South District • Kissimmee River Basin

Draft Report

Nutrient TMDLs for Lake Istokpoga (WBID 1856B) and Documentation in Support of the Development of Site-Specific Numeric Interpretations of the Narrative Nutrient Criterion

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Executive Summary

This report presents the total maximum daily loads (TMDLs) developed to address the nutrient impairments of Lake Istokpoga, located in Highlands County. Lake Istokpoga was identified as impaired for nutrients based on the applicable lake numeric nutrient criteria (NNC) in subsection 62-302.531(2), Florida Administrative Code (F.A.C.), and was included on the Verified List of Impaired Waters for the Kissimmee River Basin, Group 4, Assessment Cycle 3, adopted by Secretarial Order in July 2017. Pursuant to paragraph 62-302.531(2)(a), F.A.C., these nutrient TMDLs will constitute the site-specific numeric interpretations of the narrative nutrient criterion set forth in paragraph 62-302.530(48)(b), F.A.C., that will replace the otherwise applicable NNC in subsection 62-302.531(2), F.A.C.

TMDLs for total nitrogen (TN) and total phosphorus (TP) have been developed, and **Table EX-1** lists supporting information for the TMDLs. They were developed in accordance with Section 303(d) of the federal Clean Water Act and guidance developed by the U.S. Environmental Protection Agency.

Table EX-1. Summary of TMDL supporting information for Lake Istokpoga

Type of Information	Description
Waterbody name/ Waterbody identification (WBID) number	Lake Istokpoga (WBID 1856B)
Hydrologic Unit Code (HUC) 8	03090101
Use classification/ Waterbody designation	Class III/Fresh
Targeted beneficial uses	Fish consumption; recreation; and propagation and maintenance of a healthy, well-balanced population of fish and wildlife
303(d) listing status	Verified List of Impaired Waters for the Group 4 basins (Kissimmee River Basin) adopted via Secretarial Order dated June 27, 2017
TMDL pollutants	TN and TP
TMDLs and site-specific interpretations of the narrative nutrient criterion	**Chlorophyll *a*:** 20 micrograms per liter (µg/L), expressed as an annual geometric mean (AGM) concentration not to be exceeded more than once in any consecutive 3-year period. The Lake Istokpoga TMDL does not establish a site-specific chlorophyll criterion; therefore, the generally applicable chlorophyll criterion still applies. **TN:** 1,345,998 pounds per year (lbs/yr), expressed as a rolling 7-year average load not to be exceeded **TP:** 54,073 lbs/yr, expressed as a rolling 7-year average load not to be exceeded
Load reductions required to meet the TMDLs	A 23 % TN reduction and a 56 % TP reduction to achieve a chlorophyll *a* target of 20 µg/L
Concentration-based lake restoration targets	**Lake Istokpoga (1856B)**: The nutrient concentrations corresponding to the chlorophyll *a* criterion and the loading-based criteria are a TN AGM of 1.18 milligrams per liter (mg/L) and a TP AGM of 0.040 mg/L, not to be exceeded in any year.

Acknowledgments

This analysis was accomplished thanks to significant contributions from staff in the Florida Department of Environmental Protection (DEP) Division of Environmental Assessment and Restoration, specifically, the Office of Watershed Services, Watershed Assessment Section, Standards Development Section, Water Quality Restoration Program, South Regional Operations Center, and Watershed Evaluation and TMDL Section. DEP would like to acknowledge Dawn Ritter and J.D. Forster of Highlands County for the substantial support provided.

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List of Acronyms and Abbreviations

AADF	Annual Average Daily Flor
ac-ft	Acre-Feet
ac/ft/yr	Acre-Feet Per Year
AGM	Annual Geometric Mean
AWT	Advanced Wastewater Treatment
BMAP	Basin Management Action Plan
BMP	Best Management Practice
BOD	Biochemical Oxygen Demand
BOD_5	5-Day Biochemical Oxygen Demand
°C.	Degrees Celsius
$CaCO_3$	Calcium Carbonate
CBP	Concrete Batch Plant
CFR	Code of Federal Regulations
cfs	Cubic Feet Per Second
Chla	Chlorophyll *a*
CWA	Clean Water Act
CV	Coefficient of Variation
DEP	Florida Department of Environmental Protection
DO	Dissolved Oxygen
EPA	U.S. Environmental Protection Agency
°F.	Degrees Fahrenheit
F.A.C.	Florida Administrative Code
FAWN	Florida Automatic Weather Network
FDOH	Florida Department of Health
FDOT	Florida Department of Transportation
FL	Florida
F.S.	Florida Statutes
FWRA	Florida Watershed Restoration Act
FWS	U.S. Fish and Wildlife Service
GIS	Geographic Information System
HRU	Hydrologic Response Unit
HSPF	Hydrological Simulation Program–Fortran
HUC	Hydrologic Unit Code
ID	Insufficient Data
IPaC	Information for Planning and Conservation (tool)
IWR	Impaired Surface Waters Rule
km^2	Square Kilometer
LA	Load Allocation
lbs/yr	Pounds Per Year

LVI	Lake Vegetation Index
mgd	Million Gallons Per Day
mg/L	Milligrams Per Liter
MIA	Mapped Impervious Area
mm	Millimeter
MOS	Margin of Safety
mph	Miles Per Hour
MS4	Municipal Separate Storm Sewer System
N	Nitrogen
NA	Not Applicable
NCDC	National Climatic Data Center
NEXRAD	Next-Generation Radar
NGVD	North American Vertical Datum
NH_3	Ammonia
NH_4	Ammonium
NLCD	National Land Cover Database
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NO_3+NO_2	Nitrite-nitrate
NOx	nitrogen oxide
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
NU	No Unit
OSTDS	Onsite Sewage Treatment and Disposal System
P	Phosphorus
PCU	Platinum Cobalt Unit
PLRG	Pollutant Load Reduction Goal
PO_4	Orthophosphate
POR	Period of Record
RMU	Reduced Modeling Unit
SFWMD	South Florida Water Management District
SJRWMD	St. Johns River Water Management District
SWFWMD	Southwest Florida Water Management District
SWIM	Surface Water Improvement and Management
TMDL	Total Maximum Daily Load
TN	Total Nitrogen
TP	Total Phosphorus
U.S.	United States
USACE	U.S. Army Corps of Engineers
USGS	U.S. Geological Survey
WAM	Watershed Assessment Model

WBID	Waterbody Identification
WLA	Wasteload Allocation
W/m^2	Watts Per Square Meter
WQS	Water Quality Standards
WWTF	Wastewater Treatment Facility
WWTP	Wastewater Treatment Plant

Chapter 1: Introduction

1.1 Purpose of Report

This report presents the total maximum daily loads (TMDLs) developed to address the nutrient impairment of Lake Istokpoga, located in the Kissimmee River Basin. Pursuant to paragraph 62-302.531(2)(a), Florida Administrative Code (F.A.C.), the TMDLs will also constitute the site-specific numeric interpretations of the narrative nutrient criterion set forth in paragraph 62-302.530(48)(b), F.A.C., that will replace the otherwise applicable numeric nutrient criteria (NNC) in subsection 62-302.531(2), F.A.C., for this particular waterbody. The lake was verified as impaired for nutrients using the methodology in the Identification of Impaired Surface Waters Rule (IWR) (Chapter 62-303, F.A.C.), and was included on the Verified List of Impaired Waters for the Kissimmee River Basin that was adopted by Secretarial Order in July 2017.

The TMDL process quantifies the amount of a pollutant that can be assimilated in a waterbody, identifies the sources of the pollutant, and provides water quality targets needed to achieve compliance with applicable water quality criteria based on the relationship between pollutant sources and water quality in the receiving waterbody. The TMDLs establish the allowable loadings to Lake Istokpoga that would restore the waterbody so that it meets its applicable water quality criteria for nutrients.

1.2 Identification of Waterbody

For assessment purposes, the Florida Department of Environmental Protection (DEP) divided the Kissimmee River Basin (Hydrologic Unit Code [HUC] 8 – 03090101) into watershed assessment polygons with a unique **w**ater**b**ody **id**entification (WBID) number for each watershed or surface water segment. Lake Istokpoga is WBID 1856B. **Figure 1.1** shows the location of the WBID and major geopolitical and hydrologic features in the region, and **Figure 1.2** contains a more detailed map of the WBID and its watershed boundary.

Lake Istokpoga (Latitude N 27° 22′ 31,″ Longitude W 81° 16′ 59″) is located 5 miles northeast of Lake Placid in Highlands County. The lake has a surface area of 27,673 acres, with a mean depth of 5 feet (ft) and a maximum depth of 8 ft. It is the 5th largest lake in Florida.

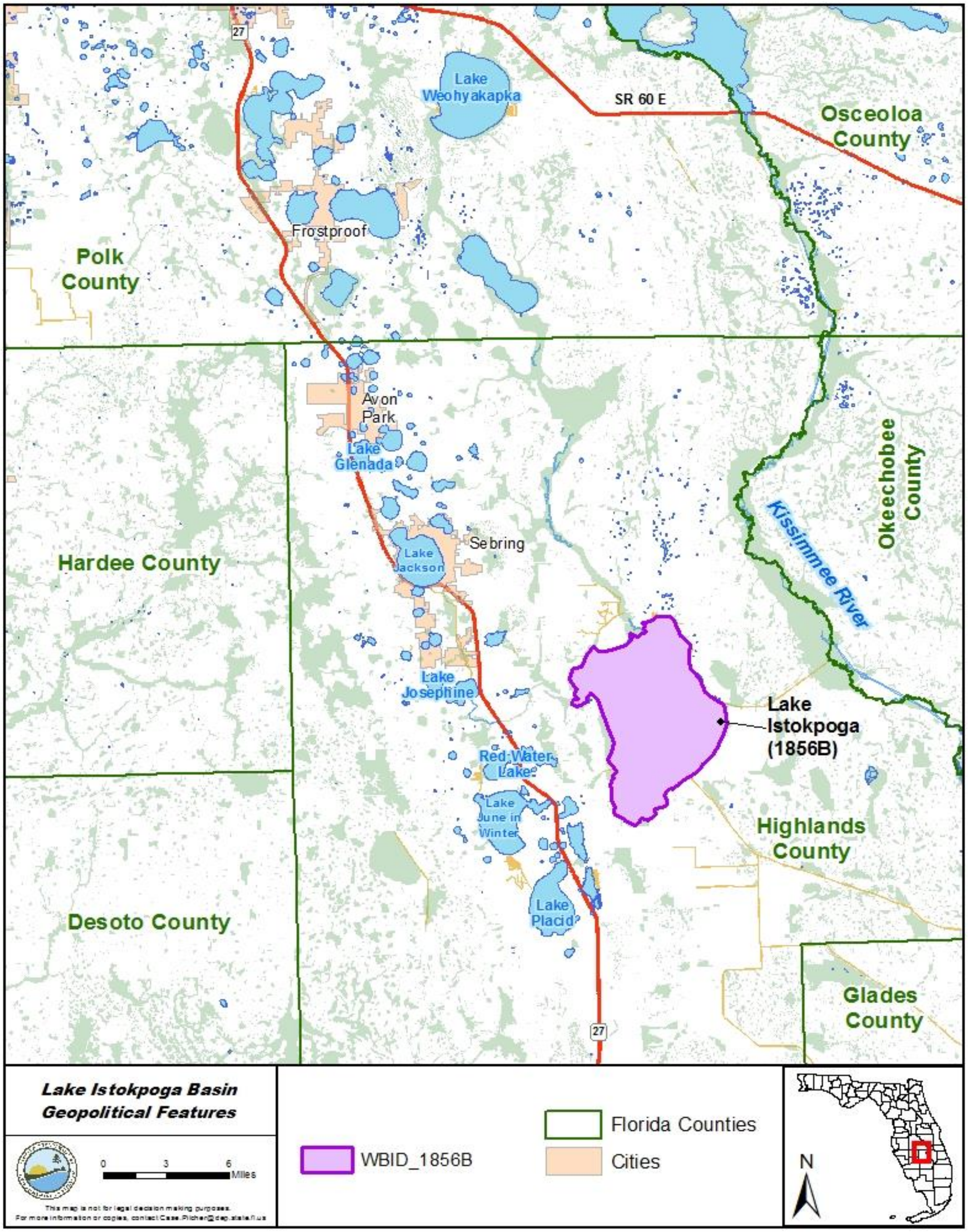

Figure 1.1. Location of Lake Istokpoga (WBID 1856B) in the Kissimmee River Basin and major geopolitical features in the area

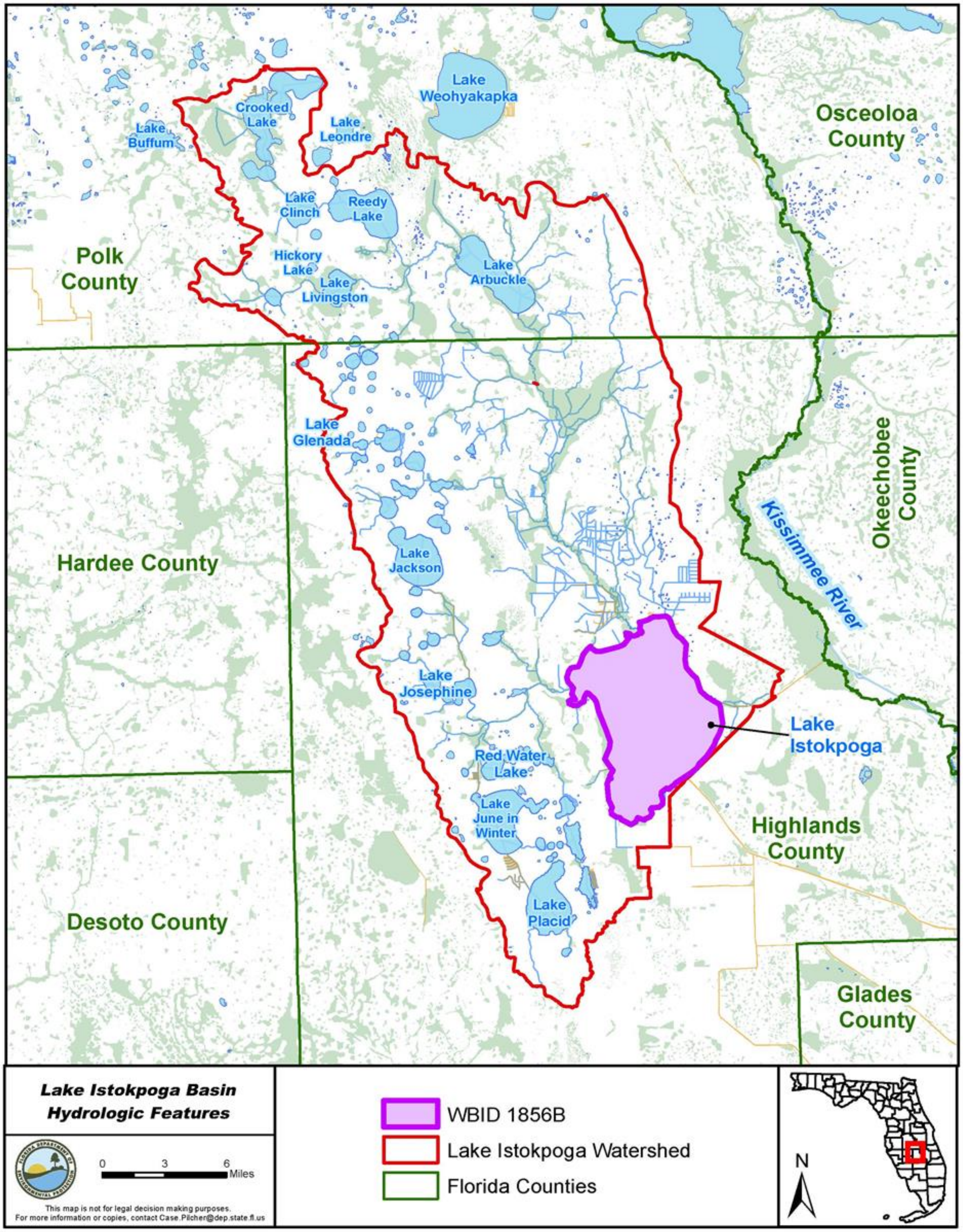

Figure 1.2. Lake Istokpoga Watershed and major hydrologic features in the Kissimmee River Basin

1.3 Watershed Information

1.3.1 Population and Geopolitical Setting

Lake Istokpoga is located in Highlands County, and its watershed expands north into southern Polk County. According to the 2018 data available from the U.S. Census Bureau, the population of Highlands County was 105,428, with a density of 101.2 persons per square mile. Highlands County occupies an area of 1,017 square miles, and in 2017, there were 55,641 housing units in the county, with a housing density of 54.7 houses per square mile (U.S. Census Bureau website 2019).

Highlands County has three incorporated municipalities: the City of Sebring, which is the county seat Avon Park; and the Town of Lake Placid. Highlands County overall is not growing as quickly as the state or many other counties, but Avon Park and Lake Placid are growing at nearly twice the rate of Florida (Central Florida Regional Planning Council 2015).

In 2018, the population of Polk County was 686,483, with a density of 381.8 persons per square mile. Polk County occupies an area of 1,798 square miles, and there are 295,126 housing units in the county, with a housing density of 164.1 houses per square mile (U.S. Census Bureau website 2019). The City of Frostproof, located in the northern Lake Istokpoga Watershed in Polk County, had a population of 3,234 in 2017.

1.3.2 Topography

Lake Istokpoga is located in the Kissimmee/Okeechobee Lowland lake region (75-35), which includes the Kissimmee Valley, a lowland with prairie-type grasslands, flatwoods, and some swamp forest (Griffith et al. 1997). The geology of this region is characterized by Pleistocene lagoonal deposits of coastal sand and shelly silt sand. The lakes in the region are alkaline, eutrophic, and colored. The land-surface altitudes of the Lake Istokpoga Watershed range from 40 ft (North American Vertical Datum [NGVD]) in the Arbuckle Creek area to 180 ft in the Crooked Lake Subwatershed.

1.3.3 Hydrogeological Setting

The greater hydrogeological context in which these lakes function is determined in part by the topography, but also by their similar soil geology, aquifer/groundwater interactions, and climate. The most prominent topographic feature of the Highlands County area is the Lake Wales Ridge (White 1970; Spechler 2010). The Lake Wales Ridge and its transition are mainly located in the western portion of the Lake Istokpoga Watershed, including the ridge margin or transition lakes that are darker colored with higher nutrients than the lakes found in the Southern Lake Wales Ridge lake region (75-33) (Griffith et al. 1997). The Lake Wales Ridge is characterized by numerous surface depressions and closed basin lakes, and its valley was formed by the dissolution of the underlying limestone and contains numerous karst features (Spechler 2010). The lake region also includes the narrow Bombing Range Ridge on the east and a small area of upland soils near Lake Buffum on the west. Most of the lakes are acidic, although about one-third are alkaline. They have low to moderate nutrients and are slightly to moderately colored.

The climate of the watershed is classified as subtropical and is characterized by hot, wet summers and relatively dry winters. During the summer months, daily maximum air temperatures usually exceed 90° Fahrenheit (F.), with an annual average temperature of 73° F. The long-term average annual rainfall in Highlands County is 51 inches per year (in/yr), based on South Florida Water Management District (SFWMD) data recorded from 1989 to 2018. Approximately 55 % to 60 % of the annual rainfall occurs during a defined rainy season from June to September.

The tributary area of the Lake Istokpoga Basin includes portions of Polk and Highland Counties, from Frostproof to the southern extent of Lake Istokpoga. Water generally flows in a south-southeast direction to Lake Istokpoga, primarily via Arbuckle Creek and Josephine Creek, which are located in the northwest and north areas of the lake, respectively. Lake Istokpoga discharges through two outlets: the S-68 Canal is a major outlet that flows south to the C-41A Canal in Indian Prairie, and the Istokpoga Canal flows east to the lower Kissimmee River.

The hydrologic characteristics of soil can significantly influence the capability of a watershed to hold rainfall or produce surface runoff. Soils are generally classified as one of four major types, as follows, based on their hydrologic characteristics (Viessman et al. 1989):

- Type A soils have high infiltration rates even if thoroughly wetted and consist chiefly of deep, well-drained to excessively drained sands or gravels. These soils have a high rate of water transmission.

- Type B soils have moderate infiltration rates if thoroughly wetted and consist chiefly of moderately deep to deep, moderately well-drained to well-drained soils with moderately fine to moderately coarse textures. These soils have a moderate rate of water transmission.

- Type C soils have slow infiltration rates if thoroughly wetted and consist chiefly of soils with a layer that impedes the downward movement of water, or soils with moderately fine to fine texture. These soils have a slow rate of water transmission.

- Type D soils have very slow infiltration rates if thoroughly wetted and consist chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a clay pan or clay layer at or near the surface, and shallow soils over nearly impervious materials. These soils have a very slow rate of water transmission.

The soil hydrologic characteristics of the Lake Istokpoga Watershed were based on the soil hydrologic classifications in the National Resources Conservation Service (NRCS) 2010 dataset developed by the National Cooperative Soil Survey. **Figure 1.3** shows the spatial distribution of soil hydrologic groups in the Lake Istokpoga Watershed. **Table 1.1** illustrates that Type A and A/D soils predominate in the watersheds. Type A/D soil has Type A soil characteristics when unsaturated but behaves like Type D soil when saturated. Soil types in some portions of the watershed were not defined in the dataset. Most were located in the areas covered by waterbodies or wetlands.

Table 1.1. Hydrologic soil groups and acreage in the Lake Istokpoga Watershed

Hydrologic Soil Group	Area (acres)	%
A	104,802	27
A/D	190,928	49
B	1,292	0
B/D	21,939	6
C	36	0
C/D	7,376	2
D	5	0
Unspecified	63,518	16

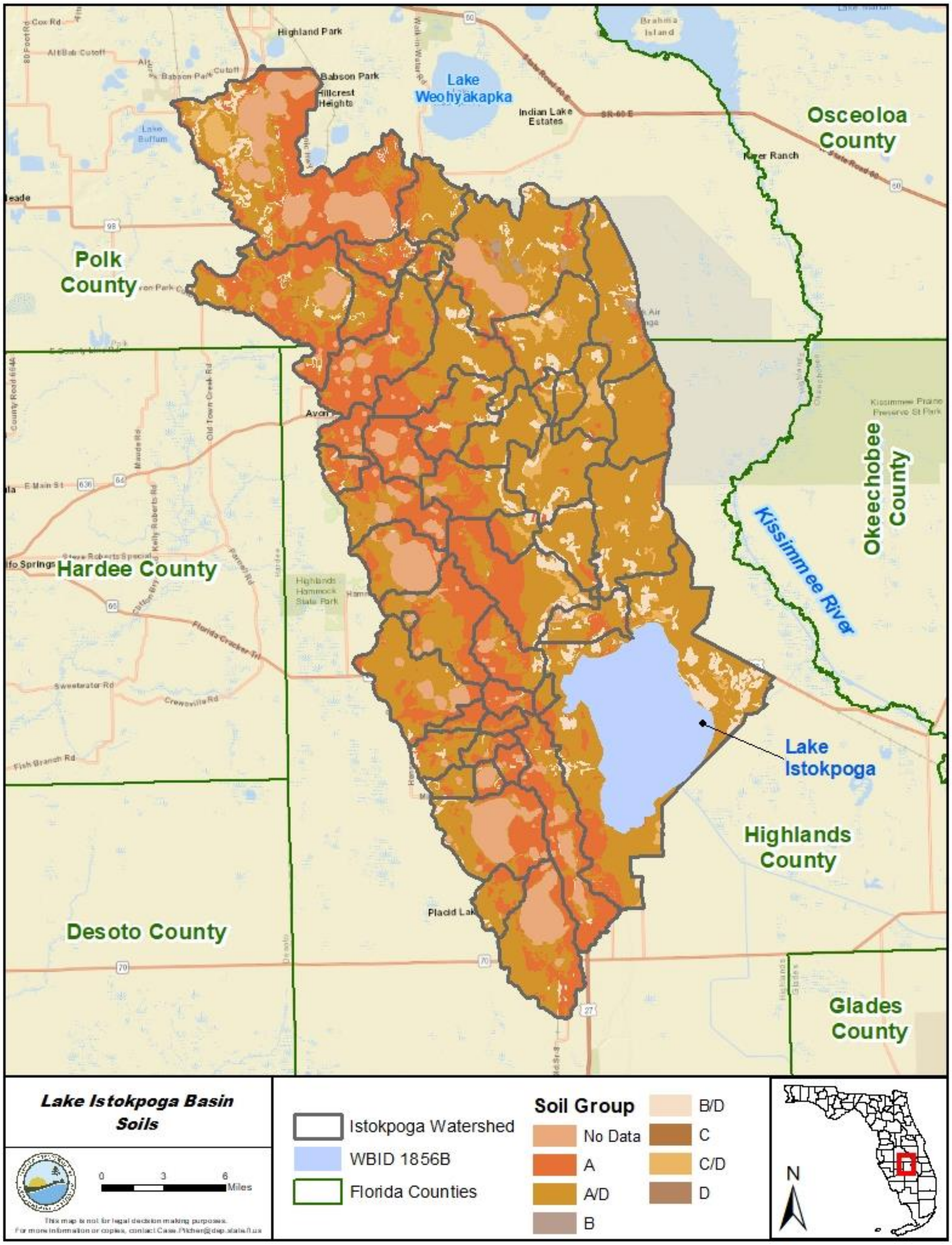

Figure 1.3. Hydrologic soil groups in the Lake Istokpoga Watershed

Chapter 2: Water Quality Assessment and Identification of Pollutants of Concern

2.1 Statutory Requirements and Rulemaking History

Section 303(d) of the federal Clean Water Act (CWA) requires states to submit to the U.S. Environmental Protection Agency (EPA) lists of surface waters that do not meet applicable water quality standards (impaired waters) and establish a TMDL for each pollutant causing the impairment of listed waters on a schedule. DEP has developed such lists, commonly referred to as 303(d) lists, since 1992.

The Florida Watershed Restoration Act (FWRA) (Section 403.067, Florida Statutes [F.S.]) directed DEP to develop, and adopt by rule, a science-based methodology to identify impaired waters. The Environmental Regulation Commission adopted the methodology as Chapter 62-303, F.A.C. (the IWR), in 2001. The rule was amended in 2006, 2007, 2012, 2013, and 2016.

The list of impaired waters in each basin, referred to as the Verified List, is also required by the FWRA (Subsection 403.067[4], F.S.). The state's 303(d) list is amended annually to include basin updates.

2.2 Classification of the Waterbody and Applicable Water Quality Standards

Lake Istokpoga is a Class III (fresh) waterbody, with a designated use of fish consumption, recreation, and propagation and maintenance of a healthy, well-balanced population of fish and wildlife. The Class III water quality criterion applicable to the verified impairment (nutrients) for this waterbody is Florida's nutrient criterion in paragraph 62-302.530(48)(b), F.A.C. Florida adopted NNC for lakes, spring vents, and streams in 2011. These were approved by the EPA in 2012 and became effective in 2014.

The applicable lake NNC are dependent on alkalinity, measured in milligrams per liter (mg/L) as calcium carbonate ($CaCO_3$) and true color (color), measured in platinum cobalt units (PCU), based on the long-term period of record (POR) geometric means. For the purpose of subparagraph 62-302.531(2)(b)1., F.A.C., color is assessed as true color and should be free from turbidity. Lake color and alkalinity are based on a minimum of 10 data points over at least 3 years with at least 1 data point in each year. Using this methodology and data from IWR Database Run 58, Lake Istokpoga is categorized as a high-color (> 40 PCU) lake, as shown in **Table 2.1**.

Table 2.1. Long-term geometric means for color and alkalinity for the period of record

Waterbody	Long-Term Geometric Mean Clor (PCU)	Long-Term Gometric Mean Alkalinity (mg/L $CaCO_3$)
Lake Istokpoga	74	17

The chlorophyll *a* NNC for high-color lakes is an annual geometric mean (AGM) value of 20 micrograms per liter (µg/L), not to be exceeded more than once in any consecutive three-year period. The associated total nitrogen (TN) and total phosphorus (TP) criteria for a lake can vary annually, depending on the availability of data for chlorophyll *a* and the concentrations of chlorophyll *a* in the lake.

If there are sufficient data to calculate an AGM for chlorophyll *a* and the mean does not exceed the chlorophyll *a* criterion for the lake type, then the TN and TP numeric interpretations for that calendar year are the AGMs of lake TN and TP samples, subject to the minimum and maximum TN and TP limits. If there are insufficient data to calculate the AGM for chlorophyll *a* for a given year, or the AGM for chlorophyll *a* exceeds the values in the table for the lake type, then the applicable numeric interpretations for TN and TP are the minimum values. **Table 2.2** lists the NNC for Florida lakes specified in subparagraph 62-302.531(2)(b)1., F.A.C.

Table 2.2. Chlorophyll *a*, TN, and TP criteria for Florida lakes (subparagraph 62-302.531[2][b]1., F.A.C.)

* For lakes with color > 40 PCU in the West Central Nutrient Watershed Region, the maximum TP limit is the 0.49 mg/L TP streams threshold for the region.

