NORTHEAST DISTRICT • AUCILLA RIVER BASIN

Final TMDL Report

Nutrient TMDL for Wacissa River and Springs (WBIDs 3424 and 3424Z) and Documentation in Support of Development of Site-Specific Numeric Interpretations of the Narrative Nutrient Criterion

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Chapter 1: Introduction

1.1 Purpose of Report

This report presents the total maximum daily loads (TMDLs) for nitrate-nitrogen (NO_3N), which was determined to contribute to the ecological imbalance in the Wacissa River and several contributing springs. These waterbodies are located in the Aucilla Basin within the Suwannee River Basin Group. They were verified by the Florida Department of Environmental Protection (DEP) as impaired by nutrients, which contribute to the excessive growth of algae, and were included on the Verified List of impaired waters for the Suwannee River Basin adopted by Secretarial Order in February 2013.

The TMDLs establish the allowable level of nutrient loadings that would restore these waterbodies so that they meet the applicable water quality criterion for nutrients. These TMDLs will constitute the site-specific numeric interpretations of the narrative nutrient criterion set forth in Paragraph 62-302.530(47)(b), Florida Administrative Code (F.A.C.), for nitrate-nitrogen. This report will also be used as the basis for discussions during the development of the basin management action plan (BMAP).

1.2 Identification of Waterbodies

The Wacissa River is a small river originating from a cluster of springs known as the Wacissa Springs Group, just south of the town of Wacissa in Jefferson County, Florida (**Figure 1.1**). These springs, plus others farther downstream, give rise to the Wacissa River, which flows 12 miles southward through the Aucilla Wildlife Management Area. The river channel then transforms into a series of braided channels that flows into the Aucilla River north of U.S. Highway 98 (Florida Department of Natural Resources 1989). **Figure 1.2** shows an aerial photograph of the upper Wacissa River and its headwaters.

Twelve named springs plus numerous unnamed springs and seeps comprise the first magnitude Wacissa Springs Group, which gives rise to the river. The Wacissa Springs Group was identified as an Outstanding Florida Spring (OFS) by the 2016 Florida Springs and Aquifer Protection Act (Chapter 373, Florida Statutes [F.S.]). Several named springs in the group include a cluster of springs located at the head of the river near a Jefferson County park; the rest are scattered along the upper two miles of the river. A number of springs in the river channel form the headsprings: Wacissa #1, Wacissa #2, Wacissa #3A and #3B, Log, and Thomas.

Other notable springs downstream include Cassidy, Little Blue, Buzzard Log, Minnow, Garner, and Big Blue. Horsehead, Brumbley, and Maggie Springs also contribute flow from small spring runs discharging into the upper river. Big Blue is the largest spring by discharge in the Wacissa Springs Group (Scott et al. 2004). Currently, five of the springs in the group are monitored for water quality: three headsprings (Wacissa #2, Log, and Thomas), Big Blue, and Cassidy.

The Wacissa River flows through a low-lying area and does not have prominent banks, appearing as a wide, flowing channel through dense river swamps and hardwood–gum hammocks. Aquatic life along much of the river is diverse and healthy, but in the upper portion, including the headspring, the spring pool and upper river are choked with exotic aquatic vegetation and algae.

For assessment purposes, DEP inventories the waters of the state by the geographic water assessment polygons in which they occur, and each of these polygons has its own unique **w**ater**b**ody **id**entification (WBID) number that corresponds to a watershed or stream reach. The Wacissa River is WBID 3424, and the headsprings (Wacissa #1, Wacissa #2, Wacissa #3A and #3B, Log, and Thomas) are in WBID 3424Z. Only two headsprings had sufficient water quality data to be assessed (Wacissa #2 and Log). **Figures 1.3** and **1.4** show the river and the assessed springs and impaired WBIDs.

The area where precipitation falls and percolates to groundwater, from which a spring (or spring group) receives its water, is known as a groundwater contributing area. The contributing area for a spring or spring group can be estimated using groundwater elevation contour maps, also known as potentiometric surface maps. Geographic information system (GIS) tools are used to create flow lines from areas of higher to lower groundwater elevation and to draw spring capture zones for multiple dates that account for a range of hydrologic conditions—since groundwater elevations change seasonally and over time due to fluctuations in rainfall and withdrawals.

The estimated groundwater contributing area for the Wacissa Springs Group was developed using potentiometric surface maps created for the Floridan aquifer by the Florida Geological Survey (FGS) for May and September 2010, 2012, 2013, and 2014. Delineation based on potentiometric surface maps provides a good general description of a contributing area but is limited by the date and resolution of the potentiometric surface map, the climatic conditions that existed when the map was created, and the assumption of uniform drainage over the mapped area.

In evaluating the potential sources of nutrients impacting these springs, DEP will consider the groundwater contributing area as well as the surface drainage basin, or watershed, of the Wacissa River. Together these encompass an area of 761 square miles. **Figure 1.1** shows the contributing area and its major geopolitical and hydrologic features. The area includes portions of Jefferson, Madison, and Taylor Counties in Florida and portions of Thomas and Brooks Counties in Georgia.

Wacissa River and Springs lie in the Coastal Lowlands geomorphic province, which includes large areas of low topographic relief with poorly drained soils, marine terraces, and karst plains and river valley lowlands. The northern part of the contributing area also includes part of the Northern Highlands geomorphic province, which includes rolling hills dissected by streams. The boundary between these two major provinces is formed by a marked topographic escarpment known as the Cody Scarp. The top of the escarpment roughly corresponds with the 100-foot land surface elevation contour. These physiographic forms were shaped by the deposition and erosion of sediments through geologic time.

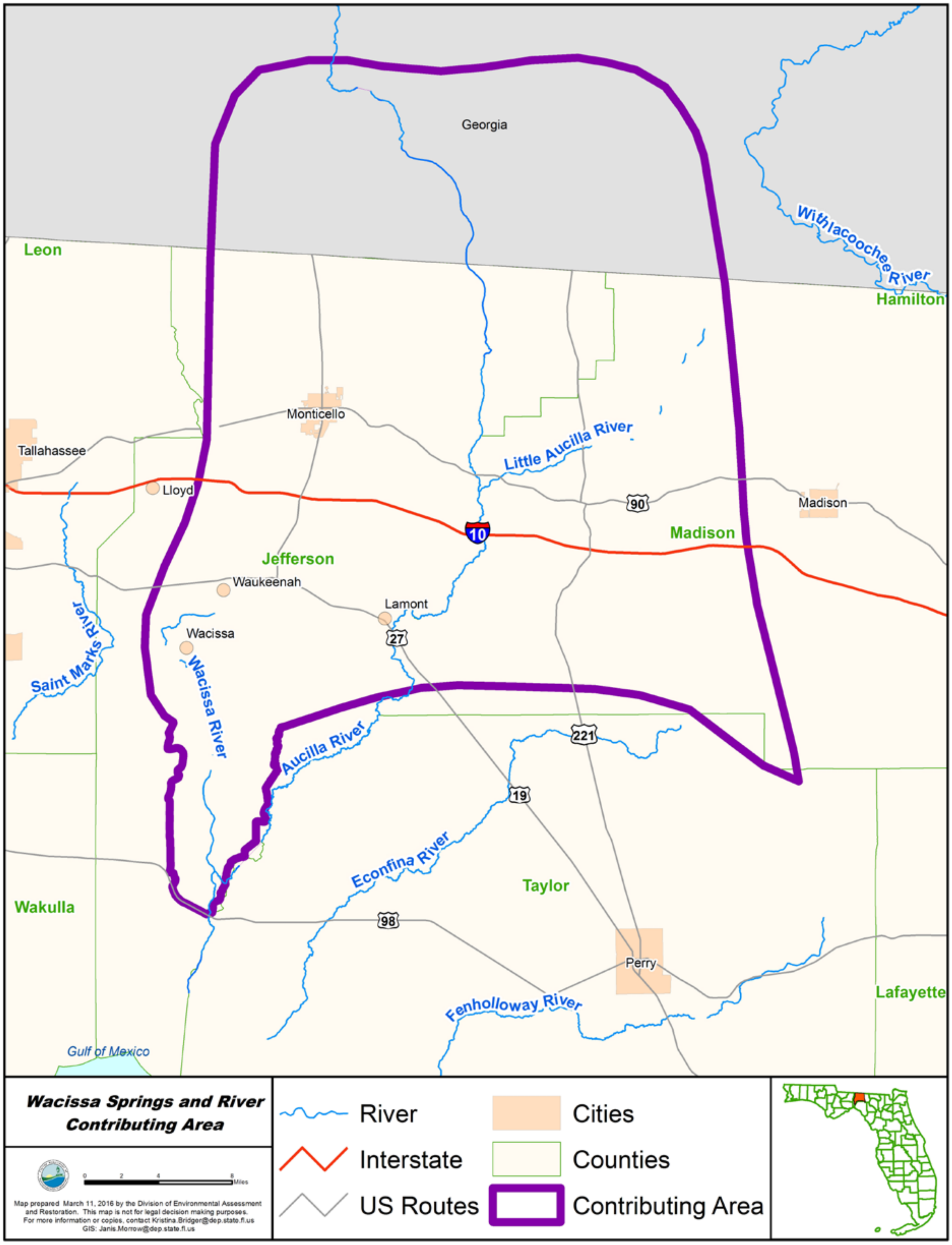

Figure 1.1. Major geopolitical and hydrologic features in the estimated contributing area of Wacissa River and Springs

Figure 1.2. Aerial photograph of the Wacissa River headsprings area (FGS 2011)

In the Northern Highlands, relatively shallow sand layers of Pleistocene to recent age are underlain by thick sequences of clayey material, silts, and dolomitic limestones of Miocene age that are in turn underlain by limestones of Oligocene and Eocene age. A surficial aquifer occurs in the shallow sands in this setting, where sandy material is underlain by less permeable material such as clay and silt that hold up infiltrating rainwater. However, the surficial aquifer is not extensive enough to be used as a water supply.

The Floridan aquifer system is found in the Oligocene and Eocene limestones. This aquifer is extensive in depth and area and is the main source of water used for potable supply, irrigation, and industrial use in much of Florida as well as other regions of the southeastern U.S. The upper Floridan aquifer is also the source of water flowing from springs and is the main source of water flowing in the Wacissa River.

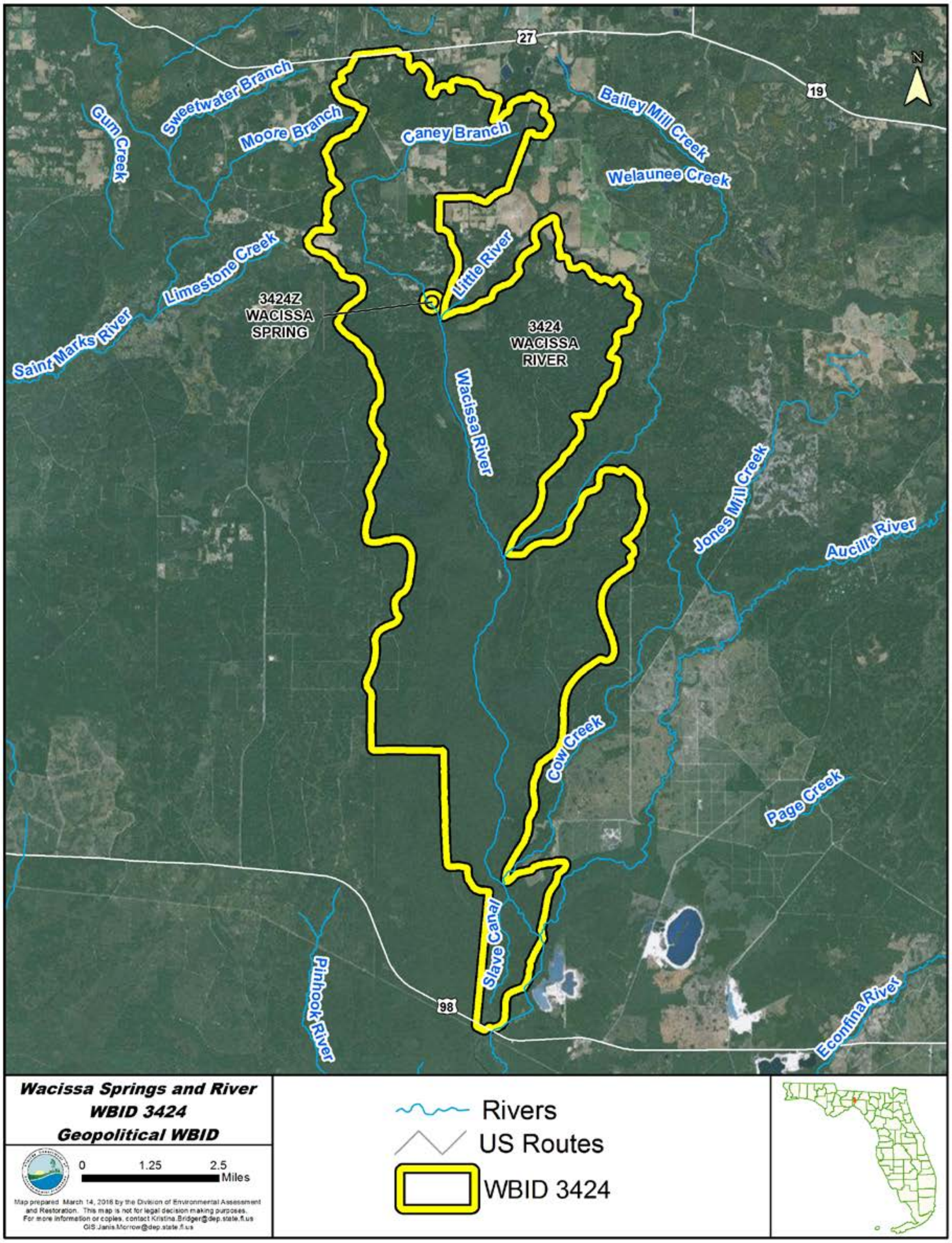

Figure 1.3. Wacissa River (WBID 3424)

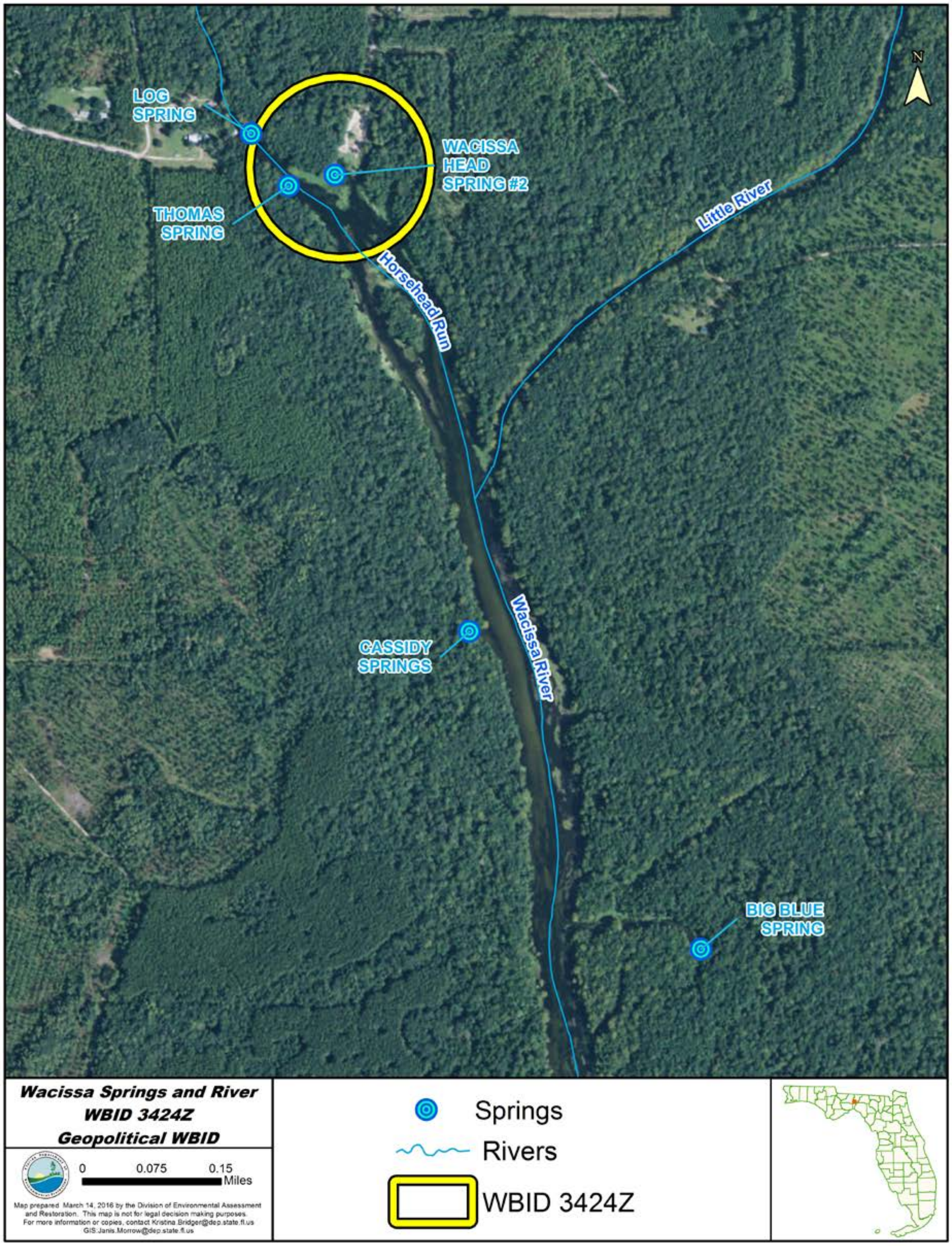

Figure 1.4. Wacissa River headsprings area (WBID 3424Z) and springs with data

The upper 100 to 200 feet of geologic material in the Northern Highlands region is absent in the Coastal Lowlands. The lithology consists mainly of sand on top of residual Miocene sediment (if present) and Oligocene to Eocene–age limestones that include the Floridan aquifer. In these areas, where the upper material is thin or absent, the Floridan aquifer can be readily recharged by precipitation. Also, in some areas where the overburden is thin, karst features such as sinkholes have developed as the limestone has eroded. These sinkholes themselves play an important role in aquifer recharge.

