydrologic soil group (HSG), and the average annual runoff coefficient, defined as the fraction of average annual rainfall volume converted to runoff. Finally, the basin shapefile includes the total acreages of each subbasin. It is noted that no base flow was assigned for this analysis. The calculation of the pollutant load associated with the runoff was based on the Harper and Baker (2007) method of rainfall excess determination and pollutant loading. This method uses an average annual rainfall volume, which is multiplied by an average annual runoff coefficient to determine the average annual runoff volume. The average annual runoff coefficient is based on the percent directly connected impervious area (DCIA) and the non-DCIA curve number (CN), which are determined based on the land use and soil conditions. The average annual loading is determined by multiplying the average annual volume of runoff and the pollutant EMC.

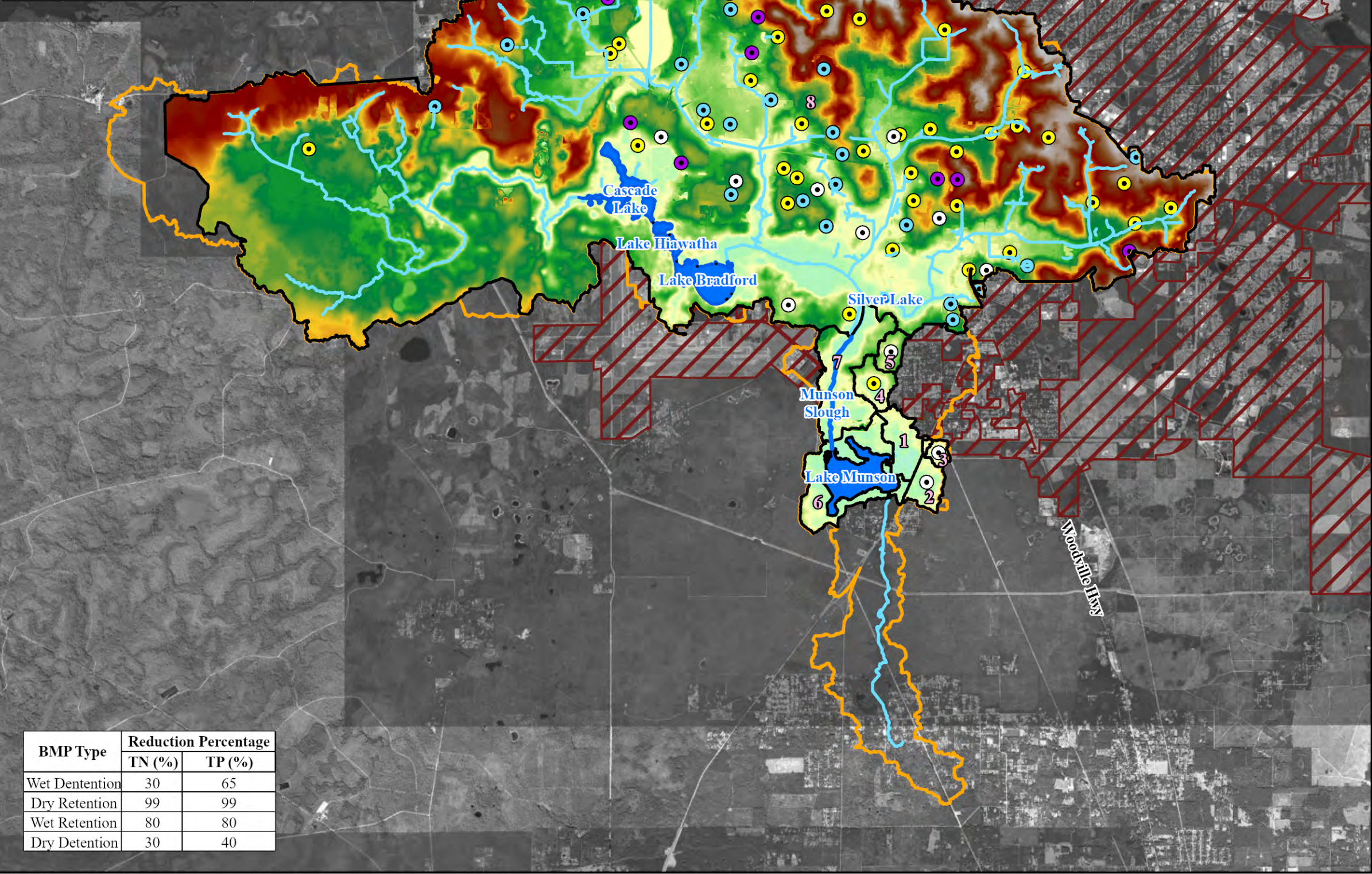
The average annual rainfall depth for this watershed was estimated to be 59 inches using the *Florida State University – Office of Institutional Research Tallahassee/Leon County, Florida*.

The topography for the study area was analyzed via a Digital Elevation Model (DEM) from Leon County (2018). The elevations within the watershed range from approximately 255 ft down to approximately 17 ft. All elevation data presented in this report are expressed in ft-NAVD88 (**Figure 3-40**). The highest elevations appear in the northeast side of the basin, with the lowest values around and below Lake Munson.

Subbasins were initially provided by the City within the Lake Munson basin. For modeling purposes, subbasins were delineated to the BMP and the outfall level to define where stormwater is generated and where it accumulates. The runoff volumes are estimated along with the associated pollutant loads. A total of 85 subbasins were delineated throughout the Lake Munson basin using the 2018 Leon County DEM and the flowlines from the U.S. Geological Survey (USGS) National Hydrological Dataset (NHD) (2020). The NHD represents the water drainage network within the study area, such as conduits, inlets, and junctions, and is used to delineate the watershed in a manner appropriate for the level of detail required for this study. The final contributing drainage area, based on the delineations, is presented in **Figure 3-40**. Additionally, the treatment percentages utilized for each BMP type are presented. For the purposes of the Munson Slough and Lake Munson stormwater load calculations, the subbasins upstream of the Lake Henrietta SWMF were merged into one single subbasin representing the inflow to the Lake Henrietta SWMF (**Figure 3-40**). The remaining subbasins (where applicable) were utilized in the stormwater load calculations for the other target waterbodies in **Section 3.5.5** and **Section 3.6.5**.

The land use data used for this modeling effort referenced the 2019 NFWFMD feature class presented in **Section 3.4.3.2**. The data were manipulated for the purposes of this analysis as described as follows. First the NFWFMD land use data were aggregated into simplified land use categories as presented in the SIMPLE guidance document (Hernando County, 2013). This was done to generalize the watershed's land uses into 13 land use categories (**Figure 3-41**), which corresponded to available EMC data. A summary of how the land uses were aggregated is presented in **Table 3-6**.

Lake Munson Subbasin Summary			
Number	Subbasin ID	Acres	BMP Type
1	LMBLM0020	213.4	None
2	LMBLM0030	162.5	Dry Retention
3	LMBLM0040	49.0	Dry Retention
4	LMBLM0060	456.6	Wet Detention
5	LMBLM0070	101.4	Dry Retention
6	LMBLM0010	470.7	None
7	LMBLM0050	607.4	None
8	LMBLMOF05	32,619.4	Lake Henrietta SWMF



BMP Type	Reduction Percentage	
	TN (%)	TP (%)
Wet Detention	30	65
Dry Retention	99	99
Wet Retention	80	80
Dry Detention	30	40

CITY OF TALLAHASSEE

Legend

- Lake Munson Drainage Basin
- Subbasins
- Waterbodies in Study
- Watercourses
- Tallahassee Corporate Limits

Topographic Elevations

Value

250

17

Sources: Elevation: COT-Leon County, 2018

Waterbodies: COT, 2020

Watercourses: COT, 2020

Subbasins: Geosyntec, 2023

Roads: COT-Leon County, 2023

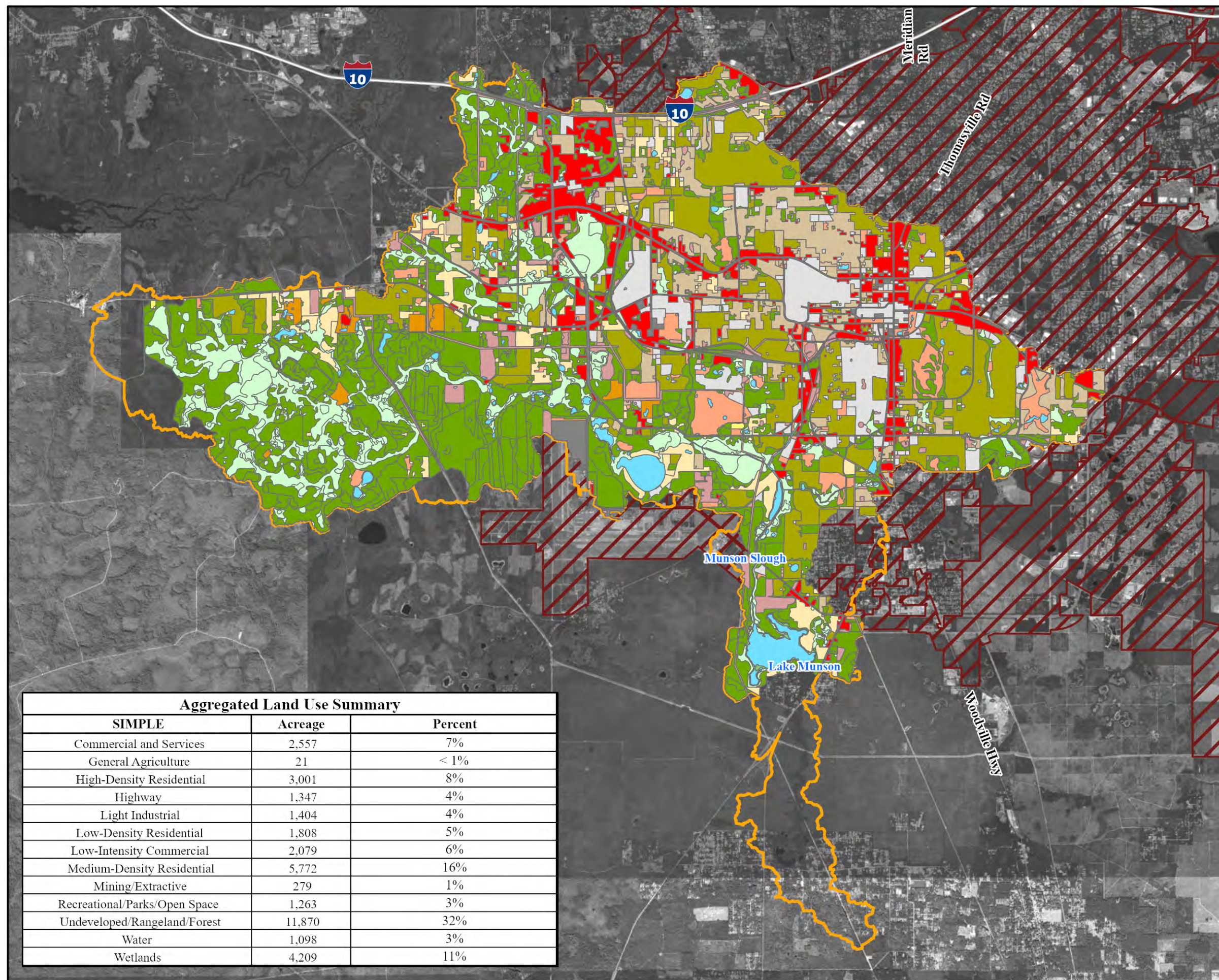
City Limits: COT, 2020

BMPs: Geosyntec, 2023

Figure 3-40:

Lake Munson Subbasin Delineation and BMPs

Tallahassee Master Plan - Surface Water (TMaPS)



Legend

- Lake Munson Drainage Basin
- Tallahassee Corporate Limits
- Land Use Type
 - Commercial and Services
 - General Agriculture
 - High-Density Residential
 - Highway
 - Light Industrial
 - Low-Density Residential
 - Low-Intensity Commercial
 - Medium-Density Residential
 - Mining/Extractive
 - Recreational/Parks/Open Space
 - Undeveloped/Rangeland/Forest
 - Water
 - Wetlands

Sources:
Waterbodies: COT, 2020
Land Use: Geosyntec, 2023
Roads: COT-Leon County, 2023
City Limits: COT, 2020

Figure 3-41:
Lake Munson and Munson Slough below
Lake Henrietta Aggregated Land Use

Tallahassee Master Plan - Surface
Water (TMaPS)



Aggregated Land Use Summary

SIMPLE	Acreage	Percent
Commercial and Services	2,557	7%
General Agriculture	21	< 1%
High-Density Residential	3,001	8%
Highway	1,347	4%
Light Industrial	1,404	4%
Low-Density Residential	1,808	5%
Low-Intensity Commercial	2,079	6%
Medium-Density Residential	5,772	16%
Mining/Extractive	279	1%
Recreational/Parks/Open Space	1,263	3%
Undeveloped/Rangeland/Forest	11,870	32%
Water	1,098	3%
Wetlands	4,209	11%

Table 3-6: Aggregated Land Use

FLUCCS Code	FLUCCS Description	SIMPLE-Seasonal Aggregated Description
1100	Low-Density Residential	Low-Density Residential
1200	Medium-Density Residential	Medium-Density Residential
1300	High-Density Residential	High-Density Residential
1400	Commercial and Services	Commercial and Services
1500	Other Light Industrial	Light Industrial
1600	Reclaimed Lands	Mining/Extractive
1700	Institutional	Low-Intensity Commercial
1800	Community Recreational Facilities	Recreational/Parks/Open Space
1900	Open Land	Recreational/Parks/Open Space
2100	Cropland and Pastureland	Undeveloped/Rangeland/Forest
2400	Nurseries and Vineyards	General Agriculture
2600	Other Open Lands (Rural)	Undeveloped/Rangeland/Forest
3100	Range Land, Herbaceous (Dry Prairie)	Undeveloped/Rangeland/Forest
3200	Shrub and Brushland	Undeveloped/Rangeland/Forest
3300	Mixed Rangeland	Undeveloped/Rangeland/Forest
4100	Upland Coniferous Forests	Undeveloped/Rangeland/Forest
4200	Upland Hardwood Forests	Undeveloped/Rangeland/Forest
4300	Hardwood Coniferous - Mixed	Undeveloped/Rangeland/Forest
4400	Forest Regeneration Areas	Undeveloped/Rangeland/Forest
5100	Streams and Waterways	Water
5200	Lakes	Water
5300	Reservoirs	Water
5600	Slough Waters	Water
6100	Wetland Hardwood Forests	Wetlands
6200	Wetland Coniferous Forests	Wetlands
6300	Wetland Forested Mixed	Wetlands
6400	Vegetated Non-Forested Wetlands	Wetlands
6500	Non-Vegetated Wetlands	Wetlands
7400	Disturbed Lands	Undeveloped/Rangeland/Forest
8100	Transportation	Highway
8200	Communications	Light Industrial
The person f 8300	Utilities	Light Industrial

Note:

1. The aggregated descriptions are based on guidance from the SIMPLE-Seasonal model guidance document.

As previously mentioned, the SIMPLE-Seasonal model uses the Harper and Baker (2007) method to determine stormwater pollutant loads. Specifically, a mean annual runoff coefficient (MARC) and the average annual rainfall depth are used to estimate average annual runoff volumes. The MARCs for all land use categories were developed based on the annual runoff coefficients for Meteorological Zone 1 in the draft *Florida Stormwater Quality Applicants Handbook* (FSQAH) (FDEP, 2010). The MARCs are assigned based on the DCIA and the non-

DCIA CN. Impervious areas within representative areas for each simplified land use type were digitized to estimate representative DCIA and impervious percentages. The representative percentages were used for each land use, with the values used provided in **Table 3-7**.

Table 3-7: Land Use DCIA and Non-DCIA Percentages

FLUCCS Code	FLUCCS Description	% Impervious	% DCIA	% Pervious
1100	Low-Density Residential	11	3	89
1200	Medium-Density Residential	37	12	63
1300	High-Density Residential	38	18	62
1400	Commercial and Services	58	58	42
1700	Institutional	44	38	56
1800	Community Recreational Facilities	29	18	71
1900	Open Land	0	0	100
2100	Cropland and Pastureland	0	0	100
2200	Tree Crops	0	0	100
2500	Specialty Farms	0	0	100
3100	Range Land, Herbaceous (Dry Prairie)	0	0	100
3200	Shrub and Brushland	0	0	100
3300	Mixed Rangeland	0	0	100
4100	Upland Coniferous Forests	0	0	100
4200	Upland Hardwood Forests	0	0	100
4300	Hardwood Coniferous – Mixed	0	0	100
4400	Forest Regeneration Areas	0	0	100
5200	Lakes	100	100	0
5300	Reservoirs	100	100	0
6100	Wetland Hardwood Forests	100	100	0
6200	Wetland Coniferous Forests	100	100	0
6300	Wetland Forested Mixed	100	100	0
6400	Vegetated Non-Forested Wetlands	100	100	0
6500	Non-Vegetated Wetlands	100	100	0
7400	Disturbed Lands	4	0	96
8100	Transportation	72	38	28
8200	Communications	12	1	88
8300	Utilities	22	22	78

The non-DCIA CNs were calculated based on the percent impervious, minus the DCIA percentage, and the pervious fractions, which were based on open space in good condition and the soil hydraulic group. The impervious areas were assigned a CN value of 98. A lookup table was developed to relate soil hydrologic group to pervious area CNs [see **Table 3-8**, which were referenced from the USDA Urban Hydrology for Small Watersheds (TR-55) (June 1986)]. The overall non-DCIA CNs were then determined by taking an area-weighted average of the impervious and pervious fractions of the non-DCIA CNs.

Table 3-8: Curve Number Lookup Table

Land Use	A	B	C	D	W
Open Space in Good Condition (Grass Cover > 75%)	39	61	74	80	100
Water	100	100	100	100	100
Wetlands	100	100	100	100	100

The soils data used for this modeling effort were presented in **Section 3.4.3.3**. Stormwater runoff is generated when the rate of rainfall exceeds the infiltration capacity of the site soils, resulting in water flow along the land surface. For pits and urban land, soil types were assumed to be HSG D soil group. When dual HSGs were found, an average value was assigned (i.e., soils A/D were assigned a B runoff potential, soils B/D were assigned a C runoff potential, soils C/D were assigned a D runoff potential). This assumption is appropriate because the SIMPLE-Seasonal model is based on an average annual analysis and dual classed soils will sometimes behave as one hydrologic group and other times behave as the other. If the worst-case hydrologic group is taken, as is done for event-based floodplain modeling, it would result in an over estimation of volume of stormwater generated and thus pollutant loading.

Pollutant loads for direct runoff are determined by multiplying the average annual runoff volumes by the appropriate EMCs. The EMC values used for this study were a combination of values determined by the City (2015) and those reported by Harper and Baker (2007). Water and wetland land use types were assigned a value of zero (0) as they are assumed in this analysis to not contribute pollutants but act as a pollutant sink. **Table 3-9** shows the EMC values used for the SIMPLE-Seasonal model. Mean annual runoff coefficients were calculated for each polygon resulting from the intersection of the land use layer and the soils layer, based on the FSQAH (FDEP, 2010).

Table 3-9: Event Mean Concentration by Land Use

SIMPLE-Seasonal Aggregated Description	TP (mg/L)	TN (mg/L)	Reference
General Agriculture	0.94	1.32	City, 2015
High-Density Residential	0.43	1.58	City, 2015
Commercial and Services	0.22	1.05	City, 2015
Highway	0.22	1.64	Harper, 2007
Light Industrial	0.13	1.22	City, 2015
Low-Density Residential	0.27	1.18	City, 2015
Low-Intensity Commercial ¹	0.18	1.18	Harper, 2007
Medium-Density Residential	0.43	1.58	City, 2015
Water ²	0.0	0.0	-
Wetlands ²	0.0	0.0	-
Undeveloped/Rangeland/Forest	0.11	0.79	City, 2015
Recreational/Parks/Open Space	1.13	2.33	City, 2015

Note:

1. Low-intensity commercial land use type was used for institutional land use type.
2. EMCs assumed to be zero (0) since water bodies and wetlands are typically assumed to be sinks and not sources of pollutant loads within a watershed.

Water quality treatment provided by existing BMPs within the subbasins was considered as part of this analysis. Runoff BMPs were identified and classified as wet detention, wet retention, dry retention, or dry detention. Aerial imagery, 2018 Leon County DEM, and BMP shapefiles from the City, Leon County, and FDOT were reviewed to identify BMPs within the subbasins draining to Lake Munson and Munson Slough downstream of Lake Henrietta SWMF greater than 1 acre. **Figure 3-40** shows the BMPs by subbasin. The BMPs were assigned a removal efficiency based on the type of practice. The removal efficiencies for BMPs are provided in **Table 3-10** and also on **Figure 3-40**. The values were based on the study conducted by Harper and Baker (2007) and based on the draft Environmental Resource Permit (ERP) Applicant's Handbook Volume I Section 8 from FDEP (2022). Based on guidance from the City, all the dry detention ponds were assumed to have sand filters due to local land development regulations.

Table 3-10: Direct Runoff BMP Removal Efficiencies

BMP Type	TN (%)	TP (%)
Wet Detention ¹	30	65
Wet Retention ²	80	80
Dry Retention ¹	99	99
Dry Detention ¹	30	40

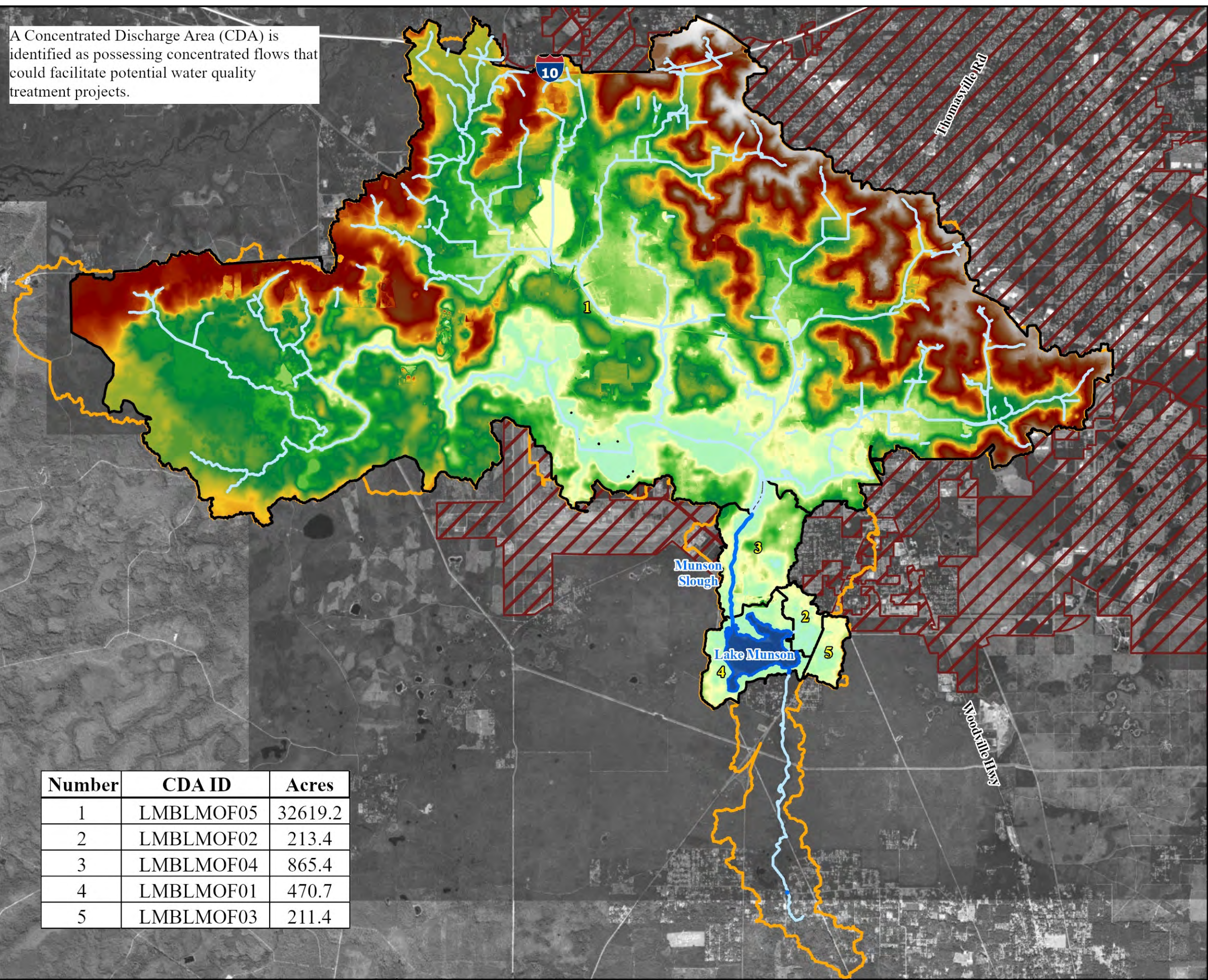
Note:

1. The values were from H. Harper and D. Baker, *Evaluation of current Stormwater Design Criteria within the State of Florida* (June 2007).
2. Stormwater quality nutrient permitting requirements (FDEP 2022)

Natural depressions, wetlands, and natural water bodies were not included as BMPs since removal efficiencies are based on retaining a certain design volume from engineered systems. Additionally, as outlined previously, any BMP less than 1 acre was not considered due to the scale of this study. Based on the assumptions outlined above, the SIMPLE modeling presented for Lake Munson, Munson Slough downstream of Lake Henrietta SWMF, and subsequent waterbodies has the potential to calculate high load values due to not considering removal associated with natural features and small local BMPs as well as other processes. As such, the purpose of the SIMPLE model is to provide total loads and per acre loading for comparison between contributing areas around the waterbody, and total loads for comparison to other loading sources to the waterbody.

For the purposes of the loading calculations, the subbasins were grouped into Concentrated Discharge Areas (CDAs) that represent discrete areas of loading to Lake Munson and Munson Slough downstream of Lake Henrietta SWMF. The loads from the subbasins were then summed for each of the CDAs. **Figure 3-42** presents the CDAs along with their associated acreage. The CDAs represent the discrete areas upon which evaluations of total loading and per acre loading are presented below.

A Concentrated Discharge Area (CDA) is identified as possessing concentrated flows that could facilitate potential water quality treatment projects.



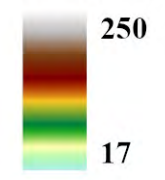
0 1.2 Miles

Legend

- Lake Munson Drainage Basin
- Lake Munson
- Munson Slough
- Concentrated Discharge Areas
- Tallahassee Corporate Limits
- Watercourses

Topographic Elevations

ft NAVD88



Sources:
Waterbodies: COT, 2020
Watercourses: COT, 2020
CDAs: Geosyntec, 2023
Roads: COT-Leon County, 2023
City Limits: COT, 2020
Elevation: COT-Leon County, 2018

Figure 3-42:
Lake Munson and Munson Slough below
Lake Henrietta Concentrated Discharge
Areas

Tallahassee Master Plan - Surface
Water (TMaPS)



Number	CDA ID	Acres
1	LMBLMOF05	32619.2
2	LMBLMOF02	213.4
3	LMBLMOF04	865.4
4	LMBLMOF01	470.7
5	LMBLMOF03	211.4

Utilizing the calculated total loads and the per acre loads, the various CDAs were ranked. The approach for the ranking was to order the total loads and the per acre loads from lowest to highest and assign a numeric order number for each waterbody where the highest load would receive the higher numeric order number and the lowest load would receive the lower. This represents a score that can be used to identify CDAs of interest. The two scores were then added together (total load rank and per acre load rank) to get a total score. These were then ordered from highest to lowest value to define the ranking. The goal was for the ranking to consider both the total load from an area (which allows focus on areas with significant load) along with the per acre loading (which allows focus on areas with high discharge concentrations or greater anthropogenic impact). The combining of the two allows focus on both available load for reduction and targeted higher concentration areas which represent greater opportunity for treatment.

Stormwater Nutrient Loads to Lake Munson and Munson Slough Downstream of Lake Henrietta SWMF

For the load coming into Lake Munson through Munson Slough, measured water quality data immediately downstream of the Lake Henrietta SWMF was used for the load calculation out of CDA LMBLMOF05 (1 on **Figure 3-42**). The data were collected at Station LMB02 and were part of the data sets presented in previous sections. The water quality at this station is representative of discharge from the Lake Henrietta SWMF, and those that bypass the facility, as it flows down Munson Slough prior to entering Lake Munson. The runoff volume calculated from the SIMPLE-Seasonal model upstream of LMB02 was used as the volume discharged from the system (**Table 3-11**). Using the measured flows presented in **Section 3.4.3.6** at LMB02 (Station 008434 on **Exhibit 3-6**) total annual flow volumes were calculated for years since 2010 where sufficient data were available. The total volumes ranged from 18,000 acre-ft up to 35,000 acre-ft. The 34,610 acre-ft modeled flow is high but within the range of measured values. The calculated loads should be considered in this context.

Table 3-11: Concentration Data, Volumes, and Calculated Loads Representing the Discharge from the Lake Henrietta SWMF

Station ID LMB02	Concentration (mg/L)	Year of data	Volume (ac-ft/yr) ¹	Loads (lb/yr)
Total N	0.618	2018-2020	34,610	58,142
Total P	0.058	2018-2020	34,610	5,449

Note:

1. The value was calculated in SIMPLE-Seasonal model.

The TN and TP loads were then calculated by multiplying the modeled volume by the measured average TN and TP concentrations (**Table 3-11**). The average value of the most recent 3 years of geometric mean TN and TP data were used for the load calculations. No data earlier than 2017 were used for this analysis to best represent current conditions.

This approach is different than the SIMPLE modeling approach presented previously as it accounts for the removal processes that occur upstream and within the Lake Henrietta SWMF. The approach is appropriate because of the nature of the Lake Henrietta SWMF as a significant

and unique regional treatment system, along with the availability of sufficient water quality data to perform the calculation.

Figure 3-43 presents the distribution of the ranking of the CDAs for TN along with the total load and per acre loads (see the table on **Figure 3-43**). The rankings are color coded, with the highest ranked CDAs in dark green moving down to the lowest ranked in pale yellow. The calculated total stormwater TN loads from the CDAs ranged from as low as 3.4 pounds per year (lb/yr) up to 58,142 lb/yr. The per acre loads ranged from near 0 lb/acre/yr up to 2.2 lb/acre/yr. The highest ranked CDAs were the overall drainage basin upstream of the Lake Henrietta SWMF (LMBLMOF05) and a small CDA immediately adjacent to Lake Munson (LMBLMOF02). The total potential stormwater runoff load for TN is 60,135 lb/yr. While the area above the Lake Henrietta SWMF is ranked highest, the per acre load along with the average concentrations as listed in **Table 3-11** would not indicate significant need for additional stormwater load reduction for TN.

Figure 3-44 presents the distribution of the ranking of the CDAs for TP along with the total load and per acre loads (see the table on **Figure 3-44**). The calculated total stormwater TP loads from the CDAs ranged from as low as 0.6 lb/yr up to 5,450 lb/yr. The per acre loads ranged from near 0 lb/acre/yr up to 0.2 lb/acre/yr. The total potential stormwater runoff load for TP is 5,840 lb/yr. The TP per acre loads from upstream of Lake Henrietta SWMF are generally lower and, therefore, despite its very high total load, the area above Lake Henrietta SWMF ranked lower relative to TP loading, which is likely a function of treatment for TP from the Lake Henrietta SWMF and the multiple other facilities upstream. The highest ranked CDAs were the ones downstream of Lake Henrietta SWMF that flow directly to Munson Slough and Lake Munson but have limited facilities for their immediate drainage areas. As with TN, the per acre TP load out of the Lake Henrietta SWMF along with the average concentrations as listed in **Table 3-11** would not indicate significant need for additional stormwater load reduction for TP.

3.4.5.2 Septic Load

Methodology

To quantify the potential nutrient load from septic tank units to Lake Munson and Munson Slough downstream of Lake Henrietta SWMF and other waterbodies within the Lake Munson basin, the SPIL method, as adopted by FDEP, was utilized. The SPIL method calculates the TN load based on the number of septic tanks within a specified distance to the waterbody and an assumed loading of 9.012 lb of TN per person per year. Additionally, per the SPIL method, a percent loss of 50 percent is assumed as septic tank effluent moves through the unsaturated zone to groundwater.

The equation for estimating potential loading is:

$$S * P * I * L = \text{Total TN (lb) per year}$$

Where:

S = Number of known septic tanks within 200 meters of a waterbody

P = Average number of people per household

I = Constituent annual load

L = Percentage of nutrient loss during seepage

A Concentrated Discharge Area (CDA) is identified as possessing concentrated flows that could facilitate potential water quality treatment projects.



Legend

- Lake Munson Drainage Basin
- Lake Munson
- Munson Slough
- Concentrated Discharge Areas
- Watercourses
- Tallahassee Corporate Limits
- Ranking
 - High (1)
 - Low (5)

Sources:
Waterbodies: COT, 2020
Watercourses: COT, 2020
CDAs: Geosyntec, 2023
Roads: COT-Leon County, 2023
City Limits: COT, 2020
Elevation: COT-Leon County, 2018

Figure 3-43:
Lake Munson and Munson Slough below
Lake Henrietta Concentrated Discharge
Areas-Total Nitrogen

Tallahassee Master Plan - Surface
Water (TMaPS)



Summary of Concentrated Discharge Areas				
Number	CDA ID	Total Load (lbs-TN/yr)	Area Load (lbs TN/ac/yr)	Ranking
1	LMBLMOF05	58,142.1	1.8	1
2	LMBLMOF02	479.8	2.2	2
3	LMBLMOF04	1,101.4	1.3	3
4	LMBLMOF01	408.1	0.9	4
5	LMBLMOF03	3.4	0.0	5
Total Load:		60,134.7		

A Concentrated Discharge Area (CDA) is identified as possessing concentrated flows that could facilitate potential water quality treatment projects.



Legend

- Lake Munson Drainage Basin
 - Lake Munson
 - Munson Slough
 - Concentrated Discharge Areas
 - Watercourses
 - Tallahassee Corporate Limits
- Ranking
- High (1)
 - Low (5)

Sources:
Waterbodies: COT, 2020
Watercourses: COT, 2020
CDAs: Geosyntec, 2023
Roads: COT-Leon County, 2023
City Limits: COT, 2020
Elevation: COT-Leon County, 2018

Figure 3-44:
Lake Munson and Munson Slough below Lake
Henrietta Concentrated Discharge Areas-Total
Phosphorus

Tallahassee Master Plan - Surface
Water (TMaPS)



Summary of Concentrated Discharge Areas				
Number	CDA ID	Total Load (lbs-TP/yr)	Area Load (lbs-TP/ac/yr)	Ranking
1	LMBLMOF02	112.0	0.5	1
2	LMBLMOF04	190.4	0.2	1
3	LMBLMOF05	5,449.5	0.2	3
4	LMBLMOF01	87.6	0.2	4
5	LMBLMOF03	0.6	0.0	5
Total Load:		5,840.0		

The latest available census data was utilized, which estimates 2.4 persons per household within Leon County. The buffer zone for selecting septic tanks was also applied to tributaries discharging to the waterbody of interest, as delineated by the City. The inclusion of the tributaries in the loading calculation deviates from the approach utilized by FDEP, but based on internal project team discussion, was felt to be a reasonable addition as these represent a direct connection to the waterbody.

The FDEP method only calculates TN load since the majority of phosphorous in septic tank effluent is assumed to be adsorbed onto soil particles before reaching the groundwater table. Published studies on phosphorus attenuation in groundwater show that phosphorus plumes from septic units typically do not extend beyond 50 meters, with approximately 96 percent of phosphorus removal occurring within the first 10 meters (Corbett et al., 2002; Robertson et al., 2019). Therefore, FDEP's decision to not include TP was followed in this study.

The literature review also indicated that the 200-meter buffer around waterways that FDEP uses to capture septic tank TN contributions is a conservative approach. The literature suggests that most of the TN attenuation takes place within the first 10 meters (Corbett et al., 2022; Robertson et al., 2019; Van Stempvoort et al., 2021). For the purpose of identifying potential problem areas, and based on general soil characteristics in and around tributaries and the lake (higher water table conditions), the 200-meter buffer (as defined by FDEP) for TN contributions was maintained. The watercourse layer provided by the City was used to assess the 200-meter buffer.

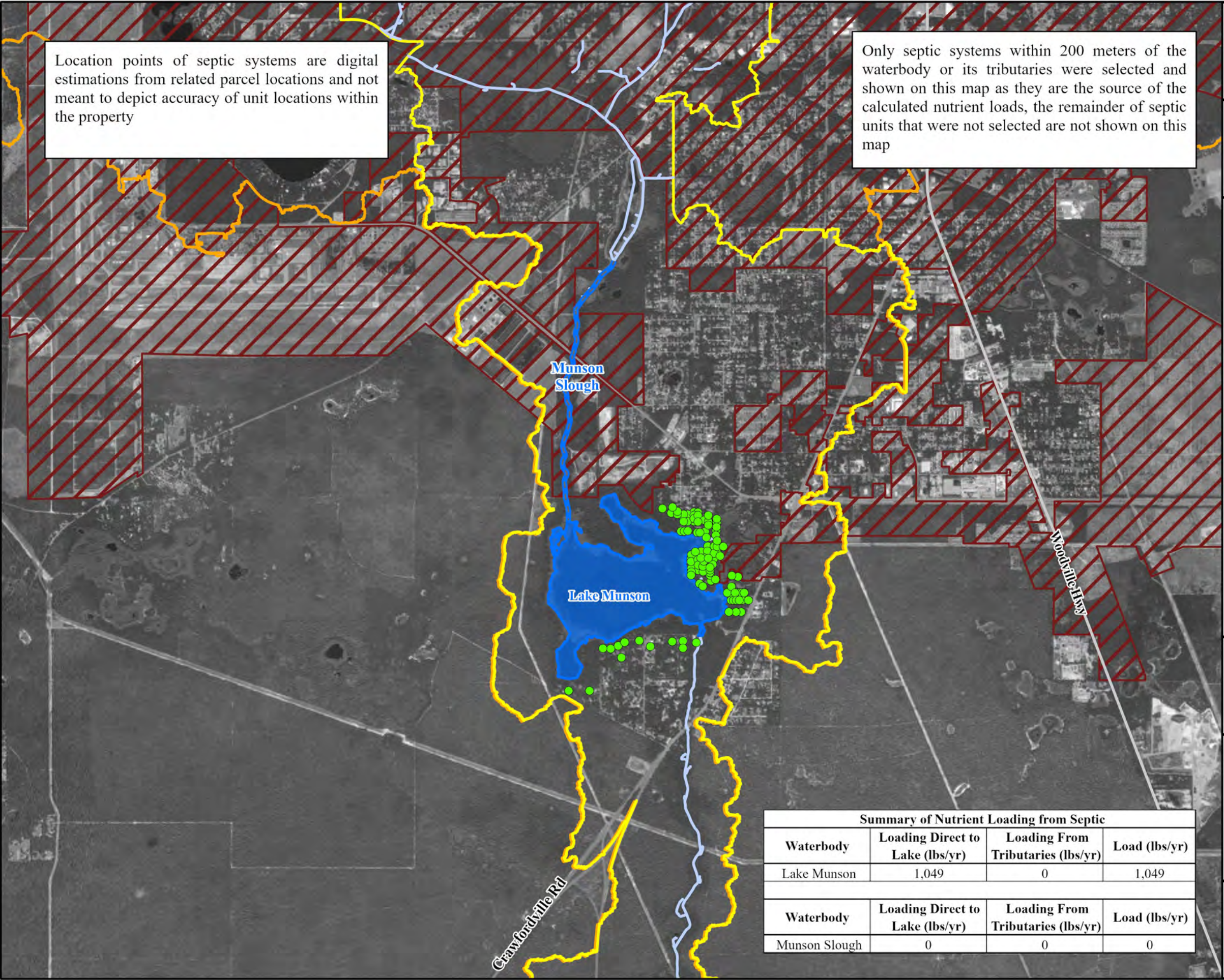
Based on the available literature on septic movement, it is understood that the approach presented herein may overpredict the nitrogen load to the waterbodies and, therefore, potentially represents a conservative potential load. Further study is needed to better quantify septic loading to the lake and other waterbodies in the basin.

Results

An estimated 100 septic tank units were identified within 200 meters of Lake Munson, with zero units within 200 meters of Munson Slough downstream of Lake Henrietta SWMF. **Figure 3-45** shows the septic systems utilized in this analysis, with green representing those associated with direct loading to the waterbody. A table provided in the figure summarizes the calculated nutrient load from septic units. Lake Munson has an estimated annual TN load of 1,049 lb/yr, all from units directly on the lake. Munson Slough downstream of Lake Henrietta SWMF has a load of 0 lb/yr.

3.4.5.3 Wastewater Load

The assessment provided in **Section 3.4.4.5** identified that wastewater loads are accounted for in the load calculation out of Lake Henrietta SWMF presented in **Section 3.4.5.1**. Additionally, point source loads were not determined to be a significant source based on flow rates and discharge methods. As such, wastewater loads were not calculated.



Location points of septic systems are digital estimations from related parcel locations and not meant to depict accuracy of unit locations within the property

Only septic systems within 200 meters of the waterbody or its tributaries were selected and shown on this map as they are the source of the calculated nutrient loads, the remainder of septic units that were not selected are not shown on this map



0 0.5 Miles

Legend

- Lake Munson Major Drainage Basin
- Lake Munson Drainage Basin
- Lake Munson
- Munson Slough
- Watercourses
- Relevant Septic Sites
 - Lake

Sources:
Waterbodies: COT, 2020
Watercourses: COT, 2020
Septic Systems: COT, 2020
Watershed: COT, 2020
Roads: COT-Leon County, 2023

Figure 3-45:
Septic Loading to Lake Munson and
Munson Slough below Lake Henrietta

Tallahassee Master Plan - Surface
Water (TMaPS)



Summary of Nutrient Loading from Septic			
Waterbody	Loading Direct to Lake (lbs/yr)	Loading From Tributaries (lbs/yr)	Load (lbs/yr)
Lake Munson	1,049	0	1,049
Waterbody	Loading Direct to Lake (lbs/yr)	Loading From Tributaries (lbs/yr)	Load (lbs/yr)
Munson Slough	0	0	0

3.4.5.4 Lake Inflow Load

Methodology

Surface water connections between waterbodies are inherently potential sources of pollutants to a downstream waterbody. This section, and others to follow, focuses on the interconnectivity of lakes within the Lake Munson basin and their potential for impacting water quality as a function of loading from one lake to another. Estimation of this loading requires having flow out of and water quality data within the upstream lake. When assessing the potential for inter-lake loading to Lake Munson and other lakes within the basin, the analyses will focus on nutrient loading (TN and TP) and considerations of impairment and nutrient concentrations in the upstream and downstream lakes.

At present, there are no direct flow measurements immediately downstream of the lakes discussed as sources in this and subsequent sections. Therefore, to calculate annual nutrient loads out of the lakes (where nutrient concentration data are available), an average annual flow volume out must be calculated. To this end, the results from the SIMPLE-Seasonal modeling performed as part of the analysis presented in **Section 3.4.5.1** were used to estimate the annual average flows into the upstream lakes. The average annual flow into the lakes was then assumed to be equivalent to the average annual flow out (rainfall and evaporation generally being equivalent on an average annual basis). The calculated flows were then multiplied by TN and TP concentrations in the upstream lake. The TN and TP concentrations represent averages of the latest 3 years of geomeans, with no data prior to 2017 utilized. This approach was utilized for all the lake loading calculations within the Lake Munson basin where recent lake nutrient concentration data are available and direct inflows have been calculated using the SIMPLE-Seasonal model.

Results

Cypress Lake is the only direct source of lake inflow to Lake Munson. **Section 3.4.4.7** identified that the inflow from this lake would not be deemed a significant source of anthropogenic load, therefore, no load is calculated here.

3.4.5.5 Internal Lake Load

Internal recycling loads represent fluxes from benthic substrate that build up from the deposition of ongoing or legacy loads coming into a waterbody. Additionally, buildup can also occur through the accumulation of organic material that settles following algal blooms. These algal blooms occur due to excess nutrient loading to the water column that results in a positive feedback loop of benthic nutrient releases followed by algal blooms. Nutrients are bound into the benthic substrate and, under different conditions (depending upon the nature of the nutrients in the sediments), can be released into the water column. In many lakes within Florida, benthic flux, or internal recycling, can be a significant portion of the nutrient budget. While naturally occurring flux does occur, it is the portion caused by the excessive historical and/or ongoing anthropogenic impacts that would require remediation. In this and sections that follow, the internal recycling loads for waterbodies in the Lake Munson basin are summarized based on the data and analyses presented in **Section 3.4.4.4** as well as through additional analyses where available data/studies support.

While no direct measurements of internal load to Lake Munson have been performed, analyses of data presented in **Section 3.4.4.4** provided an evaluation of potential historical and present significance of internal nutrient loads to the lake. The data analyses, along with other historical studies, identified that prior to 2016, internal loading of nutrients played a significant role in the lake dynamics. The analyses also demonstrated that since 2016, internal loading has played a lesser role. Based on improving water quality conditions evaluated through 2021, the internal lake load is not quantified.

3.4.5.6 Atmospheric Deposition

To calculate the atmospheric deposition loading for nutrients to Lake Munson, the data from the Quincy station (FL14), identified in earlier sections and shown on **Figure 3-24**, were utilized. The National Atmospheric Deposition Program (NADP) provides a clearinghouse for deposition data. The NADP sites collect nitrogen data but not phosphorus, as such, only TN is available. **Table 3-12** presents the annual TN loads per acre from 2010 to 2020. No data were available at the Quincy station for 2020 so the value from the next nearest station (Sumatra – FL23) was utilized. Averaging the annual load per acre over the 10-year period gives a value of 2.56 lb/acre/yr. Multiplying the 2.56 lb/acre/yr TN load by the acreage of Lake Munson (255 acres) gives a total average TN load of 653 lb/yr.

Table 3-12: Annual Atmospheric TN Load per Acre from Quincy Station

Year	TN (lb/acre)
2010	2.19
2011	2.31
2012	2.20
2013	2.57
2014	4.95
2015	2.57
2016	2.47
2017	2.31
2018	2.40
2019	1.97
2020*	2.16*

*Data from NADP Website Sumatra Station

3.4.5.7 Summary of Calculated Loads

Nutrient loads to Lake Munson and Munson Slough downstream of Lake Henrietta SWMF were calculated for stormwater runoff, septic systems, and atmospheric deposition. **Table 3-13** presents the calculated total loads to the lake for TN and TP. For septic systems and atmospheric deposition, only TN loads were calculated (see **Section 3.4.5.2** and **Section 3.4.5.6**, respectively, for explanation).

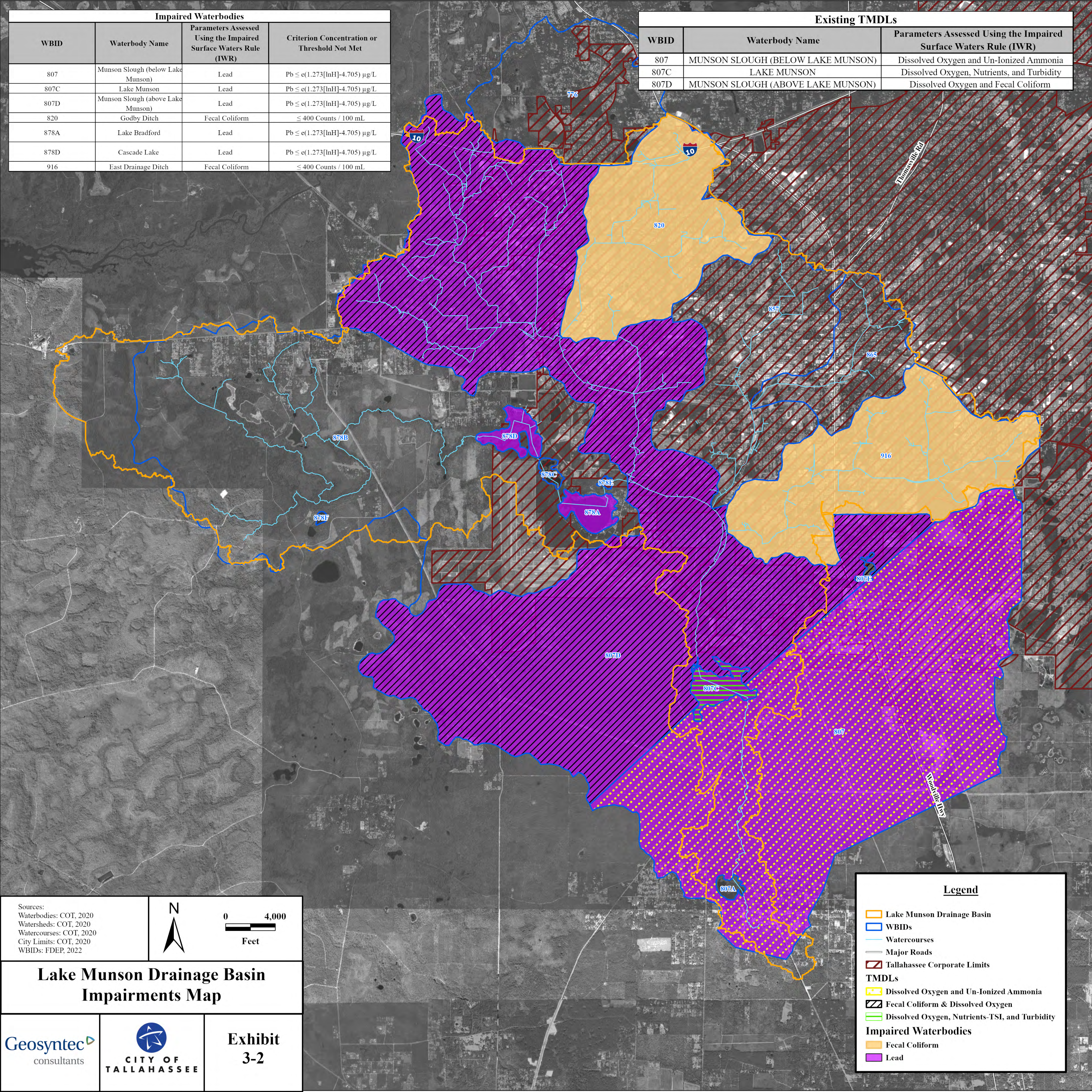
Table 3-13: Summary of Calculated Loads to Lake Munson and Munson Slough downstream of Lake Henrietta SWMF

Source	Lake Munson		Munson Slough downstream of Lake Henrietta SWMF	
	TN (lb/year)	TP (lb/year)	TN (lb/year)	TP (lb/year)
Stormwater Runoff	60,134	5,840	59,244	5,640
Septic Systems	1,049	ND	0	0
Atmospheric Deposition	563	ND	NA	NA

ND – No data to support calculation, NA – Load calculation not applicable

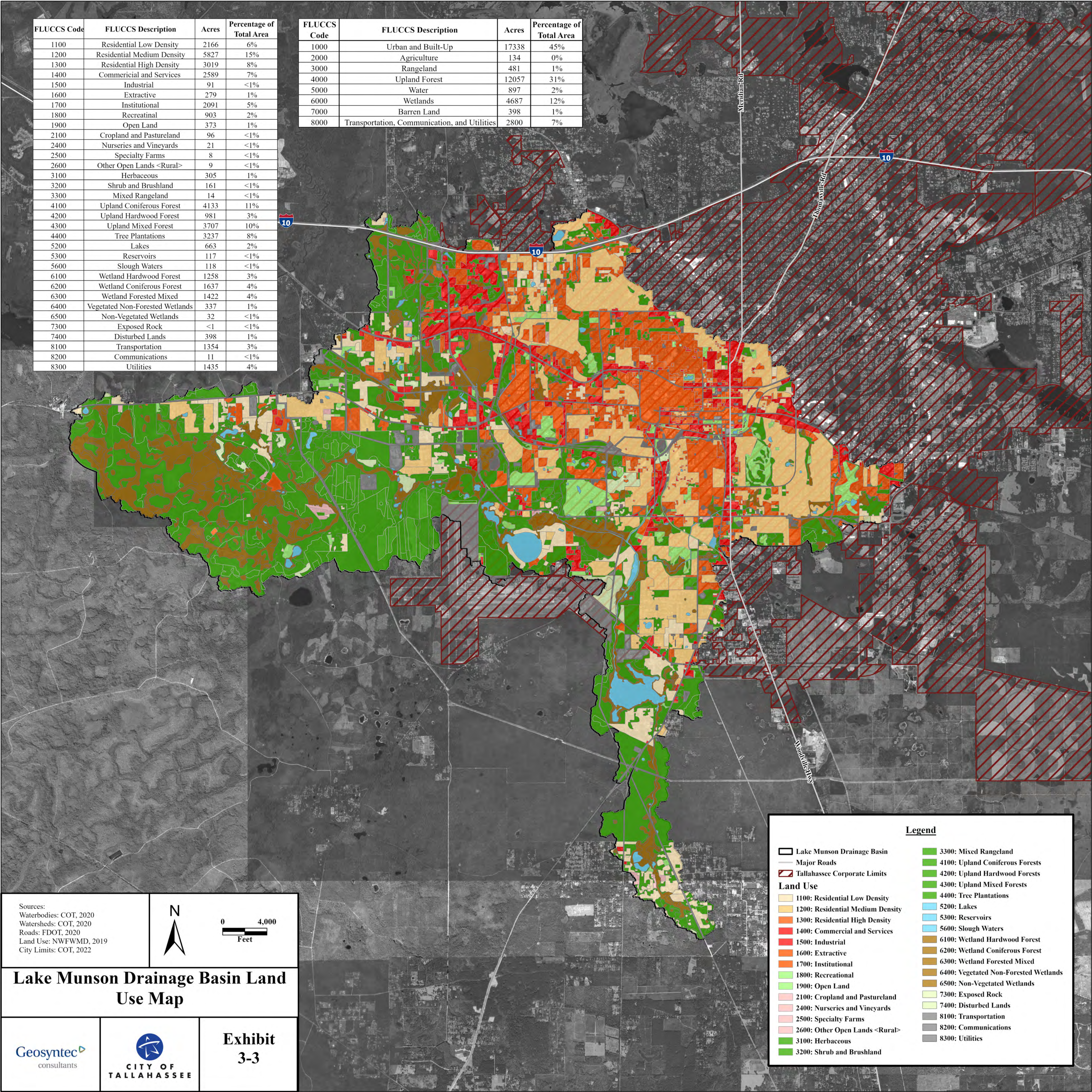
Impaired Waterbodies			
WBID	Waterbody Name	Parameters Assessed Using the Impaired Surface Waters Rule (IWR)	Criterion Concentration or Threshold Not Met
807	Munson Slough (below Lake Munson)	Lead	$Pb \leq e(1.273[\ln H]-4.705) \mu g/L$
807C	Lake Munson	Lead	$Pb \leq e(1.273[\ln H]-4.705) \mu g/L$
807D	Munson Slough (above Lake Munson)	Lead	$Pb \leq e(1.273[\ln H]-4.705) \mu g/L$
820	Godby Ditch	Fecal Coliform	$\leq 400 \text{ Counts} / 100 \text{ mL}$
878A	Lake Bradford	Lead	$Pb \leq e(1.273[\ln H]-4.705) \mu g/L$
878D	Cascade Lake	Lead	$Pb \leq e(1.273[\ln H]-4.705) \mu g/L$
916	East Drainage Ditch	Fecal Coliform	$\leq 400 \text{ Counts} / 100 \text{ mL}$

Existing TMDLs		
WBID	Waterbody Name	Parameters Assessed Using the Impaired Surface Waters Rule (IWR)
807	MUNSON SLOUGH (BELOW LAKE MUNSON)	Dissolved Oxygen and Un-Ionized Ammonia
807C	LAKE MUNSON	Dissolved Oxygen, Nutrients, and Turbidity
807D	MUNSON SLOUGH (ABOVE LAKE MUNSON)	Dissolved Oxygen and Fecal Coliform

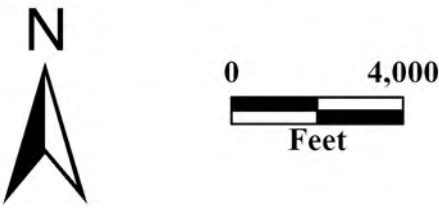


FLUCCS Code	FLUCCS Description	Acres	Percentage of Total Area
1100	Residential Low Density	2166	6%
1200	Residential Medium Density	5827	15%
1300	Residential High Density	3019	8%
1400	Commercial and Services	2589	7%
1500	Industrial	91	<1%
1600	Extractive	279	1%
1700	Institutional	2091	5%
1800	Recreational	903	2%
1900	Open Land	373	1%
2100	Cropland and Pastureland	96	<1%
2400	Nurseries and Vineyards	21	<1%
2500	Specialty Farms	8	<1%
2600	Other Open Lands <Rural>	9	<1%
3100	Herbaceous	305	1%
3200	Shrub and Brushland	161	<1%
3300	Mixed Rangeland	14	<1%
4100	Upland Coniferous Forest	4133	11%
4200	Upland Hardwood Forest	981	3%
4300	Upland Mixed Forest	3707	10%
4400	Tree Plantations	3237	8%
5200	Lakes	663	2%
5300	Reservoirs	117	<1%
5600	Slough Waters	118	<1%
6100	Wetland Hardwood Forest	1258	3%
6200	Wetland Coniferous Forest	1637	4%
6300	Wetland Forested Mixed	1422	4%
6400	Vegetated Non-Forested Wetlands	337	1%
6500	Non-Vegetated Wetlands	32	<1%
7300	Exposed Rock	<1	<1%
7400	Disturbed Lands	398	1%
8100	Transportation	1354	3%
8200	Communications	11	<1%
8300	Utilities	1435	4%

FLUCCS Code	FLUCCS Description	Acres	Percentage of Total Area
1000	Urban and Built-Up	17338	45%
2000	Agriculture	134	0%
3000	Rangeland	481	1%
4000	Upland Forest	12057	31%
5000	Water	897	2%
6000	Wetlands	4687	12%
7000	Barren Land	398	1%
8000	Transportation, Communication, and Utilities	2800	7%



Sources:
Waterbodies: COT, 2020
Watersheds: COT, 2020
Roads: FDOT, 2020
Land Use: NWFWM, 2019
City Limits: COT, 2022



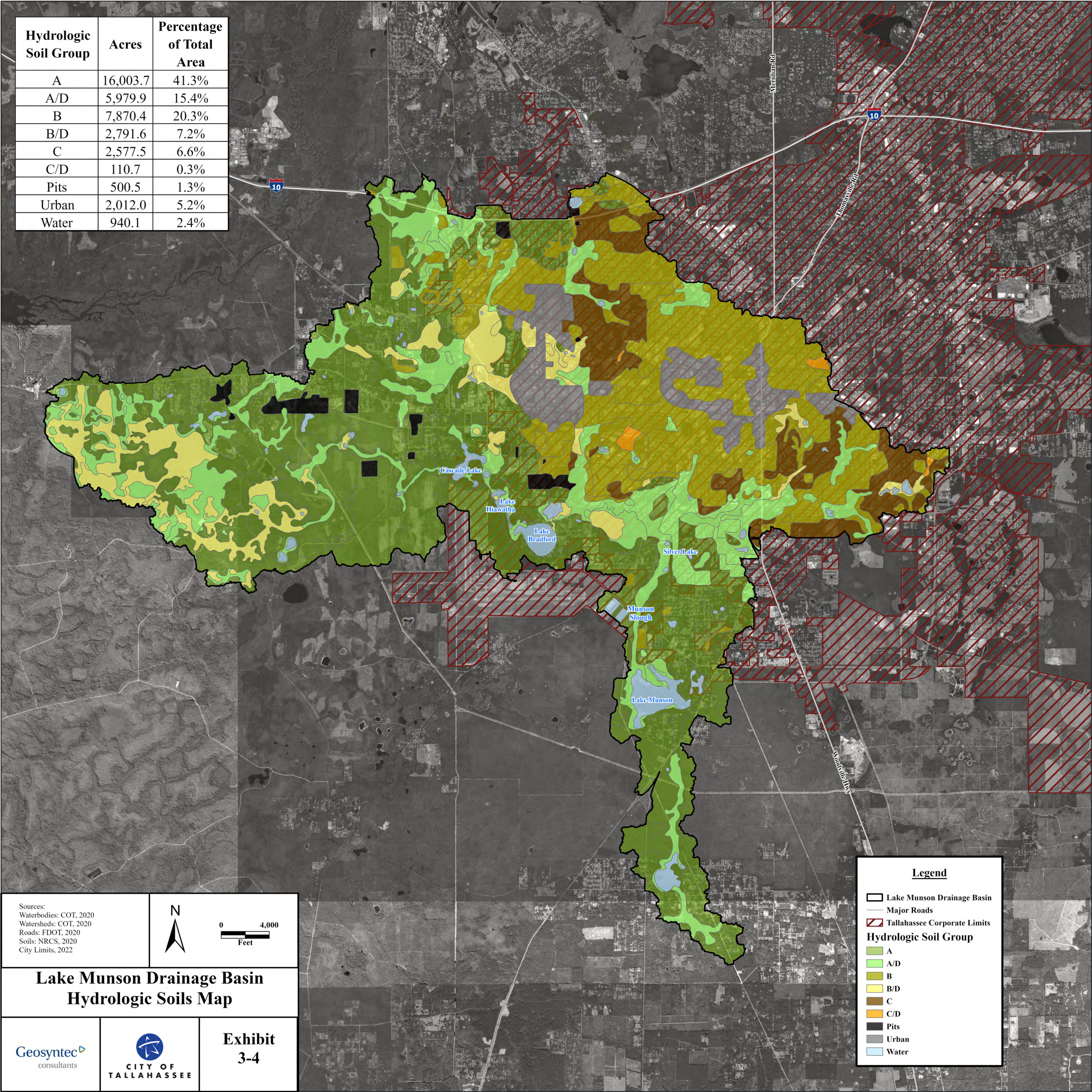
Lake Munson Drainage Basin Land Use Map

Geosyntec
consultants



Exhibit
3-3

Hydrologic Soil Group	Acres	Percentage of Total Area
A	16,003.7	41.3%
A/D	5,979.9	15.4%
B	7,870.4	20.3%
B/D	2,791.6	7.2%
C	2,577.5	6.6%
C/D	110.7	0.3%
Pits	500.5	1.3%
Urban	2,012.0	5.2%
Water	940.1	2.4%



