Southwest District • Peace River Basin

Final Report

Nutrient TMDLs for Lake Ariana (WBID 1501B), and Eagle Lake (WBID 1623M)

and Documentation in Support of the Development of Site-Specific Numeric Interpretations of the Narrative Nutrient Criterion

James C. Albright
Division of Environmental Assessment and Restoration
Florida Department of Environmental Protection

August 2018

2600 Blair Stone Road
Mail Station 3000
Tallahassee, FL 32399-2400
https://floridadep.gov

Executive Summary

The lakes discussed in this total maximum daily load (TMDL) document are located in northern Polk County. Lake Ariana is situated in the City of Auburndale and Eagle Lake is in the City of Eagle Lake. The waterbodies were originally identified as impaired for nutrients based on elevated annual average Trophic State Index values. Eagle Lake was added to the 303(d) list by Secretarial Order in 2005 as the segment with waterbody identification (WBID) number 1623M. Lake Ariana was added to the 303(d) list by Secretarial Order in 2010 as WBID 1501B. TMDLs for total nitrogen (TN) and total phosphorus (TP) have been developed, and **Table EX-1** lists supporting information for the TMDLs. The TMDLs were developed in accordance with Section 303(d) of the federal Clean Water Act and guidance developed by the U.S. Environmental Protection Agency. These TMDLs will also constitute the site-specific numeric interpretation of the narrative nutrient criterion specified in Paragraph 62-302.530(48)(b), Florida Administrative Code (F.A.C.), that will replace the otherwise applicable numeric nutrient criteria (NNC) for these waterbodies as described in Subsection 62-302.531(2), F.A.C.

Table EX-1. Summary of TMDL supporting information for Lake Ariana & Eagle Lake

Type of Information	Description
Waterbody name/ WBID number	Lake Ariana/WBID 1501B Eagle Lake/WBID 1623M
Hydrologic Unit Code (HUC) 8	03100101
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 Sarasota–Peace–Myakka Group 3 Basins, adopted via Secretarial Order in 2005 and 2010
TMDL pollutants	Lake Ariana – TN Eagle Lake – TN and TP
TMDLs and site-specific interpretations of the narrative nutrient criterion	**WBID 1501B** 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. **TN**: 0.97 milligrams per liter (mg/L), expressed as an AGM lake concentration not to be exceeded in any year. **TP**: 0.03 mg/L, expressed as an AGM lake concentration not to be exceeded in any year. **WBID 1623M** Chlorophyll ***a*****:** 6 µg/L, expressed as an AGM concentration not to be exceeded more than once in any consecutive 3-year period. **TN**: 0.63 mg/L, expressed as an AGM lake concentration not to be exceeded in any year. **TP**: 0.01 mg/L, expressed as an AGM lake concentration not to be exceeded in any year.
Load reductions required to meet the TMDLs	**WBID 1501B**: A 36 % TN reduction and a 0 % TP reduction to achieve a chlorophyll *a* target of 20 µg/L. **WBID 1623M**: A 38 % TN reduction and a 50 % TP reduction to achieve a chlorophyll *a* target of 6 µg/L.

Acknowledgments

This analysis was accomplished thanks to significant contributions from staff in the Florida Department of Environmental Protection's Division of Environmental Assessment and Restoration, specifically, the Office of Watershed Services, Watershed Assessment Section, Standards Development Section, Water Quality Restoration Program, Southwest Regional Operations Center, and Watershed Evaluation and TMDL Section.

Map production assistance was provided by Ronald Hughes.

For additional information regarding the development of this report, please contact the Division of Environmental Assessment and Restoration office:

2600 Blair Stone Road
Mail Station 3000
Tallahassee, FL 32399-2400
Phone: (850) 245–8668

Contents

List of Figures

List of Tables

Chapter 1: Introduction

1.1 Purpose of Report

This report presents the total maximum daily loads (TMDLs) developed to address the nutrient impairments of Lake Ariana and Eagle Lake; located in the Upper Peace River Planning Unit, which is a part of the larger Peace River Basin. The TMDLs will constitute the site-specific numeric interpretation of the narrative nutrient criterion set forth in Paragraph 62-302.530(48)(b), Florida Administrative Code (F.A.C.), that will replace the otherwise applicable numeric nutrient criteria (NNC) in Subsection 62-302.531(2), F.A.C., for these particular waterbodies, pursuant to Paragraph 62-302.531(2)(a), F.A.C.

The waterbodies were verified as impaired for nutrients using the methodology in the Identification of Impaired Surface Waters Rule (IWR) (Chapter 62-303, F.A.C.). Eagle Lake was placed on the Verified List of Impaired Waters for the Sarasota Bay–Peace River–Myakka River Group 3 Basin adopted by Secretarial Order in 2005, and Lake Ariana was placed on the Verified List for the Sarasota Bay–Peace River–Myakka River Group 3 Basin adopted by Secretarial Order in 2010.

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 described here establish the allowable in-lake nutrient and chlorophyll *a* concentrations for Lake Ariana and Eagle Lake that would restore these waterbodies so that they meet their applicable designated uses.

1.2 Identification of Waterbody

For assessment purposes, the Florida Department of Environmental Protection (DEP) divided the Peace River Basin (Hydrologic Unit Code [HUC] 8, 03100101) into watershed assessment polygons with a unique **w**ater**b**ody **id**entification (WBID) number for each watershed or surface water segment. Although the lakes discussed in this report are not contiguous or adjacent, they are both part of the Peace River–Saddle Creek Watershed as delineated by Polk County. This watershed includes the contributing area to Lake Hancock, which discharges in turn to Lower Saddle Creek. The creek is ultimately one of the contributors to the headwaters of the Peace River (Polk County 2014). Lake Ariana is WBID 1501B and Eagle Lake is WBID 1623M. **Figure 1.1** shows the locations of the WBIDs in the basin and major geopolitical and hydrologic features in the region. The individual lakes are shown in more detailed maps: Lake Ariana in **Figure 1.2** and Eagle Lake in **Figure 1.3**.

Lake Ariana (WBID 1501B) has a surface area of 1,030 acres (4.17 square kilometers [km^2]). The mean depth of the lake is 12 feet (ft) (3.6 meters [m]), with a maximum depth of 24 ft (3.6

m). Lake Ariana is a large, circular lake that receives water from Lakes Arietta and Whistler to the north and west, and Lake Ariana then discharges directly to Lake Lena through a very short canal (164 ft or 50 m in length) at the south end of Ariana. Lake Lena in turn discharges via Lake Lena Run into Lake Hancock from the northeast (Polk County 2014). A portion of Lake Ariana was previously included in a TMDL developed by EPA for Lake Alfred, Crystal Lake, and the northern section of Lake Ariana (USEPA 2010).

Eagle Lake (WBID 1623M), which has a surface area of 647 acres (2.6 km^2), has a mean depth of 12 ft (3.6 m) and a maximum depth of 32 ft (9.8 m). The lake is bilobed, with the smaller, northern portion known as Little Eagle Lake and the main body of Eagle Lake proper to the south. When lake levels drop sufficiently, Little Eagle Lake is sundered from the rest of Eagle Lake and becomes a disjunct waterbody, but under normal conditions these lobes are fully connected. Eagle Lake discharges into Millsite Lake, which ultimately contributes to Lake Hancock from the east (Polk County 2014).

1.3 Watershed Information

1.3.1 Population and Geopolitical Setting

The two lakes and their respective watersheds are located in Polk County. According to 2010 data available from the U.S. Census Bureau, the population size of Polk County was 602,095 with a population density of 334.9 persons per square mile. Polk County occupies an area of 1,798 square miles and there are 281,385 housing units in the county, with a housing density of 156.5 houses per square mile (U.S. Census Bureau 2017).

The majority of Lake Ariana's watershed lies within the boundaries of the City of Auburndale. In the 2010 Census, Auburndale had a population of 13,507 with a density of 1,151.6 persons per square mile. The watershed area of Eagle Lake is mostly located in unincorporated Polk County, with the remainder in both the eponymous Eagle Lake City and a small portion bordering the southwest boundary of the City of Winter Haven. According to the U.S. Census, the population size of Eagle Lake in 2010 was 2,255 with a population density of 1,329.8 persons per square mile.

1.3.2 Topography

Lake Ariana and Eagle Lake are both located in the Winter Haven/Lake Henry Ridges Lake Region (Region 75-31), which is characterized by well-drained upland areas with the dominant soil association being Candler-Tavares-Apopka. Longleaf pine and xerophytic oak are the dominant habitat type, and the underlying geology is composed of Pliocene quartz pebbly sand and the phosphatic Bone Valley Member (Peace River Formation) of the Hawthorn Group (Griffith et al. 1997). The topographic elevation of Lake Ariana has historically ranged from 101.3 to 137.7 ft National Geodetic Vertical Datum of 1929 (NGVD29) and Eagle Lake has ranged from 113.5 to 131.5 ft NGVD29 (Polk County 2014).

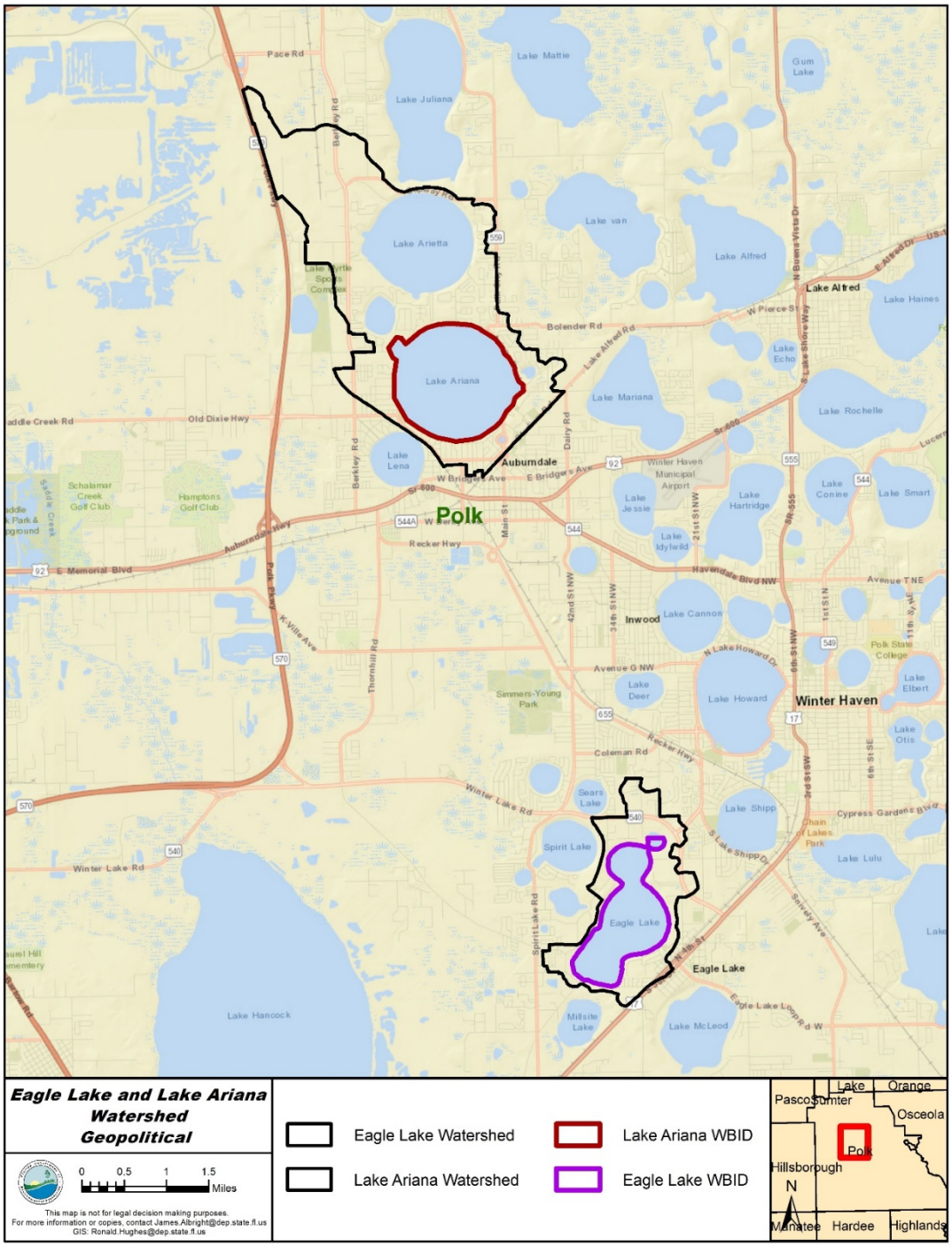


Figure 1.1. Location of Lake Ariana (WBID 1501B) and Eagle Lake (WBID 1623M) in the Upper Peace River Basin and major hydrologic and geopolitical features in the area

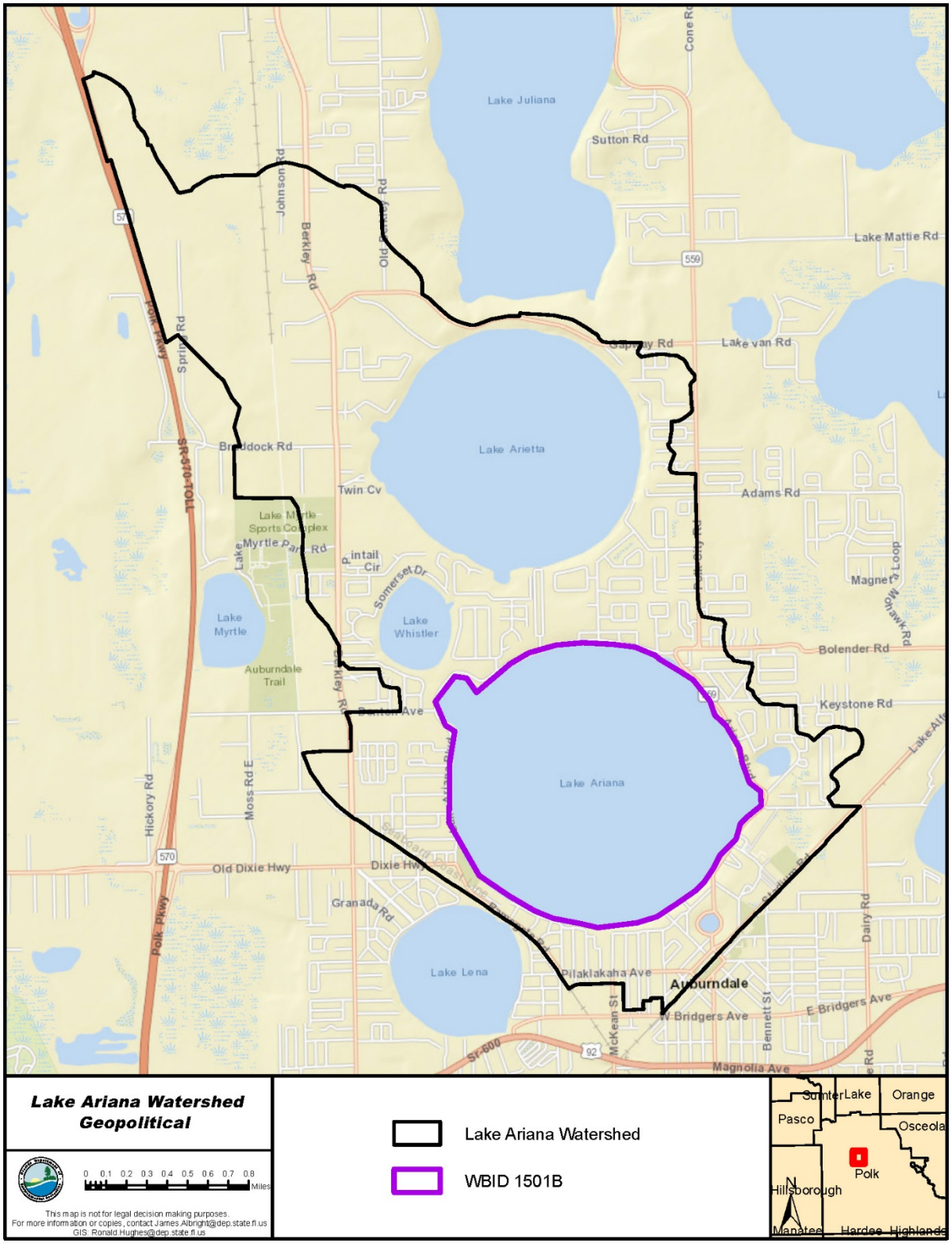


Figure 1.2. Lake Ariana (WBID 1501B) Watershed

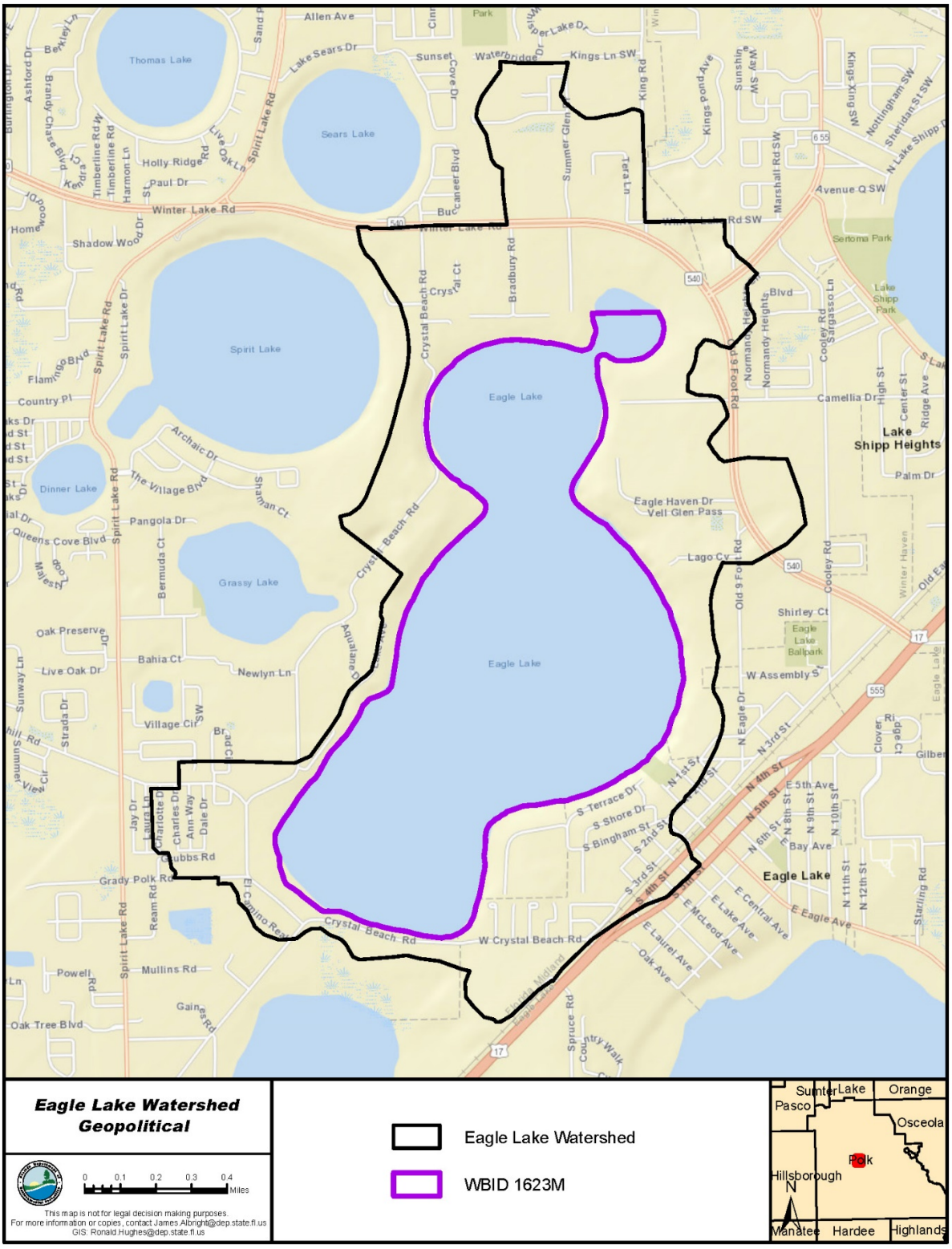


Figure 1.3. Eagle Lake (WBID 1623M) Watershed

1.3.3 Hydrogeological Setting

The greater hydrogeological context in which these lakes function is determined in part by the topography, but also by soil geology, aquifer/groundwater interactions, and climate.