Karst processes play a dominant role in the rates and directions of groundwater movement through the Upper Floridan aquifer in the basin. In karst areas, the dissolution of limestone creates and enlarges cavities along fractures in the limestone that eventually collapse and form sinkholes. Sinkholes capture surface water drainage and funnel it underground, promoting the further dissolution of the limestone. This leads to the progressive integration of voids beneath the surface and allows larger and larger amounts of water to be funneled into the underground drainage system. Dissolution is most active at the water table or in the zone of water table fluctuation, where carbonic acid contained in atmospheric precipitation and generated by reaction with carbon dioxide in the soil reacts with limestone and dolostone.

Over geologic time the elevation of the water table has shifted in response to changes in sea level, and many vertical and lateral paths or conduits have developed in the underlying carbonate strata in the basin. Many of these lie below the present water table and greatly facilitate groundwater flow. Openings along these paths or conduits provide easy avenues for water to travel toward springs. Groundwater rich in nutrients has the potential to flow rapidly through these passages in the limestone, or slowly through much smaller pore spaces in the rock matrix.

In evaluating the potential sources of nutrients impacting the springs and their impaired receiving waters, DEP considered the surface drainage basin of the river as well as the groundwater contributing area to the springs. However, except for surface water drainage near the river corridor, most of the drainage in this area is internal, either directly into closed depressions or by seepage through overlying sediments into the aquifer.

Figure 1.5 shows the Florida portion of the contributing area, with the relative rates of recharge that the Floridan aquifer is capable of receiving. The rate of recharge is a function of the thickness of the overburden material, the presence or absence of sinkholes, and the differences in aquifer water level elevations. In lowland areas near the river, recharge does not occur because the aquifer is at or near the land surface and rainwater runs off.

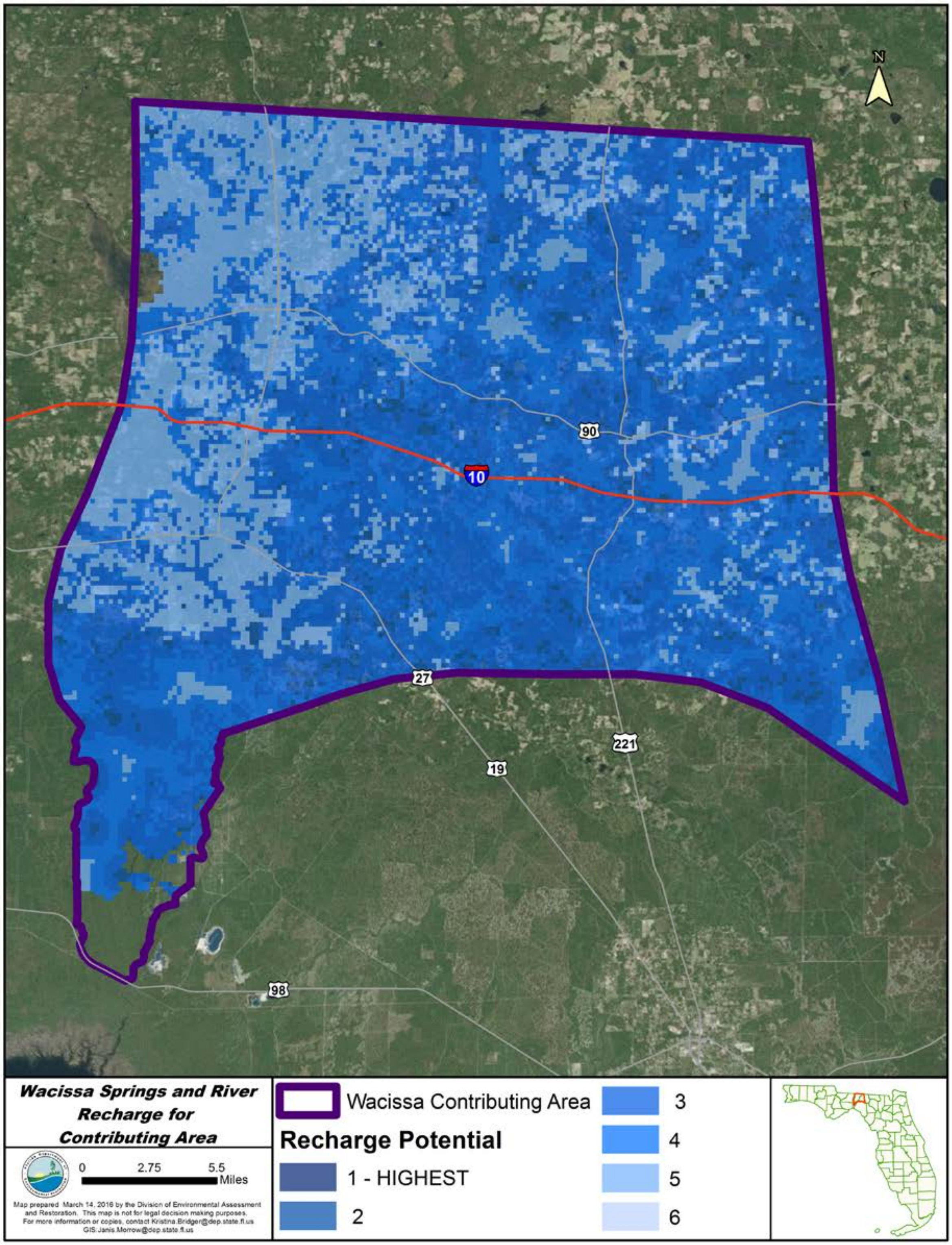

Figure 1.5. Aquifer recharge in the Wacissa River and Springs contributing area in Florida

Figure 1.6 shows the vulnerability of the Floridan aquifer system in the area contributing to the springs. The map is based on the Florida Aquifer Vulnerability Assessment (FAVA) model for the Floridan aquifer system developed by the FGS using conditions such as soil characteristics, depth to groundwater, recharge rate, and the prevalence of sinkhole features (Arthur et al. 2007). The FAVA model shows that most of the contributing area is more vulnerable to groundwater contamination compared with a smaller region in the northwestern part. In the areas classified as "more vulnerable," contaminants from the surface can more readily move vertically to the aquifer through the geological material or through sinkholes. In the area classified as "vulnerable," confining material is present and sinkholes are less prevalent. Thus, the movement of contaminants to the aquifer could occur but would be less of a potential problem.

1.3 Background

This report was developed as part of DEP's watershed management approach for restoring and protecting state waters and addressing state and U.S. Environmental Protection Agency (EPA) documentation requirements for a TMDL. The watershed approach, which is implemented using a cyclical management process that rotates through the state's 52 river basins over a 5-year cycle, provides a framework for implementing the requirements of the 1972 federal Clean Water Act and the 1999 Florida Watershed Restoration Act (FWRA) (Chapter 403.067, Laws of Florida) for TMDLs.

A TMDL is a scientific determination of the maximum amount of a pollutant that a waterbody can receive each day and still be considered healthy. TMDLs are developed for waterbodies that are verified as not meeting their water quality standards. They provide important water quality restoration goals that will guide restoration activities. These TMDLs will also serve as site-specific interpretations of the narrative nutrient criterion for nitrate-nitrogen per Paragraph 62-302.530(47)(b), F.A.C.

The adoption of nutrient TMDLs for the Wacissa River and the named springs will be followed by the development and implementation of a BMAP for reducing the levels of nutrients. The restoration of these waterbodies will depend on the active participation of stakeholders in the contributing area, including local governments (Jefferson and Madison Counties and the City of Monticello), local landowners, permitted facilities, and agricultural interests. The Florida Department of Agriculture and Consumer Services (FDACS) and the Suwannee River Water Management District (SRWMD) will play important roles in helping agricultural producers implement best management practices (BMPs) and other measures (as appropriate) to address nutrient losses.

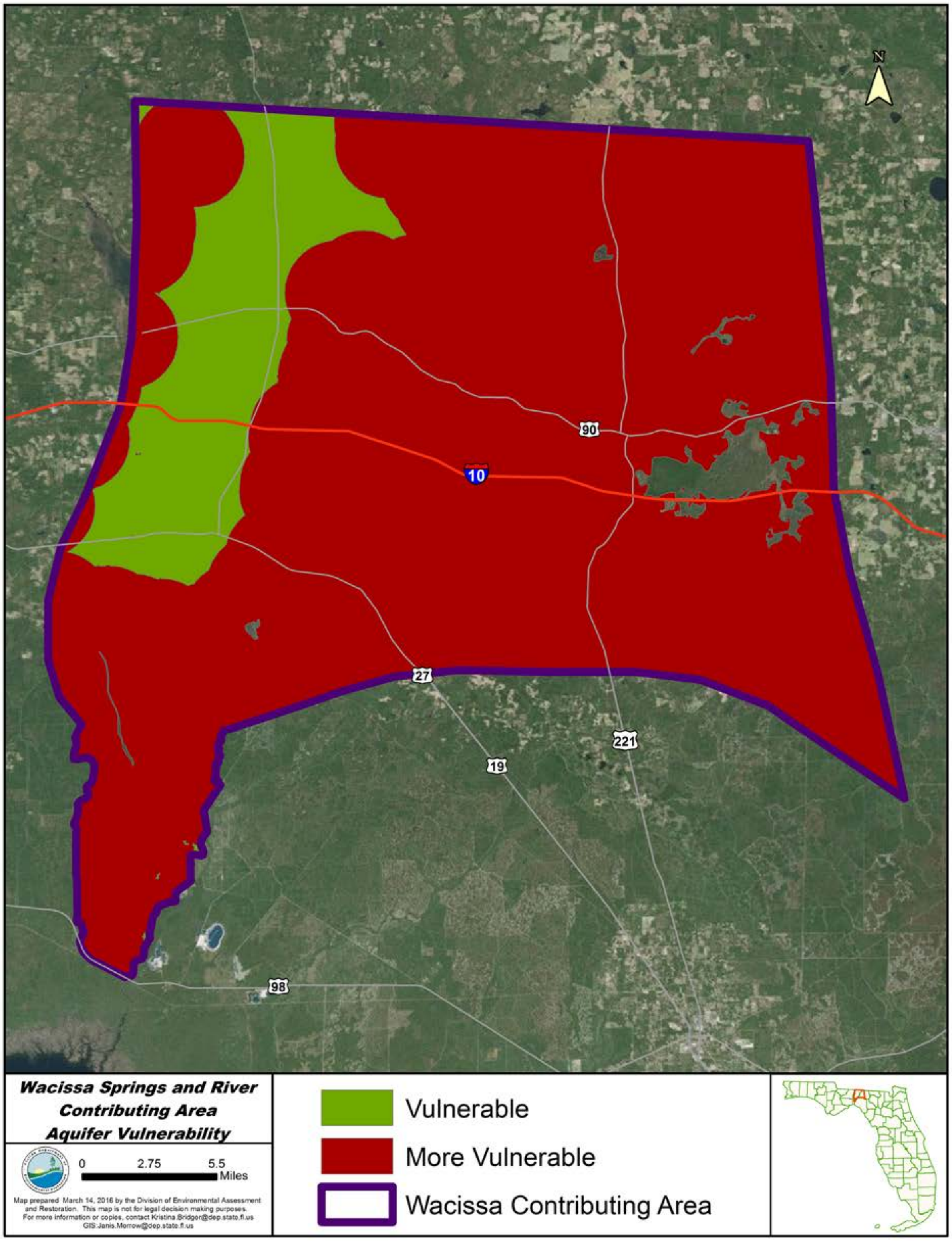

Figure 1.6. Aquifer vulnerability in the Wacissa River and Springs contributing area

Chapter 2: Description of Water Quality Problem

2.1. Statutory Requirements and Rulemaking History

Section 303(d) of the federal Clean Water Act requires states to submit to the EPA a list of surface waters or segments 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 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.), and the state's Verified List of impaired waters is amended annually to include basin updates. These updates are then submitted to the EPA with the intent of amending Florida's 303(d) list.

The FWRA (Section 403.067, F.S.) directed DEP to develop, and adopt by rule, a science-based methodology to identify impaired waters. After a long rulemaking process, the Environmental Regulation Commission adopted the new methodology as Chapter 62-303, Florida Administrative Code (F.A.C.) (Identification of Impaired Surface Waters Rule, or IWR), in April 2001. The IWR was modified in 2006, 2007, 2012, and 2013.

2.2. Information on Verified Impairment

Chapter 62-303, F.A.C., includes the methodology for listing impaired surface waters based on documentation that supports the determination of a waterbody's imbalance in flora or fauna attributable to nutrients. In 2012, DEP used all available water quality data from the SRWMD and its consultants (Biological Research Associates), DEP's own monitoring activities, and other sources to evaluate the impairment status of Wacissa River and Springs based on nutrient concentrations and evidence of ecological imbalance. Water quality data collected by DEP comprised the bulk of the nitrate data used in the evaluation.

These waterbodies were verified as impaired by nutrients because consistently elevated concentrations of nitrate in Wacissa Springs (springs in WBID 3424Z) and River (WBID 3424) contribute to an imbalance of flora caused by algal smothering in the spring run. This information was used to confirm the impairment determination to place both waterbodies on the Group 1 Suwannee Verified List adopted by Secretarial Order on February 12, 2013. **Table 2.1** lists the waterbodies on the Cycle 3, Group 1 Suwannee River Basin Verified List addressed in this report.

Table 2.1. Cycle 3 verified impaired spring-related segments in this TMDL report

WBID	Waterbody Segment	Parameters Assessed Using the IWR
3424	Wacissa River	Nutrients (Algal Mats)
3424Z	Wacissa Springs	Nutrients (Algal Mats)

2.3 Nutrient Enrichment

Nutrient enrichment contributes to the impairment of many surface waters, including springs. The two major nutrient parameters monitored are nitrogen (N) and phosphorus (P). These are essential nutrients to plant life, including algae. For aquatic vegetation and algae to grow, both nutrients must be present. In fact, one can be present in excess, but if the other is absent, the overgrowth of vegetation or algae is unlikely to occur. Historically, many spring systems have had sufficient naturally occurring phosphorus to trigger an imbalance. It is widely accepted that primary production in spring-fed waterbodies is controlled by nutrients, sunlight, flow, spring discharge, temperature, and mineral content in the groundwater.