Sources:
Waterbodies: COT, 2020
Watersheds: COT, 2020
Roads: FDOT, 2020
Soils: NRCS, 2020
City Limits, 2022



**Lake Munson Drainage Basin
Hydrologic Soils Map**

Geosyntec
consultants

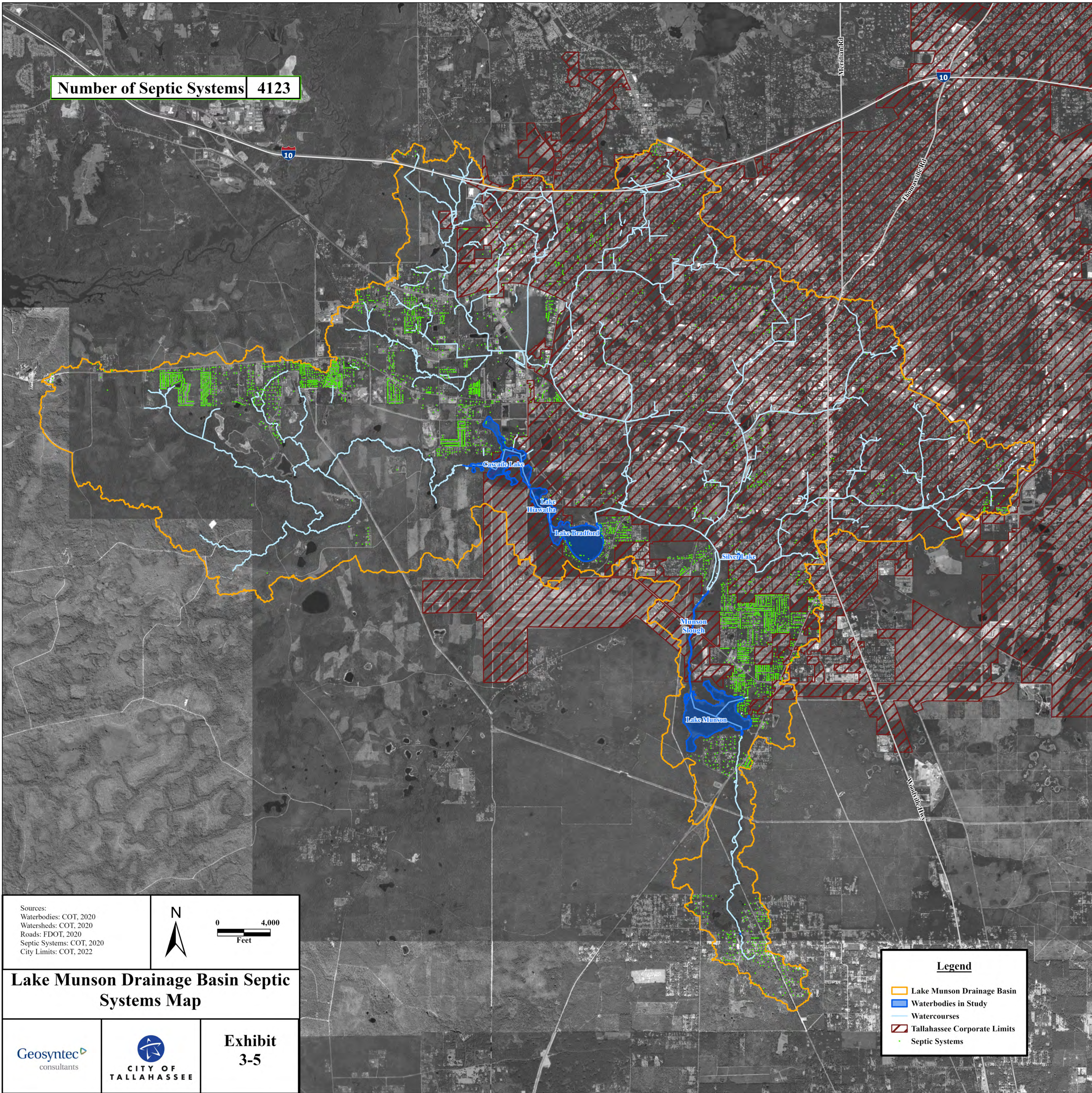


**Exhibit
3-4**

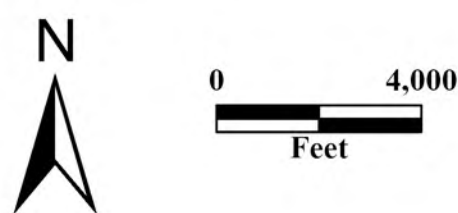
Legend

- Lake Munson Drainage Basin
- Major Roads
- Tallahassee Corporate Limits
- Hydrologic Soil Group**
 - A
 - A/D
 - B
 - B/D
 - C
 - C/D
 - Pits
 - Urban
 - Water

Number of Septic Systems 4123



Sources:
Waterbodies: COT, 2020
Watersheds: COT, 2020
Roads: FDOT, 2020
Septic Systems: COT, 2020
City Limits: COT, 2022



Lake Munson Drainage Basin Septic Systems Map

Geosyntec
consultants

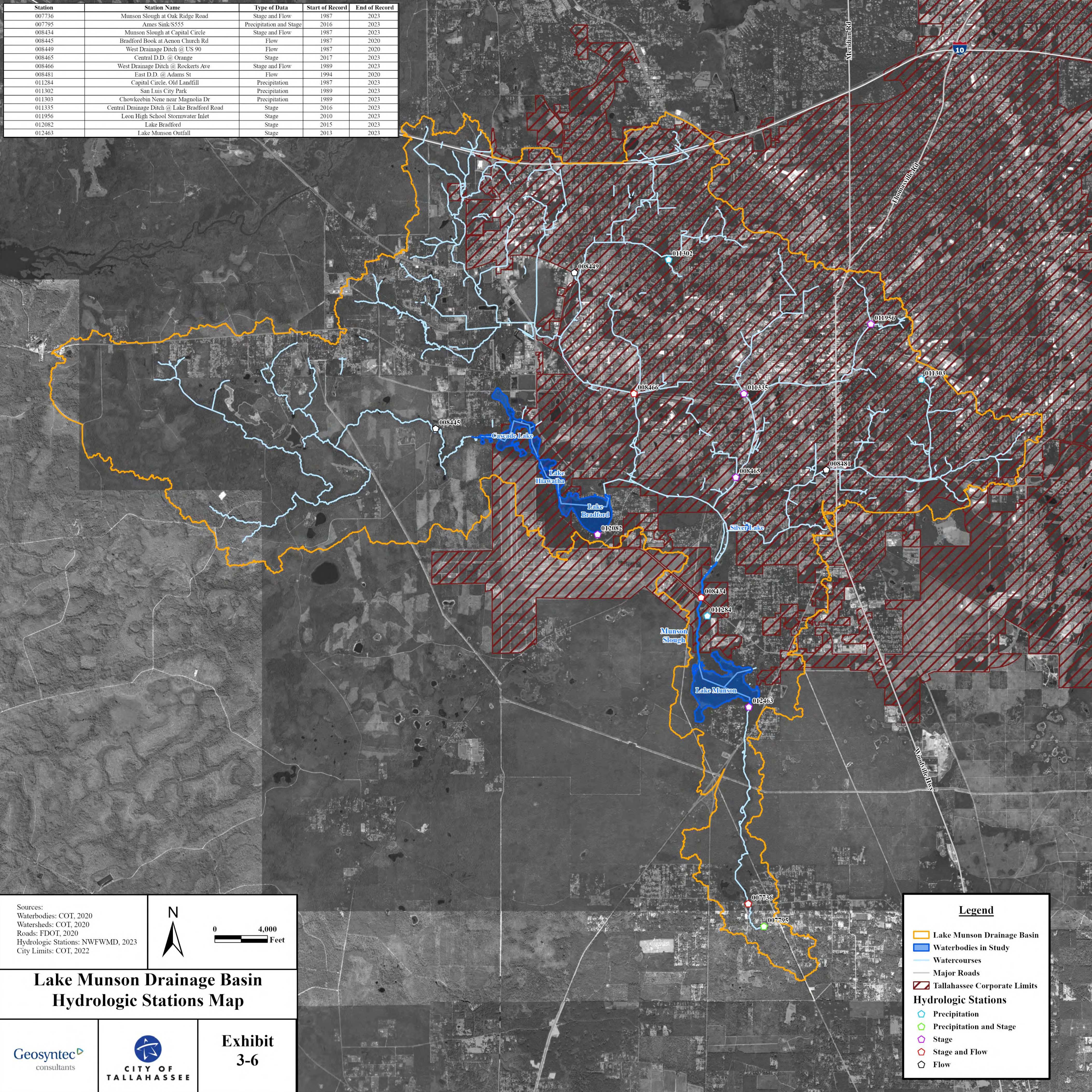


Exhibit
3-5

Legend

- Lake Munson Drainage Basin
- Waterbodies in Study
- Watercourses
- Tallahassee Corporate Limits
- Septic Systems

Station	Station Name	Type of Data	Start of Record	End of Record
007736	Munson Slough at Oak Ridge Road	Stage and Flow	1987	2023
007795	Ames Sink/S555	Precipitation and Stage	2016	2023
008434	Munson Slough at Capital Circle	Stage and Flow	1987	2023
008445	Bradford Book at Aenon Church Rd	Flow	1987	2020
008449	West Drainage Ditch @ US 90	Flow	1987	2020
008465	Central D.D. @ Orange	Stage	2017	2023
008466	West Drainage Ditch @ Rockerts Ave	Stage and Flow	1989	2023
008481	East D.D. @ Adams St	Flow	1994	2020
011284	Capital Circle, Old Landfill	Precipitation	1987	2023
011302	San Luis City Park	Precipitation	1989	2023
011303	Chowkeebin Nene near Magnolia Dr	Precipitation	1989	2023
011335	Central Drainage Ditch @ Lake Bradford Road	Stage	2016	2023
011956	Leon High School Stormwater Inlet	Stage	2010	2023
012082	Lake Bradford	Stage	2015	2023
012463	Lake Munson Outfall	Stage	2013	2023



Sources:
Waterbodies: COT, 2020
Watersheds: COT, 2020
Roads: FDOT, 2020
Hydrologic Stations: NWWFMD, 2023
City Limits: COT, 2022

**Lake Munson Drainage Basin
Hydrologic Stations Map**

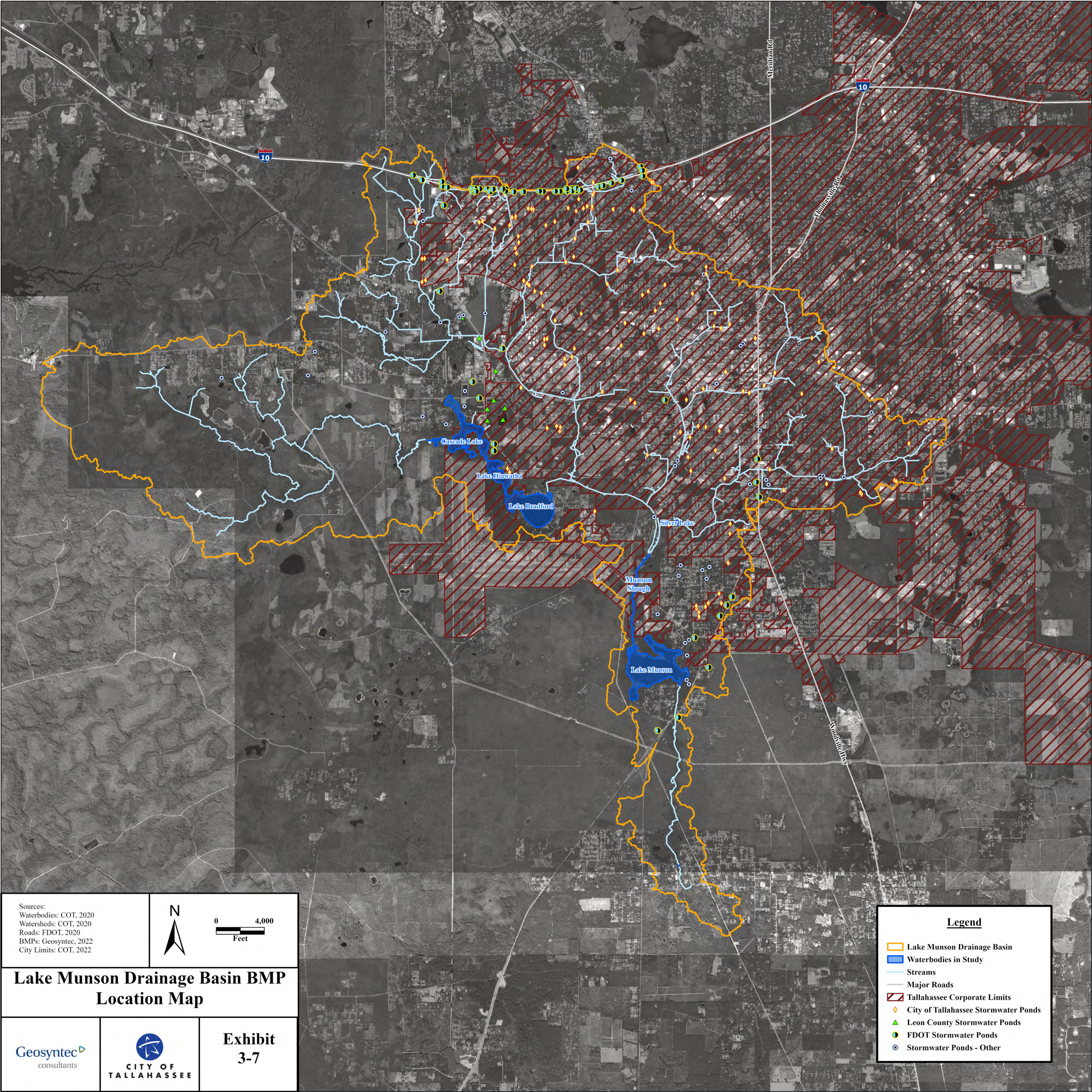
**Exhibit
3-6**

Legend

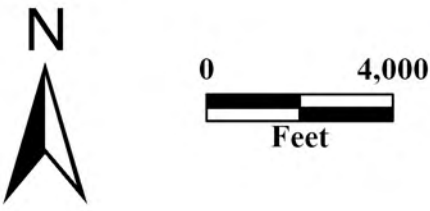
- Lake Munson Drainage Basin
- Waterbodies in Study
- Watercourses
- Major Roads
- Tallahassee Corporate Limits

Hydrologic Stations

- Precipitation
- Precipitation and Stage
- Stage
- Stage and Flow
- Flow



Sources:
Waterbodies: COT, 2020
Watersheds: COT, 2020
Roads: FDOT, 2020
BMPs: Geosyntec, 2022
City Limits: COT, 2022



Lake Munson Drainage Basin BMP Location Map

Exhibit
3-7

- Legend**
- Lake Munson Drainage Basin
 - Waterbodies in Study
 - Streams
 - Major Roads
 - Tallahassee Corporate Limits
 - City of Tallahassee Stormwater Ponds
 - Leon County Stormwater Ponds
 - FDOT Stormwater Ponds
 - Stormwater Ponds - Other

3.5 Bradford Chain of Lakes

This section presents the results from Tasks 1 through 3 for the Bradford Chain of Lakes. This includes an overview and history of the lakes and drainage basin, present impairment status, an overview of available data, a qualitative assessment of potential pollutant sources, and calculation of potential pollutant loads.

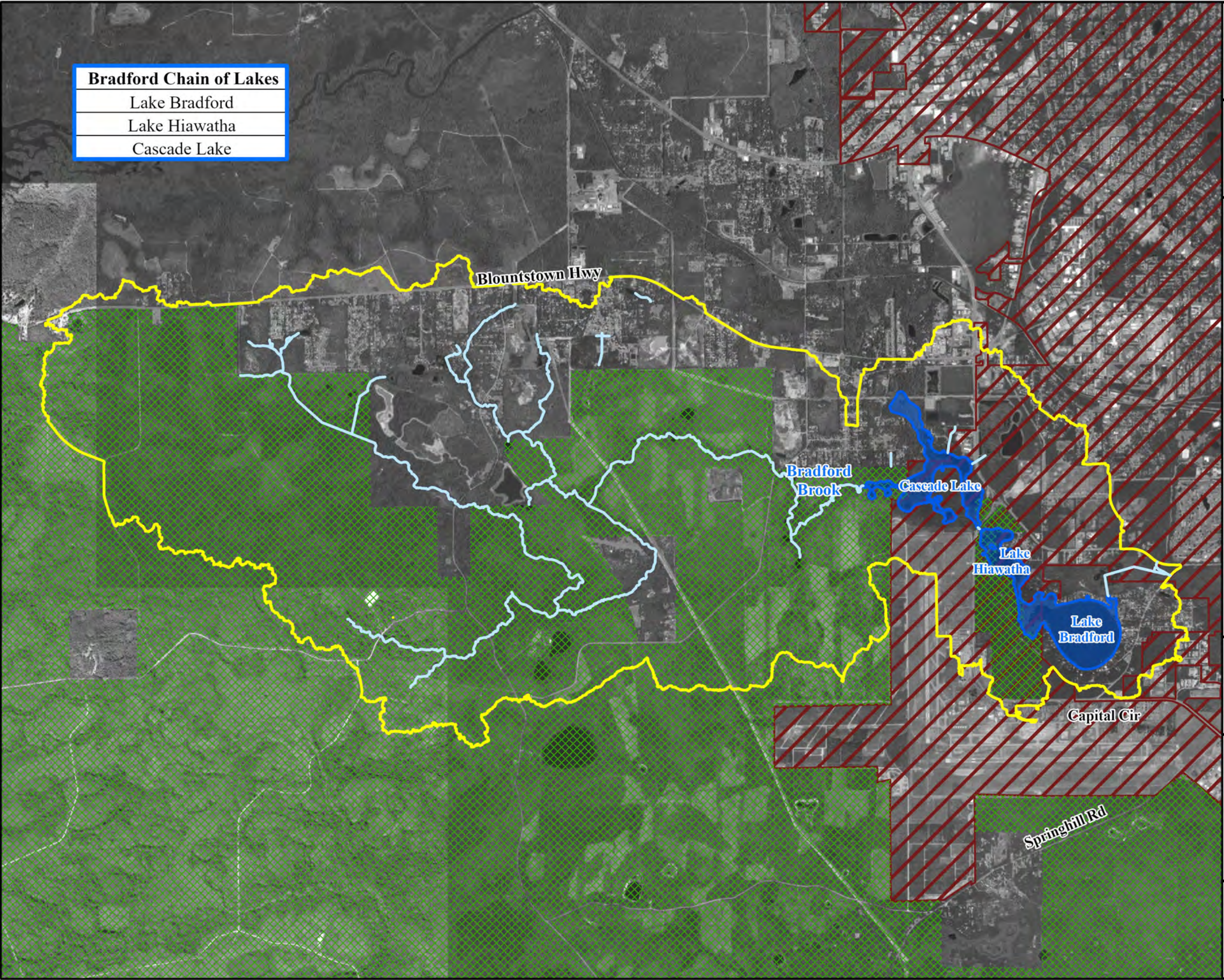
3.5.1 Overview and History

The Bradford Chain of Lakes consists of three interconnected waterbodies: Cascade Lake, Lake Hiawatha, and Lake Bradford (**Figure 3-46**). Bradford Creek, which drains the upper watershed for the Chain of Lakes, flows into Cascade Lake, which then flows into Lake Hiawatha and finally into Lake Bradford. Flow out of Lake Bradford goes into Grassy Lake before flowing into Munson Slough at the confluence with the West Drainage Ditch.

Photo 3-22 through **Photo 3-29** present aerial views of the lakes from 1937 through the present. Examination of the aerial photos shows that, overall, the structure of the chain of lakes has not changed significantly since 1937. The aerials show that the area of water changes over time, likely with dry versus wet conditions, especially in the upper reaches around Cascade Lake. Also observable is the conversion of prairie land to silviculture and then to protected forest, increases in nearby development, and the construction of Capital Circle and the airport, which first appear in the 1970 aerial (**Photo 3-22**).

Lake Bradford is a 149-acre high color lake and is the largest waterbody in the chain of lakes. **Photo 3-30** shows the northeast end of the lake. The bulk of the lake inflow is from Lake Hiawatha, which then flows through the lake and out to Grassy Lake. At times of significant rainfall, such as under storm events of 5-year return frequency or greater, flow historically reversed and flowed from Grassy Lake into Lake Bradford across Lakeview Drive. Under some conditions, backflow would also enter Lake Hiawatha (Leon County, 2019; City, 2019). Following a 2014 study, Lakeview Drive was elevated, piped conveyance was increased, and the outflow structure from Lake Bradford was updated by increasing the weir elevation and including a one-way valve to prevent backflow. **Photo 3-31** shows the present structure at the connection between Lake Bradford and Grassy Lake. The check valve can be seen in the photo. While the one-way valve prevents backflow from Grassy Lake to Lake Bradford under frequently occurring storm events, larger, less frequent storm events still have the potential to generate backflow from Grassy Lake when downstream water levels exceed the elevation of the weir. Even with the known backflow issues, Lake Bradford has been a healthy, well-balanced lake throughout its history. A recent issue within the lake is elevated lead levels, which is discussed in more detail in **Section 3.5.2**.

Lake Bradford also has a long history as a recreational resource for Leon County. Lake Bradford presently supports recreational activities including water skiing, sailing, kayaking, and fishing. The Tallahassee Museum of History and Natural Science (also known as the Junior Museum) was founded in 1957 and sits on the northwestern shoreline of the lake at the confluence with Lake Hiawatha (Lake Bradford Sector Plan, 2004). The museum has a number of historic buildings onsite including the former home of the Prince and Princess Murat. Additionally, the FSU Reservation, also known as Camp Flastacowa, is located on the lake and is a swimming and boating amenity for FSU and Leon County. **Photo 3-32** shows the FSU Reservation shoreline.



Bradford Chain of Lakes	
	Lake Bradford
	Lake Hiawatha
	Cascade Lake



Legend

- Bradford Chain of Lakes Drainage Basin
- Waterbodies in Study
- Watercourses
- Apalachicola National Forest
- Tallahassee Corporate Limits

Sources:
Waterbodies: COT, 2020
Watercourses: COT, 2020
Watersheds: COT, 2020
Roads: FDOT, 2020
Facilities: COT, 2020
Parks: COT-Leon County, 2023
City Limits: COT, 2022

Figure 3-46:
Bradford Chain of Lakes Basin Overview
Map

Tallahassee Master Plan - Surface
Water (TMaPS)





Photo 3-22: Bradford Chain of Lakes Aerial (1937)

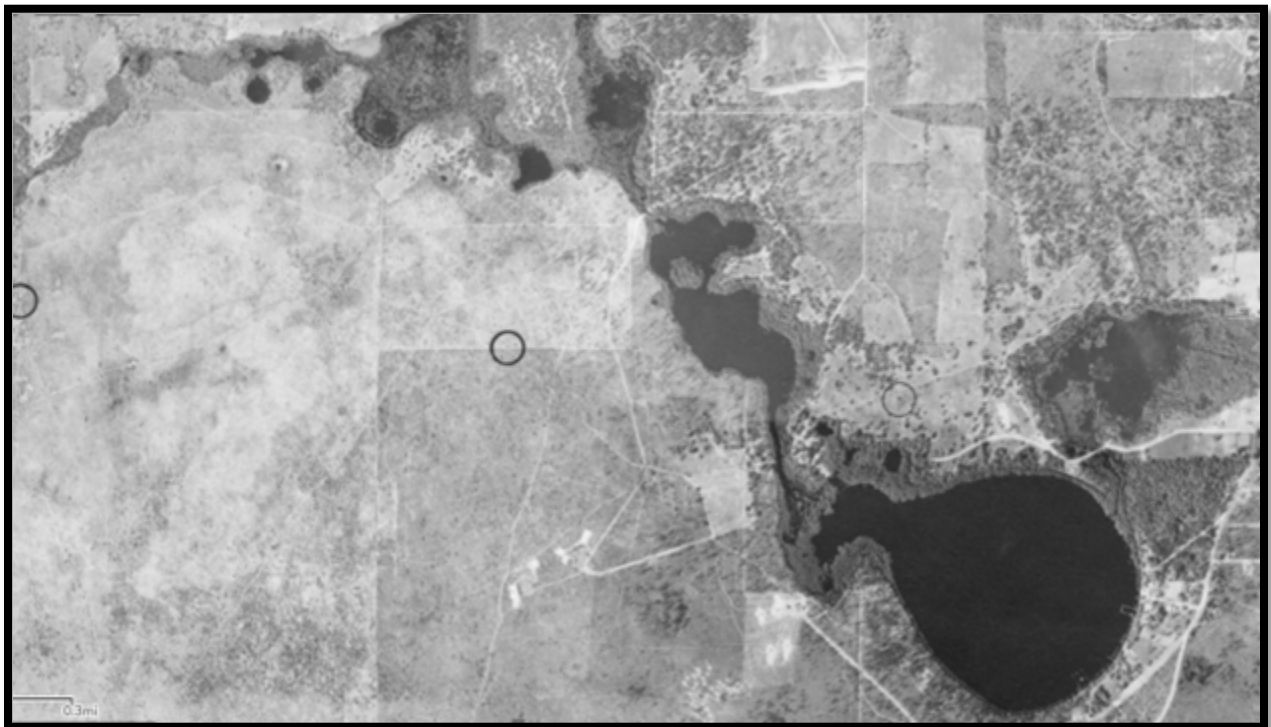


Photo 3-23: Bradford Chain of Lakes Aerial (1949)



Photo 3-24: Bradford Chain of Lakes Aerial (1954)



Photo 3-25: Bradford Chain of Lakes Aerial (1970)



Photo 3-26: Bradford Chain of Lakes Aerial (1983)



Photo 3-27: Bradford Chain of Lakes Aerial (1996)



Photo 3-28: Bradford Chain of Lakes Aerial (2007)



Photo 3-29: Bradford Chain of Lakes Aerial (2020)



Photo 3-30: Northeast Side of Lake Bradford (2013)

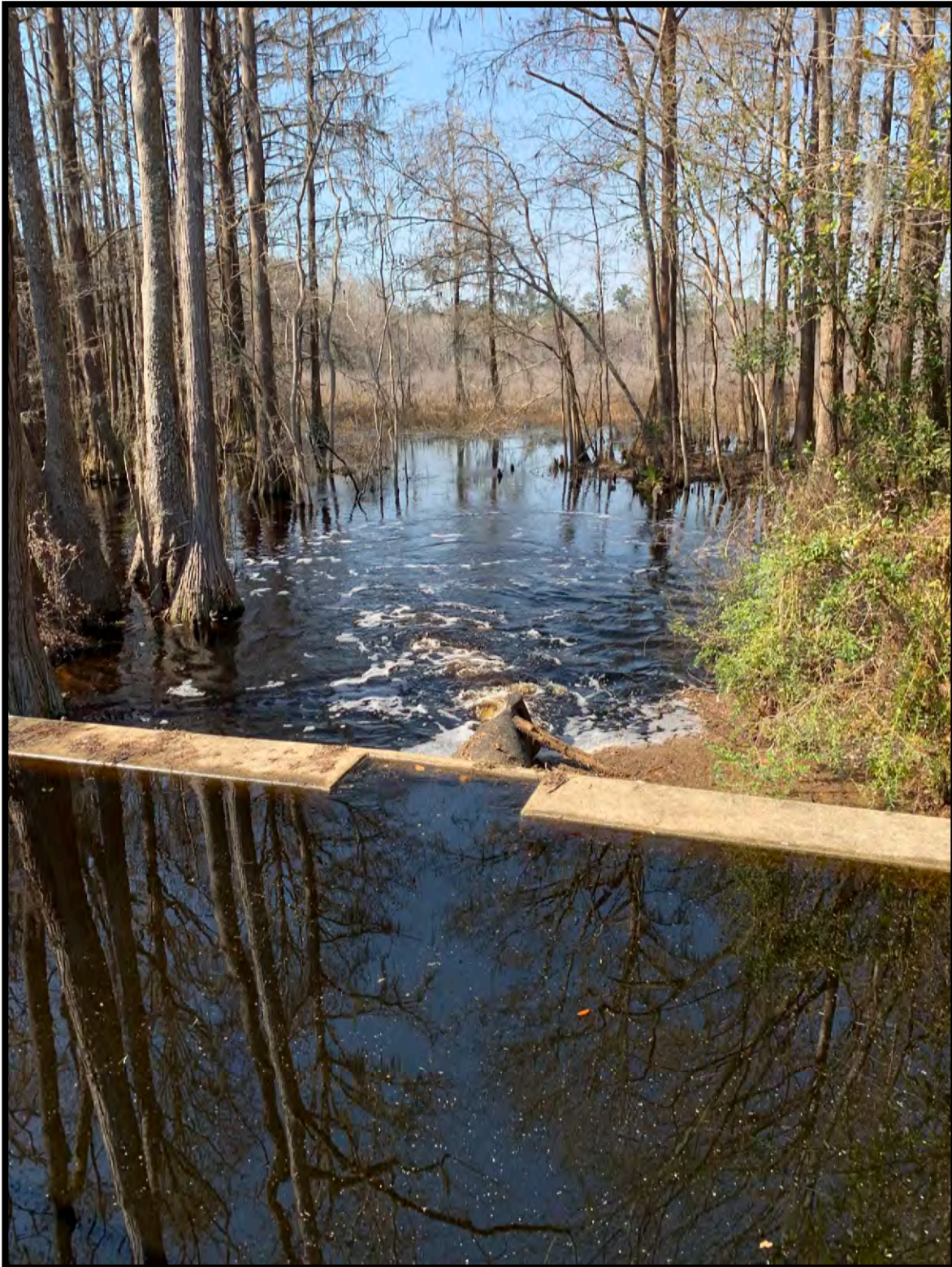


Photo 3-31: Flow through the Structure Connecting Lake Bradford and Grassy Lake (2021)



Photo 3-32: FSU Reservation on Lake Bradford (2021)

Lake Hiawatha is a 40-acre high color lake located immediately upstream of Lake Bradford. Color levels in the lake are so high that light cannot penetrate the water column thus not allowing submerged aquatic vegetative growth (City, 2019; Leon County, 2019). Lake inflow is primarily through a culvert beneath Capital Circle Southwest at the northeastern end of the airport property. Lake outflow enters the northeast end of Lake Bradford. However, as previously discussed, at times system flows will reverse. Unlike Lake Bradford, which generally maintains its permanent pool, Lake Hiawatha can dry out at times. **Photo 3-33** shows the lake in 2021 when water levels were high. **Photo 3-34** shows the lake during a dry-down period in 2011. Lake Hiawatha has been a healthy, well-balanced lake throughout its history. Like Lake Bradford, a recent issue within the lake is elevated lead levels, which is discussed in more detail in **Section 3.5.2**.

Cascade Lake is the most upstream of the sister lakes and is a 109-acre high color lake located immediately upstream of Lake Hiawatha and has been identified as a “pristine” waterbody (Lake Bradford Sector Plan, 2004). Lake inflow comes from Bradford Brook, which drains part of the Apalachicola National Forest. The lake has a sandy bottom along with an active sink and is the most prone to drying out of the chain of lakes. **Photo 3-35** shows the lake in 2021 when water levels were relatively high. **Photo 3-36** shows the lake in January of 2020 during a dry-down period. Cascade Lake has been a healthy, well-balanced lake throughout its history. Like its sister lakes, a recent issue within the lake is elevated lead levels, which is discussed in more detail in **Section 3.5.2**.



Photo 3-33: Lake Hiawatha During Higher Water Conditions (2021)



Photo 3-34: Lake Hiawatha During Low Water Conditions (2011)



Photo 3-35: Cascade Lake During Higher Water Conditions (2021)



Photo 3-36: Cascade Lake During Low Water Conditions (2020)

The drainage basin for the Bradford Chain of Lakes covers an area of approximately 12,650 acres (**Figure 3-46**). The majority of the drainage area is located within the Apalachicola National Forest so anthropogenic stormwater inflows are relatively minimal. The only significant developed areas within the drainage basin are in the immediate vicinity of the Chain of Lakes or along the northern boundary of the basin near Blountstown Highway (State Road 20).

The 2004 Lake Bradford Sector Plan identified as its Priority Issue 1 the environmental protection of the Chain of Lakes (Lake Bradford Sector Plan, 2004). The plan recognized the pristine nature of the lakes and their cultural, socioeconomic and environmental benefit to the area. The plan provided a series of recommendations to maintain the water quality conditions, which included the following:

- Continue to monitor the Chain of Lakes by both the City and Leon County, and the volunteer efforts led by Florida LAKEWATCH,
- Extend sewer lines, thereby discontinuing the use of septic systems in areas with high water table,
- Install a gate to prevent backflow from Grassy Lake to Lake Bradford,
- Maintain the current low-density residential characteristics of the area, and
- Acquire nearby parcels of land with environmental benefits to the Chain of Lakes to provide buffer areas.

3.5.2 Regulatory Status

Exhibit 3-2 presented the verified impaired waters within the overall Lake Munson basin. Lake Bradford is presently verified impaired for lead. Within the latest assessment period (2015 to 2022), 11 of 15 samples exceeded the criteria. Cascade Lake is also presently verified impaired for lead. In the last assessment cycle, 5 of 10 samples exceeded the criteria. Lake Hiawatha, while not verified impaired, did have violations of the lead criteria. No other impairments exist within the three waterbodies or the upstream tributaries.

Leon County has identified potential relict sources of lead that include a former shooting range and the former Dale Mabry airfield (Leon County, 2019). The only apparent potential current source is the Tallahassee Regional Airport (aviation fuel). Increased lead levels are likely the result of elevated lead concentrations in the lake sediments and the acidic nature of these lakes, which enhances the solubility of lead.

3.5.3 Waterbody Data Review and Summary

This section presents an overview of available data and data sources for the Bradford Chain of Lakes basin, including, bathymetry, land use, soils, septic systems, hydrologic measurements, surface water quality, groundwater quality, biological, stormwater treatment facilities, and atmospheric deposition.

3.5.3.1 Bathymetry

Figure 3-47 presents a map showing bathymetry within Lake Bradford and Lake Hiawatha from LAKEWATCH. Since the depth contours are not defined to a specific datum, they are best considered as general informational only. The contours suggest depths up to 10 ft within Lake Bradford, with average depths around 6 ft, while Lake Hiawatha has maximum depths on the order of 4 ft, with average depths around 2 ft.

While no bathymetric charts were available for Cascade Lake, prior literature states maximum depths of around 8 ft with average depths generally less than 5 ft (City, 2019). However, during relatively frequent dry-down conditions those depths are significantly reduced.

3.5.3.2 Land Use

Figure 3-48 presents a map of the Level 2 land uses within the Bradford Chain of Lakes basin. A table is provided to show the overall acreages and percent cover for the various levels. Tables are provided for both the Level 2 and grouped Level 1 land uses. The largest land use type by far within the Bradford Chain of Lakes drainage basin per the grouped Level 1 categories is Upland Forest (48 percent). The Upland Forest areas extend throughout the central, southern and western portions of the basin where it drains the Apalachicola National Forest. The next highest categories are wetlands (19 percent) followed by Urban and Built Up (16 percent). The Urban and Built Up land uses are located along the northern edge along Blountstown Highway (State Road 20) and in the immediate area of the three lakes, mostly to the north.

3.5.3.3 Soils

The most prevalent soil group in the Bradford Chain of Lakes drainage basin by far is Group A (65 percent) (**Figure 3-49**). Group A soils are considered to have a high rate of infiltration. The remainder of the basin is mostly small clusters of Group A/D and B/D soils, which are generally adjacent to stream segments, waterbodies, or other low lying areas and are considered to have good infiltration potential, but due to elevated water table conditions, will act more similarly to soils with low infiltration potential.

3.5.3.4 Septic Systems

An estimated 1,400 septic tank units are within the boundaries of the Bradford Chain of Lakes drainage basin, based on the FDOH septic tank layer (**Figure 3-50**). The septic tanks are located in clusters around the basin. A large cluster is located around and immediately to the east of Lake Bradford. Another cluster is located within a neighborhood off Jackson Bluff Road just west of Cascade Lake. The remaining clusters are located within neighborhoods off Blountstown Highway (State Road 20) on the northern border of the basin.

Effluent from septic tanks that are in good condition should be comparable to secondarily treated wastewater effluent from sewage treatment plants. However, septic systems can be a source of pollutants, pathogens, and nutrients and are identified by FDEP as a potential source of bacteria and nutrients to waterbodies in its assessment processes.



Bradford, Leon County

Florida LAKEWATCH Bathymetric Map

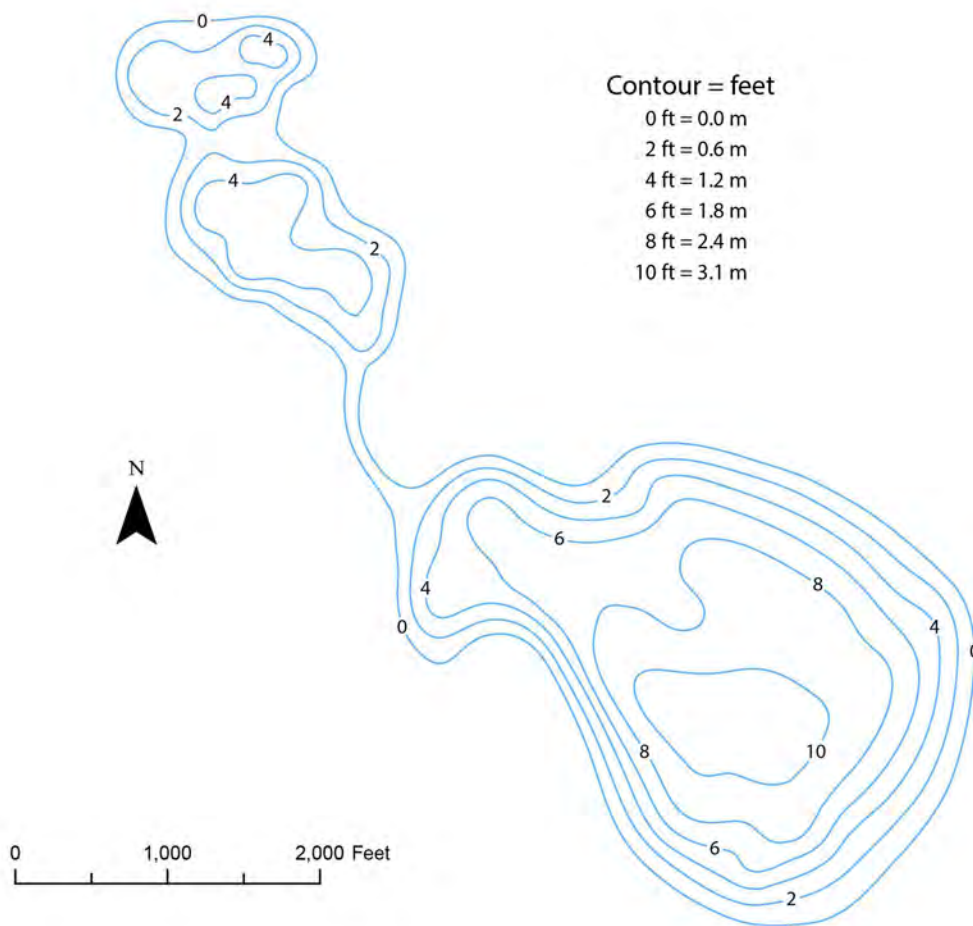
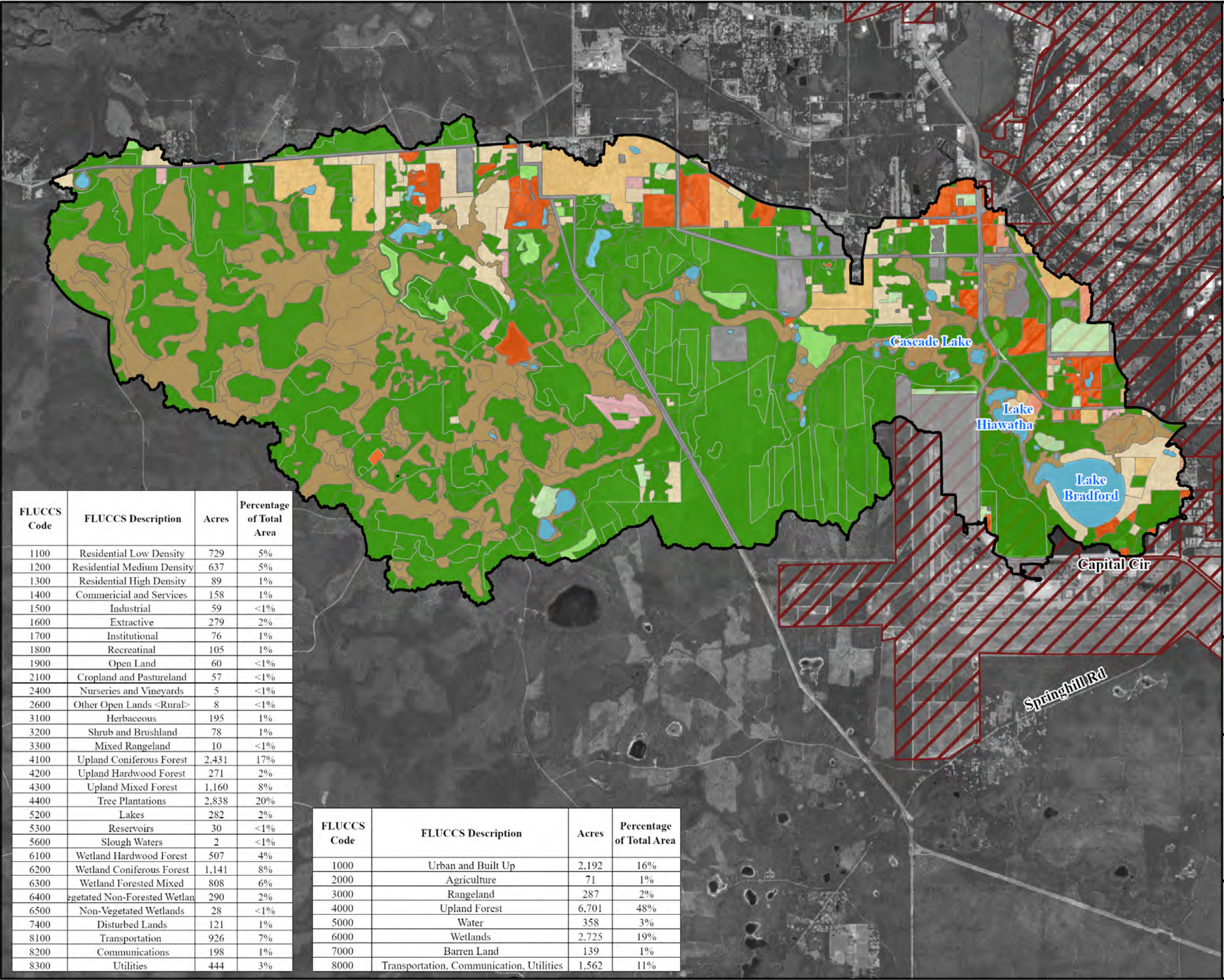


Figure 3-47: Bathymetry in Lake Bradford and Lake Hiawatha



Legend

- Bradford Chain of Lakes Drainage Basin
- Tallahassee Corporate Limits
- Land Use
 - 1100: Residential Low Density
 - 1200: Residential Medium Density
 - 1300: Residential High Density
 - 1400: Commercial and Services
 - 1500: Industrial
 - 1600: Extractive
 - 1700: Institutional
 - 1800: Recreational
 - 1900: Open Land
 - 2100: Cropland and Pastureland
 - 2400: Nurseries and Vineyards
 - 2600: Other Open Lands <Rural>
 - 3100: Herbaceous
 - 3200: Shrub and Brushland
 - 3300: Mixed Rangeland
 - 4100: Upland Coniferous Forests
 - 4200: Upland Hardwood Forests
 - 4300: Upland Mixed Forests
 - 4400: Tree Plantations
 - 5200: Lakes
 - 5300: Reservoirs
 - 5600: Slough Waters
 - 6100: Wetland Hardwood Forest
 - 6200: Wetland Coniferous Forest
 - 6300: Wetland Forested Mixed
 - 6400: Vegetated Non-Forested Wetlands
 - 6500: Non-Vegetated Wetlands
 - 7400: Disturbed Lands
 - 8100: Transportation
 - 8200: Communications
 - 8300: Utilities

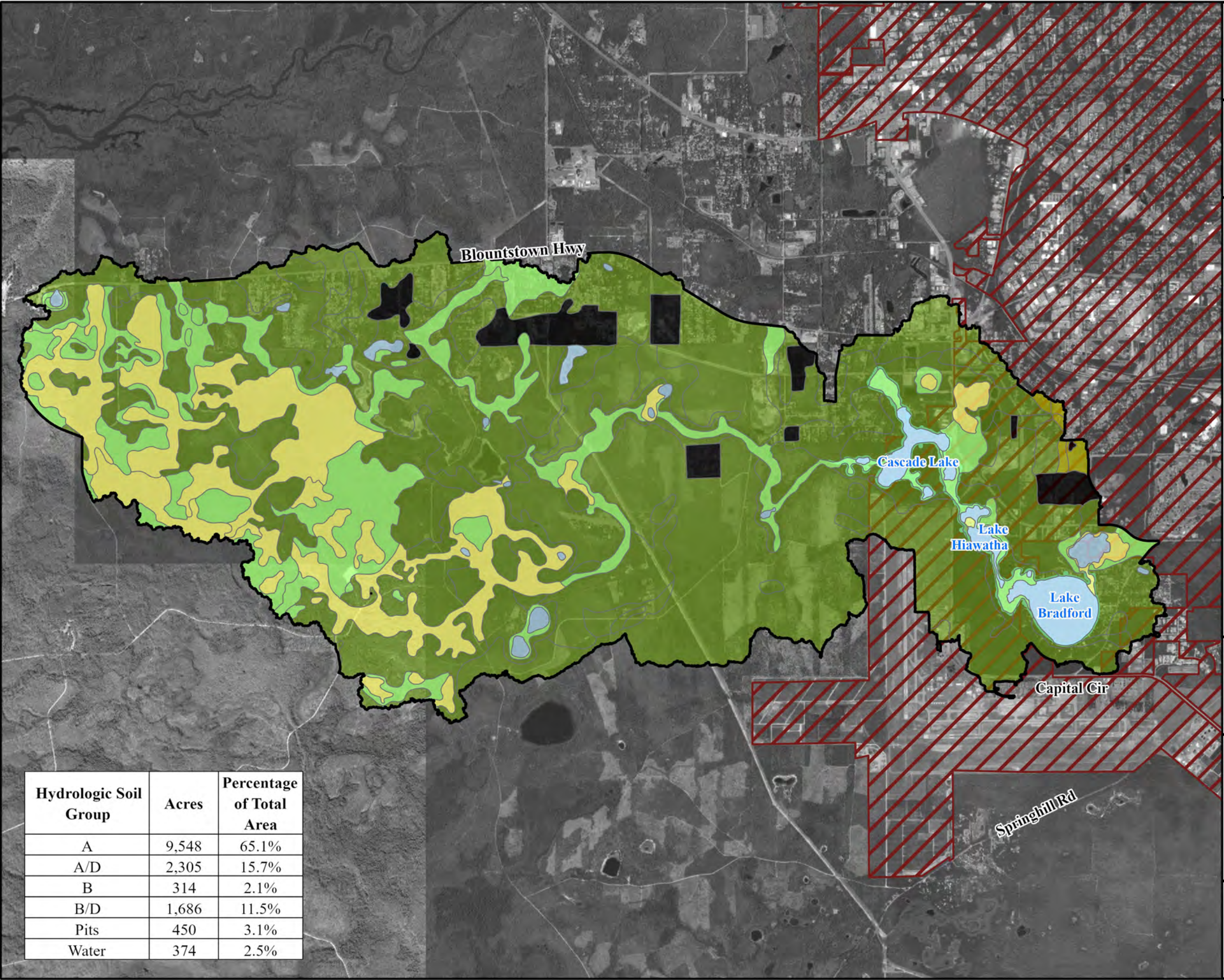
Sources:
Waterbodies: COT, 2020
Watersheds: COT, 2020
Roads: FDOT, 2020
Land Use: NWFWM, 2019
City Limits: COT, 2022

Figure 3-48:
Bradford Chain of Lakes Drainage Basin
Land Use Map

Tallahassee Master Plan - Surface
Water (TMaPS)

FLUCCS Code	FLUCCS Description	Acres	Percentage of Total Area
1100	Residential Low Density	729	5%
1200	Residential Medium Density	637	5%
1300	Residential High Density	89	1%
1400	Commercial and Services	158	1%
1500	Industrial	59	<1%
1600	Extractive	279	2%
1700	Institutional	76	1%
1800	Recreational	105	1%
1900	Open Land	60	<1%
2100	Cropland and Pastureland	57	<1%
2400	Nurseries and Vineyards	5	<1%
2600	Other Open Lands <Rural>	8	<1%
3100	Herbaceous	195	1%
3200	Shrub and Brushland	78	1%
3300	Mixed Rangeland	10	<1%
4100	Upland Coniferous Forest	2,431	17%
4200	Upland Hardwood Forest	271	2%
4300	Upland Mixed Forest	1,160	8%
4400	Tree Plantations	2,838	20%
5200	Lakes	282	2%
5300	Reservoirs	30	<1%
5600	Slough Waters	2	<1%
6100	Wetland Hardwood Forest	507	4%
6200	Wetland Coniferous Forest	1,141	8%
6300	Wetland Forested Mixed	808	6%
6400	Vegetated Non-Forested Wetlands	290	2%
6500	Non-Vegetated Wetlands	28	<1%
7400	Disturbed Lands	121	1%
8100	Transportation	926	7%
8200	Communications	198	1%
8300	Utilities	444	3%

FLUCCS Code	FLUCCS Description	Acres	Percentage of Total Area
1000	Urban and Built Up	2,192	16%
2000	Agriculture	71	1%
3000	Rangeland	287	2%
4000	Upland Forest	6,701	48%
5000	Water	358	3%
6000	Wetlands	2,725	19%
7000	Barren Land	139	1%
8000	Transportation, Communication, Utilities	1,562	11%



Legend

- Bradford Chain of Lakes Drainage Basin
- Tallahassee Corporate Limits
- Hydrologic Soil Group**
 - A
 - A/D
 - B
 - B/D
 - Pits
 - Water

Sources:
Waterbodies: COT, 2020
Watersheds: COT, 2020
Roads: FDOT, 2020
Soils: NRCS, 2020
City Limits, 2022

Figure 3-49:
Bradford Chain of Lakes Drainage Basin
Soils Map

Tallahassee Master Plan - Surface
Water (TMaPS)

Hydrologic Soil Group	Acres	Percentage of Total Area
A	9,548	65.1%
A/D	2,305	15.7%
B	314	2.1%
B/D	1,686	11.5%
Pits	450	3.1%
Water	374	2.5%



Number of Septic Systems | 1418



0 0.8
Miles

Legend

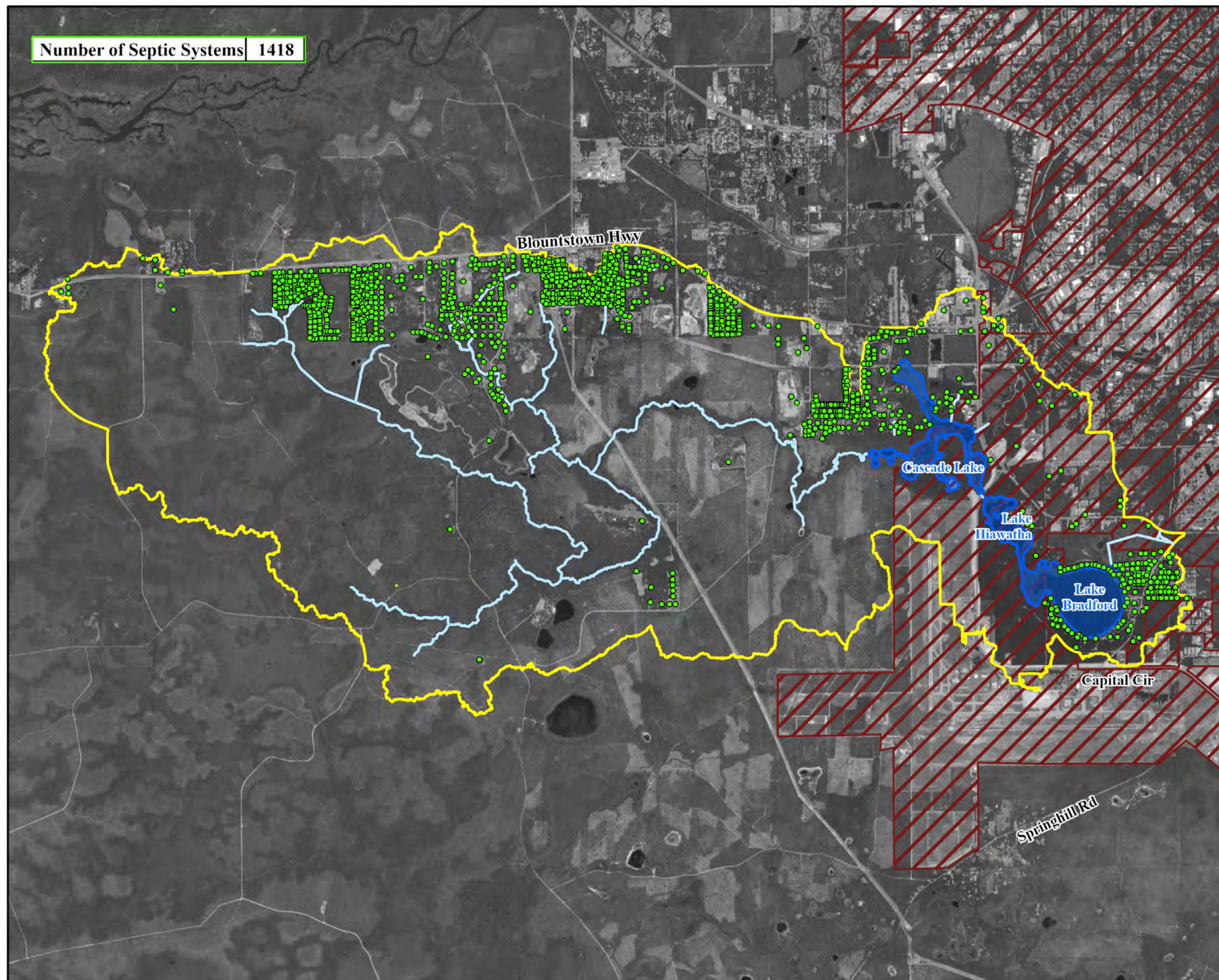
- Bradford Chain of Lakes Drainage Basin
- Waterbodies in Study
- Watercourses
- Tallahassee Corporate Limits
- Septic Systems

Sources:
Waterbodies: COT, 2020
Watersheds: COT, 2020
Roads: FDOT, 2020
Septic Systems: COT, 2020
City Limits: COT, 2022

**Figure 3-50:
Bradford Chain of Lakes Basin Septic
Systems Map**

**Tallahassee Master Plan - Surface
Water (TMaPS)**

Geosyntec
consultants



3.5.3.5 Hydrologic Data

Exhibit 3-6 presented the locations of hydrologic data stations within the Lake Munson basin. As the map shows, there is a water level station located on Lake Bradford (Station 012082). Data from this station was obtained from 2015 to 2021. **Figure 3-51** presents a plot of the measured water levels relative to NAVD88 for the period of the available data. For the period of available data, Lake Bradford fluctuates between just below 27.0 ft-NAVD88 up to around 34.0 ft, a range of around 7 ft. The low period shown in 2020 corresponds to the period of the photo from 2020 (**Photo 3-36**) when Cascade Lake exhibited dry conditions.

A flow measurement station is located upstream of Cascade Lake where Bradford Brook crosses Aenon Church Road (**Exhibit 3-6**). These data reflect the flow out of the Apalachicola National Forest. **Figure 3-52** presents a plot of the daily average flows from 1988 through 2020. In comparison to flows from Munson Slough and the West Ditch, these flows show a much less flashy extended baseflow driven signal, which represents more natural conditions. Peak flows are as high as 400 cfs, with typical peaks ranging between 100 and 200 cfs, and are of the same order of magnitude as stations in other more urbanized areas with significantly smaller drainage areas (**Section 3.4.3.6** and **Section 3.6.3.5**).

3.5.3.6 Surface Water Quality Data

The IWR datasets for Lake Bradford (WBID 878A), Lake Hiawatha (WBID 878C), and Cascade Lake (WBID 878D) span from the 1960s for Lake Bradford and the 1980s for the other lakes to the present. Data were provided by local and state agencies (City, Leon County, FDEP, USGS, NFWFMD, and Florida LAKEWATCH) as well as private sector firms (McGlynn Lab).

Figure 3-53 presents the locations of in-lake water quality monitoring stations for the Bradford Chain of Lakes (yellow) along with stations that provide water quality data within Bradford Brook and waterbodies upstream of the lakes that flow into Cascade Lake (red – see inset on **Figure 3-53**). A table is provided in **Figure 3-53** that shows the station ID, station name, period of record, sample count, data source, and if the station represents in-lake or inflowing tributary data. Based on the number of stations and the length of the station IDs, station IDs were not included on the figure, rather each of the stations is given a number and the numbers correspond to stations in the table.

Figure 3-53 shows that water quality monitoring stations have been spread throughout the three lakes for the period of record, including stations upstream of the chain of lakes in Bradford Brook and upstream waterbodies. Relative to more recent data (after 2010), there were eight stations within Lake Bradford, two within Lake Hiawatha, three within Cascade Lake and one station upstream in Silver Lake, a body of water in the Apalachicola National Forest.

Some initial plots of the available data in the lakes are provided in this section. This includes plots of the raw data and AGMs. As nutrients are the primary constituent of interest relative to water quality conditions in the Bradford Chain of Lakes, plots are provided for the key parameters related to potential nutrient impairment. These include TN, TP, Chl-a, and TSI. Additionally, based on interest relative to septic systems and other sources, FIB, specifically *E. coli*, are included. Additional data plots and analyses are provided as part of the qualitative assessment of sources in **Section 3.5.4**.