Long-Term Geometric Mean Lake Color and Alkalinity	AGM Chlorophyll *a* (µg/L)	Minimum Calculated AGM TP NNC (mg/L)	Minimum Calculated AGM TN NNC (mg/L)	Maximum Calculated AGM TP NNC (mg/L)	Maximum Calculated AGM TN NNC (mg/L)
>40 PCU	20	0.05	1.27	0.16*	2.23
≤ 40 PCU and > 20 mg/L $CaCO_3$	20	0.03	1.05	0.09	1.91
≤ 40 PCU and ≤ 20 mg/L $CaCO_3$	6	0.01	0.51	0.03	0.93

2.3 Determination of the Pollutant of Concern

2.3.1 Data Providers

The data providers for Lake Istokpoga are primarily SFWMD and DEP. **Table 2.3** summarizes the data providers, corresponding stations, and sample collection periods for the WBID. Data collected from SFWMD and DEP from 2005 to 2017 were used for TMDL development and model calibration purposes. **Figure 2.1** shows the water quality sampling locations in the WBID.

The individual water quality measurements discussed in this report are available in IWR Database Run 58 and are available on request.

Table 2.3. Data providers for Lake Istokpoga

Sampling Station	Data Provider Name	Activity Beginning Date	Activity Ending Date
21FLFTM 26010502	DEP	2001	2013
21FLFTM 26010506	DEP	2013	2013
21FLFTM G4SD0151	DEP	2016	2017
21FLFTM G4SD0152	DEP	2016	2017
21FLFTM G4SD0153	DEP	2016	2017
21FLFTM G4SD0154	DEP	2016	2017
21FLFTM G4SD0155	DEP	2016	2017
21FLFTM G4SD0156	DEP	2016	2017
21FLFTM KISSRV0029FTM	DEP	2013	2013
21FLSFWMISTK1	SFWMD	1988	2018
21FLSFWMISTK2	SFWMD	1988	2005
21FLSFWMISTK2S	SFWMD	2005	2018
21FLSFWMISTK3	SFWMD	1988	2005
21FLSFWMISTK3W	SFWMD	2005	2018
21FLSFWMISTK4	SFWMD	1988	2005
21FLSFWMISTK4N	SFWMD	2005	2012
21FLSFWMISTK5	SFWMD	1988	2005
21FLSFWMISTK5N	SFWMD	2005	2018
21FLSFWMISTK6	SFWMD	1988	2018
21FLSFWMISTK6S	SFWMD	1990	2005
21FLSFWMISTK7	SFWMD	1988	2012
FLSFWMS68	SFWMD	1988	2007

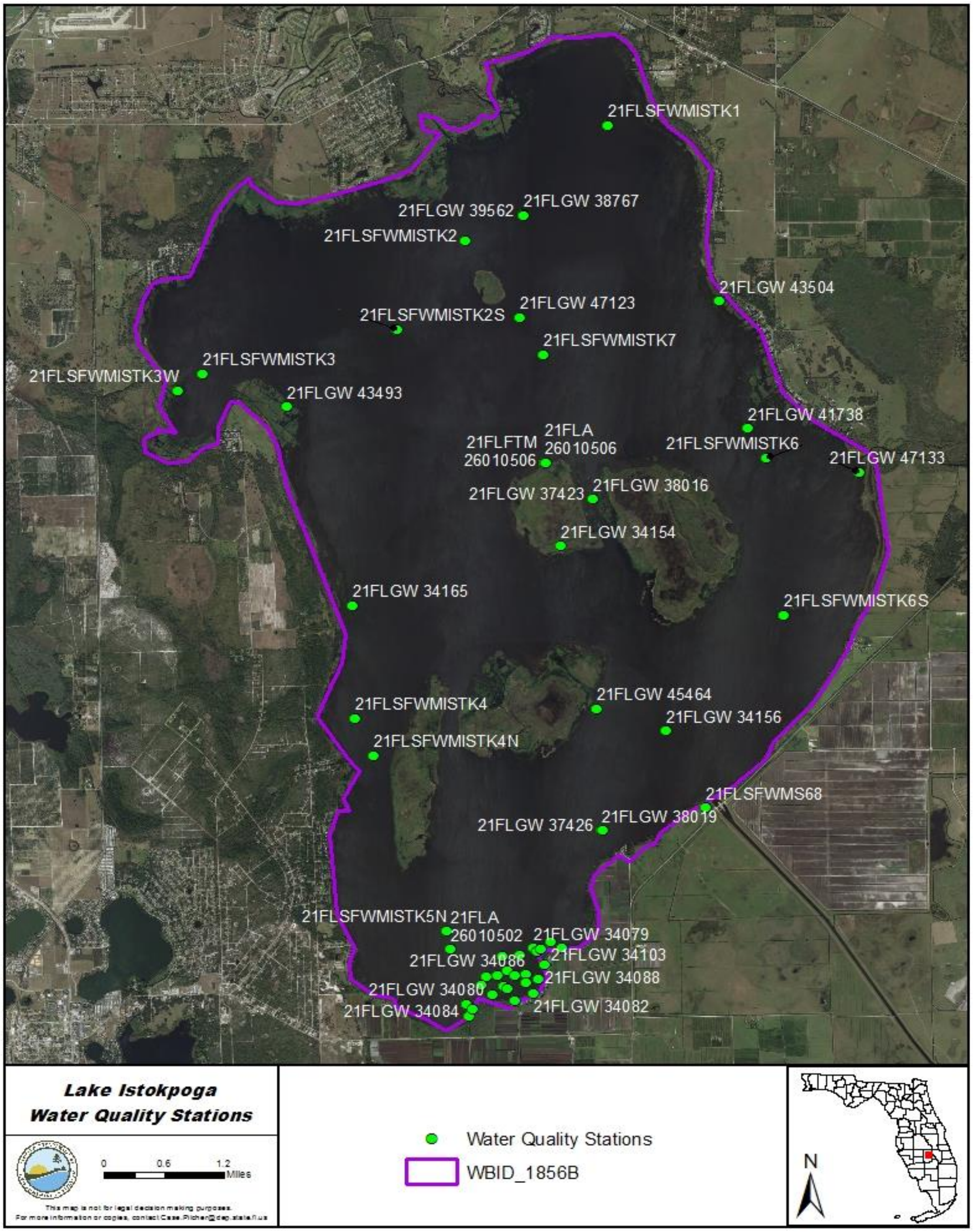

Figure 2.1. Water quality monitoring stations in Lake Istokpoga

2.3.2 Information on Verified Impairment

During the Group 4, Cycle 3 basin assessment, the NNC were used to assess Lake Istokpoga (WBID 1856B) during the verified period (January 1, 2009–June 30, 2016) based on data from IWR Database Run 53. Lake Istokpoga was assessed as impaired for biology because of failing Lake Vegetation Index (LVI) scores, chlorophyll *a*, TN, and TP because the AGMs exceeded the NNC more than once in a 3-year period. For Lake Istokpoga, chlorophyll *a* AGMs were exceeded from 2009 to 2011 and 2013 to 2015, TN AGMs were exceeded from 2009 to 2015, and TP AGMs were exceeded from 2009 to 2015. **Tables 2.4** lists the AGM values for chlorophyll *a*, TN, and TP during the 2009–16 verified period for Lake Istokpoga.

Table 2.4. Lake Istokpoga (WBID 1856B) AGM values for the 2009–16 verified period

ID = Insufficient data
Note: Values shown in boldface type with shaded cells are greater than the NNC for lakes. Rule 62-302.531, F.A.C, states that the applicable numeric interpretations for TN, TP, and chlorophyll *a* shall not be exceeded more than once in any consecutive three-year period.

Year	Chlorophyll *a* (µg/L)	TN (mg/L)	TP (mg/L)
2009	**32**	**1.57**	**0.07**
2010	**30**	**1.55**	**0.07**
2011	**27**	**1.57**	**0.07**
2012	20	1.45	0.06
2013	**26**	**1.41**	**0.07**
2014	**32**	**1.55**	**0.08**
2015	**32**	**1.41**	**0.07**
2016	ID	ID	ID

2.4 Relationships Between Water Quality Variables

When establishing a nutrient TMDL for any system, it is important to determine the degree to which stressor and response variables are related to appropriately model the impact of nutrients on algal growth and anthropogenic eutrophication, as measured by chlorophyll *a* response. **Figure 2.4** shows water quality trends for chlorophyll *a*, TN, and TP during the model simulation period from January 1, 2005, to December 31, 2017. Individual water quality measurements (daily raw data) for TN, TP, and chlorophyll *a* were also used for the model calibration and validation, as discussed in detail in **Chapter 5**.

Chlorophyll *a* concentrations ranged from 8.0 to 55.5 µg/L over the 13-year period from 2005 to 2017, with an average of 29.4 ± 10.1 µg/L (mean ± standard deviation) and a coefficient of variation (CV) of 34 %. TN concentrations ranged from 1.03 to 2.05 mg/L, with an average of 1.48 ± 0.22 mg/L. No significant temporal change in TN was observed during the period, with a CV of 15 %. A linear relationship between chlorophyll *a* and TN was observed, showing a correlation coefficient (r^2) of 0.32. TP concentrations ranged from 0.018 to 0.118 mg/L, with an average of 0.070 ± 0.22 mg/L. The TN/TP ratios (by weight) in the lake remained relatively constant, averaging 22.4 ± 6.2 (n = 86) over the period, indicating that the lake was colimited by both nitrogen (N) and phosphorus (P) for phytoplankton growth (**Figure 2.4**).

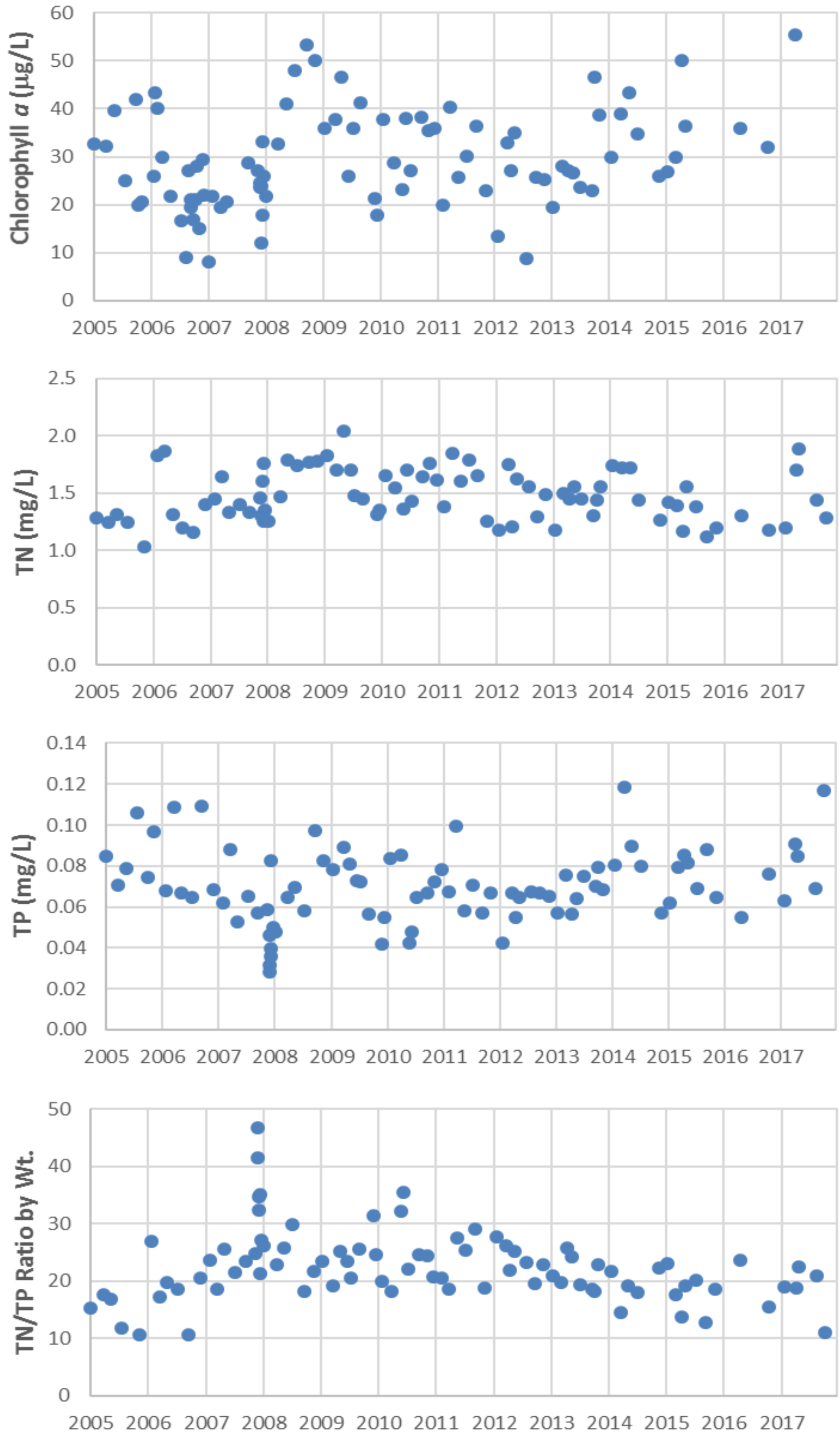

Figure 2.2. Time-series of daily concentrations of corrected chlorophyll *a*, TN, and TP, and TN/TP ratio (by weight) in Lake Istokpoga

Chapter 3: Site-Specific Numeric Interpretations of the Narrative Nutrient Criterion

3.1 Establishing the Site-Specific Interpretations

Pursuant to paragraph 62-302.531(2)(a), F.A.C., the nutrient TMDLs presented in this report, upon adoption into Rule 62-304.625, F.A.C., will constitute the site-specific numeric interpretations of the narrative nutrient criterion set forth in paragraph 62-302.530(48)(b), F.A.C., that will replace the otherwise applicable NNC in subsection 62-302.531(2), F.A.C., for this particular waterbody. **Table 3.2** lists the elements of the nutrient TMDLs that constitute the site-specific numeric interpretations of the narrative nutrient criterion. **Appendix B** summarizes the relevant details to support the determination that the TMDLs provide for the protection of Lake Istokpoga and for the attainment and maintenance of water quality standards in downstream waters (pursuant to subsection 62-302.531[4], F.A.C.), and to support using the nutrient TMDLs as the site-specific numeric interpretations of the narrative nutrient criterion.

3.2 Site-Specific Response Variable Target Selection

The development of the generally applicable lake NNC was based on the selection of a protective chlorophyll *a* criterion and then an evaluation of the relationship between chlorophyll *a* and TN and TP to develop TN and TP concentrations protective of designated uses (DEP 2012). DEP developed a chlorophyll *a* criterion of 20 μg/L for high-color (> 40 PCU) lakes that was demonstrated to be protective of designated uses, including the maintenance of a healthy, well-balanced community of aquatic flora and fauna.

The generally applicable chlorophyll *a* criterion is assumed to be protective of individual Florida lakes, absent information that shows either (1) more sensitive aquatic life use (i.e., a more responsive flora community), or (2) a significant historical change in trophic status (i.e., a significant increasing trend in color and/or alkalinity). Long-term datasets of color, alkalinity, and nutrients in Lake Istokpoga suggest that they do not differ from the population of lakes used in the development of the NNC. Therefore, DEP has determined that the generally applicable chlorophyll *a* NNC is the most appropriate site-specific chlorophyll *a* criterion for Lake Istokpoga and will serve as the TMDL water quality target.

3.3 Numeric Expression of the Site-Specific Numeric Interpretations

The site-specific interpretations of the narrative nutrient criterion were determined by using the Hydrological Simulation Program–FORTRAN (HSPF) Model (see **Chapter 5**) to find TN and TP loadings that would achieve the chlorophyll *a* criterion of 20 μg/L for Lake Istokpoga. The model was also used to determine the model-simulated natural background chlorophyll *a* to ensure that the reductions in nutrient loads under the TMDLs did not attempt to abate the natural background condition.

Model output for Lake Istokpoga was used to calculate the total annual load for each model year, and then 7-year rolling averages were calculated for each parameter (**Table 3.1**). The site-specific numeric interpretations of TN and TP were then set at the maximum 7-year averages of TN and TP loads that met the chlorophyll *a* criterion of 20 µg/L (TMDL condition) for Lake Istokpoga. The resultant TN and TP criteria for Lake Istokpoga are 1,345,998 and 54,073 pounds per year (lbs/yr), respectively, and are expressed as a rolling 7-year average not to be exceeded.

Table 3.1. Lake Istokpoga TMDL condition nutrient loads

Note: Values shown in boldface type and shaded cells indicate the maximum of the seven-year rolling averages.

Year	TMDL Condition TN Loads (lbs/yr)	7-Year Rolling Average TN Loads (lbs/yr)	TMDL Condition TP Loads (lbs/yr)	7-Year Rolling Average TP Loads (lbs/yr)
2006	586,878		28,774	
2007	434,632		21,383	
2008	1,104,525		49,402	
2009	599,938		25,992	
2010	790,509		35,173	
2011	1,141,414		47,811	
2012	1,204,801	837,528	47,468	36,572
2013	1,231,342	929,594	52,092	39,903
2014	1,475,425	1,078,279	59,008	45,278
2015	1,293,329	1,105,251	49,724	45,324
2016	1,484,751	1,231,653	52,642	49,131
2017	1,590,923	**1,345,998**	69,763	**54,073**

Table 3.2 summarizes the loads for TN and TP that will be considered the site-specific interpretations of the narrative criterion. DEP also calculated the TN and TP concentrations necessary for restoration, which are AGM concentrations of 0.040 and 1.18 mg/L for Lake Istokpoga, respectively, not to be exceeded in any year. These values are presented for informational purposes only and represent the simulated in-lake TN and TP concentrations corresponding to the chlorophyll *a* criterion of 20 µg/L.

Table 3.2. Site-specific interpretations of the narrative nutrient criterion

Note: Chlorophyll *a* shall not be exceeded more than once in any consecutive three-year period.

WBID	AGM Chlorophyll *a* (µg/L)	Rolling 7-Year Annual Average TN (lbs/yr)	Rolling 7-Year Annual Average TP (lbs/yr)
1856B	20	1,345,998	54,073

3.4 Downstream Protection

Lake Istokpoga discharges through two outlets, S-68 and Istokpoga Canal. The S-68 spillway is a major outlet that discharges south to the C-41A Canal, comprising more than 99 % of the total discharge from the lake, while the Istokpoga Canal contributed less than 1 % of the total outflow to the Kissimmee River during the simulation period. The C-41A Canal is a Class III freshwater stream in the Peninsular Stream Nutrient Region. The applicable nutrient thresholds for these stream systems are 0.12 mg/L of TP and 1.54 mg/L of TN, expressed as AGMs not to be exceeded more than once in any 3-year period (DEP 2013). Based on the Cycle 3 assessment, the C-41A Canal (WBID 3198) was listed as verified impaired for chlorophyll *a* and nutrients (macrophytes), while TN and TP AGMs did not exceed the stream thresholds during the assessment period.

The water quality in the C-41A Canal is primarily influenced by lake discharges, with minimal impacts from local sources, based on a comparison of observed TN and TP data obtained from a Lake Istokpoga outlet station versus a C-41A Canal outlet station (**Figures 3.1** and **3.2**). The concentration-based restoration targets for Lake Istokpoga under the TMDL condition were much lower than those under the current condition for the C-41A outlet station and will meet the applicable stream nutrient thresholds. Therefore, the reductions in nutrient loads described in this TMDL analysis will result in water quality improvements to downstream waters and thus be protective of downstream water quality.

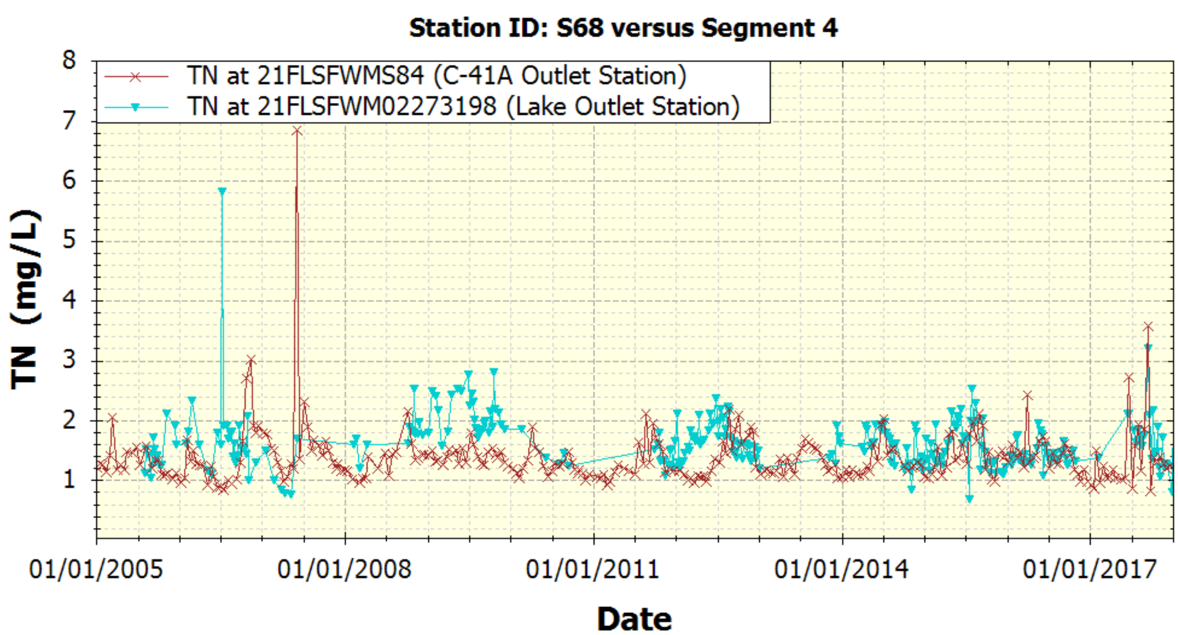

Figure 3.1. Temporal trends of TN at the outlet stations of Lake Istokpoga and C-41A

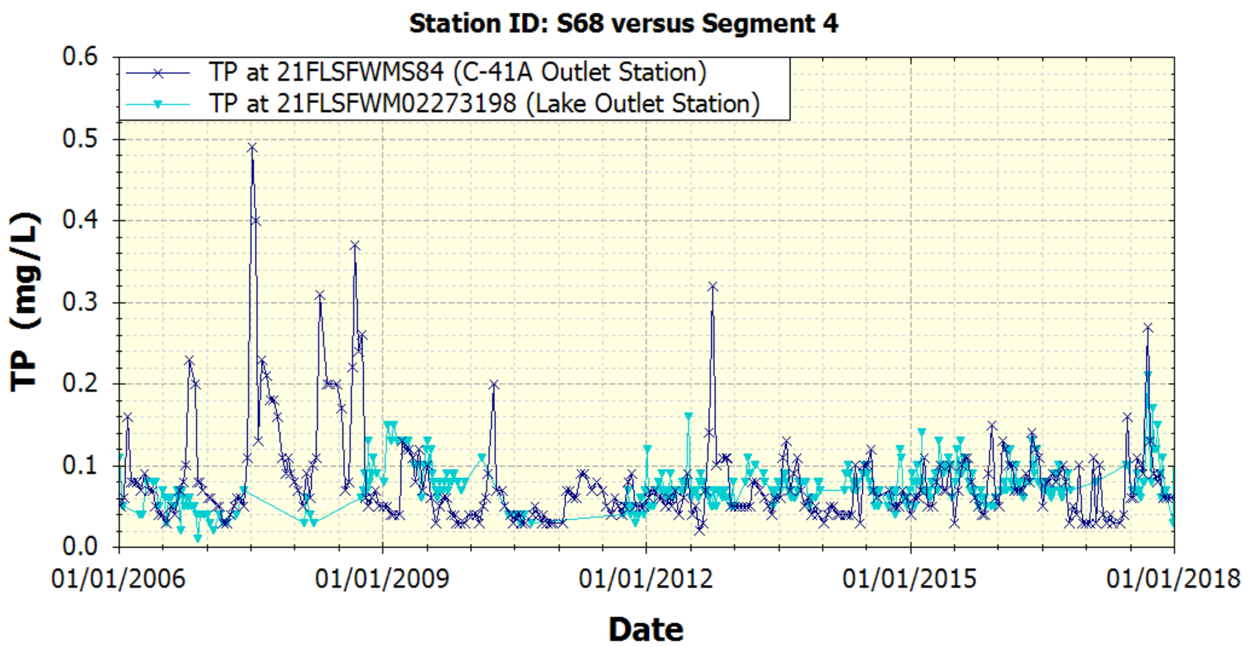

Figure 3.2. Temporal trends of TP at the outlet stations of Lake Istokpoga and C-41A

Table 3.3. Comparison of concentrations of observed TN, TP, and chlorophyll *a* AGMs in the C-41A Canal with those in Lake Istokpoga under the TMDL condition

Year	Lake TN AGM under TMDL Condition (mg/L)	Observed C-41A TN AGM (mg/L)	Lake TP AGM under TMDL Condition (mg/L)	Observed C-41A TP AGM (mg/L)	Lake Chlorophyll *a* AGM under TMDL Condition (mg/L)	Observed C-41A Chlorophyll *a* AGM (mg/L)
2006	1.14	1.37	0.038	0.066	16	
2007	1.18	1.34	0.038	0.087	13	
2008	1.16	1.48	0.040	0.092	16	
2009	1.14	1.79	0.037	0.084	15	30
2010	1.12	1.26	0.037	0.057	15	
2011	1.17	1.32	0.040	0.077	18	
2012	1.16	1.55	0.040	0.082	20	
2013	1.08	1.32	0.038	0.080	20	
2014	1.07	1.42	0.039	0.068	20	
2015	1.03	1.48	0.037	0.081	20	
2016	1.02	1.40	0.037	0.081	20	
2017	1.09	1.40	0.039	0.072	19	
Average	**1.11**	**1.43**	**0.038**	**0.077**	**18**	**30**

3.5 Endangered Species Considerations

Section 7(a)(2) of the Endangered Species Act (ESA) requires each federal agency, in consultation with the services (i.e., the U.S. Fish and Wildlife Service [FWS] and the National Oceanic and Atmospheric Administration [NOAA] National Marine Fisheries Service [NMFS]), to ensure that any action authorized, funded, or carried out is not likely to jeopardize the continued existence of listed species or result in the destruction or adverse modification of designated critical habitat. The EPA must review and approve changes in water quality standards (WQS) such as setting site-specific criteria. Prior to approving WQS changes for aquatic life criteria, the EPA will prepare an Effect Determination summarizing the direct or indirect effects of an action on the species or critical habitat, together with the effects of other activities that are interrelated or interdependent with that action. The EPA categorizes potential effect outcomes as either (1) "no effect," (2) "may affect, not likely to adversely affect," or (3) "may affect: likely to adversely affect."

The service(s) must concur on the Effect Determination before the EPA approves a WQS change. A finding and concurrence by the service(s) of "no effect" will allow the EPA to approve an otherwise approvable WQS change. However, findings of either "may affect, not likely to adversely affect" or "may affect: likely to adversely affect" will result in a longer consultation process between the federal agencies and may result in disapproval or a required modification to the WQS change.

The FWS identifies the endangered Everglade snail kite (*Rostrhamus sociabilis*) as a species that is potentially affected by activities in lowland freshwater marshes in Florida, including Lake Istokpoga. The subspecies (*R. sociabilis plumbeus*) was first listed as endangered pursuant to the Endangered Species Conservation Act in 1967. The current distribution of the Everglade snail kite is limited to central and southern portions of Florida. Six large freshwater systems are located within the current range of the snail kite: Upper St. Johns drainage, Kissimmee Valley, Lake Okeechobee, Loxahatchee Slough, the Everglades, and Big Cypress Basin. Based on the FWS online tool Information for Planning and Conservation (IPaC), no aquatic, amphibious, or anadromous endangered species are listed for Lake Istokpoga. It is expected that water quality improvements required by the TMDLs will will positively impact any species living in the lake and its respective watershed.

Chapter 4: Assessment of Sources

4.1 Types of Sources

An important part of the TMDL analysis is the identification of pollutant source categories, source subcategories, or individual sources of the pollutant of concern in the target watershed and the amount of pollutant loading contributed by each of these sources. Sources are broadly classified as either point sources or nonpoint sources. Historically, the term "point sources" has meant discharges to surface waters that typically have a continuous flow via a discernable, confined, and discrete conveyance, such as a pipe. Domestic and industrial wastewater treatment facilities (WWTFs) are examples of traditional point sources. Point sources also include certain urban stormwater discharges, such as those from local government master drainage systems, construction sites over five acres, and a wide variety of industries (see **Appendix A** for background information on the federal and state stormwater programs). In contrast, the term "nonpoint sources" was used to describe intermittent, rainfall-driven, diffuse sources of pollution associated with everyday human activities, including runoff from urban land uses, agriculture, silviculture, and mining; discharges from septic systems; and atmospheric deposition.

To be consistent with CWA definitions, the term "point source" is used to describe traditional point sources (such as domestic and industrial wastewater discharges) and stormwater systems requiring a National Pollutant Discharge Elimination System (NPDES) stormwater permit when allocating pollutant load reductions required by a TMDL (see **Section 6.1** on **Expression and Allocation of the TMDL**). However, the methodologies used to estimate nonpoint source loads do not distinguish between NPDES and non-NPDES stormwater discharges.

4.2 Point Sources

4.2.1 Wastewater Point Sources

Avon Park Correctional Institute WWTF (Permit Number FL0040029) in Polk County is the only NPDES-permitted WWTF that discharges to the surface water of Arbuckle Creek in the Lake Istokpoga Watershed. The facility provides advanced wastewater treatment (AWT) with a maximum annual average daily flow of 0.5 million gallons per day (mgd). **Table 4.1** lists permit number, chemical parameters, and maximum permitted limits for the facility. Using the permitted limits, water quality impacts on downstream waters (i.e., Lake Istokpoga) under the watershed load reduction condition were accessed using the HSPF Model simulation in **Chapter 5**.