The results of ongoing research on many Florida springs have led to significant progress in understanding the threshold concentrations of nitrogen or phosphorus that cause the overgrowth of nuisance macroalgae (Stevenson et al. 2007). Macroalgae may also sequester nutrients from groundwater seepage, which may not be apparent from surface water or spring monitoring data. The nutrient inputs contributing to the algal growth in the Wacissa River may not be exclusively related to spring discharge, as the river also receives nutrients from adjacent forestland. In addition, legacy nutrients found in the decaying vegetation and sediments can diffuse back into the water column.

2.4 Ecological Issues Related to Nutrients

The amount and type of aquatic vegetation are linked to water quality and clarity. Submerged aquatic vegetation (SAV) communities support wildlife species, stabilize sediments, prevent erosion, and remove contaminants from the water column and sediments. Evidence of an increasing trend in algal coverage, especially *Lyngbya sp.,* and algal smothering have been documented in the Wacissa River in the vicinity of the headsprings and for a distance downstream.

Lyngbya may form tangles or mats, intermixed with other phytoplankton species. Trapped gases often form in and beneath these algal mats, causing them to break free of the substrate and float to the surface. Once the mats are floating, wind and water currents can move them to other areas, impeding navigation and impairing recreational use of the waterbody. The mats can be several acres in size (University of Florida–Institute of Food and Agricultural Sciences [UF–IFAS] 2009). *Lyngbya sp.* also can trap sediments, causing the development and accumulation of muck. Upon decomposition, the algal cells release a compound (geosmin) with a strong musty odor; this further impairs the aesthetic value of the waterbody (Romie 1990).

The earliest documentation of observed algal mats in Wacissa Springs was recorded in 2001 by the FGS. The observation states that "the spring pool is choked with exotic aquatic vegetation, and algae are present throughout the pool" (Scott et al. 2004, p. 172). **Figures 2.1** and **2.2** show algal impacts under water and on the surface in 2014 and 2013, respectively.

The response of algae to nutrient enrichment in Wacissa Springs and River is not unique to this system. Unfortunately, algal growth is prolific in many spring systems where nutrient concentrations are elevated. The conditions here are similar to those documented in the nutrient TMDLs for the Suwannee and Santa Fe Rivers (Hallas and Magley 2008), Wekiva River and Rock Springs Run (Gao 2007), Wakulla River (Gilbert 2012), Silver Springs and River (Holland and Hicks 2012), Rainbow Springs and River (Holland and Hicks 2013), Jackson Blue Spring (Dodson 2013), and Weeki Wachee Spring (Dodson and Bridger 2014).

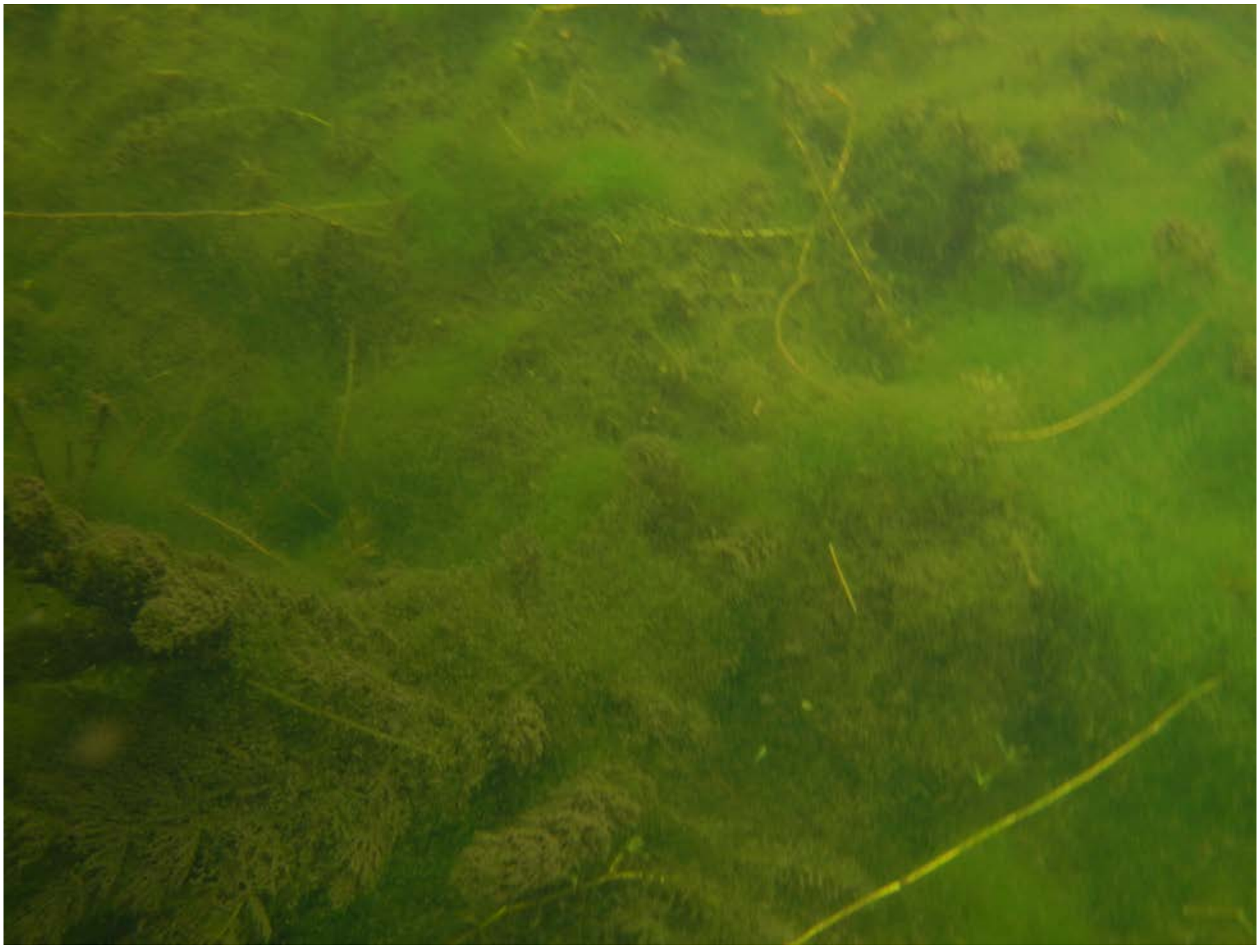

Figure 2.1. Underwater photo of algal impacts at Wacissa River and Springs, June 2014 (photo by DEP Groundwater Management Section)

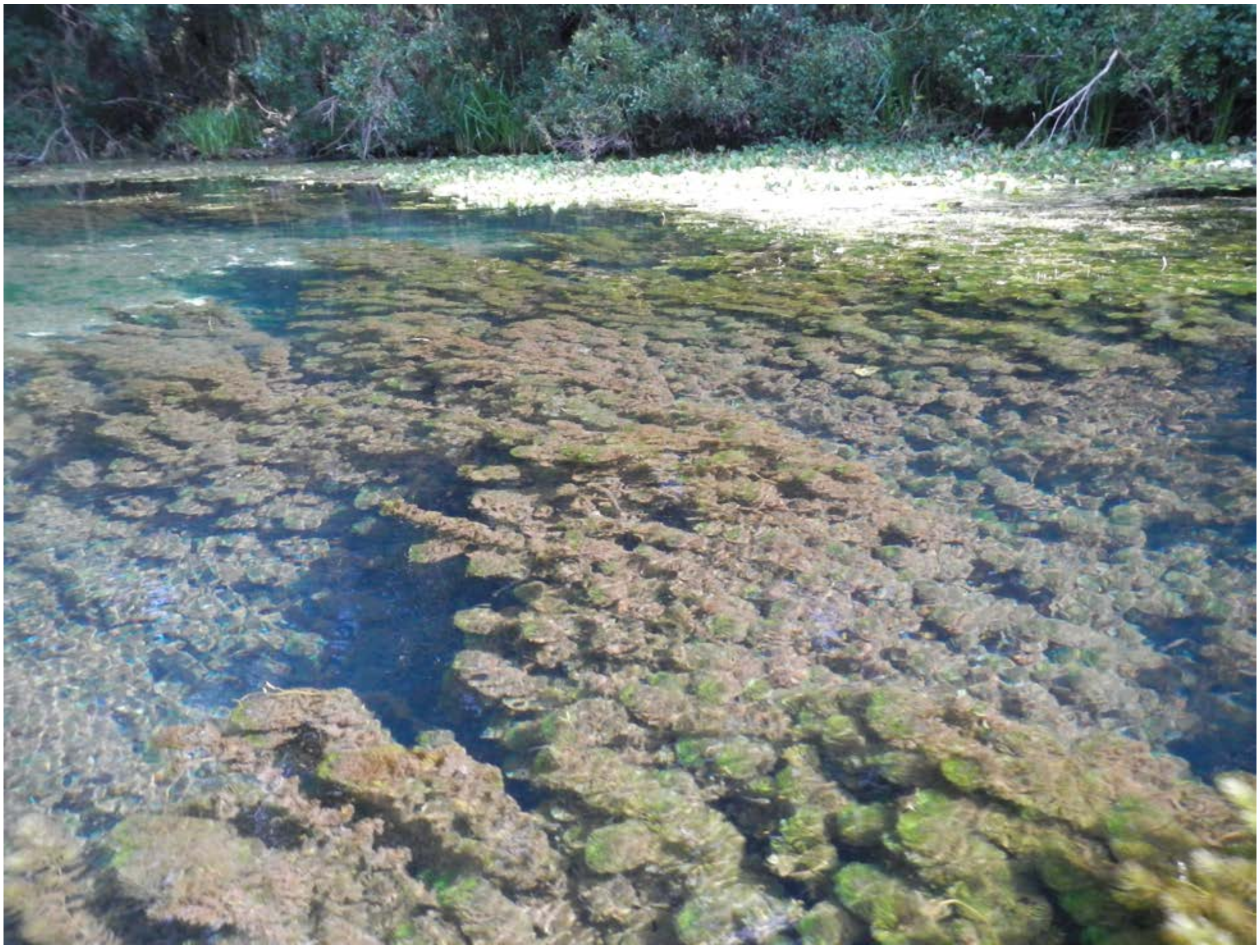

Figure 2.2. Photo of algal impacts at Wacissa River and Springs, October 2013 (photo by DEP Groundwater Management Section)

2.5 Rainfall and Temperature Data

The climate in the Wacissa River area is humid subtropical, with hot, rainy summers and cool, wet winters. Recharge to groundwater and flow in springs depend on rainfall. Rainfall amounts for Monticello, Florida, were used to calculate precipitation in the Wacissa springshed, because Monticello is centrally located in the contributing area. Rainfall and temperature data were reviewed for the 30-year period of record from January 1985 through December 2014 (**Table 2.2**). Because of significant data gaps for both temperature and precipitation at individual climate stations in the Monticello area, DEP used mean values from data compiled from two nearby stations: Monticello Water Treatment Plant (WTP) station and Florida Automated Weather Network (FAWN) Monticello Station 2m data for temperature. Precipitation data from the Monticello WTP and Monticello Station 3W were used to develop a more complete climate record. Even so, there are still data gaps for Monticello precipitation for 2001 through 2005 (**Figure 2.3**).

Annual rainfall averages 55.76 inches per year (in/yr), with an average air temperature of 66.8° F. (National Oceanic and Atmospheric Administration [NOAA] 2016).

Figure 2.3 shows the 30-year historical rainfall trend measured for Monticello. Over this period, the lowest annual rainfall of 31.11 inches occurred in 2007, and the highest annual rainfall of 92.79 inches occurred in 1994.

Table 2.2. Temperature at Monticello (NOAA National Centers for Environmental Information [NCEI] Monticello WTP Station and FAWN Monticello Station 2m data) and precipitation at Monticello (NOAA NCEI Monticello WTP and Monticello 3W Station data), January 1985–December 2014

Analysis	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
30-Year Mean–Maximum Temperature (°F.)	64.4	68.1	74.0	79.6	86.3	90.8	91.7	91.1	87.9	81.2	74.0	67.2	**79.7**
30-Year Mean–Minimum Temperature (°F.)	37.0	41.1	46.7	51.6	59.3	67.5	69.7	70.4	64.7	53.3	44.7	38.2	**53.7**
30-Year Mean–Average Temperature (°F.)	50.9	54.4	60.5	65.8	73.0	79.0	80.7	80.2	76.7	67.7	59.6	52.7	**66.8**
30-Year Mean–Precipitation (inches)	4.68	4.71	5.35	3.37	2.80	6.36	6.16	6.74	4.82	3.39	3.50	3.88	**55.76**

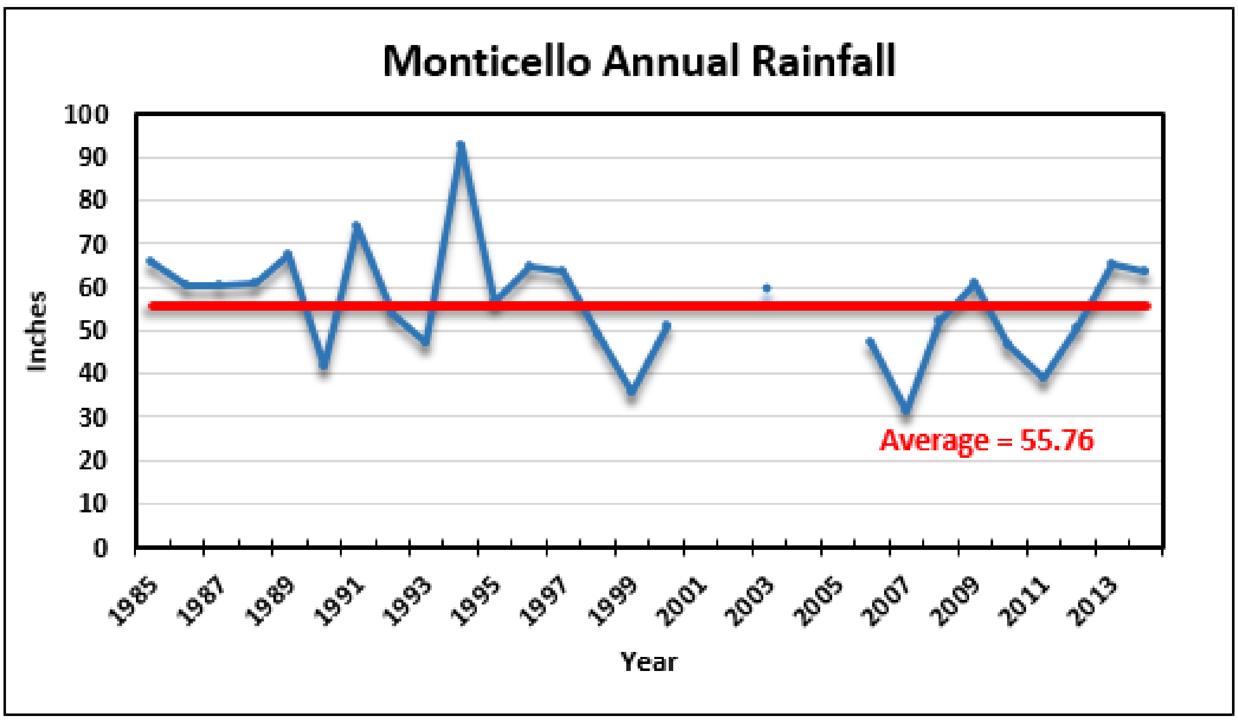

Figure 2.3. Thirty-year precipitation for Monticello, Florida, January 1985–December 2014 (FAWN and NOAA NCEI Monticello 3W Station data)

2.6 Discharge Data

The U.S. Geological Survey (USGS) has collected flow measurements and stage at a gauging station on the Wacissa River since October 2008. This station (USGS Station #02326526) is located in the upper river 0.4 kilometers (km) (0.25 miles [mi]) south of the junction of the northern (main) Big Blue Spring Run with the Wacissa River (**Figure 2.5**). The discharge measured at the Wacissa River gauging station includes contributions from all of the major springs in the upper Wacissa River, as well as the spring-fed tributaries of Horsehead Run and Little River, local runoff, and smaller unnamed springs and seeps along the river. **Figure 2.4** displays the daily mean discharge data, and **Table 2.3** shows the annual mean discharge data for the Wacissa River from 2009 through 2015.