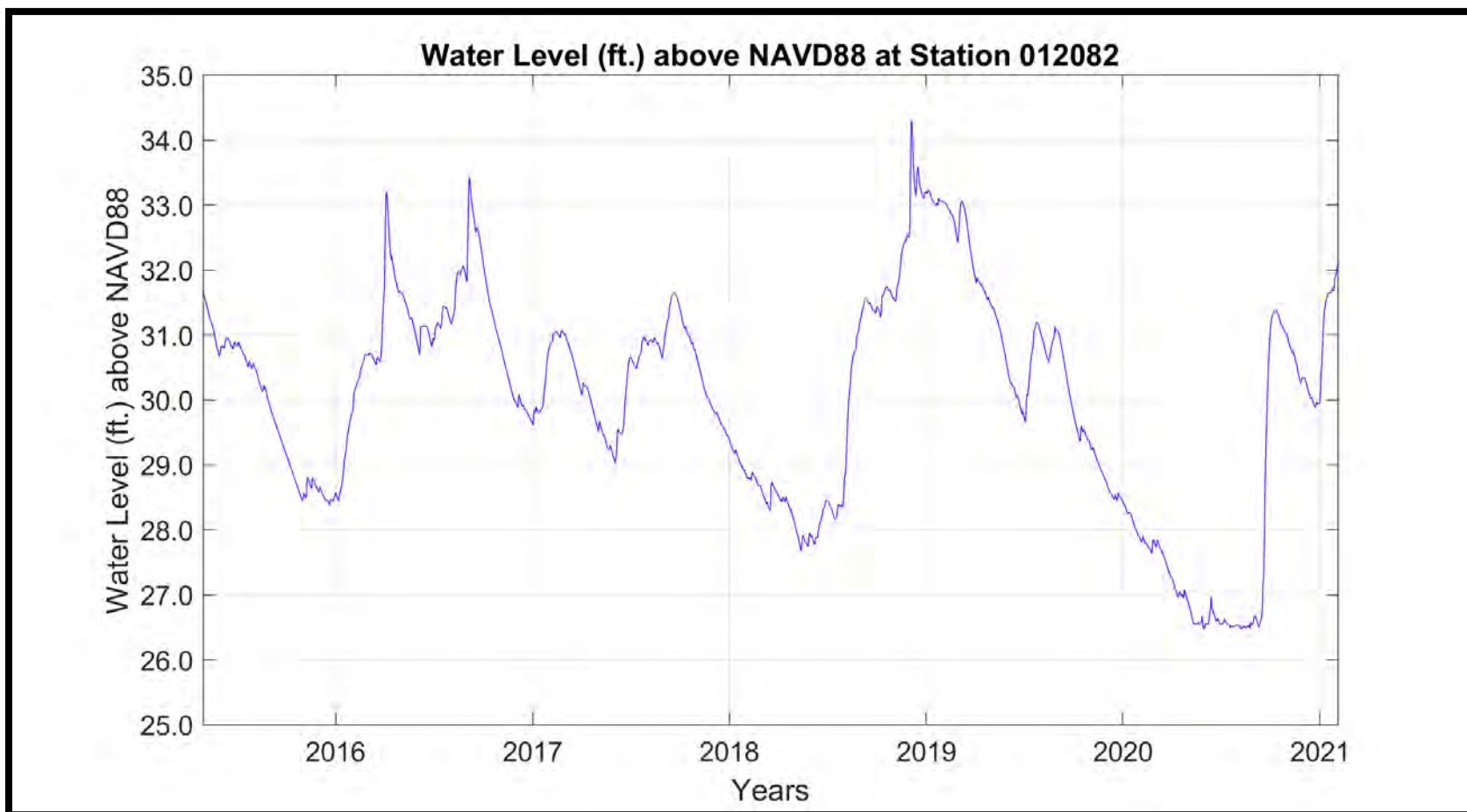


Figure 3-51: Daily Average Water Levels in Lake Bradford (Station 012082) (2015 to 2021)

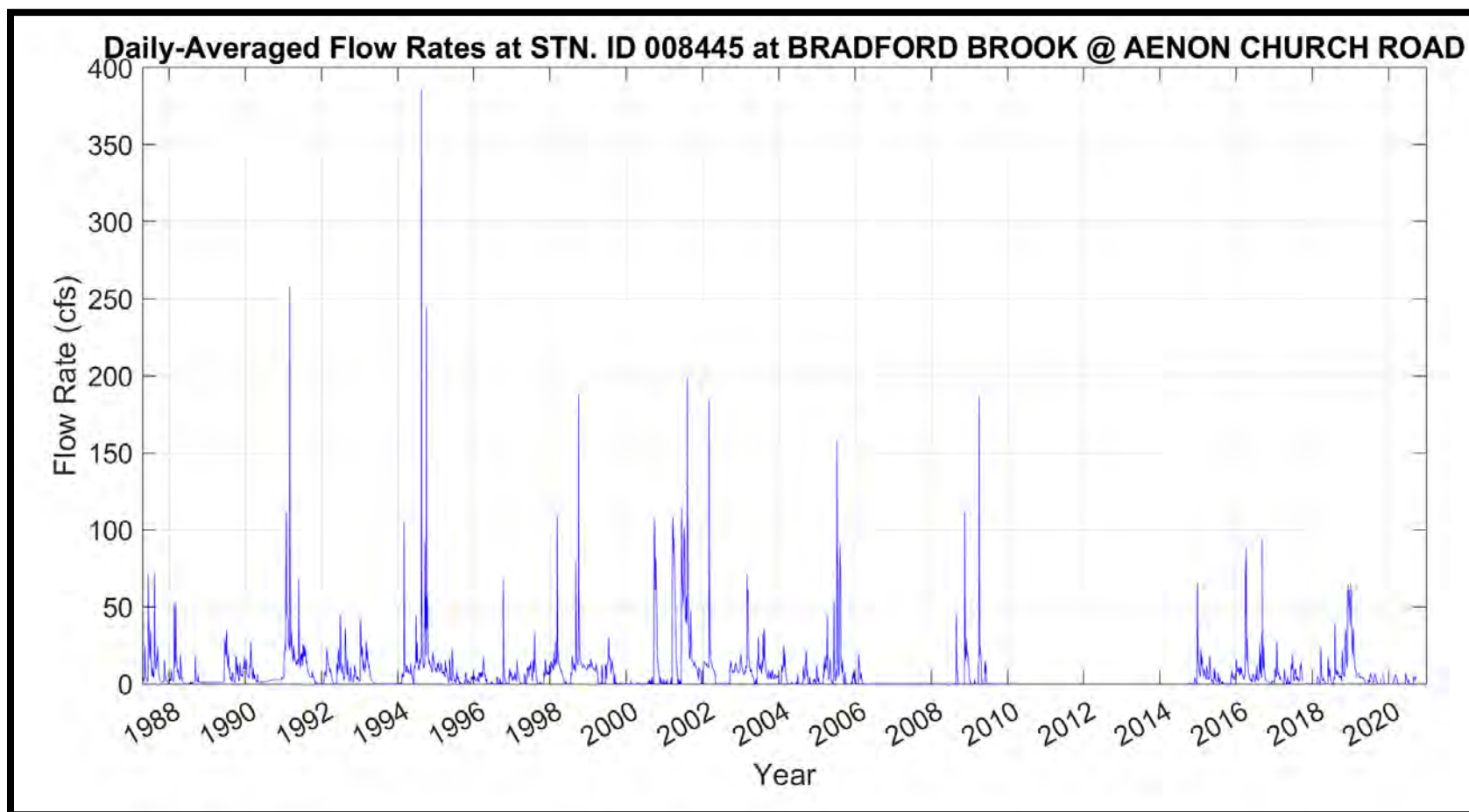
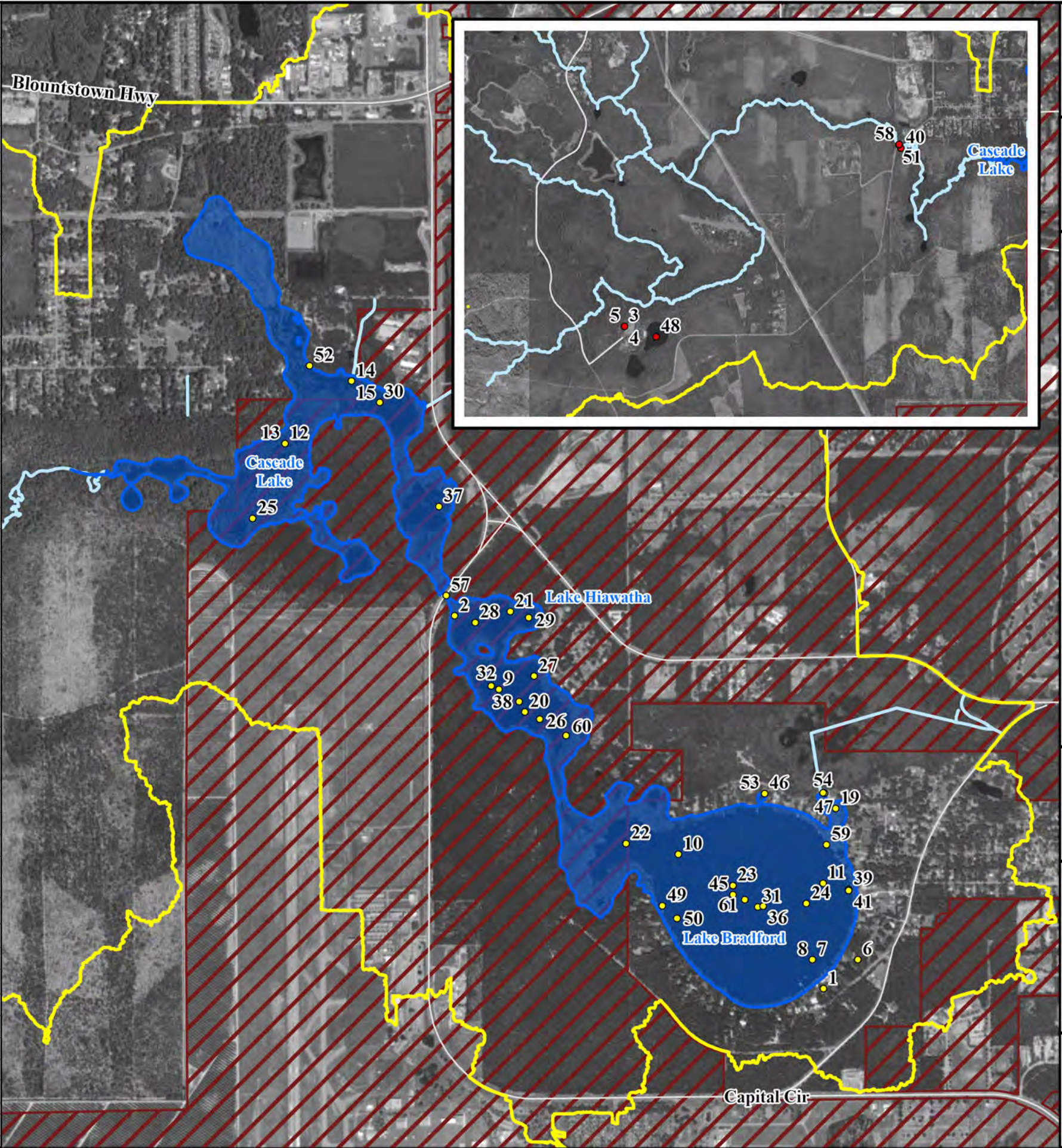


Figure 3-52: Daily Average Flow on Bradford Brook at Aenon Church Road (Station 008445) (1988 to 2020)

Number	Station ID	Station Name	Start of Record	End of Record	Position
1	1118ATL8050660	LAKE BRADFORD	1988	1989	In Lake
2	1118ATL8050661	LAKE HIAWATHA	1988	1989	In Lake
3	1118ATL8050619	SILVER LAKE, WAKULLA DISTRICT	1983	1989	Upstream
4	1118ATL8050620	AREA SWIMMING BEACH	1979	1997	Upstream
5	1118ATL8050621	AREA SWIMMING BEACH	1979	1997	Upstream
6	112WRD 02327010	LAKE BRADFORD NR TALLAHASSEE, FLA.	1966	1971	In Lake
7	112WRD 302410084201201	LKB-2	1994	1994	In Lake
8	112WRD 302410084201202	LKB-1	1994	1994	In Lake
9	12ELSI 3B3-002	LAKE HIAWATHA	1984	1984	In Lake
10	21FLCOT BRADFORD NORTH	BRADFORD NORTH	2007	2022	In Lake
11	21FLCOT BRADFORD SOUTH	BRADFORD SOUTH	2007	2022	In Lake
12	21FLCOT CASCADE AT BRAD	CASCADE AT BRADFORD BROOK	2008	2016	In Lake
13	21FLCOT CASCADE AT BRADFORD BROOK	CASCADE AT BRADFORD BROOK	2017	2022	In Lake
14	21FLCOT CASCADE AT CULV	CASCADE AT CULVERT	2008	2016	In Lake
15	21FLCOT CASCADE AT CULVERT	CASCADE AT CULVERT	2017	2022	In Lake
19	21FLCOT GRASSY LAKE	GRASSY LAKE	2008	2013	In Lake
20	21FLCOT HIAWATHA	HIAWATHA	2008	2022	In Lake
21	21FLGW 22120	NW1-L-2040 LAKE HIAWATHA	2004	2004	In Lake
22	21FLKWATLEO-BRADFORD-1	LEO-BRADFORD-1	1988	2020	In Lake
23	21FLKWATLEO-BRADFORD-2	LEO-BRADFORD-2	1988	2020	In Lake
24	21FLKWATLEO-BRADFORD-3	LEO-BRADFORD-3	1988	2020	In Lake
25	21FLKWATLEO-CASCADE-2	LEO-CASCADE-2	1988	1990	In Lake
26	21FLKWATLEO-HIAWATHA-1	LEO-HIAWATHA-1	1988	2009	In Lake
27	21FLKWATLEO-HIAWATHA-2	LEO-HIAWATHA-2	1988	2009	In Lake
28	21FLKWATLEO-MINNIEHAH-1	LEO-MINNIEHAH-1	1988	2009	In Lake
29	21FLKWATLEO-MINNIEHAH-2	LEO-MINNIEHAH-2	1989	2009	In Lake
30	21FLLEONLCCA3042484355	Cascade Lake	2008	2021	In Lake
31	21FLLEONLCLB3040584339	Lake Bradford	2006	2021	In Lake
32	21FLLEONLCLH3041384350	Lake Hiawatha	2006	2021	In Lake
36	21FLMCGLB0B	Lake Bradford, Center of Lake	2001	2006	In Lake
37	21FLMCGLB0C	Lake Cascade, Center of Lake	2002	2006	In Lake
38	21FLMCGLB0H	Lake Hiawatha, Center of Lake	2002	2006	In Lake
39	21FLNWFD302420084200601	Lake Bradford	1992	1992	In Lake
40	21FLNWFD302520084223901	AENON CHURCH ROAD	1987	1987	Upstream
41	21FLNWFD3268	Lake Bradford	1992	1992	In Lake
45	21FLPNS 302419478420239	Lake Bradford (Center of Lake)	2006	2007	In Lake
46	21FLPNS 302433008420190	Lake Bradford at FSU Reservation dock	2006	2006	In Lake
47	21FLPNS 302433108420100	Bradford Brook at Lakeview Dr outlet from Lake Bradford	2006	2007	In Lake
48	21FLTLHRG1TLHR0095	M of Silver Lake	2014	2014	Upstream
49	21FLTLHRHAB_1009200005	Lake Bradford	2020	2020	In Lake
50	21FLTLHRTLHRHAB0008	Lake Bradford	2021	2021	In Lake
51	21FLWQA 302521208422398	Bradford Brook at Aenon Church Rd	2006	2006	Upstream
52	21FLWQA 302530408421292	Cascade Lake at Geanie Drive and Nora Drive	2006	2006	In Lake
53	21FLWQA 302433008420190	Lake Bradford at FSU Reservation dock	2002	2002	In Lake
54	21FLWQA 302433108420100	Bradford Brook at Lakeview Dr outlet from Lake Bradford	2002	2005	In Lake
57	21FLWQA 302459608421082	Bradford Brook at Capital Circle SW	2002	2002	In Lake
58	21FLWQA 302503008422251	Bradford Brook at Aenon Church Rd	2002	2006	Upstream
59	21FLWQSPLEO126UL	Lake Bradford south side of lake (WBID 878A)	2005	2006	In Lake
60	21FLWQSPLEO128UL	Lake Hiawatha middle of lake (WBID 878C)	2005	2006	In Lake
61	21FLWQSP22030003	Lake Bradford	2007	2008	In Lake
60	Lake Hiawatha middle of lake (WBID 878C)	2005	2005	2006	In Lake
61	Lake Bradford	2007	2007	2008	In Lake





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Miles

Legend

- Bradford Chain of Lakes Drainage Basin
- Waterbodies in Study
- Watercourses
- Tallahassee Corporate Limits

Water Quality Stations

- Upstream of Lake
- In-Lake

Sources:
Waterbodies: COT, 2020
Watercourses: COT, 2020
Drainage Basins: COT, 2020
City Limits: COT, 2020
WQ Stations: FDEP, 2022

Figure 3-53:
Bradford Chain of Lakes Water Quality
Station Location Map

Tallahassee Master Plan - Surface
Water (TMaPS)

Geosyntec
consultants

Plots of the measured TN, TP, and Chl-a data from 2010 to 2020 are presented for Lake Bradford, Lake Hiawatha, and Cascade Lake. For Lake Bradford (**Figure 3-54** through **Figure 3-56**), TN shows a slight downward trend, while TP and Chl-a concentrations appear consistent over the 10-year period. For Lake Hiawatha (**Figure 3-57** through **Figure 3-59**), all three parameters appear consistent over the 10-year period with a slight downward trend seen for TN. Finally, Cascade Lake (**Figure 3-60** through **Figure 3-62**) data show consistent TP and Chl-a data through the 10-year period, with a somewhat more noticeable downward trend in TN. For all three of the lakes, the concentrations of all three parameters are low, indicating relatively pristine water quality. Review of historical nutrient and Chl-a data within the lakes indicates that conditions have not significantly changed from historical measurements. Lake Hiawatha and Cascade Lake have missing data in 2011, 2012 and portions of 2020 due to low water conditions not allowing sample collection.

Under FDEP's NNC, the Bradford Chain of Lakes are all defined as high color waterbodies. Based on this designation, the AGM threshold for Chl-a is 20 µg/L. For TN and TP, a range of concentrations are allowable, based on maintaining Chl-a levels in the lake below 20 µg/L. For TN, the range is 1.27 mg/L to 2.23 mg/L. For TP, the range is 0.05 mg/L to 0.16 mg/L. For *E. coli*, the criteria are monthly geometric means below 126 colonies per 100 mL of water and less than 10 percent of samples above 410 colonies per 100 mL of water in any 30-day period.

TN, TP, and Chl-a AGMs are plotted for each of the lakes as these define the status relative to nutrient impairments. Where sufficient data are available to assess the AGMs, the levels are provided from 2010 through 2020. For Chl-a, only data with corrected Chl-a are provided. The Chl-a threshold and the minimum and maximum thresholds for TN and TP relative to the NNC are provided on each of the graphs as pink dashed lines. Plots of calculated TSI values in the lake are also provided. While TSI is no longer utilized for the determination of impairment, it does serve as an indicator of lake health. Based on TSI definitions, levels below 60 are deemed good condition, levels between 60 and 70 indicate fair condition, while levels above 70 indicate poor condition. Finally, *E. coli* data for each of the lakes, for the available period of record, are presented against the 410 colonies per 100 mL threshold.

Examination of the TN plots (**Figure 3-63**, **Figure 3-66**, and **Figure 3-69**) shows that between 2010 and 2020, the TN AGMs for the three lakes were all below the minimum threshold and generally in the same range. TP AGM levels (**Figure 3-64**, **Figure 3-67**, and **Figure 3-70**) for the three lakes were all below the minimum threshold, with Lake Hiawatha and Cascade Lake levels well below the minimum and Lake Bradford slightly higher. **Figure 3-65**, **Figure 3-68**, and **Figure 3-71** present the Chl-a AGMs from 2010 through 2020. As with the other nutrient parameters (TN, TP), the Chl-a AGMs for the three lakes were all well below the 20 µg/L threshold, with Lake Hiawatha and Cascade Lake showing very low levels and Lake Bradford somewhat higher.

Examination of the TSI plots (**Figure 3-72**, **Figure 3-73**, and **Figure 3-74**) shows that the levels are nearly all in the good range for Cascade Lake and Lake Hiawatha, with only a few of the samples for Lake Bradford in the fair range and none in the poor range. These results further support the findings from the Chl-a measurements that the lakes are not presently exhibiting nutrient enrichment. Lake Bradford switches between phosphorus limitation and nutrient balance while Lake Hiawatha and Cascade Lake are more phosphorus limitation dominant.

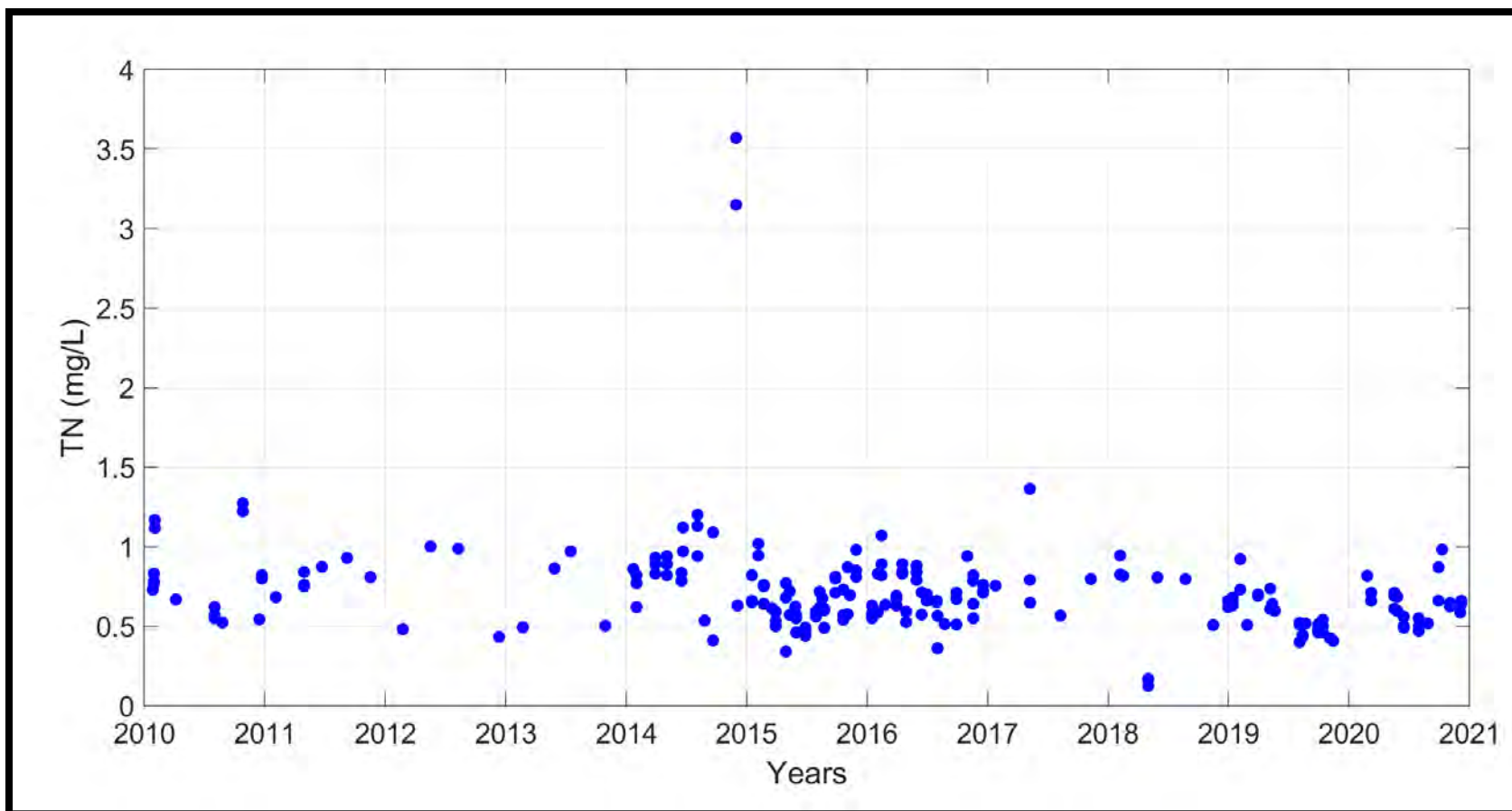


Figure 3-54: Plot of Measured TN in Lake Bradford

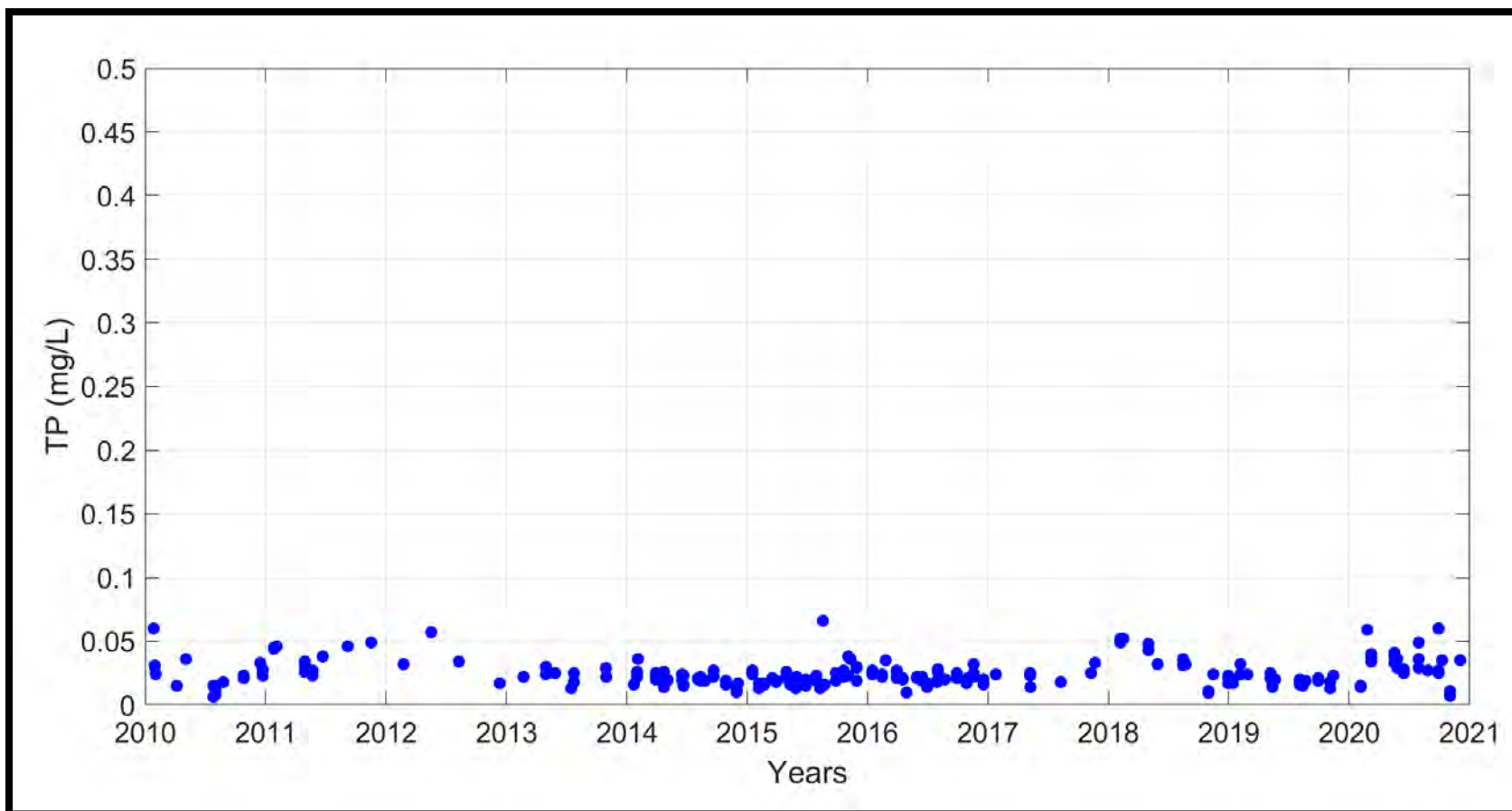


Figure 3-55: Plot of Measured TP in Lake Bradford

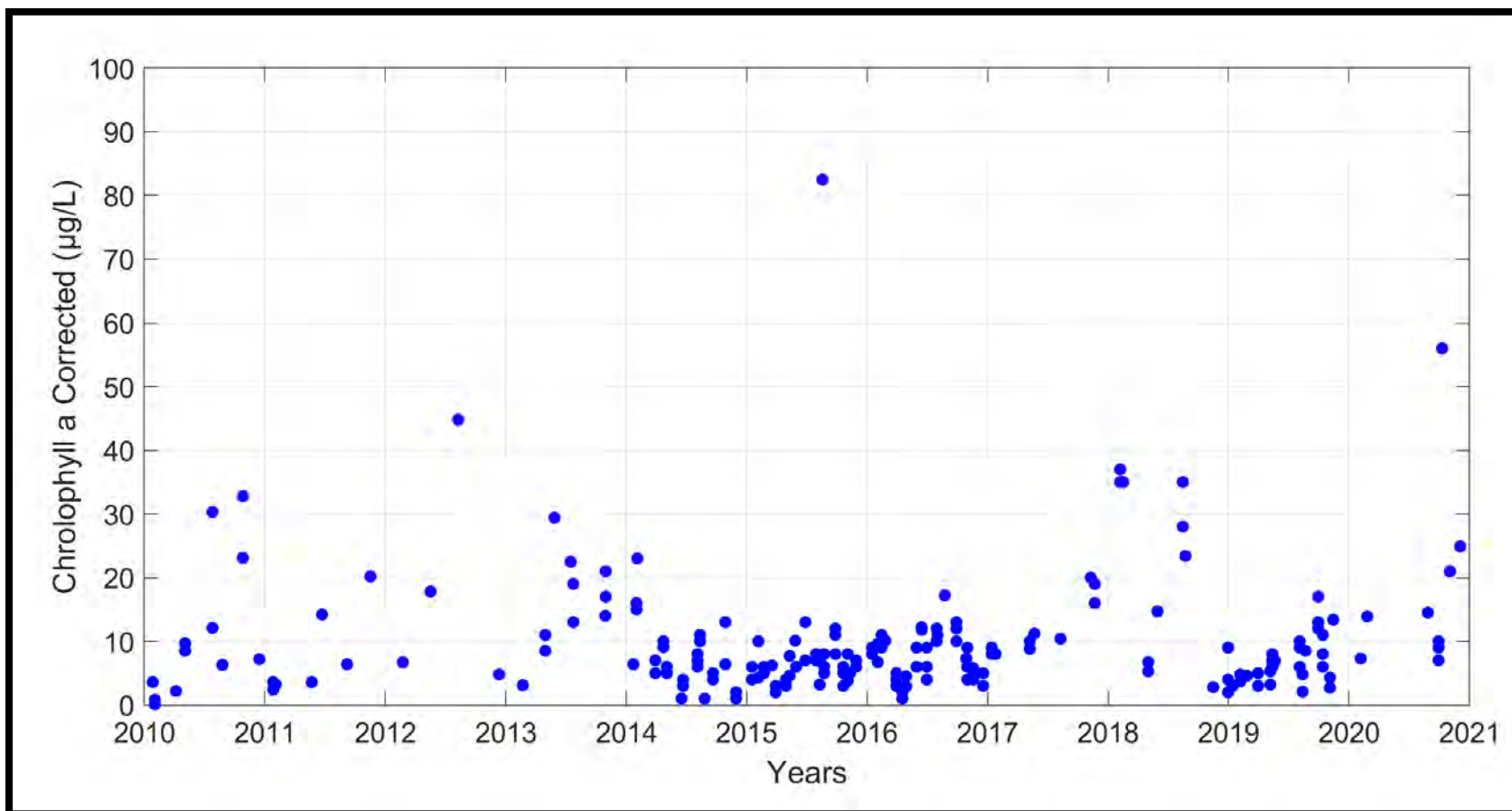


Figure 3-56: Plot of Measured Chl-a in Lake Bradford

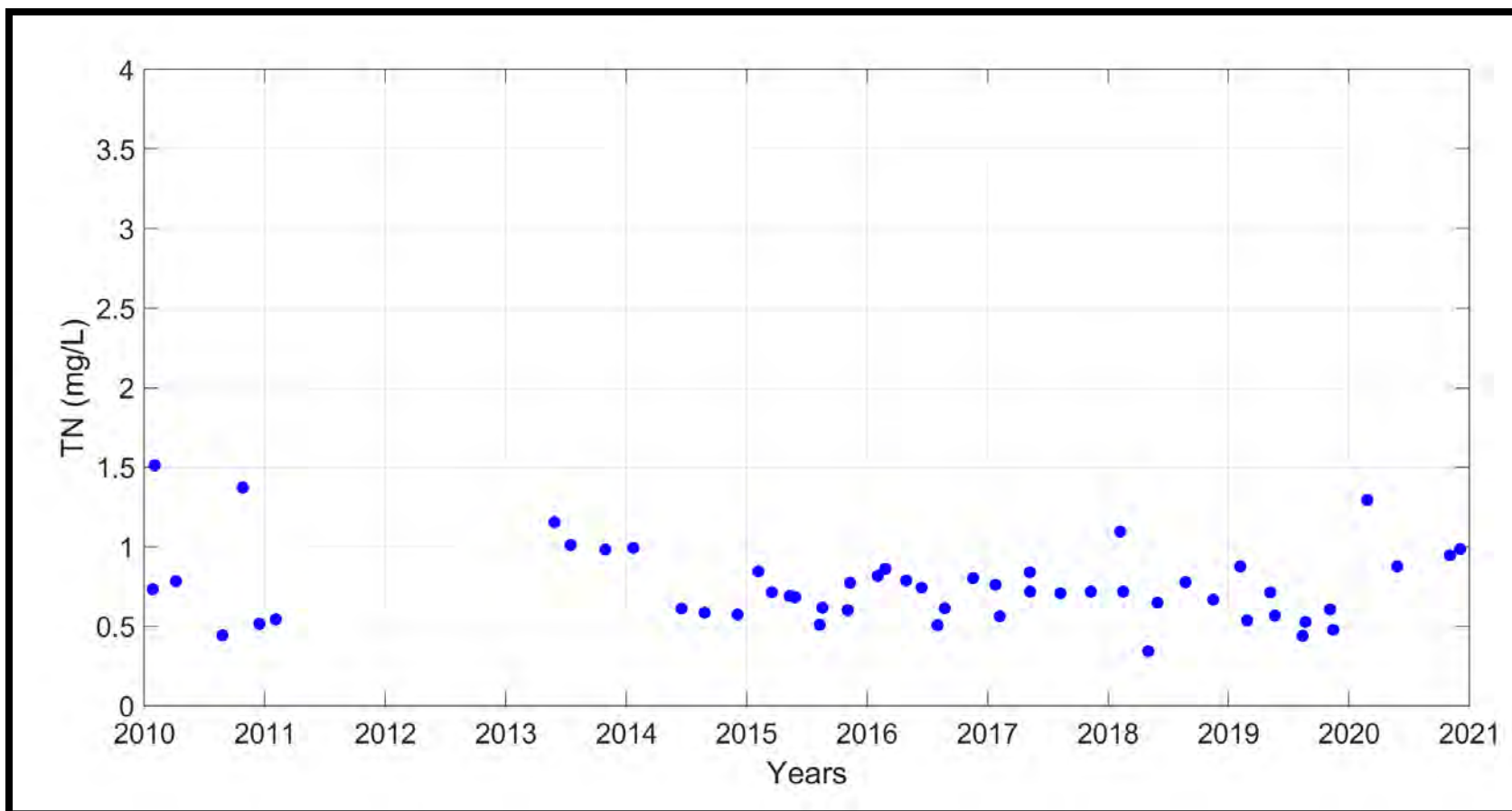
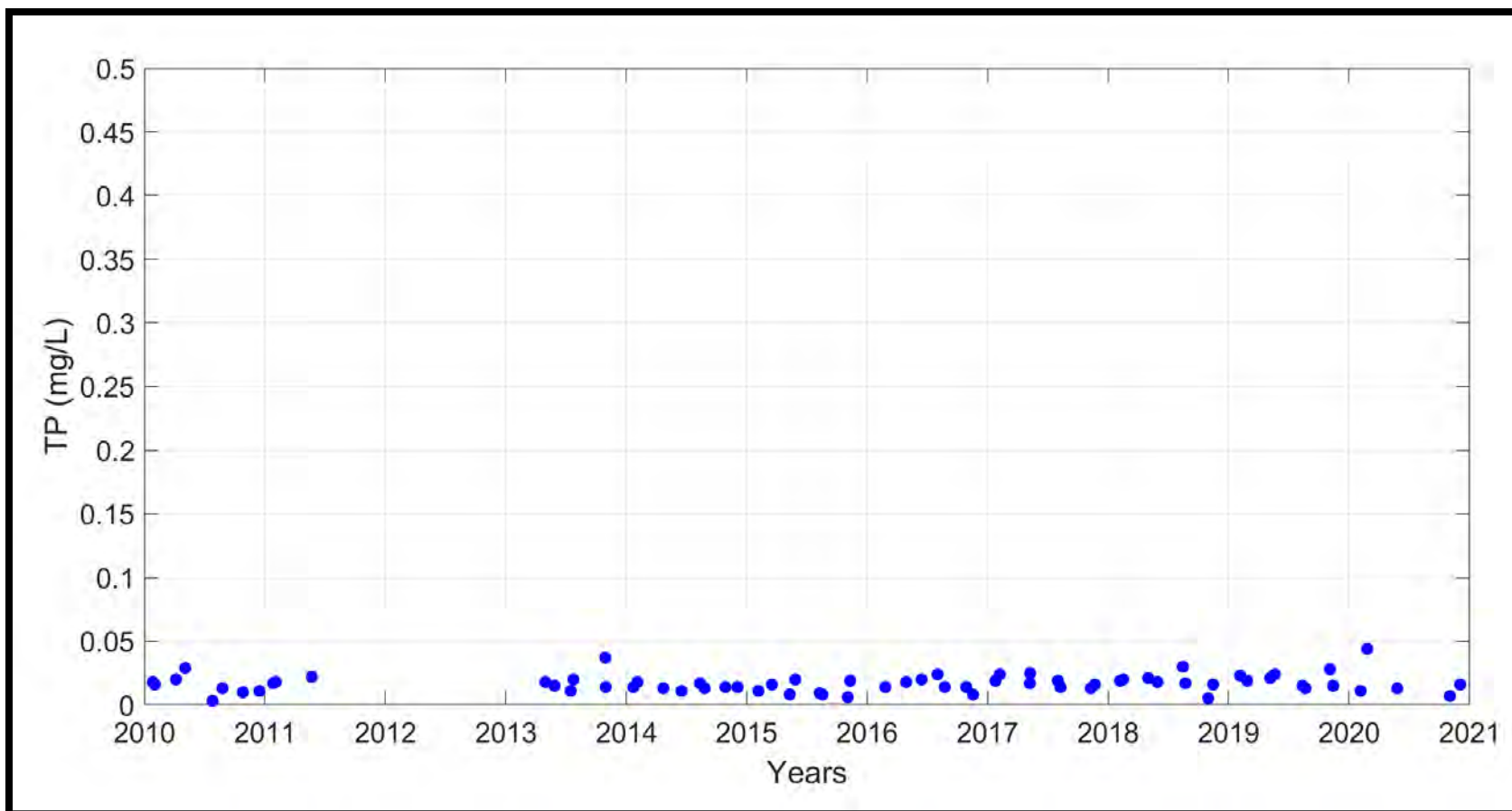


Figure 3-57: Plot of Measured TN in Lake Hiawatha



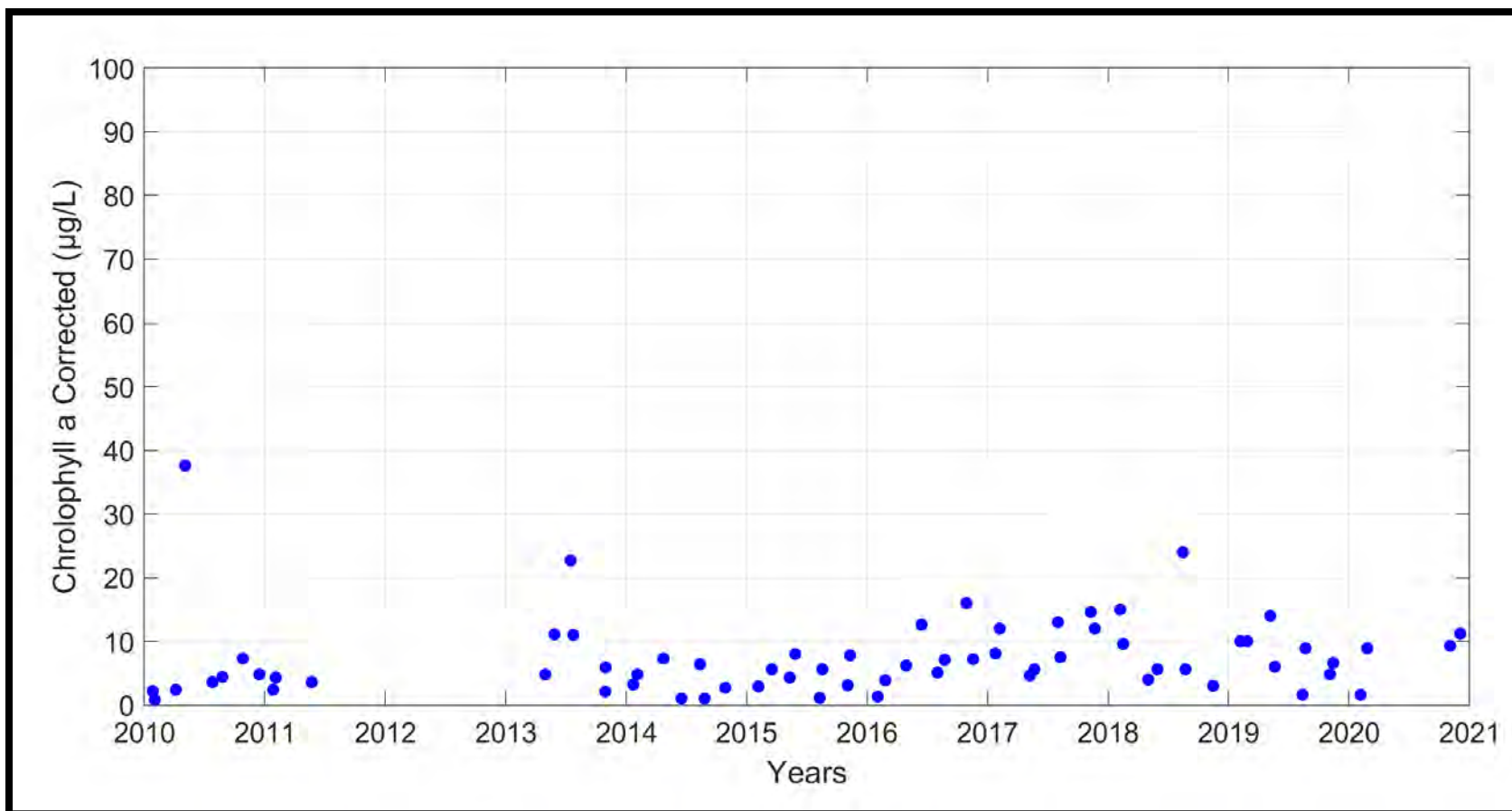


Figure 3-59: Plot of Measured Chl-a in Lake Hiawatha

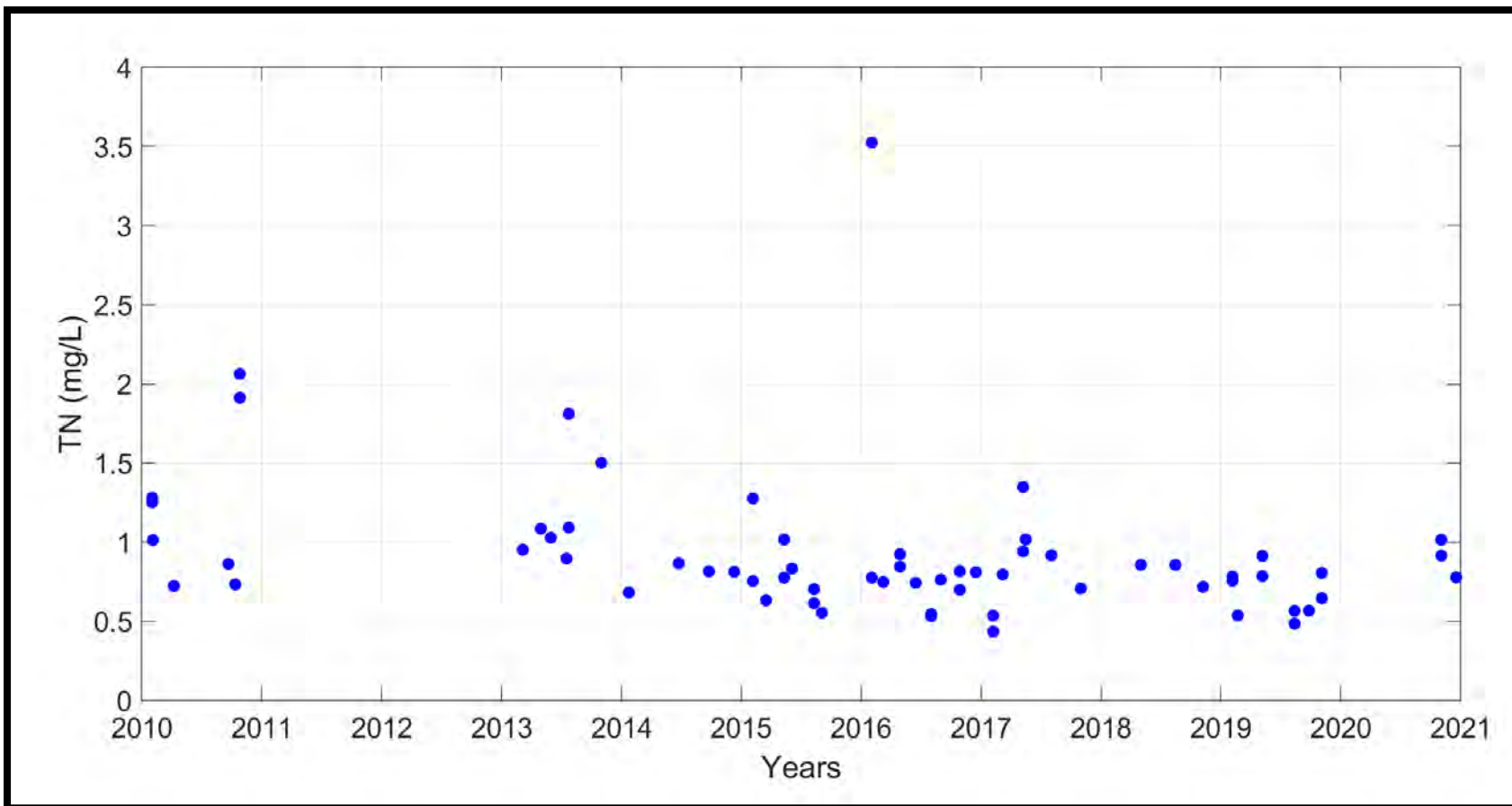


Figure 3-60: Plot of Measured TN in Cascade Lake

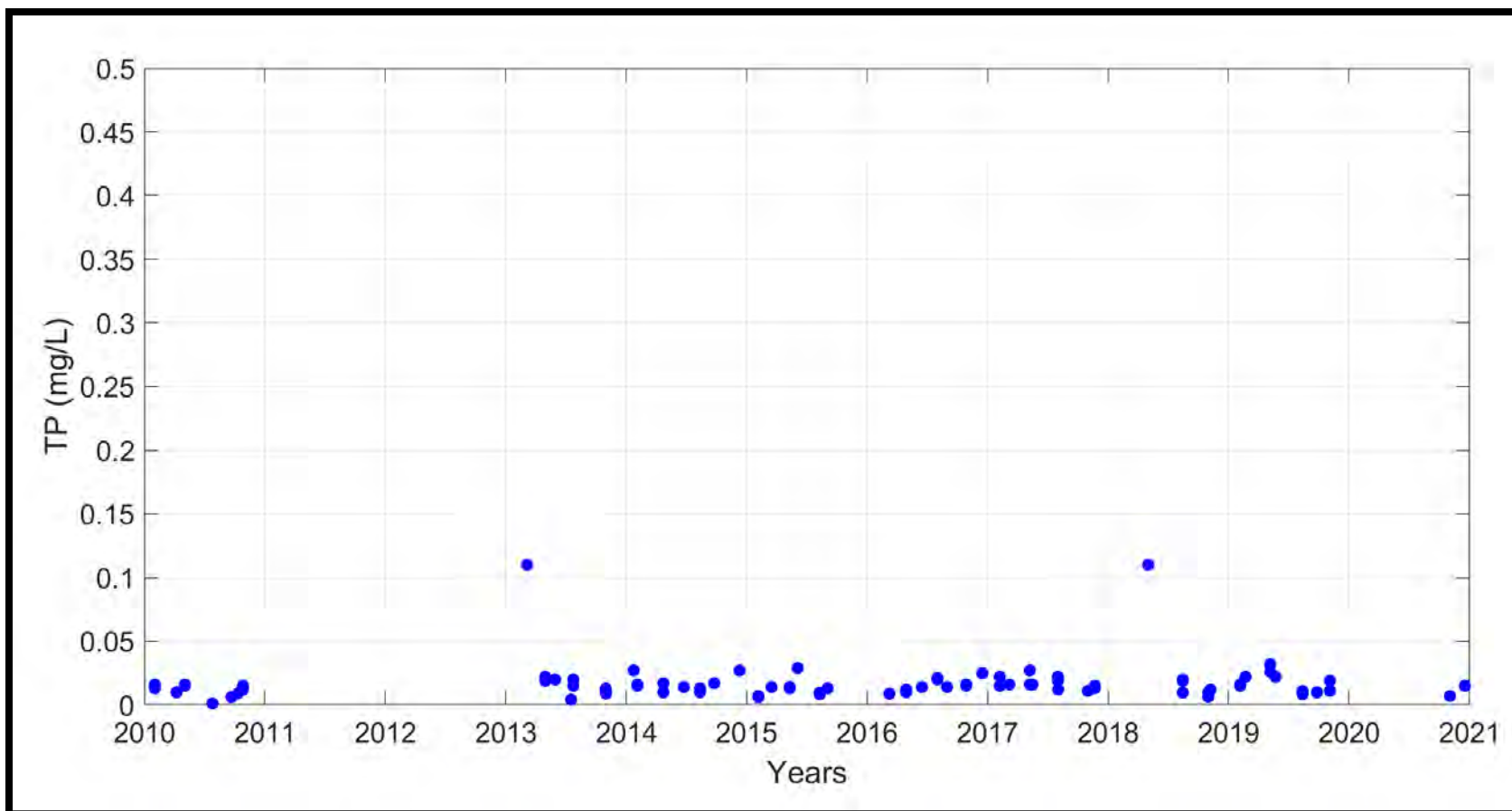


Figure 3-61: Plot of Measured TP in Cascade Lake

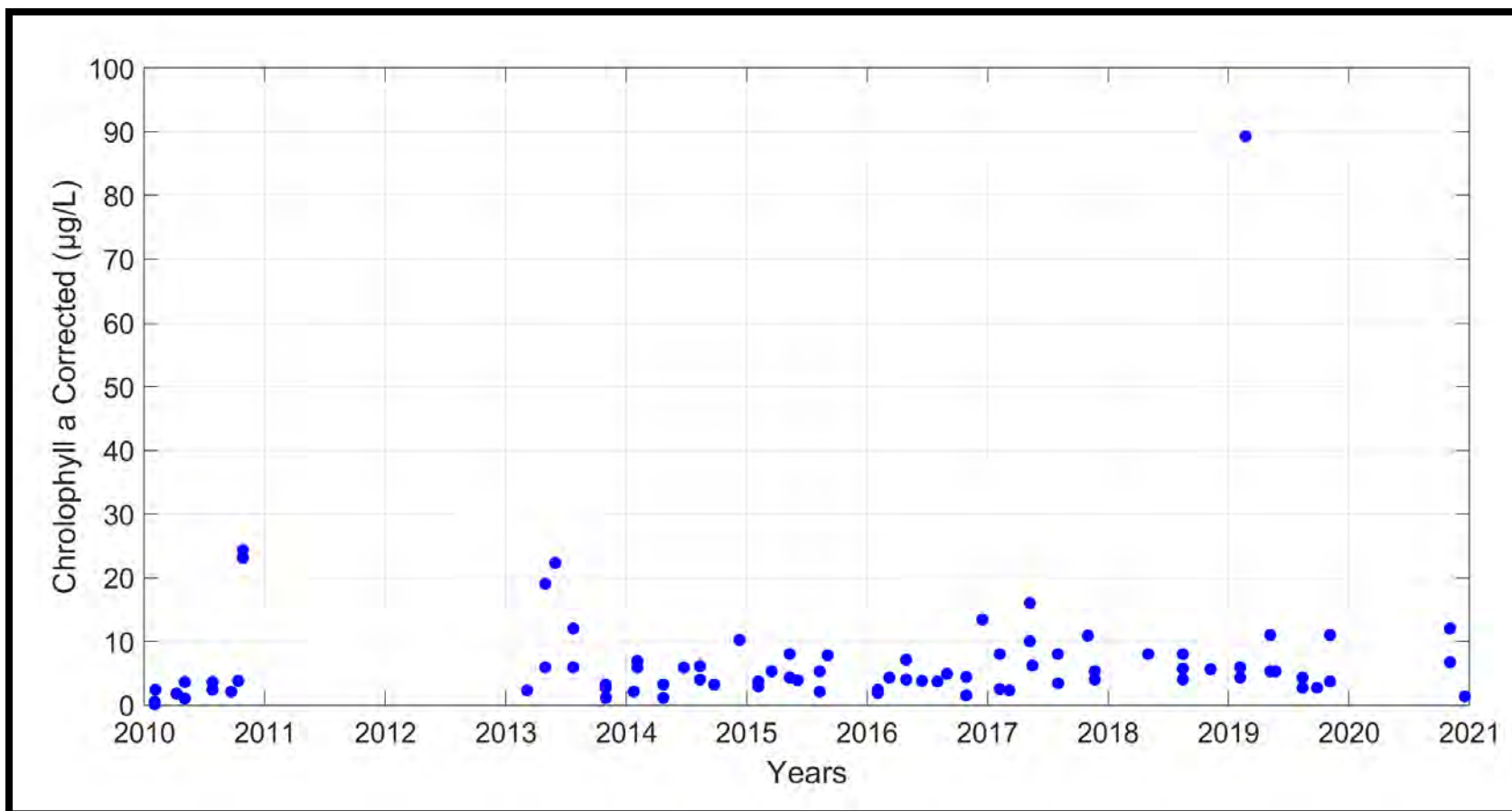


Figure 3-62: Plot of Measured Chl-a in Cascade Lake

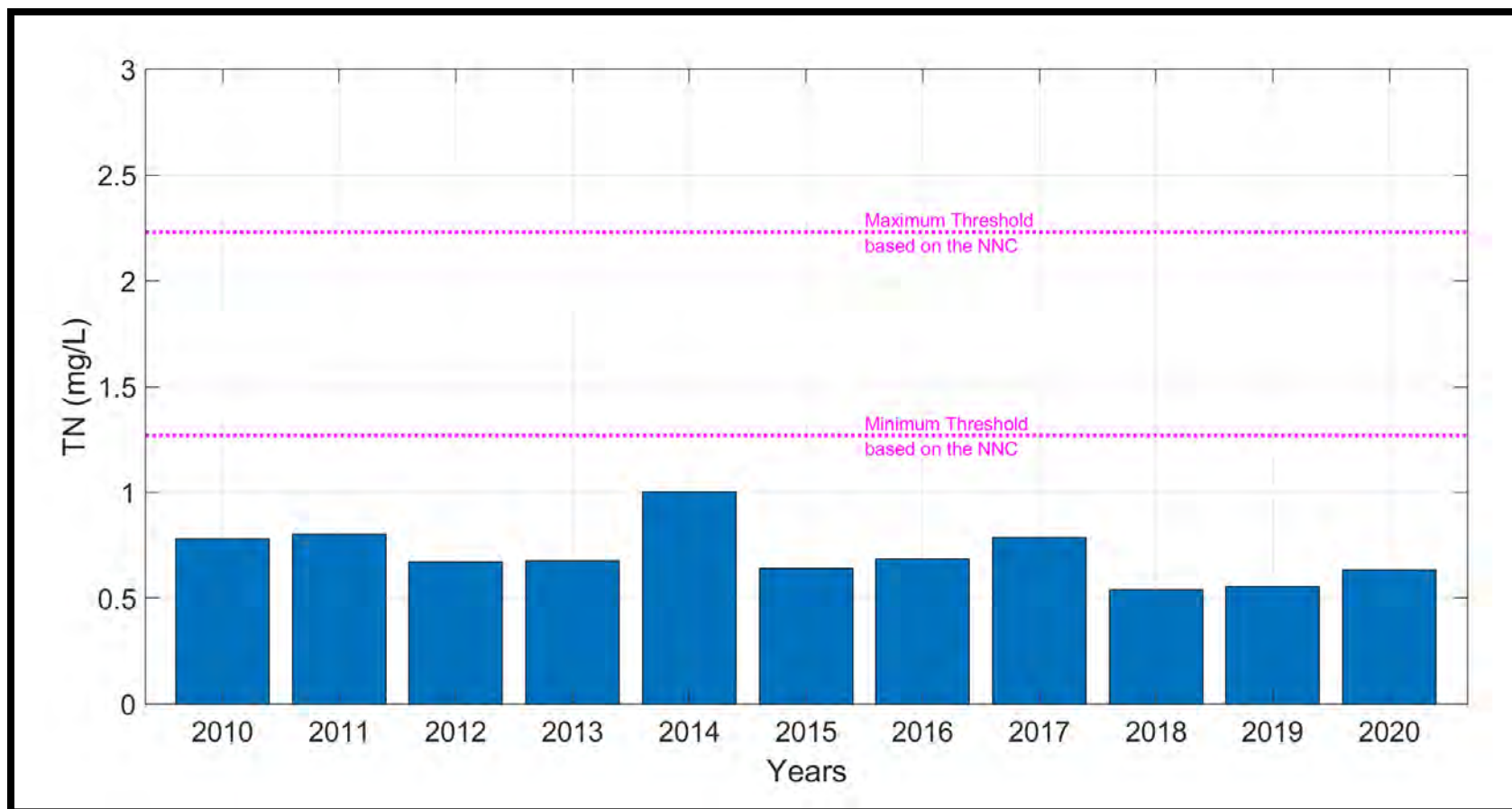


Figure 3-63: Plot of Annual Geometric Means for TN with NNC Criteria for Lake Bradford

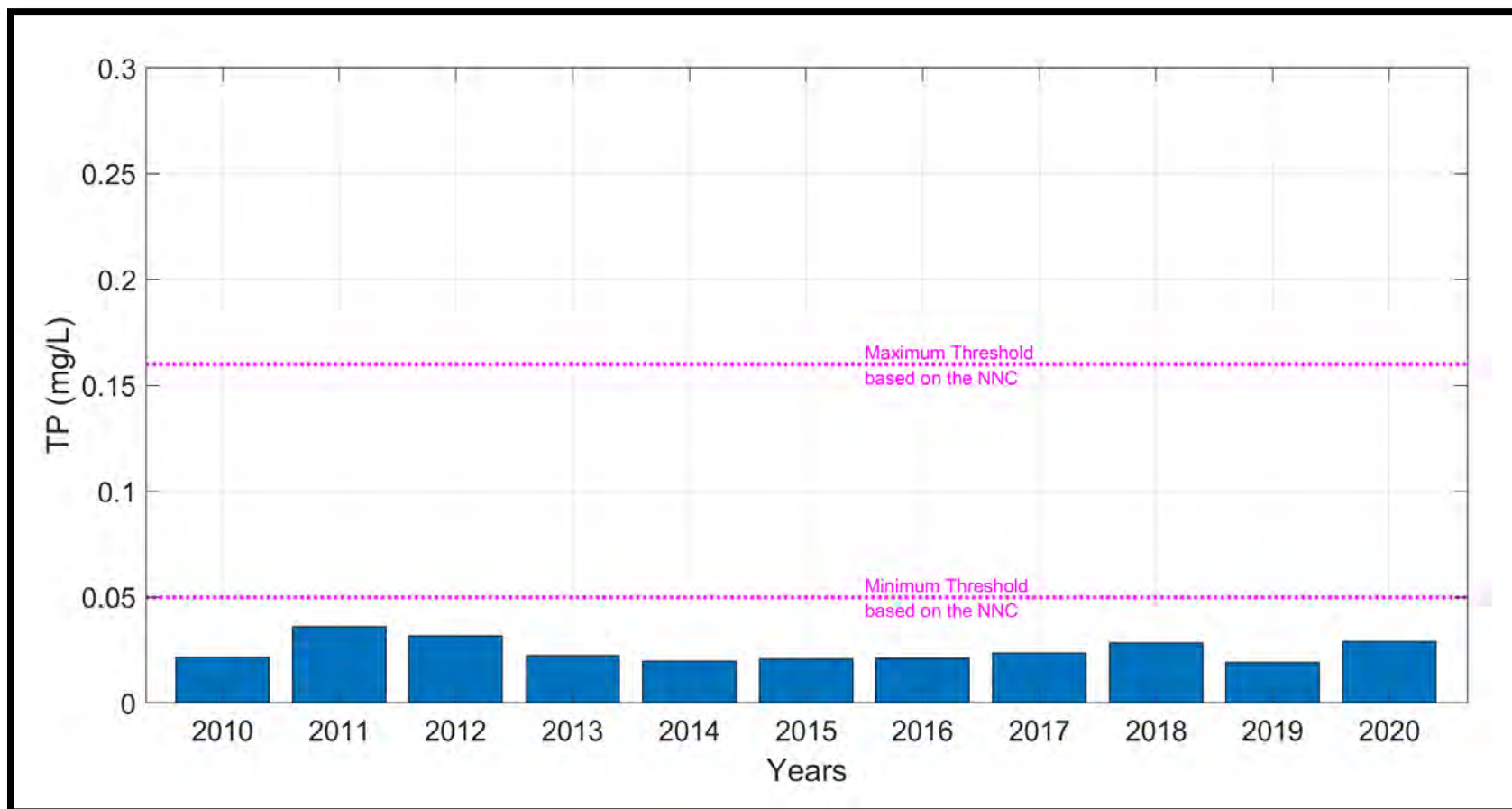


Figure 3-64: Plot of Annual Geometric Means for TP with NNC Criteria for Lake Bradford