Table 4.1. Permit information on Avon Park Correctional Institute WWTF (FL0040029)

Parameter	Units	Maximum Permitted Limit
Flow	mgd	0.5
Dissolved oxygen (DO)	mg/L	6.0
5-day biochemical oxygen demand (BOD_5)	mg/L	5.0
Ammonia (NH_3)	mg/L	0.2
Nitrite-nitrate (NO_3+NO_2)	mg/L	Report
Organic nitrogen (N)	mg/L	1.4
TN	mg/L	3.0
TP	mg/L	1.0

4.2.2 Municipal Separate Storm Sewer System (MS4) Permittees

The Lake Istokpoga Watershed is covered by a Polk County NPDES MS4 Phase I permit (FLS000015) and a Highlands County NPDES MS4 Phase II permit (FLR04E148). The Florida Department of Transportation (FDOT) District 1 is a copermittee in the MS4 Phase I and II permits. For more information on MS4s in the watershed, send an email to npdes-stormwater@dep.state.fl.us. **Table 4.2** lists the permittees/copermittees and their MS4 permit numbers.

Table 4.2. NPDES MS4 permits with jurisdiction in the Lake Istokpoga Watershed

Permit Number	Permittee/Copermittees	Phase
FLS000015	Polk County/FDOT	I
FLR04E148	Highlands County/FDOT	II

4.3 Nonpoint Sources

Nutrient loadings to Lake Istokpoga are primarily generated from nonpoint sources. Nonpoint sources addressed in this analysis primarily include loadings from surface runoff, groundwater seepage entering the lake, and precipitation directly onto the lake surface (atmospheric deposition).

4.3.1 Land Uses

Land use is one of the most important factors in determining nutrient loadings from the Lake Istokpoga Watershed. Nutrients can be flushed into a receiving water through surface runoff and stormwater conveyance systems during stormwater events. Both human land use areas and natural land areas generate nutrients. However, human land uses typically generate more nutrient loads per unit of land surface area than natural lands can produce. **Table 4.3** lists land use in the watershed, based on the statewide land use land cover dataset that included the land use datasets from the Southwest Florida Water Management District (SWFWMD) (2014) and SFWMD (2014–16). Land use aggregation for the watershed followed the same method used for the 2017 Caloosahatchee River Watershed HSPF Model (Tetra Tech 2020). **Figure 4.1** shows the information graphically.

Table 4.3. Statewide land use in the Lake Istokpoga Watershed

HSPF Land Use Code	Land Use Description	Area (acres)	%
1	Low Density Residential (LDR)	23,561	5.9
2	Medium Density Residential (MDR)	12,817	3.2
3	High Density Residential (HDR)	3,882	1.0
4	Commercial/Recreational/Transportation (CRT)	4,790	1.2
5	FDOT Right-of-Way (DOT)	1,717	0.4
6	Industrial/Extractive (IND)	3,782	1.0
7	Developed Open Space/Disturbed (OPN)	13,308	3.3
8	Sugar Cane (SUG)	3,753	0.9
9	Row and Field Crops (CRP)	784	0.2
10	Nurseries/Ornamentals/Vineyards (NUR)	1,967	0.5
11	Citrus Groves/Other Groves (GRO)	49,633	12.5
12	Improved Pasture (PAS)	43,005	10.8
13	Rangeland/Unimproved Pasture/Woodland Pasture/Shrub (RAN)	40,129	10.1
14	Upland Forests (FOR)	25,147	6.3
15	Wetlands (WET)	54,212	13.6
16	Water (WAT)	58,356	14.7
17	Avon Park (AVN)	57,038	14.3

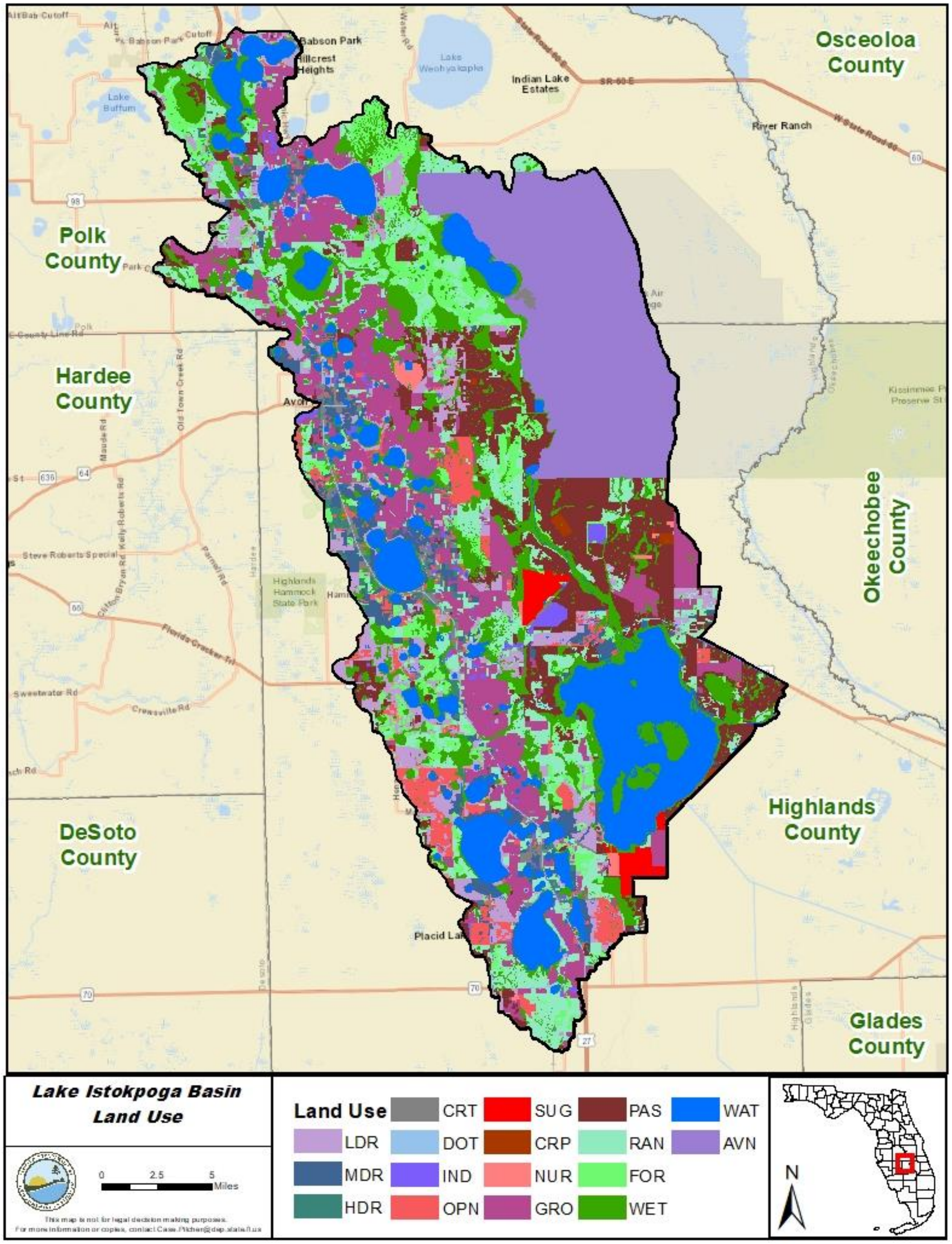

Figure 4.1. Land use in the Lake Istokpoga Watershed (land use abbreviations are listed in the table on the preceding page)

4.3.2 Onsite Sewage Treatment and Disposal Systems (OSTDS)

OSTDS, including septic tanks, are commonly used where providing central sewer service is not cost-effective or practical. When properly sited, designed, constructed, maintained, and operated, OSTDS are a safe means of disposing of domestic waste. The effluent from a well-functioning OSTDS is comparable to secondarily treated wastewater from a sewage treatment plant. OSTDS can be a source of nutrients (N and P), pathogens, and other pollutants to both groundwater and surface water. **Figure 4.2** shows the locations of OSTDS in the watershed. The Florida Department of Health (FDOH) maintains a list of septic systems by county, and the number of failing septic tanks in the area is estimated based on the septic tank datasets (FDOH 2019). Based on the septic tank maps, there are a total of 30,317 septic tanks within the Lake Istokpoga Basin boundary, including 3,211 septic tanks in Polk County and 27,106 septic tanks in Highlands County (**Figure 4.2**). The annual repair rates in Polk County and Highlands County from 2005 to 2017 were estimated at 0.9 % and 0.7 %, respectively (FDOH 2019). These repair rates were used to estimate pollutant contributions from failing septic tanks to streams and lakes.

These contributions were modeled in two ways (Tetra Tech 2017), depending on their proximity to the stream network in the Lake Istokpoga Watershed. For the septic tank parcels more than 200 ft away from streams and lakes, pollutant loadings were handled implicitly and were lumped with the pollutant loadings from other land uses where septic tanks are located. The septic tank parcels intercepting the 200 ft buffer of streams and lakes were considered direct pipes discharging untreated wastewater to the stream network. These direct pipes were explicitly modeled as point sources in HSPF. Based on the septic tank maps from FDOH, there are 5,405 septic tank parcels in Polk County and Highlands County within the 200 ft buffer of the Lake Istokpoga Watershed stream network. Based on the failing septic tank rates, the 40 direct pipes identified as point sources were assigned to associated subbasins in the HSPF Model.

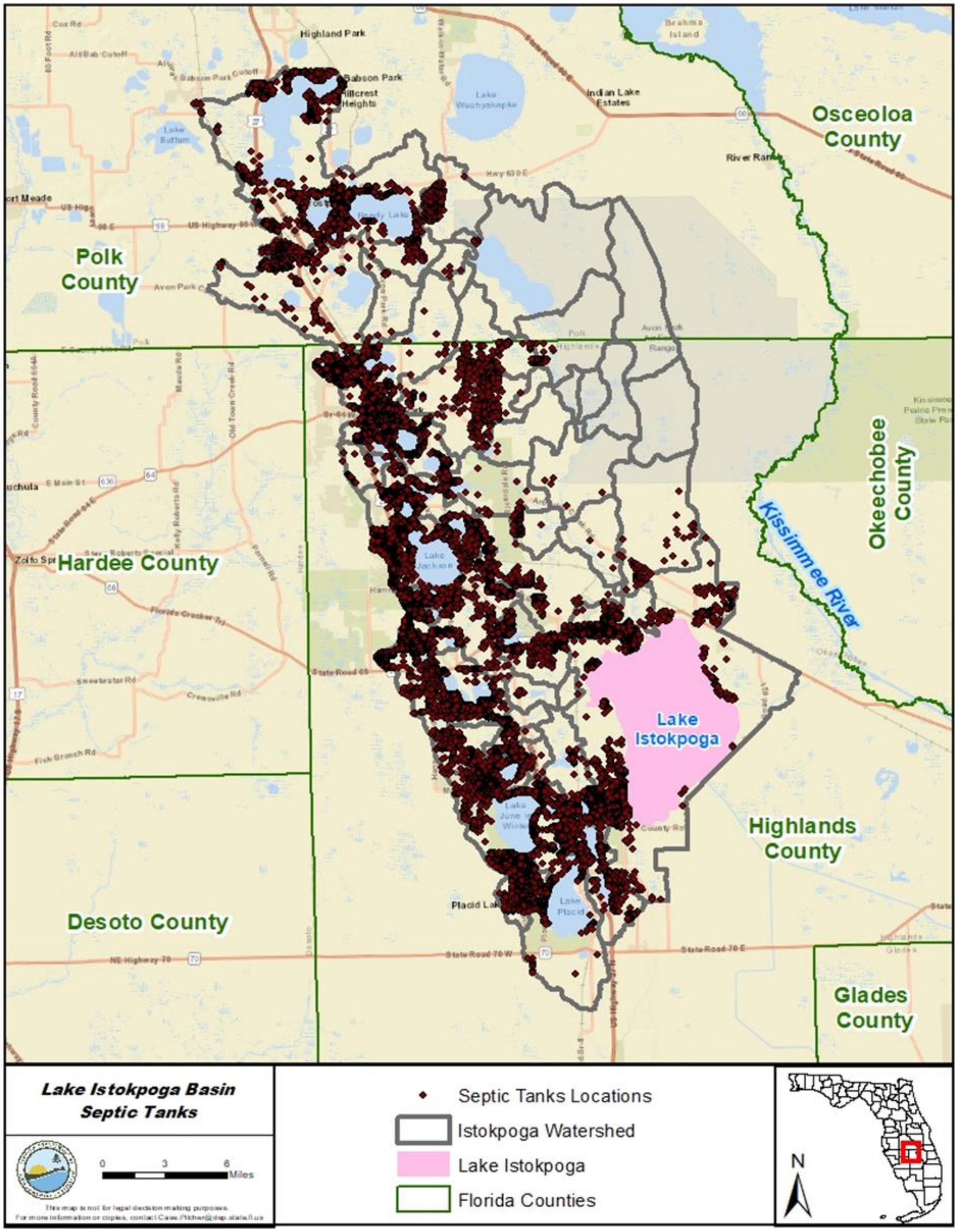

Figure 4.2. OSTDS in the Lake Istokpoga Watershed

4.3.3 Atmospheric Deposition

Nutrient loadings from the atmosphere are an important component of the nutrient budget in many Florida lakes. Nutrients are delivered through two pathways: wet atmospheric deposition with precipitation and dry particulate-driven deposition. Atmospheric deposition to terrestrial portions of the Lake Istokpoga Watershed is assumed to be accounted for in the loading rates used to estimate the watershed loading from land. Loading from atmospheric deposition directly onto the water surface was also considered in the loading estimation.

Monthly wet and dry atmospheric deposition data of both N and P collected by the St. Johns River Water Management District (SJRWMD) in Lake Apopka during the model simulation period were used to estimate the direct atmospheric loading rates of TN and TP for Lake Istokpoga. Based on monthly measured data, monthly wet deposition inputs specified as concentration to the HSPF Model ranged from 0.15 to 0.36 mg/L for ammonium (NH_4), 0.14 to 0.29 mg/L for nitrogen oxide (NOx), and 0.01 to 0.03 mg/L for orthophosphate (PO_4). Monthly dry deposition specified as flux to the model ranged from 0.0003 to 0.0012 pounds per acre per day (lbs/ac/day) for NH_4, 0.0011 to 0.0022 lbs/ac/day for NOx, and 0.0005 to 0.002 lbs/ac/day for PO_4. These wet and dry deposition inputs are comparable to those presented in the HSPF Model for Lake Jesup. The direct atmospheric loadings of TN and TP to Lake Istokpoga were estimated using the calibrated model, as described later in this chapter.

4.4 Estimating Watershed Loadings

4.4.1 HSPF Model Approach

HSPF is a comprehensive package that can be used to develop a combined watershed and receiving water model (EPA 2015; Bicknell et al. 2001). The model is capable of simulating both hydrologic and water quality processes in a watershed and receiving waterbodies. This dynamic model allows the input of rainfall, temperature, evaporation, evapotranspiration (ET), point source flows and loads, upstream or tributary inflows and constituent loads, sediment mass and associated constituent loads, and other time-series data. It also allows the input of parameters related to the physical characteristics of a watershed (including topography, land uses, soil types, and agricultural practices) to conduct watershed simulations.

HSPF is used to conduct dynamic simulations of water quantity and quality in several layers, including the land surface, several soil zones, and the groundwater table. The watershed simulations can generate stormwater runoff flows and concentrations or loads of sediments, BOD, nutrients, bacteria, pesticides, metals, toxic chemicals, and other water quality constituents. The flows and loadings from the watershed can then be used together with channel and boundary information to conduct in-stream simulations, which then yield dynamic results of flow, constituent concentrations, and loads at user-selected locations.

HSPF can also simulate the transport of flow and sediment, and their associated water quality constituents, in stream channels and mixed reservoirs. These simulations include hydraulics, constituent advection, the transport of conservative constituents, inorganic sediment, generalized quality constituents, water temperature, nutrient cycles, DO-related processes, first-order decay, sediment sorption and desorption, and other water quality processes.

4.4.1.1 Pervious and Impervious Land Segments Module

The HSPF Model uses the Stanford Watershed Model methodology as the basis for hydrologic calculations. This methodology calculates soil moisture and water flow between several different types of storage, including surface storage, interflow storage, upper soil storage zone, lower soil storage zone, active groundwater zone, and deep storage. Rain that is not converted to surface runoff or interflow infiltrates into the soil storage zones. Part of the infiltrated water is lost through ET, discharged as baseflow, or lost to deep percolation (e.g., deep aquifer recharge).

The pervious (PERLND) Module of HSPF accounts for surface runoff, interflow, and baseflow (shallow groundwater flow) from pervious land areas. The impervious (IMPLND) Module of HSPF accounts for surface runoff from impervious land areas (e.g., parking lots and highways). The hydrologic response unit (HRU) including PERLND and IMPLND for the Lake Istokpoga Watershed Model was developed by Tetra Tech with a combination of land use, soils, geology, and precipitation zone. The Lake Istokpoga HSPF modeling report by Tetra Tech describes the HRU setup for the Lake Istokpoga Watershed in detail (Tetra Tech 2020).

Briefly, Tetra Tech adopted the same methodology used for the 2017 HSPF Model for the Caloosahatchee River and Estuary and included land use classifications for Avon Park Air Force Range and tribal lands. The refined land use categories were then used to construct HRUs that accounted for ecology, soils, precipitation zone, and land use. The LANDUSE_CO attribute in the land use classification as described in **Section 4.3.1** was used to reclassify the land uses into reduced modeling unit (RMU) land and create a composite land use representation of PERLND for the watershed. To determine the mapped IMPLND area (MIA) of each RMU in each subwatershed, the composite land use coverage was intersected with the National Land Cover Database (NLCD) 2016 impervious coverage. The IMPLND areas were divided into nine impervious RMU classifications, and impervious areas associated with similar PERLND RMUs were grouped together.

4.4.1.2 Waterbody (RCHRES) Module

The RCHRES Module of HSPF conveys flow input from the PERLND and IMPLND Modules, accounts for direct water surface inflow (rainfall) and direct water surface outflow (evaporation), and routes flows based on a rating curve. For the Lake Istokpoga Watershed, an RCHRES element defines the depth-area-volume relationship for the modeled waterbody. The depth-area-volume relationships for impaired waterbodies and other major waterbodies were constructed based on the bathymetric data available from LakeWatch and cross-sectional information from the Watershed Assessment Model (WAM). To develop the FTables for the reaches in the Lake Istokpoga Watershed, Tetra Tech (2019) used the standard development method provided in

BASINS Technical Note 2 (Moore 2007), which defines the channel form as trapezoidal, with an additional larger trapezoid stacked on top to represent the floodplain. The standard method then applies Manning's equation to incremental depths to calculate the FTable values across a range of flows, volumes, and water surface area.

4.4.1.3 Meteorological and flow Data

Meteorological data—including rainfall, evapotranspiration, solar radiation, wind speed, air temperature, and dewpoint temperature–were obtained from the Sebring weather station of the Florida Automatic Weather Network (FAWN), an observation platform owned by the University of Florida, where hourly meteorological data are recorded. Hourly data from this station were extracted for the period from January 1, 2004, to December 31, 2017. More rainfall, cloud cover, and ET data were obtained from multiple database sources operated by SWFWMD, NOAA, and SFWMD, as shown in **Table 4.4**. Daily flow data were obtained from the U.S. Geological Survey (USGS) stations and SFWMD station for model calibration (**Table 4.5**).

Figure 4.3 shows the location of the weather and USGS flow gauge stations in the Lake Istokpoga Basin. Meteorological and flow data were managed using the WDMUtil included with the EPA BASINS toolkit (EPA 2015). If the period of record at a given station was missing data for a month or longer, the data from the closest station were used to complete the dataset. However, if data were missing for only a short period (i.e., days), the average of the day before and the day after was used to represent the data for the missing days.

Table 4.4. Summary of meteorological stations and data acquisition

Monitoring Station Name	Parameter and Unit	Data Source	Frequency
Sebring	Rainfall (inches [in]) Air temperature (degrees Celsius [°C.]) Wind speed (miles per hour [mph]) Evapotranspiration (millimeters [mm]) Solar radiation (watts per square meter [W/m^2]), Dewpoint (°C.)	FAWN	Hourly
West Frostproof	Rainfall (in)	SWFWMD	Daily
Lake Lotela Istokpoga and Josephine from Next-Generation Radar (NEXRAD)	Rainfall (in)	SFWMD	Daily Hourly
Bartow	Cloud Cover (NU)	NOAA	Daily
S-65A, Lake Istokpoga from NEXRAD	Evapotranspiration (in)	SFWMD	Daily

Table 4.5. Summary of flow gauge stations and data acquisition

cfs = Cubic feet per second

Station Name	Station ID	Parameter	Frequency
Livingston Creek near Frostproof	USGS 02269520	Flow (cfs)	Daily
Carter Creek near Sebring	USGS 02270000	Flow (cfs)	Daily
Josephine Creek near De Soto City	USGS 02271500	Flow (cfs)	Daily
Arbuckle Creek near De Soto City	USGS 02270500	Flow (cfs)	Daily
S-68 Spillway	SFWMD S68_S	Flow (cfs)	Daily

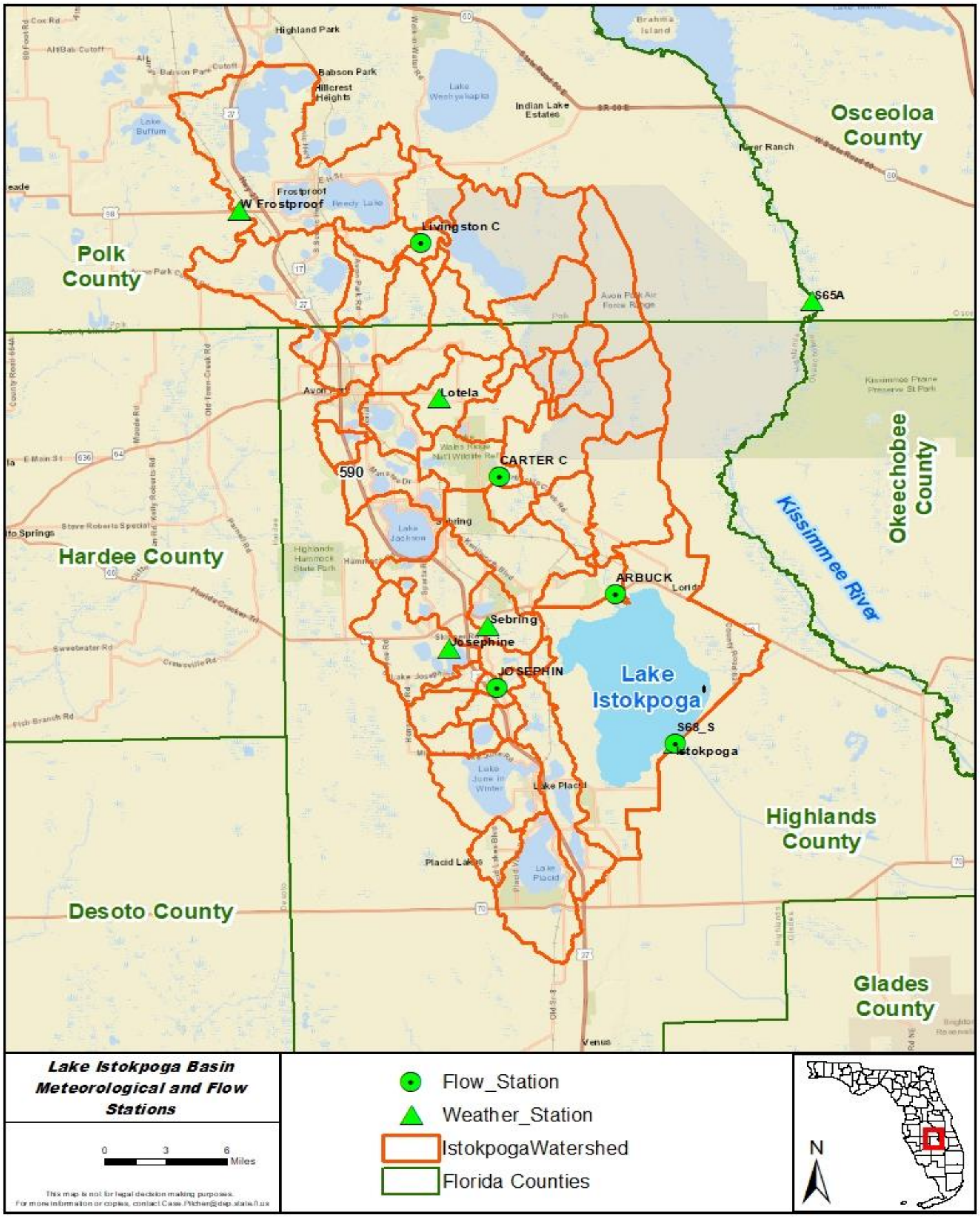

Figure 4.3. Location of meteorological and flow gauge stations for the Lake Istokpoga Watershed

4.4.2 Hydrology Calibration for the Lake Istokpoga Watershed

The HSPF model simulation period was from January 1, 2005, to December 31, 2017, with an hourly timestep. Model calibration for flow and water quality were performed from January 1, 2012, to December 31, 2017, during the Verified Period, while the model validation period was January 1, 2007, through December 31, 2011. The first year of the model simulation was designated as a model spin-up time. The available flow data used in the HSPF Model calibration included continuous flow records from four long-term daily USGS gauge stations, located along Carter Creek, Livingston Creek, Josephine Creek, and Arbuckle Creek, and from one SFWMD spillway station.

As shown in **Figure 4.3**, these flow calibration stations take account of the runoff from all the subbasins covering the entire Lake Istokpoga Watershed. Josephine Creek and Arbuckle Creek are the primary inflows to Lake Istokpoga, and the hydrology calibrations on these two streams were focused in this area to address the quantity of inflows to the impaired waterbody. The two other stations, Carter Creek and Livingston Creek, were also used for hydrology calibrations. **Appendix D** presents the calibration results.

Simulated hydrological model results were compared with the available USGS gauge data in the watershed over the calibration and validation period. **Figures 4.4** through **4.6** show graphically how the model closely simulates the observed flows at the USGS gauges and S-68. **Figures 4.7** through **4.9** show the HSPF-simulated and observed cumulative daily flows obtained from the HSPF Model, USGS gauge stations, and S-68, respectively, compared with the WAM-simulated cumulative daily flows. The comparisons were made to ensure that the WAM-simulated flow was comparable to the HSPF Model and could be used where no gauged outflow data were available for impaired streams and lakes. For comparison purposes, because the first year of the HSPF simulation was designated as a model spin-up time, it is not included in calculating cumulative daily flow.