According to the SRWMD (HSW Engineering 2016), discharge has been measured in 16 springs on the Wacissa River over the years. Of these springs, 13 were reported to have discharges of greater than 10 cubic feet per second (cfs). Big Blue and Cassidy Springs were most frequently measured for discharge. Tidal fluctuations have a small effect on spring and river discharge. Spring discharge decreases during high tide and increases during low tide. Tidal effects are slight in the upper Wacissa, with measured tidal fluctuations on the order of 1.5 centimeters (cm) (0.05 feet [ft]).

Discharge from the springs in the Wacissa River is usually lowest in late fall, likely as a result of lower precipitation and correspondingly lower groundwater recharge and resulting spring flow during this period. Higher discharge rates generally occur during spring and summer, when average precipitation is greatest. Changes in the groundwater gradients in the contributing area also influence spring discharge. Precipitation events, groundwater withdrawals, and changes in sea level have the potential to influence groundwater gradients and possibly spring and spring-run river discharges.

The plot of the Wacissa River discharge (**Figure 2.4**) shows a general decline in overall discharge from the upper Wacissa during the short period over which data from the USGS gauge were collected (2009–present). Flows appear to correlate with the periods of higher and lower rainfall shown in **Figure 2.4.** However, it is not possible to come to meaningful conclusions about flow trends in this system without a longer period of record.

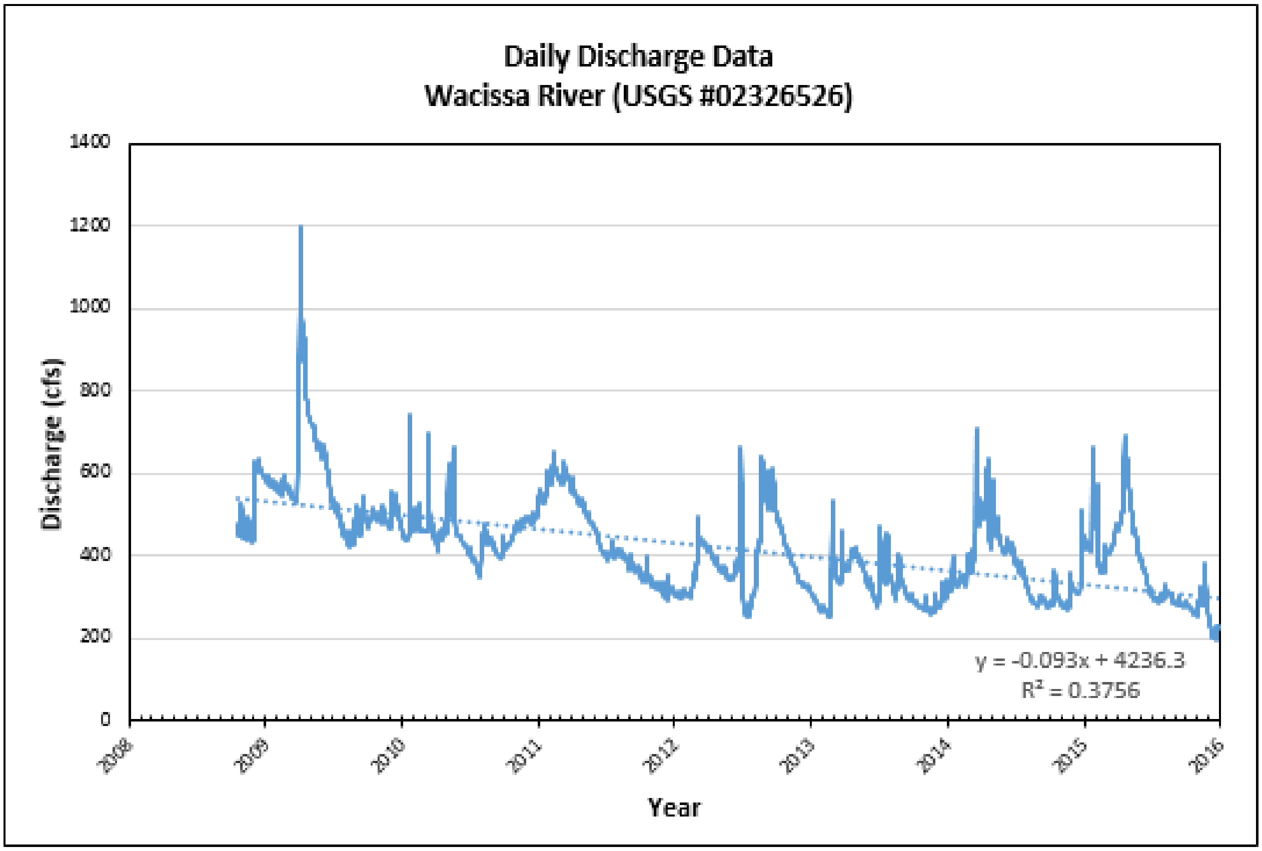

Figure 2.4. Daily mean discharge data for the Wacissa River (#02326526), October 2008–December 2015

Table 2.3. Annual mean discharge for the Wacissa River, January 2009–December 2015

*Includes USGS provisional data

Year	Adjusted Annual Mean Discharge (cfs)
2009	561.91
2010	455.60
2011	445.13
2012	385.59
2013	325.07
2014	367.41
2015	359.74

2.7 Monitoring Sites and Sampling

Historical water quality data for Wacissa River and Springs are limited, but they do provide a glimpse of current versus background water quality. Water quality data have been collected from various locations around the springs and in the river. The Florida Storage and Retrieval (STORET), USGS National Water Information System (NWIS), and SRWMD databases contain many of these data.

Prior to the mid-1990s, the USGS and FGS performed spring water quality sampling in support of FGS Bulletin 32 (Ferguson et al. 1947) and FGS Bulletin 32 (revised) (Rosenau et al. 1977). The oldest Wacissa nitrate data collected and published were from water quality samples collected for the 1947 report. A concentration of 0.07 milligrams per liter (mg/L) of nitrate (measured as N) was measured at Big Blue Spring on July 23, 1946. DEP and the SRWMD began sampling the Wacissa Springs Group more frequently in the mid-1990s.

DEP has sampled Wacissa #2 and Big Blue Springs quarterly since 2000. Wacissa #2 is the most prominent of several small vents discharging groundwater in the headspring area near the county park, just offshore near the concrete diving platform. Unlike Wacissa #2 and Big Blue Springs, the upper Wacissa River is not sampled regularly, but periodic surveys have been completed, including an extensive 2008 biological and water quality assessment of Wacissa River and Springs (DEP 2008a) and the intensive survey conducted for the development of this TMDL.

Figure 2.5 shows the locations of the water quality sampling stations used for listing and those used in the vegetative survey conducted to support setting the TMDL target. The dataset used for listing includes samples from multiple locations collected in the headspring area (WBID 3424Z) by DEP and the SRWMD. The labeled spring and river monitoring stations in **Figure 2.5** were used in the vegetative survey.

To ensure that the nutrient TMDLs were developed based on current conditions and that recent trends in spring water quality were adequately captured, monitoring data were used from samples collected during the Cycle 3 verified period (January 1, 2005–June 30, 2012) plus more recently (2012–15). **Table 2.4a** summarizes the nutrient monitoring results for Wacissa River, which include samples from multiple stations over the years plus the Wacissa River stations from the vegetative survey identified in **Figure 2.5** (WR-1 through WR-4). **Tables 2.4b** through **2.4f** summarize the nutrient monitoring results for several springs located in the upper Wacissa River that were included in the TMDL analysis.

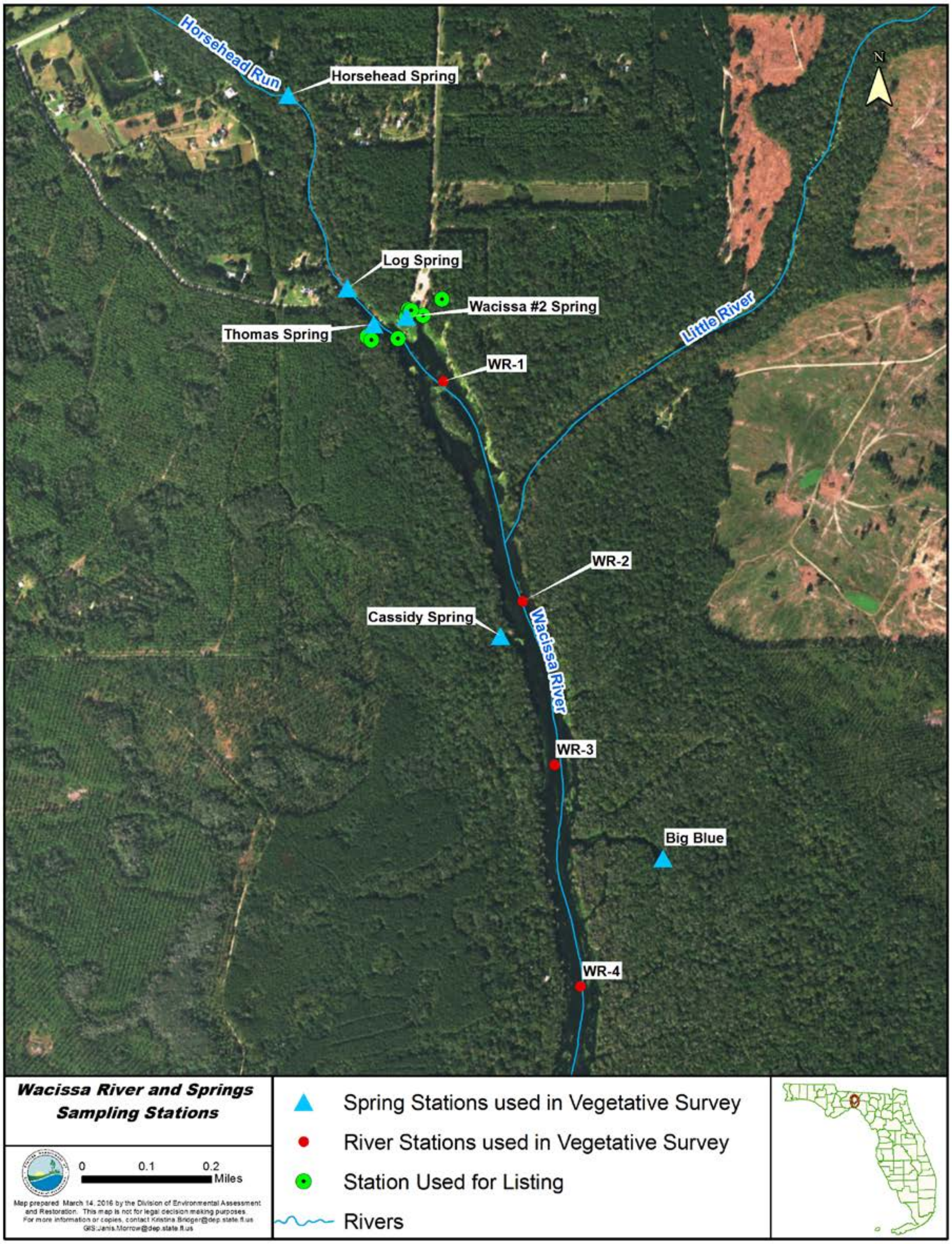

Figure 2.5. Surface water and spring monitoring sites associated with the listing of impaired Wacissa Springs (WBID 3424Z) and the development of TMDLs

2.8 Monitoring Results

2.8.1 Nitrate

Nitrogen is found in several forms and is ubiquitous in the environment. Total nitrogen (TN) is made up of both inorganic and organic fractions. Inorganic nitrogen components include ammonium, nitrate, and nitrite. Nitrate-nitrogen is the nutrient most commonly associated with ecological imbalances in spring systems because it is the most mobile and available form of nitrogen for use by plants and algae. Increases in nitrate concentrations in springs have been found to correlate with the degradation of biological systems due to the overgrowth of filamentous algal mats, phytoplankton blooms, and sometimes aquatic plants (Harrington *et al.* 2010).

Wacissa River and Wacissa Springs have not been formally assessed for nutrient impairment based on current stream criteria for TN. However, based on available data when these waters were added to Florida's list of impaired waters in 2013, Wacissa River would not have been impaired for TN. The historical median TN concentration in the samples used for listing was 0.52 mg/L, which is well below Florida's TN numeric threshold for streams in the eastern Panhandle (1.03 mg/L, in Chapter 62-302.531, F.A.C.). Florida's numeric nutrient criteria (NNC) were not in place when these waters were listed. However, Wacissa River will be assessed for nutrient impairment per the NNC in the next sampling rotation for Group 1 waters (Cycle 4). Nitrate-nitrogen will be added to the existing NNC as site-specific protection against the algae impairment.

Nitrate (NO_3-N) is the form of nitrogen that occurs in the highest concentrations in groundwater and springs, and springs are the major source of flow in the Wacissa River. Compared with typical stream values, the remaining nitrogen content (organic nitrogen and ammonium) in spring water is low. The median nitrate concentration from spring samples in the Wacissa River system based on historical data was 0.40 mg/L (n=115), and the historical median for TN in springs was 0.45 mg/L (n=152), which indicates that about 88 % of the nitrogen in the springs in this system is in the form of nitrate. Because nitrate is the main form of nitrogen in springs and spring discharge is the main source of water in the Wacissa River, nitrate is considered the target nutrient for the TMDLs for the springs and the river. **Chapter 5** discusses the nutrient impairment and the setting of the target concentration for nitrate.

While nitrite and nitrate are frequently analyzed and reported together as one concentration (nitrate + nitrite-nitrogen), the nitrite contribution is always insignificant. Nitrite-nitrogen (NO_2-N), an intermediate form of nitrogen, is almost entirely converted to nitrate in the nitrogen cycle. In this report, nitrate is NO_3-N as nitrogen and, unless otherwise stated, the sum of nitrate and nitrite nitrogen (NO_3+NO_2) is used to represent nitrate due to minimal contributions of nitrite.

Nitrate makes up about 40 % of the total nitrogen in the Wacissa River, based on historical data. **Table 2.4a** provides summary statistics for nitrate and TN concentrations in the river for the period of record used for TMDL development (January 2005–December 2015). However, in the upper river closest to the headsprings, the nitrate concentration is much higher and makes up a greater portion of the TN. In the upper Wacissa River, surface water nitrate concentrations in the river and headsprings (which include Wacissa #2, Log, and Thomas Springs in WBID 3424Z) are similar.

Nitrate (NO_3+NO_2) concentrations in the river decline rapidly downstream from the headspring area (**Figures 2.6** and **2.7**). The downstream decline is partly due to nutrient uptake by the river's SAV and partly due to dilution from the flow contribution provided by downstream springs (in particular Big Blue Spring). The nitrate concentrations in Cassidy and Big Blue Springs, farther downstream, are significantly lower than those at the headsprings

Historically, nitrogen was only a minor constituent of spring water, and typical nitrate concentrations in Florida were less than 0.2 mg/L until the early 1970s. Since then, elevated concentrations of nitrate have been found in many springs.

As in many Florida springs, nitrate trends in the monitored springs in the Wacissa River system have gone up over time, although their period of record only goes back as far as 1994. **Figure 2.8** shows the historical trends in nitrate concentrations for springs with data in the Wacissa River system. Linear trend lines show an increase of 0.003 mg/L nitrate (or NO_3+NO_2) each year for Big Blue Spring and 0.005 mg/L NO_3+NO_2 each year for Wacissa #2 Spring. Note that nitrate concentrations for several springs in the headsprings area were already higher than Florida's current criterion for spring vents (0.35 mg/L, per Chapter 62-302, F.A.C.).

Tables 2.4b through **2.4f** provide summary statistics for NO_3+NO_2 in Big Blue, Cassidy, Log, Thomas and Wacissa #2 Springs for the period of record used for TMDL development.