Soils are classified by the National Cooperative Soil Survey into four hydrologic soil groups (HSGs)—Types A, B, C, and or D—based on their runoff potential. "A" type soils are typically well drained, have deep water tables, and consist of sandy textured soils with relatively low runoff potential. "B" type soils are typically loamy with some silt component, a moderately coarse texture, and a lower infiltration rate than Type A soils and are therefore classed as moderately well-drained. "C" type soils are sand, clay, and loam with more fine textures and lower infiltration rates, especially when wet. "D" type soils are variable in texture but generally have a greater clay component and are often found at lower topography with higher water tables that generate a higher hydrologic runoff response. Multiclassed soils vary in their hydrologic response depending on in situ drainage improvements.

Most of the watershed areas for the two lakes comprise well-drained Type A soils, which, by virtue of their infiltration characteristics and the watershed elevation, are principal recharge areas for the Floridan aquifer. This can be seen for Lake Ariana in **Figure 1.4** and for Eagle Lake in **Figure 1.5**. **Table 1.1** summarizes the hydrologic soil groups in each of the lakes.

Polk County is in a humid subtropical climate zone, with hot and humid summers, mild winters, and a defined rainy season from June through September, with approximately 60% of the rainfall occurring in that period. The annual average temperature based on weather data from Bartow is 22.9º C, with the average annual maximum reaching 28.9º C and the annual average minimum temperature around 17º C. Long-term average annual rainfall data for the modeling period from 2000 to 2016 were provided by the Southwest Florida Water Management District (SWFWMD), and the average for the whole period was 49 inches/year (in/yr).

Table 1.1. Acreage and percent area of soil types in the lake watersheds

N/A = Not applicable because the area is unclassified lake bottom. Hybrid soil types are A/D, B/D, and C/D.

Soil	Lake Ariana Acres	Lake Ariana %	Eagle Lake Acres	Eagle Lake %
N/A	1,903.11	40	655.64	42
A	2,248.31	47	756.84	49
A/D	486.82	10	107.47	7
B/D	77.41	2	31.32	2
C/D	27.13	0.50	0	0

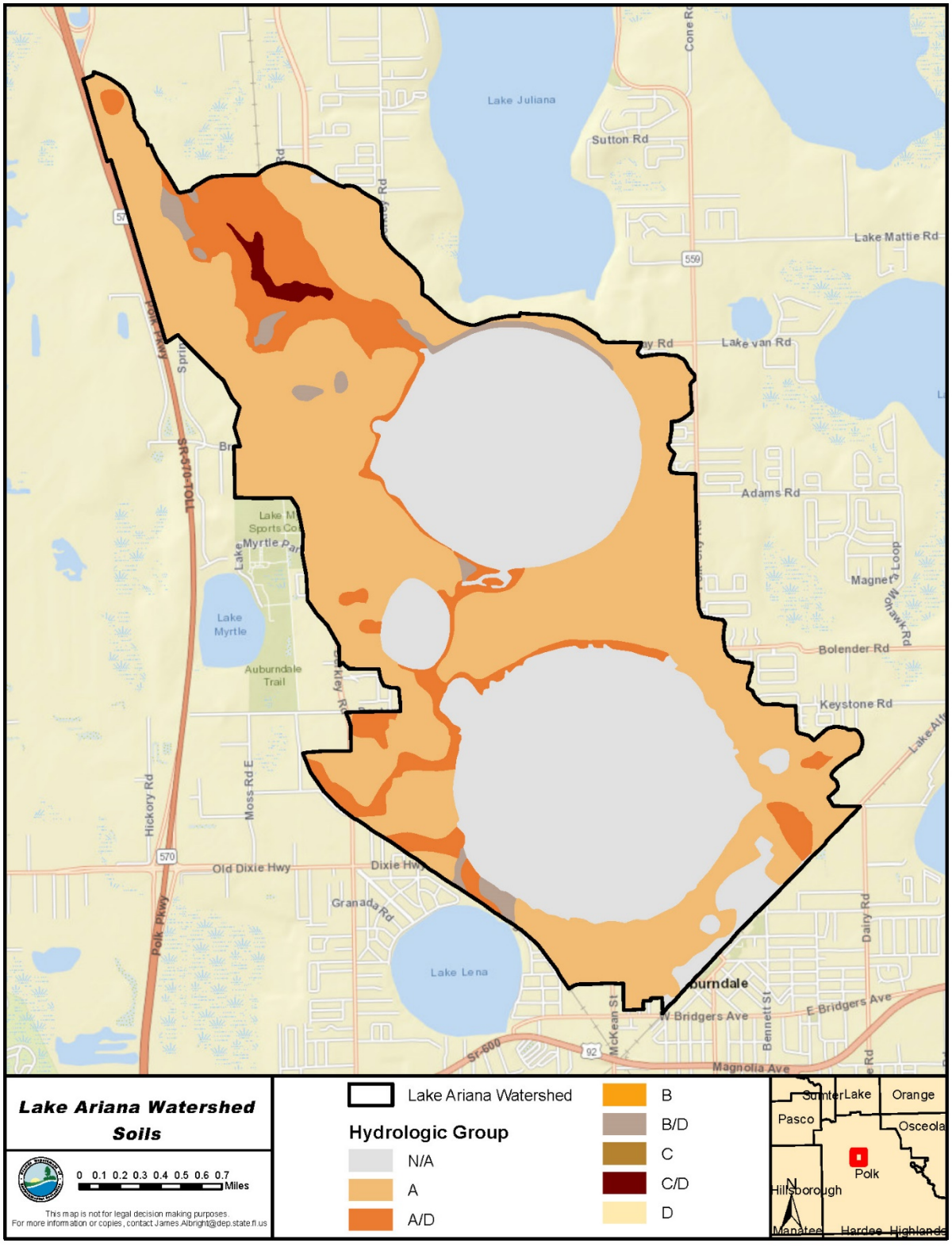


Figure 1.4. Hydrologic soil groups in the Lake Ariana Watershed

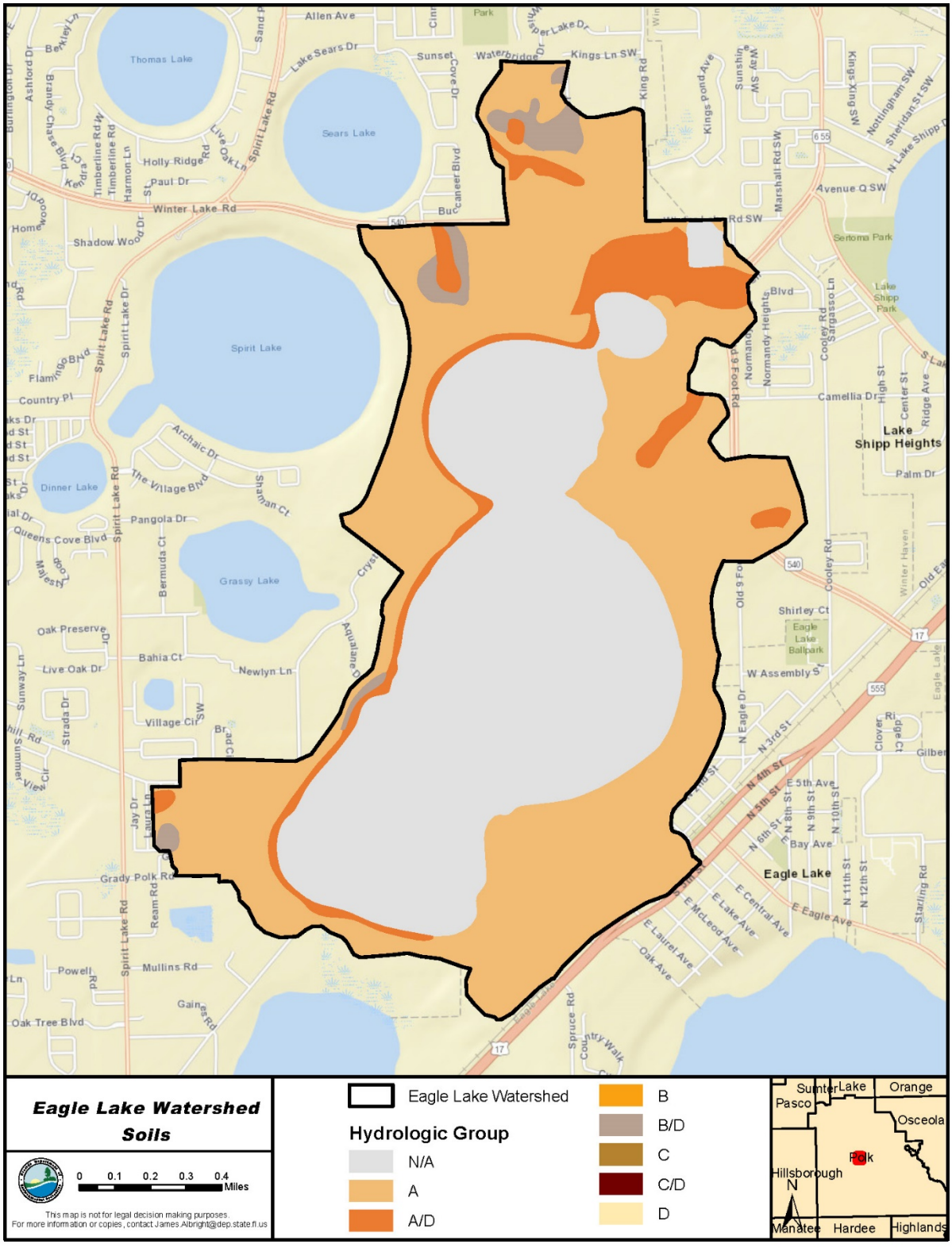


Figure 1.5. Hydrologic soil groups in the Eagle Lake Watershed

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 Ariana and Eagle Lake are Class III (fresh) waterbodies, each 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 standards applicable to the verified impairments (nutrients) for these waterbodies are Florida's nutrient criteria 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 as calcium carbonate (mg/L $CaCO_3$) and true color (color) measured in platinum cobalt units (PCU), based on long-term period of record (POR) geometric means. Using this methodology and data from IWR Database Run 53, Lake Ariana is classified as low-color (< 40 PCU), high-alkalinity (> 20 mg/L $CaCO_3$) lake, and Eagle Lake is classified as a low-color (< 40 PCU), low-alkalinity (< 20 mg/L $CaCO_3$) lake.

The chlorophyll *a* NNC for low-color, high-alkalinity lakes (Lake Ariana) is an annual geometric mean (AGM) value of 20 micrograms per liter (µg/L), not to be exceeded more than once in any 3-year period. For low-color, low-alkalinity lakes (Eagle Lake) the AGM for chlorophyll *a* is 6 micrograms per liter (µg/L), not to be exceeded more than once in any 3-year period.

The associated TN and 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 minimum and maximum 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 nutrient interpretations for TN and TP are the minimum values. These values are all listed in **Table 2.1** as specified in Subparagraph 62-302.531(2)(b)1., F.A.C.

Table 2.1. Chlorophyll *a*, TN, and TP criteria for Florida lakes (Subparagraph 62-302.531[2][b]1., F.A.C.)

[1] For lakes with color > 40 PCU in this lake region, the West Central Nutrient Watershed Region, the maximum TP limit shall be the 0.49 mg/L TP streams threshold for the region.

[2] N/A = Not applicable

Long-Term Geometric Mean Color and Alkalinity	AGM Chlorophyll *a*	Minimum NNC AGM TP	Minimum NNC AGM TN	Maximum NNC AGM TP	Maximum NNC AGM TN	Lakes in This Document
> 40 PCU[1]	20 µg/L	0.05 mg/L	1.27 mg/L	0.16 mg/L	2.23 mg/L	N/A[2]
≤ 40 PCU and > 20 mg/L $CaCo_3$	20 µg/L	0.03 mg/L	1.05 mg/L	0.09 mg/L	1.91 mg/L	Lake Ariana
≤ 40 PCU and ≤ 20 mg/L $CaCo_3$	6 µg/L	0.01 mg/L	0.51 mg/L	0.03 mg/L	0.93 mg/L	Eagle Lake

2.3 Determination of the Pollutant of Concern

2.3.1 Data Providers

Multiple entities have sampled the lakes over the total period of record (POR). However, in both lakes the majority of the data were from a single provider: Polk County Department of Natural Resources. Polk County typically has one primary station (in Ariana and Eagle these stations are '21FLPOLKARIANA1' and '21FLPOLKEAGLE1', respectively), located at the approximate center of the lake, that is regularly sampled, and that provides the most complete data record. To maintain a consistent single continuous record, only data from Polk County's primary, central stations were used in the regression analyses to determine the TMDLs for the lakes.

Data providers for Lake Ariana included the U.S. Geological Survey (USGS) (1972–81), DEP, (1972–2011), Polk County Department of Natural Resources (1985–2016), SWFWMD (1996–2002), Biological Research Associates (BRA) (2007–08), and Florida LakeWatch (1999–2002). The primary station was 21FLPOLKARIANA1, which was sampled from 1985 to 2016.

The data providers for Eagle Lake were very similar: USGS (1970–2000), DEP (2002–10), Polk County (1991–2016), SWFWMD (1996–2000), and LakeWatch (1991–2005). The principal

station was 21FLPOLKEAGLE1, which had data from 1985 to 2016. Data were also available for 21FLPOLKLTEAGLE1 which is located in the northern lobe of Eagle Lake known as Little Eagle Lake. These data were included in exploratory analyses, but it was ultimately determined that their inclusion would be inappropriate because the chlorophyll *a* record for Little Eagle Lake was shorter and because the central station was spatially more representative of the entirety of Eagle Lake. Also, combining the two stations would be inconsistent with the approach applied to other lakes in the region. The annual geometric mean results for chlorophyll *a*, TN, and TP at the sampling locations near the centers of Eagle Lake and Little Eagle Lake exhibited similar patterns and magnitudes.

Figures 2.1 and **2.2** show the sampling locations in Ariana and Eagle, respectively. The central Polk County station is highlighted in yellow in each map. The individual water quality measurements discussed in this report are available in IWR database Run 53 and are available on request.