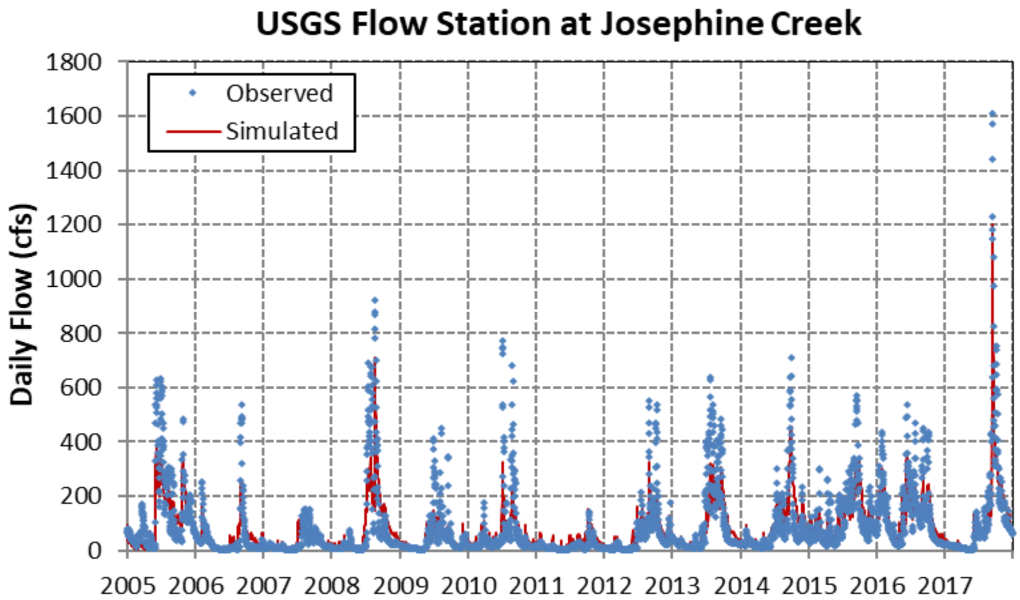

Figure 4.4. Time-series comparison of model results with USGS gauge at Josephine Creek

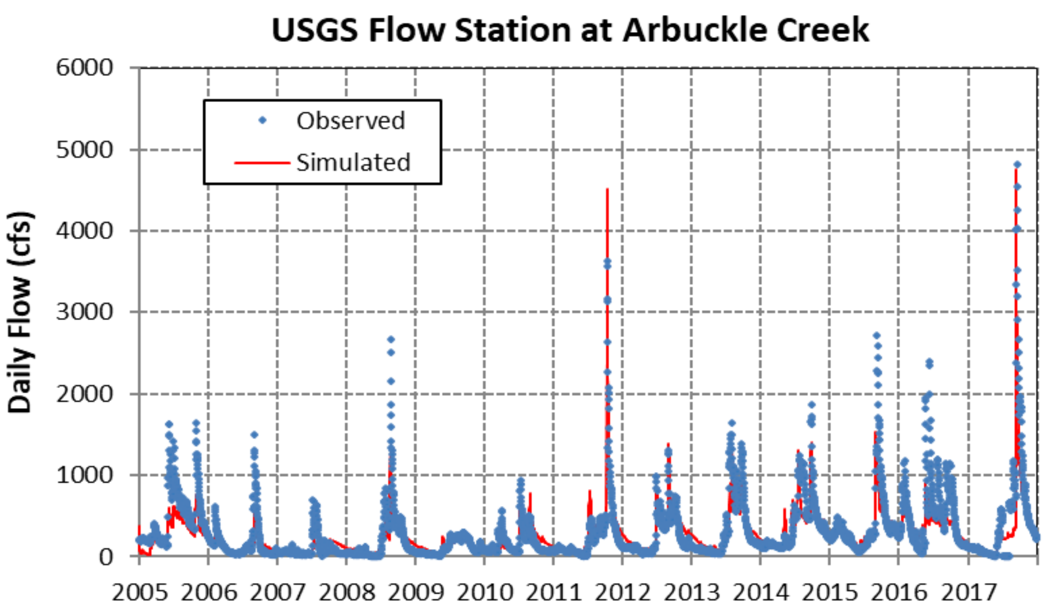

Figure 4.5. Time-series comparison of model results with USGS gauge at Arbuckle Creek

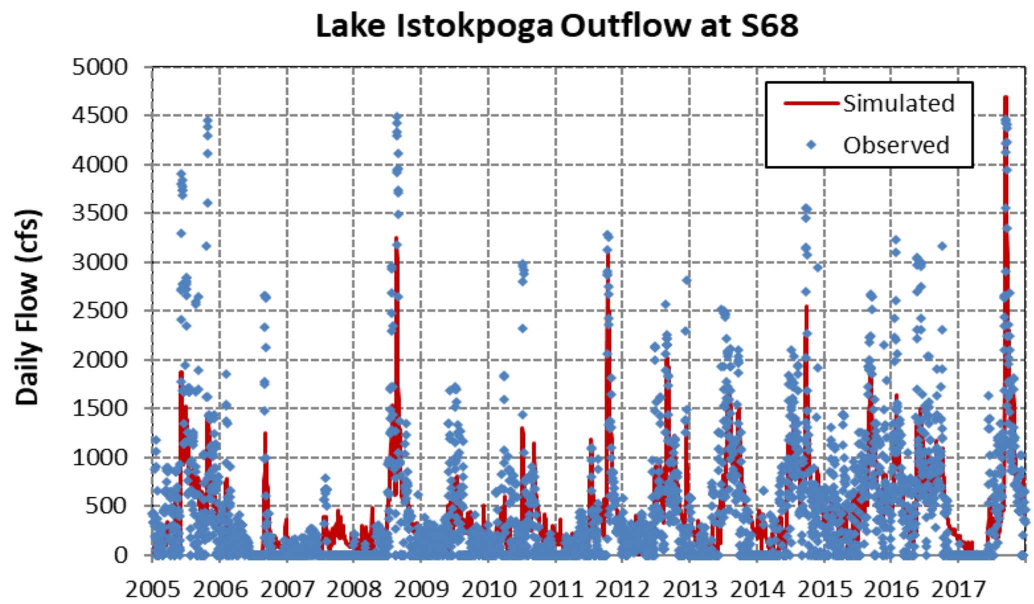

Figure 4.6. Time-series comparison of model results with observed flow at S-68

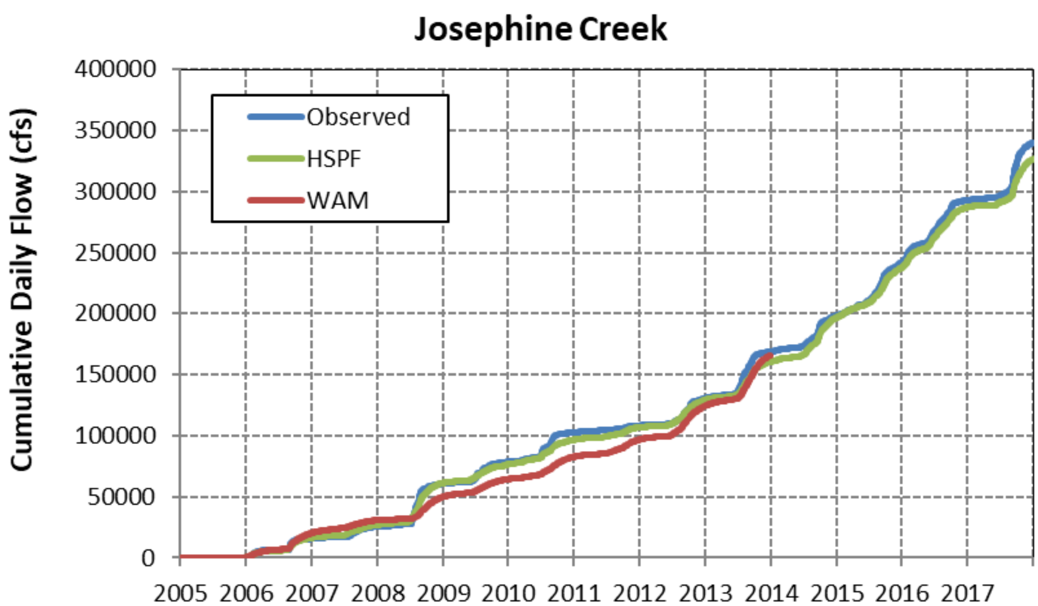

Figure 4.7. Comparison of cumulative daily flows at Josephine Creek observed from USGS gauge station and simulated by HSPF Model and WAM

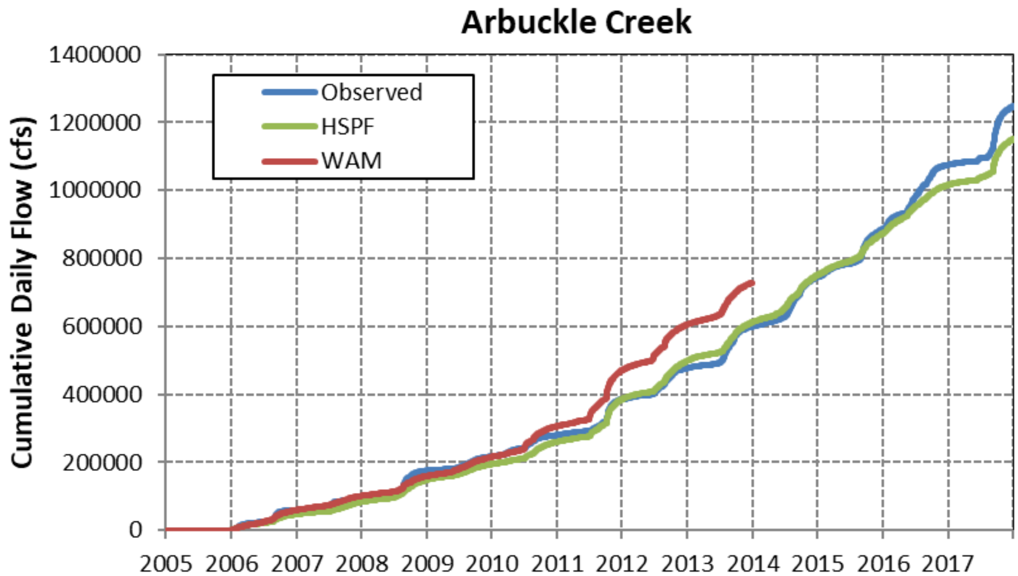

Figure 4.8. Comparison of cumulative daily flows at Arbuckle Creek observed from USGS gauge station and simulated by HSPF Model and WAM

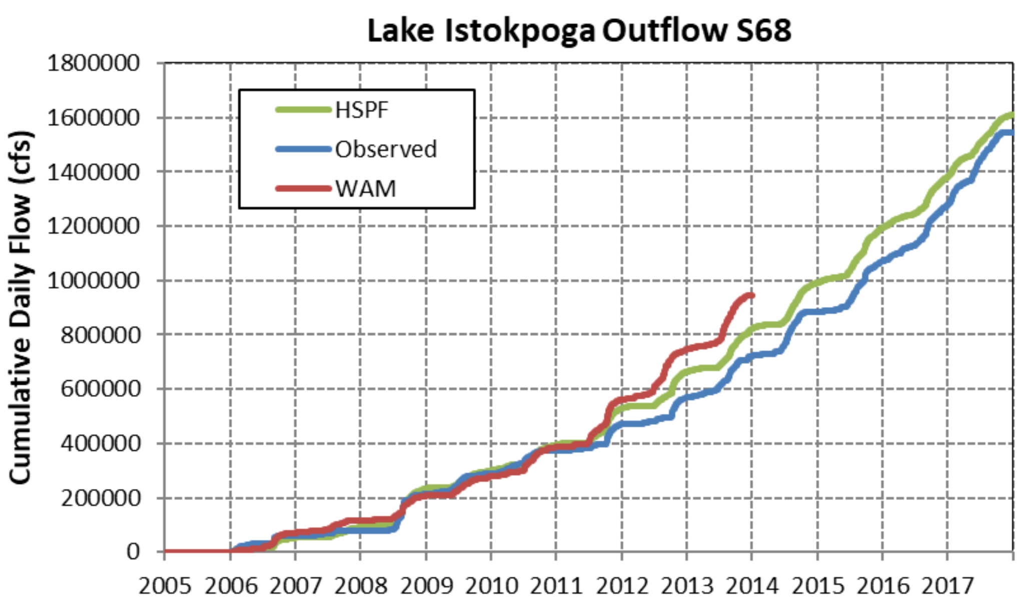

Figure 4.9. Comparison of cumulative daily flows at S-68 observed from SFWMD gauge station and simulated by HSPF Model and WAM

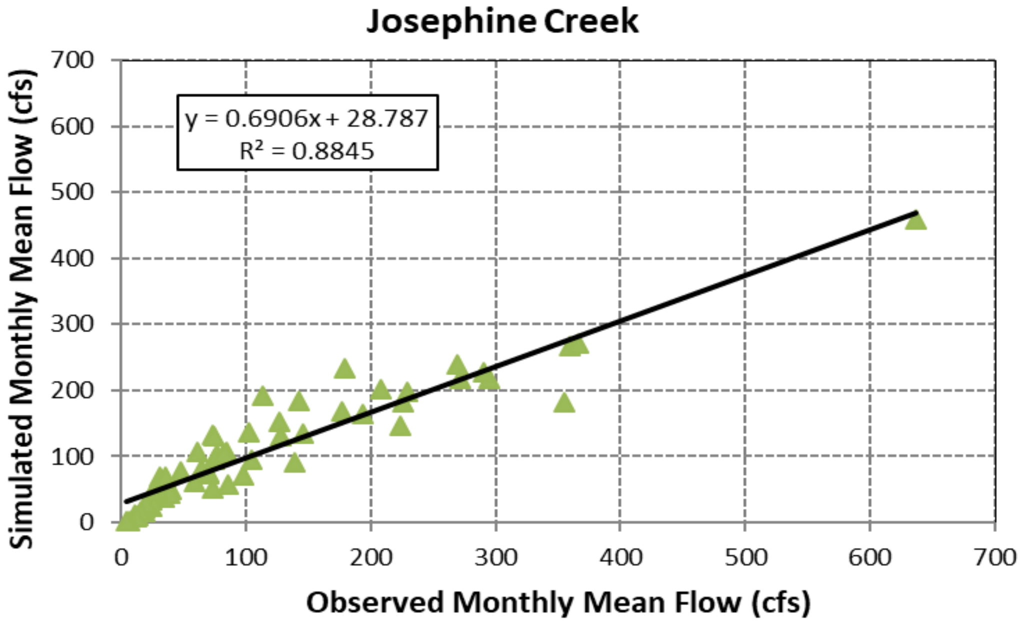

Figure 4.10. Simulated versus observed monthly flow at Josephine Creek during the calibration period

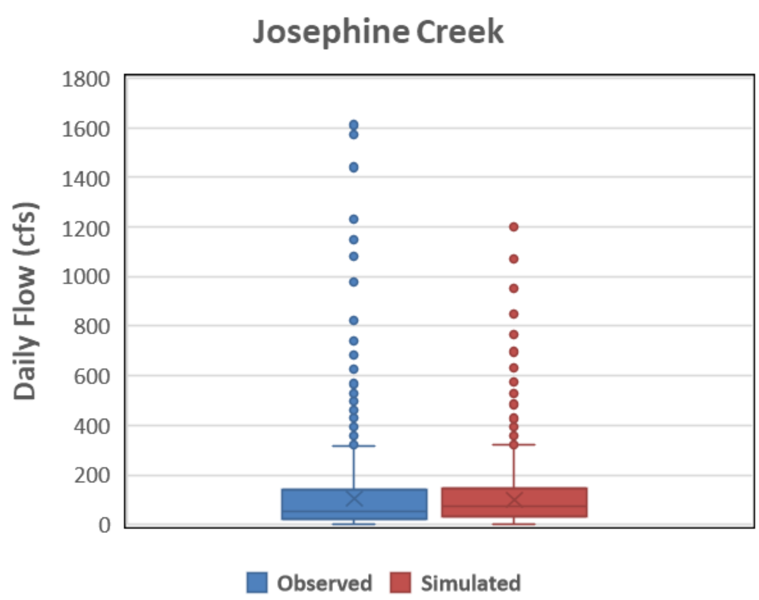

Figure 4.11. Box-whisker plot of simulated versus observed daily flow at Josephine Creek during the calibration period

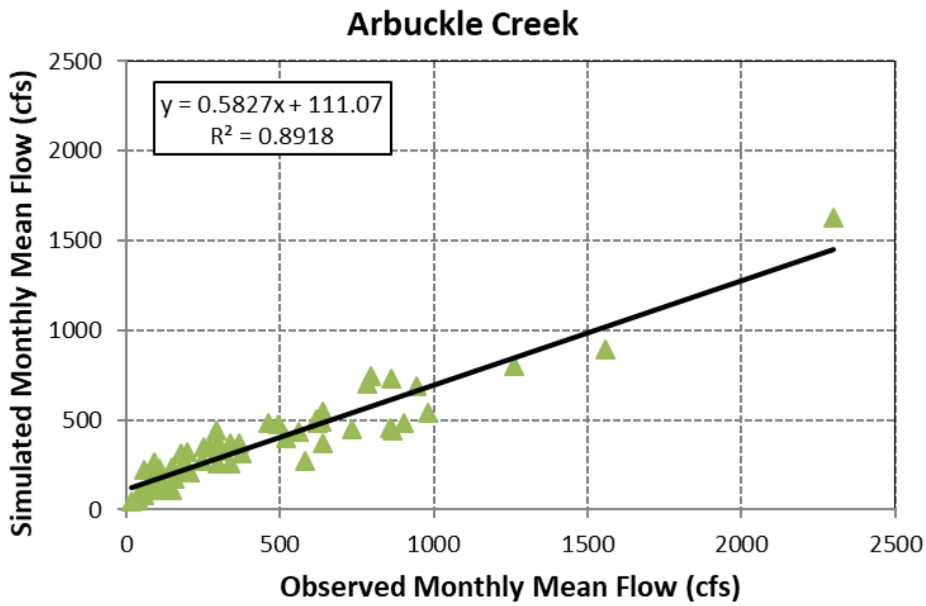

Figure 4.12. Simulated versus observed monthly flow at Arbuckle Creek during the calibration period

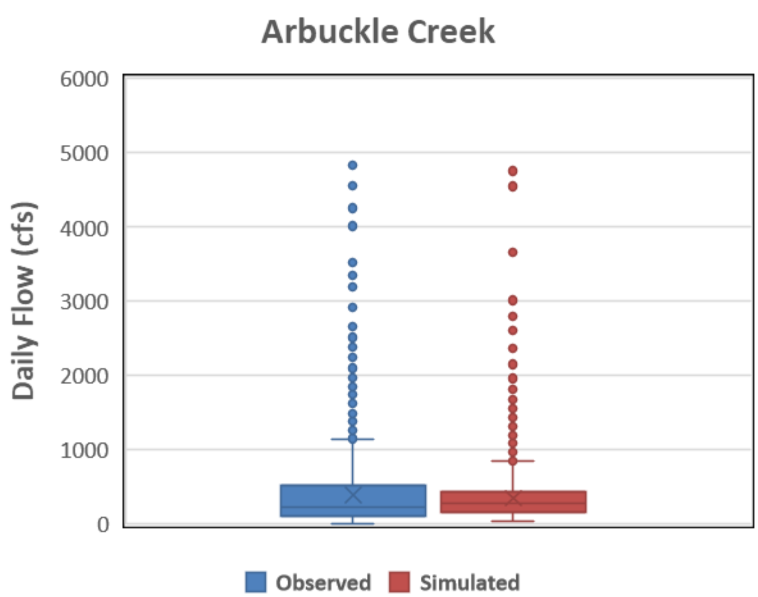

Figure 4.13. Box-whisker plot of simulated versus observed daily flow at Arbuckle Creek during the calibration period

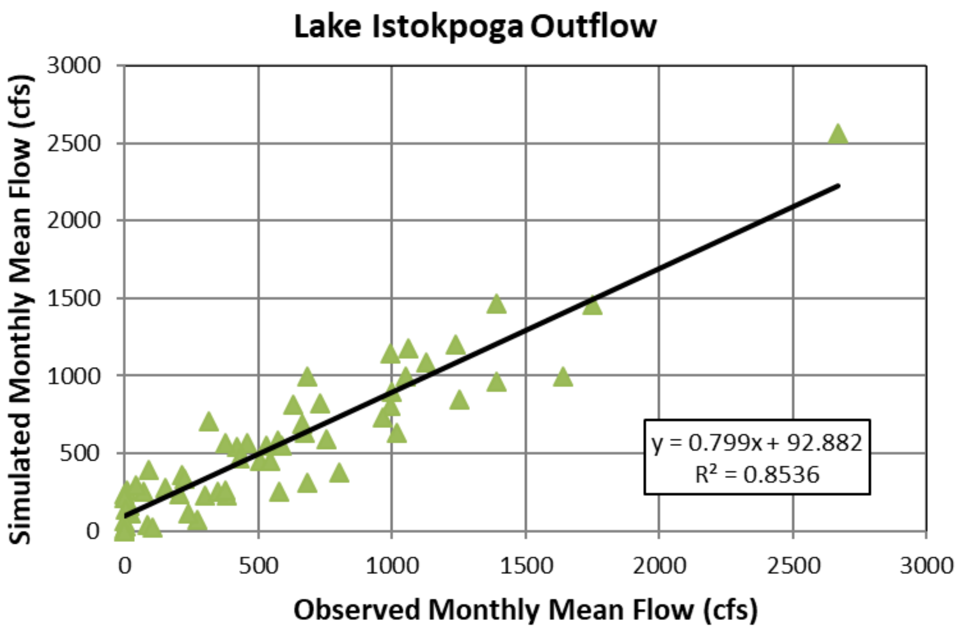

Figure 4.14. Simulated versus observed monthly flow at S-68 during the calibration period

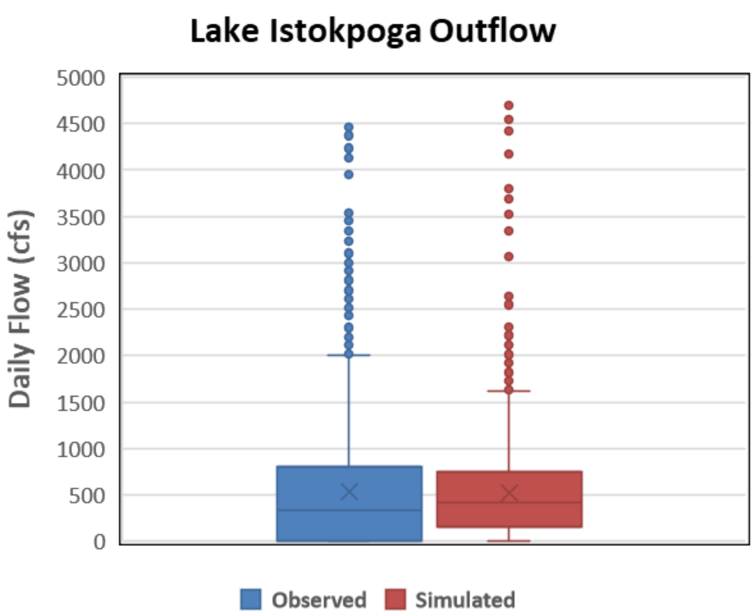

Figure 4.15. Box-whisker plot of simulated versus observed daily flow at S-68 during the calibration period

Table 4.6. Summary statistics of cumulative daily flow (cfs) at the calibration stations for Lake Istokpoga during the calibration period, 2012–17

Josephine Creek

Cumulative Daily Flow (cfs)	Mean	Median	Maximum
Observed	97,265	90,009	231,870
Simulated	93,832	89,843	219,700
% Difference	3.5%	0.2%	5.2%

Arbuckle Creek

Cumulative Daily Flow (cfs)	Mean	Median	Maximum
Observed	367,200	360,088	861,690
Simulated	357,622	366,004	765,390
% Difference	2.6%	1.6%	11.2%

Lake Istokpoga S-68

Cumulative Daily Flow (cfs)	Mean	Median	Maximum
Observed	524,431	502,747	1,178,975
Simulated	521,923	530,504	1,146,658
% Difference	0.7%	5.5%	2.7%

General calibration and validation targets by Donigian (2000) and McCutcheon et al. (1990) for HSPF applications were used to evaluate the model performance. Donigian (2000) provided some general guidance to model users on what level of agreement or accuracy may be expected from the HSPF Model application. **Table 4.6** summarizes the mean, median, and maximum of cumulative daily flow at the key calibration stations for Lake Istokpoga during the model calibration period from 2012 to 2017. Overall differences in the median values between simulated and observed data for the flow stations are less than 5 %, indicating that the model performed very well.

Table 4.7. Simulated total annual inflows and outflows for Lake Istokpoga, 2006–17

ac-ft = Acre-feet

Year	Josephine Creek (ac-ft)	Arbuckle Creek (ac-ft)	Surface Runoff (ac-ft)	Interflow (ac-ft)	Baseflow (ac-ft)	Direct Rainfall (ac-ft)	Evapora-tion (ac-ft)	Outflow (ac-ft)	% Error in Water Budget
2006	44,599	92,541	852	739	13,132	78,077	-126,683	-104,139	**0**
2007	29,873	71,575	909	178	12,314	85,285	-126,715	-74,735	**-1**
2008	93,955	127,175	4,585	7,769	38,779	128,982	-122,685	-277,814	**0**
2009	42,405	89,818	1,226	1,420	23,041	99,270	-126,306	-131,226	**0**
2010	54,815	129,570	1,240	1,289	19,026	102,366	-123,578	-184,414	**0**
2011	28,597	247,936	1,169	598	18,892	100,918	-130,647	-265,780	**0**
2012	61,427	224,792	1,906	4,535	27,969	119,732	-126,328	-311,559	**1**
2013	83,425	223,586	1,490	2,588	33,023	110,547	-123,467	-334,163	**-1**
2014	92,141	273,756	1,676	3,081	30,910	123,109	-124,219	-398,654	**0**
2015	104,577	241,941	1,427	1,253	27,824	120,111	-128,064	-369,254	**0**
2016	125,882	282,482	1,728	3,345	39,451	130,604	-129,623	-456,083	**0**
2017	101,349	265,559	2,888	7,241	30,937	123,441	-141,484	-392,062	**0**
Average	**71,920**	**189,228**	**1,758**	**2,836**	**26,275**	**110,204**	**-127,483**	**-274,990**	**0**

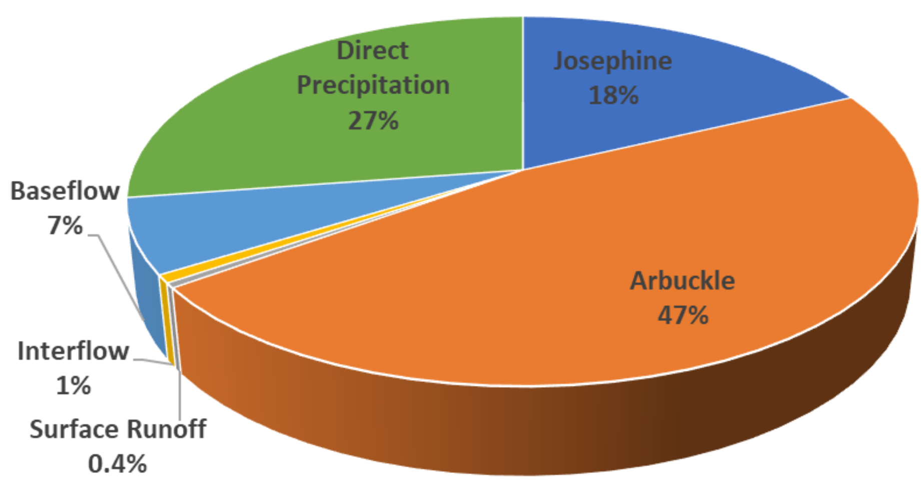

Figure 4.16. Simulated percent long-term average inflows to Lake Istokpoga during the simulation period, 2006–17

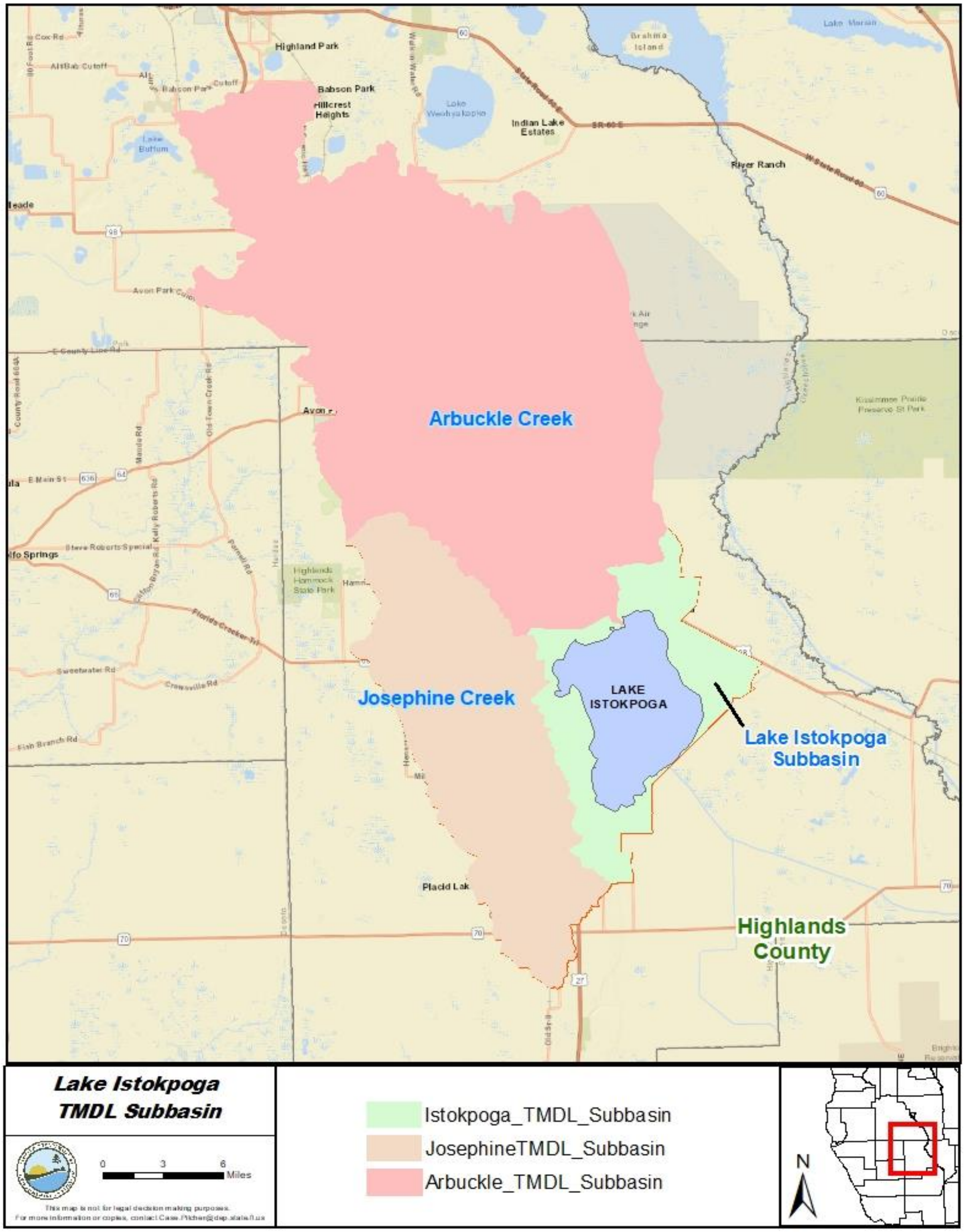

Figure 4.17. Contributing subbasins in the Lake Istokpoga Watershed

4.4.3 Water Balance for Lake Istokpoga

Lake water budget is an important tool for understanding the relative importance of water inflows. Water pathways (i.e., surface runoff, interflow, baseflow, and direct precipitation) through each land use category that carry nutrients from nonpoint and point sources were identified in the HSPF Model, and nutrient loads from different types of land use were then quantified.