2.8.2 Phosphorus

Total phosphorus (TP) includes both phosphorus from organic sources and orthophosphate. Organic phosphorus comes from peat and muck in the riverbed and floodplain and decaying aquatic vegetation. The organic phosphorus content is normally low in spring water. Orthophosphate is naturally abundant in the geologic material in much of Florida, coming from clays overlying the Floridan aquifer and in the limestone as dissolved phosphorus bound to calcium in the rock matrix (Fitts 2013). Only the inorganic form of phosphorus, orthophosphate, is generally found at significant concentrations in groundwater and springs.

Wacissa River and Wacissa Springs have not yet been assessed for nutrient impairment based on the current stream criteria for phosphorus, which are based on TP concentration. When these waters were added to Florida's 2013 list of impaired waters, the median TP concentration in the assessed river and spring samples was 0.04 mg/L. At this concentration, which is well below Florida's TP numeric nutrient threshold for streams in the eastern Panhandle (0.18 mg/L, in Chapter 62-302.531, F.A.C.), the Wacissa River would not be impaired. Florida's NNC were not in place in 2013, but these waters will be assessed for nutrient impairment per the NNC in the next monitoring cycle for Group 1 waters.

In the Wacissa River, the median TP concentration for stream stations in the period of record used for the TMDL evaluation (January 1, 2005–December 2015) was 0.039 mg/L. Orthophosphate (median concentration of 0.028 mg/L) made up approximately 72 % of the TP during the TMDL evaluation period. **Table 2.4a** provides these summary statistics. Groundwater discharged from the springs is the main source of the orthophosphate in the river, and the organic portion comes from organic matter in the river floodplain and decaying plant matter in the river.

In the springs of the Wacissa River system, orthophosphate has historically been the largest contributor to TP. Approximately 97 % of the TP is made of orthophosphate, based on historical water quality from all springs with data (historical TP median = 0.035 mg/L and historical orthophosphate median = 0.034 mg/L). Historical monitoring data for orthophosphate for all river and spring samples shown in **Figure 2.9** show no significant trends, indicating that the orthophosphate is a persistent natural condition. Orthophosphate concentrations in the springs are lower than the historical median orthophosphate in groundwater in the UFA in the Aucilla Basin, which is based mainly on ambient well data (0.11 mg/L, as measured in 32 DEP wells). **Tables 2.4b** through **2.4e** summarize orthophosphate statistics for selected springs used in the analysis for the TMDL verified period.

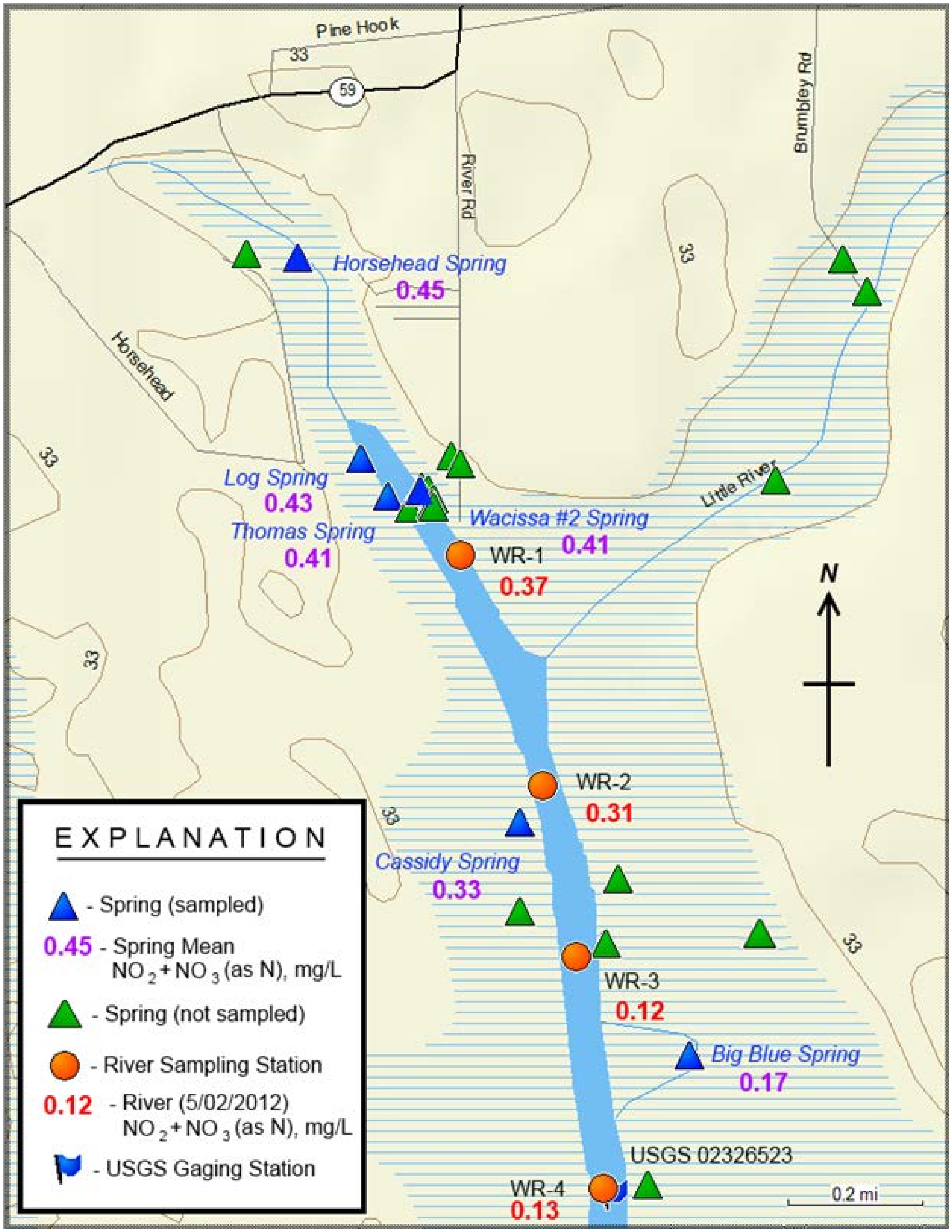

Figure 2.6. Mean nitrate (NO_3+NO_2) values for selected springs sampled during the TMDL verified period through the present (January 2005–December 2015), along with nitrate values from Wacissa River surface water stations sampled on May 2, 2012

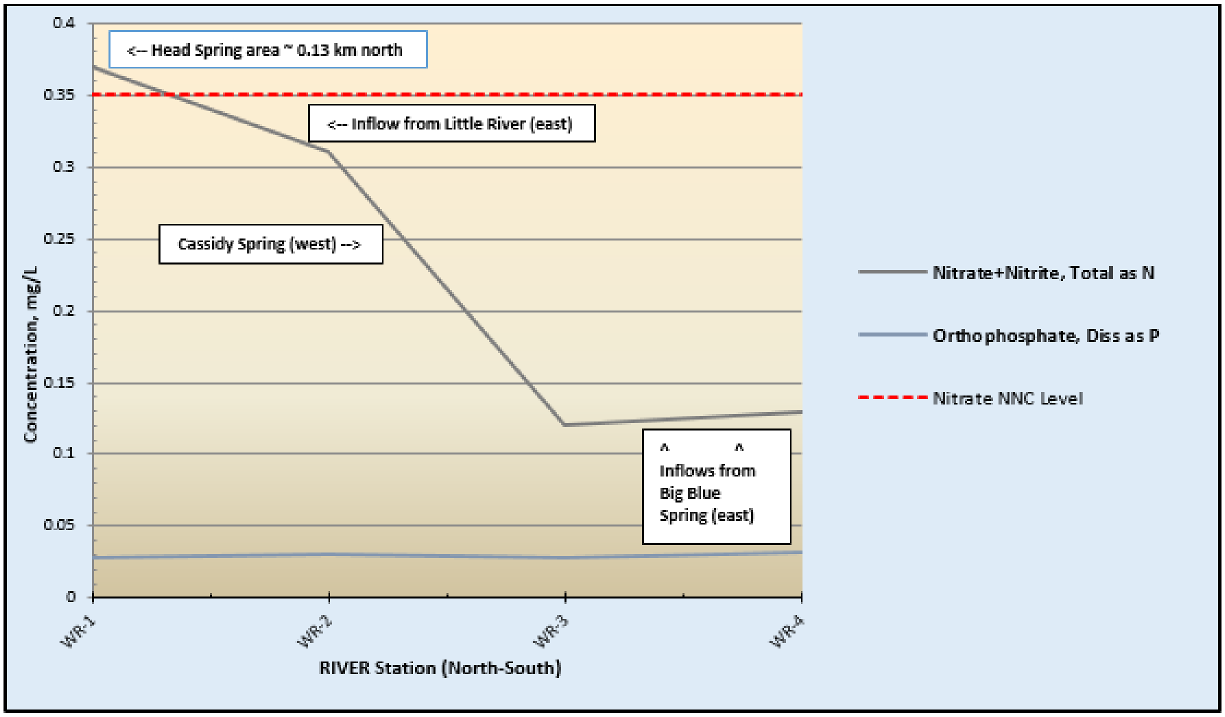

Figure 2.7. Nitrate + nitrite and orthophosphate values in the upper Wacissa River, from surface water samples collected on May 2, 2012. See Figure 2.3 for surface water station locations.

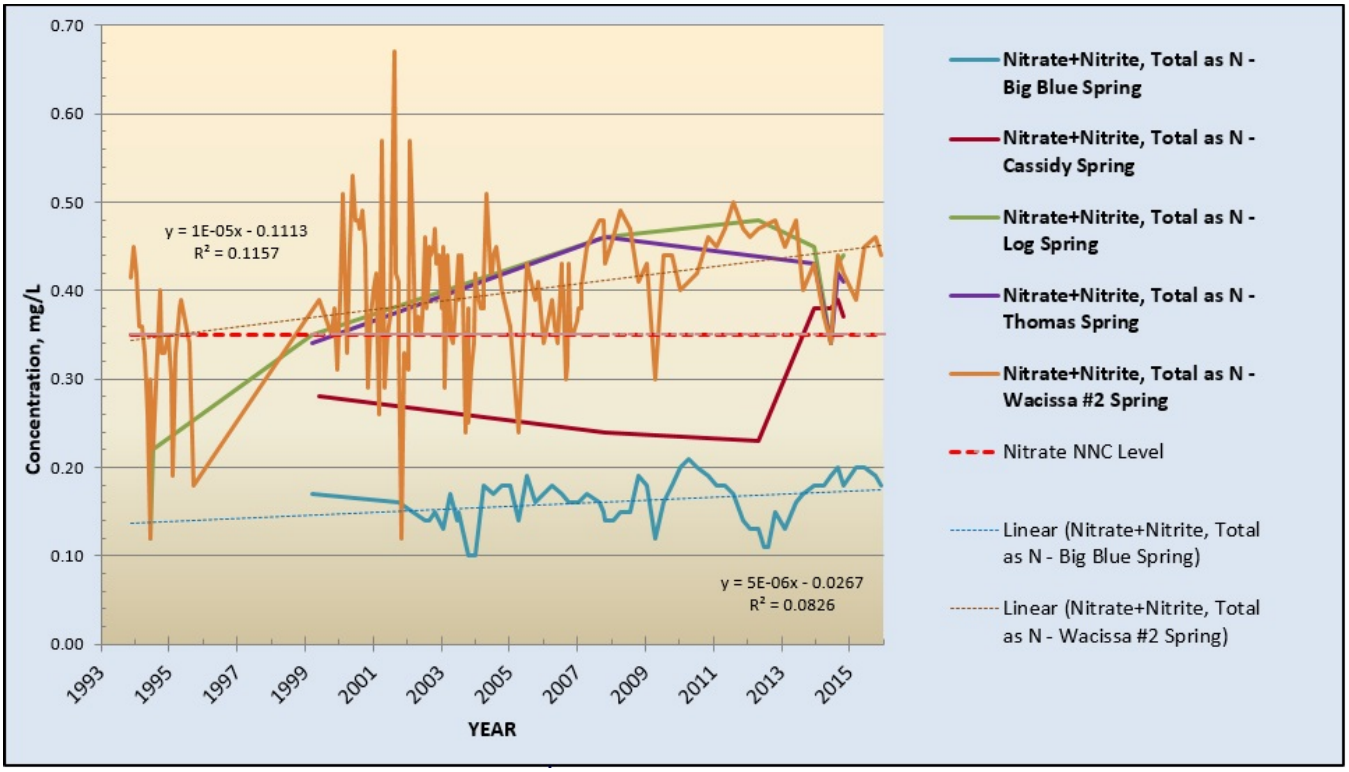

Figure 2.8. Nitrate (nitrate+nitrite) trends in Big Blue, Cassidy, Log, Thomas, and Wacissa #2 Springs, 1994–2015

Table 2.4a. Summary of selected water quality results for the Wacissa River

Data from DEP

Indicator Type	Analyte	Sampling Date	Units	Number of Samples	Mean	Median	Minimum	Maximum
Macronutrients	Nitrate+Nitrite, Total (as N)	1/2005–12/2015	mg/L	99	0.18	0.16	0.01	1.7
Macronutrients	TN (as N)	1/2005–12/2015	mg/L	74	0.47	0.42	0.11	2.0
Macronutrients	Orthophosphate, Dissolved (as P)	1/2005–12/2015	mg/L	100	0.028	0.028	0.05	0.012
Macronutrients	TP	1/2005–12/2015	mg/L	107	0.041	0.039	0.093	0.023

Table 2.4b. Summary of selected water quality results for Big Blue Spring

Data from DEP

Indicator Type	Analyte	TMDL Verified Period through 12/2015	Units	Number of Samples	Mean	Median	Minimum	Maximum
Macronutrients	Nitrate+Nitrite, Total (as N)	1/2005–12/2015	mg/L	46	0.170	0.170	0.110	0.210
Macronutrients	Orthophosphate, Dissolved (as P)	1/2005–12/2015	mg/L	47	0.045	0.046	0.039	0.051

Table 2.4c. Summary of selected water quality results for Cassidy Spring

Data from DEP

Indicator Type	Analyte	TMDL Verified Period through 12/2015	Units	Number of Samples	Mean	Median	Minimum	Maximum
Macronutrients	Nitrate+Nitrite, Total (as N)	1/2005–12/2015	mg/L	6	0.330	0.380	0.230	0.390
Macronutrients	Orthophosphate, Dissolved (as P)	1/2005–12/2015	mg/L	7	0.034	0.034	0.032	0.037

Table 2.4d. Summary of selected water quality results for Log Spring

Data from DEP

Indicator Type	Analyte	TMDL Verified Period through 12/2015	Units	Number of Samples	Mean	Median	Minimum	Maximum
Macronutrients	Nitrate+Nitrite, Total (as N)	1/2005–12/2015	mg/L	7	0.430	0.440	0.340	0.480
Macronutrients	Orthophosphate, Dissolved (as P)	1/2005–12/2015	mg/L	7	0.036	0.037	0.032	0.041

Table 2.4e. Summary of selected water quality results for Thomas Spring

Data from DEP and SRWMD

Indicator Type	Analyte	TMDL Verified Period through 12/2015	Units	Number of Samples	Mean	Median	Minimum	Maximum
Macronutrients	Nitrate+Nitrite, Total (as N)	1/2005–12/2015	mg/L	5	0.41	0.42	0.34	0.46
Macronutrients	Orthophosphate, Dissolved (as P)	1/2005–12/2015	mg/L	5	0.035	0.034	0.032	0.038

Table 2.4f. Summary of selected water quality results for Wacissa #2 Spring

Data from DEP and SRWMD

Indicator Type	Analyte	TMDL Verified Period through 12/2015	Units	Number of Samples	Mean	Median	Minimum	Maximum
Macronutrients	Nitrate+Nitrite, Total (as N)	1/2005–12/2015	mg/L	59	0.410	0.420	0.240	0.500
Macronutrients	Orthophosphate, Dissolved (as P)	1/2005–12/2015	mg/L	61	0.037	0.033	0.008	0.190