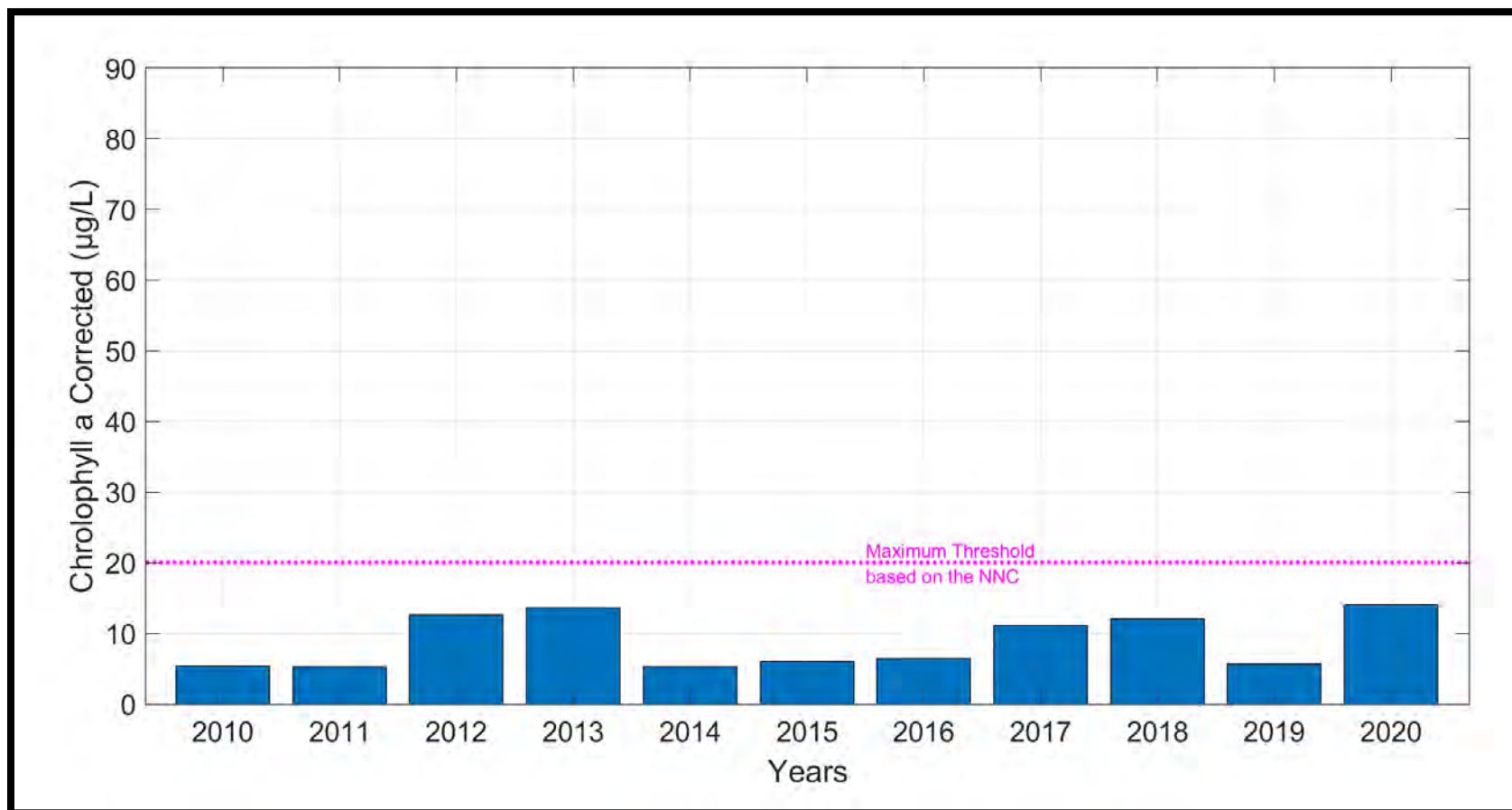


Figure 3-65: Plot of Annual Geometric Means for Chl-a with NNC Criteria for Lake Bradford

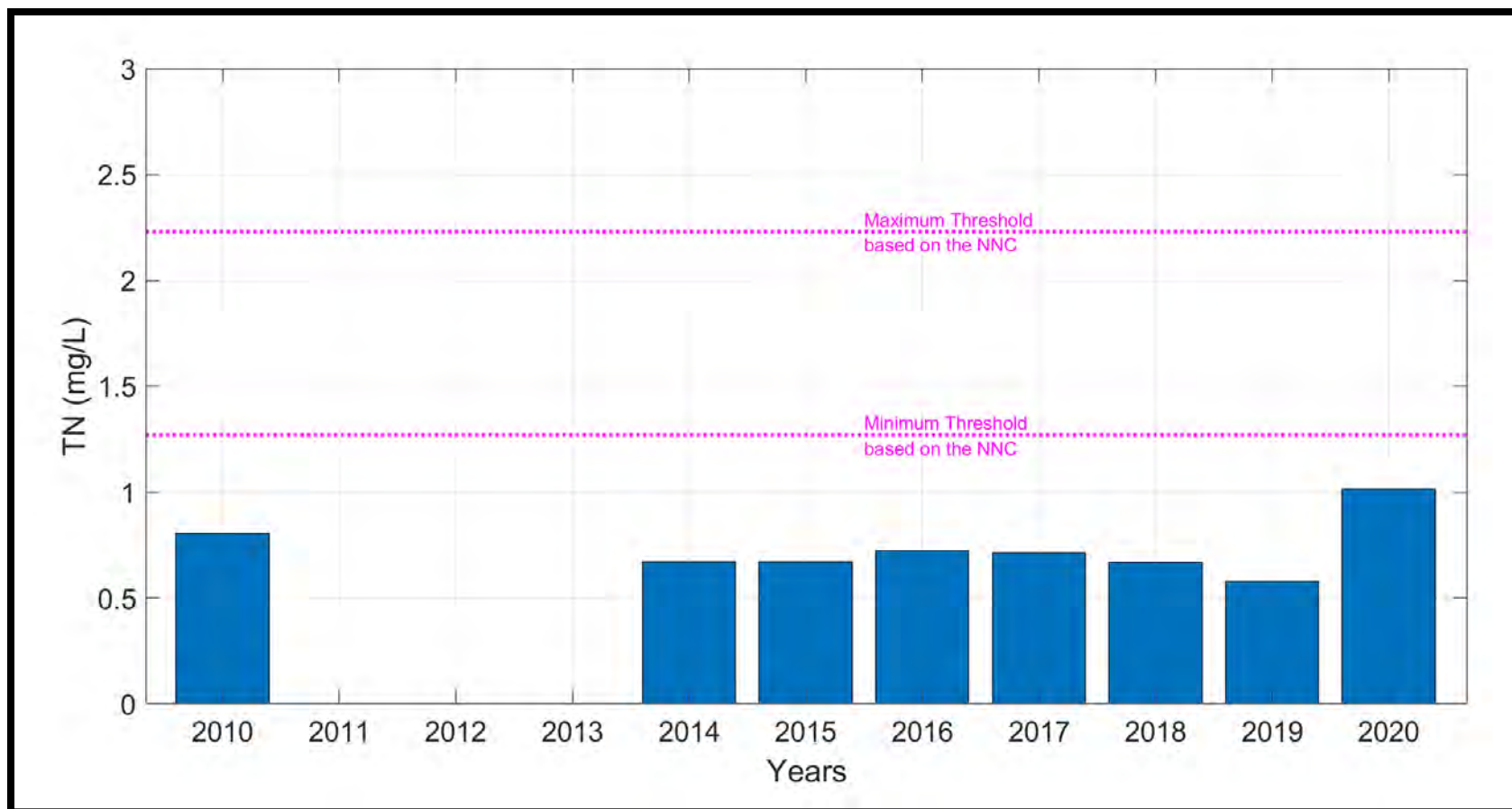


Figure 3-66: Plot of Annual Geometric Means for TN with NNC Criteria for Lake Hiawatha

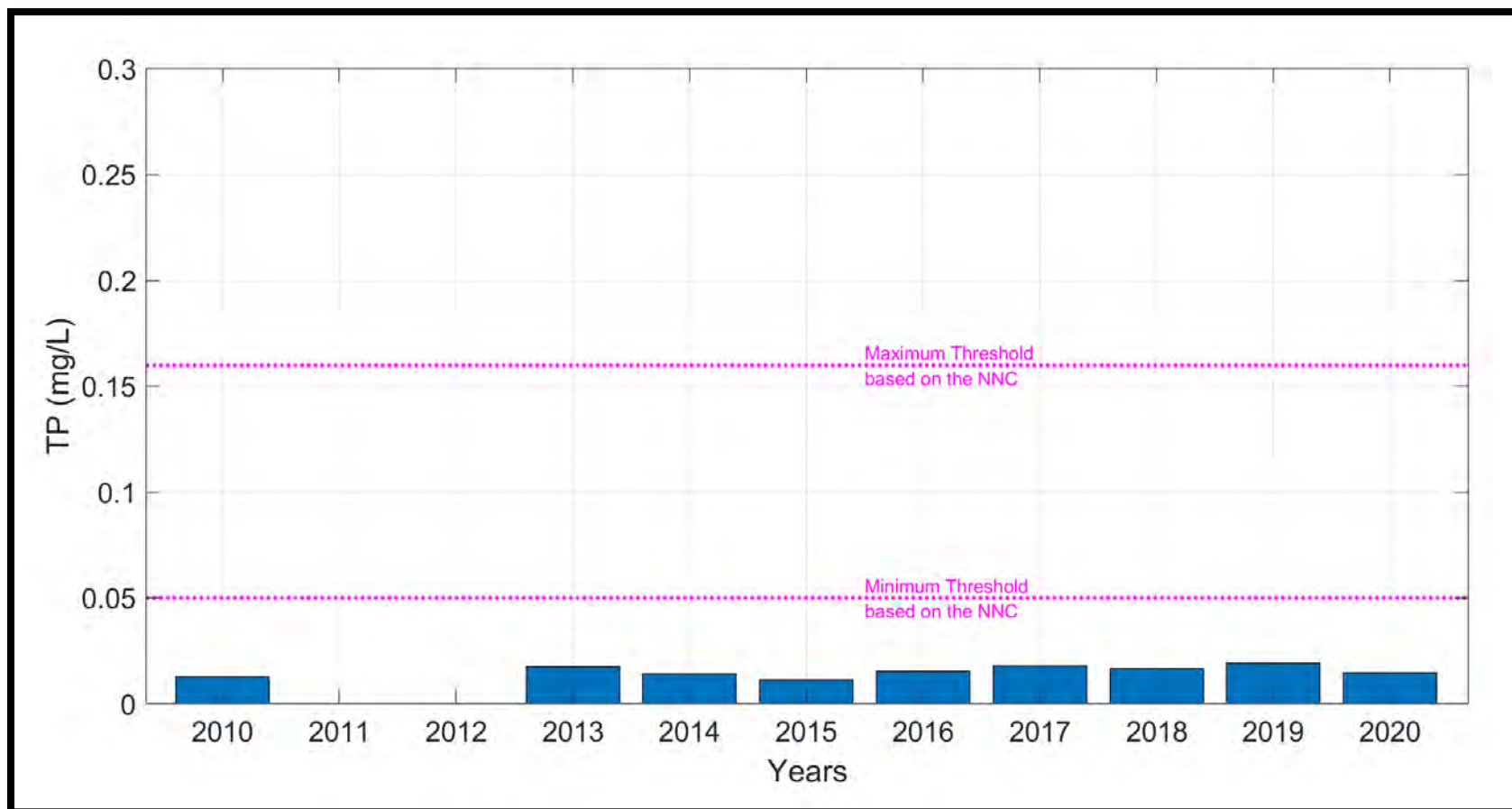


Figure 3-67: Plot of Annual Geometric Means for TP with NNC Criteria for Lake Hiawatha

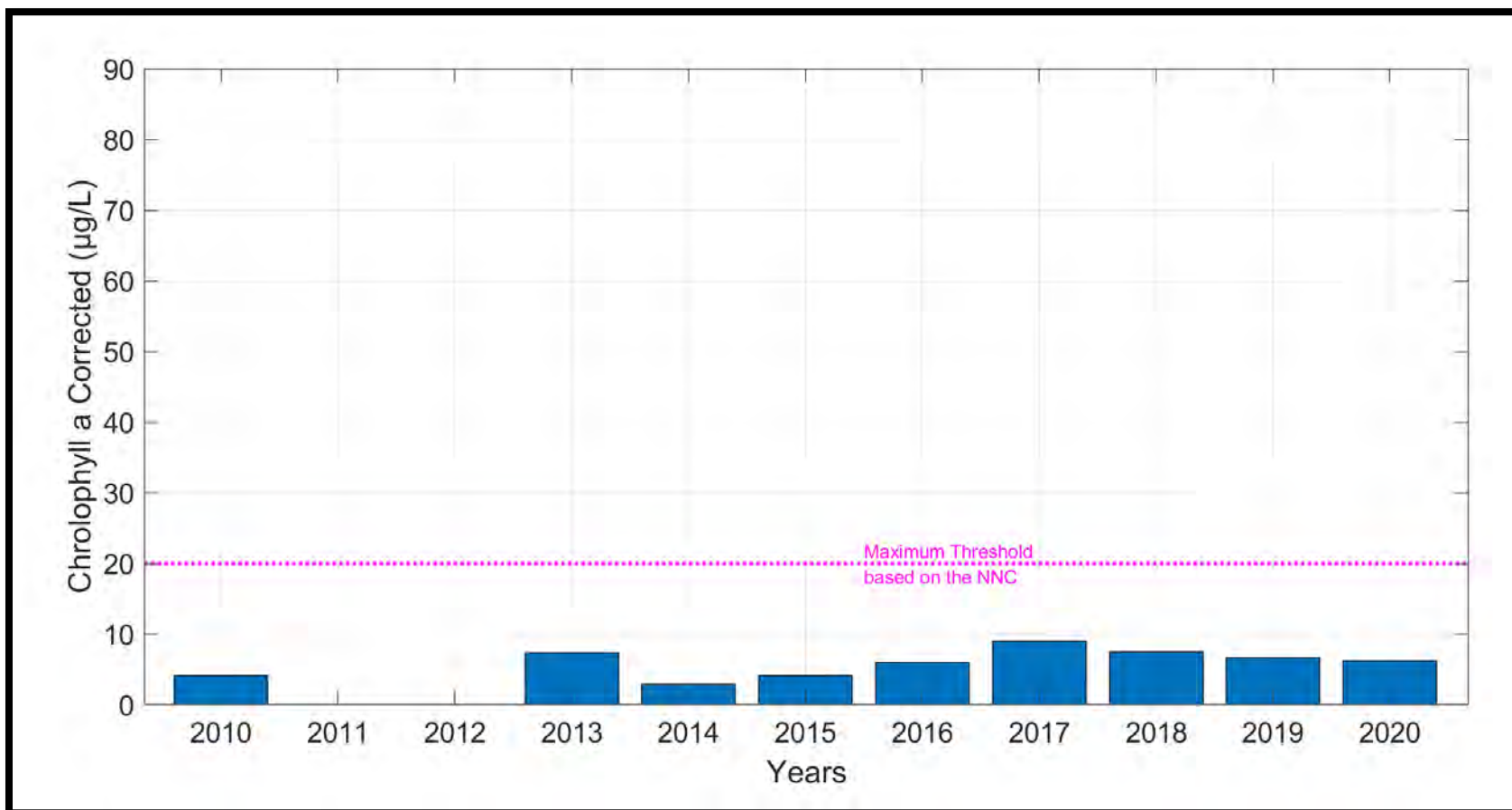


Figure 3-68: Plot of Annual Geometric Means for Chl-a with NNC Criteria for Lake Hiawatha

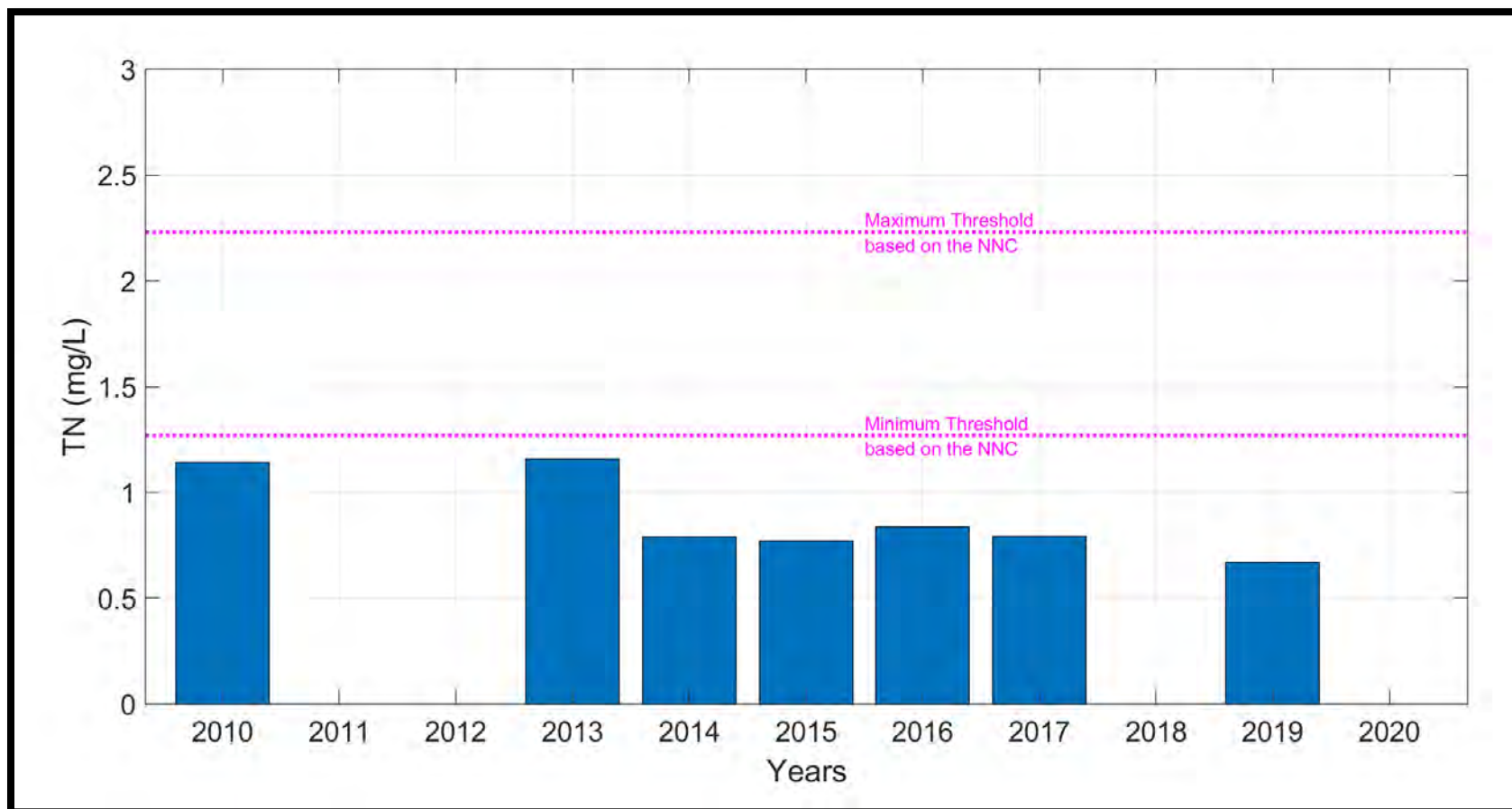


Figure 3-69: Plot of Annual Geometric Means for TN with NNC Criteria for Cascade Lake

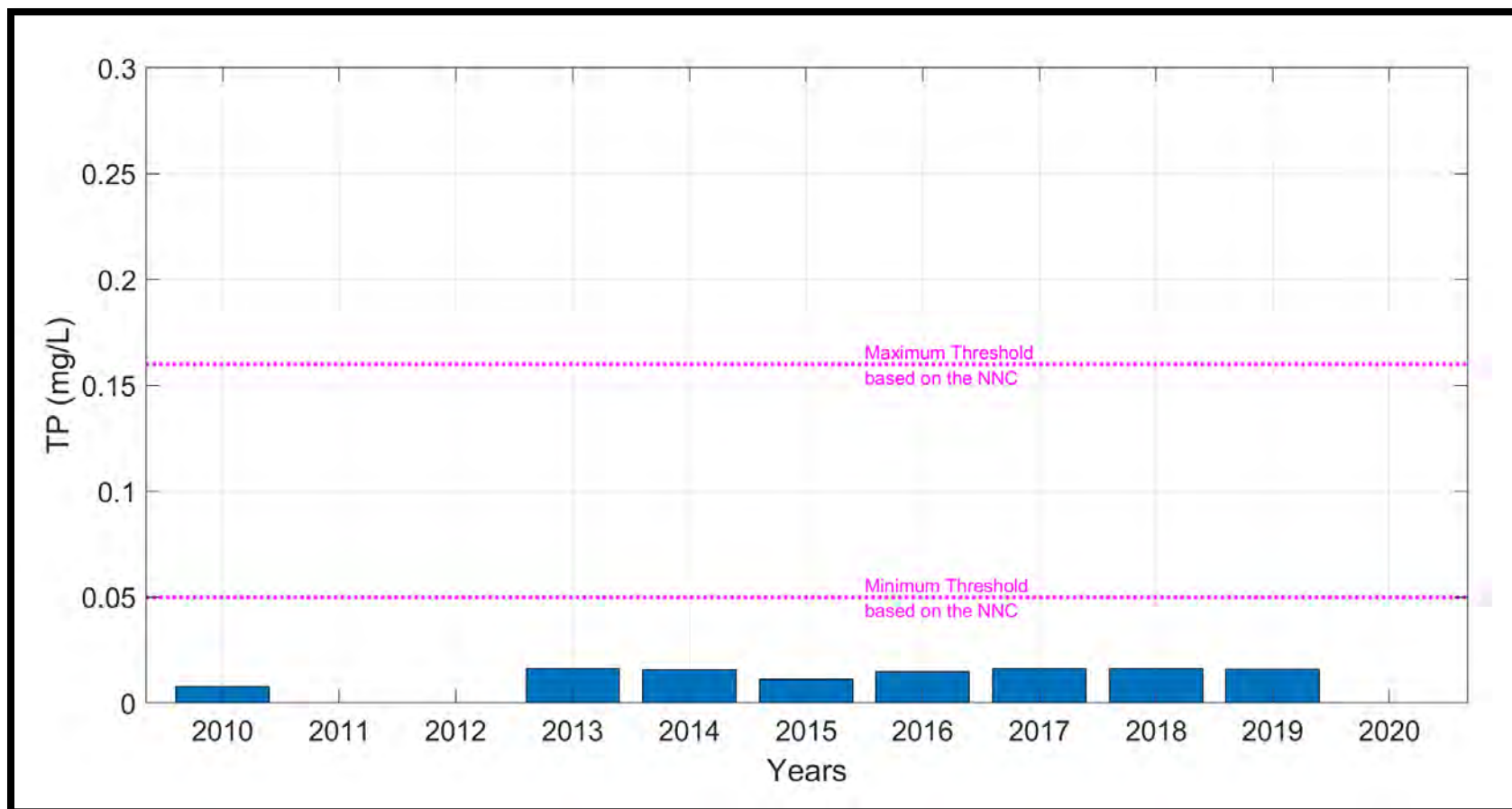


Figure 3-70: Plot of Annual Geometric Means for TP with NNC Criteria for Cascade Lake

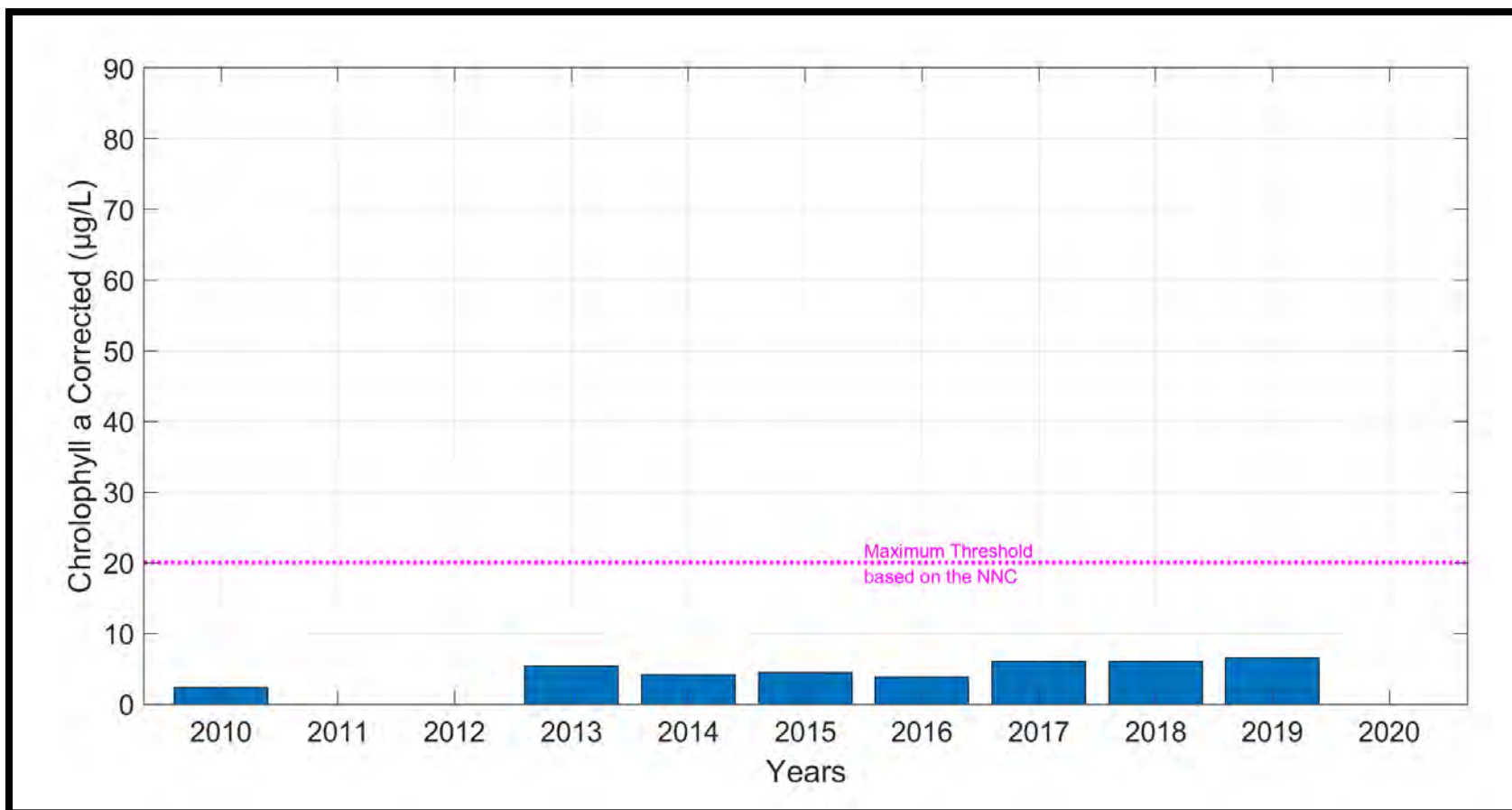


Figure 3-71: Plot of Annual Geometric Means for Chl-a with NNC Criteria for Cascade Lake

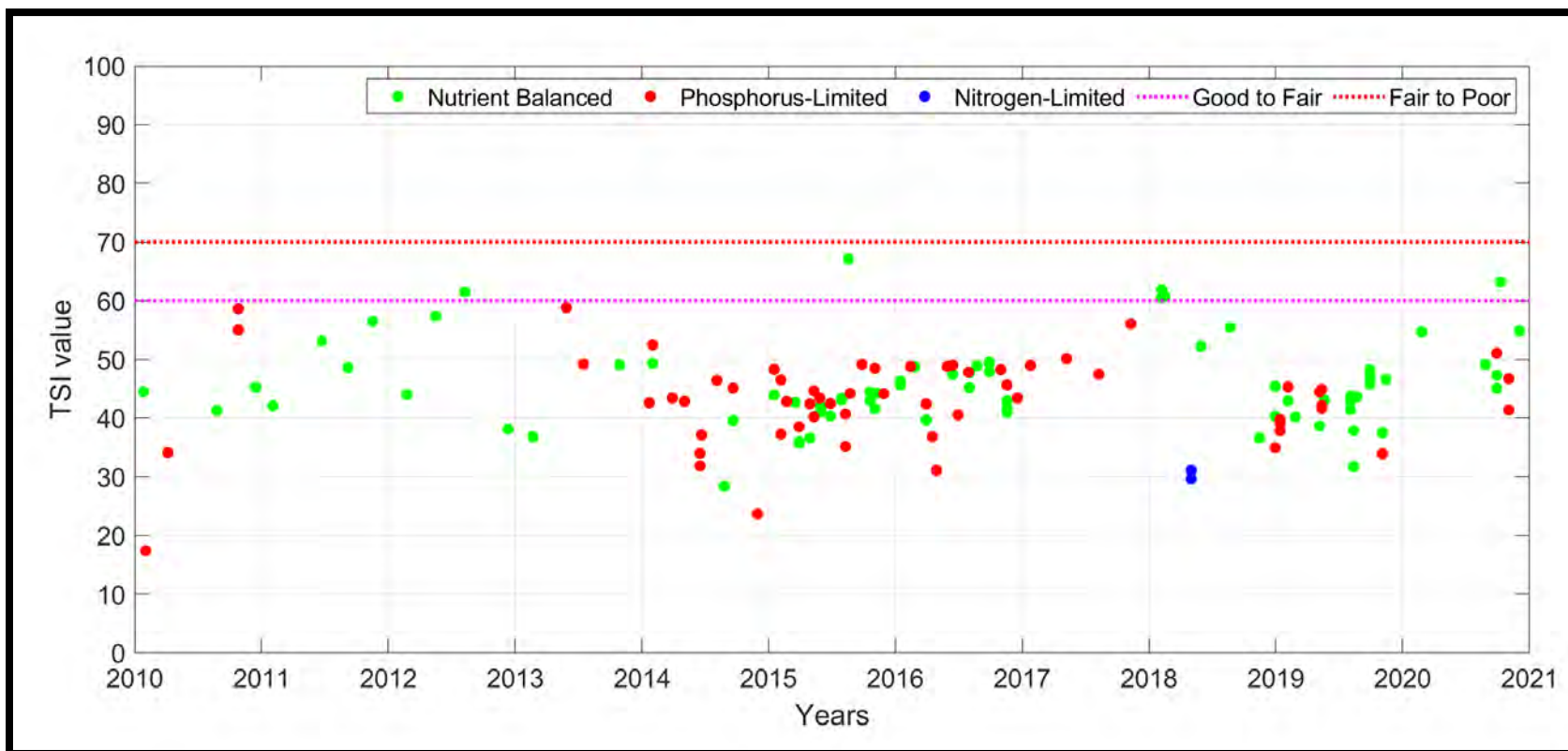


Figure 3-72: Trophic State Index for Lake Bradford

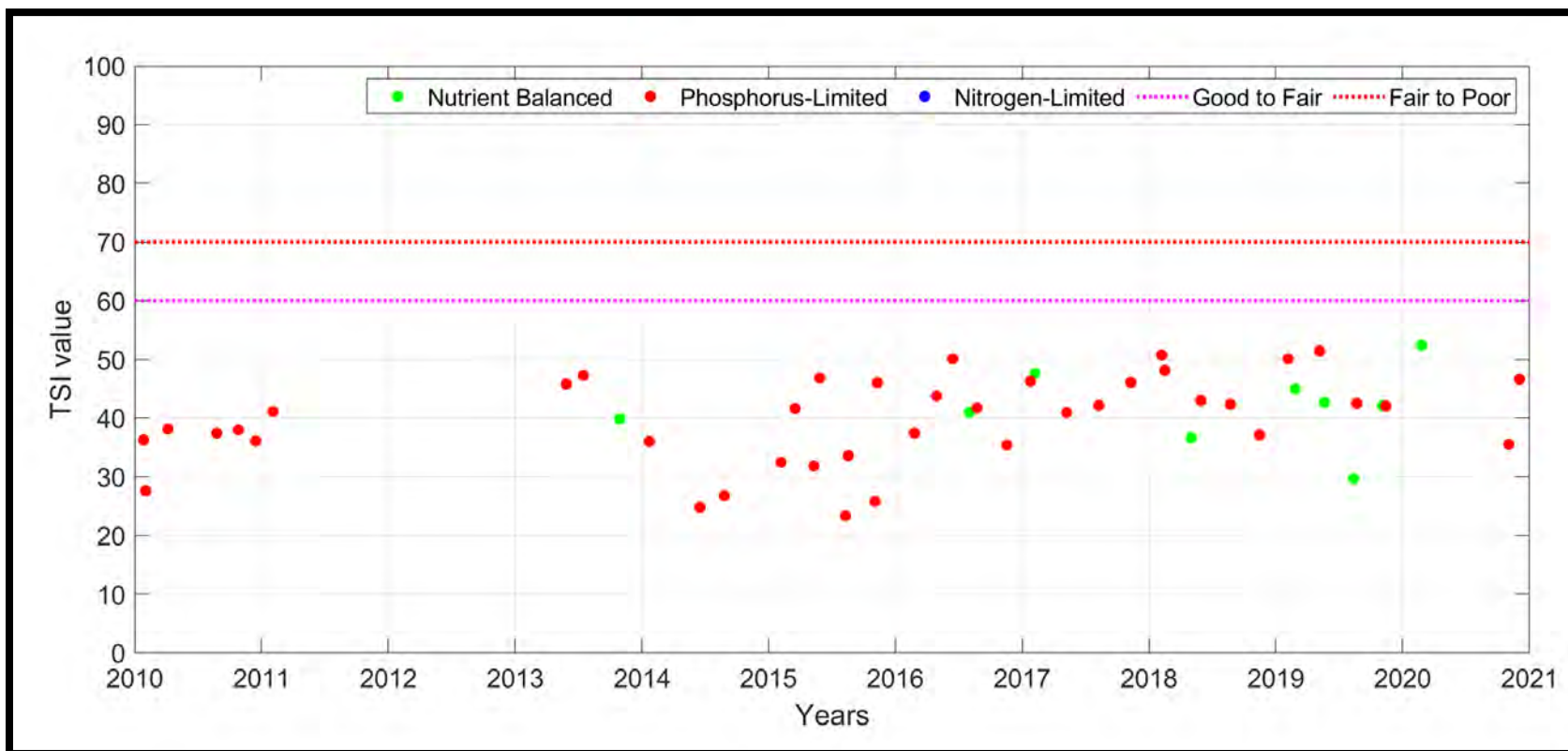


Figure 3-73: Trophic State Index for Lake Hiawatha

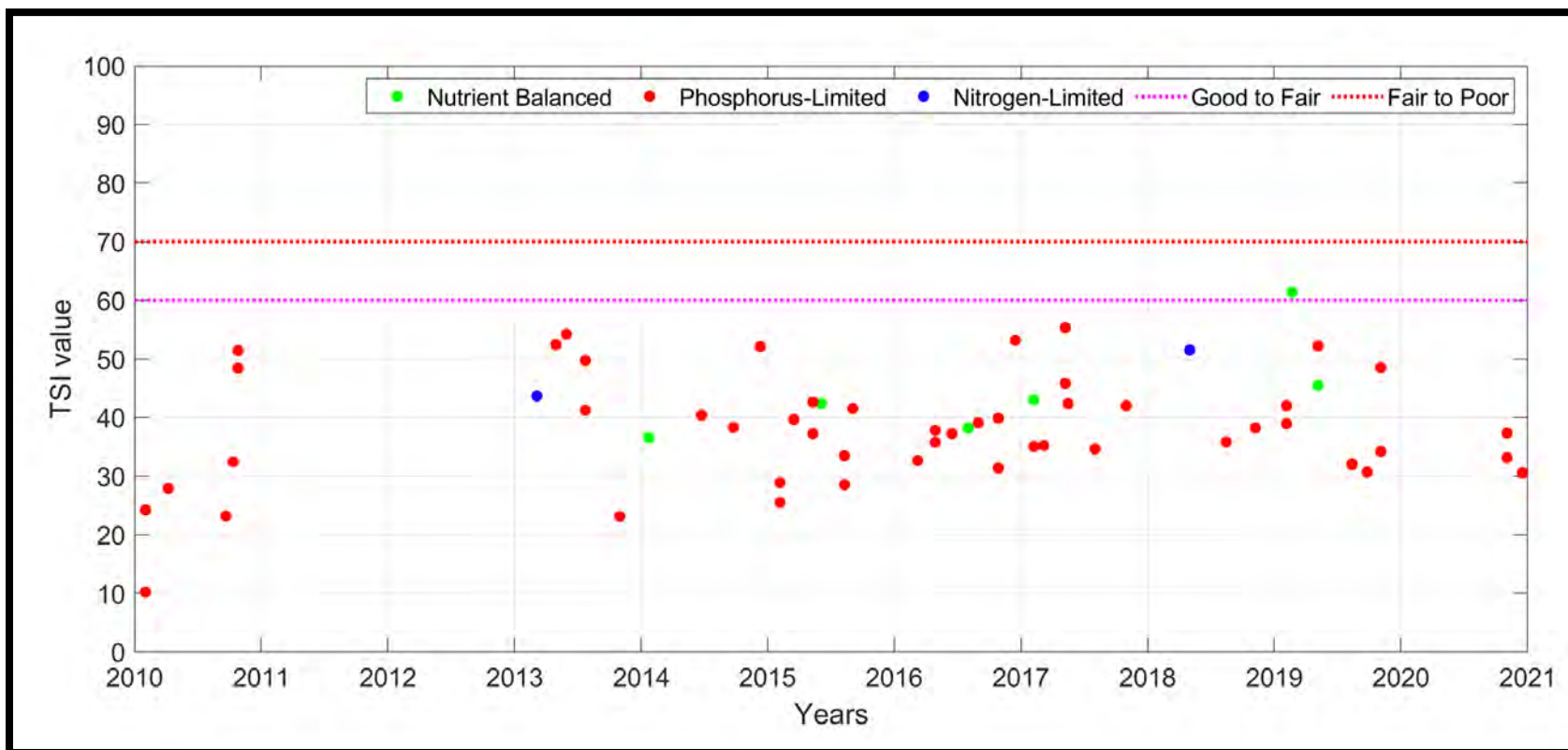


Figure 3-74: Trophic State Index for Cascade Lake

Figure 3-75, Figure 3-76, and Figure 3-77 present a plot of measured *E. coli* levels in the lakes from 2014 through 2020. The concentrations in Lake Hiawatha and Cascade Lake are all very low, with most at or below detection limits and well below the 410 MPN/100 mL threshold. The concentrations in Lake Bradford are also low, with a few higher values recorded in 2020 and one above the 410 MPN/100 mL threshold.

3.5.3.7 Groundwater Data

Figure 3-23 presented the surficial aquifer groundwater sampling wells within the Lake Munson basin boundaries. Station AAD5312 is located within the Lake Bradford Estates neighborhood downstream of Lake Bradford. Data for this station is only available from 2000. Station AAA0291 is located within the Silver Lake Recreation Area within the Apalachicola National Forest. Data for this station is available from 1993 to 1999.

3.5.3.8 Biological Data

Table 3-14 through **Table 3-16** present LVI data collected by Leon County and FDEP on the three lakes. Lake Bradford data range from 53 up to 75, reflecting conditions between healthy and exceptional. Lake Hiawatha and Cascade Lake data range from 79 up to 95, reflecting exceptional conditions for all sampling events.

3.5.3.9 Stormwater Treatment Facilities

In assessing potential sources of pollutants to the Bradford Chain of Lakes, and ultimately for targeting loads and reductions, it is important to identify treatment facilities adjacent to and along tributaries flowing into the three lakes. **Figure 3-78** presents a map showing the locations of stormwater treatment facilities throughout the Bradford Chain of Lakes subbasin. These are maintained by Leon County, the City, FDOT, and private neighborhoods. The bulk of the facilities are located in and around Capital Circle SW where it passes just north of Cascade Lake and Lake Hiawatha. Five private stormwater ponds are located in neighborhoods south of Blountstown Highway (State Road 20).

3.5.3.10 Atmospheric Deposition Data

Figure 3-24 presented the location of the nearest atmospheric deposition station to the Bradford Chain of Lakes, the Quincy, FL station. This is the same station utilized in the Lake Munson calculations.

3.5.3.11 Data Summary

For the purposes of the qualitative analysis of sources of pollutants to the Bradford Chain of Lakes (**Section 3.5.4**), the available data are reasonable. There are sufficient active surface water quality stations within the lakes to support the qualitative assessment. The water quality conditions in the lakes limit the need for additional data. Based on the relatively pristine water quality, it is assumed anthropogenic loads are minimal. The following outlines some limitations in the available data. Specific recommendations on additional data collection efforts are provided in **Section 3.8**.

- The water quality data along Bradford Creek immediately upstream of Cascade Lake is old and limited (prior to 2006).

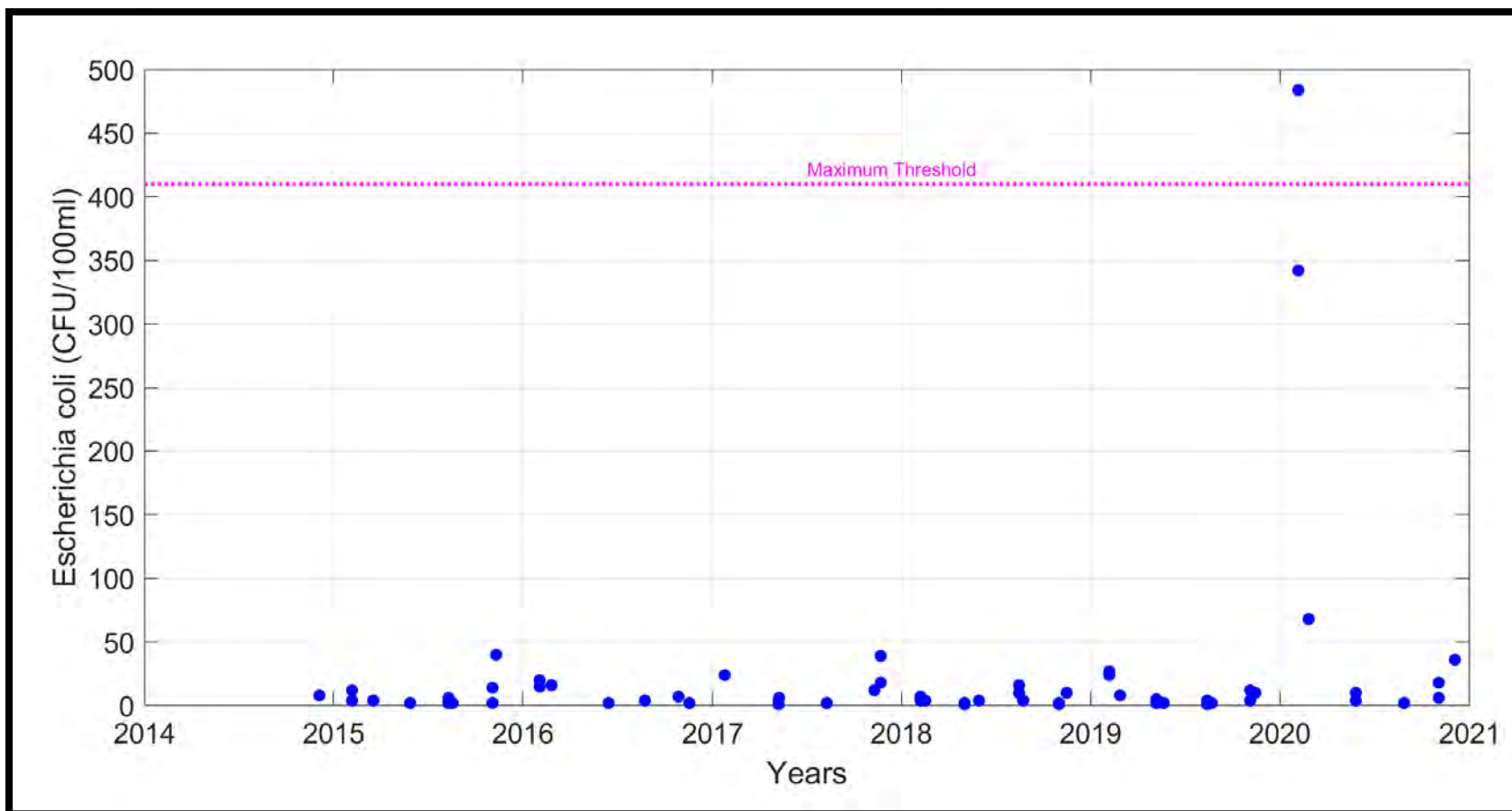


Figure 3-75: Plot of *E. coli* for Lake Bradford

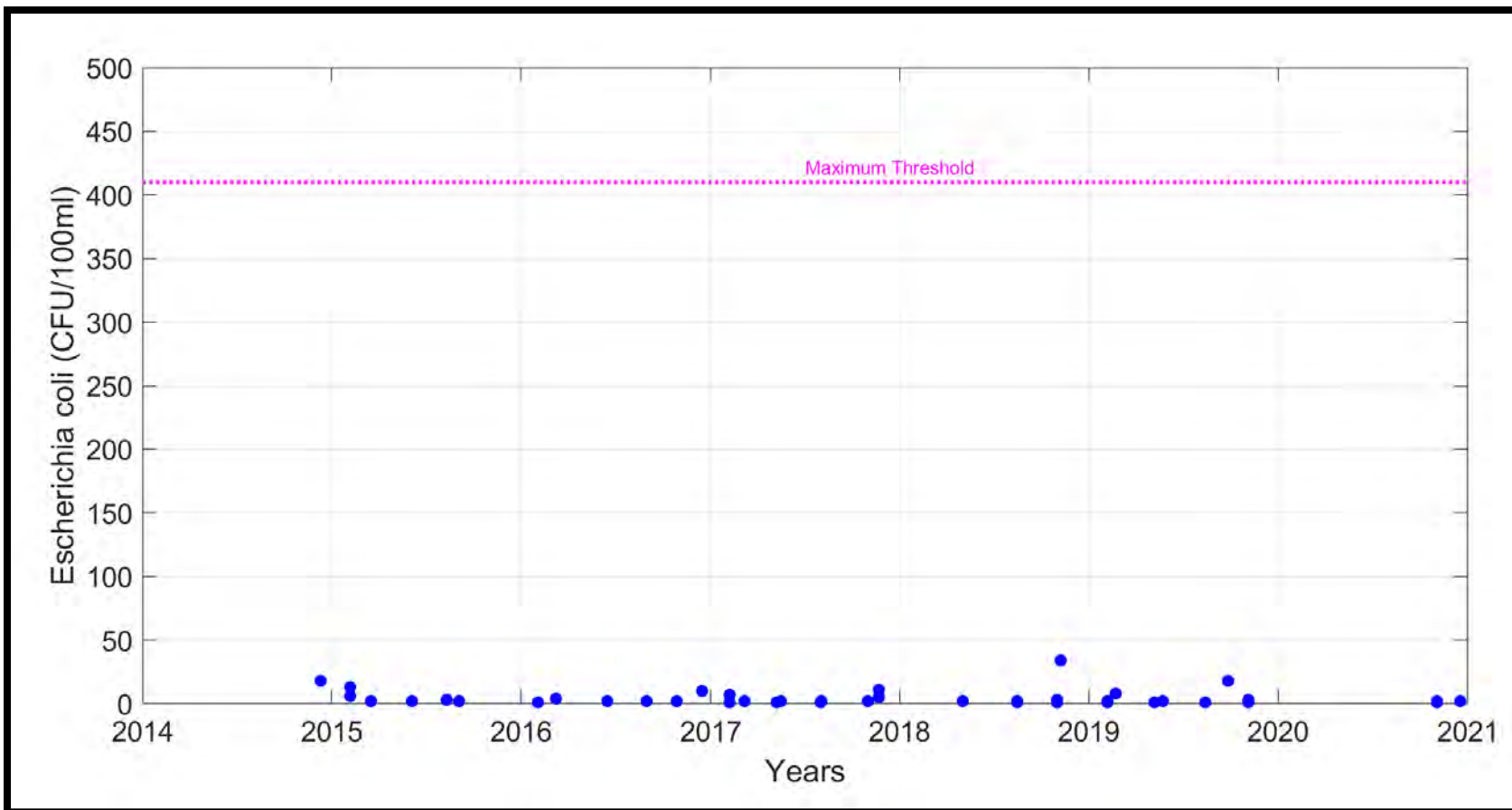


Figure 3-77: Plot of *E. coli* for Cascade Lake

Table 3-14: Summary of LVI Data for Lake Bradford

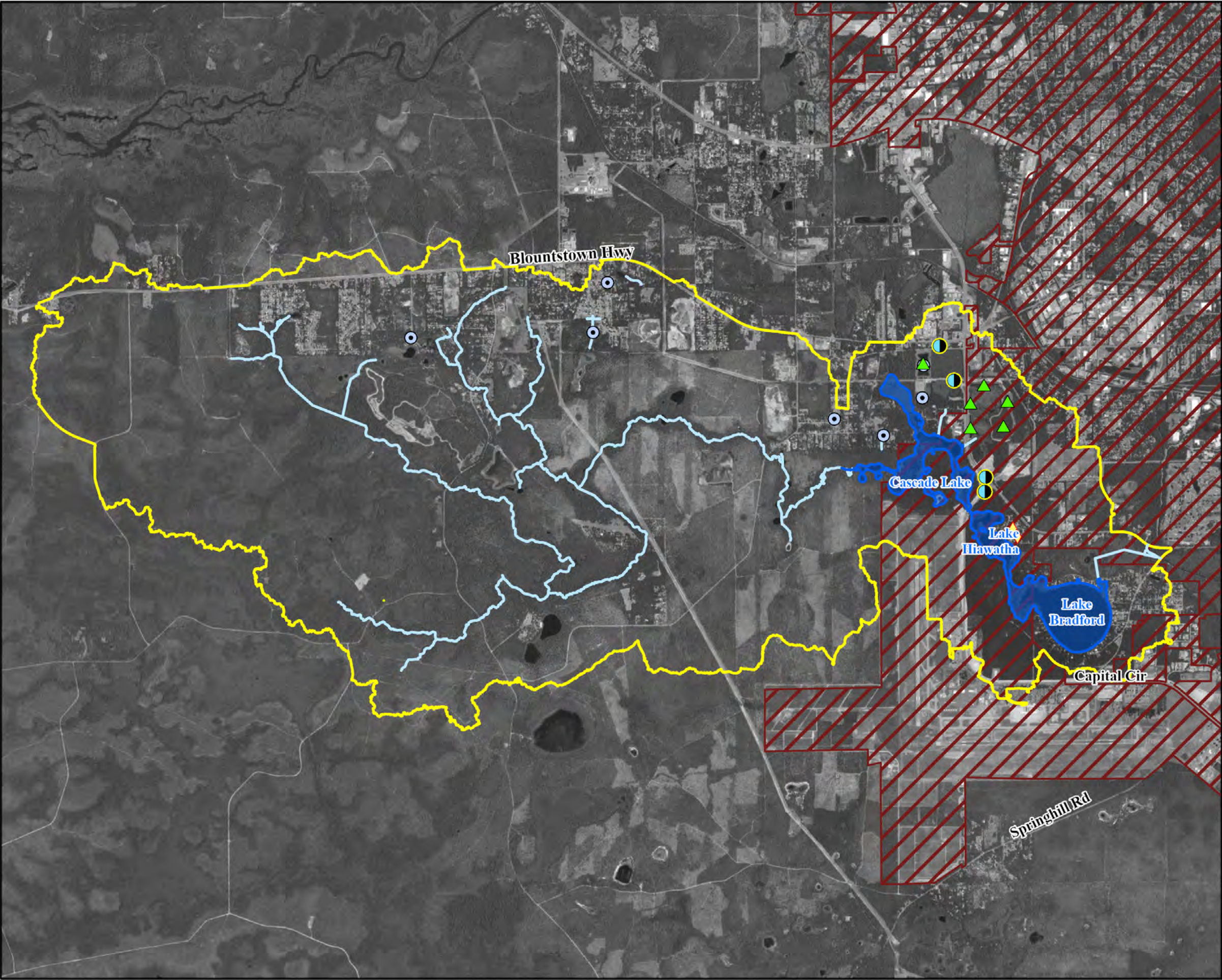
Date	Station ID	LVI	Aquatic Life Use Category
6/23/2010	21FLCOT COTLVI001	53	Healthy
8/25/2010	21FLLEONLEONLVI001	76	Exceptional
8/9/2013	21FLLEONLEONLVI001	60	Healthy
10/15/2013	21FLCOT COTLVI001	75	Exceptional
8/26/2014	21FLLEONLEONLVI001	68	Exceptional
8/19/2015	21FLLEONLEONLVI001	65	Exceptional
9/23/2015	21FLCOT COTLVI001	60	Healthy
8/24/2016	21FLLEONLEONLVI001	56	Healthy
7/26/2018	21FLLEONLEONLVI001	64	Exceptional
7/24/2019	21FLLEONLEONLVI001	72	Exceptional

Table 3-15: Summary of LVI Data for Lake Hiawatha

Date	Station ID	LVI	Aquatic Life Use Category
6/23/2010	21FLCOT COTLVI003	93	Exceptional
8/25/2010	21FLLEONLEONLVI005	79	Exceptional
8/9/2013	21FLLEONLEONLVI005	86	Exceptional
8/26/2014	21FLLEONLEONLVI005	95	Exceptional
8/18/2015	21FLLEONLEONLVI005	92	Exceptional
9/23/2015	21FLCOT COTLVI003	82	Exceptional
8/24/2016	21FLLEONLEONLVI005	80	Exceptional
7/26/2018	21FLLEONLEONLVI005	88	Exceptional
7/24/2019	21FLLEONLEONLVI005	84	Exceptional

Table 3-16: Summary of LVI Data for Cascade Lake

Date	Station ID	LVI	Aquatic Life Use Category
7/8/2010	21FLCOT COTLVI009	80	Exceptional
9/29/2010	21FLLEONLEONLVI003	79	Exceptional
8/23/2013	21FLLEONLEONLVI003	89	Exceptional
9/9/2014	21FLLEONLEONLVI003	90	Exceptional
9/14/2015	21FLLEONLEONLVI003	89	Exceptional
10/17/2016	21FLLEONLEONLVI003	90	Exceptional
7/27/2018	21FLLEONLEONLVI003	86	Exceptional
7/22/2019	21FLLEONLEONLVI003	79	Exceptional



Legend

- Bradford Chain of Lakes Drainage Basin
- Waterbodies in Study
- Watercourses
- Tallahassee Corporate Limits
- City of Tallahassee Stormwater Ponds
- Leon County Stormwater Ponds
- FDOT Stormwater Ponds
- Stormwater Ponds-Other

Sources:
Waterbodies: COT, 2020
Watersheds: COT, 2020
Roads: FDOT, 2020
BMPs: Geosyntec, 2022
City Limits: COT, 2022

**Figure 3-78:
Bradford Chain of Lakes Basin BMP
Location Map**

**Tallahassee Master Plan - Surface
Water (TMaPS)**



- There are limited data to evaluate the potential for seepage of pollutants to the lakes from the surficial aquifer, i.e., surficial groundwater sampling stations, around the lakes with recent data.

3.5.4 Qualitative Assessment of Sources

As outlined in **Section 3.4.4** for Lake Munson, prior to performing loading calculations and other analyses to quantify existing pollutant sources to the Bradford Chain of Lakes, it is important to analyze available data and summarize findings from historical studies to support identification of likely sources and quantification of the magnitude of impact.

For the Bradford Chain of Lakes, the sources to be evaluated include the following:

- Stormwater runoff
- Septic systems
- Internal recycling and seepage
- Wastewater
- Atmospheric deposition
- Interconnected flows

An overview of analyses and findings for each source listed above is provided in the following sections. Prior to the discussions of each of the potential sources, an in-lake analysis is provided to build on the information presented in **Section 3.5.3**. Following the discussions for each source type, a summary of findings for the qualitative assessment is provided.

3.5.4.1 In-Lake Water Quality

Following the methodology utilized for Lake Munson in **Section 3.4.4.1**, analyses were conducted on the available in-lake data for the three lakes from 2010 to 2020. This provides an evaluation of the baseline water quality conditions as well as the spatial variation through the system of lakes. The parameters analyzed for Bradford Chain of Lakes include color, alkalinity, TP, TN, Chl-a, TSI, and *E. coli*.

As was done for Lake Munson (**Section 3.4.4.1**), stations were clustered where they represent conditions within a specific area and all stations with data after 2010 were assigned to a specific cluster. The clustered data from 2010 to 2020 were analyzed to provide the average of the annual geomeans or the 90th percentile, depending upon the parameter. The results are presented on a map, with colors representing the results. The levels associated with the colors are reflective of water quality thresholds as outlined in 62-302 Florida Administrative Code (F.A.C.) and are discussed and presented in **Section 3.4.4.1**. The Bradford Chain of Lakes analyses use the same ranges as the Lake Munson analyses.

Figure 3-79 presents the data clustering used for the analyses and associated stations. For the Bradford Chain of Lakes, data since 2010 were available at multiple locations throughout the chain. Within Lake Bradford, there were three clusters, at the outfall of the lake prior to flowing into Grassy Lake (BE), in the center of the lake (BC), and in the northwestern lobe of the lake

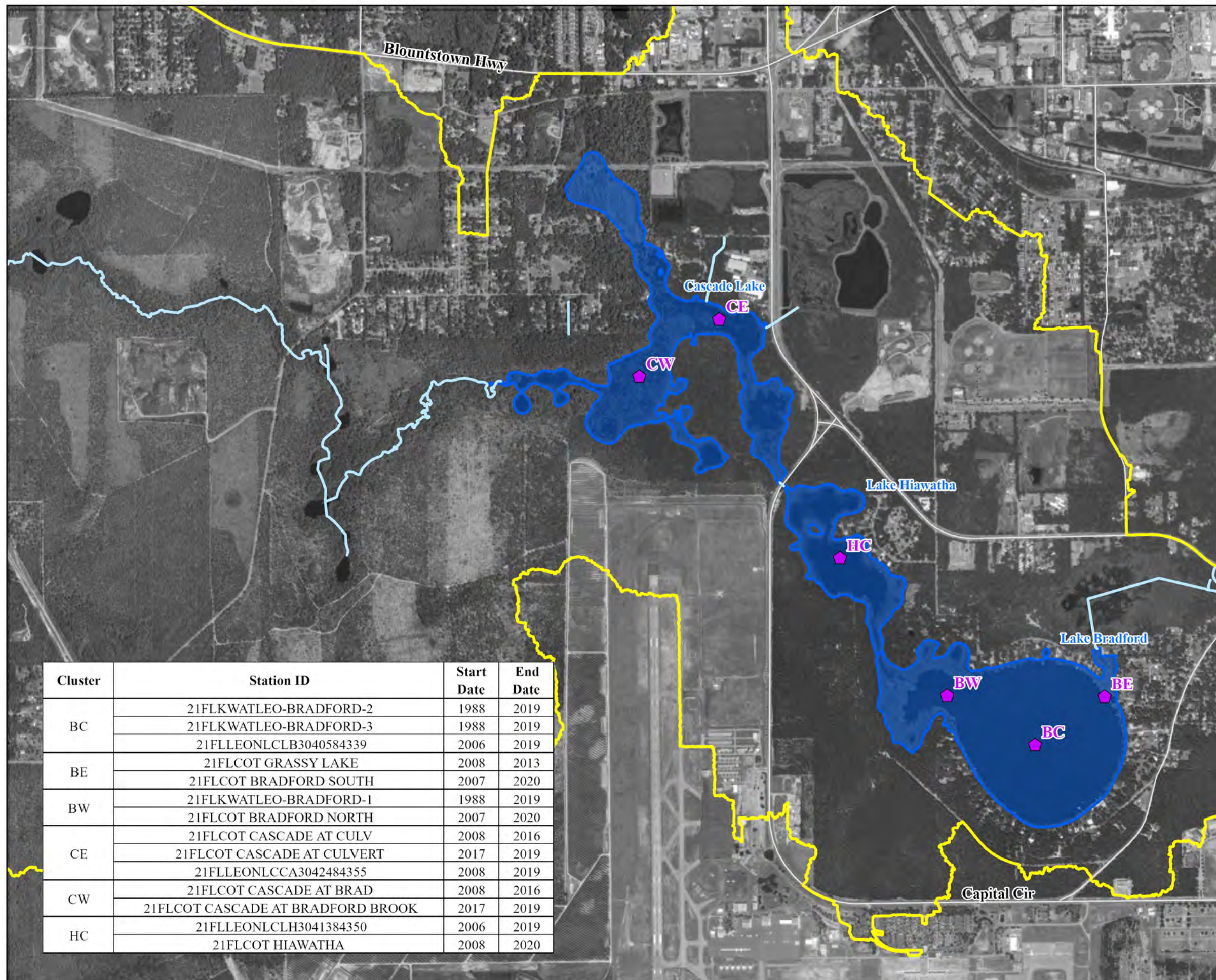
(BW). Within Lake Hiawatha, there is a single cluster (HC) in the center of the lake. Finally, within Cascade Lake, there are two clusters, one at the center of the lake (CE) and the other on the upstream end near where Bradford Brook flows in (CW). These stations, viewed together, present the spatial variation as water passes through the chain. While **Figure 3-53** did show historical water quality stations within Bradford Brook immediately upstream of Cascade Lake, the only data since 2000 was one sample collected in 2006. Based on this, no cluster analysis was performed at this location.

Figure 3-80 presents the color. For color, the scales were set such that values of 40 PCU and below were blue, with the remaining segments from green to red divided into 40 PCU segments. This is due to the high color found within the Bradford Chain and allows visualization of the color changes moving through the system. Moving from Cascade Lake down to Lake Bradford, color averages show a distinct drop from values above 160 PCU in Cascade Lake, steadily down to between 80 PCU and 120 PCU in Lake Bradford (CW=260 PCU, CE=219 PCU, HC=153 PCU, BW=119 PCU, BC=116 PCU, BE=119 PCU). The drop in color likely reflects the dilution of high color inflow from Bradford Brook with more localized, less tannic, runoff.