Table 4.7 and **Figure 4.16** list simulated total annual inflows and outflows from Lake Istokpoga from 2006 to 2017. The long-term average (12-year) of the annual total inflow was calculated using the data from 2006 to 2017. The predominant inflow to Lake Istokpoga, with a 12-year average, came from Arbuckle Creek and Josephine Creek upstream, at 261,148 ac-ft/yr, and comprised 65 % of the total inflow to the lake. The second largest annual total inflow was from direct rainfall, with a 12-year average of 110,204 ac-ft, accounting for 27 %.

The simulated upstream inflow and direct rainfall are comparable to those estimated by Walker and Havens (2003), who ran the water balance model from 1994 to 2000 for Lake Istokpoga. Their estimates on these major inflows were 261,374 ac-ft/yr for upstream inflows and 111,067 ac-ft/yr for direct rainfall, comprising 63 % and 27 %, respectively, of the total inflows to the lake. For lake water balance, long-term averages of simulated outflow and evaporation were also estimated at 274,990 and 127,483 ac-ft/yr, respectively, corresponding to those (292,991 ac-ft/yr for outflow and 128,335 ac-ft/yr for evaporation) reported by Walker and Havens (2003).

The nutrient trend analysis study conducted by SFWMD using the flow and water quality monitoring data collected from 2006 to 2015 at the subbasin loading stations in the Lake Okeechobee Watershed also estimated mean flows of 184,000 ac-ft/yr at the Arbuckle Creek station and 249,000 ac-ft/yr at the Lake Istokpoga outflow station at S-68 (Zhang et al. 2016). These independent estimates correspond to those simulated by the HSPF Model, indicating the model performance is acceptable. **Table 4.7** also lists the difference between simulated total inflows and outflows, showing that the simulated inflows to the lake are well balanced with the simulated outflows from the lake, with an error of less than 1 % over the simulation period. Therefore, the HSPF Model simulated reasonably each component of the inflow and outflow for Lake Istokpoga.

4.4.4 Estimating Watershed Nutrient Loadings

Watershed loads of TN and TP to Lake Istokpoga were generated using the BINARY output from PERLND, IMPLND, and RCHRES. The BINARY output provides all model output information and can be used for TMDL calculations. The BINARY output can be viewed and extracted by SARA Timeseries Utility for the estimates of TN and TP loadings from different land use types. Annual loads of TN and TP in PERLND and IMPLND for the Lake Istokpoga Watershed were calculated using the model outputs from all land use types, the MASS-LINK and SCHEMATIC blocks.

The TN and TP loads from contributing subbasins via various transport pathways—including streams, direct rainfall, surface runoff, interflow, and baseflow—were estimated for the existing condition to calculate the existing total TN and TP loads to Lake Istokpoga (**Figure 4.17)**. **Tables 4.8** and **4.9** list the estimated annual loads of TN and TP from each subbasin under the existing condition in the Lake Istokpoga Watershed. The Arbuckle Creek Subbasin via Arbuckle Creek is the major contributor, delivering a 12-year average annual TN load of 867,677 lbs/yr, followed by the Josephine Creek Subbasin, which contributes an annual TN load of 246,993 lbs/yr via Josephine Creek (**Table 4.8**). These TN loads accounted for 81 % of the total incoming TN load to the lake (**Figure 4.18**). The annual average TN loads from the Lake Istokpoga Subbasin via baseflow and interflow were 88,436 and 23,281 lbs/yr, respectively. Including surface runoff TN load, the Lake Istokpoga Subbasin contributed less than 10 % of the total TN load, while direct rainfall contributions were calculated at an average annual TN load of 152,602 lbs/yr, accounting for 11 % of the total TN load. The existing total TN load, including the direct rainfall contribution to the lake, was a 12-year average annual TN load of 1,386,740 lbs/yr.

The 12-year average annual TP loads from the Arbuckle Creek and Josephine Creek Subbasins were estimated to be 64,424 and 14,011 lbs/yr, respectively, accounting for 80 % of the total incoming TP load to the lake (**Table 4.9** and **Figure 4.19**). Direct rainfall contributions were calculated at an average annual TP load of 16,279 lbs/yr, accounting for 17 % of the total TP load. TP contributions from the Lake Istokpoga Subbasin via surface runoff, interflow, and baseflow were less than 3 %. Under the existing condition, the simulated existing total load of TP including the direct rainfall contribution to the lake, as a 12-year long-term average, was 98,157 lbs/yr (**Table 4.9**).

Comparable estimates of TN and TP loads for the Arbuckle Creek and S-68 stations were reported by SFWMD, which used the flow and water quality monitoring data collected from 2006 to 2015 at the subbasin loading stations in the Lake Okeechobee Watershed (Zhang et al. 2016). The annual mean TN and TP loads in the nutrient trend analysis study were estimated to be 628,317 lbs/yr for TN and 66,139 lbs/yr for TP at the Arbuckle Creek station, and 1,018,535 lbs/yr for TN and 57,320 lbs/yr for TP at the Lake Istokpoga outlet station at S-68. These independent estimates are comparable to those simulated by the HSPF TMDL Model.

Table 4.8. Simulated annual TN loads (lbs/yr) to Lake Istokpoga from each subbasin under the existing condition

Year	Josephine TN Load (lbs/yr)	Arbuckle TN Load (lbs/yr)	Surface Runoff TN Load (lbs/yr)	Interflow TN Load (lbs/yr)	Baseflow TN Load (lbs/yr)	Direct Rainfall TN Load (lbs/yr)	Total Incoming TN Load (lbs/yr)	Outflow TN Load (lbs/yr)
2006	158,730	424,000	2,302	6,014	44,221	110,428	745,695	391,600
2007	93,080	275,280	2,084	1,422	42,553	123,817	538,236	282,220
2008	363,670	663,800	20,459	64,286	128,772	173,784	1,414,772	1,111,200
2009	138,210	377,940	3,943	11,552	77,216	143,292	752,154	495,470
2010	185,680	589,360	3,541	10,428	66,165	149,128	1,004,302	698,400
2011	86,495	1,174,400	2,750	4,833	64,940	141,351	1,474,768	1,091,900
2012	205,320	1,043,000	13,189	37,192	93,717	160,488	1,552,906	1,250,700
2013	299,950	996,440	6,465	21,182	109,853	155,924	1,589,815	1,261,100
2014	315,040	1,293,900	8,170	25,159	103,047	166,438	1,911,753	1,549,100
2015	333,470	1,063,000	3,580	10,072	94,662	164,741	1,669,525	1,342,900
2016	398,920	1,175,500	6,874	27,211	132,395	179,077	1,919,976	1,620,000
2017	385,350	1,335,500	19,650	60,025	103,691	162,760	2,066,977	1,662,000
Average	**246,993**	**867,677**	**7,751**	**23,281**	**88,436**	**152,602**	**1,386,740**	**1,063,049**

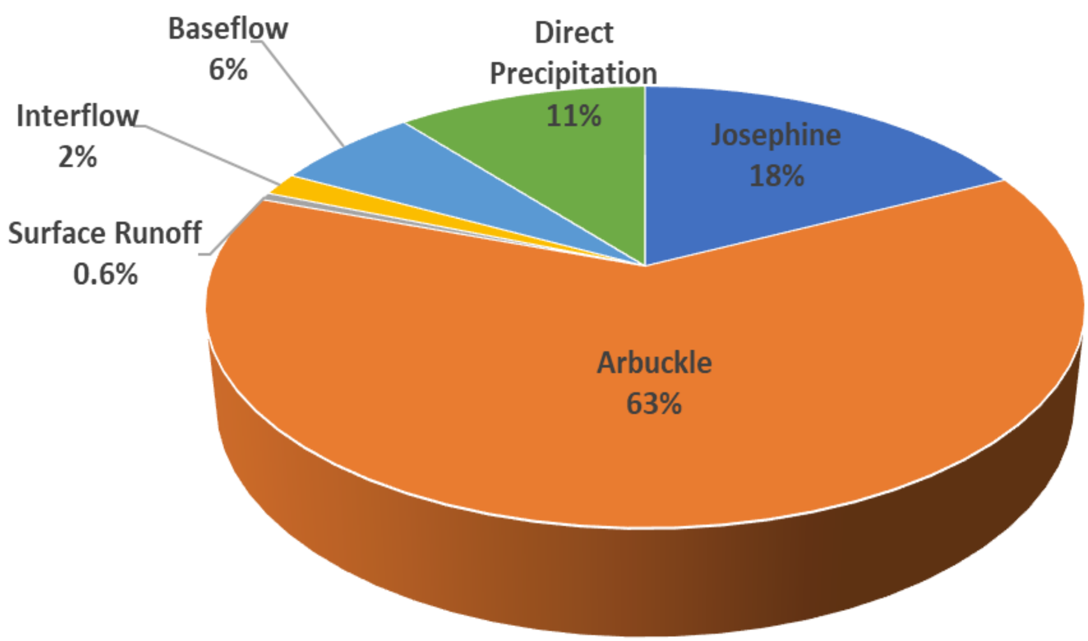

Figure 4.18. Percent TN loads to Lake Istokpoga from each subbasin during the simulation period, 2006–17

Table 4.9. Simulated annual TP loads (lbs/yr) to Lake Istokpoga from each subbasin under the existing condition

Year	Josephine TP Load (lbs/yr)	Arbuckle TP Load (lbs/yr)	Surface Runoff TP Load (lbs/yr)	Interflow TP Load (lbs/yr)	Baseflow TP Load (lbs/yr)	Direct Rainfall TP Load (lbs/yr)	Total Incoming TP Load (lbs/yr)	Outflow TP Load (lbs/yr)
2006	7,876	32,871	157	449	574	14,100	56,026	17,947
2007	3,761	14,619	176	108	576	14,649	33,889	10,954
2008	22,521	61,795	1,386	4,632	1,579	17,232	109,145	61,214
2009	5,718	22,351	194	852	972	15,462	45,549	21,140
2010	9,539	44,281	218	784	893	15,673	71,388	31,288
2011	3,527	86,945	196	362	862	15,649	107,541	54,948
2012	10,062	71,461	1,908	2,736	1,177	16,898	104,242	64,650
2013	18,453	80,321	272	1,560	1,363	16,403	118,372	67,069
2014	17,396	98,803	389	1,856	1,292	17,100	136,836	85,820
2015	19,238	72,579	218	755	1,226	16,818	110,834	65,974
2016	21,715	73,757	328	2,022	1,664	17,822	117,308	80,913
2017	28,327	113,300	1,969	4,325	1,294	17,538	166,753	101,500
Average	**14,011**	**64,424**	**618**	**1,703**	**1,123**	**16,279**	**98,157**	**55,285**

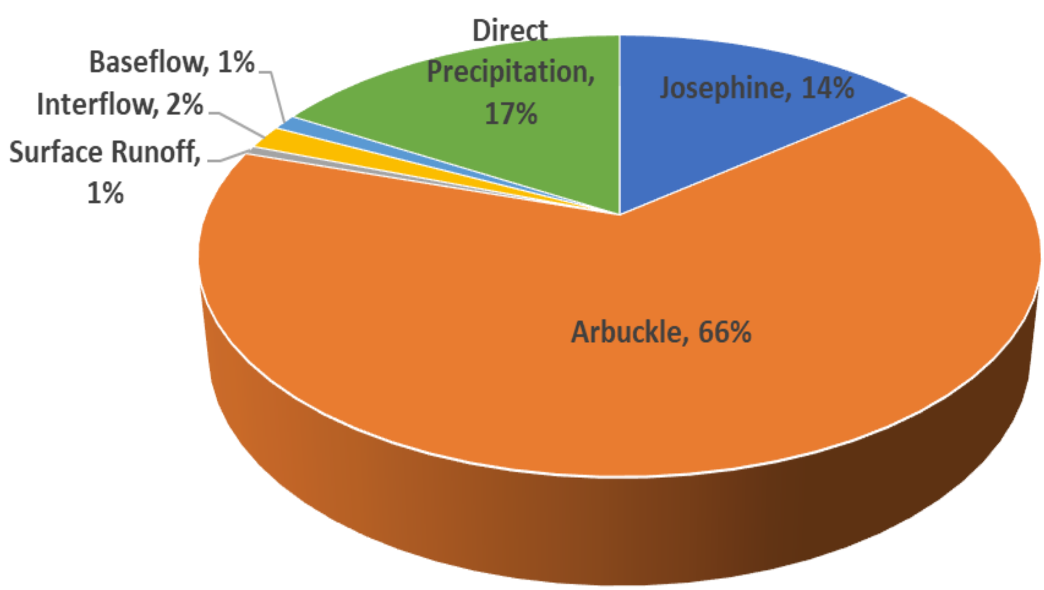

Figure 4.19. Percent TP loads to Lake Istokpoga from each subbasin during the simulation period, 2006–17

Chapter 5: Determination of Assimilative Capacity

5.1 Determination of Loading Capacity

Nutrient enrichment and the resulting problems related to eutrophication tend to be widespread and are frequently manifested far (in both time and space) from their sources. Addressing eutrophication involves relating water quality and biological effects such as photosynthesis, decomposition, and nutrient recycling as acted on by environmental factors (rainfall, point source discharge, etc.) to the timing and magnitude of constituent loads supplied from various categories of pollution sources. Assimilative capacity should be related to some specific hydrometeorological condition during a selected period or to some range of expected variation in these conditions.

The goal of this TMDL analysis is to determine the assimilative capacity of Lake Istokpoga and to identify the maximum allowable TN and TP loadings from the watershed, so that Lake Istokpoga will meet the TMDL target (chlorophyll *a*) and thus maintain its function and designated use as a Class III water.

5.2 Critical Conditions and Seasonal Variation

The estimated assimilative capacity is based on annual conditions, rather than critical/seasonal conditions, because (1) the methodology used to determine assimilative capacity does not lend itself very well to short-term assessments, (2) DEP is generally more concerned with the net change in overall primary productivity in the segment, which is better addressed on an annual basis, and (3) the methodology used to determine impairment is based on annual conditions.

5.3 Water Quality Modeling to Determine Assimilative Capacity

5.3.1 Water Quality Calibration for Lake Istokpoga

Water quality data collected in Lake Istokpoga from 2005 through 2017 were used for in-lake water quality calibration. As shown in **Figure 2.1**, water quality monitoring stations were available for model calibration purposes, and the data from each station were examined as part of data quality control processes to compare with the HSPF Model simulation results. Since the lake is shallow and well mixed, the data from the monitoring stations were combined and compared with the model simulation results. The simulated daily data obtained from the calibrated HSPF Model were later converted to AGM values for TMDL development, to be consistent with the expression of the generally applicable NNC for lakes.

Figures 5.1 through **5.12** show detailed time-series comparisons, annual means and standard deviations, box-whisker plots, and AGMs between observed versus simulated results for TN, TP, and chlorophyll *a* from 2006 to 2017. **Appendix D** presents water quality calibrations for other parameters, temperature and DO. Using the general calibration/validation targets or tolerances based on Donigian (2000) and McCutcheon et al. (1990), the percent differences in the median and mean AGM values of the observed data compared with the model-simulated results are listed in **Table 5.1**, indicating that the HSPF Model performs very well in simulating water quality in Lake Istokpoga.

Table 5.1. Summary of HSPF calibration statistics in AGMs for water quality parameters

[1] Categories are based on Donigian (2000) and McCutcheon et al. (1990) calibration/validation targets or tolerances for water quality parameters.

Calibration Measure	Temperature	DO	TN	TP	Chlorophyll *a*
% Difference in Medians	0	13	6	2	9
Category[1] for Medians	Very good	Very good	Very good	Very good	Very good
% Difference in Means	0.1	12	5	3	6
Category[1] for Means	Very good	Very good	Very good	Very good	Very good

5.3.2 Natural Background Conditions to Determine Natural Levels of Chlorophyll *a*, TN, and TP

The natural background conditions for the Lake Istokpoga Watershed were established to ensure that the proposed restoration target will not abate the natural background condition. The restoration target meets this requirement based on the natural background scenario run. For this simulation, the water, wetland, and forest land uses in the current condition model were kept the same, but all anthropogenic land uses were converted into forest or wetland land uses based on their hydrologic soil group classification. Anthropogenic land uses with Class A soils were converted to forests, and anthropogenic land uses with other soil types—Class B, C, and D as well as dual category soils—were converted to wetlands. The background simulation was performed from 2005 to 2017, with the first year of simulation used as a model spin-up time. The 12-year average AGMs of TN, TP, and chlorophyll *a* for the natural background condition were 0.98 mg/L, 0.030 mg/L, and 12.0 µg/L, respectively.

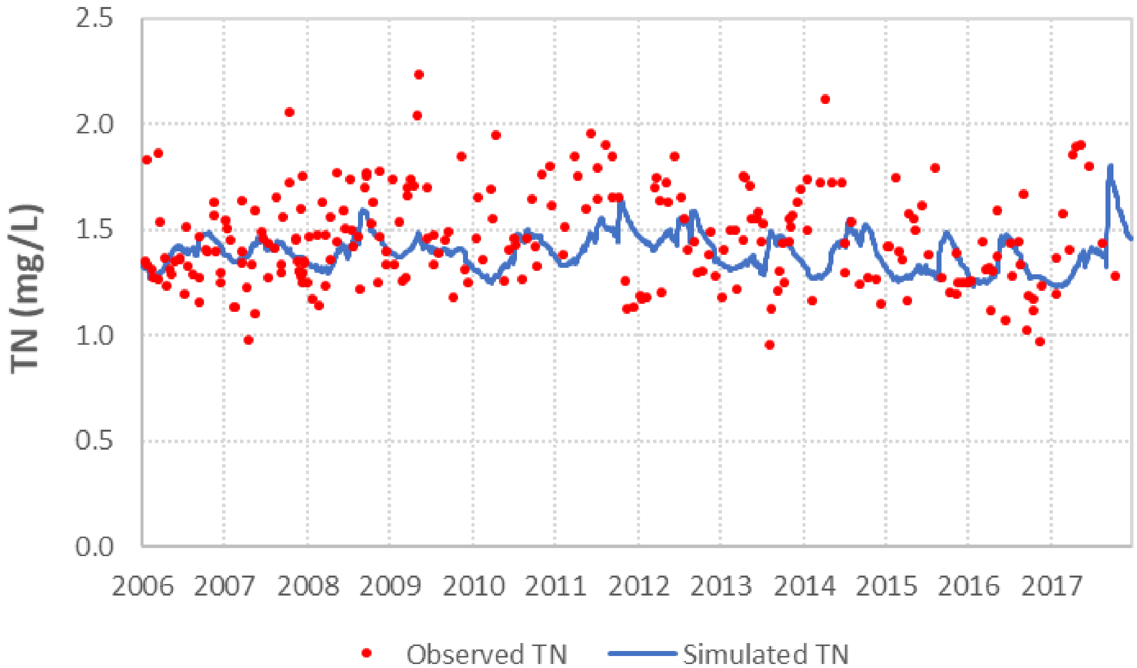

Figure 5.1. Time-series of observed versus simulated TN (mg/L) in Lake Istokpoga, 2006–17

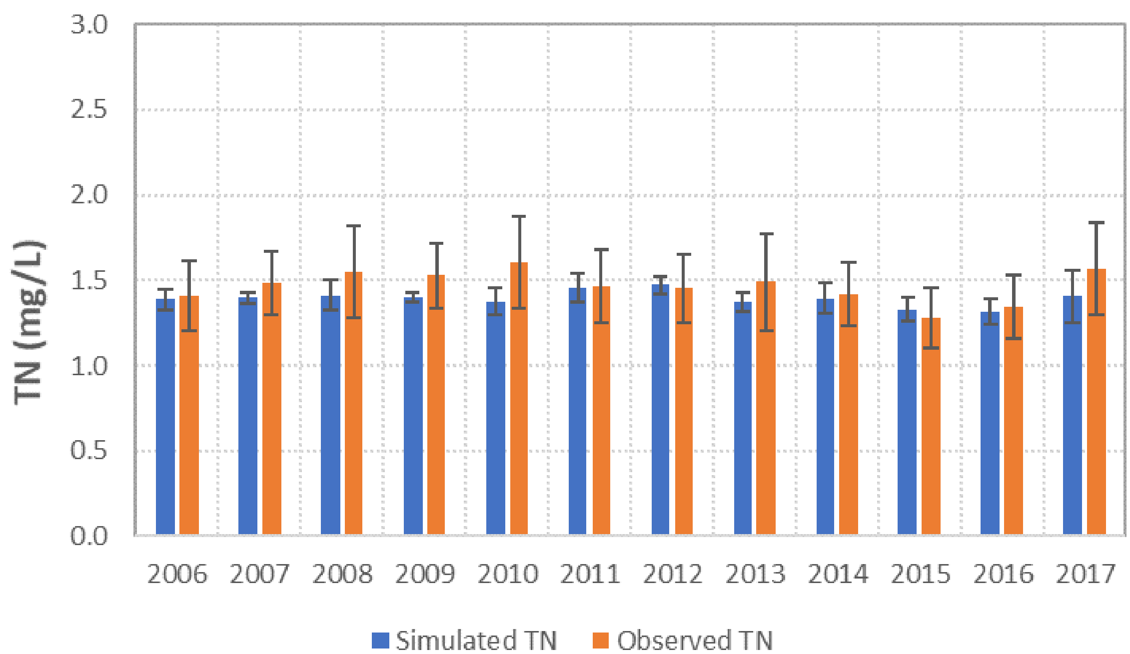

Figure 5.2. Annual mean and standard deviation of simulated versus observed TN (mg/L) in Lake Istokpoga, 2006–17

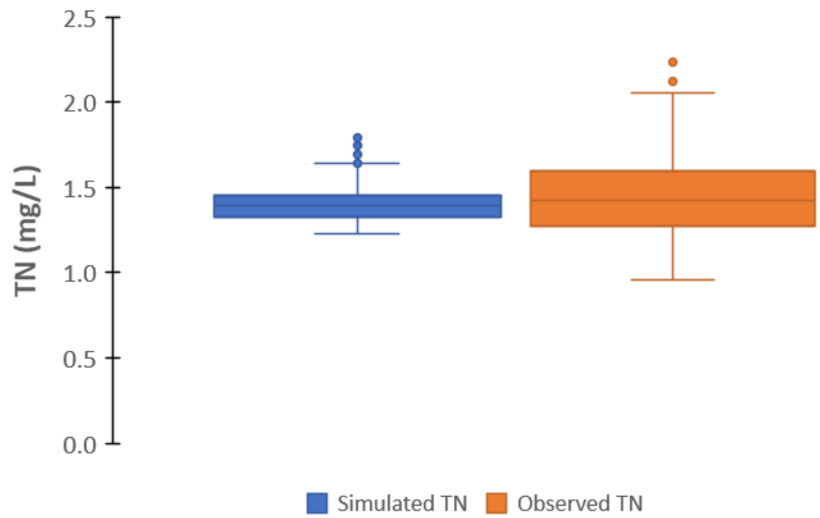

Figure 5.3. **Box-whisker plot of simulated versus observed TN (mg/L) in Lake Istokpoga**

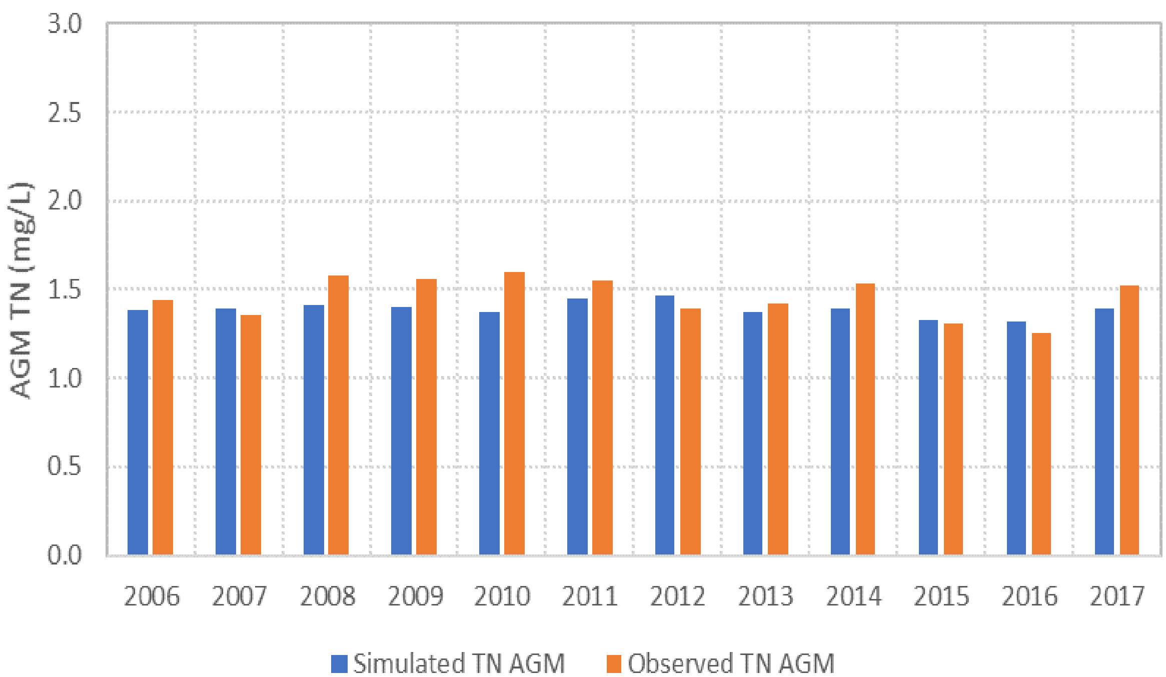

Figure 5.4. **AGMs of simulated versus observed TN (mg/L) in Lake Istokpoga**

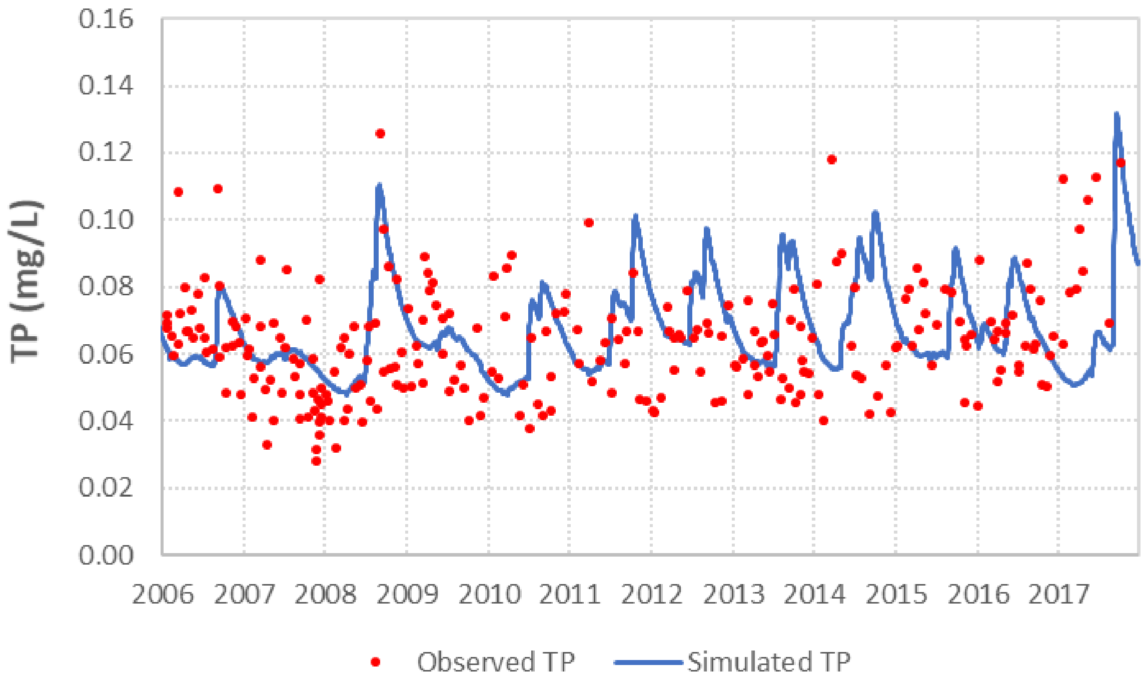

Figure 5.5. Time-series of observed versus simulated TP (mg/L) in Lake Istokpoga, 2006–17

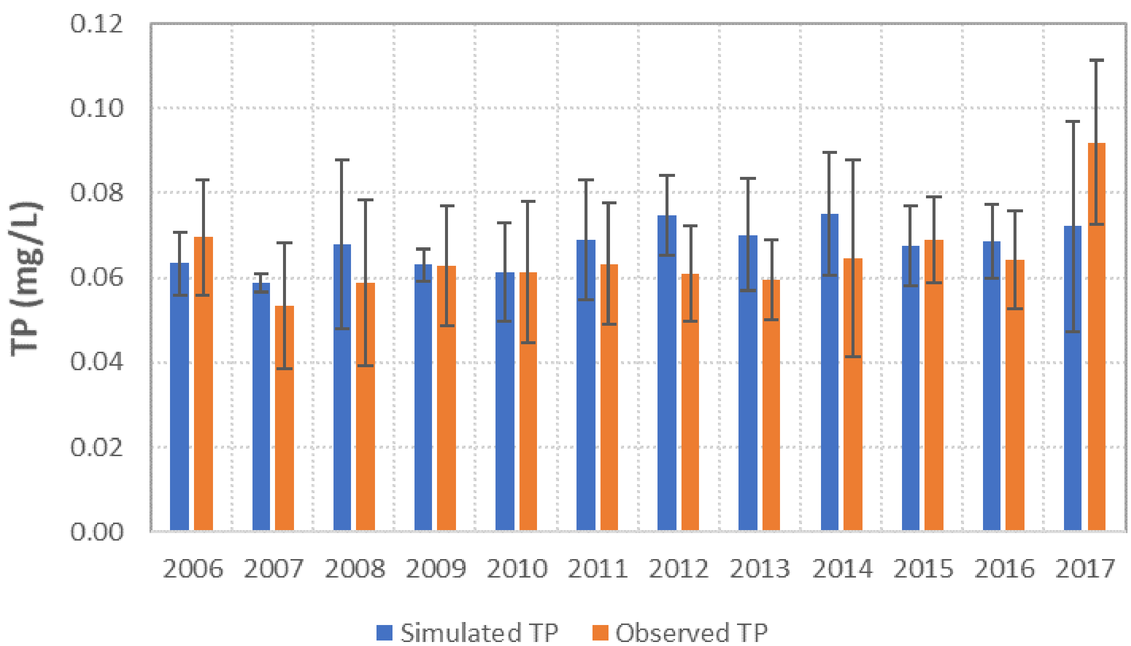

Figure 5.6. Annual mean and standard deviation of simulated versus observed TP (mg/L) in Lake Istokpoga, 2006–17