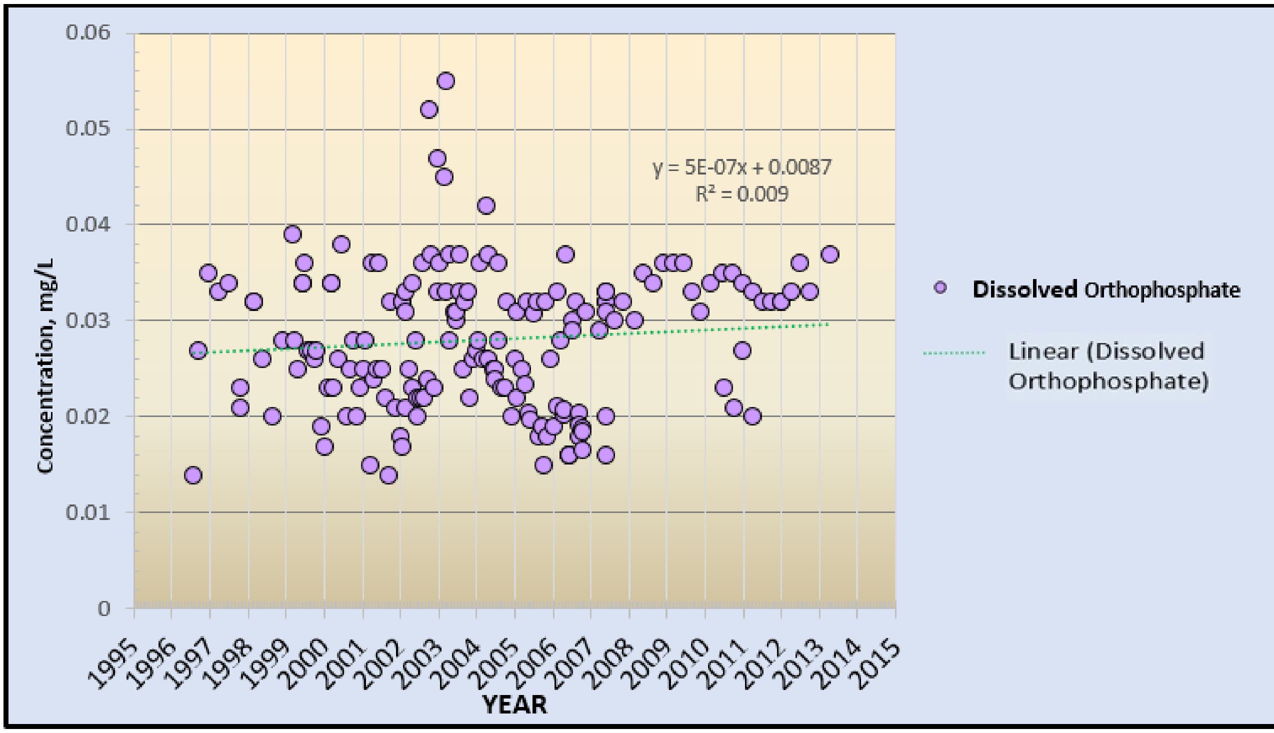

Figure 2.9. Historical orthophosphate concentrations in Wacissa River and Springs samples

Chapter 3. Description of Applicable Water Quality Standards and Targets

3.1 Classification of the Waterbody and Criterion Applicable to the TMDLs

Florida's surface waters are protected for six designated use classifications, as follows:

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

Wacissa Springs (WBID 3424Z) and Wacissa River (WBID 3424) are Class III waterbodies (with designated uses of fish consumption; recreation, propagation, and maintenance of a healthy, well-balanced population of fish and wildlife). The Class III water quality criterion applicable to the impairment addressed by these TMDLs is nutrients, which have been demonstrated to adversely affect flora or fauna in the Wacissa River.

3.2 Applicable Water Quality Standards and Numeric Water Quality Targets

3.2.1 Nutrients

The narrative nutrient water quality criterion for the protection of Class III waters, as established in Paragraph 62-302.530(47)(b), F.A.C., states that nutrient concentrations of a body of water shall not be altered so as to cause an imbalance in natural populations of aquatic flora or fauna. While Rule 62-302, F.A.C., provides NNC for spring vents and streams, Paragraph 620-302.531(2)(a), F.A.C., allows the development of site-specific numeric interpretations of the narrative nutrient criterion. This imbalance includes algal mats or blooms that are present in sufficient quantities to pose a nuisance or hinder the reproduction of a threatened or endangered species, as stated in Subsections 62-303.351(3) and 62-303.354(2), F.A.C. Accordingly, the IWR (Subsection 62-303.450[6], F.A.C.) allows the use of alternative, site-specific protective thresholds that more accurately reflect conditions beyond which an imbalance in flora or fauna occurs in a waterbody. These site-specific thresholds must provide a numeric interpretation of the narrative nutrient criterion in Paragraph 62-302.530(47)(b), F.A.C.

For the impaired waterbodies (Wacissa Springs and River), benthic macroalgae mats and epiphytic algae growing on macrophytes were shown to be a significant problem. Algal growth causes a variety of ecological impairments, including, but not limited to, the smothering of habitat, the production of toxins that may affect biota, the reduction of oxygen levels, and an increase in diurnal swings of the dissolved oxygen (DO) regime in the stream. Macroalgal mats can produce human health problems, foul swimming areas, inhibit navigation, and reduce the recreational value of clear springs or spring runs.

The results of the analysis of nutrient data for Wacissa River and Wacissa Springs indicate that the target nutrient for TMDL development should be nitrate-nitrogen, the most mobile and bioavailable form of nitrogen. As discussed in **Section 2.8**, TN and TP concentrations in the springs are much lower than the generally applicable nutrient thresholds for streams in the Panhandle East Nutrient Region. Further, orthophosphate, the main form of phosphorus in the river and springs, is from natural sources. This information indicates that the existing TN, TP, and orthophosphate concentrations are not having a detrimental effect on surface water quality and the applicable NNC are protective of the designated use. Thus, there is no need to develop a TMDL for TN, TP, or orthophosphate. Nitrate is considered the target nutrient for Wacissa Springs and River.

Chapter 5 discusses the nitrate impairment and the setting of the TMDL target concentrations for nitrate for Wacissa Springs and River. These targets (maximum monthly averages of 0.20 mg/L in Wacissa River and 0.24 mg/L in Wacissa Springs, not to be exceeded) will be submitted to the EPA for approval as site-specific (Hierarchy 1) interpretations of the narrative nutrient criterion for these waterbodies, as provided in Rule 62-302.531, F.A.C.

3.2.2 Outstanding Florida Water (OFW) Designation

The Wacissa River was listed in 1990 as one of Florida's OFWs in Rule 62-302.700, F.A.C. OFWs are designated as worthy of special protection because of their natural attributes. Projects regulated by DEP or a water management district that are proposed within an OFW must not lower existing ambient water quality, which is defined for the purposes of an OFW designation as water quality at the time of OFW designation or the year before applying for a permit, whichever is better. To date, no facilities have requested permits to discharge to the Wacissa River. There are no water quality data for the Wacissa River from 1990, and so it is not possible to compare the proposed TMDL with the water quality in the river when it was designated an OFW. However, the purpose of setting the TMDL is to provide a water quality target for restoring the waterbody to meet water quality standards and allow the waterbody to meet its designated use.

Chapter 4: Assessment of Sources

4.1 Population and Land Use in the Contributing Area for Impaired Waters

4.1.1 Population

The Florida portion of the contributing area of Wacissa Springs and River lies in Jefferson and Madison Counties. According to a 2015 estimate, total populations in these counties were 14,519 and 19,200, respectively, and they ranked 63rd and 56th in population size, respectively, out of Florida's 67 counties (University of Florida 2015). The largest population center in the contributing area is Monticello, with a 2015 population of 2,458.

4.1.2 Land Uses

Land use information for the part of the Wacissa Springs and River contributing area in Florida was obtained from the 2010–11 SRWMD and 2012–13 Northwest Florida Water Management District (NWFWMD) land use GIS coverages, which were the most recent land use data available. **Table 4.1** and **Figure 4.1** show the breakdown of the various land use categories in the Wacissa River and Springs contributing area. From 2010 through 2013, agriculture, wetlands, and forest areas were the predominant land uses in the contributing area for the river and springs, covering 12 %, 37 %, and 43 % of the area, respectively. Rangeland was fourth, comprising 4 % of the contributing area.

Table 4.1. Percentages of major land uses in the Florida portion of Wacissa Springs and River contributing area, 2010–13

Code	Land Use	Square Miles	Acres	% of Contributing Area
1100	Low-Density Residential	15.97	10,219.04	2.10%
1200	Medium-Density Residential	1.96	1,256.27	0.26%
1300	High-Density Residential	0.06	41.27	0.01%
1400	Commercial	0.95	608.31	0.12%
1500	Light Industrial	0.06	36.99	0.01%
1600	Extractive/Quarries/Mines	0.02	13.65	0.00%
1700	Institutional	0.75	482.51	0.10%
1800	Recreational (golf courses, parks, marinas, etc.)	0.29	187.53	0.04%
1900	Open Land	0.61	390.34	0.08%
2000	Agriculture	91.97	58,859.40	12.09%
3000 & 7000	Rangeland	32.32	19,864.75	4.25%
4000	Forest/Rural Open	325.76	209,308.03	42.82%
5000	Water	5.40	3,454.29	0.71%
6000	Wetlands	278.77	178,412.95	36.65%
8000	Communication and Transportation	5.83	3,730.44	0.77%
	Total	**760.73**	**486,865.79**	**100%**

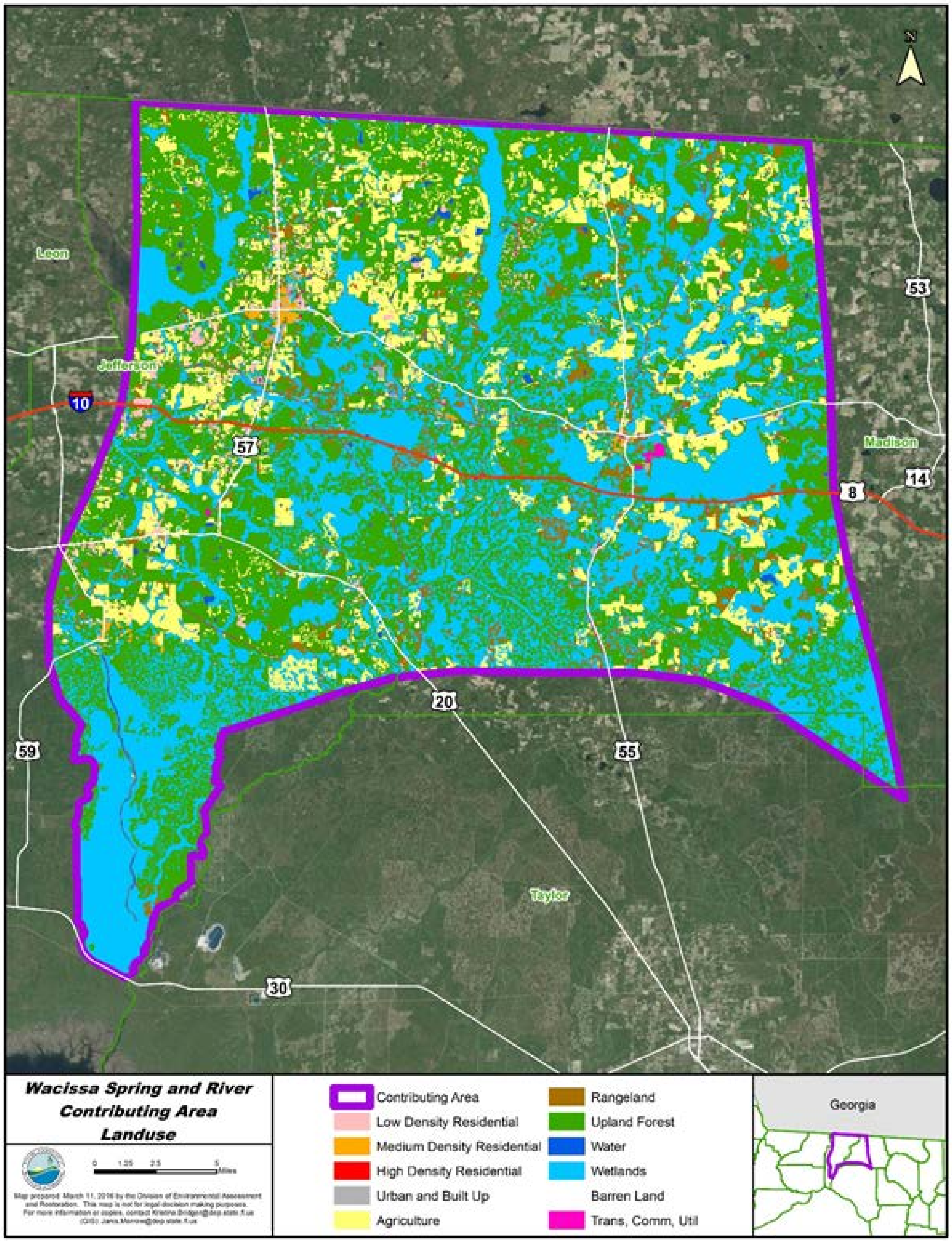

Figure 4.1. Land use in the Wacissa River and Springs contributing area of Florida

4.2 Pollutant Source Categories

An important part of the TMDL analysis is the identification of pollutant source categories, source subcategories, or individual sources of nutrients in the watershed and the magnitude of pollutant loading contributed by each of these sources. Sources are broadly classified as either "point sources" or "nonpoint sources." Historically, the term "point sources" has meant discharges to surface waters that typically have a continuous flow via a discernible, confined, and discrete conveyance, such as a pipe. Domestic and industrial wastewater treatment facilities (WWTFs) that discharge directly to surface waters and are covered by a National Pollutant Discharge Elimination System (NPDES) permit are examples of traditional point sources.

In contrast, the term "nonpoint sources" refers to intermittent, rainfall-driven, diffuse sources of pollution associated with everyday human activities and those sources that do not directly discharge to an impaired surface water, including runoff from urban land uses, wastewater treatment sites, stormwater drainage wells, agriculture, silviculture, mining, discharges from on-site treatment and disposal systems (OSTDS) (or septic systems), and atmospheric deposition. All pollutant sources that discharge to groundwater, including wastewater application sites, are also classified as nonpoint sources.

However, the 1987 amendments to the Clean Water Act redefined certain nonpoint sources of surface water pollution as point sources subject to regulation under the EPA's NPDES Program. These nonpoint sources include certain urban stormwater discharges to surface water, such as those from local government master drainage systems, construction sites with land disturbance over one acre, and a wide variety of industries (see **Appendix A** for background information on the federal and state stormwater programs).

To be consistent with Clean Water Act definitions, the term "point source" will be used to describe traditional point sources (such as domestic and industrial wastewater discharges to surface water) and stormwater system discharges to surface water that require an NPDES stormwater permit when allocating pollutant load reductions required by a TMDL (see **Section 6.1**). However, the methodologies used to estimate nonpoint source loads do not distinguish between NPDES stormwater discharges and non-NPDES stormwater discharges, and as such, this source assessment section does not make any distinction between the two types of stormwater.

4.3 Potential Nitrate Sources in the Contributing Area of Wacissa River and Springs in Florida

While nitrate occurs naturally in the environment through nitrogen fixation, bacterial processes, and lightning, the elevated and increasing levels of nitrate in the springs may come from a variety of anthropogenic sources. These may include permitted domestic wastewater treatment sites, OSTDS, fertilizer applied to residential landscaping and lawns, golf courses, agricultural operations, pet and livestock waste, and atmospheric deposition. While not a nitrate source per se, stormwater runoff is an important pathway for nitrate to reach an impaired waterbody.

4.3.1 Point Sources

4.3.1.1 Domestic Wastewater

Domestic wastewater application sites can produce a significant load of nitrogen in spring areas. **Figure 4.2** shows the locations of the four domestic WWTFs in the part of the contributing area of Wacissa River and Springs in Florida. **Table 4.2** lists the Florida-permitted facilities and their permit numbers. One domestic WWTF has an NPDES-permitted discharge to surface water, but most of the treated wastewater effluent from these facilities infiltrates to groundwater; thus by definition they are not considered point sources of pollution.