Figure 3-81 presents the alkalinity. The scales were set such that values above 20 mg/L were red, based on the NNC cutoff for low alkalinity lakes, with the remaining colors (orange down to blue), in 5 mg/L segments down to 0 mg/L. Moving from Cascade Lake down to Lake Bradford, alkalinity levels are very low, with all values (other than the center station in Lake Bradford) below 5 mg/L (CW=1.6 mg/L, CE=3.0 mg/L, HC=2.8 mg/L, BW=2.4 mg/L, BC=5.0 mg/L, BE=2.4 mg/L). These values reflect the acidic nature of the lakes.

Figure 3-82 and **Figure 3-83** present the TN and TP. The ranges were set the same way as described for Lake Munson, with blue lower than the minimum NNC threshold and red higher than the maximum. The TN plot shows all station averages at below the minimum 1.27 mg/L threshold (CW=1.07 mg/L, CE=0.80 mg/L, HC=0.67 mg/L, BW=0.71 mg/L, BC=0.61 mg/L, BE=0.76 mg/L). The data do show higher TN averages in Cascade Lake. The TP map shows all station averages below the minimum 0.05 mg/L threshold (CW=0.013 mg/L, CE=0.015 mg/L, HC=0.016 mg/L, BW=0.023 mg/L, BC=0.025 mg/L, BE=0.024 mg/L). The data show increasing averages moving through the system.

Figure 3-84 and **Figure 3-85** present maps of the Chl-a and TSI. The ranges were set the same way as described for Lake Munson, with red representing Chl-a values above the 20 µg/L NNC threshold and the TSI transition from good to fair. The Chl-a map shows all station averages below 10 µg/L (CW=4.4 µg/L, CE=5.1 µg/L, HC=5.3 µg/L, BW=8.2 µg/L, BC=8.0 µg/L, BE=9.2 µg/L). While all stations are well below the threshold, there is an increase in the averages moving through the system. The TSI map shows all station averages below the 60 threshold between good to fair, with all stations below 45 (CW=27.8, CE=20.6, HC=37.6, BW=40.8, BC=43.1, BE=32.4). The data show a similar trend with TSI that was seen for Chl-a and TP.



Cluster	Station ID	Start Date	End Date
BC	21FLKWATLEO-BRADFORD-2	1988	2019
	21FLKWATLEO-BRADFORD-3	1988	2019
	21FLLEONLCLB3040584339	2006	2019
BE	21FLCOT GRASSY LAKE	2008	2013
	21FLCOT BRADFORD SOUTH	2007	2020
BW	21FLKWATLEO-BRADFORD-1	1988	2019
	21FLCOT BRADFORD NORTH	2007	2020
CE	21FLCOT CASCADE AT CULV	2008	2016
	21FLCOT CASCADE AT CULVERT	2017	2019
	21FLLEONLCCA3042484355	2008	2019
CW	21FLCOT CASCADE AT BRAD	2008	2016
	21FLCOT CASCADE AT BRADFORD BROOK	2017	2019
HC	21FLLEONLCLH3041384350	2006	2019
	21FLCOT HIAWATHA	2008	2020



Legend

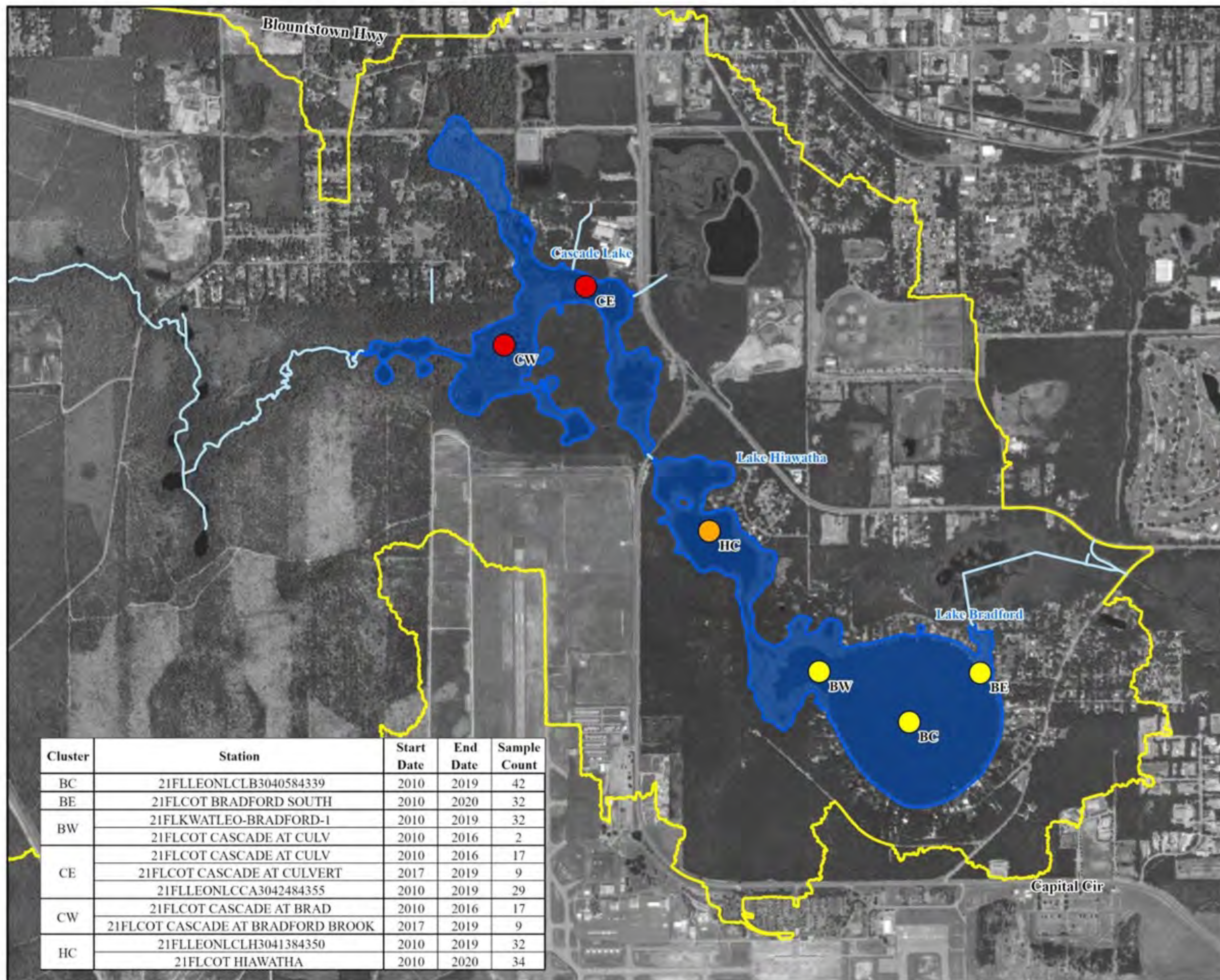
- Bradford Chain of Lakes Drainage Basin
- Waterbodies in Study
- Watercourses
- In-Lake Station Clusters

Sources:
Waterbodies: COT, 2020
Watercourses: COT, 2020
Drainage Basins: COT, 2020
Roads: COT-Leon County, 2023

Figure 3-79:
Station Clustering for Spatial Analyses of
Bradford Chain of Lakes

Tallahassee Master Plan - Surface
Water (TMaPS)





0 0.3
Miles

Legend

Bradford Chain of Lakes Drainage Basin

Waterbodies in Study

Watercourses

Color Average 2010-2020

PCU

0-40

40-80

80-120

120-160

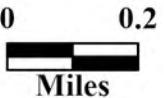
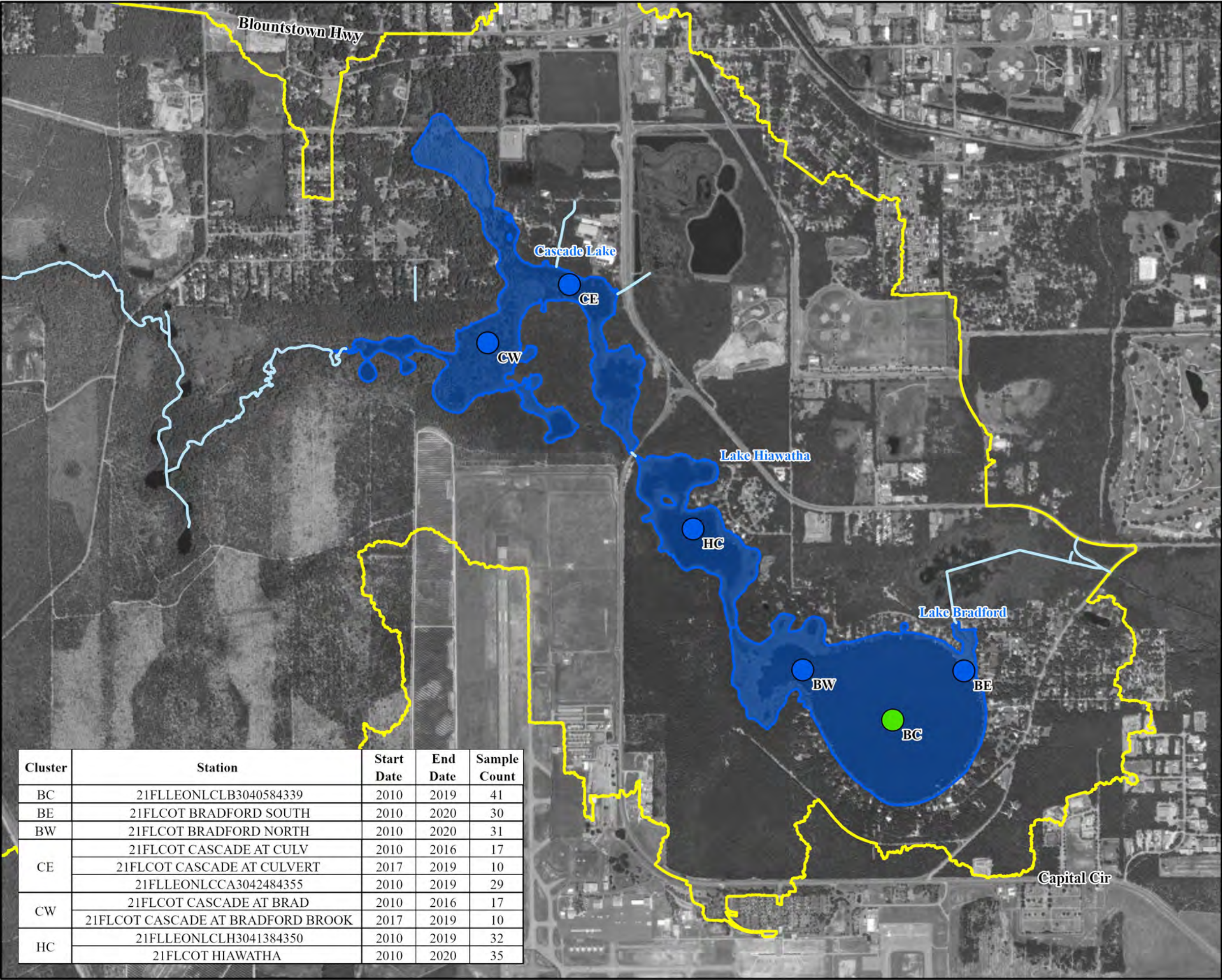
>160

Sources:
Waterbodies: COT, 2020
Watercourses: COT, 2020
Drainage Basins: COT, 2020
Roads: COT-Leon County, 2023
Station Data: FDEP, 2021

Figure 3-80:
Spatial Assessment of Color in Bradford
Chain of Lakes

Tallahassee Master Plan - Surface
Water (TMaPS)

Geosyntec
consultants



Legend

- Bradford Chain of Lakes Drainage Basin
- Waterbodies in Study
- Watercourses

Alkalinity Average 2010-2020

- mg/L
- 0-5
 - 5-10
 - 10-15
 - 15-20
 - >20

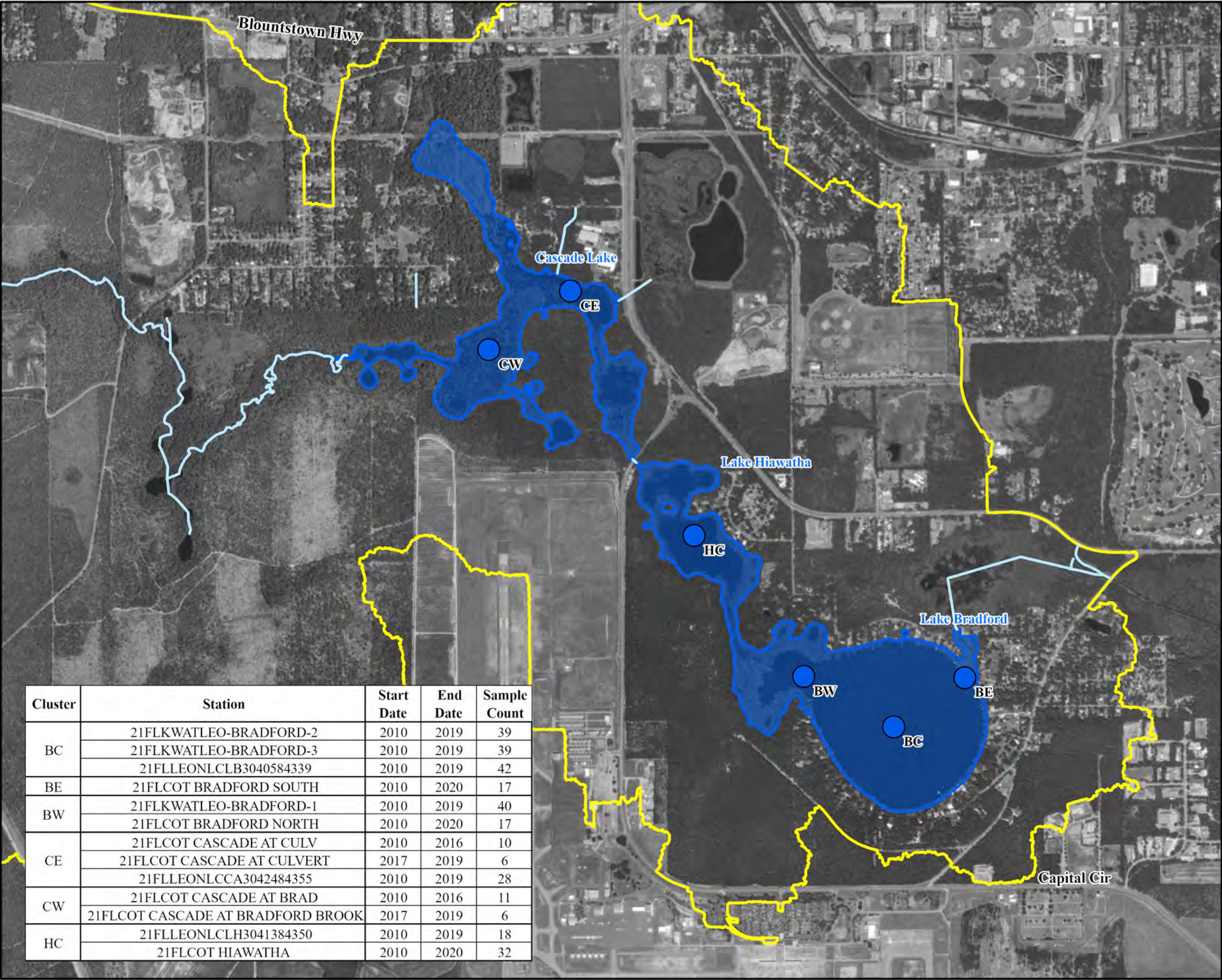
Sources:
Waterbodies: COT, 2020
Watercourses: COT, 2020
Drainage basins: COT, 2020
Roads: COT-Leon County, 2023
Station Data: FDEP, 2021

Cluster	Station	Start Date	End Date	Sample Count
BC	21FLLEONLCLB3040584339	2010	2019	41
BE	21FLCOT BRADFORD SOUTH	2010	2020	30
BW	21FLCOT BRADFORD NORTH	2010	2020	31
CE	21FLCOT CASCADE AT CULV	2010	2016	17
	21FLCOT CASCADE AT CULVERT	2017	2019	10
	21FLLEONLCCA3042484355	2010	2019	29
CW	21FLCOT CASCADE AT BRAD	2010	2016	17
	21FLCOT CASCADE AT BRADFORD BROOK	2017	2019	10
HC	21FLLEONLCLH3041384350	2010	2019	32
	21FLCOT HIAWATHA	2010	2020	35

Figure 3-81:
Spatial Assessment of Alkalinity in
Bradford Chain of Lakes

Tallahassee Master Plan - Surface
Water (TMaPS)





Cluster	Station	Start Date	End Date	Sample Count
BC	21FLKWATLEO-BRADFORD-2	2010	2019	39
	21FLKWATLEO-BRADFORD-3	2010	2019	39
	21FLLEONLCLB3040584339	2010	2019	42
BE	21FLCOT BRADFORD SOUTH	2010	2020	17
BW	21FLKWATLEO-BRADFORD-1	2010	2019	40
	21FLCOT BRADFORD NORTH	2010	2020	17
CE	21FLCOT CASCADE AT CULV	2010	2016	10
	21FLCOT CASCADE AT CULVERT	2017	2019	6
	21FLLEONLCCA3042484355	2010	2019	28
CW	21FLCOT CASCADE AT BRAD	2010	2016	11
	21FLCOT CASCADE AT BRADFORD BROOK	2017	2019	6
HC	21FLLEONLCLH3041384350	2010	2019	18
	21FLCOT HIAWATHA	2010	2020	32



Legend

Bradford Chain of Lakes Drainage Basin

Waterbodies in Study

Watercourses

In-Lake TN Average 2010-2020
mg/L

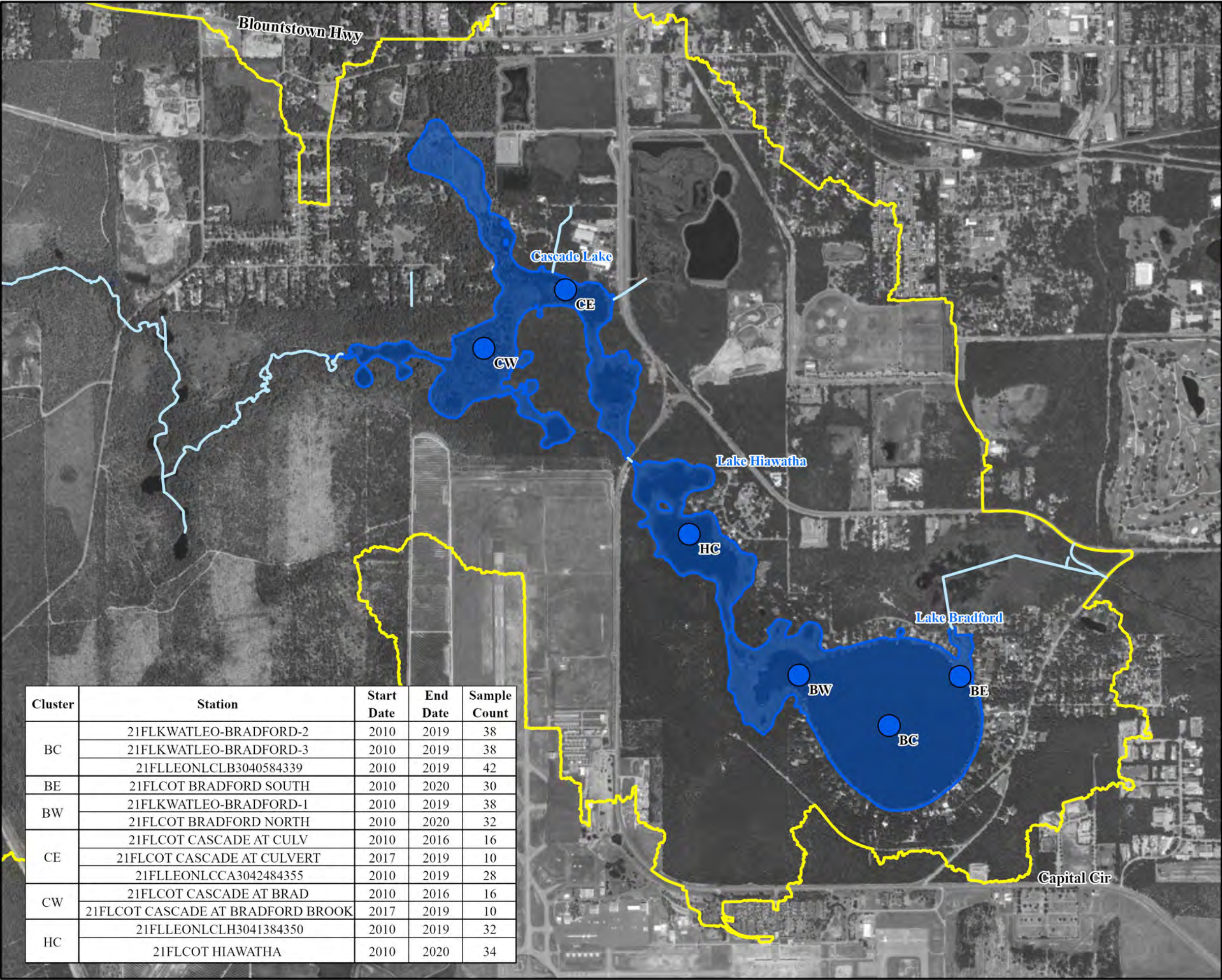
- 0-1.27
- 1.27-1.56
- 1.56-1.84
- 1.84-2.23
- >2.23

Sources:
Waterbodies: COT, 2020
Watercourses: COT, 2020
Drainage Basins: COT, 2020
Roads: COT-Leon County, 2023
Station Data: FDEP, 2021

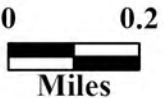
Figure 3-82:
Spatial Assessment of TN in Bradford Chain of Lakes

Tallahassee Master Plan - Surface Water (TMaPS)





Cluster	Station	Start Date	End Date	Sample Count
BC	21FLKWATLEO-BRADFORD-2	2010	2019	38
	21FLKWATLEO-BRADFORD-3	2010	2019	38
	21FLLEONLCLB3040584339	2010	2019	42
BE	21FLCOT BRADFORD SOUTH	2010	2020	30
BW	21FLKWATLEO-BRADFORD-1	2010	2019	38
	21FLCOT BRADFORD NORTH	2010	2020	32
	21FLCOT CASCADE AT CULV	2010	2016	16
CE	21FLCOT CASCADE AT CULVERT	2017	2019	10
	21FLLEONLCCA3042484355	2010	2019	28
	21FLCOT CASCADE AT BRAD	2010	2016	16
CW	21FLCOT CASCADE AT BRADFORD BROOK	2017	2019	10
HC	21FLLEONLCLH3041384350	2010	2019	32
	21FLCOT HIAWATHA	2010	2020	34



Legend

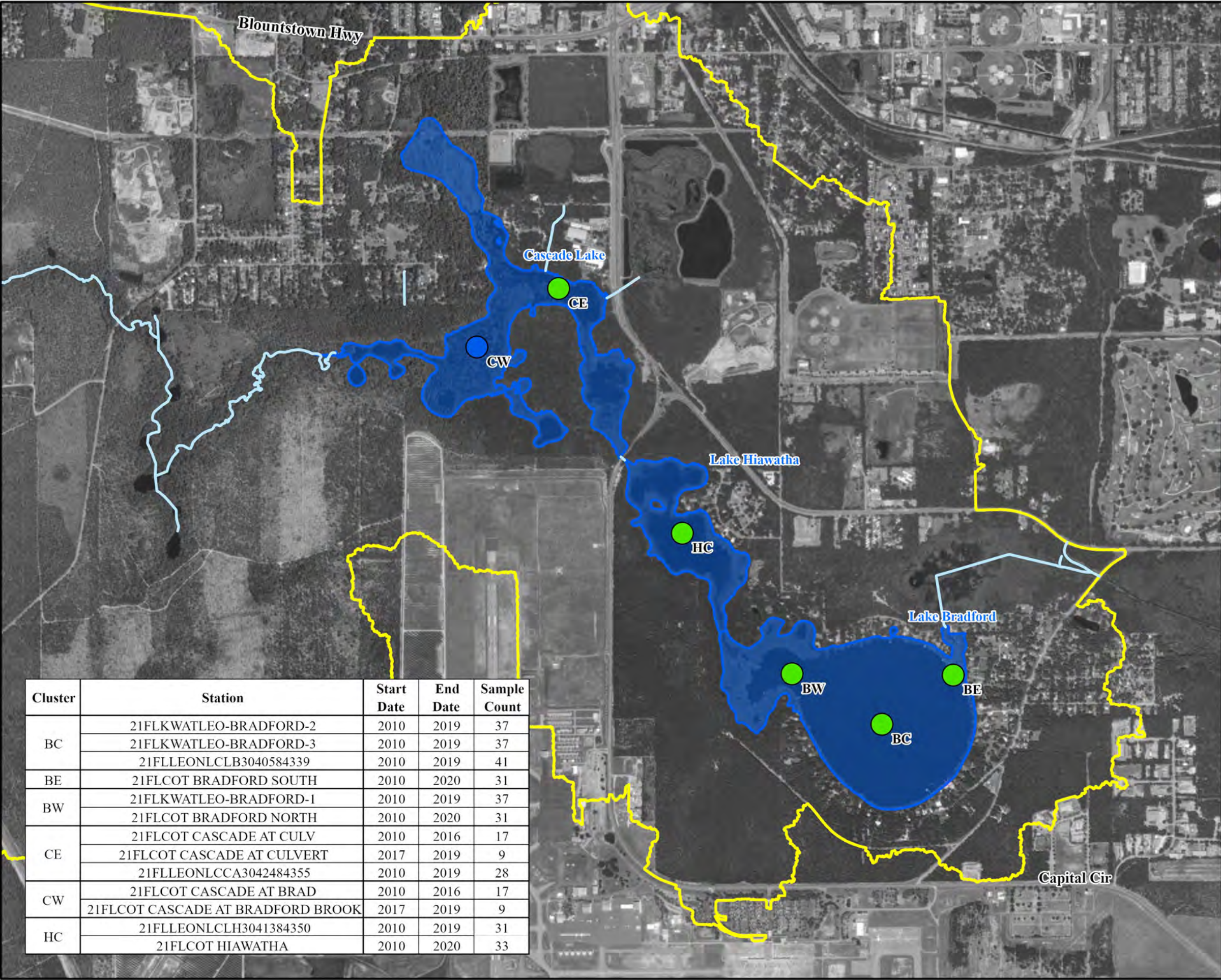
- Bradford Chain of Lakes Drainage Basin
- Waterbodies in Study
- Watercourses
- In-Lake TP Average 2010-2020
mg/L
 - 0-0.05
 - 0.05-0.09
 - 0.09-0.13
 - 0.13-0.16
 - >0.16

Sources:
Waterbodies: COT, 2020
Watercourses: COT, 2020
Drainage Basins: COT, 2020
Roads: COT-Leon County, 2023
Station Data: FDEP, 2021

Figure 3-83:
Spatial Assessment of TP in Bradford
Chain of Lakes

Tallahassee Master Plan - Surface
Water (TMaPS)





Legend

- Bradford Chain of Lakes Drainage Basin
- Waterbodies in Study
- Watercourses

Chl a Average 2010-2020

- µg/L
- 0-5
 - 5-10
 - 10-15
 - 15-20
 - >20

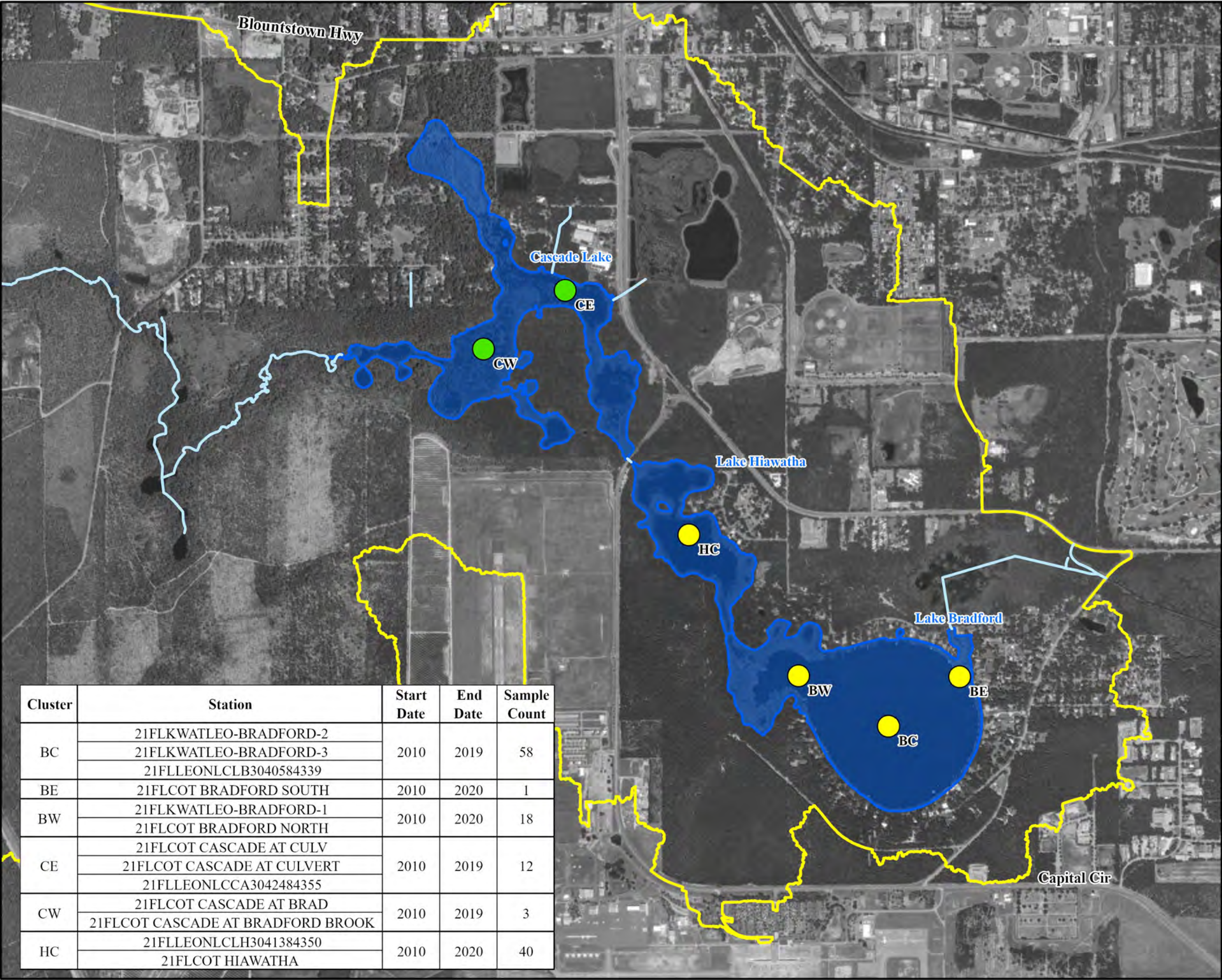
Sources:
Waterbodies: COT, 2020
Watercourses: COT, 2020
Drainage Basins: COT, 2020
Roads: COT-Leon County, 2023
Station Data: FDEP, 2021

Figure 3-84:
Spatial Assessment of Chl a in Bradford
Chain of Lakes

Tallahassee Master Plan - Surface
Water (TMaPS)



Cluster	Station	Start Date	End Date	Sample Count
BC	21FLKWATLEO-BRADFORD-2	2010	2019	37
	21FLKWATLEO-BRADFORD-3	2010	2019	37
	21FLLEONLCLB3040584339	2010	2019	41
BE	21FLCOT BRADFORD SOUTH	2010	2020	31
BW	21FLKWATLEO-BRADFORD-1	2010	2019	37
	21FLCOT BRADFORD NORTH	2010	2020	31
CE	21FLCOT CASCADE AT CULV	2010	2016	17
	21FLCOT CASCADE AT CULVERT	2017	2019	9
	21FLLEONLCCA3042484355	2010	2019	28
CW	21FLCOT CASCADE AT BRAD	2010	2016	17
	21FLCOT CASCADE AT BRADFORD BROOK	2017	2019	9
HC	21FLLEONLCLH3041384350	2010	2019	31
	21FLCOT HIAWATHA	2010	2020	33



Cluster	Station	Start Date	End Date	Sample Count
BC	21FLKWATLEO-BRADFORD-2	2010	2019	58
	21FLKWATLEO-BRADFORD-3			
	21FLLEONLCLB3040584339			
BE	21FLCOT BRADFORD SOUTH	2010	2020	1
BW	21FLKWATLEO-BRADFORD-1	2010	2020	18
	21FLCOT BRADFORD NORTH			
CE	21FLCOT CASCADE AT CULV	2010	2019	12
	21FLCOT CASCADE AT CULVERT			
	21FLLEONLCCA3042484355			
CW	21FLCOT CASCADE AT BRAD	2010	2019	3
	21FLCOT CASCADE AT BRADFORD BROOK			
HC	21FLLEONLCLH3041384350	2010	2020	40
	21FLCOT HIAWATHA			



CITY OF
TALLAHASSEE

N



0 0.2
Miles



Legend

 Bradford Chain of Lakes Drainage Basin

 Waterbodies in Study

 Watercourses

TSI Average 2010-2020

TSI Score

 0-15

 15-30

 30-45

 45-60

 >60

Sources:

Waterbodies: COT, 2020

Watercourses: COT, 2020

Drainage Basins: COT, 2020

Roads: COT-Leon County, 2023

Station Data: FDEP, 2021

Figure 3-85:
Spatial Assessment of TSI in Bradford
Chain of Lakes

Tallahassee Master Plan - Surface
Water (TMaPS)

Geosyntec
consultants

Figure 3-86 presents a map of the *E. coli* levels. The data analyzed are from 2014 through 2020 and were analyzed to provide the 90th percentile to compare against the 410 MPN/100 mL criteria per the FDEP approach in the IWR analyses. The map shows that all stations have 90th percentile values well below the 410 MPN/100 mL threshold, with all stations below 100 MPN/100 mL (CW=2.2 MPN/100 mL, CE=5.2 MPN/100 mL, HC=2.9 MPN/100 mL, BW=15.9 MPN/100 mL, BC=5.6 MPN/100 mL, BE=12.3 MPN/100 mL). The data show stations closer to the shoreline within Lake Bradford have higher averages. This may be reflective of seepage from septic systems along the shoreline of the lake.

3.5.4.2 Stormwater Runoff

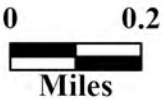
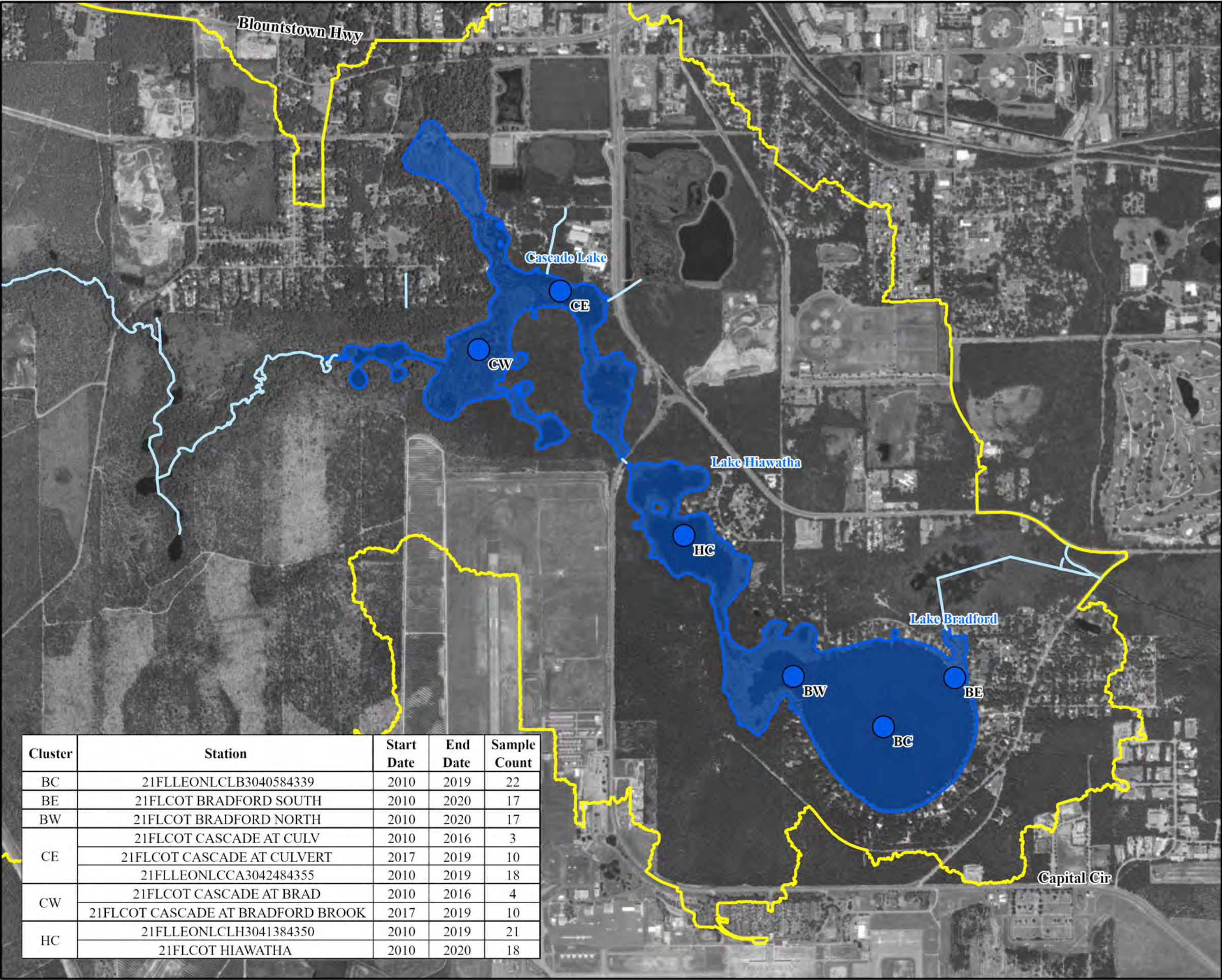
To assess stormwater runoff as a potential source of pollutant loads to the Bradford Chain of Lakes, LDI levels within the subbasins draining to the lake were assessed. In **Section 3.4.4.2**, LDI values were presented by subbasin in **Figure 3-34** for all of the Lake Munson basin. The basins draining directly to the lakes and the northern watershed draining to Bradford Brook were identified as good. The remainder of the watersheds draining to Bradford Brook were identified as excellent. These classifications indicate limited potential for anthropogenic stormwater loads to the lakes. This aspect, along with the relatively pristine nature of the water quality in the lakes relative to nutrient enrichment and bacteria, supports the determination that stormwater loads are not a significant source of anthropogenic load to the lakes.

While specific identification of potential sources of metal loads is not within the scope of this assessment, past studies indicate that potential sources of lead exist within the contributing basin. The identified sources are best mitigated by source removal versus construction of stormwater treatment facilities.

3.5.4.3 Septic Systems

Figure 3-50 presented the locations of septic systems within the Bradford Chain of Lakes basin. **Figure 3-35** presented a map showing the septic tank densities by subbasin for the full Lake Munson basin. Two of the watersheds draining to Bradford Brook show somewhat higher septic densities. These contain septic systems located within neighborhoods along Blountstown Highway (State Road 20) and just to the west of Cascade Lake. Based on the watershed area, septic densities are not high for the Lake Bradford watershed, but there are a significant number of septic systems immediately adjacent to the lake. The clusters in this area, and their proximity to the lake, can be seen in **Figure 3-50**.

Based on the bacteria data, it does not appear that septics are a significant source of bacteria load to Cascade Lake. By comparison, while bacteria levels within Lake Bradford were generally low, the analyses in **Section 3.5.4.1** indicated more elevated levels at clusters nearer to the shoreline versus the cluster in the lake center and suggest septics may be a potential source of bacteria load to Lake Bradford.



Legend

- Bradford Chain of Lakes Drainage Basin
- Waterbodies in Study
- Watercourses
- E. coli Percentile Average 2010-2020
MPN/100mL
 - 0-100
 - 100-200
 - 200-300
 - 300-410
 - >410

Sources:
Waterbodies: COT, 2020
Watercourses: COT, 2020
Drainage Basins: COT, 2020
Roads: COT-Leon County, 2023
Station Data: FDEP, 2021

Figure 3-86:
Spatial Assessment of E. coli in Bradford
Chain of Lakes

Tallahassee Master Plan - Surface
Water (TMaPS)



Cluster	Station	Start Date	End Date	Sample Count
BC	21FLLEONLCLB3040584339	2010	2019	22
BE	21FLCOT BRADFORD SOUTH	2010	2020	17
BW	21FLCOT BRADFORD NORTH	2010	2020	17
CE	21FLCOT CASCADE AT CULV	2010	2016	3
	21FLCOT CASCADE AT CULVERT	2017	2019	10
	21FLLEONLCCA3042484355	2010	2019	18
CW	21FLCOT CASCADE AT BRAD	2010	2016	4
	21FLCOT CASCADE AT BRADFORD BROOK	2017	2019	10
HC	21FLLEONLCLH3041384350	2010	2019	21
	21FLCOT HIAWATHA	2010	2020	18

3.5.4.4 Internal Recycling and Seepage

Internal Recycling

To date, no studies or data collection efforts have been undertaken to assess the potential for nutrient loading/recycling from sediments in the Bradford Chain of Lakes. Given the good water quality, healthy biological conditions, and the nature of the direct drainage areas to the lakes, internal loading is not identified as having a high potential as an anthropogenic source to any of the lakes. And since data to support calculation of the loads are not available for any of the lakes, loads are not quantified in **Section 3.5.5**.

Seepage

As outlined in **Section 3.5.3.7**, and presented in **Figure 3-23**, there was a surficial aquifer sampling site to the east of Lake Bradford. Station AAD5312 was located within the Lake Bradford Estates neighborhood. The only sample collected at this site was in June 2000 and did not show high levels of TN or TP. However, the data are insufficient to determine if seepage is a potential significant source to the lakes or to support calculation of potential seepage load from nearby groundwater. Septic systems were identified as a source to calculate (**Section 3.5.4.3**) and likely represent the primary potential source of seepage loads to the Chain of Lakes.

3.5.4.5 Wastewater

No direct wastewater discharges are currently within the Bradford Chain of Lakes basin. Additionally, no areas in the Bradford Chain of Lakes basin have reuse discharges. **Figure 3-39** presented a map of the Lake Munson basin boundaries in relation to sewer service areas. There is no sewer infrastructure in the watersheds draining to Bradford Brook. The wastewater service area is within the watersheds draining directly to Cascade Lake and Lake Hiawatha along the eastern side. Additionally, the wastewater service area is located within some portions of the watershed draining directly to Lake Bradford. The immediate area around Lake Bradford is not within the service area, hence the high density of septic systems discussed in **Section 3.5.3.4**. Based on the limited sewer service area, along with the existing water quality, wastewater infrastructure is not identified as a potential significant source of pollutant load to the Bradford Chain of Lakes.

3.5.4.6 Atmospheric Deposition

For the overall surface area (combined three lakes) of the Bradford Chain of Lakes, the ratio of the watershed area to lake area is around 35:1. With this ratio, and the potential attenuation of rainfall runoff, direct atmospheric deposition to the lakes may play a minor role in overall loading to the lakes. Atmospheric deposition will be quantified in **Section 3.5.5** for comparison to other loads. **Section 3.5.3.10** identified the nearest atmospheric deposition station as the Quincy station (FL14). The data from this station will be utilized to calculate the atmospheric deposition to the Bradford Chain of Lakes.

3.5.4.7 Interconnected Flows

Within the Bradford Chain of Lakes, Cascade Lake is the most upstream waterbody and discharges directly into Lake Hiawatha. Lake Hiawatha then flows into Lake Bradford. The

upstream lakes have the potential to contribute to nutrient loading and be a source to consider for the downstream lakes.

Cascade Lake has a surface area of about 109 acres and is located within an area that predominantly drains portions of the Apalachicola National Forest through Bradford Brook. Areas of low-density and medium-density residential drain to the lake from the north but these areas are small in relation to the overall basin. Water quality within the lake (**Section 3.5.3.6** and **Section 3.5.4.1**) was identified as pristine and was shown to be the best in the chain. As such, the flow from Cascade Lake to Lake Hiawatha is not a likely significant source of anthropogenic load.

Lake Hiawatha has a surface area of about 40 acres and is located downstream of Cascade Lake. As with Cascade Lake, areas of low-density and medium-density residential drain to Lake Hiawatha from the north, but these areas are small in relation to the overall basin. Water quality within the lake (**Section 3.5.3.6** and **Section 3.5.4.1**) is also identified as pristine and was shown to be of higher quality than conditions in Lake Bradford. As such, the flow from Lake Hiawatha to Lake Bradford is not a likely significant source of anthropogenic load.

3.5.4.8 Summary of Findings for Qualitative Assessment of Sources

At present, water quality and biological conditions in the Bradford Chain of Lakes are relatively pristine and are not exhibiting declining trends. The overall drainage basin to the lakes is mostly undeveloped and, therefore, stormwater runoff is not expected to be a significant source of pollutant loads. The only potentially significant source identified within the previous sections was septic loads to Lake Bradford, based on somewhat elevated bacteria levels nearshore in relation to the other lakes and the center station within Lake Bradford.

Though the sources do not appear significant, stormwater runoff, septic, interconnected flows (between lakes), and atmospheric deposition are quantified for comparative purposes as part of this study based on available data. Internal recycling, seepage, and wastewater do not appear to be significant sources and were not quantified as part of this study based on limited data.

3.5.5 Calculation of Potential Nutrient Loads

This section presents calculations of potential nutrient (TN and TP) loads to the Bradford Chain of Lakes for the sources identified for calculation in **Section 3.5.4.8**. These include stormwater runoff, septic systems, interconnected flow (between lakes), and atmospheric deposition. Where loads were not calculated, the following sections provide brief discussions. The load calculations are for the purpose of comparing the potential magnitudes of each source relative to one another.

3.5.5.1 Stormwater Pollutant Load

To calculate the stormwater TN and TP loads to the Bradford Chain of Lakes, average annual pollutant load modeling was performed. The goal was to identify outfalls that are contributing higher TN and TP loads relative to one another and to quantify the total TN and TP loads to the Bradford Chain of Lakes. TN and TP loads were calculated using the SIMPLE-Seasonal model. The model methodology was described in detail in **Section 3.4.5.1** for the stormwater loads to Lake Munson. The loads coming into the Bradford Chain of Lakes represent inflow from the

Apalachicola National Forest, with limited contribution from neighborhoods located along Highway 20 and neighborhoods immediately adjacent to the lakes. As such, anthropogenic sources are expected to be limited.

Figure 3-87 presents the subbasins and the DEM utilized in the SIMPLE model calculations for the Bradford Chain of Lakes. **Figure 3-88** presents the aggregated land use. The extent of the natural areas of the Apalachicola National Forest can be seen in the land use distribution, with over 70 percent of the land use being natural. Finally, **Figure 3-89** presents the CDAs for the Bradford Chain of Lakes stormwater loading to define total and per acre TN and TP loads, as well as the ranking of CDAs around the lakes.

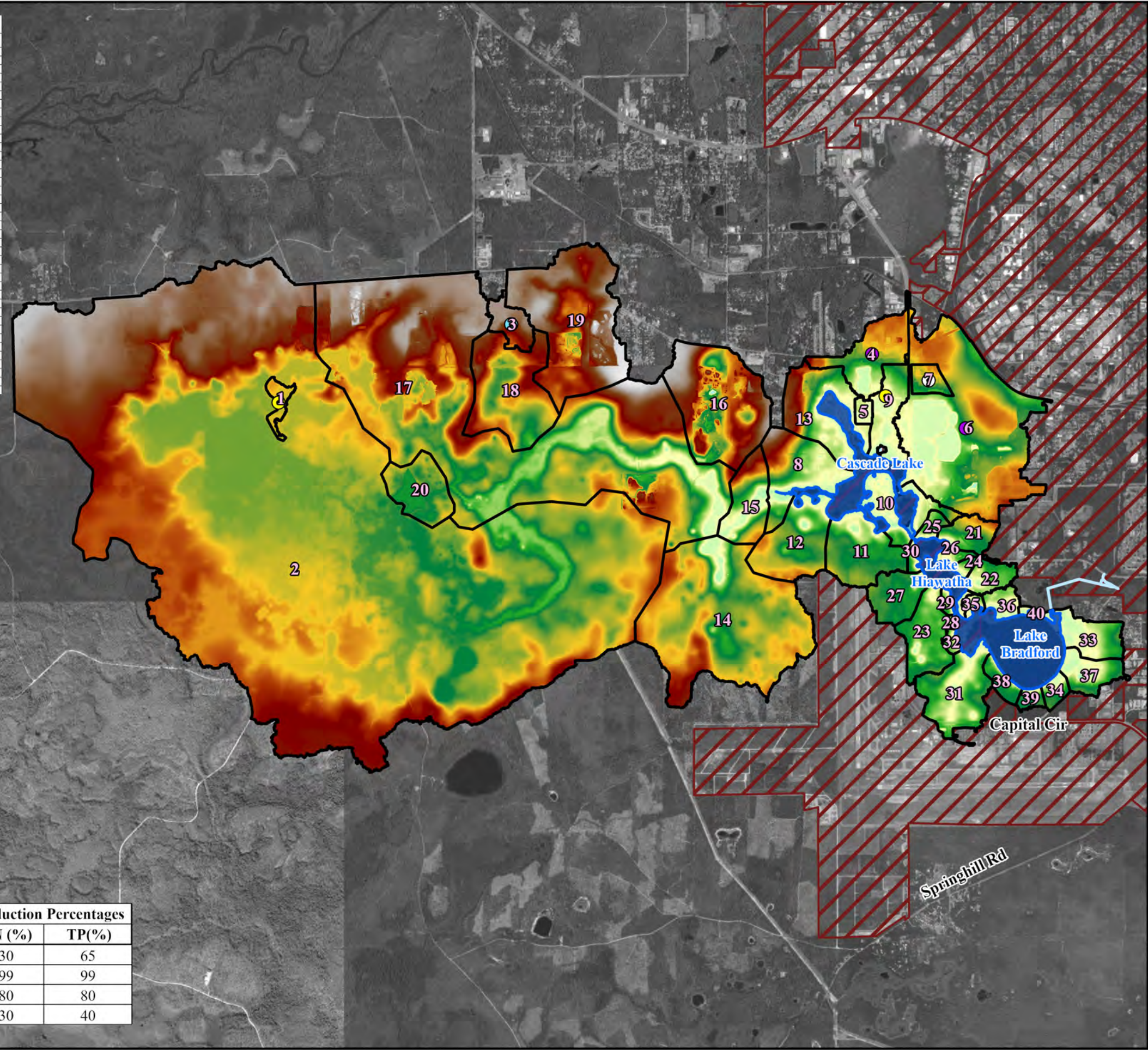
As a check on the modeled annual volumes from the SIMPLE model, the data from the flow station presented in **Section 3.5.3.5** were used to calculate measured annual volumes for years with sufficient data. The calculated annual volumes using the flow data ranged from around 3,400 acre-ft up to around 6,000 acre-ft. The annual volumes calculated at the station from the SIMPLE model were around 3,700 acre-ft. As such, the modeled annual volumes are reasonable.

Stormwater Nutrient Loads to the Bradford Chain of Lakes

Figure 3-90 presents the distribution of the ranking of the CDAs for TN along with the total load and per acre loads (see the table on **Figure 3-90**). The rankings are color coded, with the highest ranked CDAs in green moving down to the lowest ranked in pale yellow. The CDAs are color coded and ranked based on the individual waterbodies. The calculated total stormwater TN loads from the CDAs ranged from as low as 1.2 lb/yr up to 10,249 lb/yr. The per acre loads ranged from 0.1 lb/acre/yr up to 6.0 lb/acre/yr. The highest ranked CDAs for the TN loading are generally found south of the lakes associated with portions of the airport and higher density residential areas to the east of Lake Hiawatha. Other than some of the loads coming off the areas around the airport, the per acre loads are not high and generally reflect predominantly natural conditions. The calculated total TN loads to the lakes from stormwater runoff are 12,006 lb, 617 lb, and 340 lb for Cascade Lake, Lake Hiawatha, and Lake Bradford, respectively. The higher stormwater load to Cascade Lake is based on it receiving the runoff from the watershed to the west, along with local drainage. The Lake Bradford and Lake Hiawatha stormwater loads only reflect the local drainage. The additional load to Lake Bradford and Lake Hiawatha will be reflected in the interconnected loads in **Section 3.5.5.4**.

Figure 3-91 presents the distribution of the ranking of the CDAs for TP along with the total load and per acre loads (see the table on **Figure 3-91**). The calculated total stormwater TP loads from the CDAs ranged from as low as 0.2 lb/yr up to 2,428 lb/yr. The per acre loads ranged from less than 0.1 lb/acre/yr up to 0.9 lb/acre/yr. Similar to what was seen for TN, while the ranking would point to the CDA on the southeast side, overall, the low per acre loads would not indicate any as targets for load reduction. The calculated total TP loads to the lakes from stormwater runoff are 2,751 lb, 106 lb, and 74 lb for Cascade Lake, Lake Hiawatha, and Lake Bradford, respectively. As identified for the stormwater TN loads, the stormwater TP loads to Cascade Lake are based on the drainage from the full watershed, while the loads to Lake Hiawatha and Lake Bradford reflect local drainage. The loads to those lakes from the larger watershed will be reflected in the interconnected loads in **Section 3.5.5.4**.

Bradford Chain of Lakes Subbasin Summary			
Number	Basin Name	Acres	BMP
1	LMBCL0010	25.33	Wet Detention
2	LMBCL0020	5227.95	None
3	LMBCL0025	50.12	Dry Detention
4	LMBCL0030	123.52	Wet Retention
5	LMBCL0040	13.43	None
6	LMBCL0050	530.82	Wet Retention
7	LMBCL0055	29.92	Dry Retention
8	LMBCL0060	147.84	None
9	LMBCL0061	87.09	Wet Detention
10	LMBCL0062	92.23	None
11	LMBCL0063	134.66	None
12	LMBCL0065	149.33	None
13	LMBCL0070	158.79	None
14	LMBCL0080	609.13	None
15	LMBCL0090	103.13	None
16	LMBCL0100	296.18	None
17	LMBCL0110	1615.37	None
18	LMBCL0120	237.84	None
19	LMBCL0130	389.89	None
20	LMBCL0140	105.74	None
21	LMBLH0010	51.81151	None
22	LMBLH0020	40.12728	None
23	LMBLH0030	100.0694	None
24	LMBLH0040	10.14809	None
25	LMBLH0050	23.23904	None
26	LMBLH0060	13.656	None
27	LMBLH0070	74.79939	None
28	LMBLH0080	3.544313	None
29	LMBLH0090	8.519398	None
30	LMBLH0100	9.415099	None
31	LMBLH0010	140.2591	None
32	LMBLB0020	9.659549	None
33	LMBLB0030	71.72527	None
34	LMBLB0040	21.02926	None
35	LMBLB0050	10.9263	None
36	LMBLB0060	28.8303	None
37	LMBLB0070	60.45994	None
38	LMBLB0080	26.15986	None
39	LMBLB0090	15.32192	None
40	LMBLB0100	7.754142	None



Legend

Waterbodies in Study

Tallahassee Corporate Limits

Subbasins

Watercourses

BMP Type

- Dry Detention
- Dry Retention
- Wet Detention
- Wet Retention

Topographic Elevation
Ft. NAVD88

191

19

Sources:

Waterbodies: COT, 2020

Watercourses: COT, 2020

Subbasins: Geosyntec, 2023

Roads: COT-Leon County, 2023

City Limits: COT, 2020

BMPs: Geosyntec, 2023

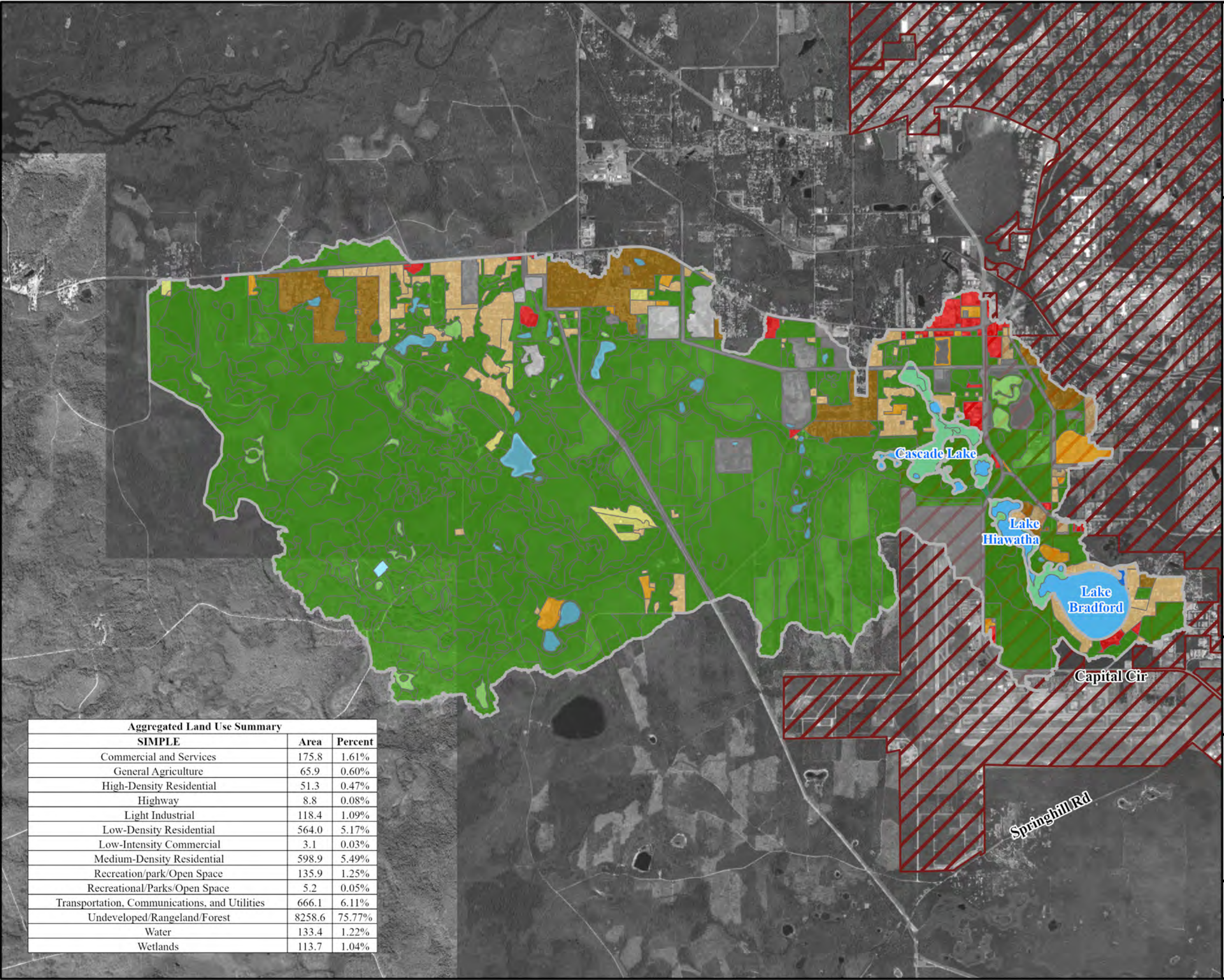
Elevation: COT-Leon County, 2018

Figure 3-87:
Bradford Chain of Lakes Subbasin
Delineation and BMPs

Tallahassee Master Plan - Surface
Water (TMaPS)



BMP Type	Reduction Percentages	
	TN (%)	TP(%)
Wet Detention	30	65
Dry Retention	99	99
Wet Retention	80	80
Dry Detention	30	40



Legend

- Waterbodies in Study
- Watercourses
- Tallahassee Corporate Limits
- Aggregated Land Use
- Land Use Type
 - Commercial and Services
 - General Agriculture
 - High-Density Residential
 - Light Industrial
 - Low-Density Residential
 - Medium-Density Residential
 - Recreation/park/Open Space
 - Transportation, Communications, and Utilities
 - Undeveloped/Rangeland/Forest
 - Water
 - Wetlands

Sources:
Waterbodies: COT, 2020
Watercourses: COT, 2020
Land Use: Geosyntec, 2023
Roads: COT-Leon County, 2023
City Limits: COT, 2020
Elevation: COT-Leon County, 2018

Aggregated Land Use Summary		
SIMPLE	Area	Percent
Commercial and Services	175.8	1.61%
General Agriculture	65.9	0.60%
High-Density Residential	51.3	0.47%
Highway	8.8	0.08%
Light Industrial	118.4	1.09%
Low-Density Residential	564.0	5.17%
Low-Intensity Commercial	3.1	0.03%
Medium-Density Residential	598.9	5.49%
Recreation/park/Open Space	135.9	1.25%
Recreational/Parks/Open Space	5.2	0.05%
Transportation, Communications, and Utilities	666.1	6.11%
Undeveloped/Rangeland/Forest	8258.6	75.77%
Water	133.4	1.22%
Wetlands	113.7	1.04%

Figure 3-88:
Bradford Chain of Lakes Aggregated Land Use

Tallahassee Master Plan - Surface Water (TMaPS)



A Concentrated Discharge Area (CDA) is identified as possessing concentrated flows that could facilitate potential water quality treatment projects.