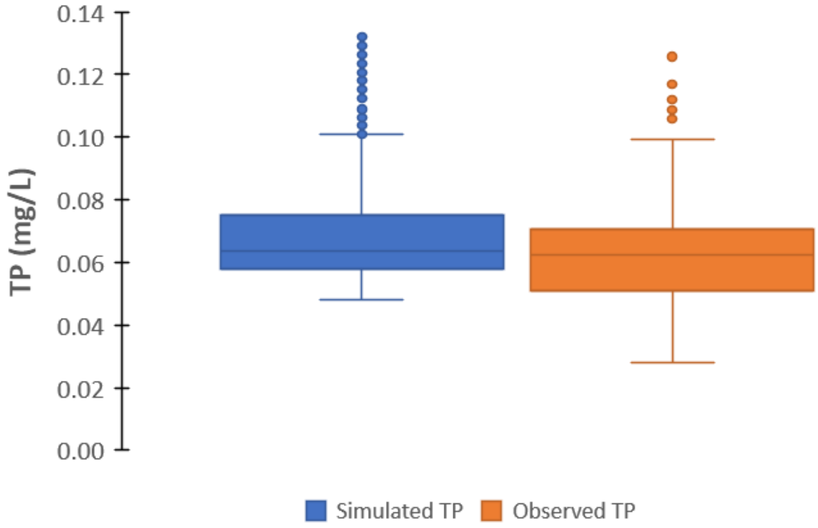

Figure 5.7. Box-whisker plot of simulated versus observed TP (mg/L) in Lake Istokpoga

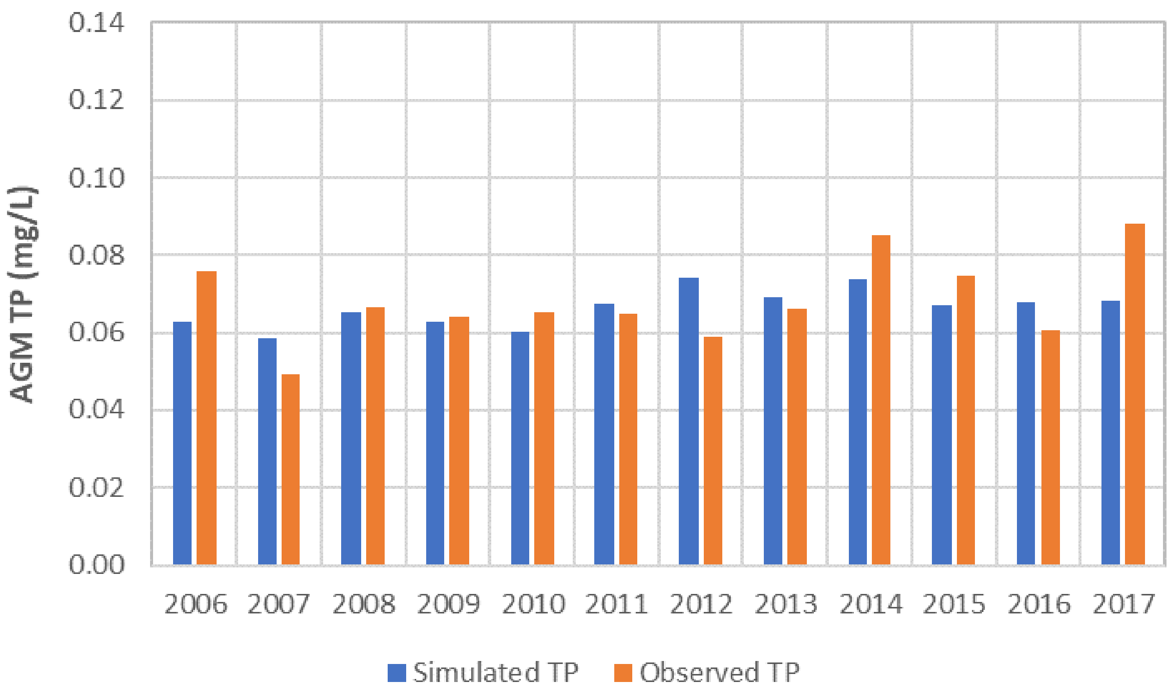

Figure 5.8. AGMs of simulated versus observed TP (mg/L) in Lake Istokpoga

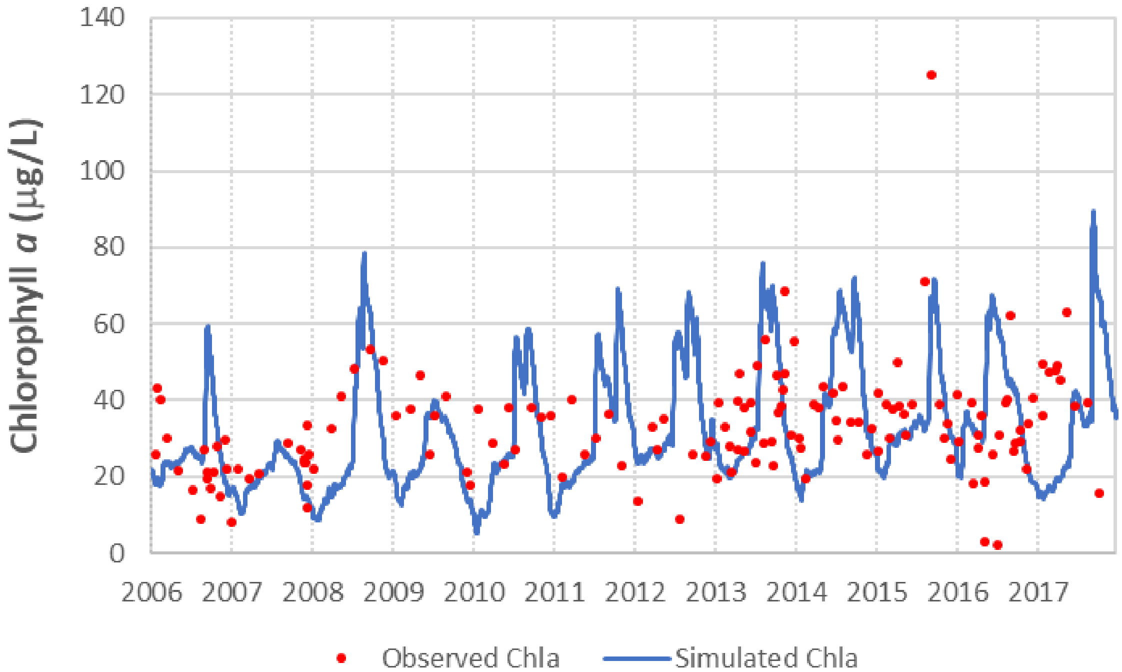

Figure 5.9. Time-series of observed versus simulated chlorophyll *a* (µg/L) in Lake Istokpoga, 2006–17

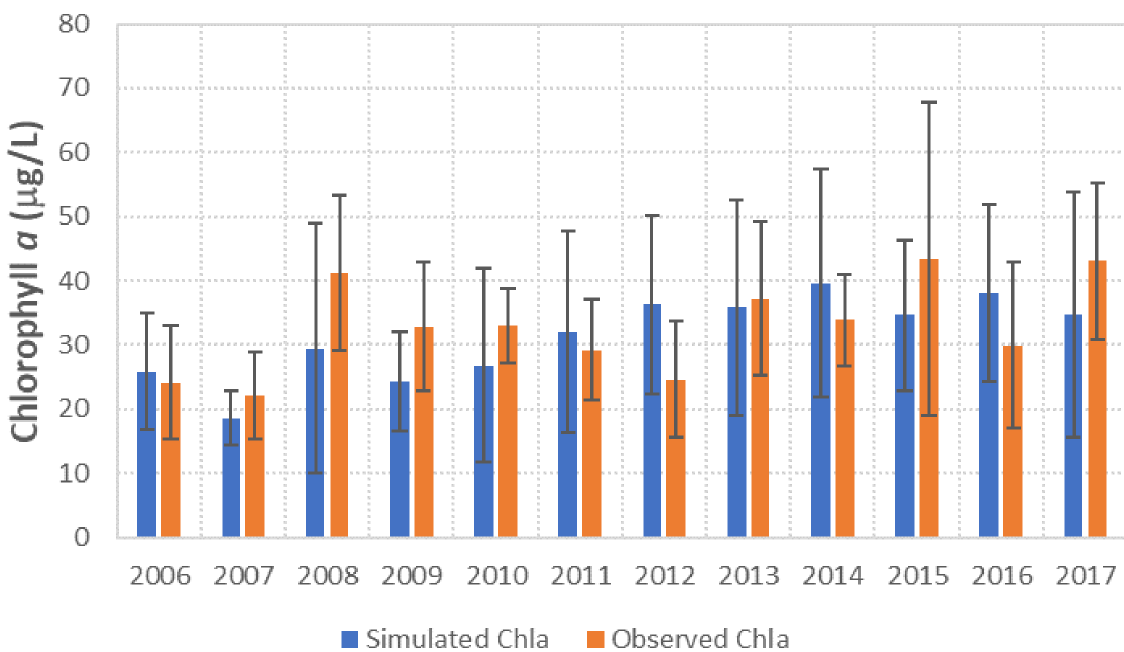

Figure 5.10. Annual mean and standard deviation of simulated versus observed chlorophyll *a* (µg/L) in Lake Istokpoga, 2006–17

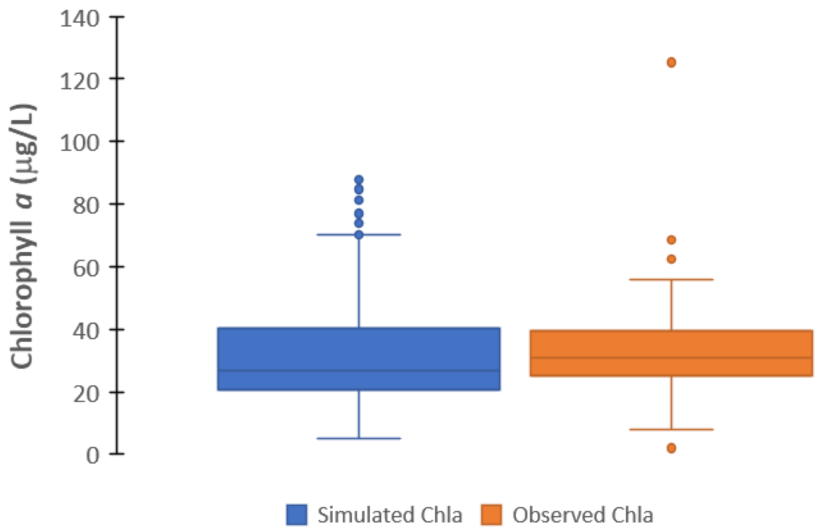

Figure 5.11. Box-whisker plot of simulated versus observed chlorophyll *a* (µg/L) in Lake Istokpoga

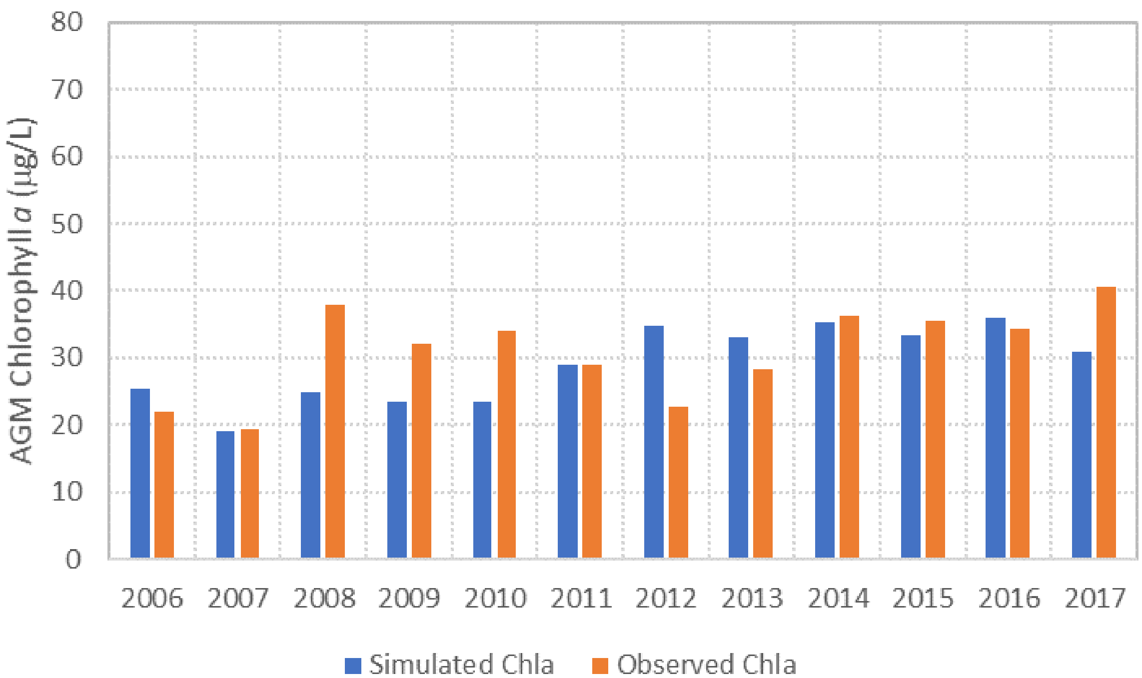

Figure 5.12. AGMs of simulated versus observed chlorophyll *a* (µg/L) in Lake Istokpoga

5.3.3 Load Reduction Scenarios to Determine the TMDLs

To achieve the TMDL target chlorophyll *a* concentration of 20 µg/L in the lake, the TN and TP loads from the watershed, but not direct atmospheric TN and TP loads, were incrementally reduced until the chlorophyll *a* target was met in every year of the modeling period. Meeting the chlorophyll *a* target in every year is considered a conservative assumption for establishing the TMDLs, as this will ensure that any conditions during the simulation period resulting in exceedances of the target, including dry and wet years, are addressed.

Figures 5.13 through **5.18** show the model results for the current condition and the load reduction scenario that attained the chlorophyll *a* target in each year. When the existing watershed TN and TP loads were reduced by 25 % and 65 %, respectively, while keeping the current permitted limits for the NPDES facility, the AGMs of simulated chlorophyll *a* did not exceed the target (20 µg/L) in any single year (**Figure 5.18** and **Table 5.2**). The model was also run with the reduced permits applying the same percent TN and TP reductions to the NPDES facility. Using this scenario, the resultant water quality impact on Lake Istokpoga was minimal, as shown in **Table 5.2**, indicating that the chlorophyll *a* target was met in every year of the modeling period under both scenario conditions. Therefore, it was determined that the TMDLs for Lake Istokpoga were expressed without additional reductions to the facility currently providing AWT.

Under the watershed load reduction condition, with a 25 % reduction in TN and a 65 % reduction in TP that meets the chlorophyll *a* target, the AGMs of simulated in-lake TP concentrations ranged from 0.037 to 0.040 mg/L, and for TN, from 1.02 to 1.18 mg/L. For informational purposes, the TP and TN concentrations resulting from the TP and TN reduction scenarios were also calculated, and "restoration nutrient targets" are set as the maximum AGMs of TP and TN at 0.040 and 1.18 mg/L, respectively, not to be exceeded in any year (**Figures 5.14** and **5.16**).

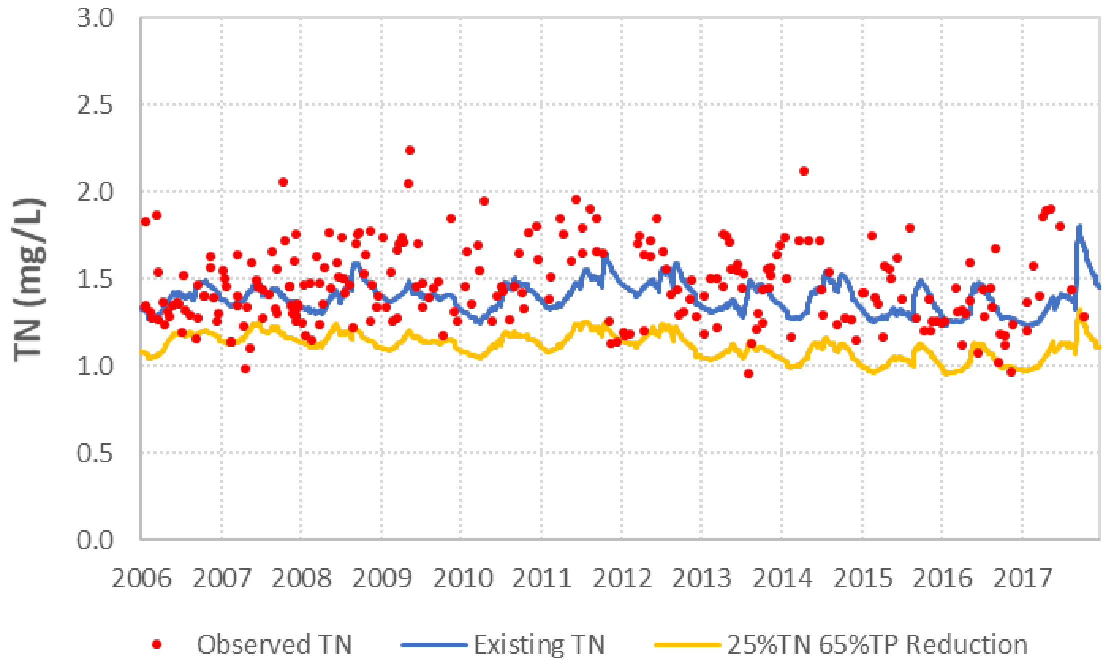

Figure 5.13. Time-series of TN (mg/L) in Lake Istokpoga for existing and load reduction conditions

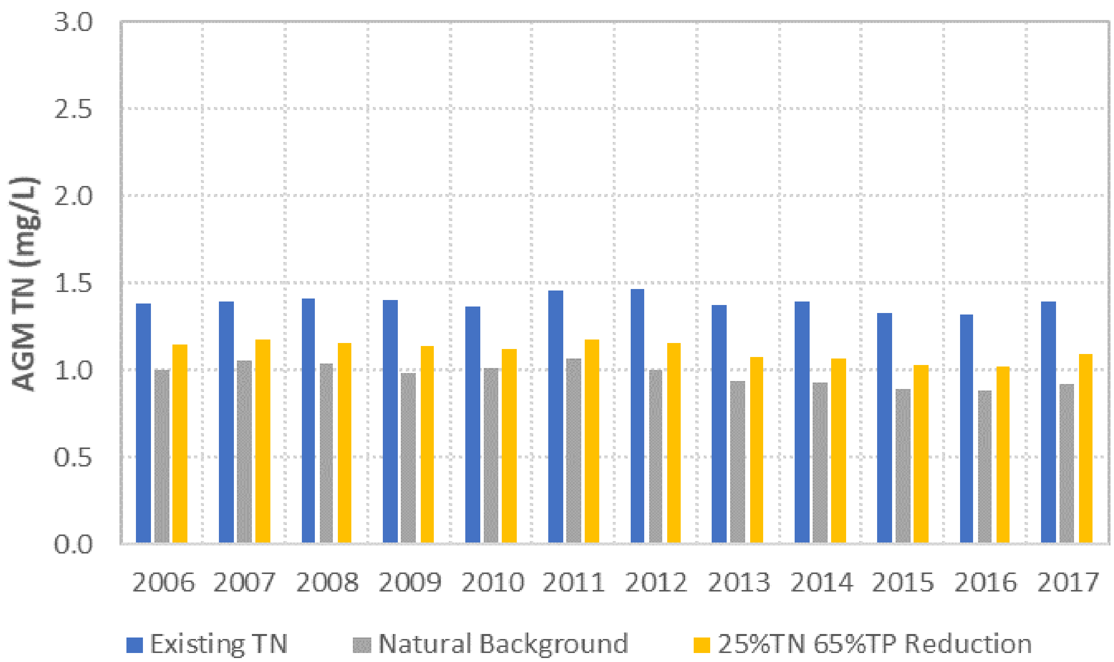

Figure 5.14. TN AGMs (mg/L) in Lake Istokpoga for existing, natural background, and load reduction conditions

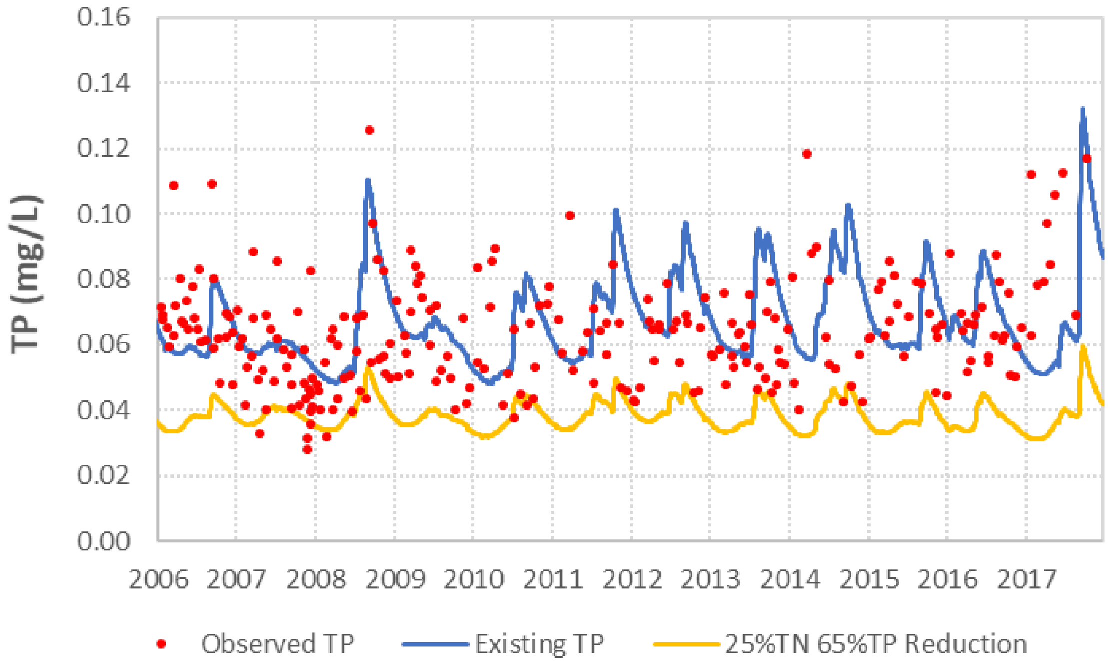

Figure 5.15. Time-series of TP (mg/L) in Lake Istokpoga for existing and load reduction conditions

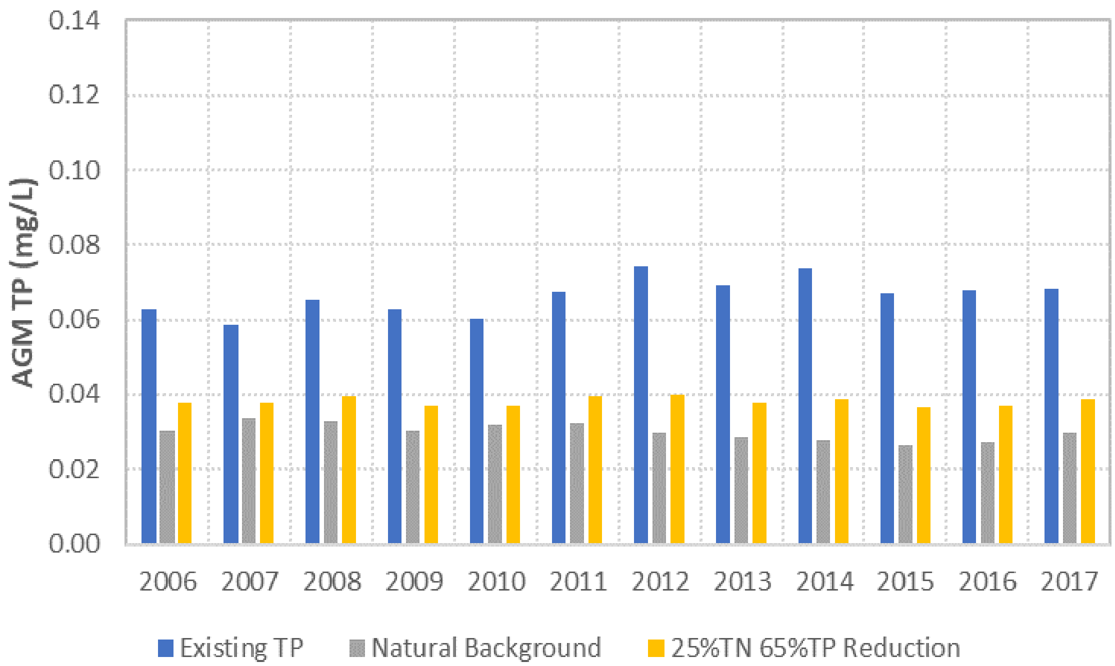

Figure 5.16. TP AGMs (mg/L) in Lake Istokpoga for existing, natural background, and load reduction conditions

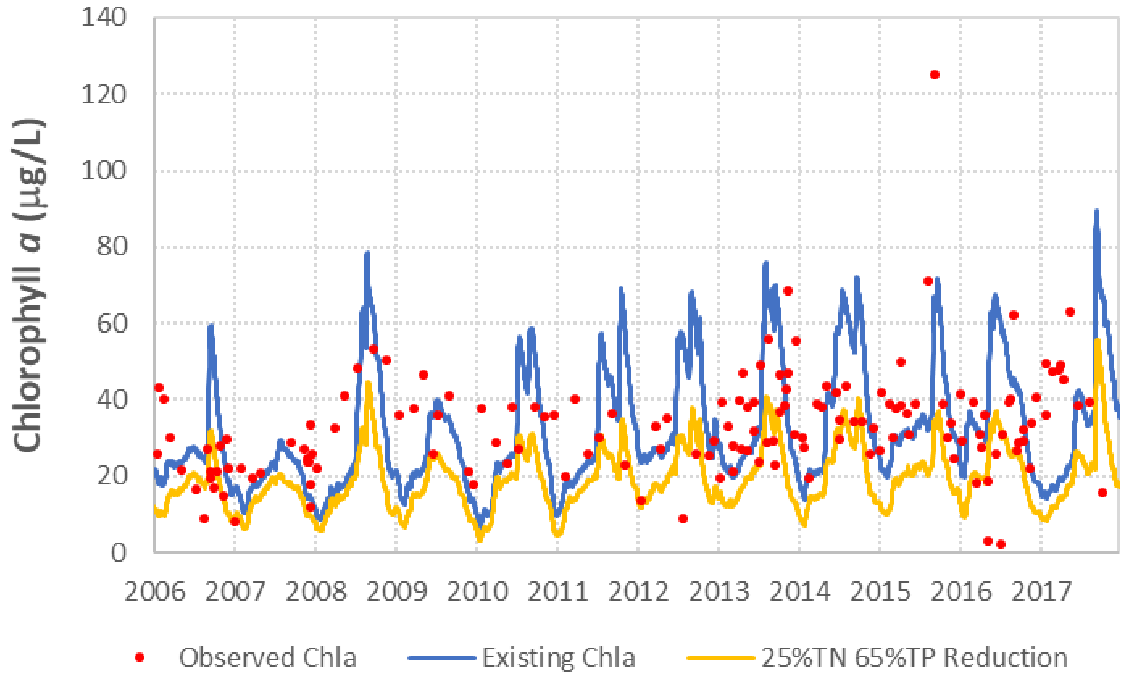

Figure 5.17. Time-series of chlorophyll *a* (µg/L) in Lake Istokpoga for existing and load reduction conditions

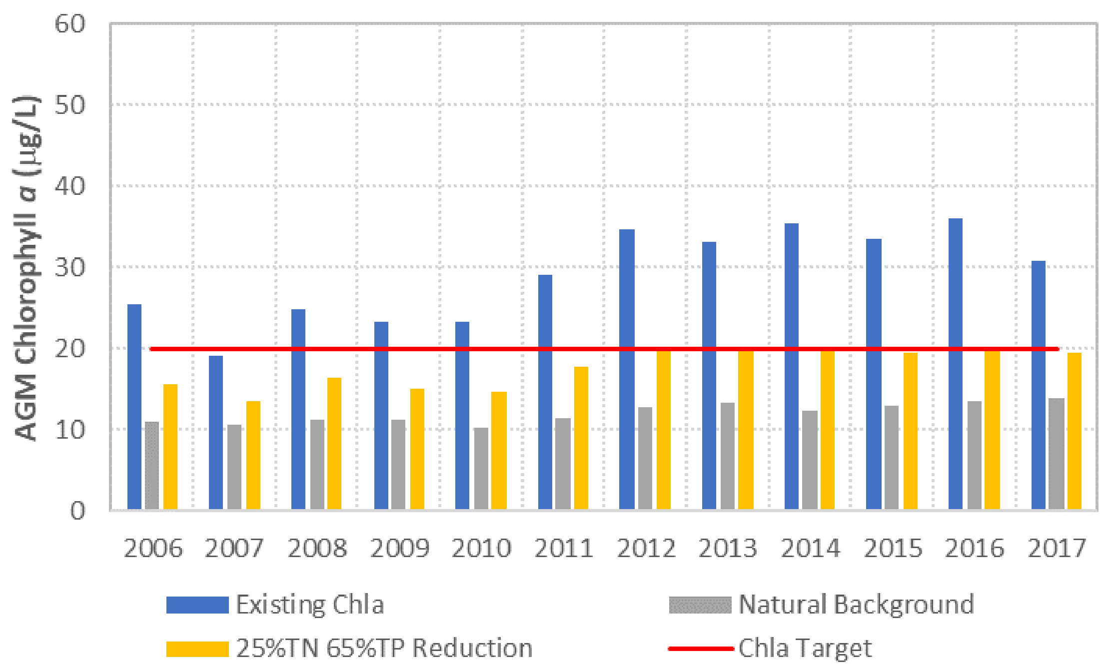

Figure 5.18. Chlorophyll *a* AGMs (µg/L) in Lake Istokpoga for existing, natural background, and load reduction conditions

Table 5.2. In-lake water quality concentrations of TP, TN, and chlorophyll *a* AGMs in Lake Istokpoga with current permit limits for the NPDES facility, and the reduced permit limits by the TMDL percent reductions

Year	In-Lake TP with Current Permits (mg/L)	In-Lake TP with Reduced Permits (mg/L)	In-Lake TN with Current Permits (mg/L)	In-Lake TN with Reduced Permits (mg/L)	In-Lake Chlorophyll *a* with Current Permits (µg/L)	In-Lake Chlorophyll *a* with Reduced Permits (µg/L)
2006	0.038	0.037	1.14	1.14	16	15
2007	0.038	0.037	1.18	1.18	13	13
2008	0.040	0.039	1.16	1.16	16	16
2009	0.037	0.036	1.14	1.14	15	14
2010	0.037	0.036	1.12	1.12	15	14
2011	0.040	0.039	1.17	1.17	18	17
2012	0.040	0.039	1.16	1.16	20	19
2013	0.038	0.037	1.08	1.08	20	19
2014	0.039	0.038	1.07	1.07	20	19
2015	0.037	0.036	1.03	1.03	20	19
2016	0.037	0.036	1.02	1.02	20	20
2017	0.039	0.038	1.09	1.09	19	19
Average	**0.038**	**0.037**	**1.11**	**1.11**	**18**	**17**

5.4 Calculation of the TMDLs

All incoming TN and TP loads from streams, surface runoff, interflow, baseflow, and direct atmospheric loads should be included to calculate the allowable TMDLs for the lake. However, the direct atmospheric deposition of TN and TP on the lake surface is not regulated by the CWA and was kept the same for the TMDL load and percent reduction as the existing atmospheric TN and TP deposition.