The largest WWTFs in the contributing area are the City of Monticello WWTF (design capacity 1 million gallons per day [mgd] and the Jefferson County Correctional Facility WWTF (design capacity 0.25 mgd). The City of Greenville facility, the third largest, has a design capacity of 0.12 mgd. Three of the four domestic WWTFs discharge treated effluent to groundwater via spray irrigation. The Monticello facility discharges effluent to a combined man-made and natural treatment wetland. **Table 4.2** contains summary information on the domestic facilities in the springs contributing area with permitted discharges.

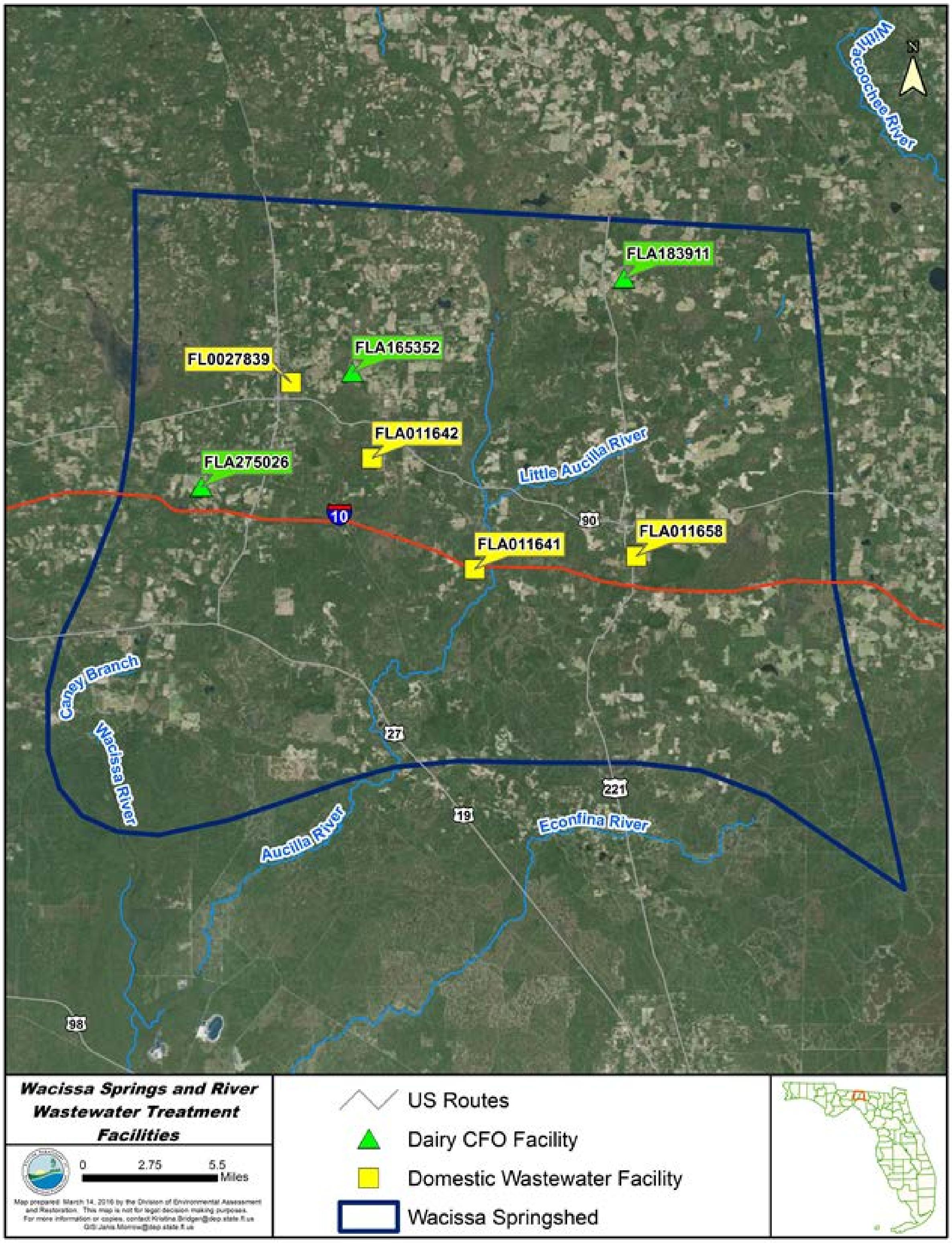

Figure 4.2. Domestic wastewater facilities and permitted confined animal feeding operations (CAFOs) in the contributing area of Wacissa River and Springs in Florida

4.3.1.2 Confined Animal Feeding Operations (CAFOs)

Three dairies in the Florida portion of the contributing area meet the definition of a CAFO and are required to have wastewater permits under Chapter 62-670, F.A.C., for feedlot and dairy wastewater treatment and management requirements. **Table 4.2** lists permit information for these facilities, and **Figure 4.2** shows their locations.

A dairy classified as a CAFO keeps a herd of more than 700 adult cows in a confined setting and must have a permit. A dairy containing fewer than 700 adult cows can also be designated a CAFO if the facility has a surface water discharge to a water of the state via a ditch or other man-made device. Of the 3 permitted CAFOs, 2 have surface water discharges and NPDES permits. Significant quantities of process-generated wastewater can be generated in the operation of CAFO dairies and may include spillage from watering systems, washing, cleaning or flushing pens, barks, manure pits, washing or spray cooling animals, and dust control.

Table 4.2. Domestic wastewater facilities and CAFOs in the contributing area of Wacissa River and Springs in Florida

N/A = Not applicable

Facility ID Number	Facility Name	Facility Type	NPDES	Permitted Flow (mgd)	County
FLA11641	FDOT I010 Rest Area WWTF	Domestic	No	0.015	Jefferson
FL0027839	City of Monticello WWTF	Domestic	Yes	0.8	Jefferson
FLA011658	City of Greenville WWTF	Domestic	No	0.12	Madison
FLA011642	Jefferson Correctional Institution WWTF	Domestic	No	0.25	Jefferson
FLA183911	Jeffco Dairy	CAFO	Yes	N/A	Jefferson
FLA165352	Walker and Sons Farm 1	CAFO	Yes	N/A	Jefferson
FLA275026	Walker and Sons Farm 2	CAFO	Yes	N/A	Jefferson

4.3.1.3 Municipal Separate Storm Sewer Systems (MS4s)

An MS4 under the federal NPDES Program is a publicly owned conveyance or system of conveyances (i.e., ditches, curbs, catch basins, underground pipes, etc.) that is designed or used for collecting or conveying stormwater and that discharges directly to surface waters of the state. Wasteload allocations (WLAs) may be assigned to MS4 entities if their discharges affect impaired surface waters. There are no MS4 entities in the contributing area.

4.3.2 Nonpoint Sources

4.3.2.1 OSTDS

OSTDS are used to dispose of domestic waste at homes that are not on central sewer, often because providing central sewer is not cost-effective or practical. When properly sited, designed, constructed, maintained, and operated, OSTDS are a sanitary means of disposing of domestic waste. The nitrogen concentrations in effluent from OSTDS are considerably higher than those in effluent from typical domestic WWTFs, although the wastewater profile can vary from home to home. The physical setting of an OSTDS (soil and aquifer characteristics and proximity) is also a factor in the amount of nitrogen it can contribute to groundwater and springs (USGS 2010).

On average, the TN concentration in the effluent from a typical OSTDS is 57.7 mg/L (Hazen and Sawyer 2009), although this concentration is reduced further as the effluent is discharged to the drainfield and percolates to groundwater. Under a low-density residential setting, nitrogen loadings from OSTDS may not be significant, but under a higher density setting, one could expect the nitrogen input to be 129 pounds per acre per year (lb/ac/yr) (Harrington et al. 2010). However, some nitrogen reduction would occur in the drainfield and soil above the water table, and, as discussed previously, the actual load to groundwater would vary based on actual use and setting.

Concern has grown over the abundance and continuing use of septic tanks as the primary sanitary sewer disposal method in the contributing areas of springs, particularly those in higher density areas close to the springs. The population in this spring contributing area is relatively low and scattered. Data for septic tanks are based on the Florida Department of Health (FDOH) statewide inventory of OSTDS (Hall and Clancy 2009). According to the FDOH parcel coverage, the Florida portion of the contributing area contains 7,500 OSTDS (**Figure 4.3**).

4.3.2.2 Runoff from Urbanized Areas

Urban areas include land uses such as residential, industrial, utility easements, recreational, institutional, commercial, and extractive (mining). Nutrient loading from urban areas (whether in an MS4 jurisdiction or not) can come from multiple sources, including groundwater seepage, stormwater runoff, illicit discharges of sanitary waste as a result of sanitary sewer overflows (SSOs), OSTDS, domestic animals, and fertilizers from home gardens, lawns, and golf courses. Of the total land area in the Florida portion of the Wacissa River and Springs contributing area, less than 3 % is mapped as urban. Virtually no urban acreage adjoins the Wacissa River. Thus, runoff from urbanized areas is not a concern in these waters. One small county park has a boat ramp and swimming area next to the river at the headsprings, but most of the area is unpaved, and the potential for significant runoff impacts is remote.

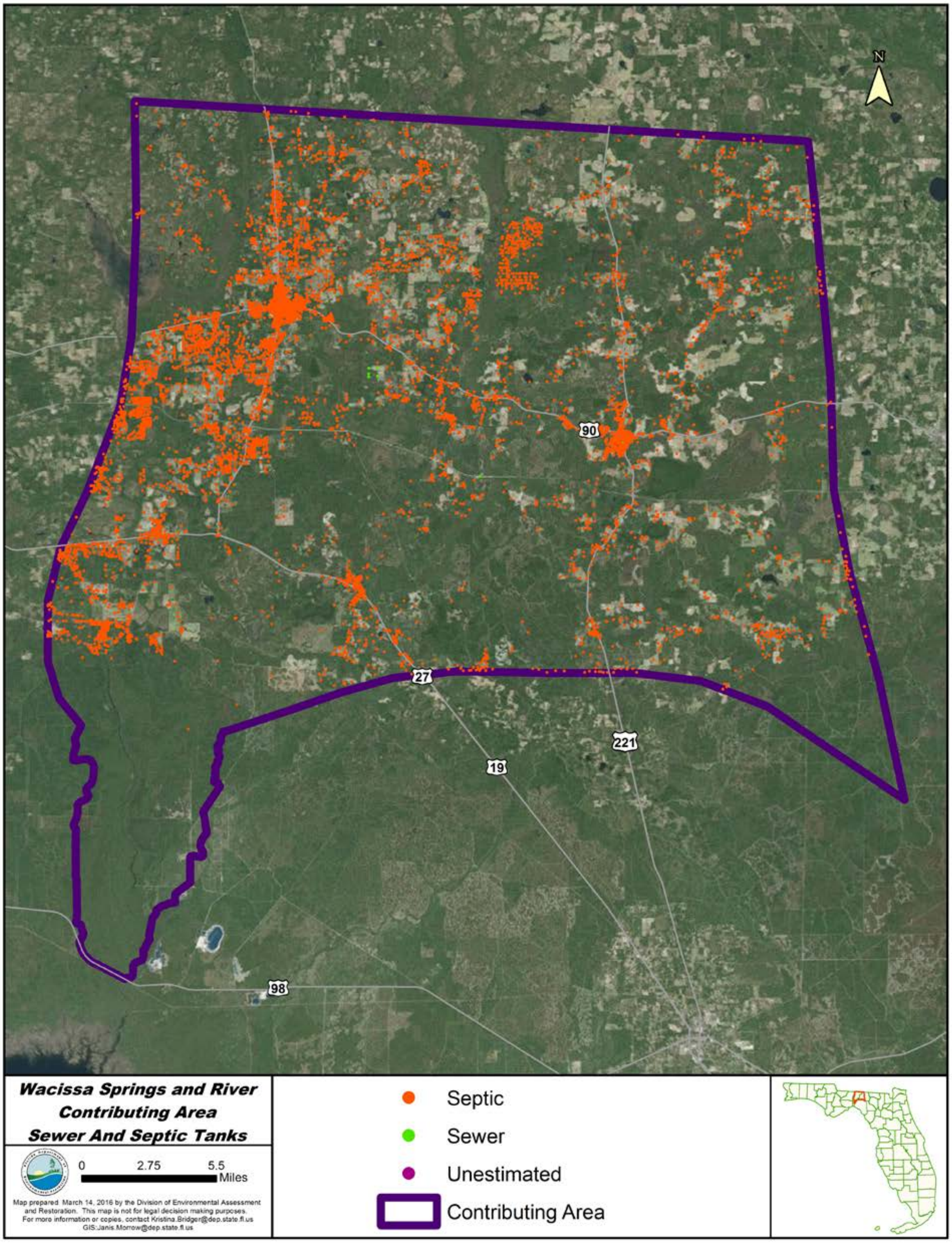

Figure 4.3. Density of OSTDS (septic tanks) in the contributing area of Wacissa River and Springs in Florida

4.3.2.3 SSOs

Untreated sewage can be a potential source of nitrogen in areas where there are leaky sewers, breaks, or lift station overflows. Leaks and overflows are common in many older sanitary sewers where capacity is exceeded, high rates of infiltration and inflow occur (i.e., outside water gets into pipes, reducing capacity), frequent blockages occur, or there is pipe deterioration associated with older systems. Power failures at pumping stations can also cause SSOs. The greatest risk of an SSO occurs during storm events. However, few comprehensive data are available to quantify SSO frequency and nutrient loads in most watersheds. There are no areas served by sanitary sewer near Wacissa River and Springs to allow for direct discharges to the river, and so discharges to groundwater are the main concern.

4.3.2.4 Agricultural Fertilizer and Livestock Waste

Agricultural land uses in the contributing area are likely to contribute nitrogen to the springs. **Table 4.3** lists the agricultural activities associated with these land use categories, along with their associated land areas and potential nitrogen inputs from fertilizer application. Pasture for cow-calf operations and dairies makes up the largest acreage, followed by hayfields, some of which may also be related to the same two types of activities. Field and row crops also cover a sizable acreage (with fallow farmland included in the combined acreage). The summary table also includes pecan groves because of the acreage and associated fertilizer use. Dairy operations, although small in acreage for the actual barn and barnyard areas, account for many acres of pasture, hayfield, and field/row crop acreage because of the hay and silage production needed to supply feed to confined milking herds, and the pastures needed for dry cows and replacement heifers.

4.3.2.5 Atmospheric Deposition

Across Florida atmospheric deposition is also an important potential nitrogen source. Wet and dry deposition was estimated using a nationwide model developed by Schwede and Lear (2014) based on several monitoring networks—including the Clean Air Status and Trend Network (CASTNET), the National Atmospheric Deposition Program (NADP) Ammonia Monitoring Network, the Southeastern Aerosol Research and Characterization Network, and modeled data from the Community Multi-Scale Air Quality Model and the National Trends Network. An average deposition rate in the Wacissa River area based on this modeling tool is 5.72 lbs-N/ac/yr, or a total of 2,797,917 lbs-N/yr across the 761-square-mile contributing area in Florida.

Table 4.3. Agricultural land uses in the contributing area of Wacissa River and Springs in Florida and their potential nitrogen inputs

[1] Mylavarapu et al. 2015.
[2] Shukla et al. 2014.
[3] Anderson 2015. Estimate is based on mature trees (18-inch diameter) at approximate 60-foot spacing (20 trees/acre), fertilized twice annually at 2 pounds per inch in diameter.

Agricultural Land Use	Acreage in Contributing Area	Associated Agricultural Activities	Applied Nitrogen (annual estimates)
Improved and woodland pastures	27,257	Cow-calf operations, dairies	For improved pasture: bahiagrass in summer, 50–60 lbs/ac (low nitrogen option); winter rye (if overseeded), 50 lbs/ac after emergence.[1] Woodland pasture is generally not fertilized.
Hayfield	15,330	Cow-calf operations, dairies	For bahiagrass, 160 lbs/ac (assuming 2 cuttings).[1]
Field crops, row crops, fallow farmland	6,894		Nonirrigated corn, 150 lbs/ac; irrigated corn, 210 lbs/ac; grain sorghum for silage, 150 lbs/ac; peanuts, 0 lbs/ac; soybeans, 0 lbs/ac; watermelon, 150 lbs/ac.[1,2]
Groves	2,533	Cow-calf operations	Pecan groves; mature groves at 60-foot spacing, 150 lbs/yr.[3]
Dairies	103	Pasture, field crops, hayfields	See pasture, silage, hayfields for estimated fertilization rates; fertilizer use may be less in areas where dairy wastewater is applied.