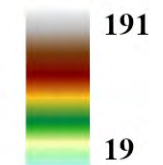


Legend

- Waterbodies in Study
- Concentrated Discharge Areas
- CDA Groupings by Waterbody
- Watercourses
- Tallahassee Corporate Limits

Topographic Elevations

ft NAVD88



Sources:
Waterbodies: COT, 2020
Watercourses: COT, 2020
CDAs: Geosyntec, 2023
Roads: COT-Leon County, 2023
City Limits: COT, 2020
Elevation: COT-Leon County, 2018

Figure 3-89:
Bradford Chain of Lakes Concentrated Discharge Areas

Tallahassee Master Plan - Surface Water (TMaPS)

Geosyntec
consultants

Lake Bradford		
Summary of Concentrated Discharge Areas		
Number	CDA ID	Acres
1	LMBLBOF01	140.3
2	LMBLBOF06	28.9
3	LMBLBOF05	10.9
4	LMBLBOF03	71.7
5	LMBLBOF07	60.5
6	LMBLBOF09	15.3
7	LMBLBOF08	26.2
8	LMBLBOF10	7.7
9	LMBLBOF04	21.0
10	LMBLBOF02	9.7

Cascade Lake		
Summary of Concentrated Discharge		
Number	CDA ID	Acres
1	LMBCLOF02	295.7
2	LMBCLOF01	610.7
3	LMBCLOF07	8,806.5
4	LMBCLOF05	134.7
5	LMBCLOF04	92.2
6	LMBCLOF03	87.1
7	LMBCLOF06	149.3

Lake Hiawatha		
Summary of Concentrated Discharge Areas		
Number	CDA ID	Acres
1	LMBLHOF03	100.1
2	LMBLHOF01	51.8
3	LMBLHOF04	10.1
4	LMBLHOF05	23.2
5	LMBLHOF06	13.7
6	LMBLHOF07	74.8
7	LMBLHOF08	3.5
8	LMBLHOF09	8.5
9	LMBLHOF10	9.4
10	LMBLHOF02	40.1

A Concentrated Discharge Area (CDA) is identified as possessing concentrated flows that could facilitate potential water quality treatment projects.



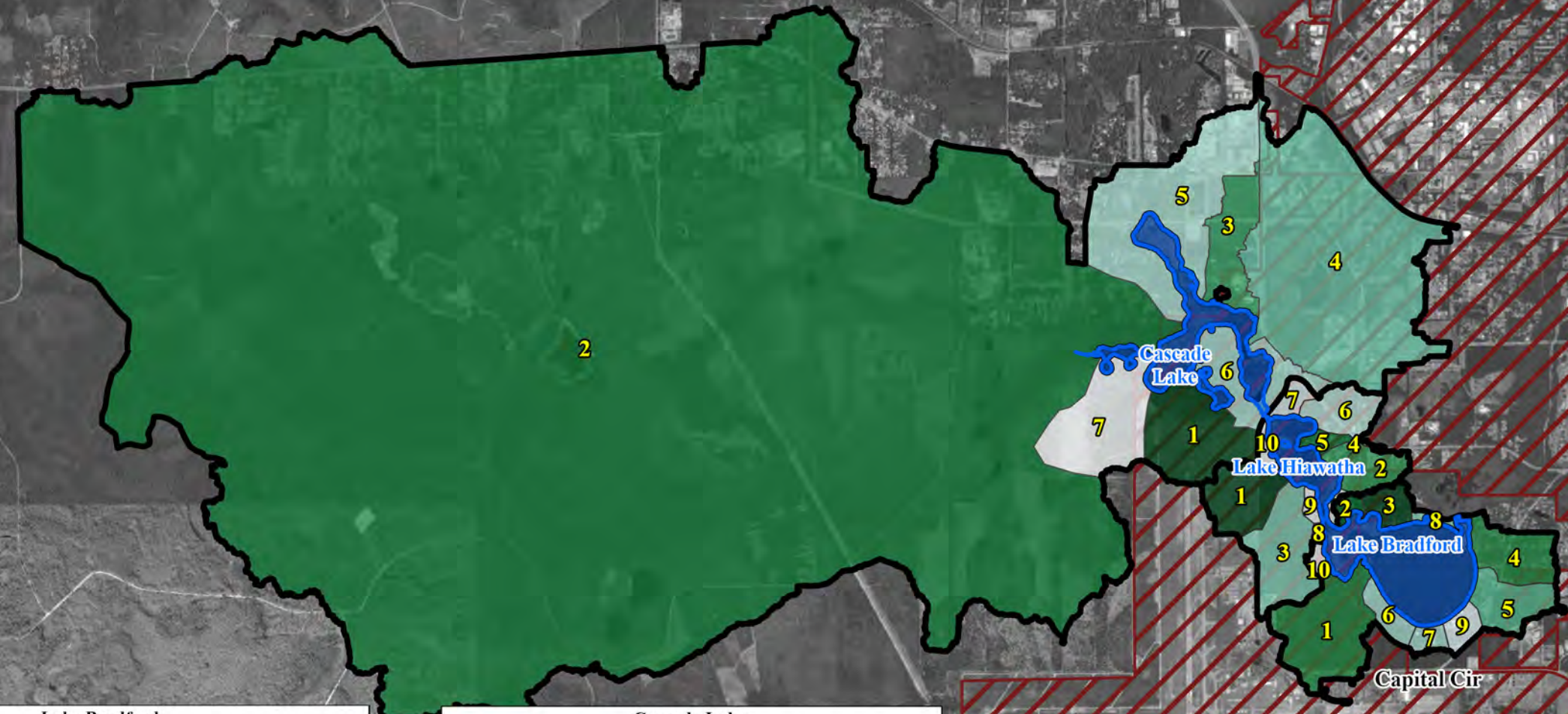
Legend

- Waterbodies
- Concentrated Discharge Areas
- Tallahassee Corporate Limits
- Ranking
 - High
 - Low

Sources:
Waterbodies: COT, 2020
Watercourses: COT, 2020
CDAs: Geosyntec, 2023
Roads: COT-Leon County, 2023
City Limits: COT, 2020
Elevation: COT-Leon County, 2018

Figure 3-90:
Bradford Chain of Lakes Concentrated
Discharge Areas-Total Nitrogen

Tallahassee Master Plan - Surface
Water (TMaPS)



Lake Bradford				
Summary of Concentrated Discharge Areas				
Number	CDA ID	Total Load (lbs-TN/yr)	Area Load (lbs-TN/ac/yr)	Ranking
1	LMBLBOF01	132.0	0.9	1
2	LMBLBOF05	19.9	1.8	2
3	LMBLBOF06	38.5	1.3	2
4	LMBLBOF03	59.7	0.8	4
5	LMBLBOF07	53.6	0.9	4
6	LMBLBOF08	13.7	0.5	6
7	LMBLBOF09	8.1	0.5	6
8	LMBLBOF10	5.4	0.7	8
9	LMBLBOF04	8.0	0.4	9
10	LMBLBOF02	1.3	0.1	10
Total Load:		340.1		

Cascade Lake				
Summary of Concentrated Discharge Areas				
Number	CDA ID	Total Load (lbs-TN/yr)	Area Load (lbs-TN/ac/yr)	Ranking
1	LMBCLOF05	806.67	6.0	1
2	LMBCLOF07	10249.80	1.2	2
3	LMBCLOF03	199.80	2.3	3
4	LMBCLOF01	364.68	0.6	4
5	LMBCLOF02	228.31	0.8	4
6	LMBCLOF04	130.41	1.4	4
7	LMBCLOF06	26.45	0.2	7
Total Load		12,006.12		

Lake Hiawatha				
Summary of Concentrated Discharge Areas				
Number	CDA ID	Total Load (lbs-TN/yr)	Area Load (lbs-TN/ac/yr)	Ranking
1	LMBLHOF07	379.0	5.1	1
2	LMBLHOF02	61.4	1.5	2
3	LMBLHOF03	68.3	0.7	2
4	LMBLHOF04	31.6	3.1	2
5	LMBLHOF06	37.7	2.8	2
6	LMBLHOF01	29.3	0.6	6
7	LMBLHOF05	6.6	0.3	7
8	LMBLHOF08	0.5	0.2	8
9	LMBLHOF09	1.2	0.1	8
10	LMBLHOF10	1.2	0.1	8
Total Load:		617.0		

A Concentrated Discharge Area (CDA) is identified as possessing concentrated flows that could facilitate potential water quality treatment projects.



Legend

- Waterbodies
- Concentrated Discharge Areas
- Tallahassee Corporate Limits
- Ranking**
 - High
 - Low

Sources:
Waterbodies: COT, 2020
Watercourses: COT, 2020
CDAs: Geosyntec, 2023
Roads: COT-Leon County, 2023
City Limits: COT, 2020
Elevation: COT-Leon County, 2018

Figure 3-91:
Bradford Chain of Lakes Concentrated
Discharge Areas-Total Phosphorus

Tallahassee Master Plan - Surface
Water (TMaPS)



Lake Bradford				
Summary of Concentrated Discharge Areas				
Number	CDA ID	Total Load (lbs-TP/yr)	Area Load (lbs-TP/ac/yr)	Ranking
1	LMBLBOF06	16.6	0.6	1
2	LMBLBOF05	9.3	0.9	2
3	LMBLBOF01	18.3	0.1	3
4	LMBLBOF03	14.3	0.2	3
5	LMBLBOF07	7.9	0.1	5
6	LMBLBOF10	1.2	0.2	6
7	LMBLBOF08	3.0	0.1	7
8	LMBLBOF09	1.8	0.1	7
9	LMBLBOF04	1.6	0.1	9
10	LMBLBOF02	0.2	0.0	10
Total Load:		74.3		

Cascade Lake				
Summary of Concentrated Discharge Areas				
Number	CDA ID	Total Load (lbs-TP/yr)	Area Load (lbs-TP/ac/yr)	Ranking
1	LMBCLOF05	110.8	0.8	1
2	LMBCLOF07	2427.6	0.3	2
3	LMBCLOF03	37.7	0.4	3
4	LMBCLOF01	100.1	0.2	4
5	LMBCLOF02	48.1	0.2	5
6	LMBCLOF04	22.9	0.2	5
7	LMBCLOF06	3.7	0.0	7
Total Load		2,750.83		

Lake Hiawatha				
Summary of Concentrated Discharge Areas				
Number	CDA ID	Total Load (lbs-TP/yr)	Area Load (lbs-TP/ac/yr)	Ranking
1	LMBLHOF07	50.9	0.7	1
2	LMBLHOF06	10.0	0.7	2
3	LMBLHOF02	17.6	0.4	3
4	LMBLHOF04	8.6	0.8	3
5	LMBLHOF03	9.6	0.1	5
6	LMBLHOF01	6.2	0.1	6
7	LMBLHOF05	2.1	0.1	7
8	LMBLHOF08	0.1	0.0	8
9	LMBLHOF09	0.2	0.0	8
10	LMBLHOF10	0.2	0.0	8
Total Load		105.5		

3.5.5.2 Septic Load

To analyze the potential impacts from septic tank units to the Bradford Chain of Lakes, the SPIL method adopted by FDEP was utilized to quantify the potential septic load. The approach and calculations were described in **Section 3.4.5.2**, which presented the septic loading to Lake Munson. As outlined earlier, the calculations were only done for nitrogen (TN), and based on literature on transport and assimilation, may represent a conservative potential load.

An estimated 100 septic tank units were identified within 200 meters of the three lakes within the chain and associated upstream tributaries, with the majority (67) around Lake Bradford. **Figure 3-92** shows the septic systems utilized in this analysis, with green representing those associated with direct loading to the waterbody and pink representing those associated with loading to tributaries. A table provided on the figure summarizes the calculated TN load from septic units to each of the lakes.

For Cascade Lake, there were a number of systems upstream along Bradford Brook and its tributaries. This accounted for a potential load of 411 lb/yr. The potential load from systems within 200 meters of Cascade Lake was 281 lb/yr. Based on the soil characteristics (highly drained) within the watershed upstream of Cascade Lake and the travel distance for the largest cluster along the tributary, the potential load from the septic along the tributaries is likely overestimated. For Lake Hiawatha, there were only seven systems within 200 meters of the lake, and no systems along tributaries that drain directly to Lake Hiawatha. The potential load was then calculated at 76 lb/yr. Lake Bradford had a significant number of septic systems in the immediate vicinity of the lake shoreline. The calculated potential load from the systems was 725 lb/yr.

3.5.5.3 Point Source Load

No active point sources were identified within the Bradford Chain of Lakes upstream of Lake Bradford. Therefore, the point source loads for TN and TP are set to 0 lb/yr for the Bradford Chain of Lakes.

3.5.5.4 Lake Inflow Load

As discussed in **Section 3.5.4.7** each of the upstream lakes (Cascade Lake and Lake Hiawatha) flow to downstream receiving lakes (Lake Hiawatha and Lake Bradford) and represents load to the downstream lake. **Figure 3-93** presents the upstream and downstream connections. The determination was made in the qualitative assessment that, based on the good water quality in each of the upstream lakes, these would not represent significant sources of anthropogenic load to the downstream lakes.

Calculations of the load are provided herein based on the availability of modeled flows and in-lake concentrations. The approach utilized in the calculation of the inter-lake loading was described in **Section 3.4.5.4** for Lake Munson. The lakes and connections are shown in **Figure 3-93**, along with a table summarizing available water quality data, flow, load calculations and impairment status. These loads represent the surface runoff and baseflow load to the lower lakes, accounting for the changes in in-lake concentrations as the water passes through.

Location points of septic systems are digital estimations from related parcel locations and not meant to depict accuracy of unit location within the property

Only septic systems within 200 meters of the waterbody or its tributaries were selected and shown on this map as they are the source of the calculated nutrient loads, the remainder of septic units that were not selected are not shown on this map



Legend

- Bradford Chain of Lakes Drainage Basin
- Waterbodies in Study
- Watercourses
- Major Roads
- Tallahassee Corporate Limits
- Relevant Septic Sites
 - Lake
 - Tributaries

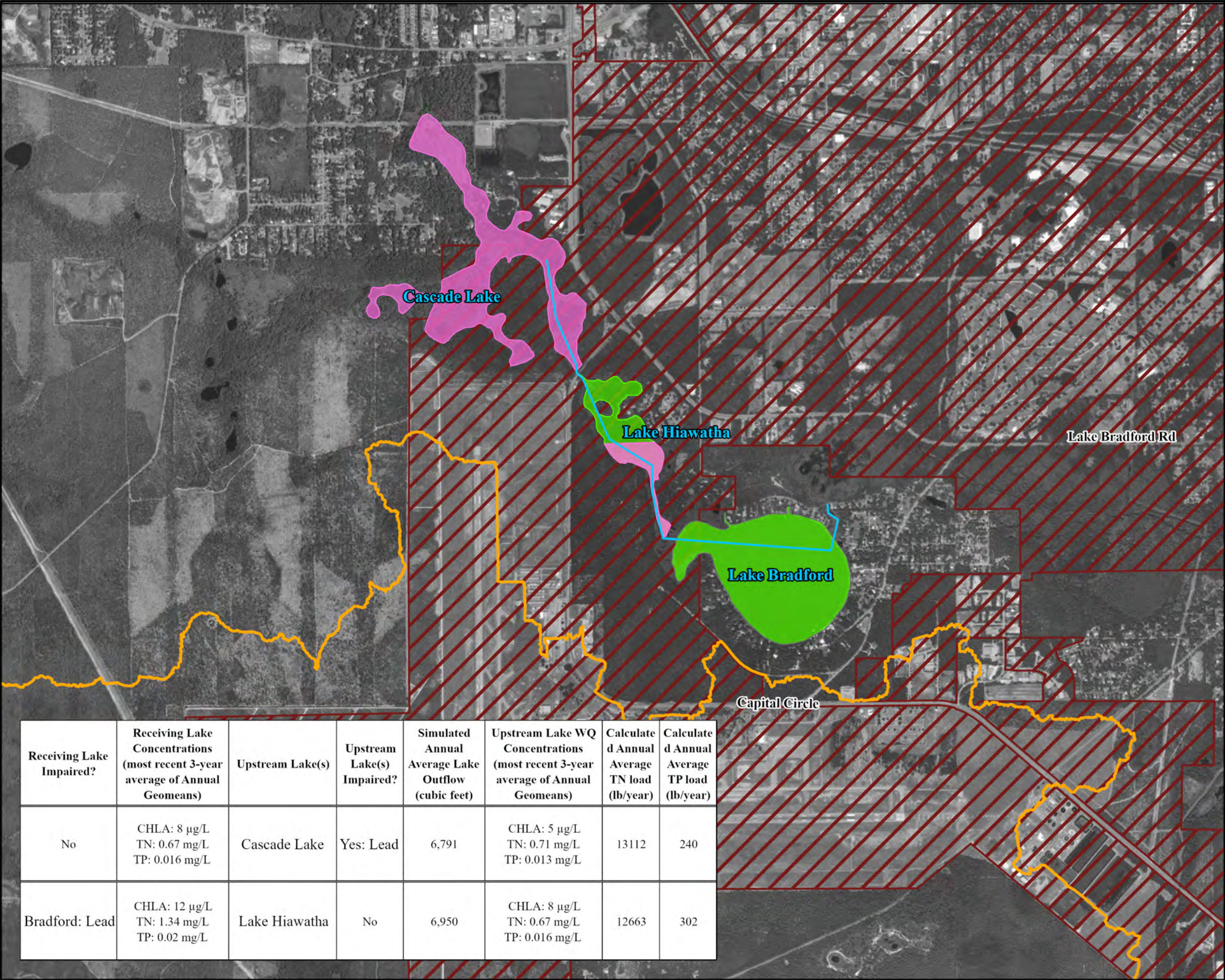
Sources:
Waterbodies: COT, 2020
Watercourses: COT, 2020
Septic Systems: COT, 2020
Watershed: COT, 2020
Roads: COT-Leon County, 2023

Figure 3-92:
Septic Loading to Bradford Chain of Lakes

Tallahassee Master Plan - Surface Water (TMaPS)



Summary of Nutrient Loading from Septic			
Waterbody	Loading Direct to Lake (lbs/yr)	Loading From Tributaries (lbs/yr)	Load (lbs/yr)
Cascade Lake	281	411	692
Waterbody	Loading Direct to Lake (lbs/yr)	Loading From Tributaries (lbs/yr)	Load (lbs/yr)
Lake Hiawatha	76	0	76
Waterbody	Loading Direct to Lake (lbs/yr)	Loading From Tributaries (lbs/yr)	Load (lbs/yr)
Lake Bradford	725	0	725



Legend

- Receiving Lakes
- Inflowing Lakes
- Flowlines
- Tallahassee Corporate Limits

Sources:
Waterbodies: COT, 2020
Flowlines: USGS, 2020
Watershed: COT, 2020
Roads: COT-Leon County, 2023
City Limits: COT, 2020

Figure 3-93:
Inflow Loading to Bradford Chain of Lakes

Tallahassee Master Plan - Surface
Water (TMaPS)



Receiving Lake Impaired?	Receiving Lake Concentrations (most recent 3-year average of Annual Geomeans)	Upstream Lake(s)	Upstream Lake(s) Impaired?	Simulated Annual Average Lake Outflow (cubic feet)	Upstream Lake WQ Concentrations (most recent 3-year average of Annual Geomeans)	Calculate d Annual Average TN load (lb/year)	Calculate d Annual Average TP load (lb/year)
No	CHLA: 8 µg/L TN: 0.67 mg/L TP: 0.016 mg/L	Cascade Lake	Yes: Lead	6,791	CHLA: 5 µg/L TN: 0.71 mg/L TP: 0.013 mg/L	13112	240
Bradford: Lead	CHLA: 12 µg/L TN: 1.34 mg/L TP: 0.02 mg/L	Lake Hiawatha	No	6,950	CHLA: 8 µg/L TN: 0.67 mg/L TP: 0.016 mg/L	12663	302

The calculated TN and TP loads from Cascade Lake to Lake Hiawatha were 13,112 lb/year and 240 lb/year, respectively. The calculated TN and TP loads from Lake Hiawatha to Lake Bradford were 12,663 lb/year and 302 lb/year, respectively.

3.5.5.5 Internal Lake Load

In the qualitative assessment of potential pollutant loads to the Bradford Chain of Lakes (see **Section 3.5.4.4**), an assessment was made relative to the potential for anthropogenically driven internal loading to play a significant role in the nutrient budget. The assessment determined that, given the water quality, healthy biological conditions, and nature of the direct drainage areas to the lakes, internal loading was not likely to have a high potential for loading to the lakes.

3.5.5.6 Atmospheric Deposition

As presented and discussed in **Section 3.4.5.6** the annual average atmospheric TN load per acre was calculated from the Quincy NADP station (FL14) at 2.56 lb/acre/year. Multiplying this by the acreage for each of the lakes within the Bradford Chain gives total TN loads for each. No data are available for TP, therefore, only the nitrogen load is provided. Cascade Lake has a surface area of 109 acres and a calculated TN load of 279 lb/yr. Lake Hiawatha has a surface area of 40 acres and a calculated TN load of 102 lb/yr. Lake Bradford has a surface area of 149 acres and a calculated TN load of 381 lb/yr.

3.5.5.7 Summary of Calculated Loads

Nutrient loads to each of the lakes within the Bradford Chain were calculated for stormwater runoff, septic systems, lake inflow, and atmospheric deposition. **Table 3-17** presents the calculated total loads to the lake for TN and TP. For septic systems and atmospheric deposition, only TN loads were calculated (see **Section 3.5.5.2** and **Section 3.5.5.6**, respectively, for explanation).

Table 3-17: Summary of Calculated Loads to the Bradford Chain of Lakes

Source	Lake Bradford		Lake Hiawatha		Cascade Lake	
	TN (lb/yr)	TP (lb/yr)	TN (lb/yr)	TP (lb/yr)	TN (lb/yr)	TP (lb/yr)
Stormwater Runoff	340	74	617	105	12,006	2,751
Septic Systems	725	ND	76	ND	692	ND
Lake Inflow	12,646	302	13,095	240	NA	NA
Atmospheric Deposition	381	ND	102	ND	279	ND

ND – No data available to calculate, NA – Load calculation not applicable

3.6 Silver Lake/East Drainage Ditch

This section presents the results from Tasks 1 through 3 for the Silver Lake/East Drainage Ditch basin. This includes an overview and history of the lake and basin, present impairment status, an overview of available data, a qualitative assessment of potential pollutant sources, and calculation of potential pollutant loads.

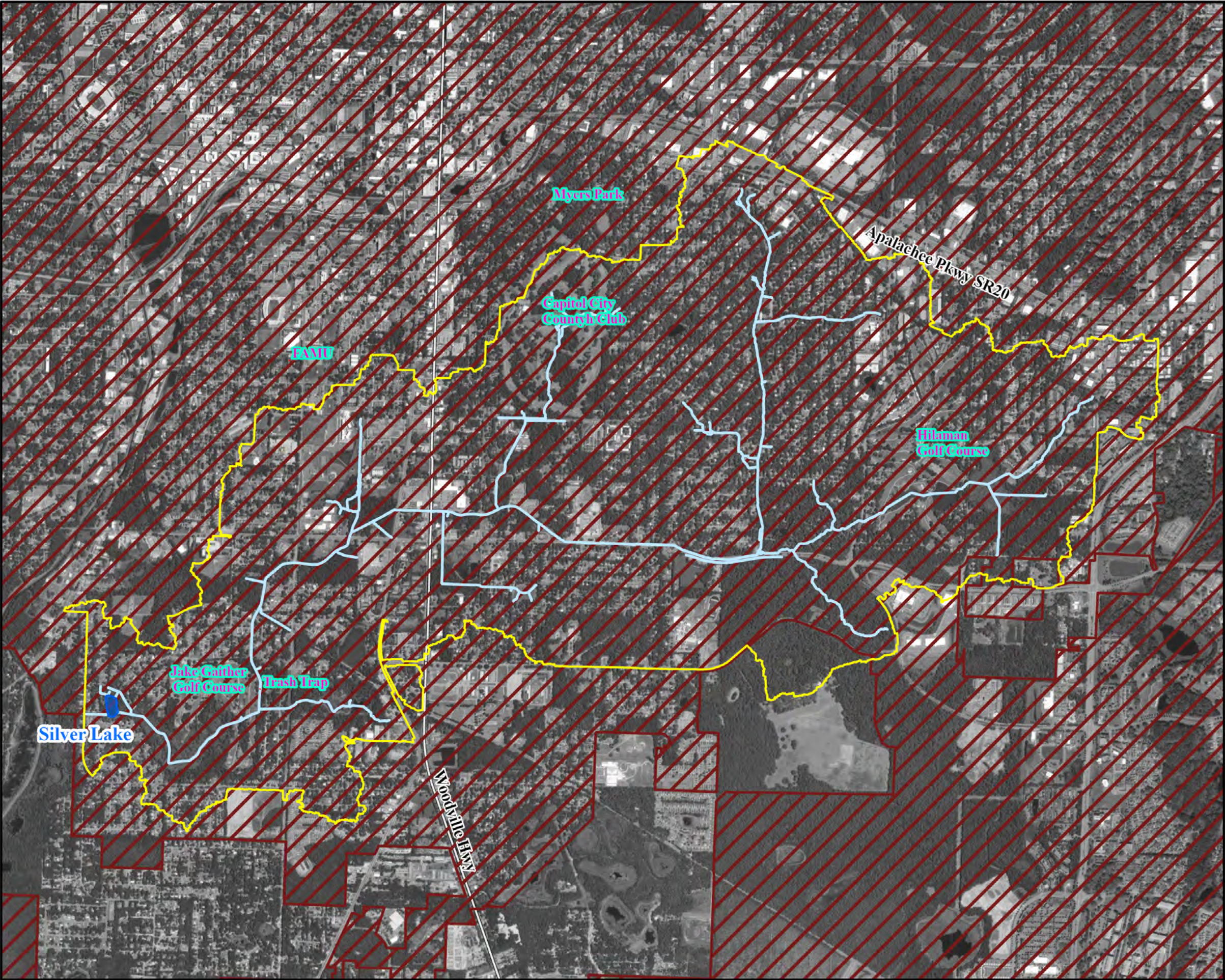
3.6.1 Overview and History

Silver Lake is a 2.1-acre open water area located at the downstream end of the East Drainage Ditch (**Figure 3-94**). The Silver Lake/East Drainage Ditch basin includes two watersheds, the Hydrangea watershed and the Indian Head watershed (**Exhibit 3-1**). The drainage basin is approximately 3,800 acres and is bordered by Apalachee Parkway along the northeast, Capital Circle SE on the east, and Paul Russell Road along portions of the southern side. Key areas that drain into the East Drainage Ditch and ultimately through Silver Lake include portions of Florida Agricultural and Mechanical (A&M) University (FAMU), highly urbanized areas along South Monroe and Orange Avenue, portions of the Myers Park neighborhood along Magnolia, and multiple other high-density and medium-density neighborhoods. There are three golf courses within the Silver Lake/East Drainage Ditch basin: the Jake Gaither Golf Course, the Capital City Country Club, and the Hilaman Golf Course. Outflows from Silver Lake flow under North Ridge Road and into the Lake Henrietta SWMF upstream of Lake Munson under baseflow conditions and for smaller storm events. Water from the basin will bypass the Lake Henrietta SWMF for larger storm events, discharging directly to Munson Slough and then Lake Munson.

Photo 3-37 through **Photo 3-44** present aerial views of Silver Lake from 1937 through 2020. The earlier aerial photos show that historically, Silver Lake consisted of two connected waterbodies (**Photo 3-37** and **Photo 3-38**), with the eastern waterbody susceptible to being at times dry and with the more permanent pool located at what is known as Silver Lake today. Ditching upstream continued through the years and altered the nature of the upstream areas.

Silver Lake sits between neighborhoods off North Ridge Road. **Photo 3-45** presents a photo of the lake taken in 2021 from the dock within Silver Lake Park, which is a City park. **Photo 3-46** shows the outflow canal from the lake that drains under North Ridge Road and into Munson Slough, also taken from the dock. **Photo 3-47** shows the discharge canal taken just upstream from the crossing of North Ridge Road. Immediately upstream of Silver Lake are wetlands through which the East Drainage Ditch flows. These wetlands are bordered to the north by the Jack Gaither Golf Course. Historical issues with trash coming down the East Drainage Ditch led to the construction of a trash trap just upstream of the adjacent wetland areas (**Figure 3-94**). **Photo 3-48** shows a picture of the trash trap taken in 2021. It is noted that at the time of this study, improvements to the trap are under design.

The East Drainage Ditch is primarily a heavily vegetated ditch with natural slopes along the reaches upstream of the crossing at South Monroe Street. **Photo 3-49** shows a portion of the ditch where it crosses Texas Street, exemplifying the typical vegetation density and side slopes. **Photo 3-50** shows a portion of the ditch just upstream of the crossing of South Monroe Street, showing bank erosion and some slope failure. In the downstream sections of the ditch, stabilization projects have been completed along portions of the ditch. **Photo 3-51** shows an area where gabion baskets and reno mattresses were installed to reduce erosion.



Legend

- Silver Lake Drainage Basin
- Silver Lake
- Watercourses
- Major Roads
- Tallahassee Corporate Limits

Sources:
Waterbodies: COT, 2020
Watercourses: COT, 2020
Roads: COT-Leon County, 2023
City Limits, COT, 2022

Figure 3-94:
Silver Lake/East Drainage Ditch Basin
Overview Map

Tallahassee Master Plan - Surface
Water (TMaPS)





Photo 3-37: Silver Lake Aerial (1937)



Photo 3-38: Silver Lake Aerial (1949)



Photo 3-39: Silver Lake Aerial (1954)



Photo 3-40: Silver Lake Aerial (1970)



Photo 3-41: Silver Lake Aerial (1983)



Photo 3-42: Silver Lake Aerial (1996)



Photo 3-43: Silver Lake Aerial (2007)



Photo 3-44: Silver Lake Aerial (2020)



Photo 3-45: Photo of Silver Lake from the Public Dock in Silver Lake Park (2021)



Photo 3-46: Photo of Outflow Canal on Silver Lake from the Public Dock (2021)



Photo 3-47: Photo of Silver Lake Outflow Canal Immediately Upstream of North Ridge Road (2021)



Photo 3-48: Photo of Trash Trap on East Ditch Upstream of Silver Lake (2021)



Photo 3-49: Photo of East Ditch at Texas Street Crossing (2023)



**Photo 3-50: Photo of Erosion Along East Ditch Upstream of Crossing of South Monroe Street
(2023)**



Photo 3-51: Photo of Bank Stabilization along East Ditch West of South Adams Street (2021)

3.6.2 Regulatory Status

Exhibit 3-2 presented the verified impaired waters within the overall Lake Munson basin. The open water area of Silver Lake presently is not classified as a lake in the IWR database, but rather it is assessed as part of the East Drainage Ditch WBID (916) as a part of the stream segment. The City collects and has collected data within the open water area as well as upstream and downstream within the ditched areas. WBID 916 is classified as a stream segment by FDEP, so the applicable criteria for assessment for data collected within the WBID are the stream criteria. This includes the Panhandle East NNC thresholds and other stream criteria.

At present, WBID 916 is verified impaired for fecal coliform. However, fecal coliform is no longer the applicable bacteria parameter for its waterbody classification. *E. coli* is utilized as the assessment parameter for bacteria impairment. Presently, there is insufficient data in the IWR database to assess against *E. coli*. The fecal coliform impairment will remain on the Verified List until such time as the WBID can be assessed against *E. coli*.

Section 3.6.3.6 presents plots of the data from the WBID against the stream NNC and *E. coli* thresholds, including data from the open water areas of Silver Lake and the upstream and downstream stations. This is consistent with the present FDEP classification for the waterbodies.

3.6.3 Waterbody Data Review and Summary

This section presents an overview of available data and data sources for Silver Lake and the East Drainage Ditch basin, including bathymetry, land use, soils, septic systems, hydrologic measurements, surface water quality, groundwater quality, biological, stormwater treatment facilities, and atmospheric deposition.

3.6.3.1 Bathymetry

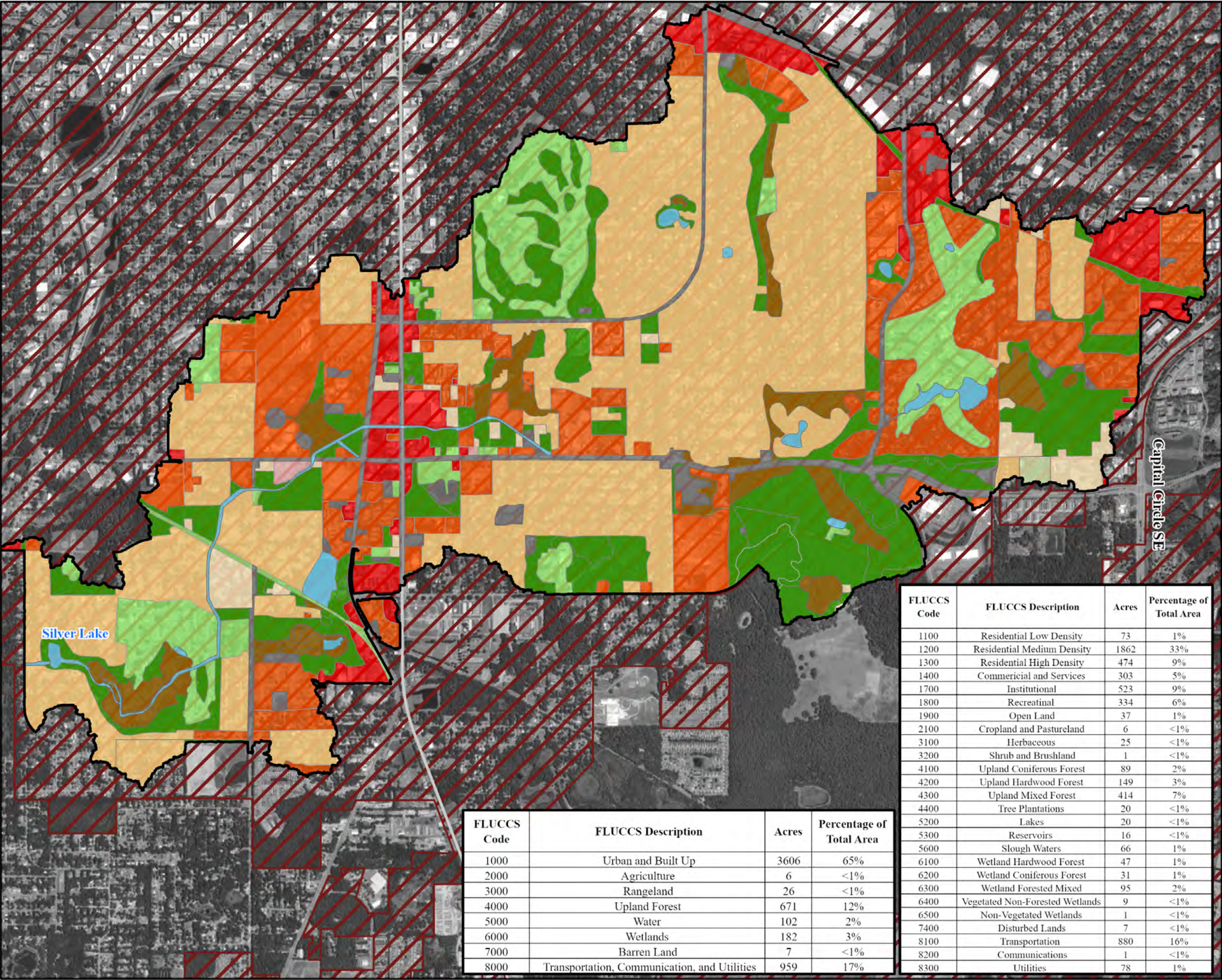
No bathymetric data were available for the open water areas of Silver Lake.

3.6.3.2 Land Use

Figure 3-95 presents a map of the Level 2 land uses within the Silver Lake/East Drainage Ditch basin. A table is provided to show the overall acreages and percent cover for the various levels. Tables are provided for both the Level 2 and grouped Level 1 land uses. The largest land use type by far within the basin per the grouped Level 1 categories is Urban and Built Up (65 percent), with the next highest being Transportation, Communications and Utilities at 17 percent. Within the Urban and Built Up Level 1, the largest use is medium-density residential at 33 percent. Within the Level 1 Transportation, Communications, and Utilities, nearly all is under Transportation.

3.6.3.3 Soils

The two most prevalent soil groups in the Silver Lake/East Drainage Ditch basin are Group C (33 percent) and Group B (31 percent) (**Figure 3-96**). Group B soils are considered to have a moderate rate of infiltration while Group C soils are considered to have a low rate of infiltration. These types of soils are located throughout the eastern portions of the basin. Soils near the wetlands just upstream of Silver Lake are predominantly Group A/D (26 percent). These are considered to have good infiltration potential, but due to elevated water table conditions, will act more similarly to soils with low infiltration potential.



Legend

- Silver Lake Drainage Basin
- Tallahassee Corporate Limits
- Landuse
 - 1100: Residential Low Density
 - 1200: Residential Medium Density
 - 1300: Residential High Density
 - 1400: Commercial and Services
 - 1700: Institutional
 - 1800: Recreational
 - 1900: Open Land
 - 2100: Cropland and Pastureland
 - 3100: Herbaceous
 - 3200: Shrub and Brushland
 - 4100: Upland Coniferous Forests
 - 4200: Upland Hardwood Forests
 - 4300: Upland Mixed Forests
 - 4400: Tree Plantations
 - 5200: Lakes
 - 5300: Reservoirs
 - 5600: Slough Waters
 - 6100: Wetland Hardwood Forest
 - 6200: Wetland Coniferous Forest
 - 6300: Wetland Forested Mixed
 - 6400: Vegetated Non-Forested Wetlands
 - 6500: Non-Vegetated Wetlands
 - 7400: Disturbed Lands
 - 8100: Transportation
 - 8200: Communications
 - 8300: Utilities

Sources:
Waterbodies: COT, 2020
Watersheds: COT, 2020
Roads: FDOT, 2020
Land Use: NWFWM, 2019
City Limits: COT, 2022

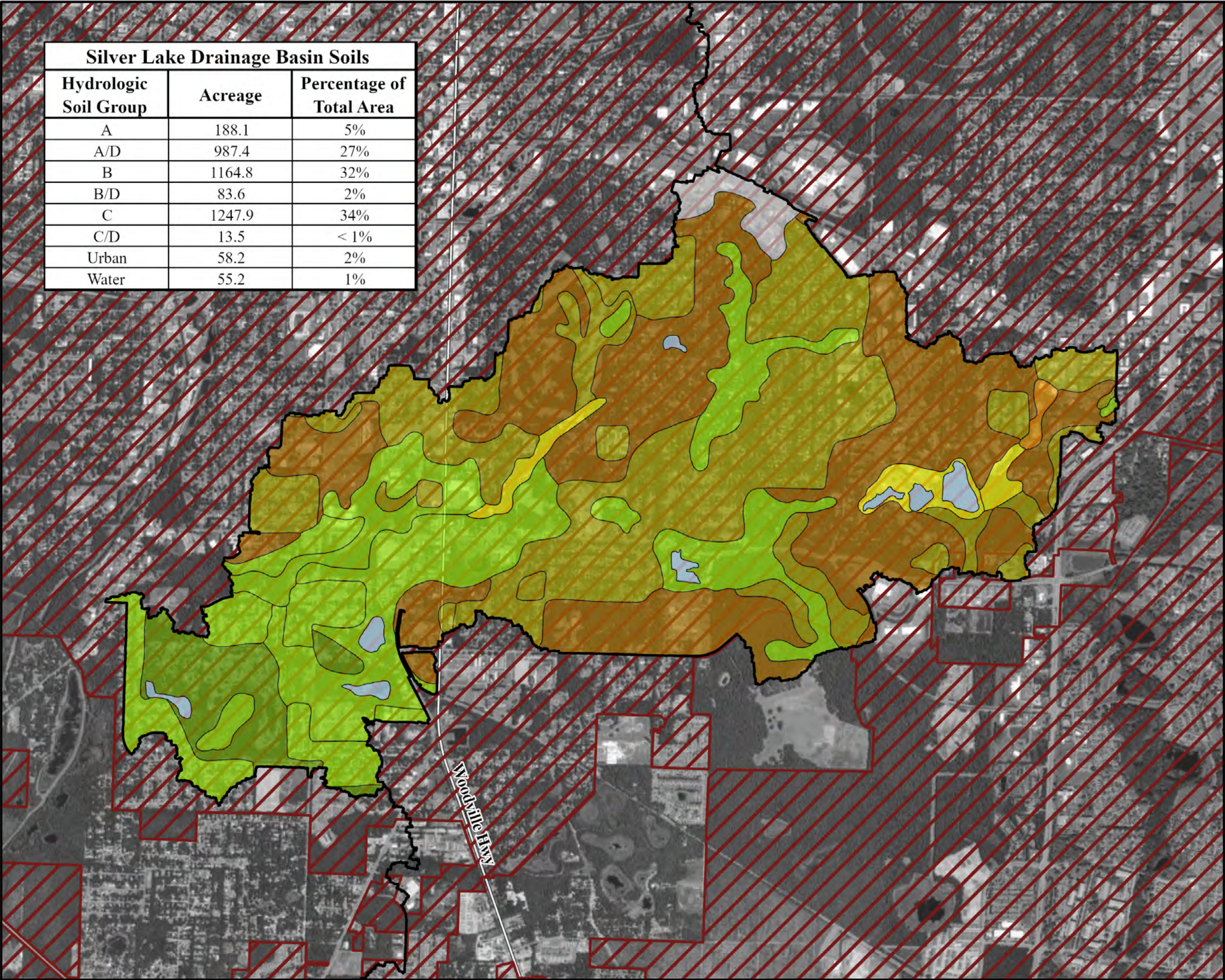
Figure 3-95:
Silver Lake/East Drainage Ditch Basin
Land Use Map

Tallahassee Master Plan - Surface
Water (TMaPS)



FLUCCS Code	FLUCCS Description	Acres	Percentage of Total Area
1000	Urban and Built Up	3606	65%
2000	Agriculture	6	<1%
3000	Rangeland	26	<1%
4000	Upland Forest	671	12%
5000	Water	102	2%
6000	Wetlands	182	3%
7000	Barren Land	7	<1%
8000	Transportation, Communication, and Utilities	959	17%

FLUCCS Code	FLUCCS Description	Acres	Percentage of Total Area
1100	Residential Low Density	73	1%
1200	Residential Medium Density	1862	33%
1300	Residential High Density	474	9%
1400	Commercial and Services	303	5%
1700	Institutional	523	9%
1800	Recreational	334	6%
1900	Open Land	37	1%
2100	Cropland and Pastureland	6	<1%
3100	Herbaceous	25	<1%
3200	Shrub and Brushland	1	<1%
4100	Upland Coniferous Forest	89	2%
4200	Upland Hardwood Forest	149	3%
4300	Upland Mixed Forest	414	7%
4400	Tree Plantations	20	<1%
5200	Lakes	20	<1%
5300	Reservoirs	16	<1%
5600	Slough Waters	66	1%
6100	Wetland Hardwood Forest	47	1%
6200	Wetland Coniferous Forest	31	1%
6300	Wetland Forested Mixed	95	2%
6400	Vegetated Non-Forested Wetlands	9	<1%
6500	Non-Vegetated Wetlands	1	<1%
7400	Disturbed Lands	7	<1%
8100	Transportation	880	16%
8200	Communications	1	<1%
8300	Utilities	78	1%



Silver Lake Drainage Basin Soils		
Hydrologic Soil Group	Acreage	Percentage of Total Area
A	188.1	5%
A/D	987.4	27%
B	1164.8	32%
B/D	83.6	2%
C	1247.9	34%
C/D	13.5	< 1%
Urban	58.2	2%
Water	55.2	1%



CITY OF
TALLAHASSEE



0 0.4



Miles

Legend

- Silver Lake Drainage Basin
- Tallahassee Corporate Limits
- Hydrologic Soil Group
 - A
 - A/D
 - B
 - B/D
 - C
 - C/D
- Urban land
- Water

Sources:
Waterbodies: COT, 2020
Watercourses: COT, 2020
Roads: COT-Leon County, 2023
City Limits, COT, 2020
Soils: NRCS, 2020

Figure 3-96
Silver Lake/East Drainage Ditch Basin Soils
Map

Tallahassee Master Plan - Surface
Water (TMaPS)

3.6.3.4 Septic Systems

An estimated 119 septic tank units are within the boundaries of the Silver Lake/East Drainage Ditch basin, based on the FDOH septic tank layer (**Figure 3-97**). The septic tanks are located in small, sparse clusters all around the basin.

Effluent from septic tanks that are in good condition should be comparable to secondarily treated wastewater effluent from sewage treatment plants. However, septic systems can be a source of pollutants, pathogens, and nutrients and are identified by FDEP as a potential source of bacteria and nutrients to waterbodies in its assessment processes.

3.6.3.5 Hydrologic Data

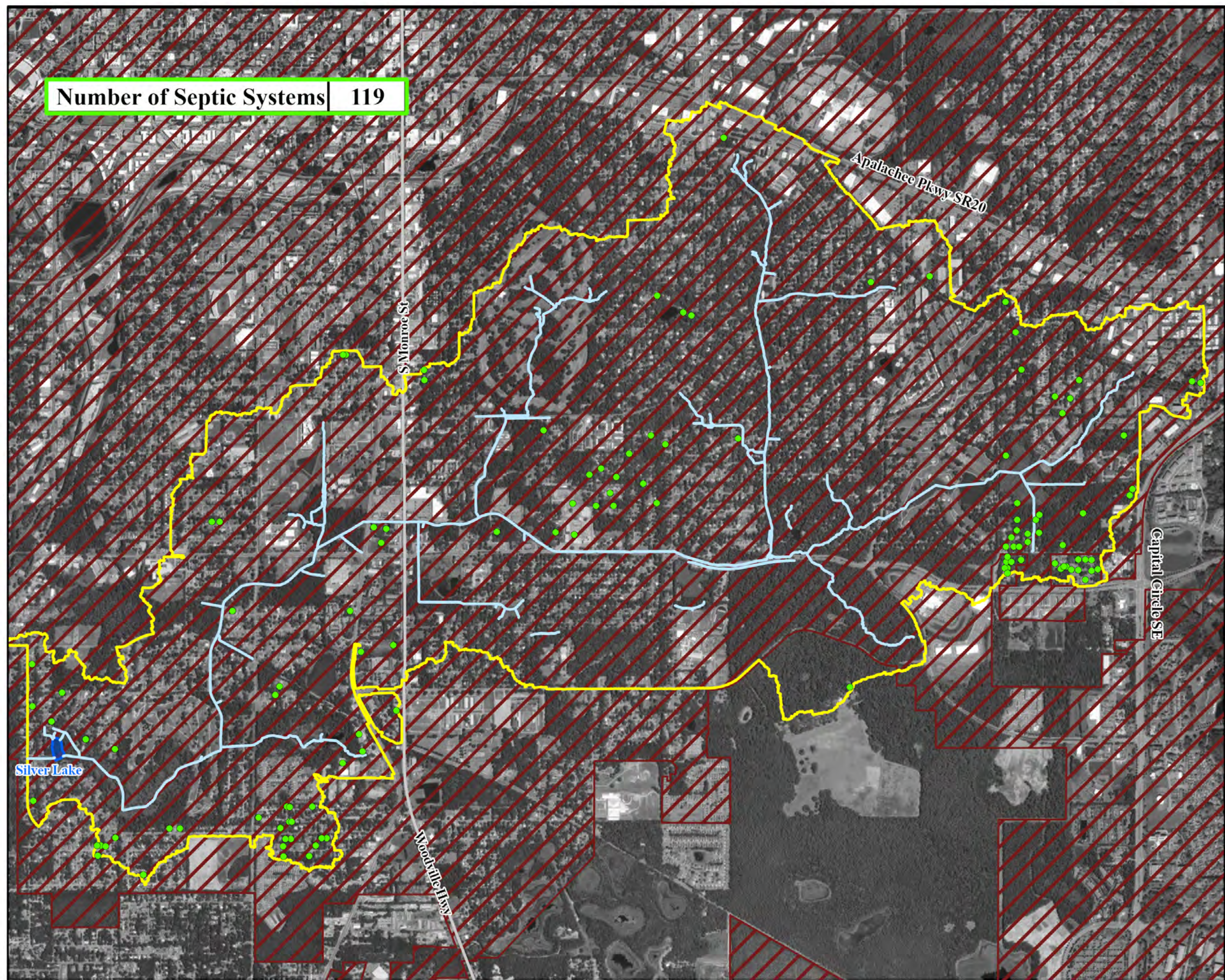
Exhibit 3-6 presented the locations of hydrologic data stations within the Lake Munson basin. There is a flow monitoring station located along the East Drainage Ditch at Adams Street (Station 008481). The flows at this station represent around two-thirds of the overall basin flow. **Figure 3-98** presents a plot of the calculated flows from 1994 through 2020. As with the calculated flows in Munson Slough and the West Ditch, the flows are highly flashy with extensive peak flows. Maximum flows over 200 cfs were calculated, with peak flows ranging between 50 and 100 cfs generally. It is noted that peak flows after 2010 were reduced in relation to peak flows in prior years. Whereas peak flows ranged between 100 and 300 cfs in the earlier years, peak flows after 2010 rarely exceeded 50 cfs. This may be reflective of additional attenuation within the watershed upstream of the flow station due to stormwater treatment pond construction and other BMPs. While the peak flows were attenuated, calculation of the annual total volumes indicated that the annual runoff volumes have not been reduced significantly.

3.6.3.6 Surface Water Quality Data

Figure 3-99 presents the location of the in-lake water quality monitoring station in Silver Lake (yellow) along with four stations that provide water quality data along the East Drainage Ditch upstream of the lake (red) and two downstream (orange). A table is provided in **Figure 3-99** that shows the station ID, station name, period of record, sample count, data source, and if the station represents in-lake or upstream/downstream data. Station IDs were not included on the figure, rather each of the stations is given a number and the numbers correspond to stations in the table.

The City collected water quality data in the lake since 2010 (Station 3 on map). Within the East Drainage Ditch upstream of Silver Lake, data were collected between 2011 and 2014 at two locations, one where the ditch flows under the St. Marks Historic Railroad Trail (Station 2 on map) and another in the ditch as it passes through the Indian Head neighborhood (Station 1 on map). Additional data, collected between 2010 and 2016 were taken at two stations where the East Drainage Ditch crosses North Ridge Road (Stations 4 and 5 on the map).

Some initial plots of the available data are provided in this section. This includes plots of the raw data and AGMs. As nutrients are the primary constituent of interest relative to water quality conditions in the basin, plots are provided for TN and TP against the NNC stream criteria. Additionally, based on interest relative to septic systems and other sources, FIB, specifically *E. coli*, are included where data are available. Additional data plots and analyses are provided as part of the qualitative assessment of sources in **Section 3.6.4.1**.



Legend

- Silver Lake Drainage Basin
- Waterbodies in Study
- Watercourses
- Major Roads
- Tallahassee Corporate Limits
- Septic Systems

Sources:
Waterbodies: COT, 2020
Watersheds: COT, 2020
Roads: FDOT, 2020
Septic Systems: COT, 2020
City Limits: COT, 2022

Figure 3-97:
Silver Lake/East Drainage Ditch Basin
Septic Systems Map

Tallahassee Master Plan - Surface
Water (TMaPS)



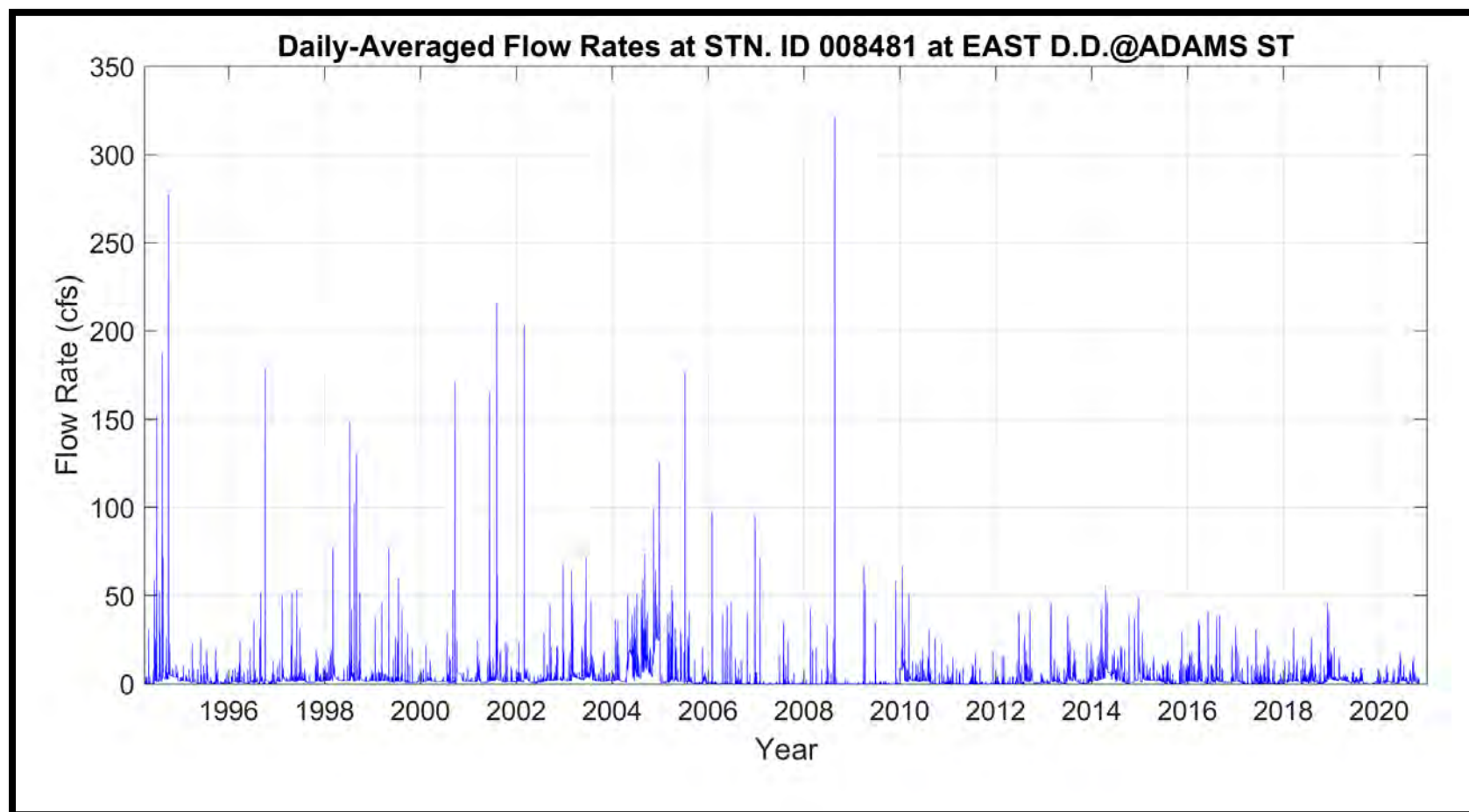
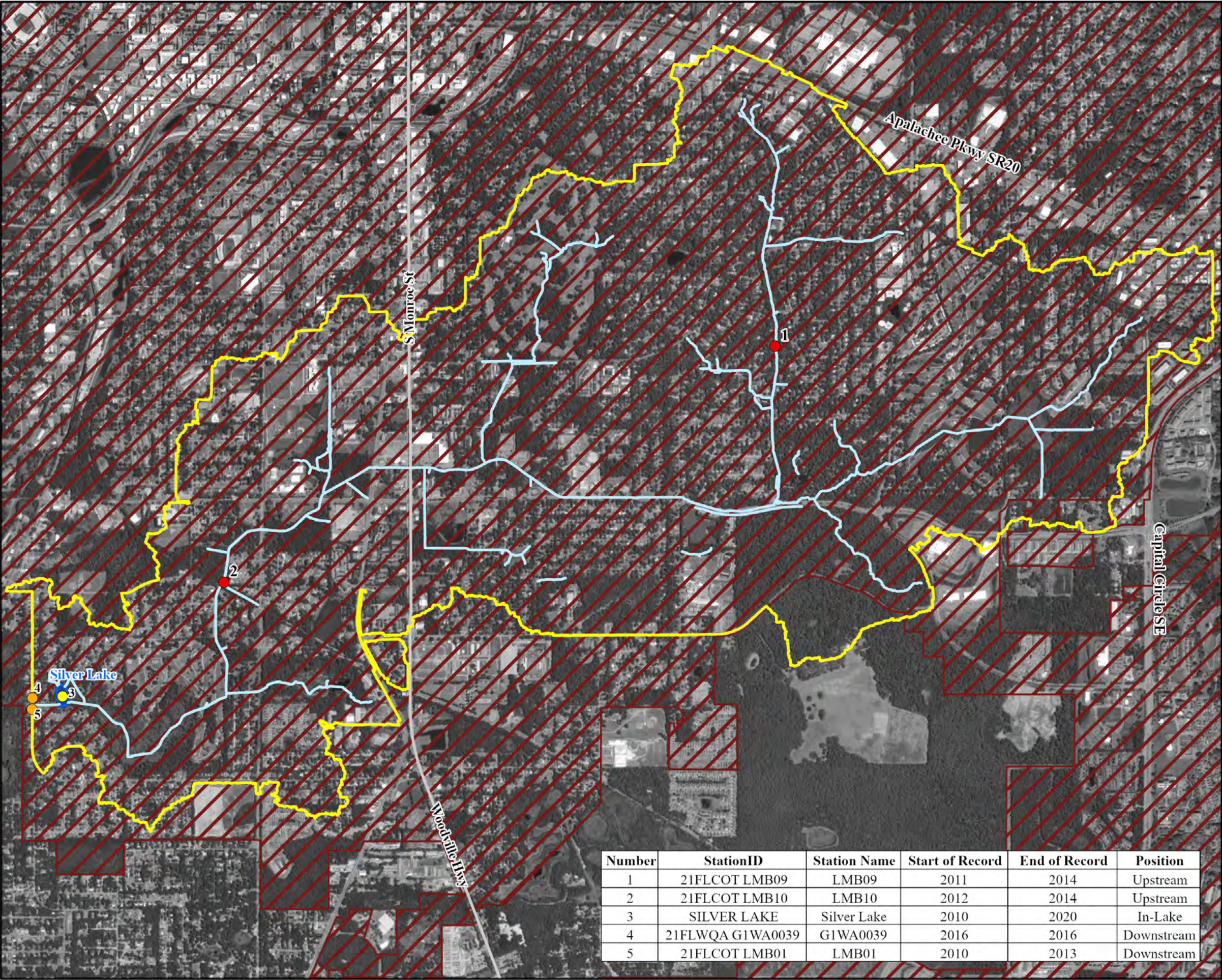


Figure 3-98: Daily Average Flow on East Drainage Ditch at Adams Street (Station 008481) (1994 to 2020)



Legend

- Silver Lake Drainage Basin
- Waterbodies in Study
- Watercourses
- Major Roads
- Tallahassee Corporate Limits
- Water Quality Stations**
- Position**
- In-Lake
- Upstream of Lake
- Downstream of Lake

Sources:
Waterbodies: COT, 2020
Watercourses: COT, 2020
Drainage Basins: COT, 2020
City Limits: COT, 2020
WQ Stations: FDEP, 2022

Figure 3-99:
Silver Lake/East Drainage Ditch Basin
Water Quality Stations Map

Tallahassee Master Plan - Surface
Water (TMaPS)

Number	StationID	Station Name	Start of Record	End of Record	Position
1	21FLCOT LMB09	LMB09	2011	2014	Upstream
2	21FLCOT LMB10	LMB10	2012	2014	Upstream
3	SILVER LAKE	Silver Lake	2010	2020	In-Lake
4	21FLWQA G1WA0039	G1WA0039	2016	2016	Downstream
5	21FLCOT LMB01	LMB01	2010	2013	Downstream



Plots of the measured TN and TP from 2010 to 2020 are presented in **Figure 3-100** and **Figure 3-101**. The higher density of samples between 2011 and 2014 reflects the inclusion of the upstream and downstream East Drainage Ditch samples (Stations 1, 2, 4, and 5) that were discontinued around 2014. Data after 2015 generally reflect data from only the open water Silver Lake portions of the ditch. TN and TP both show a general downward trend over the period of record from 2010 to 2020. This downward trend is seen in all of the data, including just the Silver Lake data.

The NNC Panhandle East stream thresholds for TN and TP are 1.03 mg/L and 0.18 mg/L. For *E. coli*, the criteria is monthly geometric means below 126 colonies per 100 mL of water and less than 10 percent of samples above 410 colonies per 100 mL of water in any 30-day period.

TN and TP AGM plots are provided for the Silver Lake/East Drainage Ditch basin as these define status relative to nutrient impairment. Where sufficient data are available to assess the AGMs, the levels are provided from 2010 through 2020. The TN and TP maximum NNC thresholds are provided on each of the graphs as pink dashed lines. *E. coli* data for the basin are presented against the 410 colonies per 100 mL threshold. *E. coli* data were available only from samples taken within the open water areas of Silver Lake after 2014.

Examination of the TN plot (**Figure 3-102**) shows that between 2010 and 2020, the TN AGMs in the basin were all below the NNC threshold (1.03 mg/L), with the bulk of the years at or below 50 percent of the threshold (0.5 mg/L). TP AGM levels (**Figure 3-103**) were all below the NNC threshold, with a significant downward trend after 2012. AGMs after 2016 were all around or below 0.1 mg/L, with the latter years showing significant drop offs.