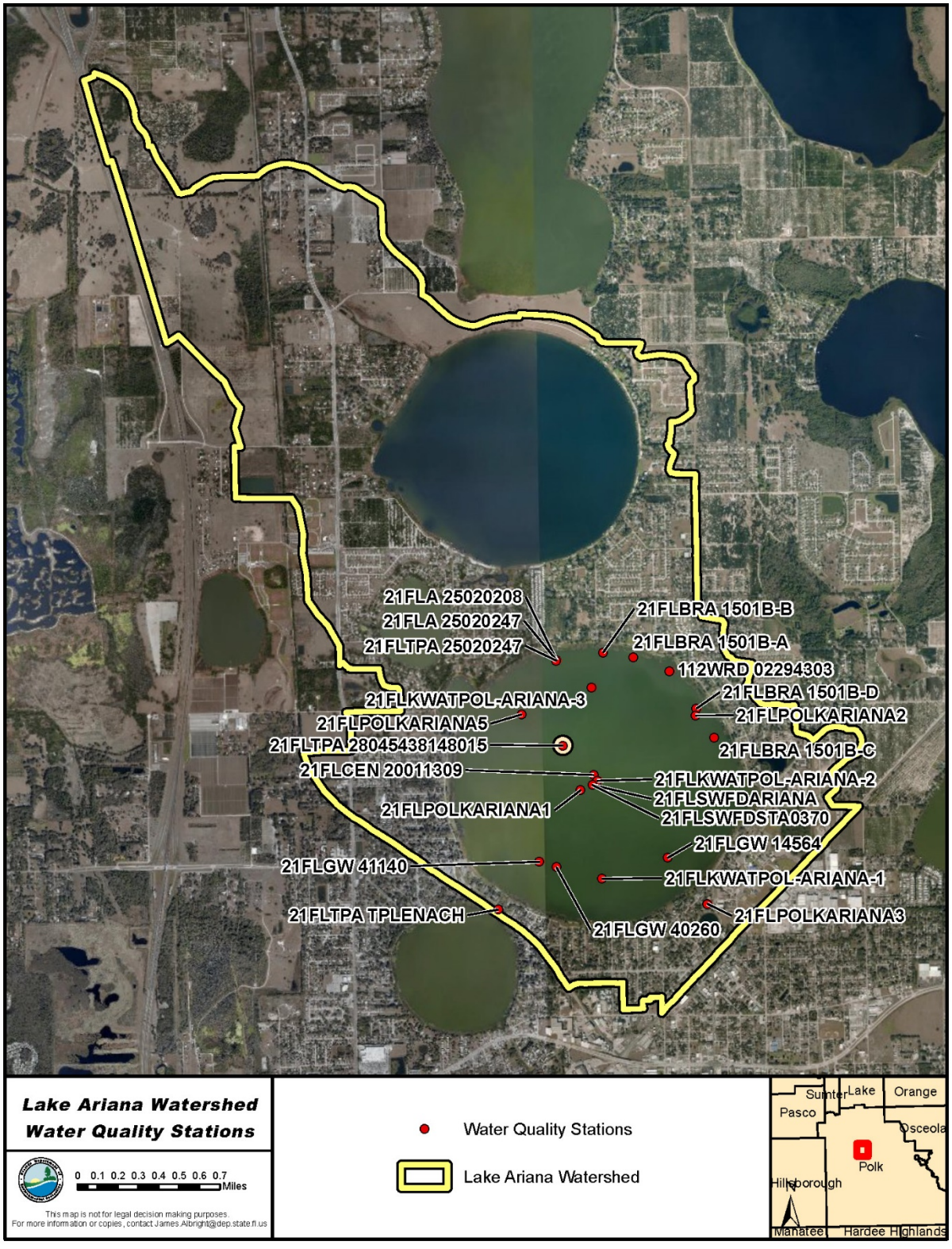


Figure 2.1. Monitoring stations in the Lake Ariana (WBID 1501B) Watershed

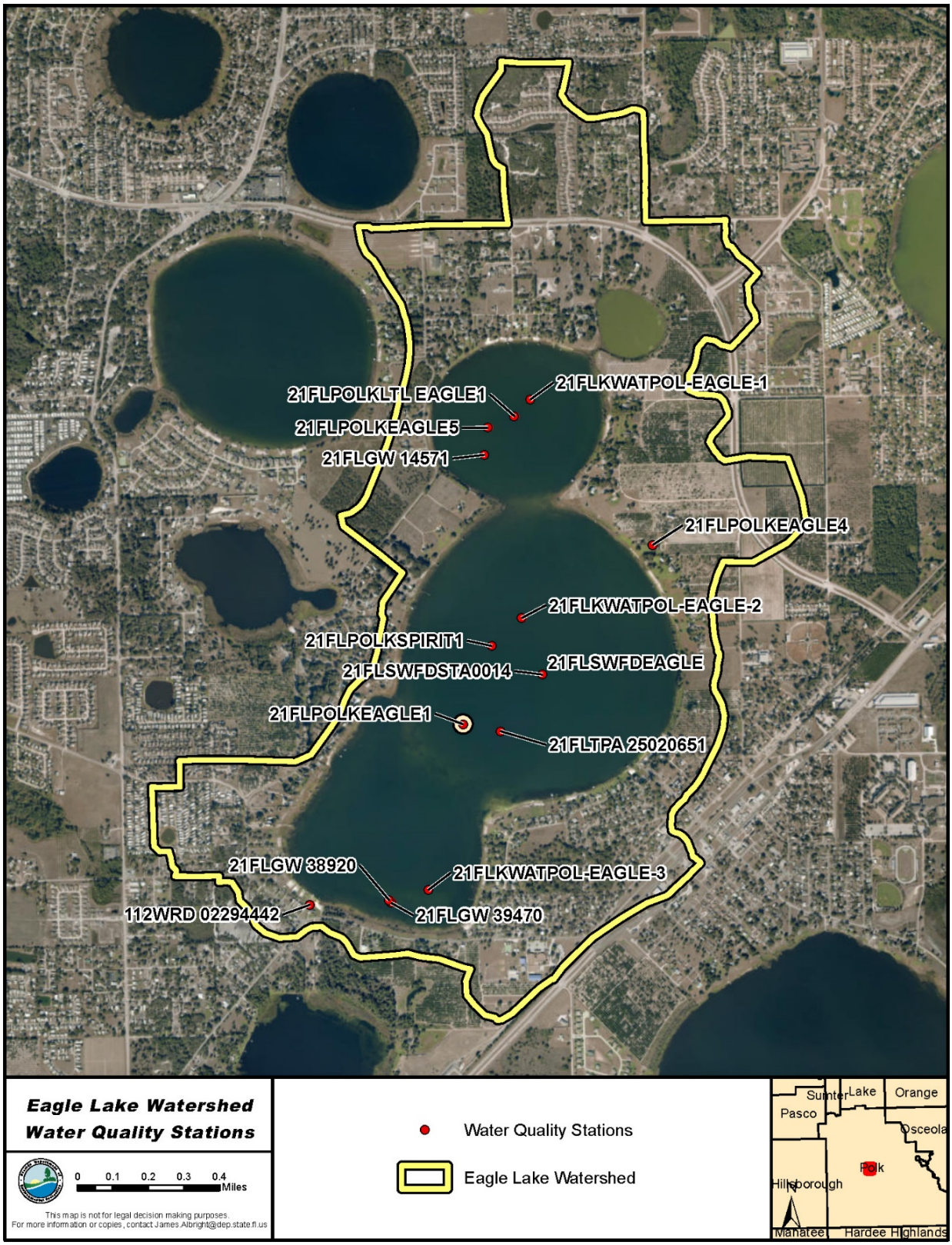


Figure 2.2. Monitoring stations in the Eagle Lake (WBID 1623M) Watershed

2.3.2 Information on Verified Impairment

Prior to the adoption of NNC, DEP employed annual average Trophic State Index (TSI) scores to assess Florida lakes for impairments. The TSI thresholds were set based on annual mean color, where high-color lakes (> 40 platinum cobalt units [PCU]) had a TSI threshold of 60, and lower color lakes (≤ 40 PCU) had a TSI threshold of 40. Exceeding the TSI threshold in any one year of the verified period was sufficient to identify a lake as impaired for nutrients.

As part of the Cycle 1 assessment, Eagle Lake was identified as impaired based on TSI values exceeding the threshold of 60, the threshold for a high-color lake. In the subsequent Cycle 2 assessment, Lake Ariana was also identified as impaired based on annual average TSI values exceeding 40, the applicable threshold for low-color lakes.

Florida adopted new NNC for lakes, spring vents, and streams in 2011 that were approved by the EPA in 2014. The TSI assessment is no longer used. In the Cycle 3 assessment performed in 2016, these NNC were applied to reassess the lakes in the Sarasota Bay–Peace River–Myakka River Basin. The applicable nutrient criteria for chlorophyll *a* are based on a combination of a lake's color and its alkalinity.

The lakes are now considered low color (< 40 PCU), and so alkalinity determines the chlorophyll *a* AGM criterion (< 20 mg/L $CaCo_3$, the chlorophyll *a* criterion is 6 µg/L; otherwise the criterion is 20 µg/L). Eagle Lake is assessed against the criterion of 6 µg/L and Lake Ariana is assessed against the criterion of 20 µg/L. In the case of Lake Ariana, the AGMs for chlorophyll *a* and TN exceeded their criteria more than once in a 3-year period, and the waterbody was added to the 303(d) list for these parameters. Eagle Lake also exceeded its criteria for TP, and so in addition to chlorophyll *a* and TN, this lake was also added to the 303(d) list for TP. **Tables 2.2** for Lake Ariana and **Table 2.3** for Eagle Lake, list the AGM values for chlorophyll *a*, TN, and TP from 2003 to 2016, spanning the Cycle 3 planning period from 2003 to 2012 and the verified period from 2008 to 2015.

In order to provide an overview of the lakes, graphs of the nutrient data along with color and alkalinity are provided below in **Figures 2.3** through **2.12**. All of the available data from 1990 to the 2016 are included in these time-series charts. For the most part, these parameters have remained relatively stable. Although there does appear to be an increase in alkalinity in Eagle Lake over the time-period, Eagle Lake is still a low-alkalinity lake.

Table 2.2. Lake Ariana (WBID 1501B) AGM values, 2003–16

ID = Insufficient data
Note: Values shown in shaded cells and boldface type 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)
2003	**34**	**1.44**	0.03
2004	ID	ID	ID
2005	14	0.78	ID
2006	**25**	0.96	ID
2007	13	0.80	0.01
2008	20	1.02	0.02
2009	19	1.10	0.02
2010	**29**	**1.33**	0.02
2011	**36**	**1.51**	0.02
2012	**28**	**1.19**	0.02
2013	**24**	**1.28**	0.02
2014	**26**	**1.34**	0.02
2015	**27**	**1.32**	0.02
2016	**27**	**1.24**	0.02

Table 2.3. Eagle Lake (WBID 1623M) AGM values, 2003–16

ID = Insufficient data
Note: Values shown in shaded cells and boldface type 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)
2003	ID	ID	ID
2004	ID	ID	ID
2005	**15**	**0.74**	ID
2006	ID	**0.60**	**0.02**
2007	**16**	**0.78**	**0.02**
2008	**10**	**0.58**	**0.01**
2009	**8**	0.43	**0.02**
2010	6	0.40	0.02
2011	**7**	**0.60**	**0.02**
2012	**9**	**0.65**	**0.02**
2013	**10**	**0.62**	**0.02**
2014	**13**	**0.75**	**0.02**
2015	**18**	**0.88**	**0.02**
2016	**24**	**1.01**	**0.02**

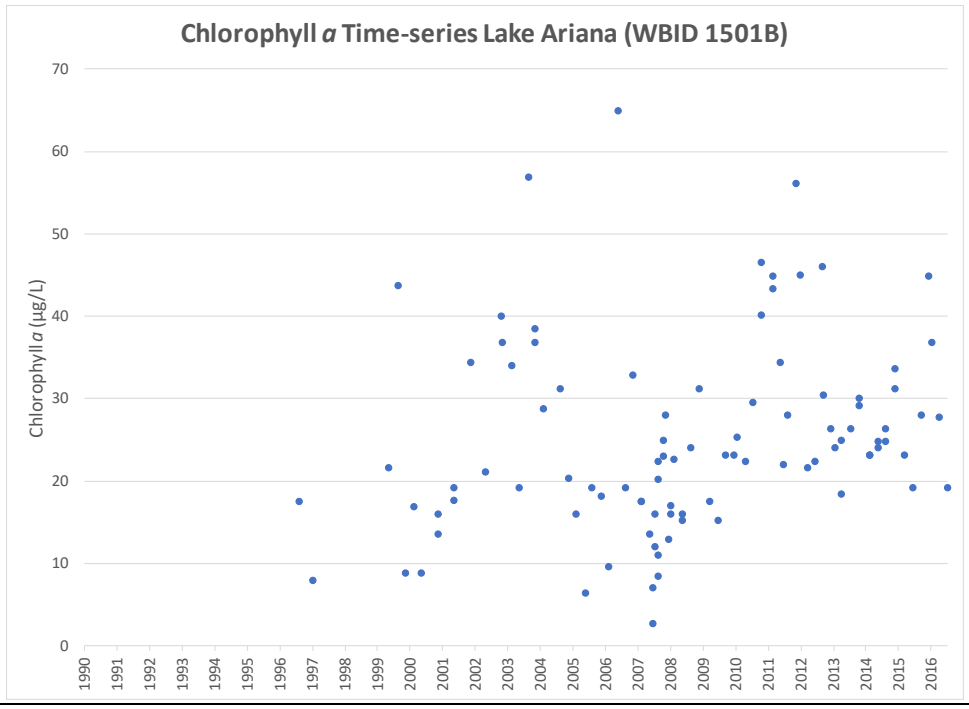


Figure 2.3. Chlorophyll *a* time-series for Lake Ariana (WBID 1501B)

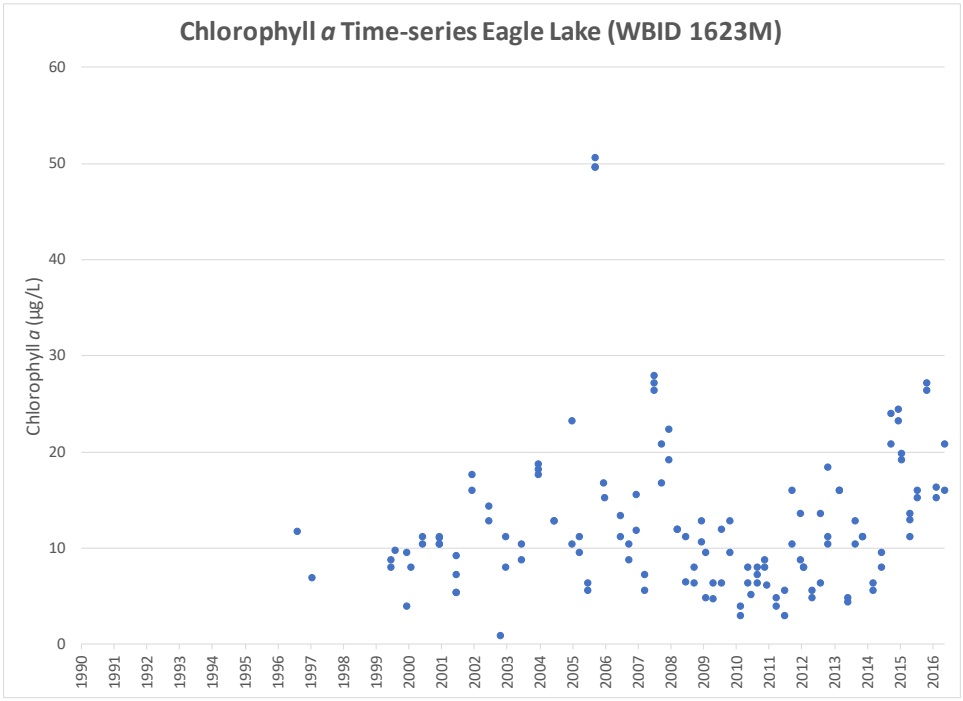


Figure 2.4. Chlorophyll *a* time-series for Eagle Lake (WBID 1623M)

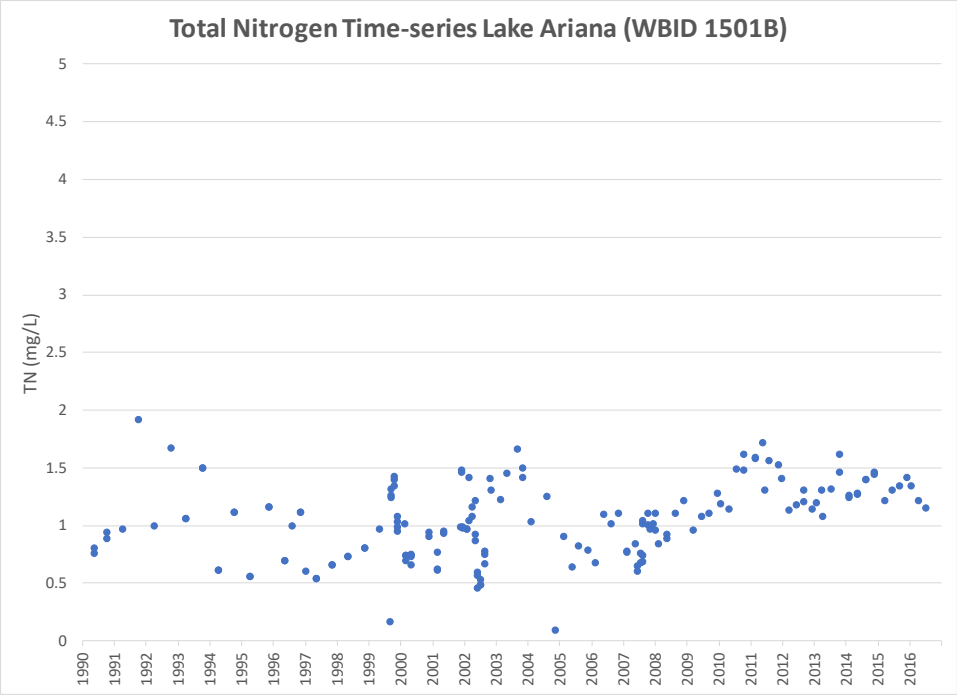


Figure 2.5. TN time-series for Lake Ariana (WBID 1501B)

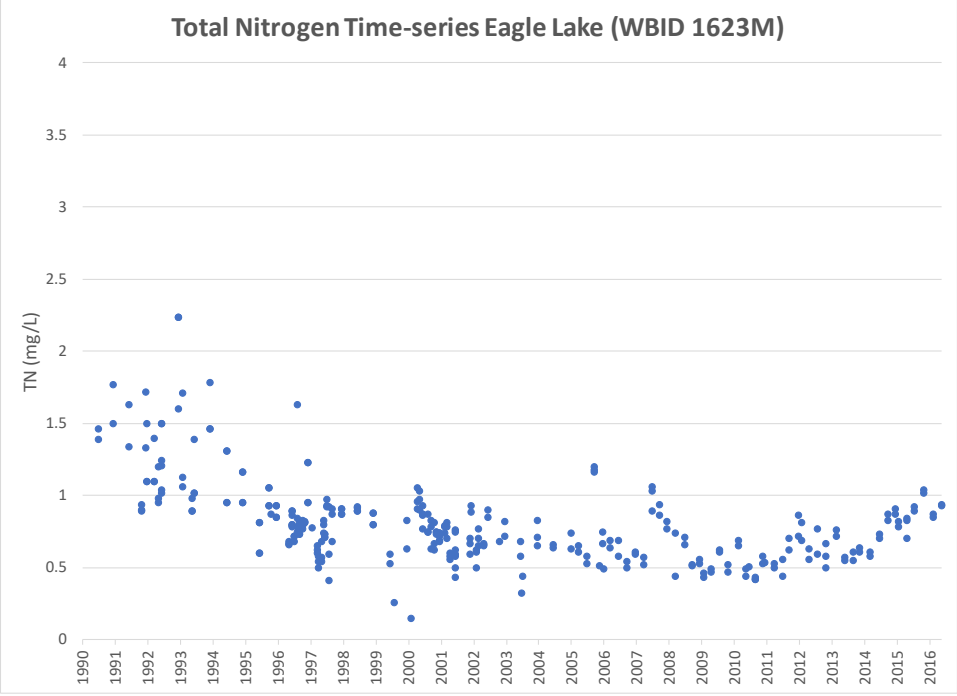


Figure 2.6. TN time-series for Eagle Lake (WBID 1623M)

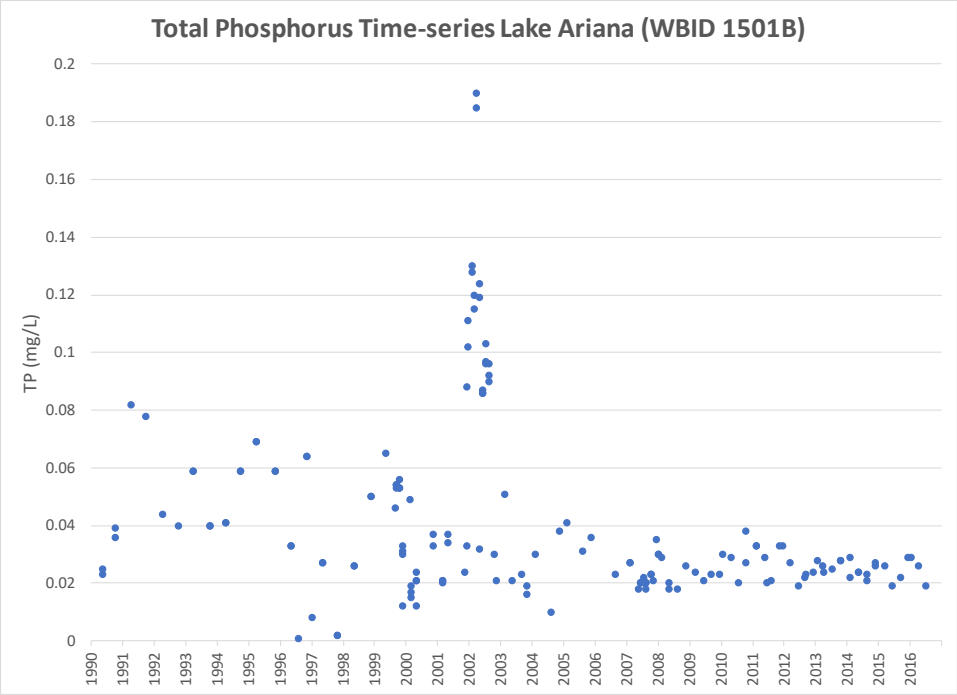


Figure 2.7. TP time-series for Lake Ariana (WBID 1501B)