Tables 5.2 and **5.3** list the annual existing watershed, direct rainfall, and allowable total loads of TN and TP for Lake Istokpoga. TMDL percent reductions for TN and TP were calculated from the maximum of the rolling 7-year averages of the existing total (watershed plus direct rainfall) TN and TP loads and the maximum of the rolling 7-year averages of allowable total TN and TP loads. The calculated percent reductions are 23 % for TN and 56 % for TP. The final TMDLs for TN and TP, calculated as the maximum loads of TN and TP from 7-year rolling averages of the allowable total TN and TP loads, are 1,345,998 lbs/yr for TN and 54,073 lbs/yr for TP from all sources, not to be exceeded in any year.

Table 5.3. Existing watershed TN loads and allowable total (watershed plus direct rainfall) TN loads for the TMDL condition

Year	Existing Watershed TN Load (lbs/yr)	Direct Rainfall TN Load (lbs/yr)	Existing Total TN Load (lbs/yr)	Allowable Total TN Load (lbs/yr)	7-Year Rolling Average Existing Total TN Load (lbs/yr)	7-Year Rolling Average Allowable Total TN Load (lbs/yr)
2006	635,267	110,428	745,695	586,878		
2007	414,419	123,817	538,236	434,632		
2008	1,240,988	173,784	1,414,772	1,104,525		
2009	608,862	143,292	752,154	599,938		
2010	855,174	149,128	1,004,302	790,509		
2011	1,333,417	141,351	1,474,768	1,141,414		
2012	1,392,418	160,488	1,552,906	1,204,801	1,068,976	837,528
2013	1,433,891	155,924	1,589,815	1,231,342	1,189,565	929,594
2014	1,745,315	166,438	1,911,753	1,475,425	1,385,781	1,078,279
2015	1,504,784	164,741	1,669,525	1,293,329	1,422,175	1,105,251
2016	1,740,899	179,077	1,919,976	1,484,751	1,589,007	1,231,653
2017	1,904,217	162,760	2,066,977	1,590,923	1,740,817	1,345,998
Maximum 7-Year Average					**1,740,817**	**1,345,998**

Table 5.4. Existing watershed TP loads and allowable total (watershed plus direct rainfall) TP loads for the TMDL condition

Year	Existing Watershed TP Load (lbs/yr)	Direct Rainfall TP Load (lbs/yr)	Existing Total TP Load (lbs/yr)	Allowable Total TP Load (lbs/yr)	7-Year Rolling Average Existing Total TP Load (lbs/yr)	7-Year Rolling Average Allowable Total TP Load (lbs/yr)
2006	41,926	14,100	56,026	28,774		
2007	19,240	14,649	33,889	21,383		
2008	91,913	17,232	109,145	49,402		
2009	30,087	15,462	45,549	25,992		
2010	55,715	15,673	71,388	35,173		
2011	91,892	15,649	107,541	47,811		
2012	87,344	16,898	104,242	47,468	75,397	36,572
2013	101,969	16,403	118,372	52,092	84,304	39,903
2014	119,736	17,100	136,836	59,008	99,010	45,278
2015	94,016	16,818	110,834	49,724	99,252	45,324
2016	99,486	17,822	117,308	52,642	109,503	49,131
2017	149,215	17,538	166,753	69,763	123,127	54,073
Maximum 7-Year Average					**123,127**	**54,073**

Chapter 6: Determination of Loading Allocations

6.1 Expression and Allocation of the TMDL

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

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

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

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

It should be noted that the various components of the revised TMDL equation may not sum up to the value of the TMDL because (1) the WLA for NPDES stormwater is typically based on the percent reduction needed for nonpoint sources and is also accounted for within the LA, and (2) TMDL components can be expressed in different terms (for example, the WLA for stormwater is typically expressed as a percent reduction, and the WLA for wastewater is typically expressed as mass per day). Stormwater reductions are included in both the MS4 WLA and LA, as applicable. However, in determining the overall stormwater reductions needed, DEP does not differentiate between the MS4 WLA and LA, and instead applies the same overall reductions to both as if the two categories were a single category source, unless otherwise specified.

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

This approach is consistent with federal regulations, which state that TMDLs can be expressed in terms of mass per time (e.g., pounds per day), toxicity, or other appropriate measure—see 40 Code of Federal Regulations (CFR) § 130.2(i). The TMDLs for Lake Istokpoga are expressed in terms of lbs/yr and percent reductions of TN and TP, and represent the loads of TN and TP from all sources that the waterbody can assimilate while maintaining a balanced aquatic flora and fauna (**Table 6.1**). The TMDLs are based on the maximum of 7-year rolling averages of simulated data from 2006 through 2017. The restoration goal is for the lake to attain the chlorophyll *a* criterion of 20 µg/L, expressed as an AGM not to be exceeded more than once in any consecutive 3-year period, meeting the water quality criteria and thus protecting the lake's designated use.

Table 6.1 lists the TMDLs for the Lake Istokpoga Watershed. The TMDLs will constitute the site-specific numeric interpretations of the narrative nutrient criterion set forth in paragraph 62-302.530(48)(b), F.A.C., that will replace the otherwise applicable NNC in subsection 62-302.531(2), F.A.C.

Table 6.1. TMDL components for nutrients in Lake Istokpoga (WBID 1856B)

Note: The LA and TMDL daily load for TN is 3,688 lbs/day, and for TP 148 lbs/day.
NA = Not applicable
* The required percent reductions listed in this table represent the reduction from all sources.

Waterbody (WBID)	Parameter	TMDL (lbs/yr)	WLA Wastewater (% reduction)	WLA NPDES Stormwater (% reduction)*	LA (% reduction)*	MOS
1856B	TN	1,345,998	NA	23	23	Implicit
1856B	TP	54,073	NA	56	56	Implicit

6.2 Load Allocation

To achieve the load allocation (LA), a 23 % and 56 % reduction in current TN and TP loads, respectively, will be required.

The TMDLs are based on the percent reduction in total watershed loading; however, it is not DEP's intent to abate natural conditions. It should be noted that the LA includes loading from stormwater discharges regulated by DEP and the water management districts that are not part of the NPDES stormwater program (see **Appendix A**).

6.3 Wasteload Allocation

6.3.1 NPDES Wastewater Discharges

As noted in **Chapter 4**, there is one active NPDES-permitted facility in the Lake Istokpoga Watershed, consisting of an existing 0.5 mgd annual average daily flow (AADF) discharge to Arbuckle Creek. The outfall is 4 ft long and discharges at a depth of 3 ft. Water quality impacts to Lake Istokpoga were addressed using the model scenarios in **Chapter 5**. The model results with the current effluent limits and the TMDL percent reductions to the permitted limits showed that the resultant water quality impact on Lake Istokpoga was minimal, as shown in **Table 5.2**, indicating that the chlorophyll *a* target was met in every year of the modeling period under both scenario conditions. Therefore, it was determined that the TMDLs for Lake Istokpoga were expressed without additional reductions to the facility that currently provides AWT. Therefore, a WLA for wastewater discharges is not applicable.

6.3.2 NPDES Stormwater Discharges

The Lake Istokpoga Watershed is covered by a Polk County NPDES MS4 Phase I permit (FLS000015) and a Highlands County NPDES MS4 Phase II permit (FLR04E148). FDOT District 1 is a copermittee in the MS4 Phase I and II permits. Any MS4 permittee is only responsible for reducing the anthropogenic loads associated with stormwater outfalls that it owns or otherwise has responsible control over, and it is not responsible for reducing other nonpoint source loads in its jurisdiction.

Stormwater reductions are included in both the MS4 WLA and LA. In determining the overall stormwater reductions needed, however, the TMDLs do not differentiate between the two and instead apply the same overall percent reductions to both as if they were a single category source. The stormwater reductions for these TMDLs are a 23 % reduction in TN and a 56 % reduction in TP from the current anthropogenic loading. Aggregated allocations for a category of sources are not intended to be applied uniformly to individual sources in that category. Pollutant reductions to attain a TMDL can come from many sources, and these percent reductions do not directly apply to any individual MS4 outfall.

6.4 Margin of Safety (MOS)

The MOS can either be implicitly accounted for by choosing conservative assumptions about loading or water quality response, or explicitly accounted for during the allocation of loadings. Consistent with the recommendations of the Allocation Technical Advisory Committee (DEP 2001), an implicit MOS was used in the development of these TMDLs. The MOS is a required component of a TMDL and accounts for the uncertainty about the relationship between pollutant loads and the quality of the receiving waterbody—see CWA, Section 303(d)(1)(C). Considerable uncertainty is usually inherent in estimating nutrient loading from nonpoint sources, as well as in predicting water quality response. The effectiveness of management activities (e.g., stormwater management plans) in reducing loading is also subject to uncertainty.

Conservative decisions associated with a number of the modeling assumptions were made in determining the assimilative capacity (i.e., watershed loading and water quality response) of the lake. For example, the model calibration and validation period was extended to the 13-year simulation to capture a worst-case condition, to ensure that any exceedances of the TMDL target would be addressed. Additionally, the TMDL nutrient load targets are established as annual limits not to be exceeded based on the development of site-specific alternative water quality criteria, and were derived based on meeting the chlorophyll *a* target in every year of the model simulation. These provide a MOS for achieving the restoration goal, which is a chlorophyll *a* concentration of 20 μg/L, expressed as an AGM, not to be exceeded more than once in any consecutive 3-year period.

Chapter 7: Implementation Plan Development and Beyond

7.1 Implementation Mechanisms

Following the adoption of a TMDL, implementation takes place through various measures. The implementation of TMDLs may occur through specific requirements in NPDES wastewater and MS4 permits, and, as appropriate, through local or regional water quality initiatives or basin management action plans (BMAPs).

Facilities with NPDES permits that discharge to the impaired waterbody must respond to the permit conditions that reflect target concentrations, reductions, or wasteload allocations identified in the TMDLs. NPDES permits are required for Phase I and Phase II MS4s as well as domestic and industrial wastewater facilities. MS4 Phase I permits require a permit holder to prioritize and act to address a TMDL unless management actions to achieve that particular TMDL are already defined in a BMAP. MS4 Phase II permit holders must also implement the responsibilities defined in a BMAP or other form of restoration plan (e.g., a reasonable assurance plan).

7.2 BMAPs

Information concerning the development and implementation of BMAPs can be found in Section 403.067, F.S. (the FWRA). DEP or a local entity may initiate and develop a BMAP that addresses some or all of the contributing areas to the TMDL waterbody. BMAPs are adopted by the DEP Secretary and are legally enforceable.

BMAPs describe the fair and equitable allocations of pollution reduction responsibilities to the sources in the watershed, as well as the management strategies that will be implemented to meet those responsibilities, funding strategies, mechanisms to track progress, and water quality monitoring. Local entities usually implement these strategies, such as wastewater facilities, industrial sources, agricultural producers, county and city stormwater systems, military bases, water control districts, state agencies, and individual property owners. BMAPs can also identify mechanisms to address potential pollutant loading from future growth and development.

The Lake Istokpoga Watershed is located within the Lake Okeechobee BMAP area. The BMAP was adopted in December 2014 to implement the TP TMDL in the Lake Okeechobee Watershed, and an updated BMAP was adopted in February 2020. Activities are ongoing throughout the larger watershed to reduce nutrient loads to Lake Okeechobee. All agricultural nonpoint sources in the BMAP area, including the Lake Istokpoga Watershed, are statutorily required either to implement appropriate BMPs or to conduct water quality monitoring that demonstrates compliance with water quality standards. Management strategies in the Lake Istokpoga Watershed will also address nutrient impairments for Lake Istokpoga and will likely benefit the lake at a different level than reported in the Lake Okeechobee BMAP. In Polk County and

Highlands County, education practices (e.g., pamphlets and public service announcements) and outreach on fertilizer ordinances, illicit discharges, and septic tank regulations to reduce nutrient loading to Lake Istokpoga and these practices are further described in the Lake Okeechobee BMAP. Additional information about BMAPs is available online.

7.3 Implementation Considerations for the Waterbody

In addition to addressing reductions in watershed pollutant contributions to impaired waters during the implementation phase, it may also be necessary to consider the results of any associated remediation projects on surface water quality. For Lake Istokpoga, other factors such as the calibration of watershed and water quality components via interflow and baseflow also influence lake nutrient budgets and the growth of phytoplankton. Approaches to addressing these other factors should be included in a comprehensive management plan for the waterbody. Additionally, the current water quality monitoring and surface water and well–level monitoring of Lake Istokpoga should continue and be expanded, as necessary, during the implementation phase to ensure that adequate information is available for tracking restoration progress.

References

Bicknell, B.R., J.C. Imhoff, J.L. Kittle, A.S. Donigian, Jr., and R.C. Johanson. 2001. *Hydrologic Simulation Program–Fortran, user's manual for release 12.* EPA/600/R-97/080. Athens, GA: U.S. Environmental Protection Agency, Environmental Research Laboratory.

Central Florida Regional Planning Council. 2015. *Highlands County Parks and Recreation Master Plan.* Final report to Highlands County, FL.

Donigian, A.S., Jr. 2000. Lecture #19. *Calibration and verification issues, Slide #L19-22.* HSPF Training Workshop Handbook and CD. Presented to and prepared for the U.S. Environmental Protection Agency, Office of Water, Office of Science and Technology, Washington, DC.

Florida Department of Environmental Protection. 2001. A *report to the Governor and the Legislature on the allocation of total maximum daily loads in Florida.* Tallahassee, FL: Bureau of Watershed Management.

———. 2012. *Development of numeric nutrient criteria for Florida lakes, spring vents, and streams.* Technical support document. Tallahassee, FL: Division of Environmental Assessment and Restoration, Standards and Assessment Section.

———. 2013. *Implementation of Florida's numeric nutrient standards.* Technical support document. Tallahassee, FL: Division of Environmental Assessment and Restoration, Standards and Assessment Section.

———. 2014. *Basin management action plan for the implementation of total maximum daily loads for total phosphorus by the Florida Department of Environmental Protection in Lake Okeechobee*. Tallahassee, Florida: Division of Environmental Assessment and Restoration, Water Quality Restoration Program.

———. 2015. *Chapter 62-303, Florida Administrative Code. Identification of impaired surface waters.* Tallahassee, FL: Division of Environmental Assessment and Restoration.

———. 2020. *Lake Okeechobee basin management action plan*. Tallahassee, FL: Division of Environmental Assessment and Restoration, Water Quality Restoration Program.

Florida Department of Health. 2013. *Onsite sewage treatment and disposal systems statistical data*.

———. 2019. Onsite Sewage Treatment Disposal Systems GIS Coverage.

Florida Department of Transportation. 1999. *Florida Land Use, Cover and Forms Classification System (FLUCCS).* Tallahassee, FL: Thematic Mapping Section.

Florida Watershed Restoration Act. Chapter 99-223, Laws of Florida.

Griffith, G.E., D.E. Canfield, Jr., C.A. Horsburgh, and J.M. Omernik. 1997. *Lake regions of Florida.* EPA/R-97/127. Corvallis, OR: U.S. Environmental Protection Agency, National Health and Environmental Effects Research Laboratory.

McCutcheon, S.C., J.L. Martin, and R.B. Ambrose. 1990. *Technical guidance manual for performing waste load allocations, Book III: Estuaries, Part 2: Application of estuarine waste load allocation models.* Washington, DC: U.S. Environmental Protection Agency.

Moore, K. 2007. BASINS Technical Note 2. *Two automated methods for creating hydraulic function tables (FTABLES).* Washington, DC: U.S. Environmental Protection Agency.

Spechler, R.M. 2010. Hydrogeology and groundwater quality of Highlands County, Florida. *U.S. Geol Surv Sci-Invest Rep* 2010-5097.

Tetra Tech. 2017. *HSPF Model update and processing methodology for the Caloosahatchee River and Estuary, Florida.* Prepared for the Florida Department of Environmental Protection, Tallahassee, FL.

———. 2019. *Lake Istokpoga Watershed updates to the Hydrological Simulation Program–FORTRAN (HSPF) Model.* Prepared for the Florida Department of Environmental Protection, Tallahassee, FL.

———. 2020. *Lake Istokpoga, C-41A Canal, and Indian Prairie Canal Watershed updates to the Hydrological Simulation Program–FORTRAN (HSPF) Model*. Prepared for the Florida Department of Environmental Protection, Tallahassee, FL.

U.S. Census Bureau website. 2019.

U.S. Environmental Protection Agency. 2015. *Better Assessment Science Integrating Point and Nonpoint Sources BASINS Version 4.1 user manual.* Electronic file. Available: EPA Basins. Accessed March 2018.

Viessman, W., Jr., G.L. Lewis, and J.W. Knapp. 1989. *Introduction to hydrology.* Third edition. New York: Harper Collins.

Walker, W.W., and K.E. Havens. 2003. Development and application of a phosphorus balance model for Lake Istokpoga, Florida. *Lake and Reservoir Management 19(1)*: 79–91.

White, W.A. 1970. The geomorphology of the Florida peninsula. *Florida Geol Surv Bull* 51: 164.

Zhang, J., P. Burke, L. Baldwin, C. Mo, and S. Hill. 2016. *Lake Okeechobee Watershed tributary nutrient loading trends WY2006–WY2015.* WR-2016-004. Report to the South Florida Water Management District, Brooksville, FL.

Appendices

Appendix A: Background Information on Federal and State Stormwater Programs

In 1982, Florida became the first state in the country to implement statewide regulations to address the issue of nonpoint source pollution by requiring new development and redevelopment to treat stormwater before it is discharged. The Stormwater Rule, as authorized in Chapter 403, F.S., was established as a technology-based program that relies on the implementation of BMPs designed to achieve a specific level of treatment (i.e., performance standards) as set forth in Chapter 62-40, F.A.C. In 1994, DEP stormwater treatment requirements were integrated with the stormwater flood control requirements of the water management districts, along with wetland protection requirements, into the Environmental Resource Permit regulations, as authorized under Part IV of Chapter 373, F.S.

Chapter 62-40, F.A.C., also requires the state's water management districts to establish stormwater pollutant load reduction goals (PLRGs) and adopt them as part of a Surface Water Improvement and Management (SWIM) Program plan, other watershed plan, or rule. Stormwater PLRGs are a major component of the load allocation part of a TMDL. To date, they have been established for Tampa Bay, Lake Thonotosassa, the Winter Haven Chain of Lakes, the Everglades, Lake Okeechobee, and Lake Apopka.

In 1987, the U.S. Congress established Section 402(p) as part of the federal CWA Reauthorization. This section of the law amended the scope of the federal NPDES permitting program to designate certain stormwater discharges as "point sources" of pollution. The EPA promulgated regulations and began implementing the Phase I NPDES stormwater program in 1990 to address stormwater discharges associated with industrial activity, including 11 categories of industrial activity, construction activities disturbing 5 or more acres of land, and large and medium MS4s located in incorporated places and counties with populations of 100,000 or more.

However, because the master drainage systems of most local governments in Florida are physically interconnected, the EPA implemented Phase I of the MS4 permitting program on a countywide basis, which brought in all cities (incorporated areas), Chapter 298 special districts, community development districts, water control districts, and FDOT throughout the 15 counties meeting the population criteria. DEP received authorization to implement the NPDES stormwater program in 2000. The authority to administer the program is set forth in Section 403.0885, F.S.

The Phase II NPDES stormwater program, promulgated in 1999, addresses additional sources, including small MS4s and small construction activities disturbing between 1 and 5 acres, and urbanized areas serving a minimum resident population of at least 1,000 individuals. While these urban stormwater discharges are technically referred to as "point sources" for the purpose of regulation, they are still diffuse sources of pollution that cannot be easily collected and treated by a central treatment facility, as are other point sources of pollution such as domestic and industrial wastewater discharges. It should be noted that Phase I MS4 permits issued in Florida include a reopener clause that allows permit revisions to implement TMDLs when the implementation plan is formally adopted.

Appendix B: Information in Support of Site-Specific Interpretations of the Narrative Nutrient Criterion

Table B-1. Spatial extent of the numeric interpretation of the narrative nutrient criterion

Location	Description
Waterbody name	Lake Istokpoga
Waterbody type(s)	Lake
WBID	WBID 1856B (see **Figure 1.1** of this report)
Description	Lake Istokpoga is located in Highlands County, and its watershed expands north to southern Polk County. The lake has a surface area of 27,673 acres, with a mean depth of 5 ft and a maximum depth of 8 ft. The Lake Istokpoga Watershed extends from Frostproof to the southern extent of Lake Istokpoga. Water in the watershed generally flows south-southeast to Lake Istokpoga, primarily via Arbuckle and Josephine Creeks, which are located in the northwest and north areas of the lake, respectively. The lake discharges through two outlets: the S-68 Canal is a major outlet that flows south to the C-41A Canal in Indian Prairie, and the Istokpoga Canal flows to the lower Kissimmee River. The dominant land use type in the Lake Istokpoga Watershed is agriculture (35 %), followed by water, which makes up 15 % of the watershed. **Chapter 1** of this report describes the Lake Istokpoga system in more detail.
Specific location (latitude/longitude or river miles)	The center of Lake Istokpoga is located at N 27° 22′ 31,″ W 81° 16′ 59.″ The site-specific criteria apply as a spatial average for the lake, as defined by WBID 1856B.
Map	**Figure 1.1** shows the general location of Lake Istokpoga and its watershed, and **Figure 4.1** shows the land uses in the watershed.
Classification(s)	Class III Freshwater
Basin name (HUC 8)	Kissimmee River Basin (03090101)

Table B-2. Description of the numeric interpretation of the narrative nutrient criterion

Numeric Interpretation of Narrative Nutrient Criterion	Information on Parameters Related to Numeric Interpretation of the Narrative Nutrient Criterion
NNC summary: Generally applicable lake classification (if applicable) and corresponding NNC	Lake Istokpoga is a high-color lake, and the generally applicable NNC, expressed as AGM concentrations not to be exceeded more than once in any 3-year period, are chlorophyll *a* of 20 µg/L, TN of 1.27 to 2.23 mg/L, and TP of 0.05 to 0.16 mg/L.
Proposed TN, TP, chlorophyll *a*, and/or nitrate + nitrite concentrations (magnitude, duration, and frequency)	Numeric interpretations of the narrative nutrient criterion: The NNC for chlorophyll *a* in Lake Istokpoga is 20 µg/L, expressed as an AGM concentration not to be exceeded more than once in any consecutive 3-year period. The Lake Istokpoga TMDL does not establish a site-specific chlorophyll criterion; therefore, the generally applicable chlorophyll criterion still applies. The TN and TP TMDLs are expressed as rolling 7-year annual average loads not to be exceeded, and are 1,345,998 lbs/yr and 54,073 lbs/yr for TN and TP, respectively. Nutrient concentrations are provided for comparative purposes only. The in-lake TN and TP AGM concentrations for Lake Istokpoga at the allowable TMDL loadings are 1.18 and 0.04 mg/L, respectively. These restoration concentrations represent the in-lake concentrations that would meet the target chlorophyll *a* concentration of 20 µg/L.
Period of record used to develop numeric interpretations of the narrative nutrient criterion for TN and TP	The criteria were developed based on the application of the HSPF Model, which simulated hydrology and water quality conditions from 2005 to 2017. The primary datasets for this period include water quality data from IWR Database Run 58, and rainfall and ET data from 2005 to 2017. Data from statewide land use coverage, including the land use dataset from SWFWMD (2014) and SFWMD (2014–16), were used to establish watershed nutrient loads. **Sections 4.4** and **5.3** of this report describe the data used in the derivation of the proposed site-specific criteria.
How the criteria developed are spatially and temporally representative of the waterbody or critical condition	The model simulated the 2005–17 period, which included both wet and dry years. During the simulation period, total annual average rainfall varied from 35.4 to 59.6 in and averaged 50.0 in at the Sebring station. Rainfall was below average from 2006 to 2007 and 2009 to 2011. The years 2008 and 2012 through 2017 were wetter than average. This period captures the hydrologic temporal variability of the Lake Istokpoga system. NEXRAD rainfall data from Lake Istokpoga and Josephine Creek stations were used as the model input for estimating nutrient loads from the watershed. These rainfall datasets have a spatial resolution of 2 square kilometers (km^2), which accurately represents the spatial heterogeneity of rainfall in the watershed. The model simulated the entire watershed to evaluate how changes in watershed loads impact lake nutrient and chlorophyll *a* concentrations. **Figure 4.3** shows the locations of meteorological and flow gauge stations for the Lake Istokpoga Watershed. **Figure 2.1** shows the locations of the sampling stations in Lake Istokpoga used in the model calibration process.

Table B-3. Summary of how designated use(s) are protected by the criterion

Designated Use Requirements	Information Related to Designated Use Requirements
History of assessment of designated use support	DEP used the IWR Database to assess water quality impairments in Lake Istokpoga (WBID 1856B). During the Cycle 3 assessment, the NNC were used to assess the lake during the verified period (January 1, 2009–June 30, 2016) using data from IWR Database Run 53. Lake Istokpoga was assessed as impaired for biology because of failing LVI scores, chlorophyll *a*, TN, and TP because the AGMs exceeded the NNC more than once in a 3-year period. For the lake, chlorophyll *a* AGMs exceeded the criterion from 2009 to 2011 and from 2013 to 2015, TN AGMs from 2009 to2015, and TP AGMs from 2009 to 2015. The waterbody was added to the 303(d) list for chlorophyll *a*, TN, and TP. See **Section 2.3.2** of this report for a detailed discussion.
Basis for use support	The basis for use support is the NNC chlorophyll *a* concentration of 20 µg/L, which is protective of designated uses in high-color lakes. Based on the available information, there is nothing unique about Lake Istokpoga that would make the use of the chlorophyll *a* threshold of 20 µg/L inappropriate for the lake.
Approach used to develop criteria and how it protects uses	For the Lake Istokpoga nutrient TMDLs, DEP created loading-based criteria using the HSPF watershed model to simulate loading from the Lake Istokpoga Watershed. DEP established the site-specific TN and TP loadings using the calibrated model to achieve an in-lake chlorophyll *a* AGM concentration of 20 µg/L, because this target is the generally applicable NNC demonstrated to be protective of designated use in high-color lakes. The maximum of the 7-year rolling averages of TN and TP loadings to achieve the chlorophyll *a* target was determined by decreasing TN and TP loads from anthropogenic sources into the lake until the chlorophyll *a* target was achieved. **Chapter 5** of this report provides a more detailed description of the derivation of the TMDLs and criteria.
How the TMDL analysis will ensure that nutrient-related parameters are attained to demonstrate that the TMDLs will not negatively impact other water quality criteria	Model simulations indicated that the target chlorophyll *a* concentration (20 µg/L) in the lake will be attained at the TMDL loads for TN and TP. DEP notes that no other impairments were verified for Lake Istokpoga that may be related to nutrients (such as DO or un-ionized ammonia). Reducing the nutrient loads entering the lake will not negatively impact other water quality parameters of the lake.