Figure 3-104 presents a plot of measured *E. coli* levels from 2014 through 2020. All but 1 of the 23 measurements are below the 410 colonies per 100 mL threshold, with elevated measurement above 600, and 2 measurements were above 100.

3.6.3.7 Groundwater Data

Figure 3-23 presented the surficial aquifer groundwater sampling wells within the Lake Munson basin boundaries. No groundwater stations were located within the Silver Lake/East Drainage Ditch basin.

3.6.3.8 Biological Data

No biological sampling has been performed on Silver Lake. Biological sampling was conducted along the East Drainage Ditch, with data available from two sampling events in 2016. Habitat assessments of the ditch were performed where it crosses Ridge Road. The results of the assessment generally showed marginal to poor conditions based on issues of bank stability, limited riparian buffer, water velocity, and habitat smothering.

3.6.3.9 Stormwater Treatment Facilities

In assessing potential sources of pollutants to the Silver Lake, and ultimately for targeting loads and reductions, it is important to identify treatment facilities that presently exist with the basin. **Figure 3-105** presents a map showing the locations of stormwater treatment facilities throughout the Silver Lake/East Drainage Ditch basin. These are maintained by the City, FDOT, and private neighborhoods.

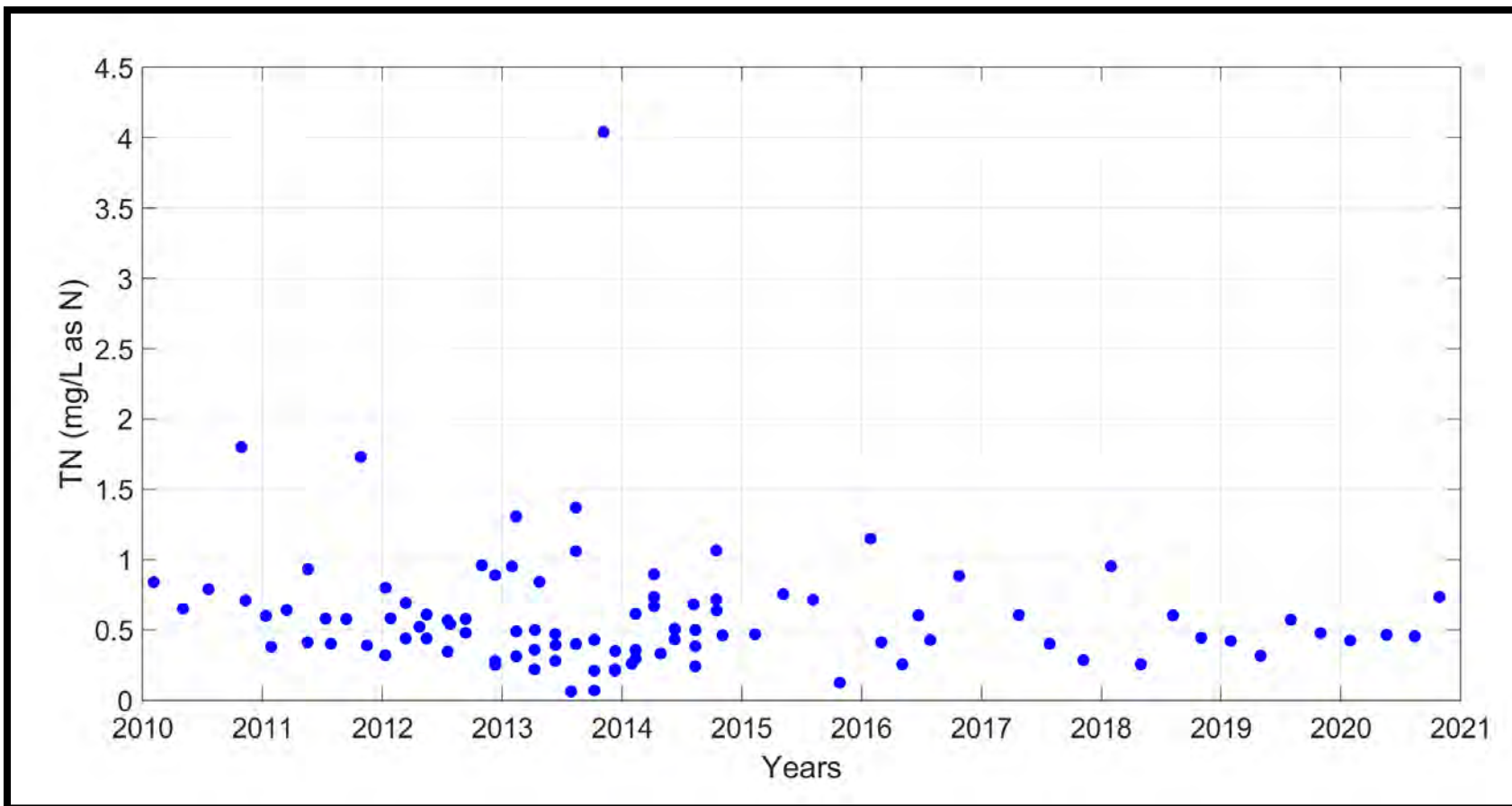


Figure 3-100: Plot of Measured TN in Silver Lake/East Drainage Ditch Basin

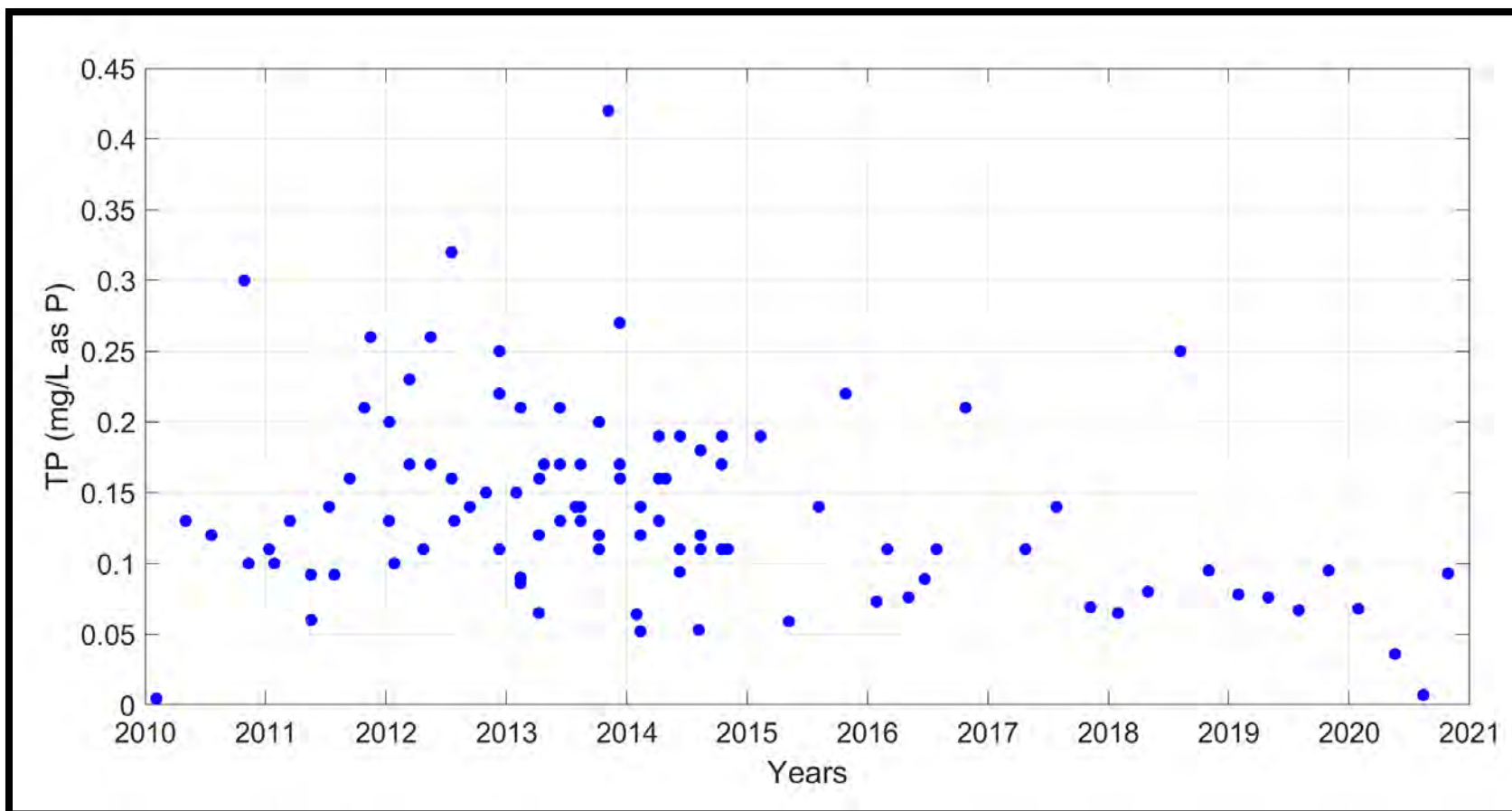


Figure 3-101: Plot of Measured TP in Silver Lake/East Drainage Ditch Basin

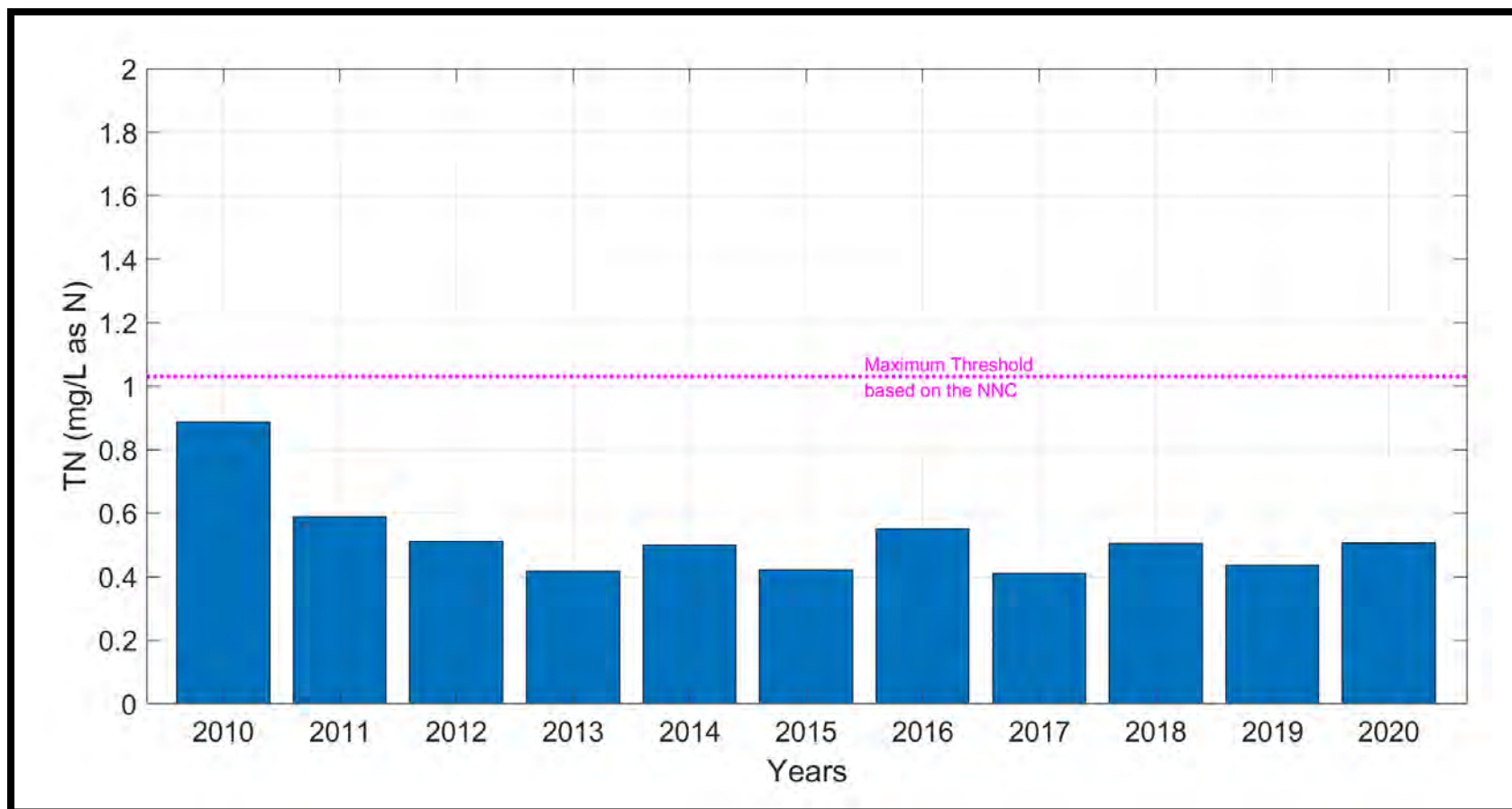


Figure 3-102 Plot of Annual Geometric Means for TN with NNC Criteria for Silver Lake/East Drainage Ditch Basin

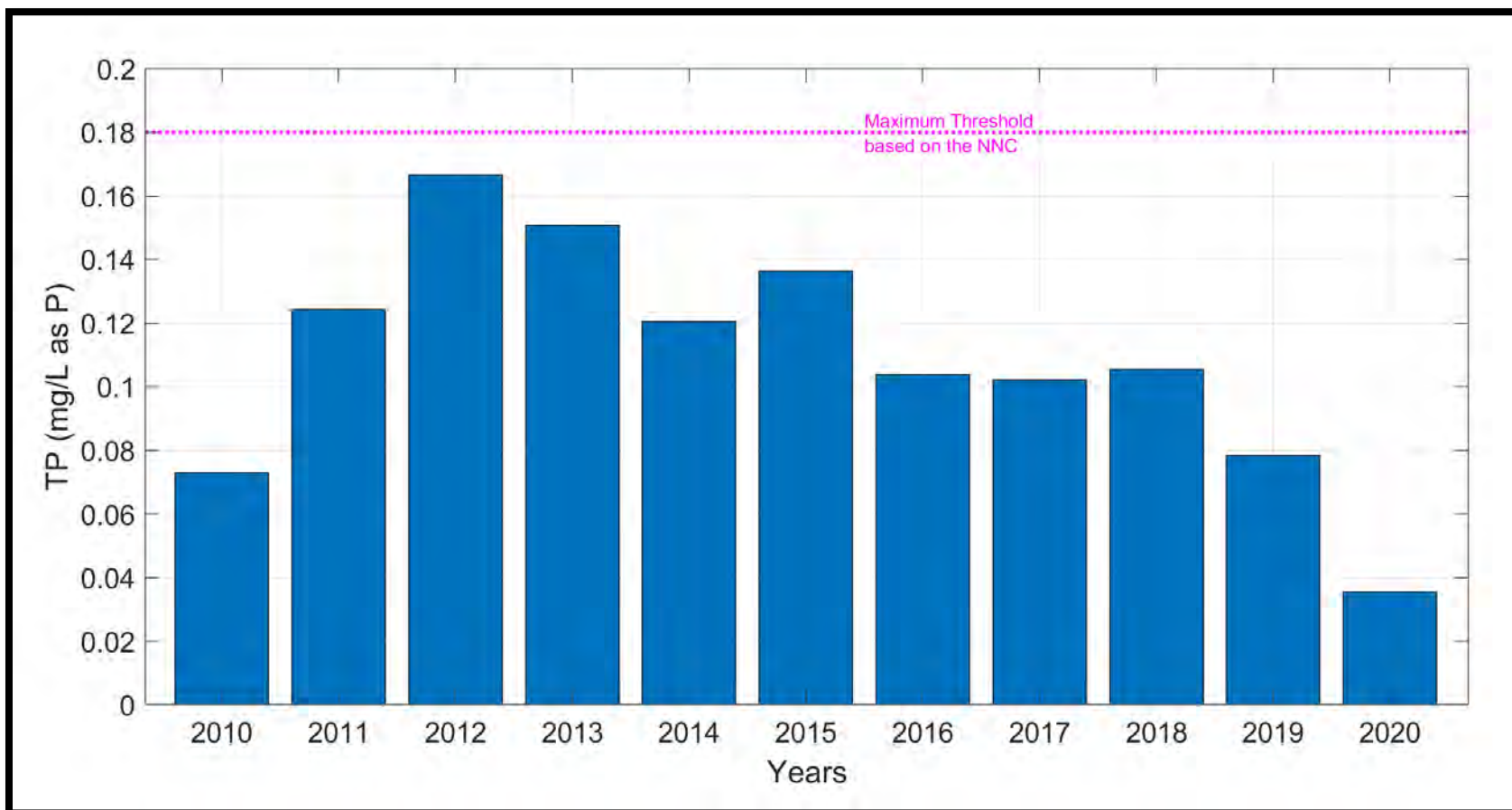


Figure 3-103: Plot of Annual Geometric Means for TP with NNC Criteria for Silver Lake/East Drainage Ditch Basin

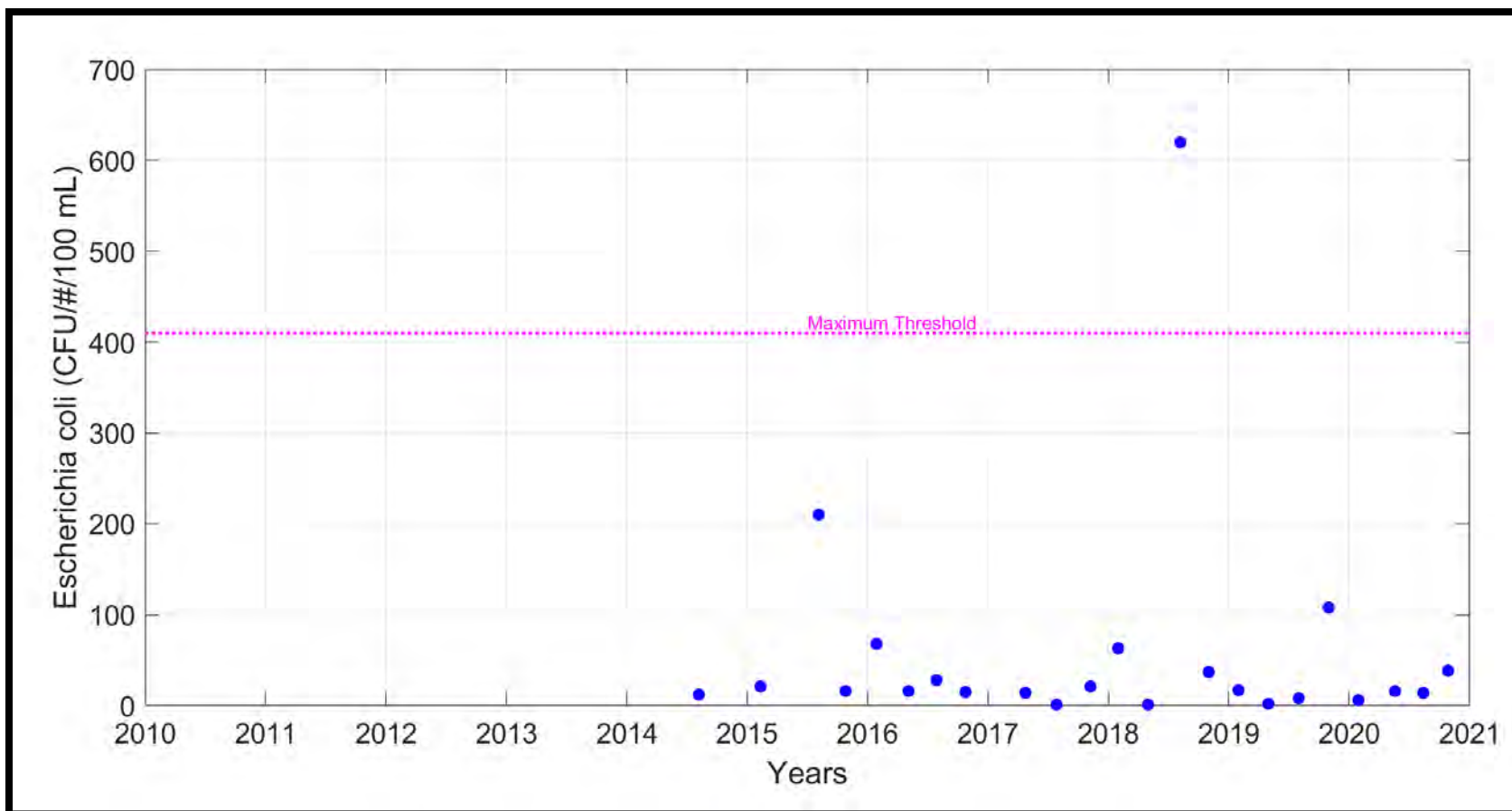
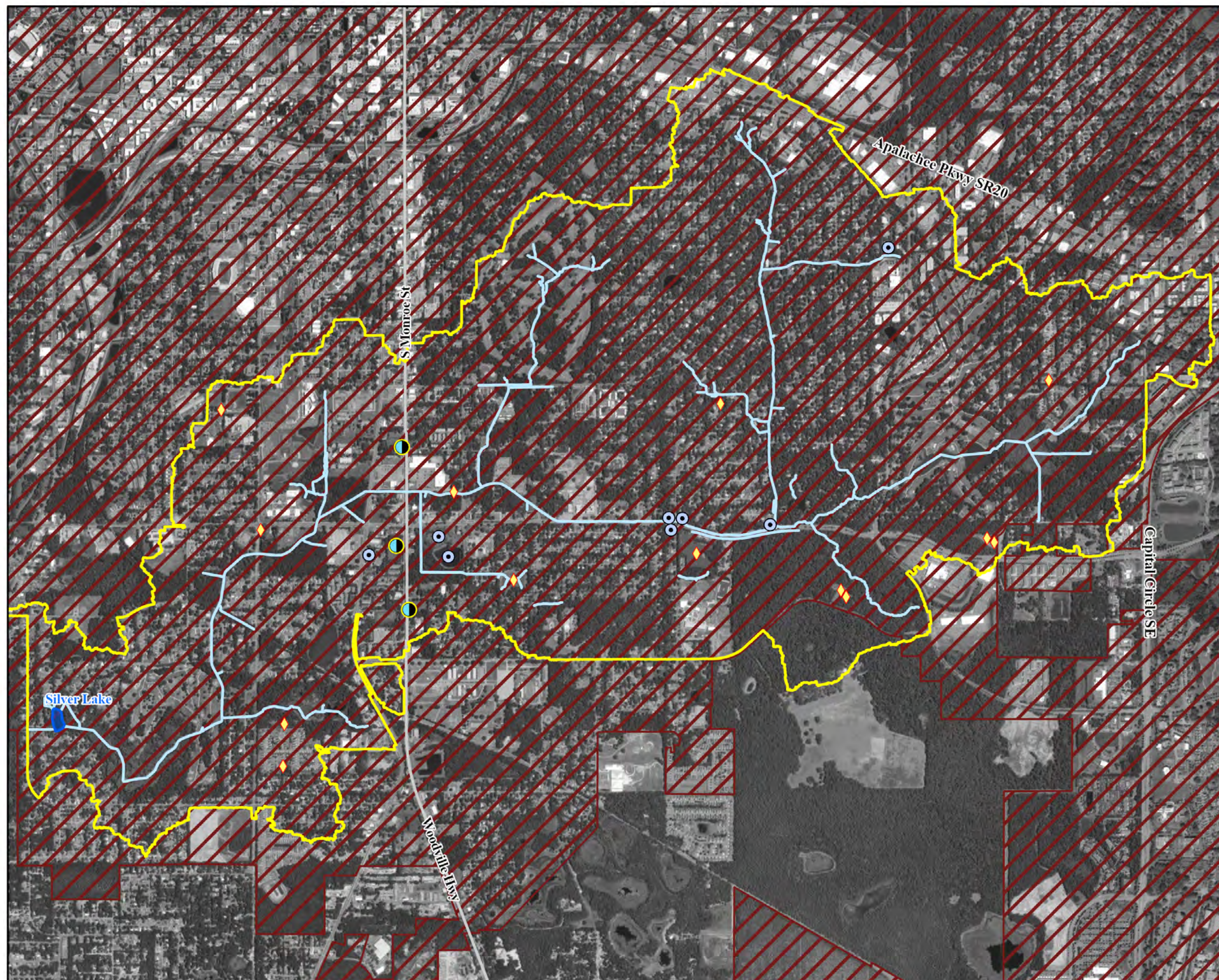


Figure 3-104: Plot of *E. coli* Measurements in Silver Lake (2014 to 2020)



Legend

- Silver Lake Drainage Basin
- Waterbodies in Study
- Watercourses
- Tallahassee Corporate Limits
- City of Tallahassee Stormwater Ponds
- FDOT Stormwater Ponds
- Stormwater Ponds-Other

Sources:
Waterbodies: COT, 2020
Watersheds: COT, 2020
Roads: FDOT, 2020
BMPs: Geosyntec, 2022
City Limits: COT, 2022

Figure 3-105:
Silver Lake/East Drainage Ditch Basin
BMP Location Map

Tallahassee Master Plan - Surface
Water (TMaPS)

3.6.3.10 Atmospheric Deposition Data

Figure 3-24 presented the location of the nearest atmospheric deposition station to the Silver Lake/East Drainage Ditch basin, the Quincy, FL station. This is the same station utilized in the Lake Munson calculations.

3.6.3.11 Data Summary

For the purposes of the qualitative analysis of sources of pollutants to Silver Lake and the East Drainage Ditch (**Section 3.6.4**), the available data are limited. There is an active surface water quality station within the open water areas of the lake, but data in the upstream and downstream reaches of the ditch are limited. Specific recommendations on additional data collection efforts are provided in **Section 3.8**. The following outlines limitations in the available data.

- The water quality monitoring stations in the East Drainage Ditch upstream and downstream of the lake were discontinued around 2014, which limits available recent data on conditions in the ditch upstream and downstream of the lake.
- No surficial groundwater monitoring stations are located in the vicinity to determine the quality of potential seepage into the lake or ditch segments.

3.6.4 Qualitative Assessment of Sources

As outlined in **Section 3.4.4** for Lake Munson, prior to performing loading calculations and other analyses to quantify existing pollutant sources to Silver Lake and the East Drainage Ditch, it is important to analyze available data and summarize findings from historical studies to support identification of likely sources of anthropogenic load.

For Silver Lake, the sources to be evaluated include the following:

- Stormwater runoff
- Septic systems
- Internal recycling and seepage
- Wastewater
- Atmospheric deposition
- Interconnected flows

An overview of analyses and findings for each source listed above is provided in the following sections. Prior to the discussions for each potential source, additional analyses of the data within the basin are provided to build on the information presented in **Section 3.6.3**. Following the discussions for each source type, a summary of findings for the qualitative assessment is provided.

3.6.4.1 In-Stream Water Quality

Following the methodology utilized for Lake Munson in **Section 3.4.4.1**, analyses were conducted on the available data along the East Drainage Ditch and within Silver Lake from 2010

to the present. This provides an evaluation of the baseline water quality conditions and the spatial differences along the ditch (where data support a spatial assessment). The parameters analyzed include TP, TN, and TSS. *E. coli* data are only available in the lake, so no spatial analysis is provided.

As was done for Lake Munson (**Section 3.4.4.1**), stations were clustered where they represent conditions within a specific area, and all stations with data after 2010 were assigned to a specific cluster. The clustered data from 2010 to the present were analyzed to provide the average of the annual geomeans or the 90th percentile, depending upon the parameter. The results are presented on a map, with colors representing the results. The levels associated with the colors are reflective of water quality thresholds as outlined in 62-302 F.A.C. and are discussed and presented in **Section 3.4.4.1**. The Silver Lake/East Drainage Ditch basin analyses use the stream NNC thresholds for TN and TP based on the applicable Panhandle East NNC criteria.

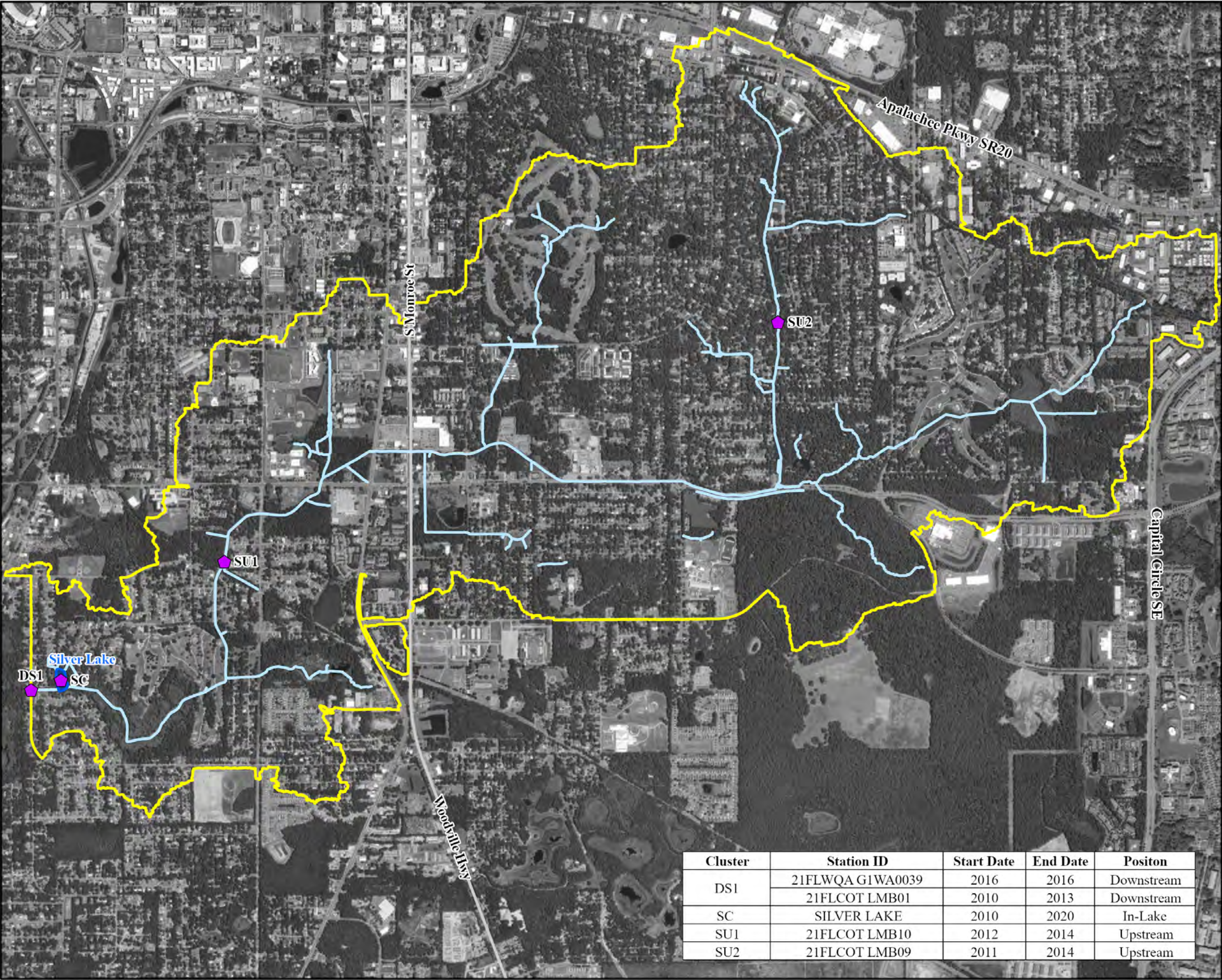
Figure 3-106 presents the data clustering used for the analyses and associated stations. Four locations were defined. Cluster SC represents the station in the lake. Cluster DS1 represents conditions immediately downstream of the lake. Clusters SU1 and SU2 represent the two locations along East Drainage Ditch where data were available. The table on **Figure 3-106** gives the period of record when data are available. Note that the stations have different periods of available data, therefore, intercomparisons discussed below should be weighed with that understanding.

Figure 3-107 and **Figure 3-108** present the TN and TP averages for each cluster. The TN averages within the East Drainage Ditch and the lake are all below the NNC stream threshold (DS1=0.55 mg/L, SC=0.58 mg/L, SU1=0.38 mg/L, SU2=0.47 mg/L). While not significantly different, the upstream TN levels appear to be somewhat lower than the downstream levels. The TP levels in the East Drainage Ditch and the lake, while below the stream condition NNC threshold, are in the higher range (DS1=0.14 mg/L, SC=0.10 mg/L, SU1=0.12 mg/L, SU2=0.17 mg/L). While the SC station shows lower values in relation to the other stations, this is mostly due to the period of record for that station having data in more recent years where the levels are lower. In general, the TP levels are relatively constant through the basin, with the most upstream station showing somewhat elevated levels.

Figure 3-109 presents the TSS levels. Generally, the stations all show low TSS levels, but as the data are collected during ambient flow conditions, they may not reflect sediment transport through the system during storm events.

3.6.4.2 Stormwater Runoff

The TN levels throughout are on average well below the stream threshold, with average levels less than one-half the threshold value for the stream criteria (**Figure 3-107**). TP levels on average are also below the stream threshold but they are closer to the threshold values (**Figure 3-108**).



Legend

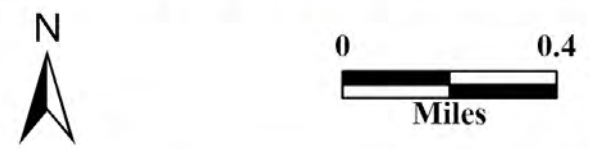
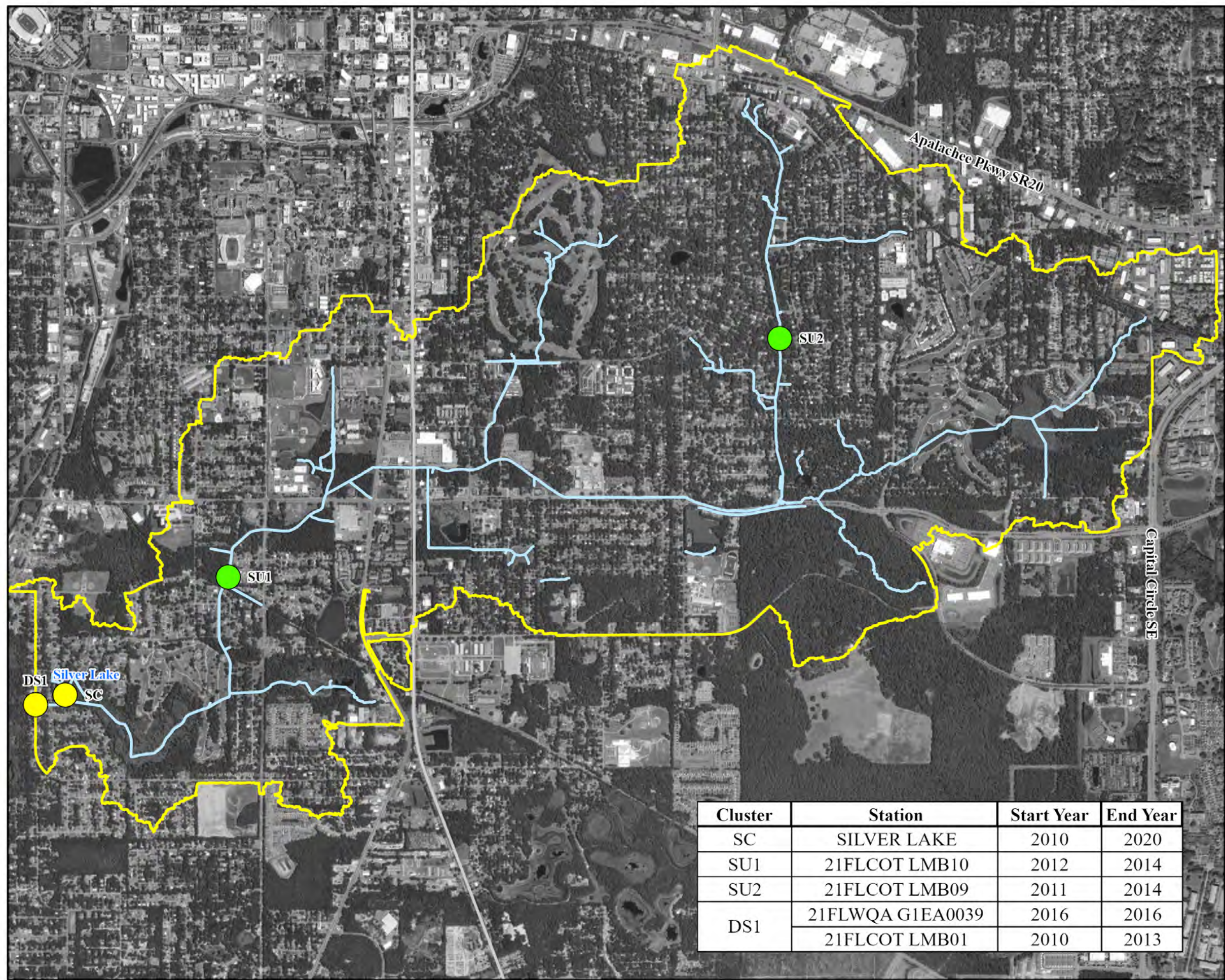
- Silver Lake Drainage Basin
- Waterbodies in Study
- Watercourses
- Station Clusters

Sources:
Waterbodies: COT, 2020
Watercourses: COT, 2020
Drainage Basin: COT, 2020
Roads: COT-Leon County, 2023

Figure 3-106:
Station Clustering for Silver Lake/East
Drainage Ditch Basin

Tallahassee Master Plan - Surface
Water (TMaPS)

Cluster	Station ID	Start Date	End Date	Position
DS1	21FLWQA G1WA0039	2016	2016	Downstream
	21FLCOT LMB01	2010	2013	Downstream
SC	SILVER LAKE	2010	2020	In-Lake
SU1	21FLCOT LMB10	2012	2014	Upstream
SU2	21FLCOT LMB09	2011	2014	Upstream



- Legend**
- Silver Lake Drainage Basin
 - Waterbodies in Study
 - Watercourses
- TN Average 2010-2020**
mg/L
- 0 - 0.25
 - 0.25 - 0.5
 - 0.5 - 0.75
 - 0.75 - 1.03
 - > 1.03

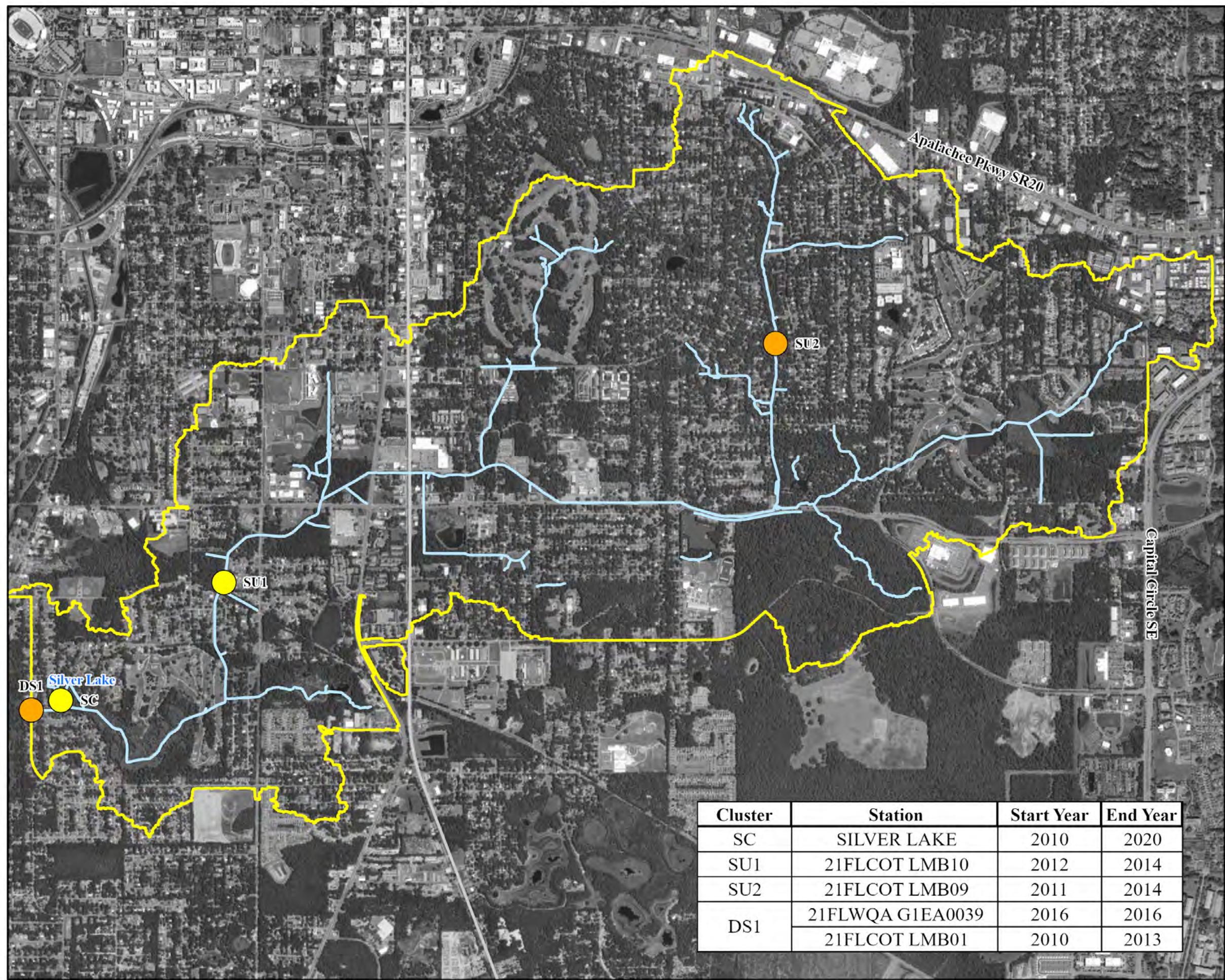
Sources:
Waterbodies: COT, 2020
Watercourses: COT, 2020
Drainage Basins: COT, 2020
Roads: COT-Leon County, 2023
Station Data: FDEP, 2021

Figure 3-107:
**Spatial Assessment of TN in Silver Lake/
East Drainage Ditch Basin**

**Tallahassee Master Plan - Surface
Water (TMaPS)**

Cluster	Station	Start Year	End Year
SC	SILVER LAKE	2010	2020
SU1	21FLCOT LMB10	2012	2014
SU2	21FLCOT LMB09	2011	2014
DS1	21FLWQA G1EA0039	2016	2016
	21FLCOT LMB01	2010	2013





Legend

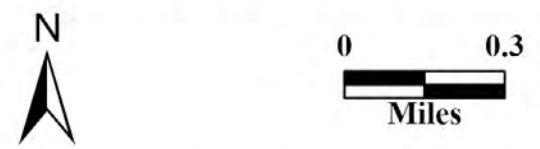
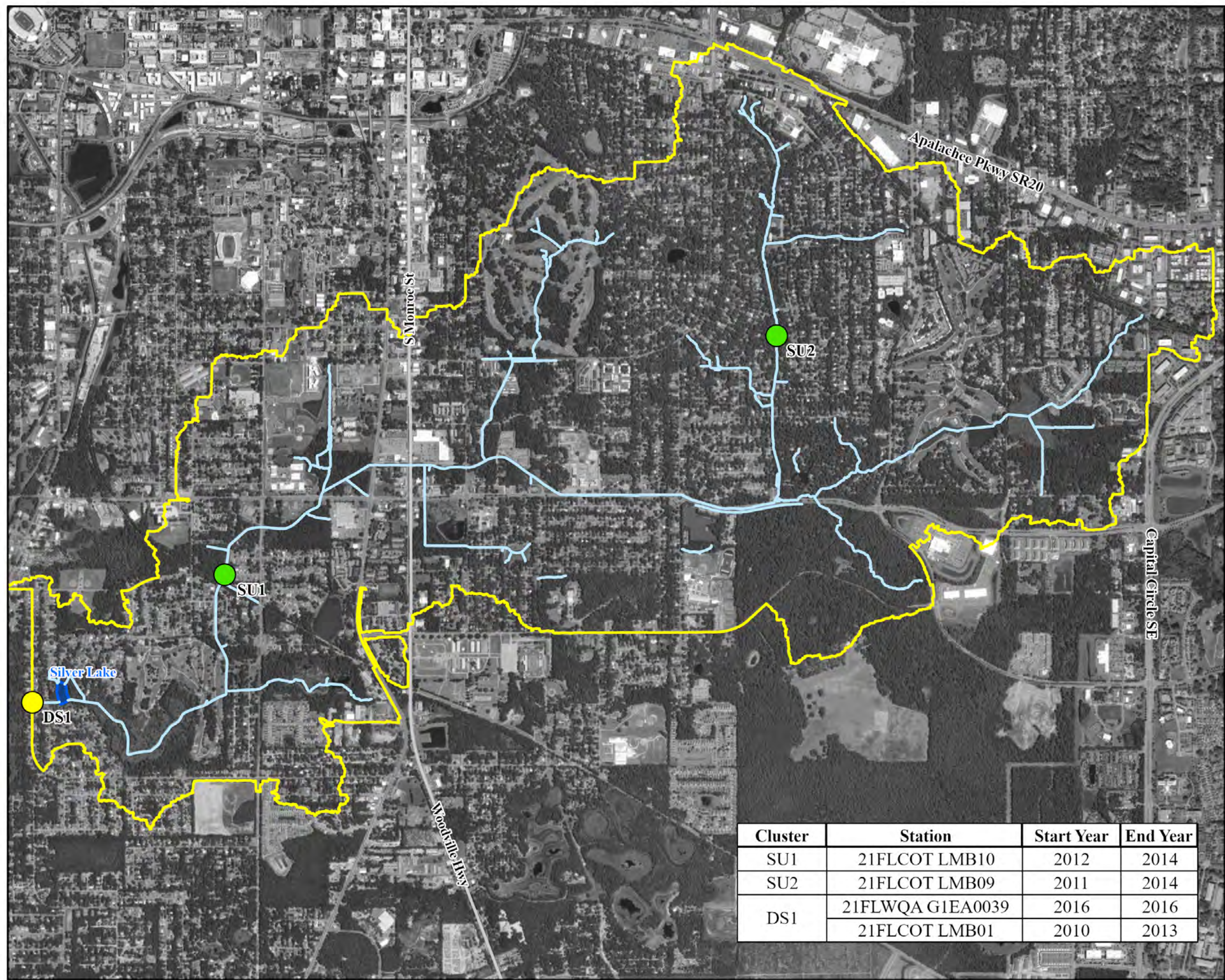
- Silver Lake Drainage Basin
- Waterbodies in Study
- Watercourses
- TP Average 2010-2020
mg/L
 - 0 - 0.045
 - 0.045 - 0.09
 - 0.09 - 0.135
 - 0.135 - 0.18
 - > 0.18

Sources:
Waterbodies: COT, 2020
Watercourses: COT, 2020
Drainage Basins: COT, 2020
Roads: COT-Leon County, 2023
Station Data: FDEP, 2021

Figure 3-108:
Spatial Assessment of TP in Silver Lake/
East Drainage Ditch Basin

Tallahassee Master Plan - Surface
Water (TMaPS)





- Legend**
- Silver Lake Drainage Basin
 - Waterbodies in Study
 - Watercourses
 - TSS Average 2010-2020
mg/L
 - 0-2.5
 - 2.5-5.0
 - 5.0-7.5
 - 7.5-10.0
 - >10.0

Sources:
Waterbodies: COT, 2020
Watercourses: COT, 2020
Drainage Basins: COT, 2020
Roads: COT-Leon County, 2023
Station Data: FDEP, 2021

Figure 3-109:
**Spatial Assessment of TSS in Silver Lake/
East Drainage Ditch Basin**

Tallahassee Master Plan - Surface
Water (TMaPS)

Cluster	Station	Start Year	End Year
SU1	21FLCOT LMB10	2012	2014
SU2	21FLCOT LMB09	2011	2014
DS1	21FLWQA G1EA0039	2016	2016
	21FLCOT LMB01	2010	2013



In addition to the examination of the tributary data, to assess stormwater runoff as a potential source of pollutant loads to Silver Lake, the LDI levels within the subbasins draining to the lake were evaluated. In **Section 3.4.4.2**, LDI values were presented by subbasin in **Figure 3-34** for all of the Lake Munson basin. The figure shows that LDI levels within the Silver Lake basin are moderate. These LDI values, along with the water quality data in the East Drainage Ditch, indicate that stormwater runoff is a potential loading source to Silver Lake/East Ditch and downstream to Lake Munson.

3.6.4.3 Septic Systems

Figure 3-97 presented the locations of septic systems within the Silver Lake/East Drainage Ditch basin. **Figure 3-35** presented a map showing the septic tank densities by subbasin for the full Lake Munson basin. The septic density map shows low densities throughout the basin. As presented previously, approximately 120 septic systems are located within the Silver Lake/East Drainage Ditch basin. They are generally spread throughout the basin. Based on the limited number of septic systems, septic loads are not identified as a potential significant source. Given the readily available data, the septic load will be calculated in **Section 3.6.5** for comparison to other sources.

3.6.4.4 Internal Recycling and Seepage

Internal Recycling

To date, no studies or data collection efforts have been undertaken to assess the potential for nutrient loading/recycling from sediments in Silver Lake. Comparison of the TN and TP levels upstream, in-lake, and downstream (when samples are available during the same year) do not show significant increases moving through the lake. Additionally, given the high watershed to lake area ratio, internal loading from the lake area would not be expected to be a significant source in relation to stormwater runoff. Based on this, internal recycling from the lake is not identified as a significant load to the system. Loads are not quantified in **Section 3.5.5**.

Seepage

No studies have been performed to determine the potential for seepage as a load to Silver Lake or the East Drainage Ditch. Additionally, as outlined in **Section 3.6.3.7**, no surficial aquifer sampling stations are located in the Silver Lake/East Drainage Ditch basin to assess the quality of groundwater that may seep into the lake. Data to support calculation of the seepage load are not available, so loads are not quantified in **Section 3.5.5**.

3.6.4.5 Wastewater

No direct wastewater discharges are currently within the Silver Lake/East Drainage Ditch basin. Additionally, no areas in the Lake Munson basin presently have reuse discharges. **Figure 3-39** presented a map of the Lake Munson basin boundaries in relation to sewer service areas. Within the Silver Lake basin, the available data from the tributaries did not show elevated bacteria levels, indicating that there is not a persistent source associated with wastewater leakage in this area.

While SSOs occur from time to time, SSOs are acute events with impacts lasting for relatively short periods of time (hours to several days), depending on magnitude and environmental

conditions. The mechanism for abatement would not be treatment projects but rather any needed maintenance to sewer infrastructure. The City presently tracks, reports, and addresses these issues as they arise.

3.6.4.6 Atmospheric Deposition

Section 3.6.3.10 identified the nearest atmospheric deposition station as the Quincy station (FL14). The data from this station will be utilized to calculate the atmospheric deposition to Silver Lake for TN in **Section 3.6.5** for comparison to other loads. However, given that the ratio of watershed area to lake area is around 1,800:1 and the potential attenuation of rainfall runoff, direct atmospheric deposition to the lake likely does not play a significant role in overall loading.

3.6.4.7 Interconnected Flows

There are no lakes located upstream of Silver Lake, therefore, inter-lake loading (interconnected flow) is zero.

3.6.4.8 Summary of Findings for Qualitative Assessment of Sources

Based on the discussions above, and data and information presented in **Section 3.6.3**, various sources were identified as potential loads to the Silver Lake/East Drainage Ditch basin. Load calculations are provided in **Section 3.5.5** where data are available. The following summarizes the findings for each of the potential pollutant sources.

- Stormwater Runoff – Stormwater runoff was identified as a potential source of nutrient load to the Silver Lake/East Drainage Ditch basin, and the load will be quantified in **Section 3.6.5.1**.
- Septic Systems – Based on the limited number of septic systems, septic loads were not identified as a potential significant source. Calculation of the loading is provided based on available data.
- Interconnected Flows – No lakes are located upstream of Silver Lake, therefore, interconnected flows are zero.
- Internal Recycling – Internal recycling is not identified as a significant potential load to Silver Lake and downstream and, based on lack of available data, the loads are not quantified.
- Seepage – Insufficient data is available to support calculation of direct seepage into the lake or the East Drainage Ditch.
- Wastewater – No permitted point sources are located within the Silver Lake/East Drainage Ditch basin. SSOs can contribute to loading but are short-term events that are typically addressed quickly. Based on the available data, SSOs were not identified as a potential significant source and their load is not calculated.
- Atmospheric Deposition – Based on the ratio of the direct watershed discharge to the area of the lake, atmospheric deposition is not identified as a significant load. Based on available data, the loads are calculated.

3.6.5 Calculation of Potential Nutrient Loads

This section presents calculations of potential nutrient (TN and TP) loads to Silver Lake and the East Drainage Ditch for the sources identified for calculation in **Section 3.6.4.8**. These include stormwater runoff, septic systems, and atmospheric deposition. Where loads were not calculated, the following sections provide brief discussions. The load calculations are for the purpose of comparing the potential magnitudes of each source relative to one another to support determination of sources to target for load reduction.

3.6.5.1 Stormwater Pollutant Load

To calculate the stormwater TN and TP loads to Silver Lake and the East Drainage Ditch, average annual pollutant load modeling was performed. The goal was to identify areas that are contributing higher TN and TP loads relative to one another and to quantify the total TN and TP loads from stormwater runoff to the ditch and lake. TN and TP loads were calculated using the SIMPLE-Seasonal model. The model methodology was described in detail in **Section 3.4.5.1** for the stormwater loads to Lake Munson.

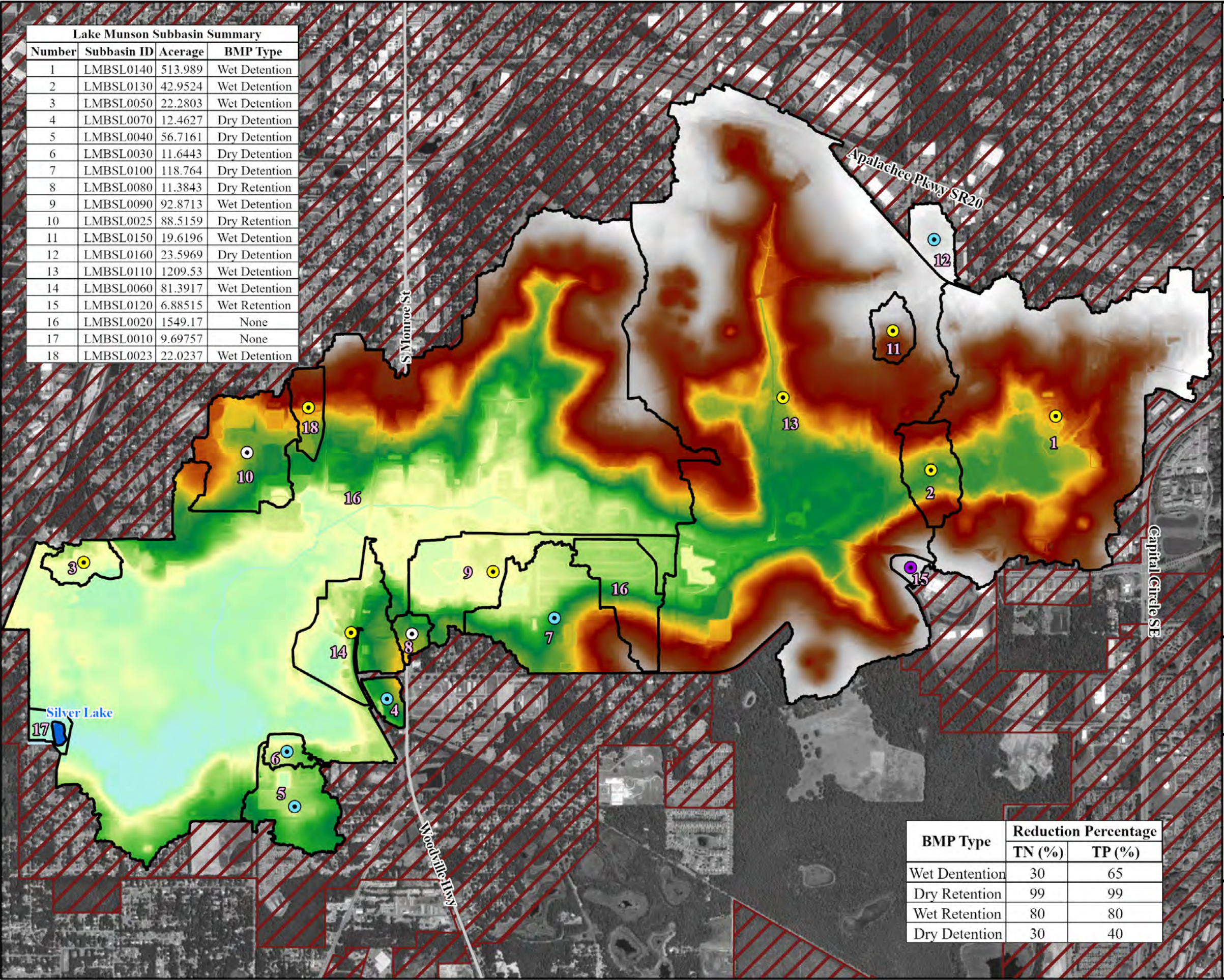
Figure 3-110 presents the subbasins and the DEM utilized in the SIMPLE model calculations for Silver Lake and the East Drainage Ditch. **Figure 3-111** presents the aggregated land use. Finally, **Figure 3-112** presents the CDAs for Silver Lake stormwater loading to define total and per acre TN and TP loads, as well as the ranking of CDAs around the Lake.

As a check on the modeled annual volumes from the SIMPLE model, the data from the flow station presented in **Section 3.6.3.5** were used to calculate measured annual volumes for years with sufficient data. The calculated annual volumes using the flow data ranged from 1,200 acre-ft up to 4,400 acre-ft. The annual volumes calculated at the station from the SIMPLE model were around 3,059 acre-ft. As such, the modeled annual volumes are reasonable, if on the high end.

Stormwater Nutrient Loads to Silver Lake

Figure 3-113 presents the distribution of the ranking of the CDAs for TN, along with the total load and per acre loads (see the table on **Figure 3-113**). The rankings are color coded with the highest ranked CDAs in green moving down to the lowest ranked in pale yellow. The calculated total stormwater TN loads from the CDAs ranged from as low as 22.8 lb/yr up to 13,365 lb/yr. The per acre loads ranged from 2.4 lb/acre/yr up to 3.5 lb/acre/yr. These per acre loads are high in relation to other areas within the Lake Munson basin. The total TN load is 13,554 lb.

Figure 3-114 presents the distribution of the ranking of the CDAs for TP along with the total load and per acre loads (see the table on **Figure 3-114**). The calculated total stormwater TP loads from the CDAs ranged from as low as 6.0 lb/yr up to 2,997 lb/yr. The per acre loads ranged from 0.6 lb/acre/yr up to 0.8 lb/acre/yr. These per acre TP loads are high in relation to other areas within the Lake Munson basin. The total TP load is 3,049 lb.