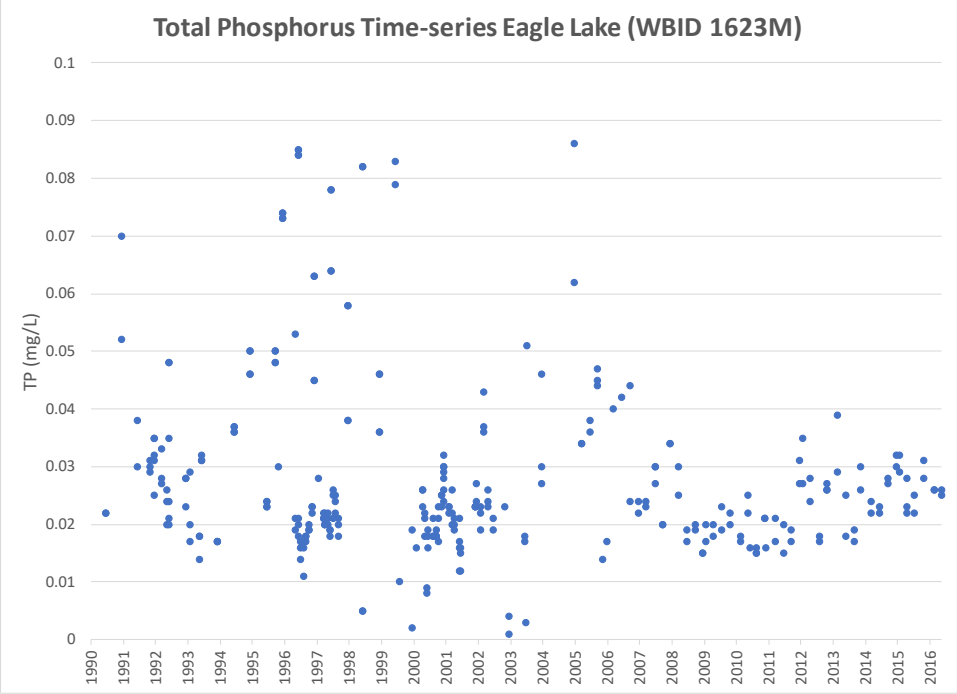


Figure 2.8. TP time-series for Eagle Lake (WBID 1623M)

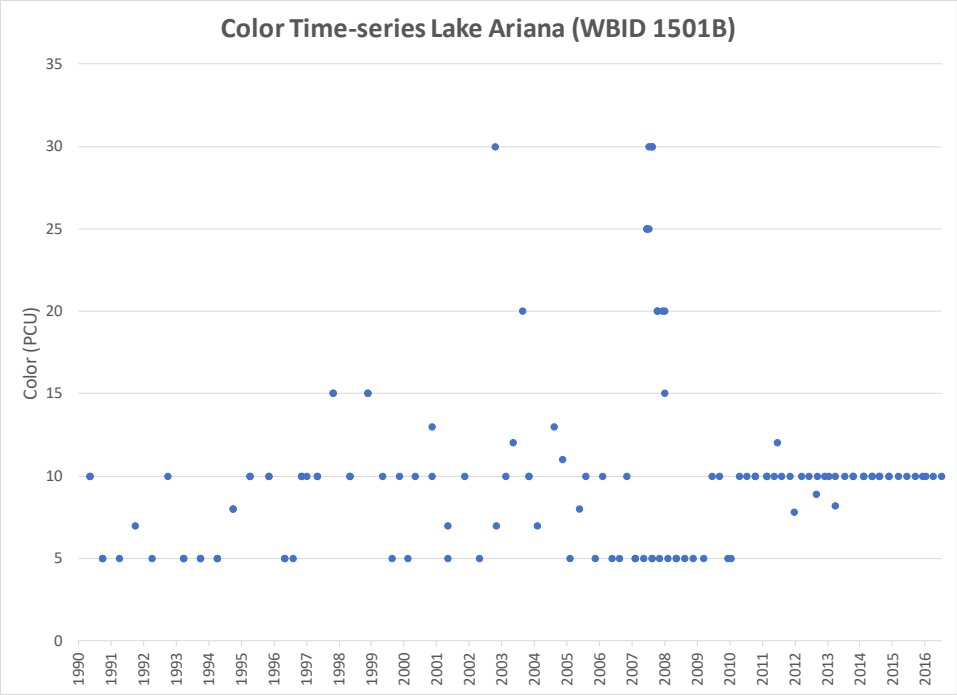


Figure 2.9. Color time-series for Lake Ariana (WBID 1501B)

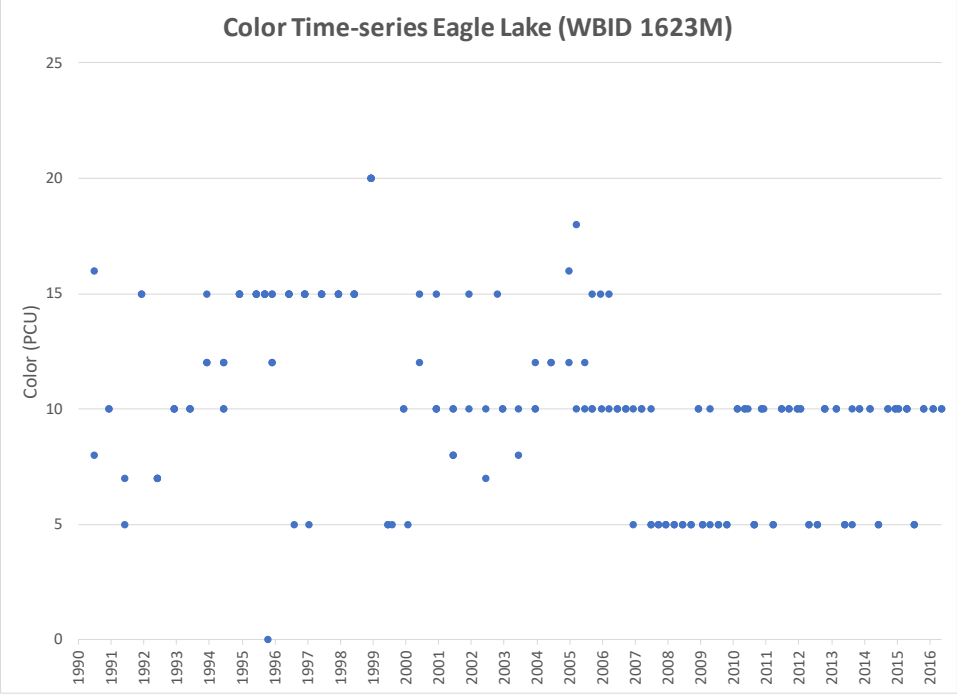


Figure 2.10. Color time-series for Eagle Lake (WBID 1623M)

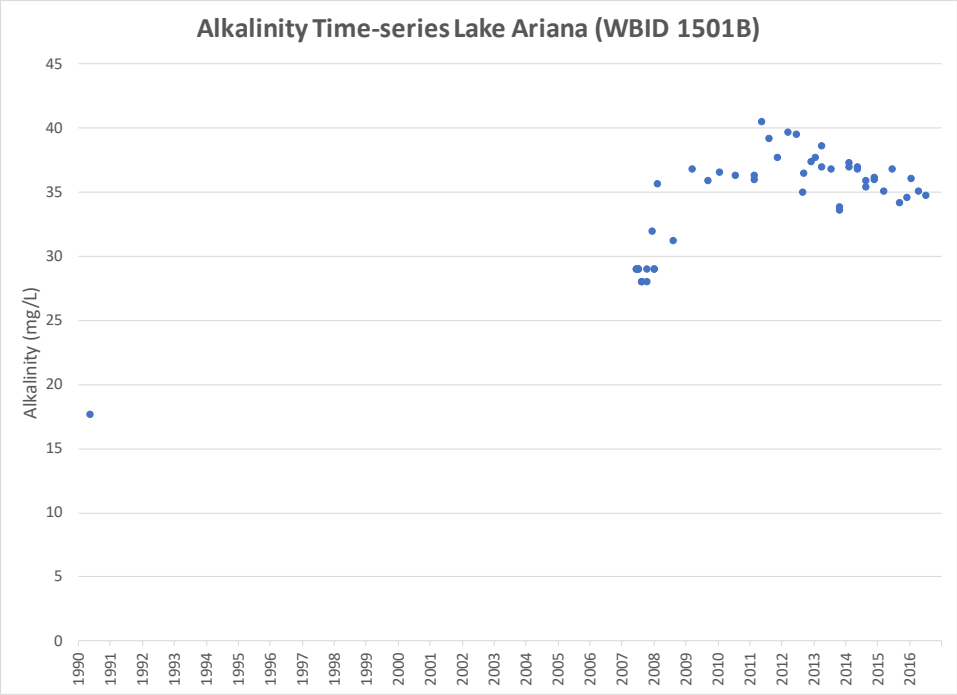


Figure 2.11. Alkalinity time-series for Lake Ariana (WBID 1501B)

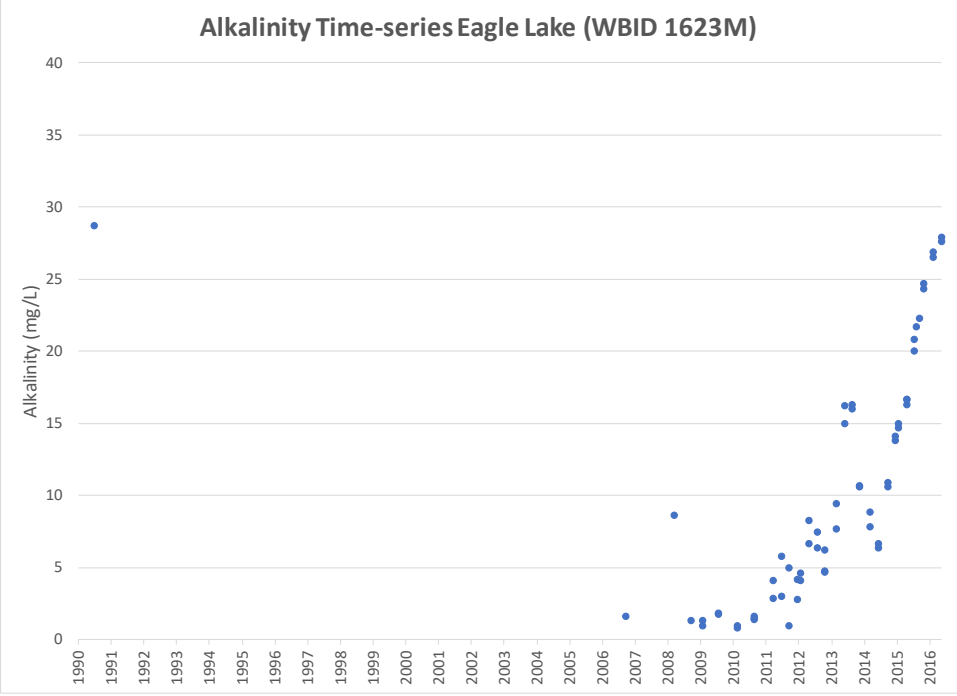


Figure 2.12. Alkalinity time-series for Eagle Lake (WBID 1623M)

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

3.1 Establishing the Site-Specific Interpretation

The nutrient TMDLs presented in this report, upon adoption into Rule 62-304.625, F.A.C., will constitute the site-specific numeric interpretation 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 these particular waterbodies, pursuant to Paragraph 62-302.531(2)(a), F.A.C. **Table 3.1** 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 Ariana and Eagle Lake, 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.

When developing TMDLs to address nutrient impairment, it is essential to address those nutrients that typically contribute to excessive plant growth. In Florida waterbodies, nitrogen and phosphorus are most often the limiting nutrients. The limiting nutrient is defined as the nutrient(s) that limit plant growth (both macrophytes and algae) when it is not available in sufficient quantities. A limiting nutrient is a chemical that is necessary for plant growth, but available in quantities smaller than those needed for algae, represented by chlorophyll *a*, and macrophytes to grow. In the past, management activities to control lake eutrophication focused on phosphorus reduction as phosphorus was generally recognized as the limiting nutrient in freshwater systems. Recent studies, however, have supported that the reduction of both nitrogen and phosphorus is necessary to control algal growth in aquatic systems (Conley et al. 2009, Paerl 2009, Lewis et al. 2011, Paerl and Otten 2013). Furthermore, the analysis used in the development of the Florida lake NNC support this idea as statistically significant relationships were found between chlorophyll *a* values and both nitrogen and phosphorus concentrations (DEP 2012).

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 as well as the evaluation of the relationship between chlorophyll *a* and TN and TP concentrations protective of designated uses (DEP 2012). Based upon these lines of evidence, DEP concluded that an annual average chlorophyll *a* of 20 µg/L in colored or high alkalinity lakes, or 6 µg/L in low-alkalinity lakes, is protective of the designated uses of recreation and aquatic life support (DEP 2012). Color and alkalinity were used as morphoedaphic factors to predict the natural trophic status of lakes. Colored (≥40 PCU), and high alkalinity lakes (≥ 20 mg $CaCO_3$/L) are mesotrophic or eutrophic. Since DEP has

demonstrated that the chlorophyll *a* concentrations are protective of designated uses and maintain a balanced aquatic flora and fauna, these values are used as the water quality targets to address the lakes' nutrient impairments. The generally applicable chlorophyll *a* criteria for lakes were established by taking into consideration multiple lines of evidence, including; an analysis of lake chlorophyll *a* concentrations statewide, comparisons to a smaller population of select reference lakes, paleolimnological studies, expert opinions, user perceptions, and biological responses. Based upon these lines of evidence, DEP concluded that annual average chlorophyll *a* of 20 µg/L in colored lakes or high alkalinity clear lakes and 6 µg/L in low alkalinity clear lakes is protective of the designated uses of recreation and aquatic life support (DEP 2012). Color and alkalinity were used as morphoedaphic factors to predict the natural trophic status of lakes. Colored ($\geq$ 40 PCU), and high alkalinity ($\geq$ 20 mg $CaCO_3$/L) are mesotrophic[1] or eutrophic, while low-color (< 20 PCU) with low alkalinity (<20 $CaCO_3$/L) lakes tend to be oligotrophic. The generally applicable chlorophyll *a* criteria are assumed to be protective of individual Florida lakes absent information that shows either 1) more sensitive aquatic life (i.e., more responsive floral community); or, 2) a significant historic change in trophic status (i.e., significant increasing trend in color and/or alkalinity).

As a low-color, high-alkalinity lake, a target of 20 µg/L will apply to Lake Ariana and, as a low-color, low-alkalinity lake, Eagle Lake will have a target of 6 µg/L. Long-term datasets of color, alkalinity, and nutrients in these lakes suggest that they do not differ from the population of lakes used in the development of the NNC, and therefore DEP has determined that the generally applicable NNC criteria are the most appropriate site-specific chlorophyll *a* criteria.

In the statewide NNC for lakes, DEP allows for an acceptable range of AGMs for TN and TP, up to the values shown in the "maximum calculated numeric interpretation" column, as long as the applicable chlorophyll *a* criterion is achieved in that same year. These numeric interpretations for TN, TP, and chlorophyll *a* cannot be exceeded more than once in any consecutive calendar three-year period and apply statewide. If there are insufficient data to calculate the AGM chlorophyll *a* for a given year, or the AGM chlorophyll *a* exceeds the values for the lake type, then the applicable numeric interpretations for TN and TP are the minimum values in the table. If there are sufficient data to calculate the AGM chlorophyll *a* and the mean does not exceed the chlorophyll *a* value for the lake type, then the TN and TP numeric interpretations for that calendar year are the AGMs of ambient TN and TP samples for that lake, up to the maximum TN and TP criteria.

The TN concentrations identified as the site-specific TN criterion were determined using the regression approach in order to achieve the applicable chlorophyll *a* criteria (20 µg/L for Lake Ariana and 6 µg/L for Eagle Lake), not to be exceeded more than once in any consecutive 3-year

[1] The 20 µg/L chl-a criterion was set to be protective of a mesotrophic condition. However, many Florida lakes may naturally be eutrophic or even hypertrophic; therefore, the department may use paleolimnological evidence to establish appropriate chl-a targets for these lakes.

period. As a conservative measure, the TP concentrations that will be used as the site-specific TP criterion never to be exceeded in any year were taken from the minimum values expressed in the NNC for each lake type.

3.3 Numeric Expression of the Site-Specific Numeric Interpretation

Empirical equations that describe the relationships between chlorophyll *a* and nutrient concentrations (TN for Lake Ariana and both TN and TP for Eagle Lake) were then used in the TMDL development approach, which is explained in detail in **Chapter 5**. This approach uses the regression relationships between nutrients and chlorophyll *a* based on the station in each lake with the most comprehensive dataset in order to set target concentrations to be used to determine percent reductions from the WBID-wide observed in-lake concentrations for the period from 2003 to 2016.

The nutrient criteria are all expressed as AGM concentrations in the lakes. The chlorophyll *a* concentration is expressed as an AGM concentration not to be exceeded more than once in any consecutive 3-year period. Because there are no data to suggest that an alternative chlorophyll *a* criterion different from the existing NNC for chlorophyll *a* should be selected for these two lakes, the new criterion for chlorophyll *a* is identical to the current criterion (20 µg/L for Lake Ariana and 6 µg/L in Eagle Lake). Establishing the frequency of the chlorophyll *a* criterion as not to be exceeded more than once in any consecutive 3-year period is consistent with the frequency expression of the generally applicable criterion and ensures protection of the designated use while accounting for year to year variability.

The site-specific TN concentration is determined through the simple linear or multiple linear regression approach. As with the chlorophyll a criterion the TN criterion is expressed as an in-lake AGM concentration. Establishing the frequency as not to be exceeded in any year ensures that the chlorophyll *a* NNC, which is protective of the designated use, is achieved.

There are no in-lake data available to suggest that an alternative TP criterion should be selected for these lakes, and so the existing NNC was used as a starting point to determine the targets for TP. The generally applicable NNC for TP in lakes is a pair of values consisting of minimum and maximum criteria, the minimum of which is selected if the chlorophyll *a* criterion is exceeded. To maintain the current relationship of TN and TP and not result in degradation of the TP condition, the lower end of the range (0.03 mg/L for Lake Ariana and 0.01 mg/L for Eagle Lake) is used for the new site-specific TP criterion. As with the TN criterion, the TP concentration is expressed as an AGM concentration never to be exceeded in order to ensure that the chlorophyll *a* NNC is not exceeded. **Table 3.1** summarizes the narrative nutrient criteria concentrations for each lake.

Table 3.1. Site-specific interpretations of the narrative nutrient criterion

[1] Chlorophyll *a* shall not be exceeded more than once in any consecutive three-year period.
[2] TN and TP are never to be exceeded.