Table B-4. Documentation of the means to attain and maintain water quality standards for downstream waters

Protection of Downstream Waters and Monitoring Requirements	Information Related to Protection of Downstream Waters and Monitoring Requirements
Identification of downstream waters: List receiving waters and identify technical justification for concluding downstream waters are protected	Lake Istokpoga discharges through two outlets, S-68 and Istokpoga Canal. The S-68 spillway, a major outlet that discharges south to the C-41A Canal, comprises more than 99 % of the total discharge from the lake, and the Istokpoga Canal discharged less than 1 % of the total outflow to Kissimmee River during the simulation period. The C-41A Canal is a Class III freshwater stream in the Peninsular Stream Nutrient Region. The applicable nutrient thresholds for these stream systems are 0.12 mg/L of TP and 1.54 mg/L of TN, expressed as AGMs not to be exceeded more than once in any 3-year period (DEP 2013). Based on the Cycle 3 assessment, the C-41A Canal (WBID 3198) was listed as verified impaired for chlorophyll *a* and nutrients (macrophytes), while the TN and TP AGMs did not exceed the stream thresholds during the assessment period. C-41A Canal water quality is primarily influenced by lake discharges, with minimal impacts from local sources, based on a comparison of observed TN and TP data obtained from a Lake Istokpoga outlet station versus a C-41A Canal outlet station (**Figures 3.1** and **3.2**). The restoration targets for Lake Istokpoga under the TMDL condition are much lower than those under the current condition, and will meet the applicable stream nutrient thresholds. Therefore, the reductions in nutrient loads described in this TMDL analysis will result in water quality improvements to downstream waters and thus be protective of downstream water quality (see **Section 3.6** of this report).
Summary of existing monitoring and assessment related to the implementation of Subsection 62-302.531(4), F.A.C., and trends tests in Chapter 62-303, F.A.C.	Highlands County and DEP conduct routine monitoring of Lake Istokpoga. The data collected through these monitoring activities will be used to evaluate the effect of BMPs implemented in the watershed on lake TN and TP loads in subsequent water quality assessment cycles. Additionally, the current water quality monitoring of Lake Istokpoga should continue and be expanded, as necessary, during the implementation phase to ensure that adequate information is available for tracking restoration progress.

Table B-5. Documentation of endangered species consideration

Administrative Requirements	Information for Administrative Requirements
Endangered species consideration	The FWS identifies the endangered Everglade snail kite (*Rostrhamus sociabilis*) as a species potentially affected by activities in lowland freshwater marshes in Florida, including Lake Istokpoga. As described in **Section 3.5**, the existing water quality in Lake Istokpoga does not appear to be negatively affecting this aquatic species. The nutrient TMDLs will improve water quality conditions in the lake.

Table B-6. Documentation that administrative requirements are met

Administrative Requirements	Information for Administrative Requirements
Notice and comment notifications	DEP published a Notice of Development of Rulemaking on xxx, 2021, to initiate TMDL development for impaired waters in the Kissimmee River Basin. Technical workshops for the Lake Istokpoga TMDLs were held on August 28, 2019, to present the general TMDL approach to local stakeholders. A rule development public workshop for the TMDLs was held on xxx, 2021.
Hearing requirements and adoption format used; responsiveness summary	Following the publication of the Notice of Proposed Rule, DEP will provide a 21-day challenge period and a public hearing that will be noticed no less than 45 days prior. The hearing was held on XXX, 2021.
Official submittal to EPA for review and General Counsel certification	If DEP does not receive a rule challenge, the certification package for the rule will be prepared by the DEP program attorney. DEP will prepare the TMDLs and submittal package for the TMDLs to be considered a site-specific interpretation of the narrative nutrient criterion, and will submit these documents to the EPA.

Appendix C: Model Calibration Parameters

Table C-1. HSPF input parameters and values for model calibration

Name	Description	Unit	Value
FOREST	Fraction forest cover	none	0.0
LZSN	Lower zone nominal soil moisture storage	in	2.0–7.5
INFILT	Index to infiltration capacity	in/hr	0.1–0.66
LSUR	Length of overland flow	ft	150–500
SLSUR	Slope of overland flow plane	ft/ft	0.001
KVARY	Variable groundwater recession	1 in	0.0
AGWRC	Base groundwater recession	none	0.92–0.99
PETMAX	Temp below which ET is reduced	deg F	40
PETMIN	Temp below which ET is set to zero	deg F	35
INFEXP	Exponent in infiltration equation	none	2.0
INFILD	Ratio of max/mean infiltration capacity	none	2.0
DEEPFR	Fraction of groundwater inflow to deep recharge	none	0.0–0.68
BASETP	Fraction of remaining ET from baseflow	none	0.0
AGWETP	Fraction of remaining ET from active groundwater	none	0.0–0.5
CEPSC	Interception storage capacity	in	0.03–0.10
UZSN	Upper zone nominal soil moisture storage	in	0.5–3.0
NSUR	Manning's n for overland flow	none	0.2–0.4
INTFW	Interflow inflow parameter	none	0.0–3.0
IRC	Interflow recession parameter	none	0.01–0.85
LZETP	Low zone ET parameter	none	0.4–0.7
CEPS	Initial interception storage	in	0.00
SURS	Initial overland storage	in	0.0
UZS	Initial upper zone storage	in	0.15–0.75
IFWS	Initial interflow storage	in	0.0
LZS	Initial lower zone storage	in	1.5–7.5

Appendix D: Model Calibration Results

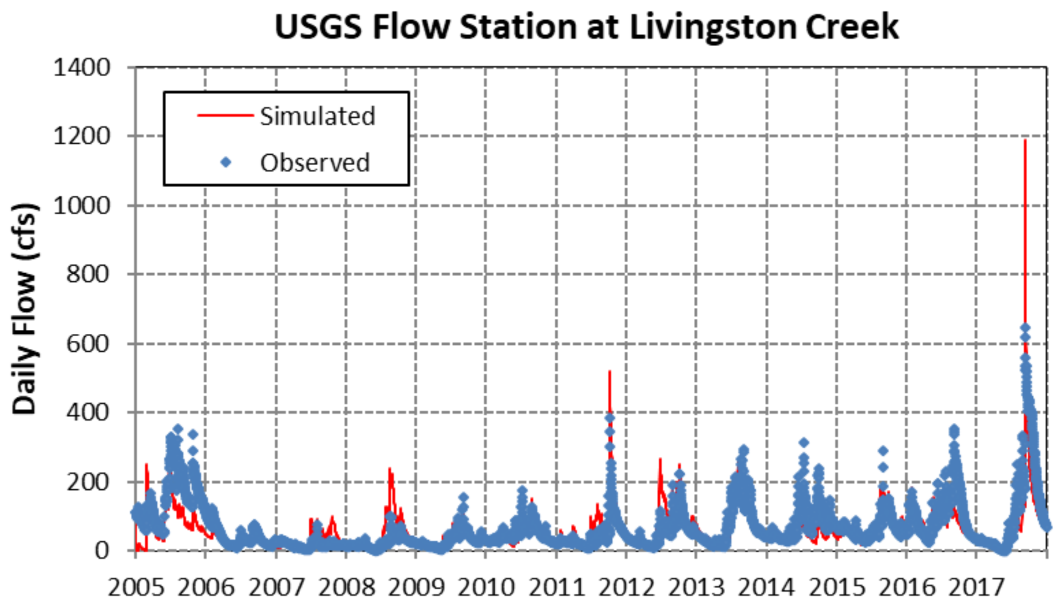

Figure D-1. Time-series comparison of model results with USGS gauge at Livingston Creek

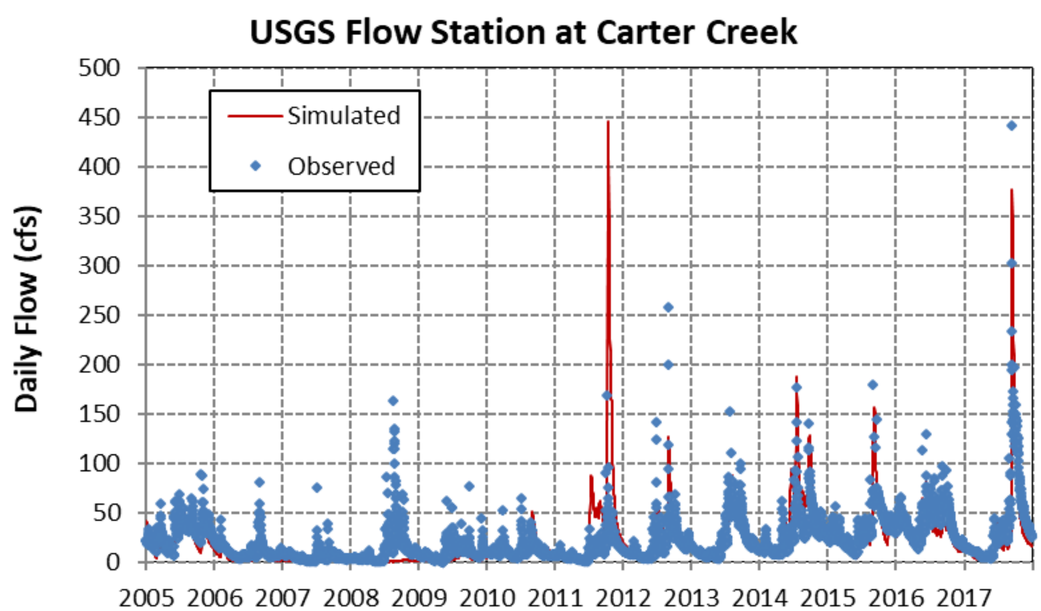

Figure D-2. Time-series comparison of model results with USGS gauge at Carter Creek

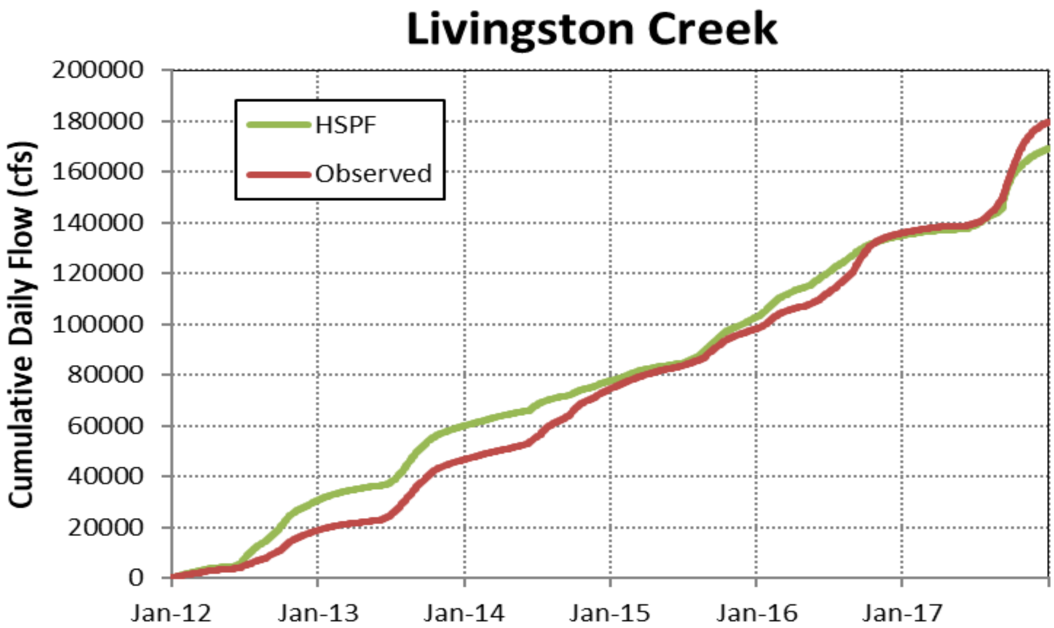

Figure D-3. **Comparison of cumulative daily flows at Livingston Creek observed from USGS gauge station and simulated by HSPF during the calibration period**

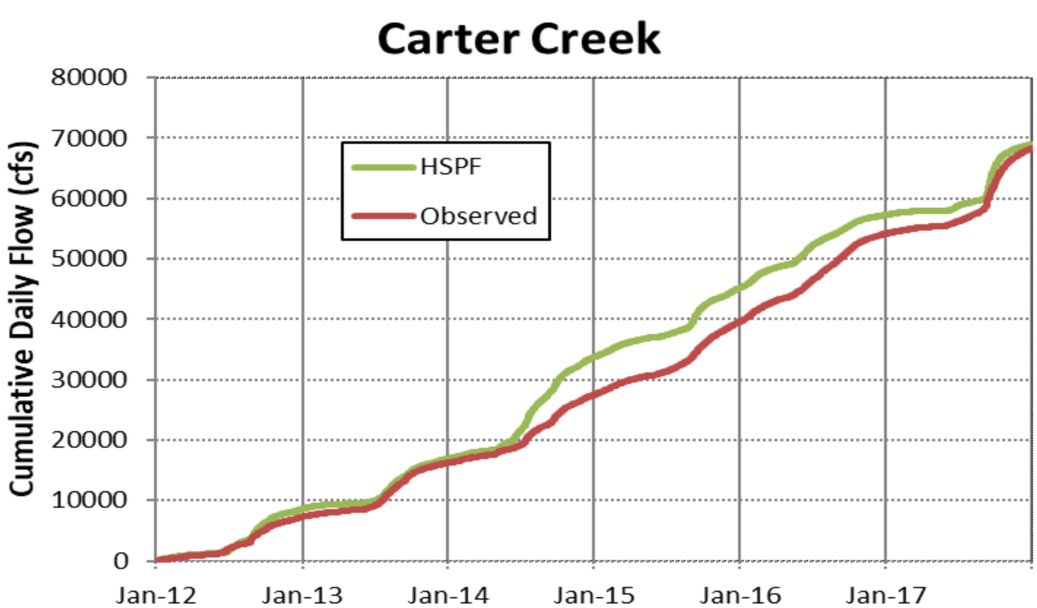

Figure D-4. **Comparison of cumulative daily flows at Carter Creek observed from USGS gauge station and simulated by HSPF during the calibration period**

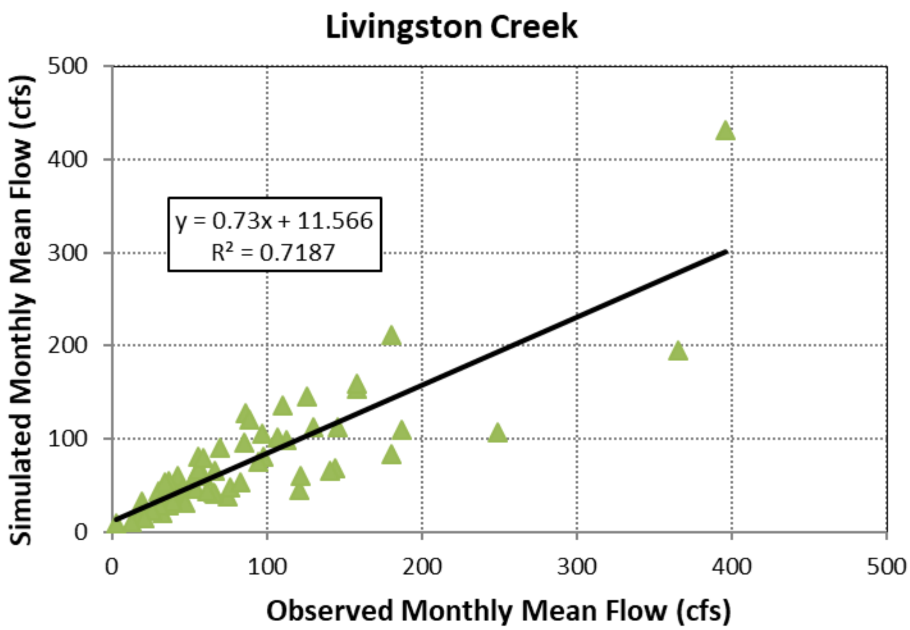

Figure D-5. Simulated versus observed monthly flow at Livingston Creek during the calibration period

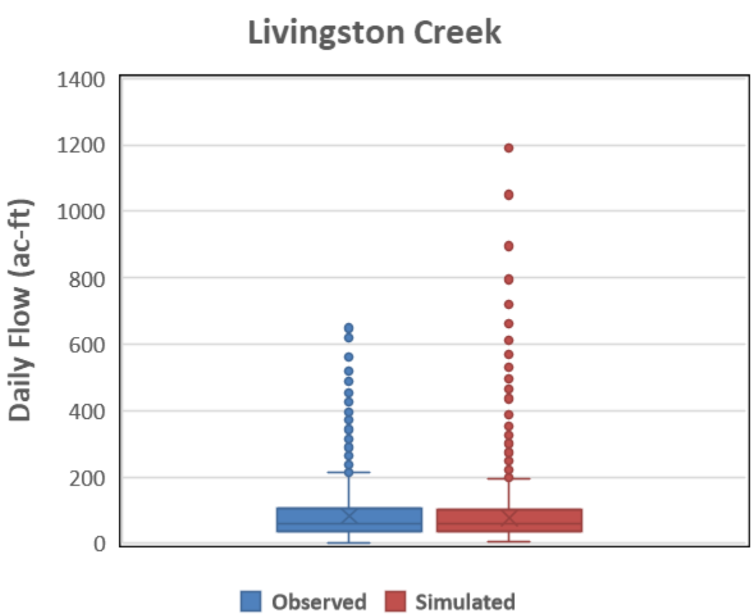

Figure D-6. Box-whisker plot of simulated versus observed daily flows at Livingston Creek during the calibration period

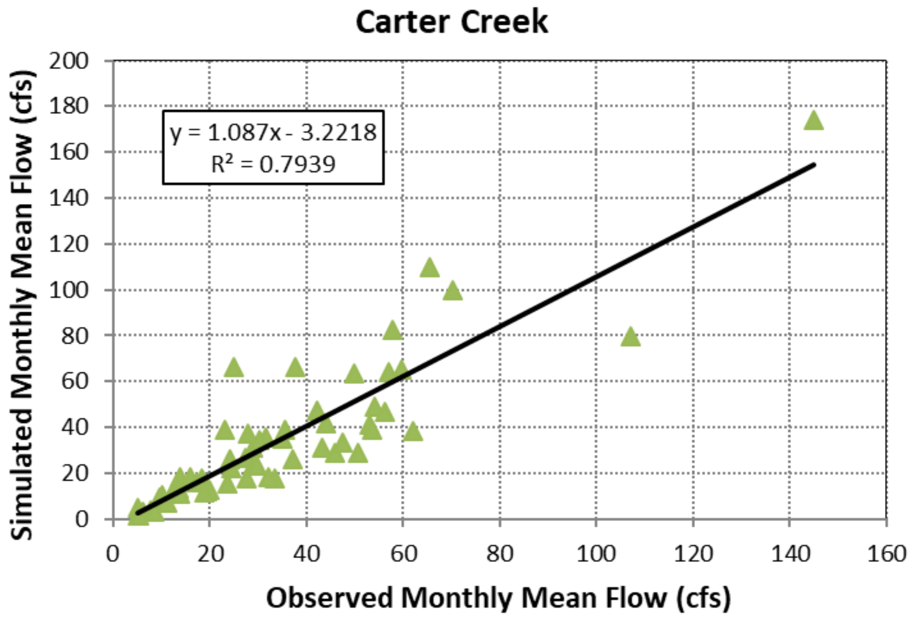

Figure D-7. Simulated versus observed monthly flows at Carter Creek during the calibration period

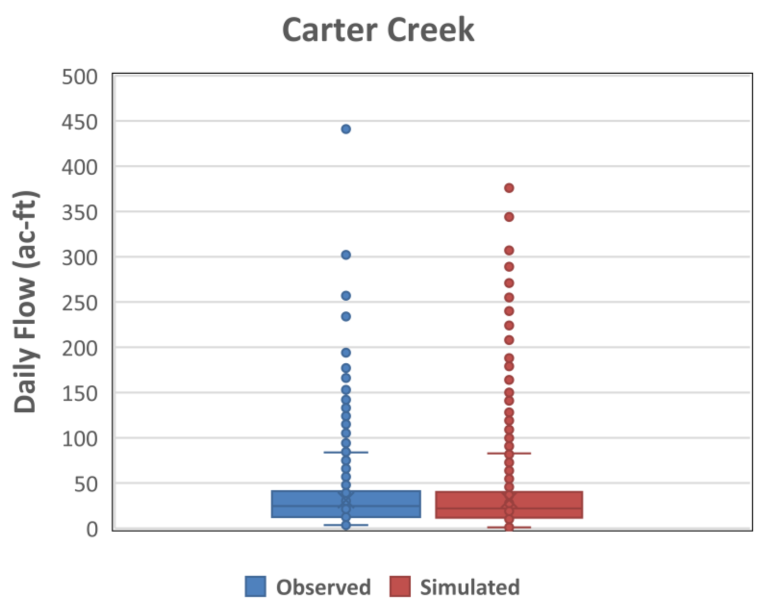

Figure D-8. Box-whisker plot of simulated versus observed daily flows at Carter Creek during the calibration period

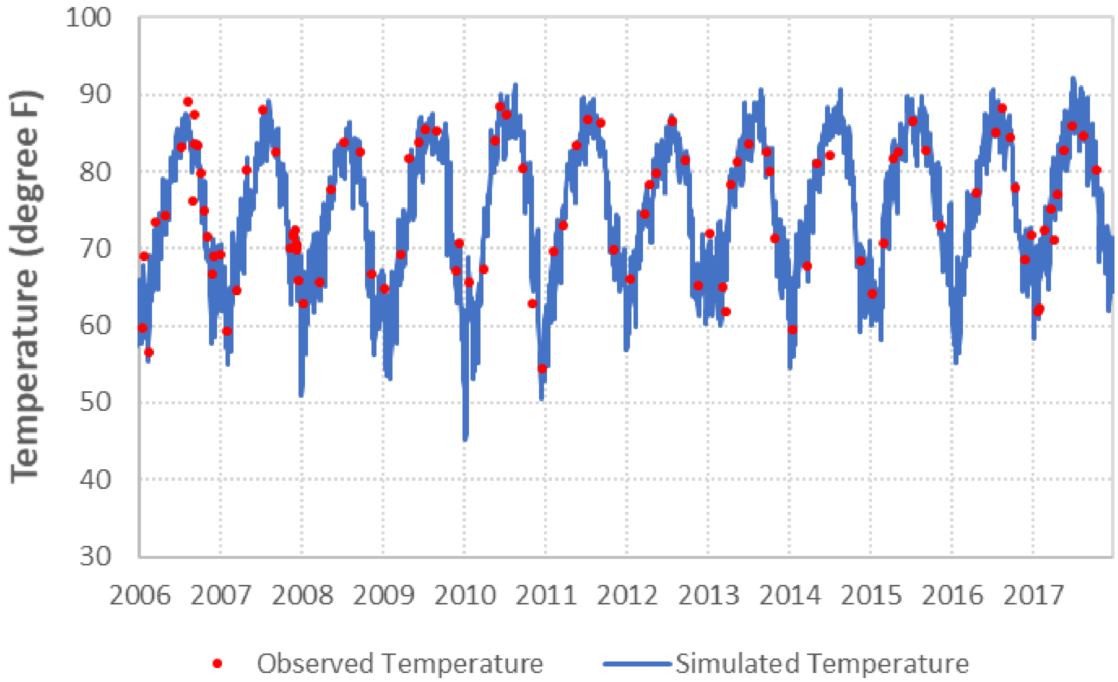

Figure D-9. Time-series of observed versus simulated temperature (°F.) in Lake Istokpoga, 2006–17

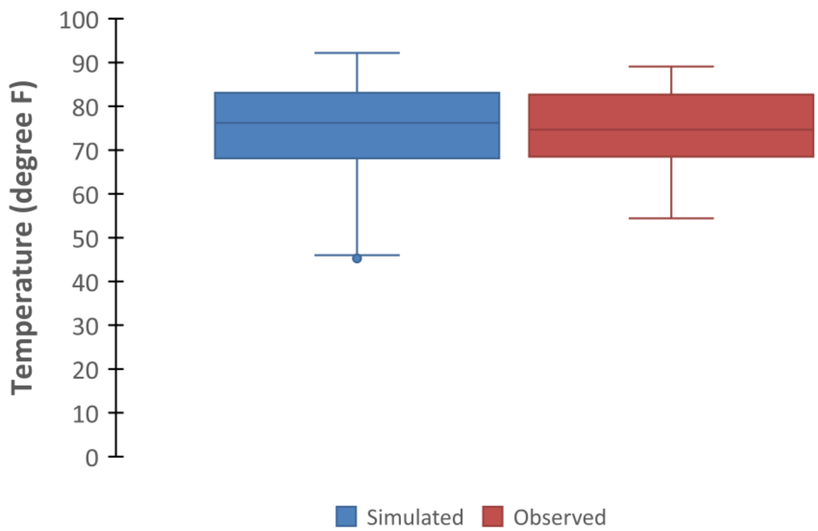

Figure D-10. Box-whisker plot of simulated versus observed temperature (°F.) in Lake Istokpoga

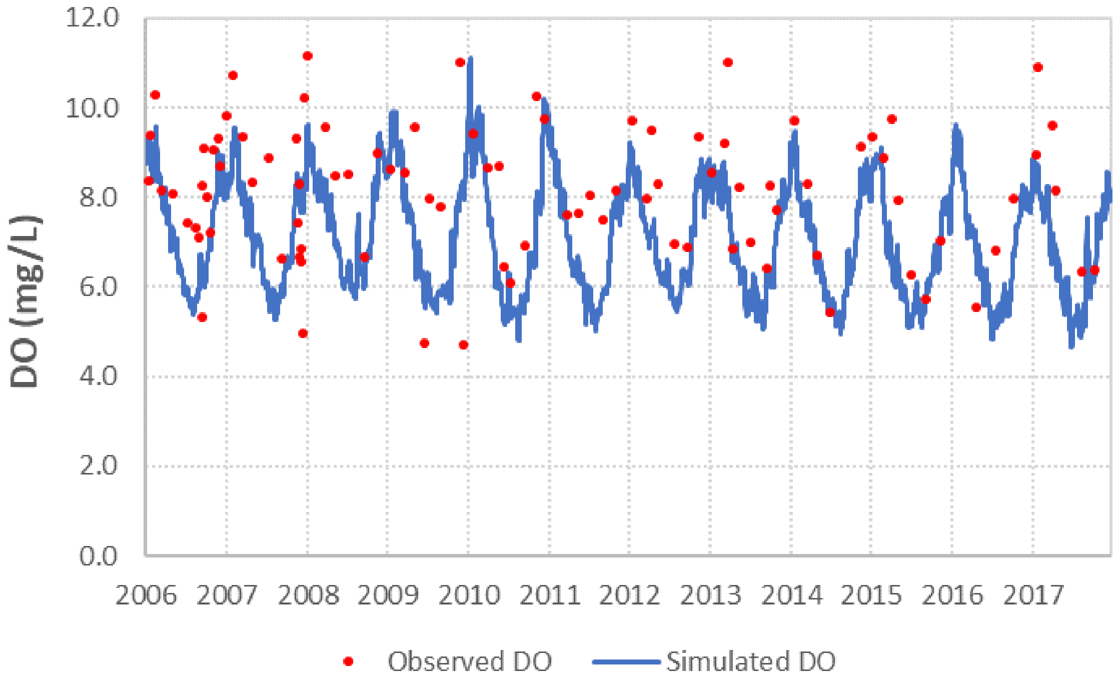

Figure D-11. Time-series of observed versus simulated DO (mg/L) in Lake Istokpoga, 2006–17

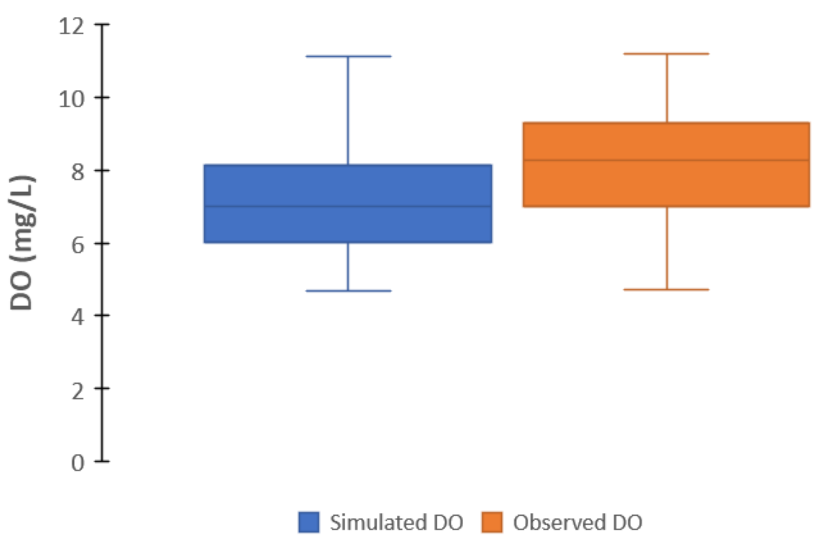

Figure D-12. Box-whisker plot of simulated versus observed DO (mg/L) in Lake Istokpoga