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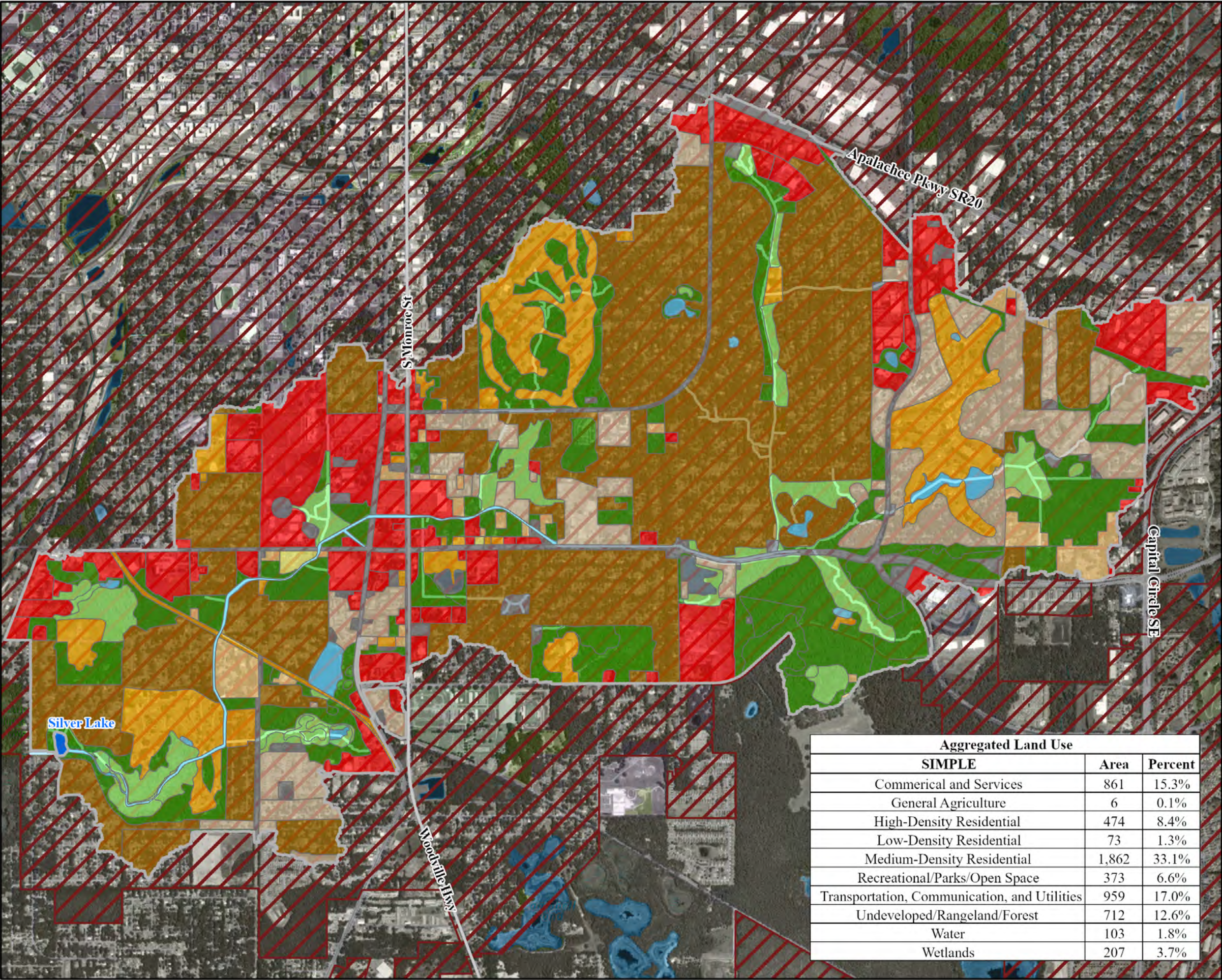
0 0.4
Miles

Sources:
Waterbodies: COT, 2020
Watercourses: COT, 2020
Subbasins: Geosyntec, 2023
Roads: COT-Leon County, 2023
City Limits: COT, 2020
BMPs: Geosyntec, 2023
Elevation: COT-Leon County, 2018

Figure 3-110:
Silver Lake/East Drainage Ditch Subbasin Delineation and BMPs

Tallahassee Master Plan - Surface Water (TMaPS)

Geosyntec
consultants



Legend

- Waterbodies in Study
- Watercourses
- Tallahassee Corporate Limits
- Land Use Type
 - Commerical and Services
 - General Agriculture
 - High-Density Residential
 - Low-Density Residential
 - Medium-Density Residential
 - Recreational/Parks/Open Space
 - Transportation, Communication, and Utilities
 - Undeveloped/Rangeland/Forest
 - Water
 - Wetlands

Sources:
Waterbodies: COT, 2020
Watercourses: COT, 2020
Land Use: Geosyntec, 2023
Roads: COT-Leon County, 2023
City Limits: COT, 2020
Elevation: COT-Leon County, 2018

Aggregated Land Use		
SIMPLE	Area	Percent
Commerical and Services	861	15.3%
General Agriculture	6	0.1%
High-Density Residential	474	8.4%
Low-Density Residential	73	1.3%
Medium-Density Residential	1,862	33.1%
Recreational/Parks/Open Space	373	6.6%
Transportation, Communication, and Utilities	959	17.0%
Undeveloped/Rangeland/Forest	712	12.6%
Water	103	1.8%
Wetlands	207	3.7%

Figure 3-111:
Silver Lake/East Drainage Ditch
Aggregated Land Use

Tallahassee Master Plan - Surface
Water (TMaPS)



A Concentrated Discharge Area (CDA) is identified as possessing concentrated flows that could facilitate potential water quality treatment projects.



Legend

-  Silver Lake
-  Concentrated Discharge Areas
-  Flowlines
-  Tallahassee Corporate Limits
- Topographic Elevations
ft NAVD88
 -  255
 -  64

Sources:
Waterbodies: COT, 2020
Watercourses: COT, 2020
CDAs: Geosyntec, 2023
Roads: COT-Leon County, 2023
City Limits: COT, 2020
Elevation: COT-Leon County, 2018

Figure 3-112:
Silver Lake/East Drainage Ditch
Concentrated Discharge Areas

Tallahassee Master Plan - Surface
Water (TMaPS)

Summary of Concentrated Discharge Areas		
Number	CDA ID	Acres
1	LMBSLOF02	3,830.3
2	LMBSLOF03	53.5
3	LMBSLOF01	9.7

A Concentrated Discharge Area (CDA) is identified as possessing concentrated flows that could facilitate potential water quality treatment projects.



Legend

- Silver Lake
- Concentrated Discharge Areas
- Watercourses
- Tallahassee Corporate Limits
- TN Ranking**
 - High (1)
 - Low (3)

Sources:
Waterbodies: COT, 2020
Watercourses: COT, 2020
CDAs: Geosyntec, 2023
Roads: COT-Leon County, 2023
City Limits: COT, 2020
Elevation: COT-Leon County, 2018

Figure 3-113:
Silver Lake/East Drainage Ditch
Concentrated Discharge Areas - Total
Nitrogen

Tallahassee Master Plan - Surface
Water (TMaPS)



Summary of Concentrated Discharge Area				
Number	CDA ID	Total Load (lb-TN/yr)	Area Load (lbs TN/ac/yr)	Ranking
1	LMBSLOF02	13,365.0	3.5	1
2	LMBSLOF03	165.8	3.1	2
3	LMBSLOF01	22.8	2.4	3
Total Load:		13,553.6		

A Concentrated Discharge Area (CDA) is identified as possessing concentrated flows that could facilitate potential water quality treatment projects.



Legend

-  Silver Lake
-  Concentrated Discharge Areas
-  Watercourses
-  Tallahassee Corporate Limits
- TP Ranking
 -  High (1)
 -  Low (3)

Sources:
Waterbodies: COT, 2020
Watercourses: COT, 2020
CDAs: Geosyntec, 2023
Roads: COT-Leon County, 2023
City Limits: COT, 2020
Elevation: COT-Leon County, 2018

Figure 3-114:
Silver Lake/East Drainage Ditch
Concentrated Discharge Areas - Total
Phosphorus

Tallahassee Master Plan - Surface
Water (TMaPS)

Summary of Concentrated Discharge Area

Number	CDA ID	Total Load (lb-TP/yr)	Area Load (lbs TP/ac/yr)	Ranking
1	LMBSLOF02	2,997.2	0.8	1
2	LMBSLOF03	45.5	0.8	1
3	LMBSLOF01	6.0	0.6	3
Total Load:		3,048.7		

3.6.5.2 Septic Load

To quantify the potential loads from septic tank units to Silver Lake, the SPIL method adopted by FDEP was utilized. The approach and calculations were described in **Section 3.4.5.2**, which presented the septic loading to Lake Munson. As outlined earlier, the calculations were only done for nitrogen (TN) and, based on literature on transport and assimilation, may represent a conservative potential load.

There were 2 septic tank units identified within 200 meters of Silver Lake and a total of 43 within 200 yards of the East Drainage Ditch. **Figure 3-115** shows the septic systems utilized in this analysis, with green representing systems associated with direct loading to Silver Lake and pink representing those associated with loading to the East Drainage Ditch. A table provided on the figure summarizes the calculated TN load from septic units. The loads are split between load to the East Drainage Ditch (476 lb/yr) and direct inputs to Silver Lake (22 lb/yr), for a total potential septic load of 497 lb/yr.

3.6.5.3 Wastewater Load

No active point sources were identified within the Lake Munson basin. Therefore, the point source loads for TN and TP are set to 0 lb/yr for the Silver Lake and East Drainage Ditch.

3.6.5.4 Lake Inflow Load

As discussed earlier, no lakes are located upstream of Silver Lake, therefore the lake inflow load is zero.

3.6.5.5 Internal Lake Load

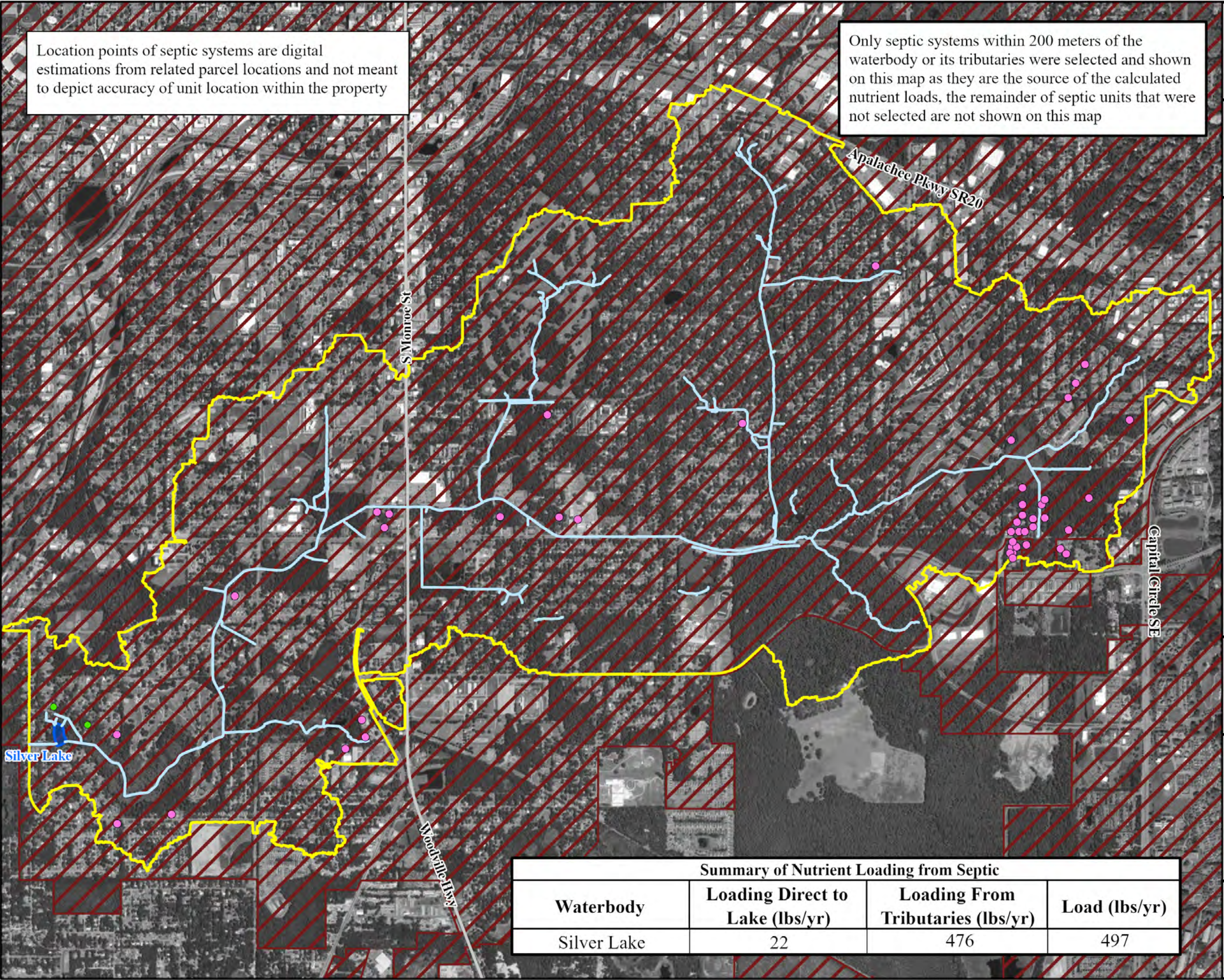
In the qualitative assessment of potential pollutant loads to Silver Lake (see **Section 3.5.4.4**), an assessment was made relative to the potential for anthropogenically driven internal loading. The assessment determined that internal recycling from the lake is not identified as a significant load to the system.

3.6.5.6 Atmospheric Deposition

As presented and discussed in **Section 3.4.5.6**, the annual average atmospheric TN load per acre was calculated from the Quincy NADP station (FL14) at 2.56 lb/acre/year. Multiplying this by the acreage of Silver Lake (2.1 acres) gives a total TN load of 5 lb/year. No data are available for TP, therefore, only the nitrogen load is provided.

3.6.5.4 Summary of Calculated Loads

Nutrient loads to Silver Lake were calculated for stormwater runoff, septic systems, and atmospheric deposition. **Table 3-18** presents the calculated total loads to the lake for TN and TP. For septic systems and atmospheric deposition, only TN loads were calculated. It is clear that for the calculated loads, stormwater runoff represents the primary source of nutrient loading to Silver Lake/East Drainage Ditch and downstream.



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0 0.4
Miles

Legend

- Silver Lake Drainage Basin
- Waterbodies in Study
- Watercourses
- Major Roads
- Relevant Septic Sites
 - Lake
 - Tributaries

Sources:
Waterbodies: COT, 2020
Watercourses: COT, 2020
Septic Systems: COT, 2020
Watershed: COT, 2020
Roads: COT-Leon County, 2023

Figure 3-115:
Silver Lake/East Drainage Ditch Septic Loading

Tallahassee Master Plan - Surface Water (TMaPS)

Geosyntec
consultants

Table 3-18: Summary of Calculated Loads to Silver Lake

Source	TN (lb/year)	TP (lb/year)
Stormwater Runoff	13,554	3,049
Septic Systems	497	NC
Atmospheric Deposition	5	NC

NC – Not calculated

3.7 Lake Munson Basin Hot Spot Analysis

Using the information presented and discussed in **Section 3.4** through **Section 3.6**, qualitative and quantitative rankings were performed to identify target areas (hot spots) within the Lake Munson basin for development of structural and non-structural projects to reduce loads and improve water quality.

The hot spot analysis was completed in three steps. The first step was to collate information presented for each of the waterbodies to support their ranking from highest to lowest based on need for water quality restoration. The second step was to utilize the load calculations presented for each of the waterbodies to rank the sources (by waterbody) from lowest to highest based on total load and other factors. The final step was to provide spatial ranking of CDAs (as defined in the TN and TP load calculations) by waterbody for use in the identification of structural and non-structural projects. The higher ranked CDAs within a highly ranked waterbody are hot spots and will be targeted for potential pollutant load reduction projects.

For the rankings, nutrients were the primary driver, with FIB data used to support some of the determinations. All rankings using actual loading data were based on nutrients. The following discusses the data utilized, the methodology, and the results of each step of the hot spot analysis, culminating in stormwater runoff and septic hot spot maps for the Lake Munson basin.

3.7.1 Waterbody Ranking

The waterbodies within the Lake Munson basin were ranked with respect to water quality or factors that could negatively affect water quality, using a qualitative approach. The ranking identified those waterbodies most in need of restoration. The waterbodies evaluated in this analysis include the following:

- Lake Munson,
- Munson Slough downstream of Lake Henrietta SWMF,
- Lake Bradford,
- Lake Hiawatha,
- Cascade Lake, and
- Silver Lake/East Drainage Ditch.

The information utilized in the development of the waterbody ranking included:

- Verified impairment status (nutrients and bacteria),
- Waterbody and tributary water quality data analyses,
- Biological data,
- Land development indices, and
- Septic densities.

Table 3-19 presents a summary of the information by waterbody for each of the categories listed above. The waterbodies were ranked for each of the four categories. Based on the summary information available, the rankings were qualitative for some categories and quantitative in others. The five rankings were then averaged. Using the average ranking, the waterbodies were ranked from highest to lowest based on need for water quality restoration.

For impairment status, the rankings were based on if the waterbodies were verified impaired for nutrients or FIB, their present status relative to TMDL development, and if the waterbody is meeting its TMDL. Waterbodies that were impaired for nutrients were given the higher ranking. Munson Slough and Lake Munson have completed nutrient TMDLs, and Munson Slough has a completed fecal coliform TMDL. As discussed in **Sections 3.4.2** and **3.4.3.7**, Munson Slough is presently meeting its nutrient TMDL and has been placed in Category 2t. Additionally, recent assessments of Munson Slough and Lake Munson relative to *E. coli* show those waterbodies as not impaired for *E. coli*. Lake Munson is presently meeting the NNC and TMDL Chl-a, and TN targets, with recent TP levels very close to the NNC and TMDL targets. As such, Lake Munson received the highest ranking relative to verified impairment, with Munson Slough just below it. The Bradford Chain of Lakes has never been and is not impaired for either nutrients or FIB and thus ranked the lowest. Silver Lake and the East Drainage Ditch have never been impaired for nutrients relative to the stream NNC but is presently impaired for fecal coliform, although recent data would indicate that once assessed against *E. coli*, the system would not be impaired for FIB. Based on this, Silver Lake and the East Drainage Ditch are ranked below Munson Slough and above the Bradford Chain of Lakes.

Analyses of water quality data presented earlier, which included evaluations of the data against the NNC and TMDL targets for the waterbodies, were utilized for the waterbody water quality ranking. The highest ranked waterbody was Lake Munson. This is based on the AGMs for TN, TP, and Chl-a exceeding the TMDL criteria for many of the years since 2010. While recent TN and Chl-a AGMs are below the threshold, TP AGMs, while near the TMDL threshold in 2020, are still above the target. Munson Slough and the Silver Lake/East Drainage Ditch data showed very similar levels of TP against the stream criteria. Munson Slough had higher TN AGMs overall, therefore, Munson Slough was identified as the second ranked waterbody and Silver Lake/East Drainage Ditch the third ranked. Finally, the Bradford Chain of Lakes all exhibit relatively pristine water quality. The rankings (Lake Bradford at fourth, Lake Hiawatha at fifth, and Cascade Lake at sixth) were determined based on which had the lower AGMs for nutrients.

For the biological assessment, the LVI waterbody rankings used the exceptional, healthy, and impaired determinations for the rankings and the numbers of each. For the waterbodies assessed as stream segments (Munson Slough below Lake Henrietta, Silver Lake/East Drainage Ditch), the evaluations were based on available HA and SCI data. Based on this assessment (outlined in **Table 3-19**), the top ranked waterbodies were Silver Lake/East Drainage Ditch and Munson Slough. These are then followed by Lake Munson, Lake Bradford, and then Lake Hiawatha and Cascade Lake (tied).

Table 3-19: Waterbody Ranking

Waterbody	Impairment Status	Rank	Waterbody and Tributary Water Quality Analyses	Rank	Biological Data (LVI, HA or SCI)	Rank	LDI	Rank	Septic Density	Rank	Average Rank	Waterbody Rank
Lake Munson	Previously impaired for nutrients, TMDL Completed, TP levels close to the NNC and TMDL Targets.	1	AGMs for TN, TP, and Chl-a exceeded the TMDL criteria for many of the years since 2010. Recent TN and Chl-a AGMs are below the threshold, TP AGMs, while near the TMDL threshold in 2020 are still above the target.	1	LVI: 9 Healthy, 2 Exceptional	3	Mixture of Poor, Moderate, Good, and Excellent areas drain to Lake Munson.	2	Immediate areas around Lake Munson have densities between 0.16 to 0.31 units per acre.	2	1.80	1
Munson Slough (below Lake Henrietta)	Previously impaired for nutrients and FIB, TMDLs completed, Moved to 2t.	2	In 2010 and 2013 TN AGMs were above the NNC stream threshold. From 2010 to 2016 TN levels were below the NNC threshold but above the TMDL target. 2017 to 2020 TN AGMs below the TMDL target. From 2010 to 2020 TP AGMs were below the NNC threshold. Only 1 year (2012) had values above the TMDL target.	2	HA: Marginal to Poor, SCI: 45	1	Mixture of Poor, Moderate, Good, and Excellent areas drain to Lake Munson.	2	Immediate areas around Munson Slough have ranges from 0.12 to 0.31 units per acre but no system within 200 meters.	3	2.00	2
Lake Bradford	Never impaired for nutrients or bacteria.	4	TN and TP AGMs were below the NNC minimum thresholds for all years. Chl-a AGMs were below the NNC threshold for all years. Highest values for all of the three Bradford Chain of Lakes waterbodies.	4	4 Healthy, 7 Exceptional	4	Bulk of area draining to the Bradford Chain of Lakes is Excellent with some areas as Good.	3	Lake Bradford has relatively high density around the lake.	1	3.20	4
Lake Hiawatha	Never impaired for nutrients or bacteria.	4	TN and TP AGMs were below the NNC minimum thresholds for all years. Chl-a AGMs were below the NNC threshold for all years. AGMs were lower than Lake Bradford but higher than Cascade Lake.	5	All Exceptional	5	Bulk of area draining to the Bradford Chain of Lakes is Excellent with some areas as Good.	3	Very few systems in the immediate area of Lake Hiawatha.	4	4.20	6
Cascade Lake	Never impaired for nutrients or bacteria.	4	TN and TP AGMs were below the NNC minimum thresholds for all years. Chl-a AGMs were below the NNC threshold for all years. Lowest values for all of the three Bradford Chain of Lakes waterbodies.	6	All Exceptional	5	Bulk of area draining to the Bradford Chain of Lakes is Excellent with some areas as Good.	3	Some septic areas immediately north of Cascade Lake with densities between 0.16 to 0.31 units per acre.	2	4.00	5
Silver Lake/East Drainage Ditch	Never impaired for nutrients, impaired for fecal coliform, but likely not for <i>E. coli</i> .	3	TN AGMs well below the stream criteria from 2010 to the present. All TP AGM values below the stream criteria from 2010 to the present with some values between 2010 to 2015 near the criteria.	3	HA: Marginal to Poor	1	All of the drainage area to Silver Lake is rated as Moderate.	1	All areas draining to Silver Lake have densities between 0.03 and 0.06 units per acre.	5	2.60	3

Using the LDI scores presented earlier, the individual waterbodies were ranked based upon where they fell overall in the potential for anthropogenic loading based on the watershed that drains to it (**Figure 3-34**). Based on LDI, the highest ranked waterbody was Silver Lake followed by Lake Munson and Munson Slough (tied). The Bradford Chain of Lakes was the lowest ranked.

The final waterbody ranking criteria was septic density within the immediate drainage area. The top ranked waterbody was Lake Bradford, which has a significant number of septic systems immediately adjacent to the lake. Lake Munson and Cascade Lake were tied for second. Munson Slough was third. Lake Hiawatha and Silver Lake were ranked fourth and fifth, respectively.

Table 3-19 provides an average ranking for each of the waterbodies and then a final ranking based on the average ranking. The final rankings by waterbody, with respect to the need for restoration activities, are presented from most pressing (1) to least pressing (6) in the order shown below:

1. Lake Munson,
2. Munson Slough,
3. Silver Lake,
4. Lake Bradford,
5. Cascade Lake, and
6. Lake Hiawatha.

3.7.2 Pollutant Source Ranking

The pollutant source ranking utilizes load calculations presented in the **Calculation of Potential Nutrient Loads** sections for each waterbody. The specific loads quantified (where data allowed) include the following:

- Stormwater pollutant load,
- Septic load,
- Lake inflow load, and
- Atmospheric deposition.

Presently, data are not available to calculate the point source loads and the internal lake loads. The qualitative assessment of sources identified that point source loads are not significant in the basin. Silver Lake was identified as not having a significant potential for internal nutrient loads. Recent water quality data for Lake Munson indicates that internal nutrient loads have decreased but may still be a source. **Section 3.8** provides a recommendation for a study to define internal loads for Lake Munson.

Using the calculated total loads for nutrients, the load sources are ranked for each individual waterbody to support assessment of the loads to prioritize. The ranking (by waterbody) is based upon the total loads, with the highest rank (the top source to target) assigned to the largest load.

Where insufficient data are available, the load sources are not considered in the ranking. Additionally, where the loads are zero, i.e., no load, these source types are not included in the ranking. This is the case for point source loads in the Lake Munson basin as well as inter-lake loads for some of the waterbodies.

Table 3-20 presents the results of the source ranking by waterbody. As some of the load types only had TN data, TN was the main driver of the rankings. For Lake Munson, Munson Slough, and Silver Lake/East Drainage Ditch, stormwater loads are identified as the top ranked source. Based on the assessments presented earlier that evaluated concentrations in Munson Slough downstream of the Lake Henrietta SWMF, the present levels are such that while stormwater loads are the largest single load, they would likely not be targeted for reduction for Munson Slough downstream of the Lake Henrietta SWMF or Lake Munson. Those loads are highly dependent upon treatment within Lake Henrietta, so a study is recommended in **Section 3.8** to assess performance.

Due to limited data along the ditched portions upstream and downstream of Silver Lake after 2014, additional data collection is recommended in **Section 3.8** to fully quantify the loading coming from the Silver Lake/East Drainage Ditch basin and the load to Silver Lake.

Within the Bradford Chain of Lakes, stormwater loading from the Apalachicola National Forest is the primary source to Cascade Lake, but due to the flow through nature of the system, the highest loads to Lake Hiawatha and Lake Bradford are lake inflow loads from upstream lakes. Given the nature of the land uses within the Apalachicola National Forest, while these are the largest loads, they were not identified as reduction targets in the qualitative assessment (**Section 3.5.4**) due to the present water quality conditions in the system. Relative to septic loading (in relation to other loads) Lake Bradford and Cascade Lake exhibit potentially significant septic loads.

Finally, atmospheric loads were calculated to evaluate its potential relative to other sources. In general, atmospheric loads are small in relation to the stormwater loads and do not rank high for any of the waterbodies.

Based on the limited data and loading analyses that showed high per acre loads, the Silver Lake/East Drainage Ditch is a potential target for stormwater load reduction. Another target is septic loading to Lake Bradford. Other loading sources are at zero, are low compared to the stormwater or septic, are not addressable through projects (atmospheric deposition), or have insufficient data at this time (internal load to Lake Munson).

Again, however, this analysis is limited to the available data. No data is available to calculate the internal loads for any of the waterbodies. Internal loads to Lake Munson were identified as significant prior to 2016. Based on recent data, the internal loads appear to have decreased. Based on Lake Munson's history relative to internal loads, while water quality data indicate the internal load has decreased, there is a need to quantify the present internal load to determine need for further action. A study is recommended in **Section 3.8**.

Table 3-20: Source Ranking

Waterbody	Lake Area	Stormwater Pollutant Load			Septic Load			Lake Inflow Load			Atmospheric Deposition		
		Total		Rank	Total		Rank	Total		Rank	Total		Rank
		TN (lb/yr)	TP (lb/yr)		TN (lb/yr)	TP (lb/yr)		TN (lb/yr)	TP (lb/yr)		TN (lb/yr)	TP (lb/yr)	
Lake Munson	255	60,135	5,840	1	1,049	NC	2	ND	ND		653	ND	3
Munson Slough (below Lake Henrietta)	NA	59,244	5,640	1	0	NC	NC	0	0	NC	NA	NA	NC
Lake Bradford	149	340	74	4	725	NC	2	12,646	302	1	381	ND	3
Lake Hiawatha	40	617	105	2	76	NC	4	13,095	240	1	102	ND	3
Cascade Lake	109	12,006	2,751	1	692	NC	2	0	0	NC	279	ND	3
Silver Lake/East Drainage Ditch	2.1	13,533	3,049	1	130	NC	2	0	0	NC	5	ND	3

3.7.3 Identification of Hot Spot Areas

Section 3.7.1 ranked the waterbodies in the Lake Munson basin based on their relative need for water quality restoration. The next step in the evaluation of the waterbodies was to determine if each one should be considered for development of projects. This is a qualitative assessment that accounts for the present conditions and the potential for future degradation. For the Lake Munson basin, it was determined that Silver Lake and its associated drainage basin (East Drainage Ditch) should be targeted for projects relative to stormwater loads. Lake Bradford was targeted for potential projects to reduce septic loads.

The next step was to present the stormwater and septic load rankings for each of the chosen waterbodies presented on a basin-wide map. The stormwater load rankings were presented by waterbody drainage area in the **Calculation of Potential Nutrient Loads** sections. The highest to lowest ranked CDAs were highlighted from dark green to pale yellow, with the dark green representing the top ranked areas to target for load reduction activities.

For septic loads, the total loads (calculated and presented in earlier sections) were subdivided into the CDAs based upon the location of septic systems that were determined to load the waterbodies or tributaries draining to the waterbodies. The total septic load for each of the CDAs was calculated and then ranked (by waterbody drainage area) as largest to smallest based on total load, with the highest ranked having the largest total load. The septic load CDA rankings are presented separately as their loads will be different and the potential project types also different, i.e., septic-to-sewer conversions.

Exhibit 3-8 and **Exhibit 3-9** present the CDA rankings for the stormwater and septic loads, respectively, for each of the chosen waterbodies, with the drainage areas for the waterbodies not identified for projects (Lake Munson and Munson Slough for stormwater and septic, Cascade Lake and Lake Hiawatha for stormwater and septic, Bradford Lake for stormwater, and Silver Lake/East Drainage Ditch for septic) greyed out. The rankings are by waterbody drainage area and are shown as green for the highest ranked areas and pale yellow for the lowest ranked areas. These two maps provide the basis for project targeting for the two primary sources identified, stormwater and septic loads.

Waterbody	Rank
Lake Munson	1
Munson Slough	2
Silver Lake	3
Lake Bradford	4
Cascade Lake	5
Lake Hiawatha	6

The stormwater load ranking by CDA for Lake Bradford, Lake Hiawatha, and Cascade Lake are not provided as these waterbodies were not targeted for stormwater load reduction projects based on the qualitative assessment presented in Section 3.7.3

Legend

Lake Munson Drainage Basin

Waterbodies in Study

Watercourses

Tallahassee Corporate Limits

Stormwater Load Ranking

High
Low

Sources:
Waterbodies: COT, 2020
Watersheds: COT, 2020
Watercourses: COT, 2020
City Limits: COT, 2020

N

04,000

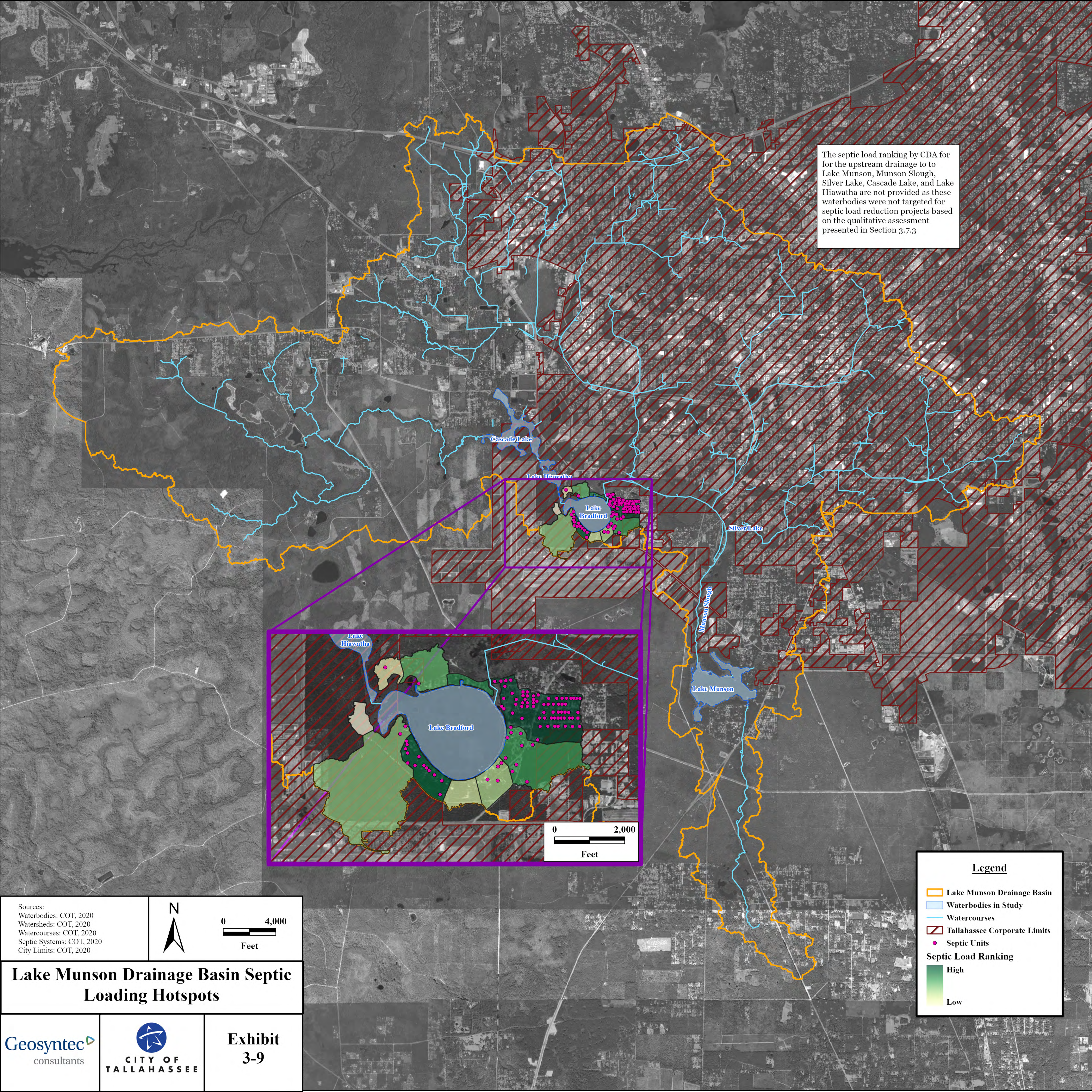
Feet

Lake Munson Drainage Basin
Stormwater Loading Hotspots

Geosyntec
consultants

CITY OF
TALLAHASSEE

Exhibit
3-8



Sources:
Waterbodies: COT, 2020
Watersheds: COT, 2020
Watercourses: COT, 2020
Septic Systems: COT, 2020
City Limits: COT, 2020

Lake Munson Drainage Basin Septic Loading Hotspots

Geosyntec consultants


CITY OF TALLAHASSEE

Exhibit 3-9

3.8 Water Quality Study Identification and Prioritization

As part of the data review and summary provided for each of the target waterbodies (**Section 3.4** through **Section 3.7**), limitations in available hydrologic, water quality (groundwater and surface water), and benthic sediment data were identified. Additionally, as part of the qualitative assessment of sources for each waterbody, specific key stressors, i.e., significant potential sources of anthropogenic load or factors contributing to degraded water quality, were identified. Finally, **Section 3.7** presented a hot spot analysis for the Lake Munson basin that ranked the waterbodies relative to their need for restoration and identified specific waterbodies to target for restoration projects, additional data collection, or studies.

Utilizing the information outlined above, potential water quality improvement studies needed to address data gaps and quantify key stressors were proposed and ranked. The results of the previous tasks are summarized in **Section 3.8.1**, along with an overview of key stressors for the priority waterbodies (Lake Munson, Silver Lake/East Drainage Ditch and Lake Bradford). Studies are identified that fill in data gaps, support quantification of specific waterbody stressor(s) or support waterbody restoration (**Section 3.8.2**). The proposed studies include new water quality data collection, internal nutrient loading assessment, evaluation of potential septic loading, and a performance assessment for the Lake Henrietta SWMF.

3.8.1 Summary of Data Limitations, Waterbody Prioritization, and Key Stressors

Table 3-21 provides a summary of the data limitations presented at the end of the data review and summary sections for each of the waterbodies in this study (**Section 3.4** through **Section 3.6**). The data limitations identified include old water quality data, no groundwater quality data in the area of the study waterbodies to allow assessment of potential seepage, and no data to quantify internal nutrient loading.

Section 3.7.3 presented the prioritized waterbodies for restoration within the Lake Munson basin. These included Silver Lake for stormwater loads and Lake Bradford for septic loading. These waterbodies are targeted for development of projects to support water quality improvement. Identified projects are discussed in **Volume 7 – Non-Structural and Structural Project Development**.

The prioritized waterbodies are also targeted for studies to fill data gaps to further refine restoration strategies. As such, the proposed studies focus on these waterbodies.

A key task under the scope of work for the basin studies identification was to review and assess stressors for the priority waterbodies. The stressors were reviewed to confirm potential water quality impact and pathways of pollutant migration to the waterbodies. The intent is to identify where additional data collection and analysis of advanced analytic parameters might help better understand the expected load/contribution of the source. The following sections outline the key stressors identified in previous sections for the prioritized waterbodies within the Lake Munson basin (Lake Munson, Silver Lake/East Drainage Ditch and Lake Bradford).

Table 3-21: Summary of Identified Data Limitations for Waterbodies in the Lake Munson Basin

Lake Munson and Munson Slough	Silver Lake	Bradford Chain of Lakes
Limited data to evaluate the potential for seepage of pollutants to the lake from the surficial aquifer, i.e., surficial groundwater sampling stations around the lake and along the slough.	The water quality monitoring stations along the East Drainage Ditch were discontinued around 2014 which limits available recent data on the primary discharge to the lake.	The water quality data along Bradford Creek immediately upstream of Cascade Lake is old and limited (prior to 2006).
No direct measurements of internal nutrient flux within Lake Munson have been completed that reflect the internal loading conditions that exist today.	No surficial groundwater monitoring stations are located in the vicinity of the lake to determine the quality of potential seepage into the lake.	There are limited data to evaluate the potential for seepage of pollutants to the lakes from the surficial aquifer, i.e., surficial groundwater sampling stations around the lakes with recent data.
	No data are available to assess potential internal loading.	

3.8.1.1 Lake Munson Key Stressors

Water quality analyses and the qualitative assessment of sources identified internal nutrient loading as a potential key stressor to Lake Munson. The analyses of data within Munson Slough showed that stormwater inputs, while representing the largest quantified load, were at concentrations well below the stream NNC and the TMDL target for the slough and as such, stormwater loading was not identified as a key stressor. At present, no direct measurements of internal loading for the lake have been completed. Analyses of available data upstream, within, and downstream of the lake (**Section 3.4.4.4**) indicates that the internal load has decreased in more recent years and may be playing a lesser role. However, based on the lake's history relative to internal loading and the lack of data, internal loading may still be a stressor to the lake and should be quantified.

3.8.1.2 Silver Lake/East Drainage Ditch Key Stressors

Water quality analyses and the qualitative assessment of sources (**Section 3.6.3.6** and **Section 3.6.3.7**) identified stormwater loading as the key potential stressors. This was based on limited data to perform a full assessment since data collection within the East Drainage Ditch, upstream and downstream of the lake, were discontinued in 2014. Based on this, recommendations are made below on re-establishing monitoring within the East Drainage Ditch.

3.8.1.3 Lake Bradford Key Stressors

Lake Bradford is presently exhibiting relatively pristine water quality and biology. In the qualitative assessment of sources (**Section 3.5.4.8**), septic loading was identified as a potential

stressor to the lake based on somewhat elevated bacteria levels nearshore in relation to the other lakes in the chain and the center station in Lake Bradford. The present density of septic systems around the lake and recommendations in the Lake Bradford Sector Plan (**Section 3.5.1**) to extend sewer to the area also indicate the need for a study of the potential impacts of septic loading on Lake Bradford.

While nutrients and FIB are the primary focus of this study, lead impairments exist in the Bradford Chain of Lakes and, therefore, a study is recommended to try to determine the potential source of the impairment.

3.8.2 Study/Data Collection Recommendations

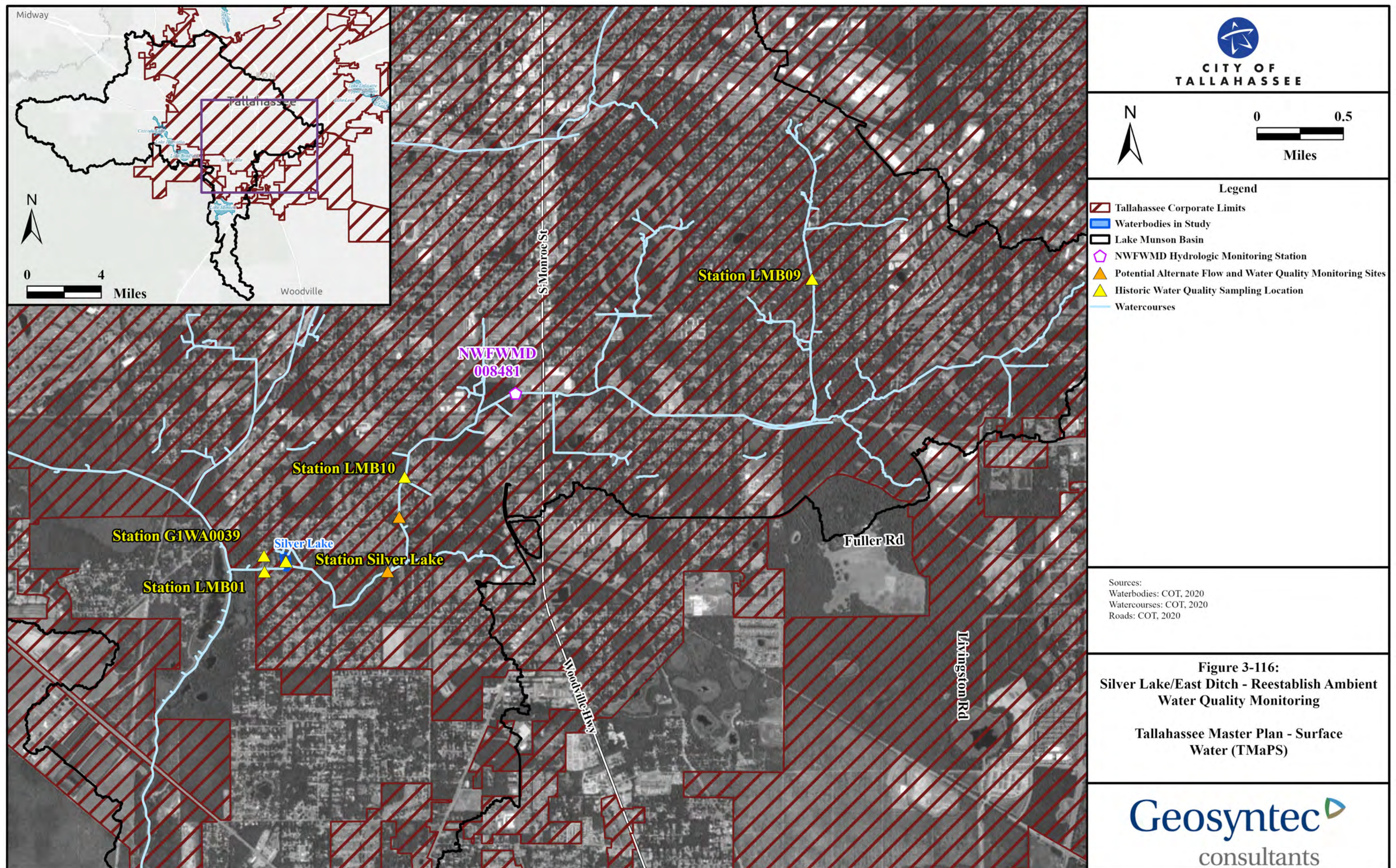
Based on the data limitations and waterbody stressors outlined in **Section 3.8.1**, additional data collection and waterbody study recommendations were developed in conjunction with City staff. The list of recommended studies includes the following:

- East Ditch/Silver Lake – Re-establish Ambient Water Quality Monitoring,
- Lake Munson – Internal Nutrient Load Study,
- Lake Munson/Munson Slough – Lake Henrietta Treatment Facility Inflow/Outflow Study,
- Lake Bradford – Septic Study, and
- Bradford Chain of Lakes – Lead Source Assessment.

The following outlines the justification, what stressors or data limitations are being addressed, and a general description of the work to be performed, along with initial scope items for each of the data collection/studies listed previously. It is noted that some of these studies are outside of the City's incorporated areas and, therefore, the studies would need to occur under the jurisdiction of the state or county.

3.8.2.1 East Ditch: Re-Establish Ambient Water Quality Monitoring

Section 3.8.1 identified that historical ambient water quality sampling on the East Ditch was discontinued in 2014. **Figure 3-116** presents a map showing the location of the historical ambient stations. These stations were sampled from 2011 to 2014. **Section 3.8.1.2** identified nutrient loading (specifically phosphorus) to Silver Lake as one of the potential stressors. Based on this, ambient water quality monitoring of the East Ditch should be re-established with specific focus on nutrients along with *E. coli* data to support evaluation of the bacteria impairment on the ditch.



Presently, NFWFMD maintains a hydrologic monitoring station (008481) along the East Ditch at the crossing with Adams Street (**Figure 3-116**). This station collects continuous water levels and calculates flow based on rating curves for the site. The ambient water quality sampling, in conjunction with the continuous flows, will allow quantification of the concentrations and loads going to Silver Lake/East Drainage Ditch and ultimately transported downstream to Lake Munson. The scope of the data collection should evaluate historical station locations versus establishment of new stations to define optimal locations, recognizing the benefit of comparison to historic data. **Figure 3-116** presents some alternative sampling locations that would quantify a larger percentage of the watershed flowing into Silver Lake than historical locations. Additionally, as the Silver Lake/East Drainage Ditch basin flows to Lake Munson, monitoring of downstream should be re-established. An additional recommendation for this study is to evaluate the accuracy of the continuous flow measurements and, if needed, make recommendations on improving the accuracy of the measurements or potentially relocating the station.

The recommended elements for the data collection effort described above are as follows.

- Site reconnaissance to understand the site logistics, including historical and potential future monitoring locations, as well as develop consensus with City staff on station locations and monitoring approach.
- Assessment of the accuracy of the continuous flow measurements at NFWFMD Station 008481 and development of recommendations for updates to the monitoring approach, including recommendations on station relocation.
- Re-establish ambient monitoring.

3.8.2.2 Lake Munson: Internal Load Measurements

In **Section 3.8.1**, an internal nutrient load study was recommended for Lake Munson based on historical conditions and lack of data to quantify present conditions. Based on this, a study is recommended to characterize the sediments in the lake and to determine if nutrient flux from those sediments is a significant load to the lake.

The recommended elements for the study outlined above are as follows.

- Site reconnaissance to understand the site logistics, lake access, and potential sites and number for sediment and core sampling.
- Development of a Quality Assurance Project Plan (QAPP) that details staff responsibilities, sampling procedure, sediment and core sampling locations, methodology, equipment, and laboratory analytical requirements for the data collection.
- Sediment sampling and collection of cores for performing nutrient flux measurements.
- Data reporting and analyses that present the raw data and any analyses outlined in the QAPP, along with an overview of the sampling methodology, issues encountered, and methods of resolution.

3.8.2.3 Lake Munson/Munson Slough: Lake Henrietta SWMF Inflow/Outflow Study

The primary stormwater treatment facility and the last point of treatment for waters draining to Lake Munson is the Lake Henrietta SWMF. This facility accepts drainage from nearly all of the Lake Munson basin. **Figure 3-117** shows the location of the Lake Henrietta SWMF, the facility components, and photos of the present conditions taken in 2021 of the northern and southern portions.

The Lake Henrietta facility resides outside the City limits and is currently operated by Leon County. However, based on identification of sedimentation and other potential issues within the system, an assessment of the present performance is warranted. Based on this, a study is proposed to do concurrent inflow and outflow monitoring during various flow conditions.

The recommended components of the monitoring outlined above are as follows.

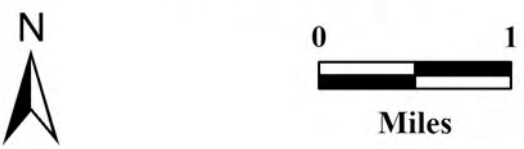
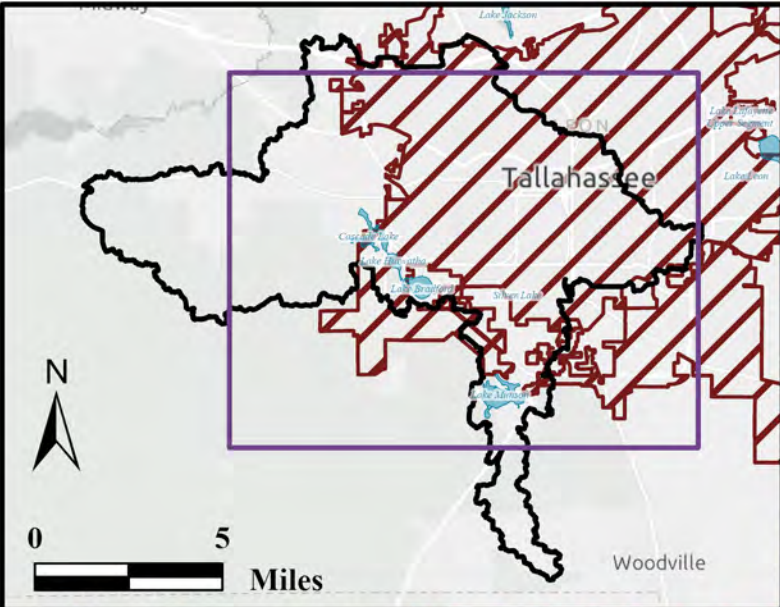
- Site reconnaissance to understand the site logistics, including historical and potential future monitoring locations, as well as develop consensus with City staff on station locations and monitoring approach.
- Assessment of the accuracy of the continuous flow measurements at NFWFMD Station 008481 and development of recommendations for updates to the monitoring approach.
- Development of a QAPP that details staff responsibilities, sampling procedures, sampling locations, methodology, equipment, and laboratory analytical requirements for the data collection.
- Execution of the monitoring plan as outlined in the QAPP.
- Development of a final report summarizing the findings of the study.

3.8.2.4 Lake Bradford: Septic Study

In **Section 3.8.1.3**, which outlined the stressors for Lake Bradford and the qualitative assessment of sources (**Section 3.5.4.8**), the need for a quantitative analysis of the impact of septic loading to Lake Bradford was identified.

Figure 3-118 shows the distribution of septic coverage around the Bradford Chain of Lakes, showing Lake Bradford fully surrounded by lots with septic systems. Additionally, the station clusters discussed in **Section 3.5.4.8** are presented showing the nearshore clusters in the lake (BW, BE) with elevated *E. coli* averages in relation to other station clusters on the lakes.

The study approach would be to utilize targeted sampling around the lake in conjunction with advanced analytic parameters such as isotopic analysis, pharmaceuticals, and microbial source tracking. Additionally, monitoring of surficial groundwater in the immediate shoreline areas of the lake would provide information on the potential for seepage from septic systems.



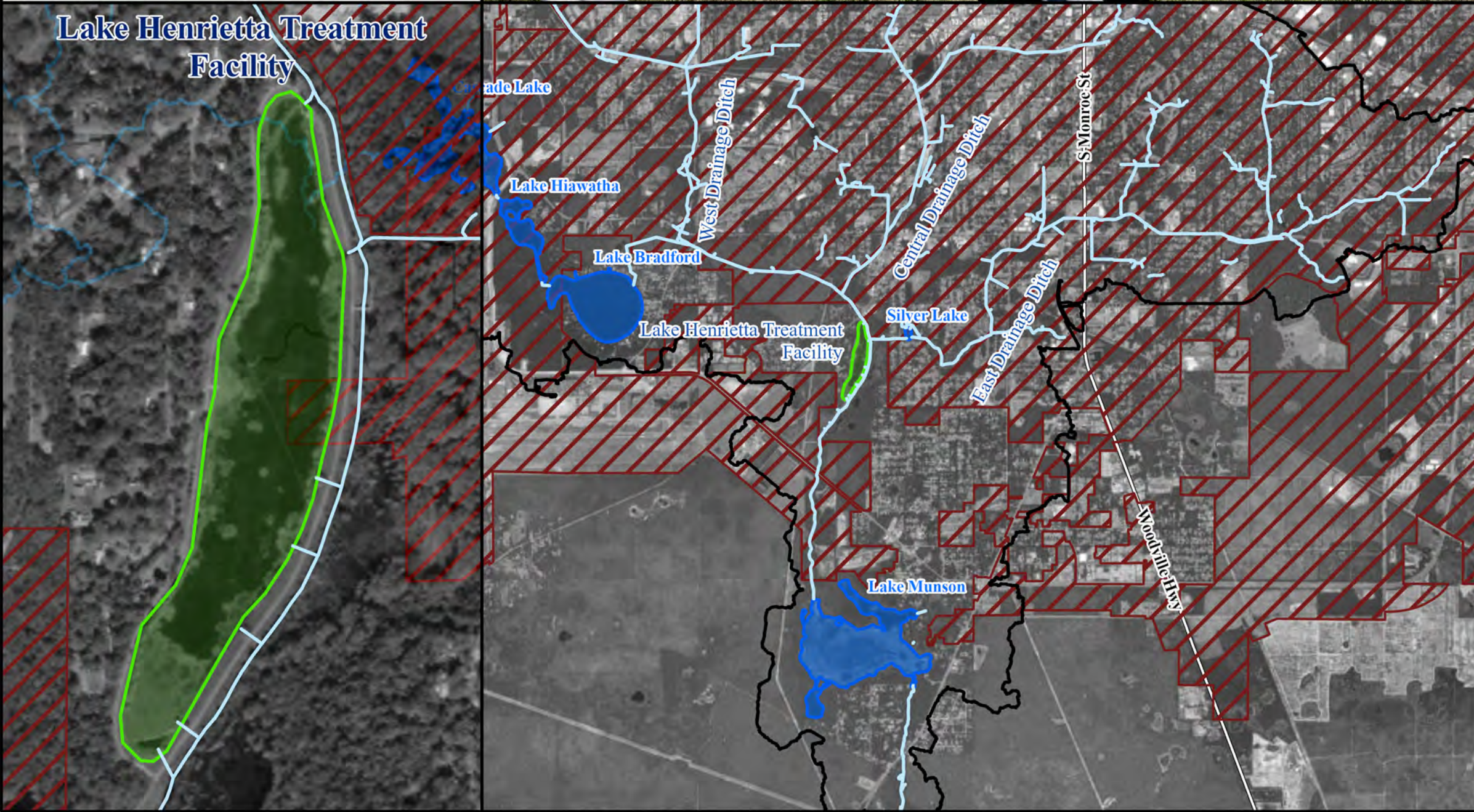
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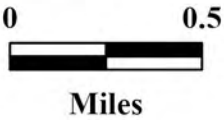
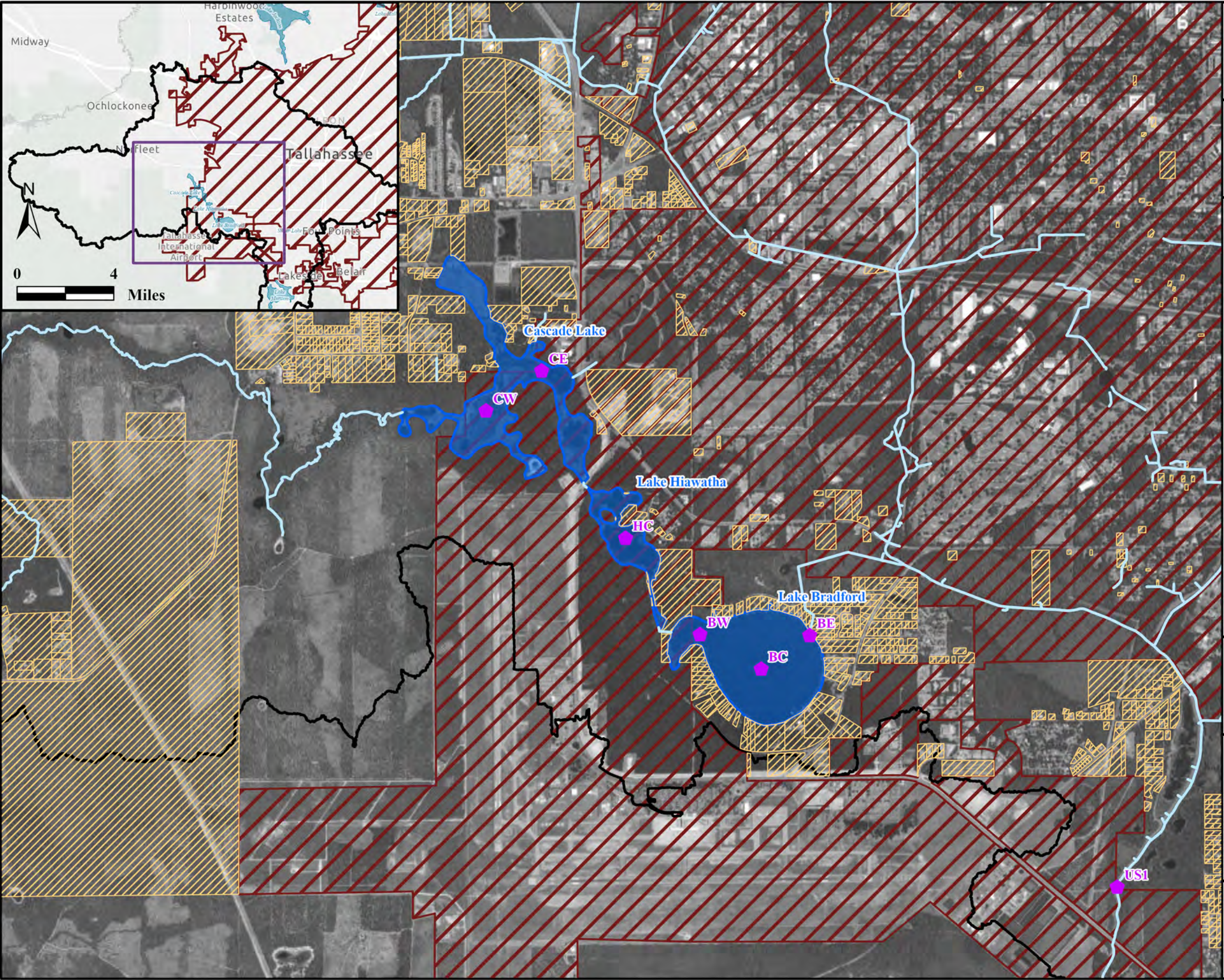
- Waterbodies in Study
- Tallahassee Corporate Limits
- Lake Munson Basin
- Lake Henrietta Treatment Facility
- Watercourses

Sources:
Waterbodies: COT, 2020
Watercourses: COT, 2020
Roads: COT, 2020

Figure 3-117:
Lake Henrietta Treatment Facility Inflow/
Outflow Study

Tallahassee Master Plan - Surface
Water (TMaPS)





Legend

-  Waterbodies in Study
-  Tallahassee Corporate Limits
-  Lake Munson Basin
-  Septic Coverage
-  In-Lake Station Clusters
-  Watercourses

Sources:
 Waterbodies: COT, 2020
 Watercourses: COT, 2020
 Roads: COT, 2020

Figure 3-118:
Lake Bradford - Septic Study

**Tallahassee Master Plan - Surface
 Water (TMaPS)**

The recommended elements for the study described above are as follows.

- Detailed review of historical data within Lake Bradford.
- Reconnaissance to understand the site logistics, including historical and potential future monitoring locations, as well as develop consensus with City staff on station locations, monitoring approach, and development of the QAPP.
- Development of a QAPP that details staff responsibilities, sampling procedure, methodology, equipment, and laboratory analytical requirements for this project.
- Field monitoring and sampling as outlined in the QAPP.
- Data analyses to evaluate results of the study and provide a determination on septic loading to the lake.
- Develop a final report summarizing the findings from the study.

3.8.2.5 Bradford Chain of Lakes – Lead Source Assessment

In **Section 3.5.2**, lead impairments and elevated levels were identified for the Bradford Chain of Lakes. Determination of the sources of lead is necessary to identify any potential remediation measures needed or to explain the present impairment status. A study is recommended to review the available data, perform literature review to identify potential sources or factors that presently exacerbate levels, and where appropriate, conduct additional sampling or site reconnaissance to support determination of potential sources.

The following study scope of work is proposed, with brief descriptions of the work that may be performed. A project kick-off meeting task and project management task would also be included.

- Field reconnaissance of the Bradford Chain of Lakes sub-watersheds to familiarize with conditions and potential sources as well as potential sampling locations.
- Literature review to support identification of potential sources or factors that exacerbate levels in the systems.
- Analysis of existing water quality data including data related to parameters that might exacerbate levels in the system.
- Identification of the need for additional sampling and development of a monitoring plan if sampling is needed.
- Development of a QAPP that details staff responsibilities, sampling procedure, methodology, equipment, and laboratory analytical requirements for the project.
- Execution of the monitoring plan.
- Development of a draft and final report summarizing the findings from the study.

3.8.3 Study Prioritization

To prioritize the proposed studies, a ranking table was developed that scored each of the projects in relation to the following:

- Waterbody priority ranking (**Table 3-19**),
- Source target ranking (the overall ranking of the source addressed by the study, **Table 3-20**),
- Restoration benefits (qualitative assessment of the benefits of the study),
- Extent of missing data, and
- Relative estimated cost.

Table 3-22 presents the study rankings for each of the individual metrics, the average score based on the individual rankings, and the final study ranking. The studies are divided between those that are within the City's incorporated area and those within unincorporated Leon County. These are shown on **Table 3-22**.

For the studies within the City's incorporated area, the top priority is the re-establishment of the ambient water quality monitoring on East Ditch, which is the only recommended study within the City's incorporated area.

For the studies within Leon County, the internal loading measurements in Lake Munson was identified as the top ranked study. The Lake Henrietta inflow/outflow study was second. The Lake Bradford septic study was ranked next. The lowest priority is the lead assessment study.

Table 3-22: Proposed Study Ranking

Target Waterbody	Proposed Study	Study Location	Waterbody Priority Ranking	Source Ranking	Restoration Benefits	Extent of Missing Data	Relative Estimated Cost	Average Rank	Study Ranking
East Ditch/Silver Lake	Re-Establish Ambient Water Quality Monitoring on East Ditch	City Incorporated Area	3	1	2	3	1	2.00	2
Lake Munson	Internal Loading Measurements in Lake Munson	Leon County	1	1	1	1	5	1.80	1
Munson Slough (Below Lake Henrietta)	Lake Henrietta Treatment Facility Inflow/Outflow Study	Leon County	2	1	3	2	2	2.00	2
Lake Bradford	Septic Study	Leon County	4	2	1	2	4	2.60	4
Bradford Chain of Lakes	Lead Source Assessment	Leon County	5	4	1	2	3	3.00	5

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