Waterbody	WBID	AGM Chlorophyll *a* (µg/L)[1]	AGM TN (mg/L)[2]	AGM TP (mg/L)[2]
Lake Ariana	1501B	20	0.97	0.03
Eagle Lake	1623M	6	0.63	0.01

3.4 Downstream Protection

As discussed in **Section 1.2**, Lake Ariana discharges through an outlet on the south side of the lake. The immediate receiving waterbody is Lake Lena (WBID 1501), a Class III freshwater lake with an existing TMDL and adopted Hierarchy 1 site-specific NNC. Lake Lena in turn discharges into Lake Lena Run (WBID 1501A), a Class III freshwater stream. The applicable NNC for Lake Lena are 1.14 mg/L of TN, as set by the existing TMDL, 0.03 to 0.09 mg/L of TP, and 20 µg/L of chlorophyll *a*, expressed as AGMs not to be exceeded more than once in a 3-year period. The applicable NNC for Lake Lena Run are 1.65 mg/L of TN, 0.49 mg/L of TP, and 20 µg/L of chlorophyll *a*, expressed as AGMs not to be exceeded more than once in a 3-year period.

During the most recent assessment period for the Group 3 basins (Cycle 3), Lake Lena was assessed as impaired (Category 4a, TMDL in effect) for chlorophyll *a* and TN. The AGM values for TP did not exceed their applicable criteria. Lake Lena Run did not exceed any of its applicable nutrient criteria. No biological data were available at the time of the assessment to support or refute the not impaired status of Lake Lena Run, however a recent SCI of 44 does provide support that Lake Lena Run is currently supporting a healthy community of benthic macroinvertebrates under current conditions, and upstream improvements should continue to support the existing in-stream biological community.

A nutrient TMDL is in effect for Lake Lena with a new TN AGM criterion of 1.14 mg/L, representing a 42 % reduction of the maximum TN AGM observed in Lake Lena (Petrus 2015). Lake Lena met its NNC for TP of 0.03 mg/L, and there were no changes to the criterion for this nutrient. The new criteria for Lake Ariana set forth in this TMDL analysis are a TN AGM of 0.97 mg/L, a TP AGM of 0.03 mg/L, and a chlorophyll *a* AGM of 20 µg/L. Since the restoration concentrations for Lake Ariana are lower than the nutrient targets for the Lake Lena TMDL, the Lake Ariana TMDL nutrient reductions meet or exceed the reduction goals set forth by the Lake Lena TMDL. The TN and TP loads coming from Lake Ariana are protective of the nutrient conditions in downstream waters.

Eagle Lake discharges to Eagle Lake Outlet (WBID 1623N), a Class III freshwater stream, and to Millsite Lake (WBID 1623M2), a Class III freshwater lake. The applicable NNC for Eagle Lake Outlet are 1.65 mg/L of TN, 0.49 mg/L of TP, and 20 µg/L of chlorophyll *a*, expressed as

AGMs not to be exceeded more than once in a 3-year period. Millsite Lake has only one color value from its period of record (50 PCU in 1995). At 50 PCU it is potentially a high-color lake and would then be assessed against NNC of 20 µg/L of chlorophyll *a*, 1.27 to 2.23 mg/L of TN, and 0.05 to 0.16 mg/L of TP, all expressed as AGMs not to be exceeded more than once in a 3-year period. During the most recent assessment period for the Group 3 basins (Cycle 3), no data were available to assess either Millsite Lake or Eagle Lake Outlet for any parameter. In fact the only data available for Millsite Lake are from a single sampling event in September 1995 (DO = 95% sat, Chlorophyll a = 8.45 µg/L, TN = 0.89 mg/L, TP = 0.05 mg/L). The new site-specific criteria for Eagle Lake are a TN AGM of 0.63 mg/L, a TP AGM of 0.01 mg/L, as well as a chlorophyll *a* AGM of 6 µg/L. These restoration concentrations for Eagle Lake are stricter than those for both Eagle Lake Outlet and Millsite Lake, so the site-specific targets are protective of the waters located downstream.

As outlined in **Section 1.2**, both lakes ultimately contribute to Lake Hancock, the receiving body for the entire drainage area. The applicable NNC for Lake Hancock are 1.27 to 2.23 mg/L of TN, 0.05 to 0.16 mg/L of TP, and 20 µg/L of chlorophyll *a*, expressed as AGMs not to be exceeded more than once in a 3-year period. As part of the Cycle 1 assessment, Lake Hancock was identified as impaired based on TSI values exceeding the threshold of 60, the threshold for a high-color lake. On the most recent Cycle 3 assessment performed in 2016, the lake exceeded the chlorophyll *a*, TN, and TP criteria more than once in a 3-year period resulting in impairments for these nutrient parameters. Any improvements upstream in the larger Lake Hancock Basin will potentially improve the conditions in Lake Hancock. All in all, the new criteria being set for Lake Ariana and Eagle Lake are lower than the existing criteria for Lake Hancock. Therefore, the new criteria are protective of the nutrient conditions in Lake Hancock.

3.5 Endangered Species Consideration

Section 7(a)(2) of the Endangered Species Act (ESA) requires each federal agency, in consultation with the services (i.e., U.S. Fish and Wildlife Service [FWS] and U.S. National Oceanic and/or 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 a disapproval or a required modification to the WQS change.

DEP is not aware of any endangered species present in the lakes in question. The FWS online Information for Planning and Conservation (IPac) tool identifies endangered species within regions of interest. The only endangered species listed in the area are terrestrial species; no aquatic, amphibious, or anadromous endangered species are associated with lake habitats in Lake Ariana or Eagle Lake. Furthermore, it is expected that restoration efforts toward a more natural system should positively impact any species living in the lakes and their respective watersheds.

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. 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.

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

To be consistent with CWA definitions, the term "point source" is used to describe traditional point sources (such as domestic and industrial wastewater discharges) and stormwater systems requiring an NPDES stormwater permit when allocating pollutant load reductions required by a TMDL (see **Section 6.1** 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, and as such, this source assessment section does not make any distinction between the two types of stormwater.

4.2 Point Sources

4.2.1 Wastewater Point Sources

There is currently only one NPDES permitted surface water discharger in either of the two watersheds. Universal Forest Products, Auburndale LLC (Permit FL0133132) is a facility involved in the treatment of lumber and the manufacture of wood products. The facility uses a closed loop system and discharges do not occur normally, but in the event of a discharge this consists of effluent from Outfall D-001 as stormwater runoff in Lake Ariana Drain (WBID 1501F). Lake Ariana Drain is a contributing basin for Lake Ariana (WBID 1501B). The facility is monitored regularly both for groundwater intrusion at test wells and at the outfall. There is no evidence of a discharge since 2004.

4.2.2 Municipal Separate Storm Sewer System (MS4) Permittees

The Lake Ariana and Eagle Lake watersheds are covered by a NPDES MS4 Phase I permit (FLS000015). The stormwater collection systems in these watersheds are owned and operated by Polk County, in conjunction with the Florida Department of Transportation (FDOT) District 1. The cities of Auburndale, Eagle Lake, and Lakeland are co-permittees in the county's MS4 permit. For more information on MS4s in the watershed, send an email to NPDES-stormwater@dep.state.fl.us.

Table 4.1. NPDES MS4 permits with jurisdiction in the watersheds of Lake Ariana and Eagle Lake

Permit Number	Permittee/Co-Permittees	Phase
FLS000015	Polk County	I
FLS266604	City of Auburndale	I
FLS266647	City of Eagle Lake	I
FLS266779	FDOT District 1 - Polk	I

4.3 Nonpoint Sources

Pollutant sources that are not NPDES wastewater or stormwater dischargers are generally considered nonpoint sources. Nutrient loadings to the Lake Ariana and Eagle Lake watersheds 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 Ariana and Eagle Lake watersheds. 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. **Tables 4.1** and **4.2** list land use in the respective watersheds in 2011 based on data from the Southwest Florida Water Management District (SWFWMD), and **Figures 4.1** and **4.2** show the information graphically. Land use codes are those referenced in FDOT (1999).

Table 4.1. SWFWMD land use in the Lake Ariana (WBID 1501B) Watershed in 2011

Land Use Code	Land Use Classification	Acres	% of Watershed
1100	Low-Density Residential	343.86	7.21
1200	Medium-Density Residential	1,189.77	24.96
1300	High-Density Residential	79.94	1.68
1400	Commercial	48.91	1.03
1500	Light Industrial	13.25	0.28
1700	Institutional	86.94	1.82
1800	Recreational	41.25	0.87
1900	Open Land	124.39	2.61
2000	Agriculture	756.76	15.88
3000 and 7000	Rangeland	0.39	0.01
4000	Forest/Rural Open	12.43	0.26
5000	Water	1,848.22	38.77
6000	Wetlands	133.86	2.81
8000	Communication and Transportation	86.26	1.81
Total		**4,766.23**	**100**

Table 4.2. SWFWMD land use in the Eagle Lake (WBID 1623M) Watershed in 2011

Land Use Code	Land Use Classification	Acres	% of Watershed
1100	Low-Density Residential	192.42	12.32
1200	Medium-Density Residential	276.03	17.67
1300	High-Density Residential	30.01	1.92
1400	Commercial	27.38	1.75
1700	Institutional	29.87	1.91
1900	Open Land	29.18	1.87
2000	Agriculture	243.07	15.56
3000 and 7000	Rangeland	2.32	0.15
4000	Forest/Rural Open	28.00	1.79
5000	Water	641.53	41.06
6000	Wetlands	28.02	1.79
8000	Communication and Transportation	34.57	2.21
Total		**1,562.40**	**100**

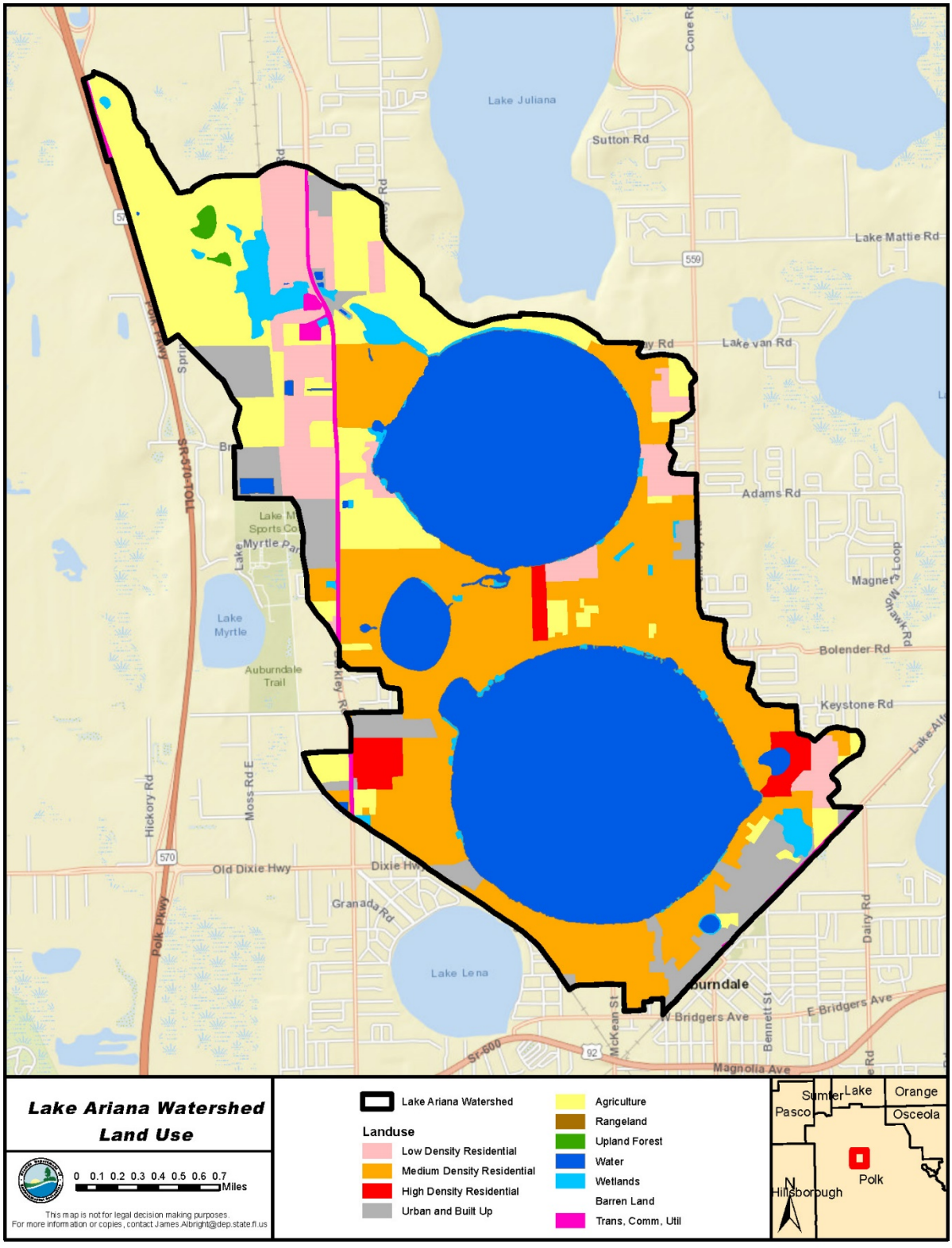


Figure 4.1. Land use in the Lake Ariana (WBID 1501B) Watershed in 2011

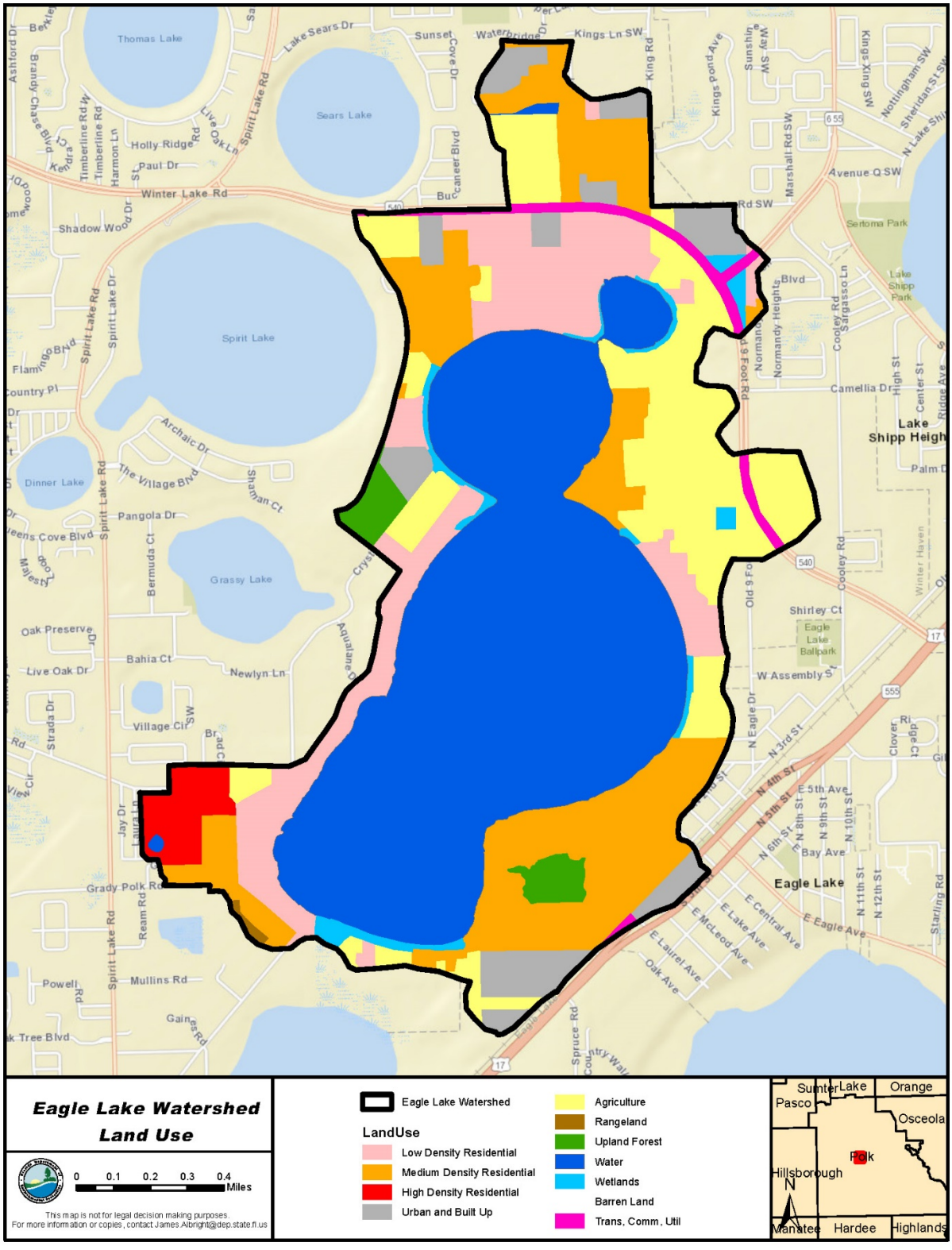


Figure 4.2. Land use in the Eagle Lake (WBID 1623M) Watershed in 2011

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 (nitrogen and phosphorus), pathogens, and other pollutants to both groundwater and surface water. **Figures 4.3** through **4.4** show the locations of OSTDS in the watersheds. Currently the numbers of septic tanks in the Lake Ariana and Eagle Lake watersheds are estimated to be 571 and 245, respectively.

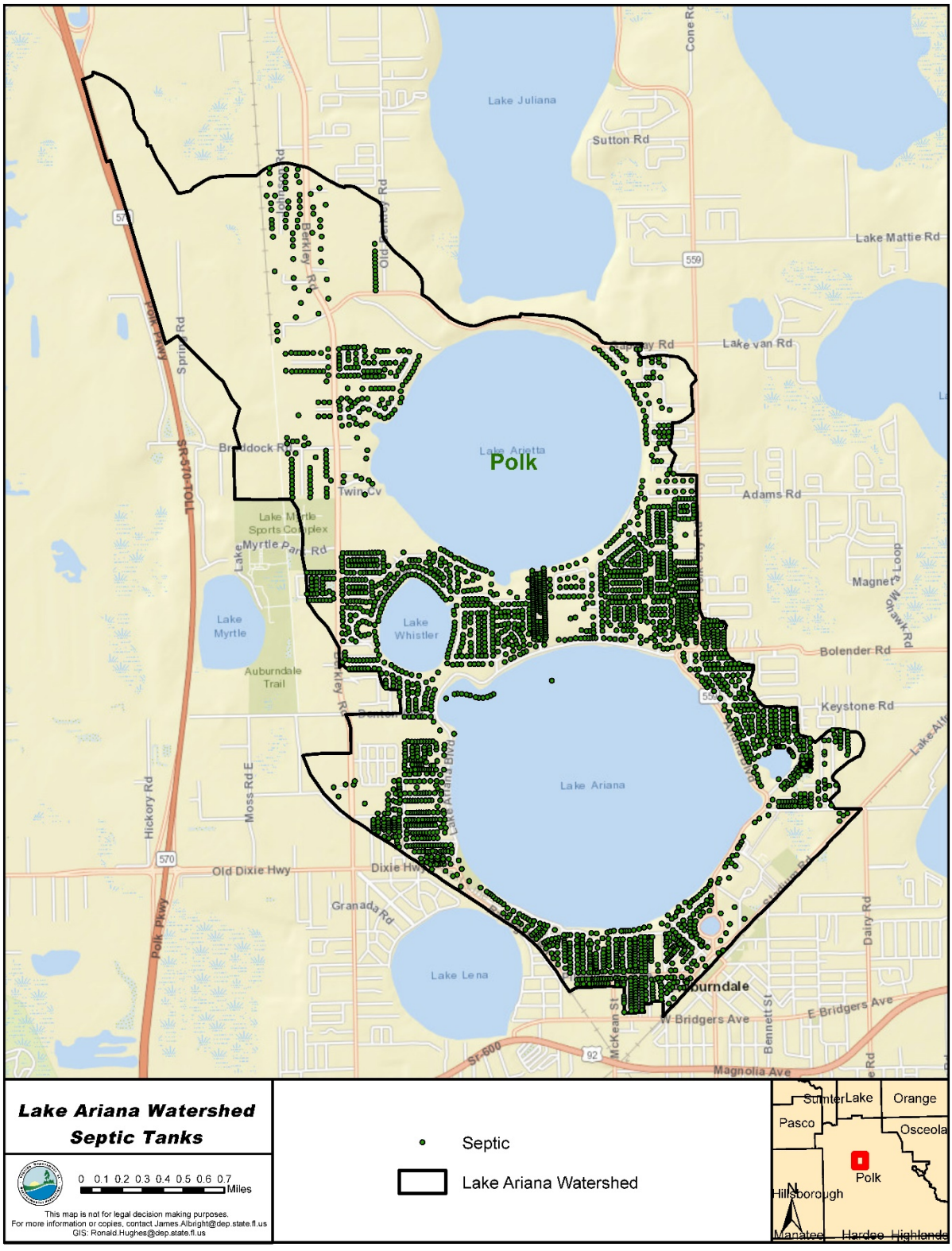


Figure 4.3. OSTDS in the Lake Ariana (WBID 1501B) Watershed

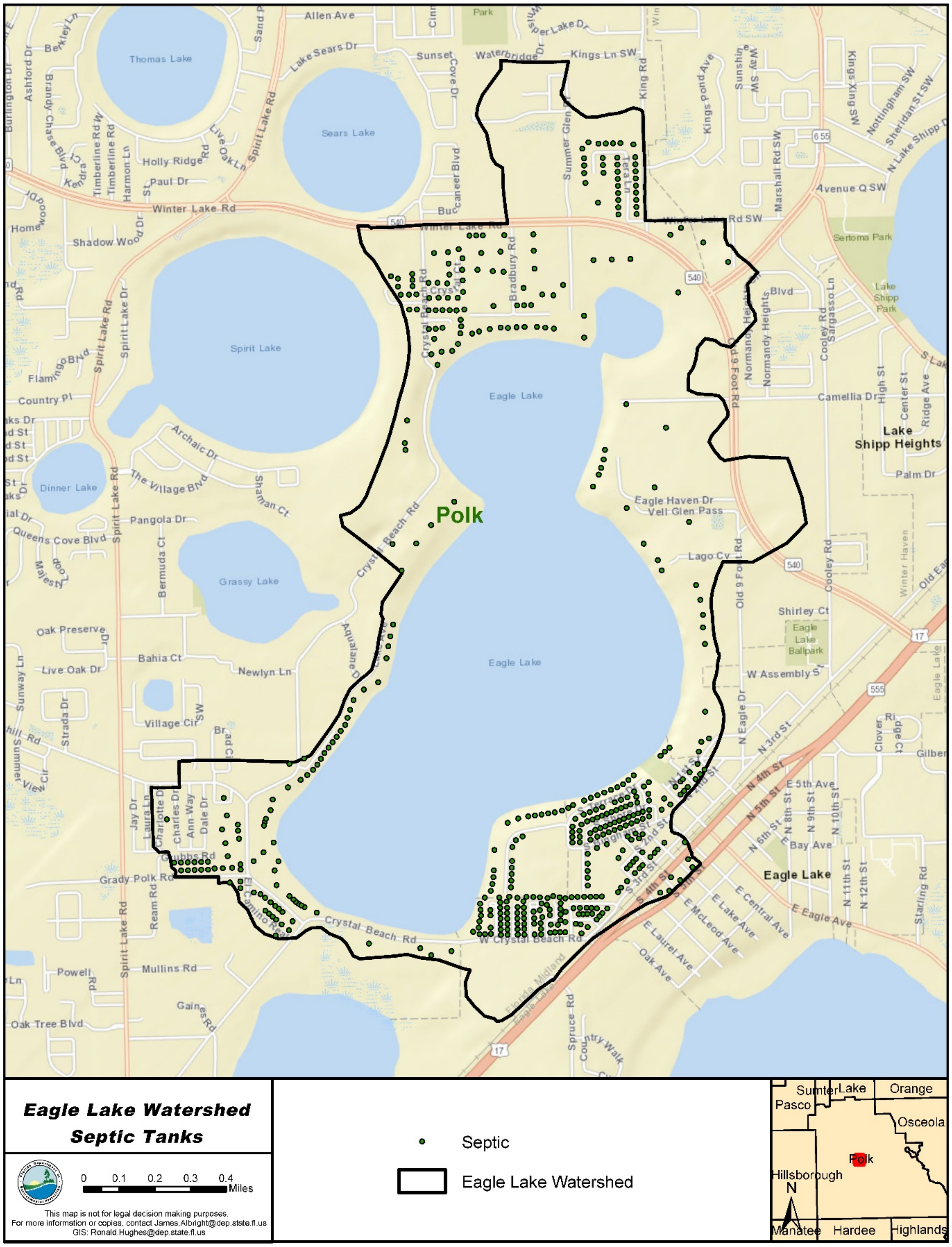


Figure 4.4. OSTDS in the Eagle Lake (WBID 1623M) Watershed

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 discharges, 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 Ariana and Eagle Lake, and to identify the maximum allowable TN and TP in-lake concentrations, so that the lakes will meet their TMDL targets and thus maintain their function and designated use as Class III waters.

5.2 Evaluation of Water Quality Conditions

Water quality monitoring in the lakes was performed primarily by Polk County Natural Resources Division, with most of the other recent data available in the IWR database collected by DEP. Polk County has routinely sampled each of these lakes for over 25 years (Lake Ariana and Eagle Lake have both been monitored since 1985). Other sampling organizations (e.g., SWFWMD and Florida LakeWatch) have conducted monitoring intermittently for short periods. Polk County data were selected for this analysis because they provide the most complete, uninterrupted, and consistent record. Data used for these analyses were derived from centrally located stations which should be the most characteristic of lake water quality overall.

The results collected at the Polk County sampling locations near the center of each lake were evaluated to determine if relationships exist between nutrient concentrations and chlorophyll *a* levels. The county monitoring near the lake center provides a consistent dataset for evaluating surface water quality. The county is the only organization that has routinely sampled the lakes over an extended period. The nutrient and corrected chlorophyll *a* AGMs were used in this evaluation to be consistent with the expression of the adopted NNC for lakes. In 1999, the county began sampling for corrected chlorophyll *a*, which is the more common form of chlorophyll *a* used in assessing surface water quality. For this analysis, the geometric means for each year were calculated using a minimum of two Polk County sample results per year, collected in different quarters, with at least one of the results collected in the May to September time frame. From 1999 to 2016, sufficient results were collected in most years to calculate AGM values for corrected chlorophyll *a* and nutrients for both lakes.

AGMs could be calculated in Lake Ariana from 2003 to 2016 with one year, 2006, when there were insufficient data to calculate an AGM for TP. During this period, TN AGMs ranged from 0.5 to 1.60 mg/L, and TP AGMs ranged from 0.02 to 0.03 mg/L. For Eagle Lake, it was possible to calculate AGMs from 2000 to 2015 except for the AGM for TP in 2004. The range of TN AGMs in Eagle Lake was 0.49 to 0.90 mg/L, and the range of TP AGMs was 0.01 to 0.04 mg/L. **Figures 5.1** and **5.2** show the AGM values for TN and TP measured in the center of the lakes. The similar pattern of nutrient concentration changes over time found in these exploratory data analyses provided support for the application of the regression approach in each of the lakes. The regression analyses are presented in **Section 5.4**.

Figures 5.3 and **5.4** show the chlorophyll *a* AGM values for the lakes along with annual total rainfall for Polk County. The long-term average rainfall for the period is also shown for comparison with the annual averages. No clear relationships, direct or inverse, were evidenced between rainfall and chlorophyll in these graphs. Furthermore, simple linear regressions of rainfall on chlorophyll *a* did not uncover any significant relationships. The lack of strong relationships between nutrients and rainfall suggests that adjustments for seasonality and rainfall are unlikely to have an impact on the TMDL determination.

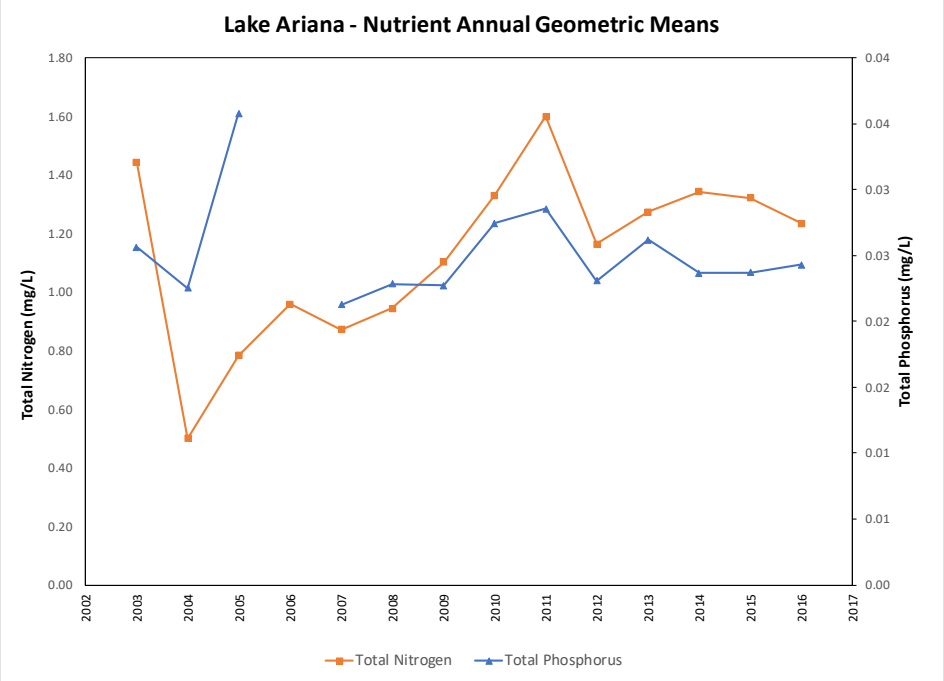


Figure 5.1. TN and TP AGMs in Lake Ariana (WBID 1501B)

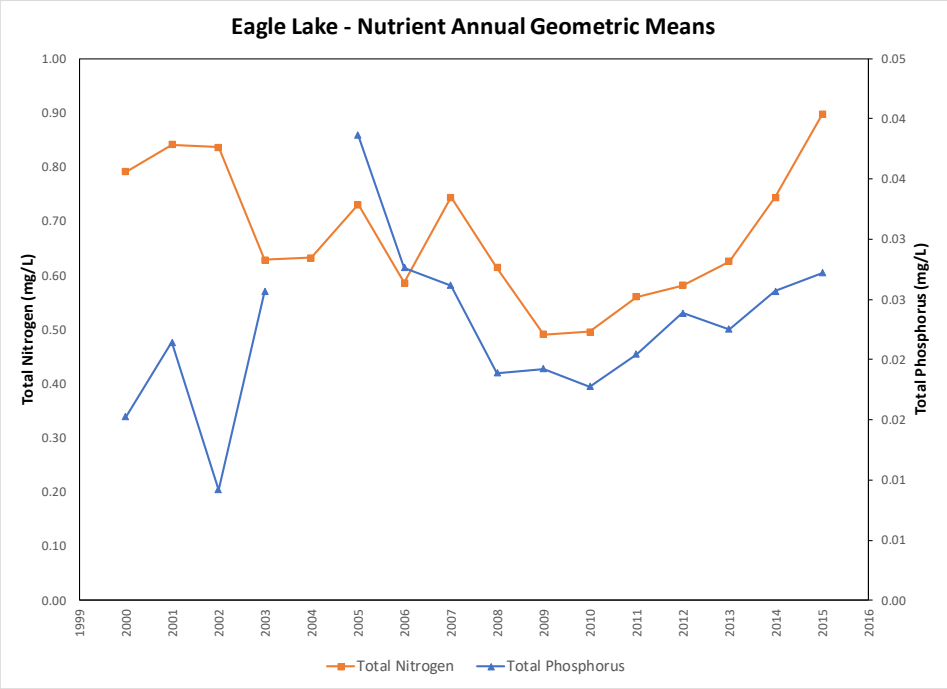


Figure 5.2. TN and TP AGMs in Eagle Lake (WBID 1623M)

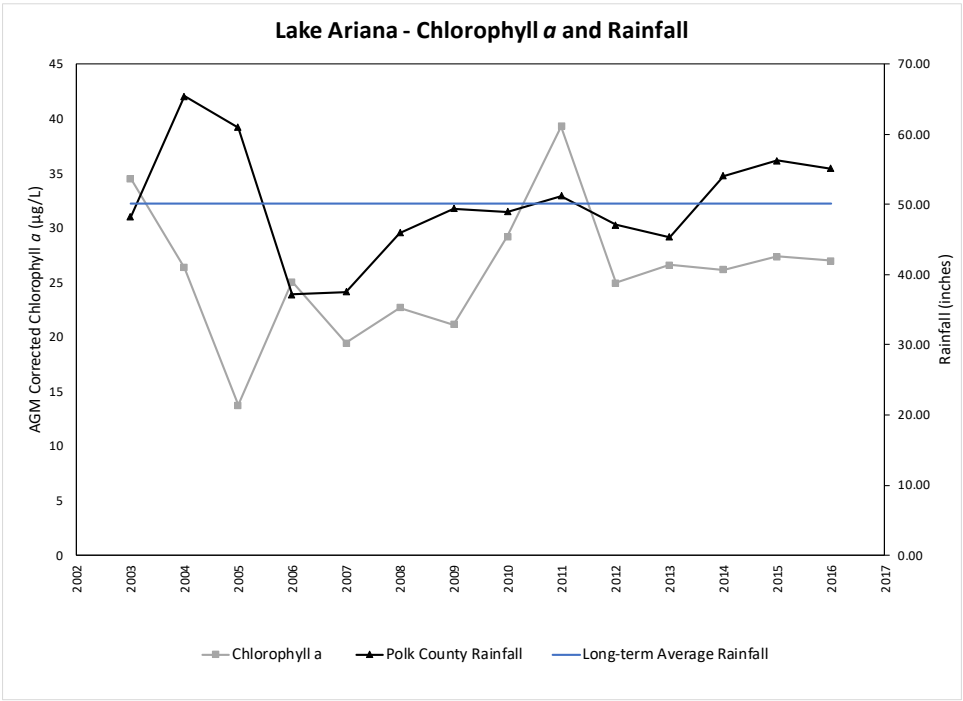


Figure 5.3. Lake Ariana (WBID 1501B) chlorophyll *a* AGMs and annual rainfall versus long-term average rainfall, 2003–16

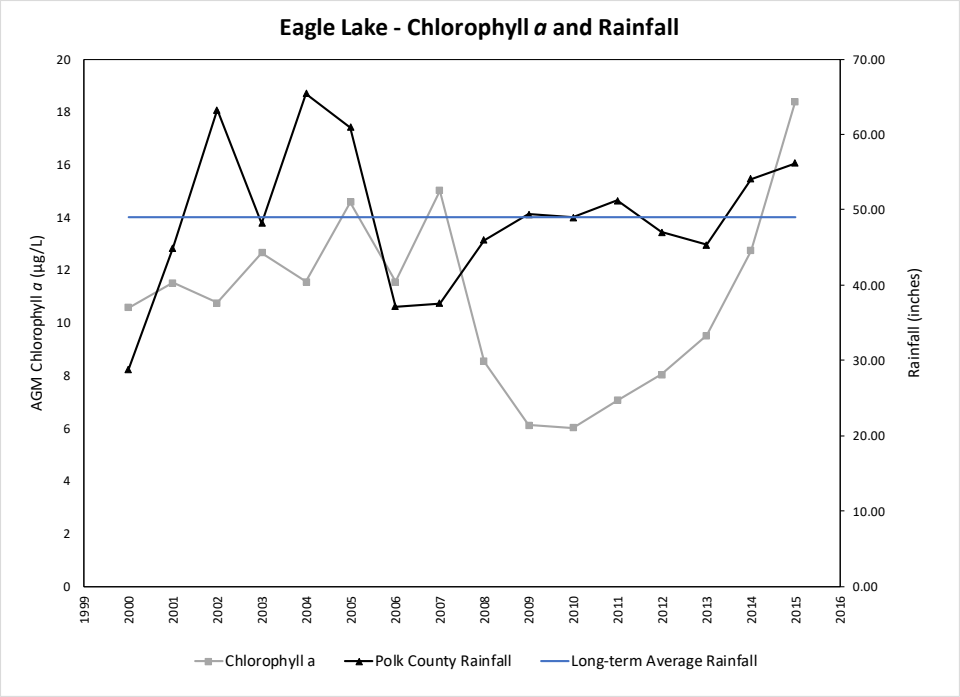


Figure 5.4. Eagle Lake (WBID 1623M) chlorophyll *a* AGMs and annual rainfall versus long-term average rainfall, 2003–16

5.3 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 for nutrients 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.

5.4 Water Quality Analysis to Determine Assimilative Capacity

The method used for developing the nutrient TMDLs is a percent reduction approach where the percent reductions in the existing lake TN and TP concentration are calculated to meet the nutrient water quality targets. As discussed in **Chapter 3**, the NNC chlorophyll *a* thresholds of 20 and 6 µg/L, expressed as AGMs not to be exceeded more than once every three years, were selected as the response variable target for TMDL development. Lake Ariana has a target of 20 µg/L, and Eagle Lake has a target of 6 µg/L.

As is the case with TN, the generally applicable NNC for TP in lakes consist of maximum and minimum values that are applied based on the chlorophyll *a* criterion (the minimum criterion for TP is applied in years when the chlorophyll *a* criterion is exceeded). The TP water quality targets

are derived from the lower end of NNC values applicable for each lake type. This is done to maintain the current relationship of TN and TP and not result in degradation of the TP condition. For Ariana the TP target is 0.03 mg/L, and for Eagle Lake the target is 0.01 mg/L. The available data for Lake Ariana demonstrate that the lake is meeting the TP target every year, but the TP values exceed the target NNC every year for Eagle Lake.

The TN water quality targets for the lakes were derived from the regression equations explaining the relationship between AGM chlorophyll *a* concentrations and the TN and TP levels in the lakes. The TN target was the concentration necessary to meet the chlorophyll *a* target of 20 µg/L for Lake Ariana or 6 µg/L for Eagle Lake in every year. **Figures 5.5** and **5.6** show the relationship of TN versus chlorophyll *a* for the lakes. Note that these are not the regressions that were used to derive the TMDL targets. These figures show that there are generally strong relationships between TN and chlorophyll *a* in the lakes. One outlier is evident in **Figure 5.5**. It was determined that this was related to an incorrectly calculated TN value uploaded to the IWR database for November of 2004. The TN value for that date was recalculated (TN = Total Kjeldahl Nitrogen + Nitrate + Nitrite) resulting in a value of 1.014 mg/L rather than the outlier value of 0.097 mg/L. The corrected value was used in the linear regression for Lake Ariana, yielding a much stronger relationship between the TN and chlorophyll *a* variables.

Shapiro-Wilks tests for normality were applied to the chlorophyll *a*, TN, and TP AGM datasets. In both of the lakes the AGMs for chlorophyll *a* and TN are normally distributed. TP was not required for the simple linear regression of chlorophyll *a* and TN in Lake Ariana. TP was required for the multiple regression performed on Eagle Lake. The TP AGMs in Eagle Lake significantly deviated from normality with $p = 0.01$. Therefore log transformations were applied to the AGM data in Eagle Lake before using those data to calculate the new nutrient targets for TN. The AGMs for Lake Ariana were not transformed in this manner.

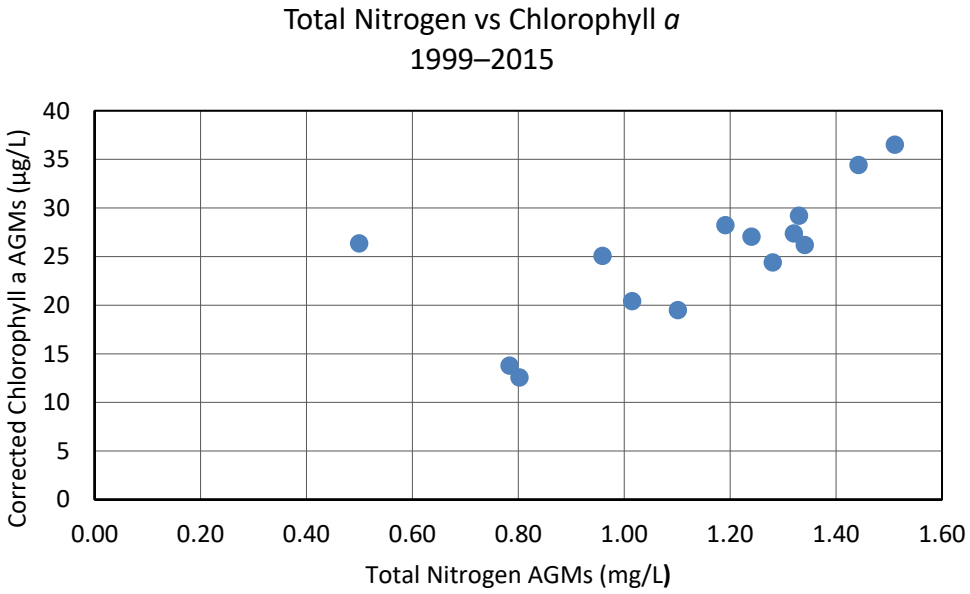


Figure 5.5. Relationship between AGMs of chlorophyll *a* and TN in Lake Ariana (WBID 1501B)

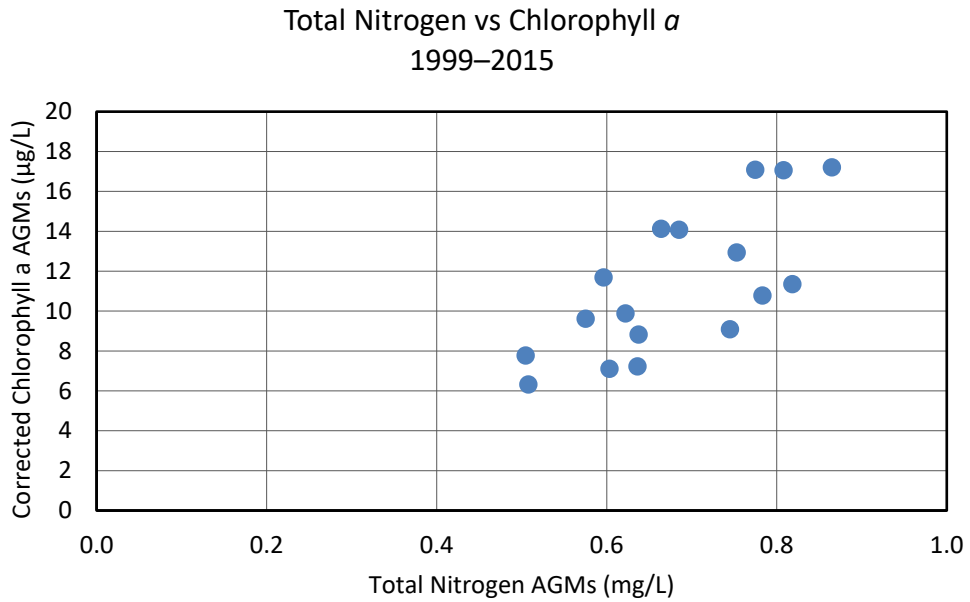


Figure 5.6. Relationship between AGMs of chlorophyll *a* and TN in Eagle Lake (WBID 1623M)

Because Lake Ariana was only impaired for TN and chlorophyll *a*, and because there was no clear relationship between TP and chlorophyll *a*, a simple linear model relating chlorophyll *a* concentrations to TN levels was used to derive the TN target. For Eagle Lake where the generally applicable TP criteria was not being achieved and where chlorophyll *a* levels were more strongly related to TP concentrations, a multiple regression model that relates both TN and TP concentrations to chlorophyll *a* concentrations were used to derive the TN targets. **Figures 5.7** and **5.8** show the relationships between TP and chlorophyll *a* in the lakes. As with the figures relating the relationship of TN and chlorophyll *a*, these figures do not show the regressions used in developing the TMDL targets.

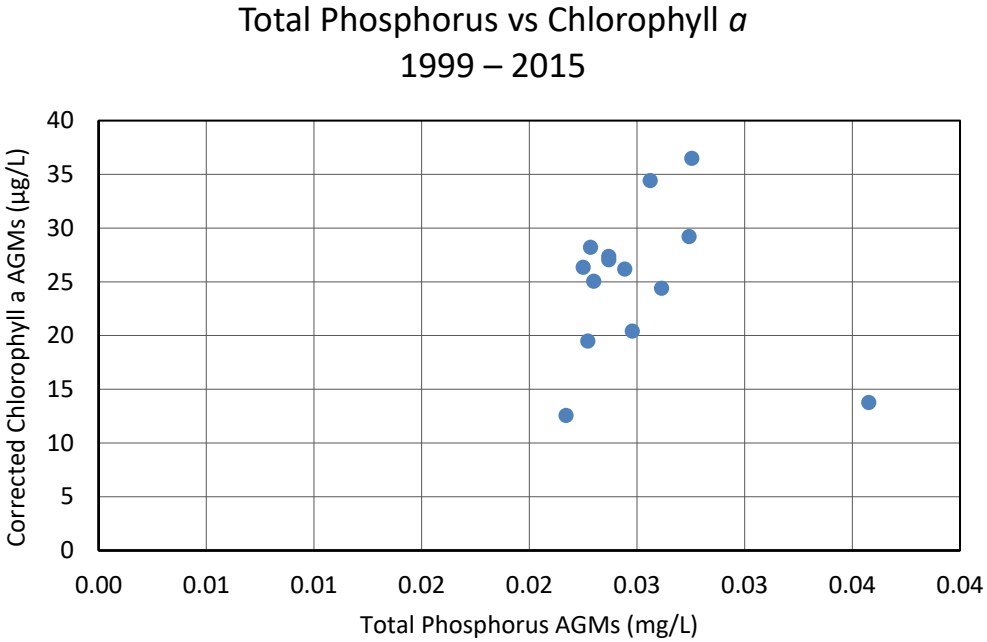


Figure 5.7. Relationship between AGMs of chlorophyll *a* and TP in Lake Ariana (WBID 1501B)

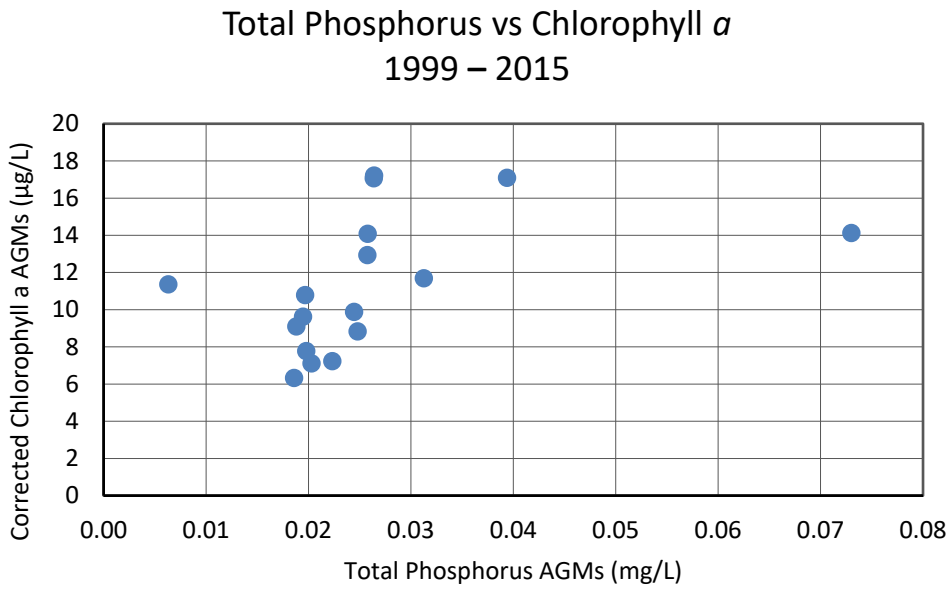


Figure 5.8. Relationship between AGMs of chlorophyll *a* and TP in Eagle Lake (WBID 1623M)

The regression models were developed using the AGMs of corrected chlorophyll *a*, TN, and (in the multiple regressions) TP, as calculated from Polk County lake measurements. For Eagle Lake, the AGMs were log-transformed because the AGMs of TP were not normally distributed. The regression equations used to derive the TN concentration targets for the lakes are provided below. The full results of the simple linear and multiple linear regression analyses are shown in **Appendix C**.

In the simple linear regression equation derived for Lake Ariana, the only variable to solve for was TN, given the chlorophyll *a* target of 20 µg/L. The R^2 value for the regression of TN on chlorophyll *a* is 0.79 with a p-value of < 0.0001. For Eagle Lake, both the TP and chlorophyll *a* targets taken from the generally applicable criteria were used in the regression equations specified below to solve for the TN concentrations necessary to achieve the applicable chlorophyll *a* target. Eagle Lake's multiple regression of TN and TP on chlorophyll *a* produced an $R^2 = 0.92$ with $p < 0.0001$.

Achieving the TN and TP AGM targets is expected to result in the lakes meeting the chlorophyll *a* targets of 20 µg/L for Lake Ariana, and 6 µg/L for Eagle Lake. By achieving the specified nutrient targets, the lakes are expected to maintain their function and designated uses as Class III waters. Additionally, the required percent reductions in nutrient concentrations necessary to meet the nutrient targets will address the anthropogenic contributions to the water quality impairment.

Regression Equations:

Lake Ariana (Chlorophyll *a* = 20 µg/L)

Chlorophyll a *AGM = -6.54 + 27.25 * TN AGM*

Eagle Lake (Chlorophyll *a* = 6 µg/L, TP = 0.01 mg/L)

Log Chlorophyll a *AGM = 2.13 + 1.62 * Log (TN AGM) + 0.51 * Log (TP AGM)*

5.5 Calculation of the TMDLs

Existing lake nutrient conditions used in establishing the TMDLs are those conditions measured from 2003 to 2016. This includes the entire Cycle 3 planning period (2003–12) and verified period (2008–15). The existing nutrient conditions used in the percent reduction calculation are the AGMs calculated from nutrient results available in IWR Database Run 53 for data from all stations in each WBID using the established IWR assessment methodology. The maximum observed AGMs over the 2003–16 period were used as the existing condition as a conservative assumption, as this ensures that all exceedances of the TN targets are addressed. The TN and TP AGMs were rounded to two decimal points before being used to calculate percent reductions.

The equation used to calculate the percent reduction is as follows:

$$\frac{\text{[measured exceedance – target]}}{\text{Measured exceedance}} \times 100$$

The measured exceedances correspond to the maximum observed AGMs for TN and TP for the existing conditions.

For Lake Ariana's existing maximum TN concentration of 1.51 mg/L to achieve the target concentration of 0.97 mg/L, a 36 % reduction in the lake TN concentration is necessary. No reduction in the existing AGM for TP concentration is necessary to meet the target concentration of 0.03 mg/L.

Eagle Lake's existing maximum TN concentration is 1.01 mg/L, which requires a 38 % reduction to achieve the target TN concentration of 0.63 mg/L. The maximum TP concentration of 0.02 requires a 50 % reduction to achieve the target TP concentration of 0.01 mg/L.

These nutrient TMDL values, which are expressed as AGMs, address the anthropogenic nutrient inputs that contribute to the exceedances of the chlorophyll *a* restoration targets.

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:

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

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

$$\mathbf{TMDL \cong \sum WLAs_{wastewater} + \sum WLAs_{NPDES\ Stormwater} + \sum LAs + MOS}$$

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

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

This approach is consistent with federal regulations (40 Code of Federal Regulations [CFR] § 130.2[I]), which state that TMDLs can be expressed in terms of mass per time (e.g., pounds per day), toxicity, or other appropriate measure. The TMDLs for Lake Ariana and Eagle Lake are expressed in terms of nutrient concentrations and percent reduction of TN and TP, and represent the maximum lake nutrient concentrations that these waterbodies can assimilate while maintaining a balanced flora and fauna.

Table 6.1 lists the TMDLs for the Lake Ariana and Eagle Lake Watersheds. The TMDLs constitute the site-specific numeric interpretations of the narrative nutrient criterion set forth in Paragraph 62-302.530(48)(b), F.A.C., that replace the otherwise applicable NNC in Subsection 62-302.531(2), F.A.C., for these particular waters.

Table 6.1. TMDL components for nutrients in Lake Ariana and Eagle Lake (WBIDs 1501B, 1623M)

† Represents the AGM lake values.
NA = Not applicable
* The required percent reductions listed in this table represent the reduction from all sources.

Waterbody (WBID)	Parameter	TMDL (mg/L)†	WLA Wastewater (% reduction)	WLA NPDES Stormwater (% reduction)*	LA (% reduction)*	MOS
1501B	TN	0.97	NA	36	36	Implicit
1501B	TP	0.03	NA	NA	NA	Implicit
1623M	TN	0.63	NA	38	38	Implicit
1623M	TP	0.01	NA	50	50	Implicit

6.2 Load Allocation

To achieve the target lake concentrations for Lake Ariana, a 36 % reduction in current TN concentrations is required. To achieve the target lake concentrations for Eagle Lake, a 38 % and 50 % reduction in current TN and TP concentrations, respectively, are required. The percent reductions represent the generally needed total nitrogen and total phosphorus reductions from all sources; including stormwater runoff, groundwater contributions, and septic tanks, and internal sources. Although the TMDLs are based on the percent reductions from all sources to the lakes; it is not DEP's intent to abate natural conditions. The needed reduction from anthropogenic inputs will be calculated based on more detailed source information when a restoration plan is developed. The reductions in nonpoint source nutrient loads are expected to result in reduced sediment nutrient flux, which is commonly a factor in lake eutrophication.

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**, one NPDES-permitted facility (Universal Forest Products, Auburndale LLC) is permitted for periodic discharges into the Lake Ariana Watershed (Permit FL0133132). Nutrients are not discharged, and the discharges are infrequent because the facility maintains a

closed loop system with reuse of the treatment chemicals. Therefore, a WLA for wastewater discharges is not required for this facility.

6.3.2 NPDES Stormwater Discharges

The permittees/co-permittees in the Lake Ariana Watershed are Polk County and the City of Auburndale; in the Eagle Lake Watershed, Polk County and the City of Eagle Lake. Areas within their jurisdiction in the Lake Ariana Watershed may be responsible for a 36 % reduction in TN and a 0 % reduction in TP from the current anthropogenic loading. In the Eagle Lake Watershed, they may be responsible for a 38 % reduction in TN and a 50 % reduction in TP from the current anthropogenic loading.

It should be noted that any MS4 permittee is only responsible for reducing the anthropogenic loads associated with stormwater outfalls that it owns or otherwise has responsible control over, and it is not responsible for reducing other nonpoint source loads in its jurisdiction.

6.4 Margin of Safety (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 (CWA § 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.

Consistent with the recommendations of the Allocation Technical Advisory Committee (Department February 2001), an implicit MOS was used in the development of the TMDL because of the conservative assumptions that were applied. The TMDLs were developed using the highest TN and TP AGM values to calculate the percent reductions and requiring the TMDL targets not to be exceeded in any one year. Additionally, the TN target of 0.97 mg/L mg/L in Lake Ariana results in chlorophyll *a* concentrations less than the criterion of 20 µg/L. Similarly the TN target of 0.63 mg/L in Eagle Lake in conjunction with its TP target results in a chlorophyll *a* concentration less than 6 µg/L.

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 TMDL waterbody must respond to the permit conditions that reflect target concentrations, reductions, or wasteload allocations identified in the TMDL. 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).

As outlined in Subsection 403.9337(2), F.S., all county and municipal government located within a waterbody listed as impaired by nutrients pursuant to s. 403.067, shall, at a minimum, adopt DEP's *Model Ordinance for Florida-Friendly Fertilizer Use on Urban Landscapes.* The Model Ordinance contains numerous best management practices (BMPs) addressing setbacks from water bodies, recommended fertilizer blends and slow release application rates, and proper irrigation practices. Municipal governments may adopt additional or more stringent standards if deemed necessary to better address the impairment.

7.2 BMAPs

Information concerning the development and implementation of BMAPs are 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. Currently, no BMAPs are under development in the Upper Peace Basin. Additional information about BMAPs is available on the DEP website.

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 impacts of internal sources (e.g., sediment nutrient fluxes or the presence of nitrogen-fixing cyanobacteria) and the results of any associated remediation projects on surface water quality. In the case of Lake Ariana and Eagle Lake, other factors—such as the calibration of watershed nutrient loading, sediment nutrient fluxes, and/or nitrogen fixation—also influence lake nutrient budgets and the growth of phytoplankton. Aquatic invasive plant management using herbicides can contribute to the cycling of nutrients in the lakes and can be a source factor influencing phytoplankton growth. Approaches for addressing these other factors should be included in comprehensive management plans for the waterbodies. Additionally, the current water quality and water level monitoring of Lake Ariana and Eagle Lake should continue and be expanded, as necessary, during the implementation phase to ensure that adequate information is available for tracking restoration progress.

A draft water quality management plan has been developed for Eagle Lake by Polk County in partnership with Amec Foster Wheeler Environment and Infrastructure, Inc. In addition to an analysis of the current status of Eagle Lake, the plan also provides recommendations for future management practices and stormwater improvements to begin restoration of the lake (Amec Foster Wheeler 2015).

References

Amec Foster Wheeler Environment and Infrastructure Inc. 2015. *Eagle Lake water quality management plan.* Prepared for Polk County.

Conley, D.J., H.W. Paerl, R.W. Howarth, D.F. Boesch, S.P. Seitzinger, K.E. Havens, C. Lancelot, and G.E. Likens. 2009. *Controlling eutrophication: Nitrogen and phosphorus.* Science 323: 1014–1015.

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.

Florida Department of Environmental Protection. February 2001. *A report to the Governor and the Legislature on the allocation of total maximum daily loads in Florida.* Tallahassee, FL: Florida Department of Environmental Protection, Allocation Technical Advisory Committee, Division of Water Resource Management, Bureau of Watershed Management.

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

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

Lewis, W.M., W.A. Wurtsbaugh, and H.W. Paerl. 2011. *Rationale for control of anthropogenic nitrogen and phosphorus in inland waters.* Environmental Science & Technology 45:10300–10305.

Paerl, H.W. 2009. *Controlling eutrophication along the freshwater-marine continuum: Dual nutrient (N and P) reductions are essential.* Estuaries and Coasts 32: 593–601.

Paerl, H.W. and T.G. Otten. 2013. *Harmful cyanobacterial blooms: Causes, consequences and controls.* Microbial Ecology 65: 995–1010.

Petrus, K. 2015. *Nutrient TMDL for Lake Lena (WBID 1501).* Tallahassee, FL: Division of Environmental Assessment and Restoration, Water Quality Evaluation and TMDL Section.

Polk County. 2014. *Polk County water atlas.*

U.S. Census Bureau. 2017. *Quickfacts: Polk County, Florida.*

U.S. EPA. 2010. *Total Maximum Daily Loads For the Lake Alfred (WBID 1488D), Crystal Lake (WBID1497A), and Lake Ariana North (WBID 1501B), Nutrients.*

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 Ariana and Eagle Lake
Waterbody type(s)	Lake
WBID	WBIDs 1501B & 1623M (see **Figures 1.1** through **1.3** of this report)
Description	Lake Ariana is in the City of Auburndale and Eagle Lake is in the City of Eagle Lake, both in Polk County. The Lake Ariana watershed comprises 4,766 acres and the Eagle Lake watershed is 1,562 acres in size. Lake Ariana has a surface area of 1,030 acres and an average depth of 12 ft. It discharges to Lake Lena and then to Lake Lena Run via an outlet on the south side of the lake. The dominant land use type in the Lake Ariana Watershed is water (39 %), followed by medium-density residential (25 %), agriculture (16 %), and low-density residential (7 %). Eagle Lake has a surface area of 647 acres and an average depth of 12 ft, and discharges to Millsite Lake to the south. The dominant land use is water (41 %), followed by medium-density residential (18 %), agriculture (16 %), and low-density residential (7 %). **Chapter 1** of this report describes the Ariana & Eagle systems in more detail.
Specific location (latitude/longitude or river miles)	The center of Lake Ariana is located at Latitude N: 28° 04' 44", Longitude W: 81° 47' 52". The center of Eagle Lake is located at Latitude N: 27° 59' 12", Longitude W: 81°46' 00". The site-specific criteria apply as spatial averages for the lakes, as defined by WBIDs 1501B, 1623M, and 1497A.
Map	**Figures 1.1** and **1.3** show the general location of Lake Ariana and Eagle Lake, and their watersheds, respectively, and **Figures 4.1** and **4.2** show the land uses in these watersheds, respectively.
Classification(s)	Class III Freshwater
Basin name (HUC 8)	Peace River Basin (03100101)

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 Ariana is a low-color, high-alkalinity lakes and the generally applicable NNC expressed as AGM concentrations not be exceeded more than once in any 3-year period are chlorophyll *a* of 20 µg/L, TN of 1.05 to 1.91 mg/L, and TP of 0.03 to 0.09 mg/L. Eagle Lake is a low-color, low-alkalinity lake and the generally applicable NNC expressed as AGM concentrations not be exceeded more than once in any 3-year period are chlorophyll *a* of 6 µg/L, TN of 0.51 to 0.93 mg/L, and TP of 0.01 to 0.03 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 Ariana is 20 µg/L, expressed as an AGM concentration not to be exceeded more than once in any consecutive 3-year period. The NNC for chlorophyll *a* in Eagle Lake are 6 µg/L, expressed as an AGM concentration not to be exceeded more than once in any consecutive 3-year period. Lake Ariana's in-lake TN and TP AGM concentrations at the TMDL are 0.97 and 0.03 mg/L, not to be exceeded in any year. Eagle Lake's in-lake TN and TP AGM concentrations at the TMDL are 0.63 and 0.01 mg/L, not to be exceeded in any year. These restoration concentrations represent the in-lake concentrations that would still meet the target chlorophyll *a* concentration of 20µg/L or 6 µg/L with a 1-in-3-year exceedance rate.
Period of record used to develop numeric interpretations of the narrative nutrient criterion for TN and TP	The criteria were developed based on an empirical regression approach of TN and TP concentrations on chlorophyll *a* concentration from 1999 to 2016. The primary datasets for this period include water quality data from IWR Database Run 53. **Section 2.3** of this TMDL report provides a complete description of 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 water quality results applied in the analysis spanned the 1999 - 2016 period, which included both wet and dry years. The annual average rainfall for 1999-2016 was 49.2 inches/year. The years 2000, 2006, and 2007 were dry years, 2009 to 2011 were average years, and 2002, 2004, 2005, and 2015 were wet years. **Figures 2.1** and **2.2** show the locations of the sampling stations in Lake Ariana and Eagle Lake, respectively. The central Polk County stations used in the regression analysis are highlighted in yellow. Monitoring stations were located across the spatial extent and represent the spatial distribution of nutrient dynamics in the lake, as follows: Polk County (21FLPOLK…), Florida LakeWatch (21FLKWAT…), SWFWMD (21FLSWFD…), Biological Research Associates (21FLBRA…), and DEP (21FLA… 21FLGW… 21FLTPA). Water quality data for variables relevant to TMDL development are available on request.

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 Ariana (WBID 1501B) and Eagle Lake (WBID 1623M). Eagle Lake was verified as impaired for nutrients based on an elevated annual average TSI during the Cycle 1 verified period for the Group 3 basins (January 1, 1997–June 30, 2004). Lake Ariana was verified as impaired for nutrients based on elevated annual average TSI during the Cycle 2 verified period for the Group 3 basins (January 1, 2002–June 30, 2009). During the Cycle 3 assessment, the NNC were used to assess the lake during the verified period (January 1, 2008–June 30, 2015) using data from IWR Database Run 53. Lake Ariana was found to be impaired for chlorophyll *a* and TN because the AGMs exceeded the NNC more than once in a 3-year period, and Lake Ariana was added to the 303(d) list for chlorophyll *a* and TN. The waterbody was found not to be impaired (Category 2) for TP. Eagle Lake was found to be impaired for chlorophyll *a*, TN, and TP because the AGMs exceeded the NNC more than once in a 3-year period, and both lakes were added to the 303(d) list for all 3 parameters. See **Section 2.3.2** of this report for a detailed discussion.
Basis for use support	The bases for use support are the NNC chlorophyll *a* concentrations of 20 µg/L for Lake Ariana and 6 µg/L for Eagle Lake, which are protective of designated uses for high- and low-alkalinity lakes, respectively. Based on the available information, there is nothing unique about Lake Ariana and Eagle Lake that would make the use of the associated chlorophyll *a* thresholds inappropriate for the lakes.
Approach used to develop criteria and how it protects uses	For the Lake Ariana nutrient TMDL, a linear regression of in-lake chlorophyll *a* concentrations on TN was used to derive a regression equation. For Eagle Lake, multiple regression of in-lake chlorophyll *a* concentrations on TN and TP was used to derive regression equations. Given the TP concentrations set to the generally applicable criteria, these equations were used to determine TN concentration values required to achieve the in-lake chlorophyll *a* AGM concentrations of 20 µg/L in Lake Ariana and 6 µg/L in Eagle Lake. The 20 µg/L and 6 µg/L chlorophyll *a* targets are the generally applicable NNC demonstrated to be protective of the designated use for low-color lakes with high and low alkalinity, respectively. The maximum observed AGMs of TN and TP were used to achieve the chlorophyll *a* targets, and percent reductions were based off those values compared with the derived targets for TN and TP. **Chapters 3** and **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	Empirical model simulations indicate that the target chlorophyll *a* concentration (20 µg/L in Lake Ariana or 6 µg/L in Eagle Lake) in the lake will be attained at the TMDL concentrations for TN and TP. DEP notes that no other impairments were verified for Lake Ariana and Eagle Lake 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 in 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:	An outlet on the south side of Lake Ariana discharges into Lake Lena, which flows into Lake Lena Run, which in turn discharges south into Lake Hancock. Eagle Lake discharges to Eagle Lake Outlet and Millsite Lake. The lakes ultimately discharge into Lake Hancock. Lake Lena and Millsite Lake are Class III freshwater lakes, and Lake Lena Run and Eagle Lake Outlet are Class III freshwater streams. The applicable NNC for Lake Lena are 1.14 mg/L of TN, 0.03 to 0.09 mg/L of TP, and 20 µg/L of chlorophyll *a*, expressed as AGMs not to be exceeded more than once in a 3-year period. The applicable NNC for Lake Lena Run are 1.65 mg/L of TN, 0.49 mg/L of TP, and 20 µg/L of chlorophyll *a*, expressed as AGMs not to be exceeded more than once in a 3-year period. The Lake Lena nutrient TMDL (Petrus 2015) required a 42 % reduction in nitrogen concentrations, and no reductions in phosphorus were required; this corresponds to TN, TP, and chlorophyll *a* concentrations of 1.14 mg/L, 0.03 mg/L, and 20 µg/L, respectively. The TN and TP TMDL concentrations for Lake Ariana are 0.97 and 0.03 mg/L, respectively, and the target chlorophyll *a* concentration remains at 20 µg/L. Since the concentrations for Lake Ariana are lower than the nutrient targets for the Lake Lena TMDL, the Lake Ariana TMDL nutrient reductions meet or exceed the reduction goals set forth by the Lake Lena TMDL. The applicable NNC for Eagle Lake Outlet are 1.65 mg/L of TN, 0.49 mg/L of TP, and 20 µg/L of chlorophyll *a*, expressed as AGMs not to be exceeded more than once in a 3-year period. Millsite Lake has only one color value from its period of record (50 PCU in 1995). At 50 PCU it is potentially a high-color lake and would then be assessed against NNC of 20 µg/L of chlorophyll *a*, 1.27 to 2.23 mg/L of TN, and 0.05 to 0.16 mg/L of TP, all expressed as AGMs not to be exceeded more than once in a 3-year period. The new site-specific criteria for Eagle Lake are a TN AGM of 0.63 mg/L, a TP AGM of 0.01 mg/L, as well as a chlorophyll *a* AGM of 6 µg/L. Since the restoration concentrations for Eagle Lake are lower than the nutrient targets for the Eagle Lake Outlet and Millsite Lake, the Eagle Lake TMDL nutrient reductions meet or exceed the existing criteria. The reductions in nutrient loads described in this TMDL analysis are not expected to cause nutrient impairments downstream but will improve water quality in downstream waters (see **Section 3.6** of this report). All new nutrient criteria are lower than the applicable criteria for downstream waters.
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.	Polk County and DEP conduct routine monitoring of Lake Ariana and Eagle Lake. The data collected through these monitoring activities will be used to evaluate the effect of BMPs implemented in the watersheds on lake TN and TP loads in subsequent water quality assessment cycles.

Table B-5. Documentation of endangered species consideration

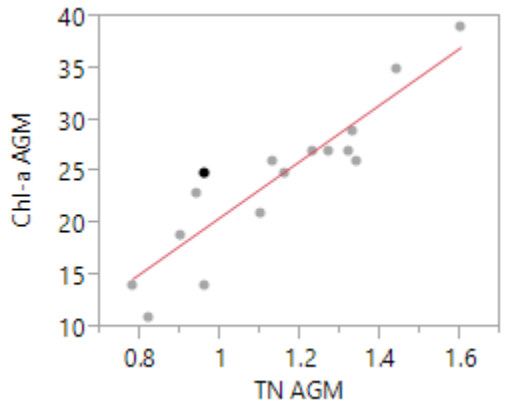
Administrative Requirements	Information for Administrative Requirements
Endangered species consideration	DEP is not aware of any endangered species present in the lakes in question. The FWS online Information for Planning and Conservation (IPac) tool identifies endangered species within regions of interest. The only endangered species listed in the area are terrestrial species; no aquatic, amphibious, or anadromous endangered species are associated with lake habitats in Lake Ariana or Eagle Lake. Furthermore, it is expected that restoration efforts toward a more natural system should positively impact any species living in the lakes and their respective watersheds.

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 February 21, 2018, to initiate TMDL development for impaired waters in the Peace River Basin. A Technical Public meeting to present the general TMDL approach for Lakes Ariana and Eagle was held on November 8, 2017. A rule development public workshop for the TMDLs was held on March 6, 2018.
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. Hearing held on June 29, 2018
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: Regression Model Results

Simple Linear Regression of TN and chlorophyll *a* in Lake Ariana



Summary of Fit	Value
RSquare	0.789425
RSquare Adj	0.775386
Root Mean Square Error	3.375284
Mean of Response	24.29412
Observations (or Sum Wgts)	17

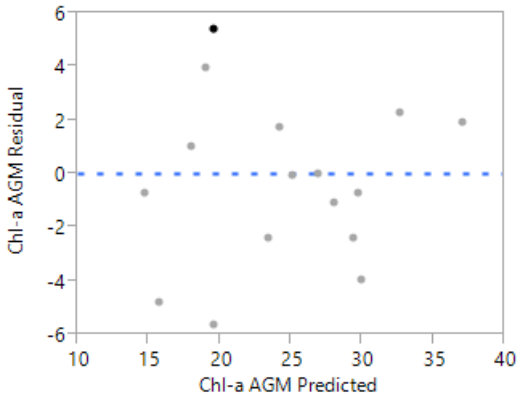
Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	640.64125	640.641	56.2334
Error	15	170.88816	11.393	**Prob > F**
C. Total	16	811.52941		<.0001*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	-6.544627	4.193127	-1.56	0.1394
TN AGM	27.248371	3.633653	7.50	<.0001*

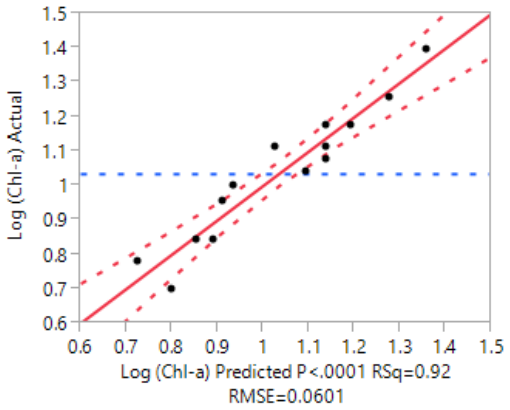
Residuals



Prediction Expression

Chlorophyll a *AGM = -6.54 + 27.25 * TN AGM*

Multiple Linear Regression of TN and TP on chlorophyll *a* in Eagle Lake



Summary of Fit	Value
RSquare	0.919559
RSquare Adj	0.904933
Root Mean Square Error	0.060059
Mean of Response	1.033958
Observations (or Sum Wgts)	14

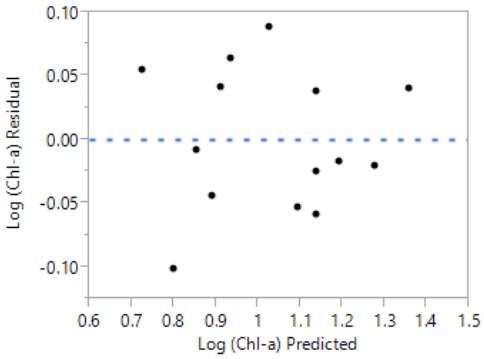
Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	2	0.45358201	0.226791	62.8730
Error	11	0.03967839	0.003607	**Prob > F**
C. Total	13	0.49326039		<.0001*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|	VIF
Intercept	2.1274599	0.19966	10.66	<.0001*	.
Log (TN)	1.6188705	0.227722	7.11	<.0001*	1.3437972
Log (TP)	0.5103847	0.131361	3.89	0.0025*	1.3437972

Residuals



Prediction Expression

Log (Chlorophyll a *AGM) = 2.13 + 1.62 * Log (TN AGM) + 0.51 * Log (TP AGM)*

Annual Geometric Means Used in the Multiple Regression Model

Waterbody	Year	Polk County Station 1 CHLAC Annual Geometric Mean (µg/L)	Polk County Station 1 TN Annual Geometric Mean (µg/L)	Polk County Station 1 TP Annual Geometric Mean (µg/L)
Lake Ariana	1999	14	0.96	0.03
Lake Ariana	2000	11	0.82	0.02
Lake Ariana	2001	25	0.96	0.03
Lake Ariana	2002		1.26	0.03
Lake Ariana	2003	35	1.44	0.03
Lake Ariana	2004	26	0.50	0.02
Lake Ariana	2005	14	0.78	0.04
Lake Ariana	2006	25	0.96	
Lake Ariana	2007	19	0.90	0.02
Lake Ariana	2008	23	0.94	0.02
Lake Ariana	2009	21	1.10	0.02
Lake Ariana	2010	29	1.33	0.03
Lake Ariana	2011	39	1.60	0.03
Lake Ariana	2012	25	1.16	0.02
Lake Ariana	2013	27	1.27	0.03
Lake Ariana	2014	26	1.34	0.02
Lake Ariana	2015	27	1.32	0.02
Lake Ariana	2016	27	1.23	0.02
Eagle Lake	1999	6	0.58	0.01
Eagle Lake	2000	11	0.79	0.02
Eagle Lake	2001	12	0.84	0.02
Eagle Lake	2002		0.84	
Eagle Lake	2003	13	0.63	0.03
Eagle Lake	2004		0.63	
Eagle Lake	2005	15	0.73	0.04
Eagle Lake	2006		0.59	0.03
Eagle Lake	2007	15	0.74	0.03
Eagle Lake	2008	9	0.61	0.02
Eagle Lake	2009		0.49	0.02
Eagle Lake	2010	5	0.52	0.02

Waterbody	Year	Polk County Station 1 CHLAC Annual Geometric Mean (µg/L)	Polk County Station 1 TN Annual Geometric Mean (µg/L)	Polk County Station 1 TP Annual Geometric Mean (µg/L)
Eagle Lake	2011	7	0.56	0.02
Eagle Lake	2012	7	0.59	0.02
Eagle Lake	2013	10	0.63	0.02
Eagle Lake	2014	13	0.74	0.03
Eagle Lake	2015	18	0.90	0.03
Eagle Lake	2016	25	1.01	0.03