4.3.2.6 Decomposing Organic Matter

Decomposing vegetation, filamentous algal mats, and decaying aquatic organisms also release nutrients as they break down. As aquatic weeds and algae slowly decompose, a portion of the nitrogen and phosphorus is released back into the water column, and some of it settles into the sediments (Sickman et al. 2009). Decomposing organic matter tends to release organic nitrogen that converts to ammonium. The scenario for the conversion of nitrogen in decaying aquatic plants to nitrate in the water column—the form of nitrogen of concern to the health of Wacissa River and Springs—is remote. However, the accumulation of decomposing organic matter has other significant adverse effects, as it can physically smother vegetation and blanket a sandy or rocky bottom with muck.

4.3.2.7 Livestock and Wildlife

Livestock and wildlife contribute nitrogen loading by depositing feces onto land surfaces, where they can be transported to nearby streams during storm events or by direct deposition to the waterbody. Nitrogen loads originating from local wildlife are generally considered to represent natural background concentrations. In most impaired watersheds, the contribution from wildlife is small compared with the load from urban and agricultural areas. The actual livestock counts in the contributing area for Wacissa River and Springs have not been calculated but could be significant, considering the amount of acreage in pasture and the presence of CAFO dairies in the area. A more detailed evaluation of potential nitrogen inputs from livestock will be performed during BMAP development.

4.3.2.8 Wastewater and Fertilizer Chemical Tracers

Studies have shown that the artificial sweetener sucralose is relatively stable in the environment and can pass through wastewater treatment systems and septic tank drainfields largely intact. As a result, sucralose is used as a tracer of human wastewater sources.

DEP collected water samples from Wacissa #2 for sucralose analyses 4 times in 2012, twice in 2013, and once in 2014. In addition, on March 26, 2014, 4 other springs along the Wacissa River (Big Blue, Cassidy, Log, and Thomas) were sampled for sucralose. None of the water samples from Wacissa #2 or the other springs had detectable concentrations of sucralose. The reported DEP laboratory detection limit is 0.01 micrograms per liter (µg/L) for sucralose analyses.

NITROGEN AND OXYGEN ISOTOPES OF NITRATE

The stable nitrogen and oxygen isotopes of nitrate molecules have been used as tracers to evaluate nitrogen sources and processes that affect nitrate in groundwater and springs. Nitrate (NO_3) in groundwater is composed of two stable isotopes of nitrogen (^{14}N and ^{15}N) and oxygen (^{16}O and ^{18}O). The vast majority of naturally occurring stable isotopes of elemental nitrogen and oxygen are ^{14}N and ^{16}O, respectively. The difference between the lighter and heavier isotopes involves extra neutrons present in the nuclei of the ^{15}N and ^{18}O isotopes. The ratio of the heavier N isotope to the lighter isotope in the atmosphere is constant. However, the additional weight conveyed by the presence of the neutron in ^{15}N causes isotope fractionation in natural systems. Due to its lighter weight, ^{14}N is preferentially returned to the atmosphere during denitrification. Because animal and plant tissue is ^{15}N enriched, nitrogen in groundwater can be traced to an organic or inorganic source.

Nitrogen and oxygen isotope ratios are reported in parts per thousand (ppt) using the standard delta (δ) notation (Kendall and Aravena 2000). Nitrogen isotope ratios are reported relative to N_2 in atmospheric air, while oxygen isotope ratios are reported relative to Vienna Standard Mean Ocean Water (VSMOW). Typically, $\delta^{15}N\text{-}NO_3$ in groundwater with an enrichment of over 10 ppt is considered representative of septic tank discharge and animal waste. Levels of $\delta^{15}N\text{-}NO_3$ below 3 ppt are representative of sources of nitrogen not entrained in the natural system, such as inorganic fertilizer. Levels of $\delta^{15}N\text{-}NO_3$ between 3 and 10 ppt indicate mixed inorganic and organic sources (Katz et al. 1999; Katz 2004).

Anthropogenic sources of inorganic nitrate include fertilizer applied to agricultural fields, residential lawns, and golf courses. Anthropogenic sources of nitrate derived from organic material include domestic wastewater and residuals, septic tank effluent, and animal waste from equine, poultry, and cow/calf operations.

Based on data from numerous studies reported in the literature (Kendall and Aravena 2000; Choi et al. 2003), nitrogen and oxygen isotope values fall into ranges that can be attributed to different sources of nitrate. The four main nitrogen source categories are inorganic (from synthetic fertilizers), organic (from animal waste or domestic wastewater), rainfall, and soil (which includes nitrogen from any source assimilated by soil and accumulated in soil organic matter).

DEP does not consider soil nitrogen to be a significant factor affecting springs, because most of the soils in the contributing area to the springs have a low content of organic material and contain little or no nitrogen. The nitrate isotopic composition is similar for animal manure and human wastes. Therefore, other chemical indicators, such as sucralose and/or pharmaceutical compounds, are helpful in distinguishing between these two sources. The isotopes of nitrogen and oxygen in nitrate are most commonly used to distinguish between inorganic fertilizer and organic waste sources. **Figure 4.4** shows the typical ranges of isotopic values for these two sources.

DEP collected water samples for nitrate isotopes from Wacissa #2 Spring from 2011 through 2014. Samples were also collected three times in 2014 (March, June, and October) from Big Blue, Cassidy, Log, and Thomas Springs. Nitrate isotope data from many of these samples cluster within or near the range for an inorganic fertilizer source (**Figure 4.4**). However, water samples from Wacissa #2 Spring in 2013 and 2014 had slightly higher $\delta^{15}N\text{-}NO_3$ and $\delta^{18}O\text{-}NO_3$ values that are more consistent with a mixture of inorganic and organic nitrogen sources.

There are two possible scenarios for the higher values of $\delta^{15}N\text{-}NO_3$ and $\delta^{18}O\text{-}NO_3$ in the more recent samples. One scenario may be related to microbially mediated denitrification, which would result in slight enrichment in the heavier isotopes of N and O. The nitrate isotope data for the entire period from 2011 through 2014 cluster along a denitrification trend line where the isotopic composition of both $\delta^{15}N\text{-}NO_3$ and $\delta^{18}O\text{-}NO_3$ becomes more enriched (**Figure 4.4**). This finding is consistent with lower mean (and median) nitrate-N concentrations of 0.47 and 0.41 mg/L in samples from 2013 and 2014, respectively, compared with samples from 2011 through 2012 (**Figure 4.5**). Also, $\delta^{15}N\text{-}NO_3$ and nitrate-N concentrations are inversely related, which could be an indication of denitrification (**Figure 4.6**).

The second scenario may be related to nitrate originating from an organic waste source being added to water recharging the aquifer. Given that sucralose was not detected, an animal waste source could be more likely, although nondetects of sucralose do not provide conclusive information.

Previous studies indicate that inorganic fertilizer is a significant source of nitrate to springs in the Suwannee River Basin, based on the measured ratios of the two stable isotopes of nitrogen (^{14}N and ^{15}N) (Katz et al. 1999). The high potential for fertilizer to leach through the well-drained sandy soils typical of spring areas is a major reason that inorganic fertilizer is such a prevalent source of nitrate in groundwater and springs. In addition to fertilizer applied for agricultural activities, fertilizer applied to residential lawns and landscaping could potentially contribute nitrate to the impaired waters, although the contributing area has few urban land uses.

BMPs and local ordinances and programs are designed to encourage the conservative use of fertilizers and where implemented can reduce fertilizer leaching. Similarly, BMPs for manure management of cow-calf operations and dairies have been developed. Examples include the row crop, cow-calf, dairy, equine, and container nursery BMP manuals produced by FDACS.

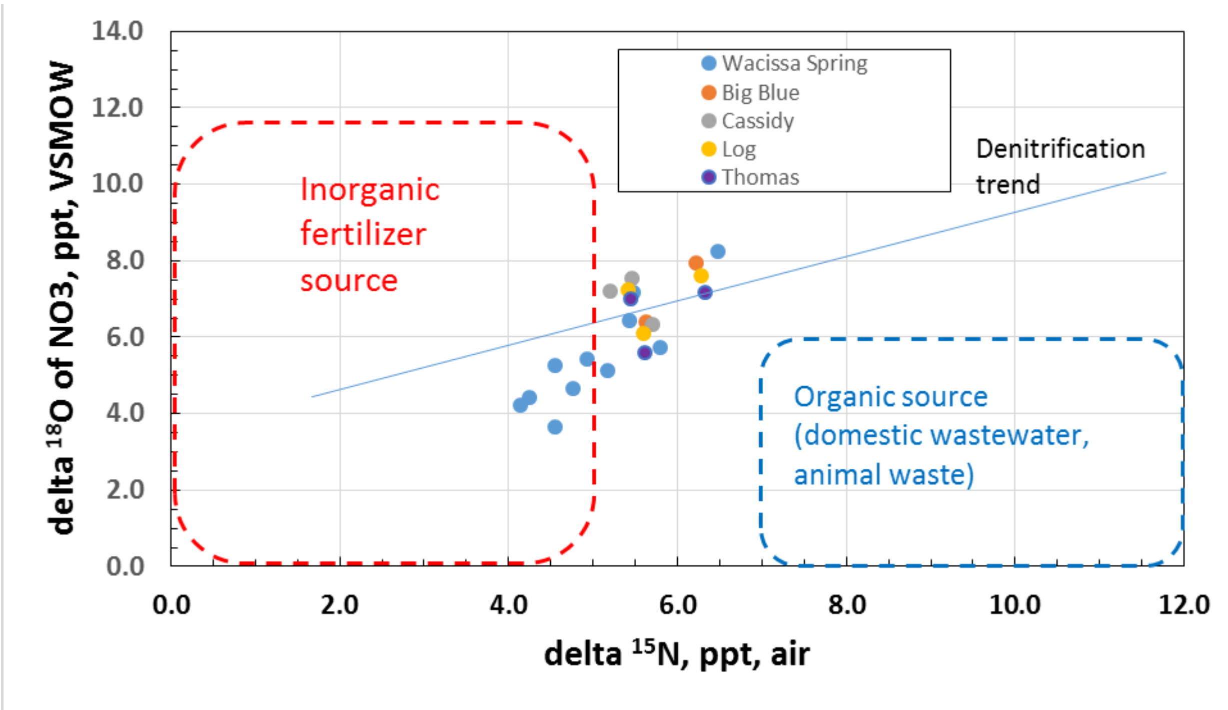

Figure 4.4. Plot of nitrogen and oxygen isotope values of nitrate for samples collected from Wacissa Springs

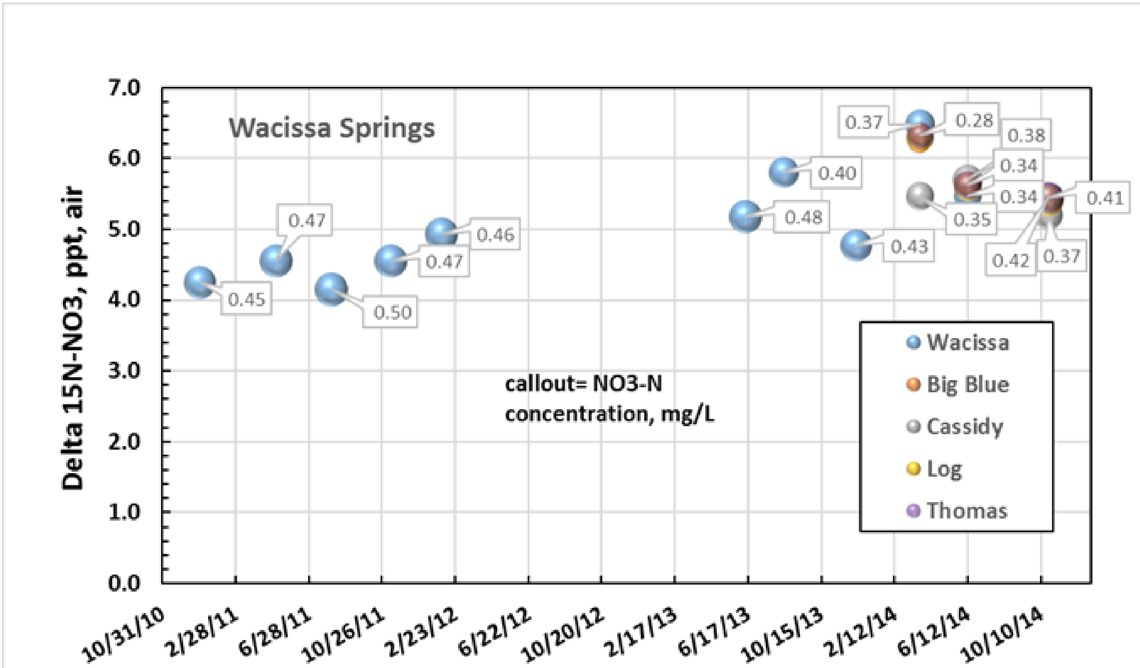

Figure 4.5. Nitrogen isotope values of nitrate in water samples collected from Wacissa Springs, 2011–14. Size of bubble is proportional to nitrate-N concentrations, which range from 0.34 to 0.50 mg/L.

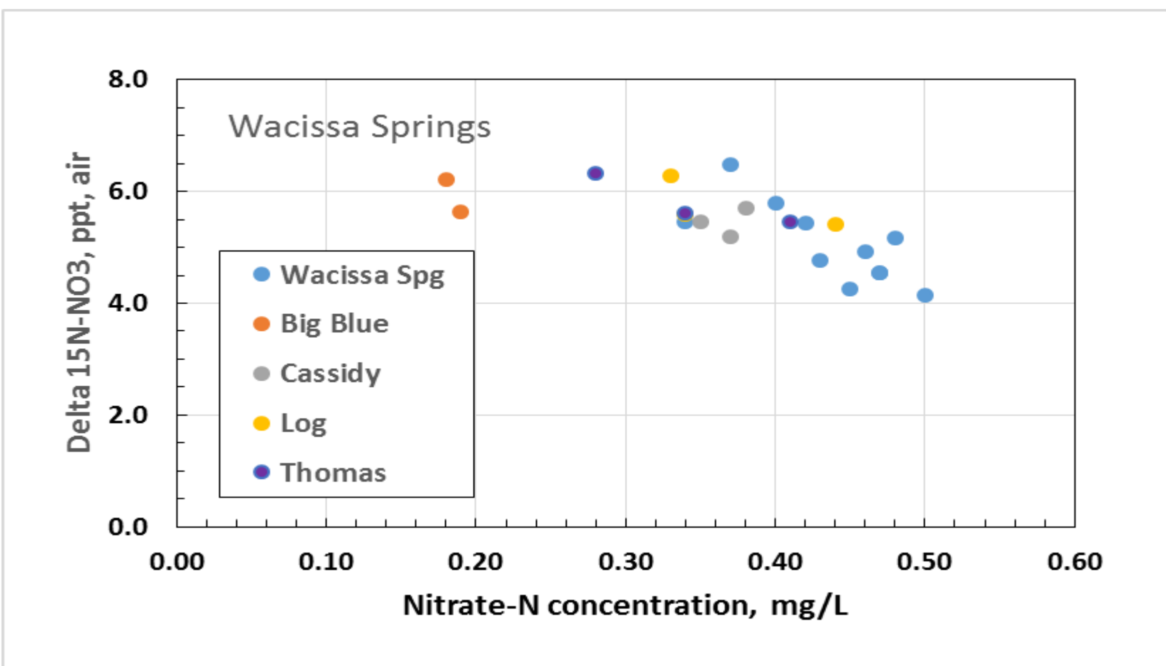

Figure 4.6. Inverse relation between nitrogen isotope values of nitrate and nitrate-N concentrations in water samples collected from Wacissa Springs, 2011–14

4.3.3 Nitrogen Source Inventory Loading Tool (NSILT)

During the BMAP development process, DEP will develop a nitrogen source inventory to estimate current loads of nitrogen to groundwater in the Wacissa Springs Group contributing area. The NSILT for estimating nitrogen loads uses a consistent, well-documented methodology that has been employed at other spring systems in the state. Similar estimates have been made in the past and have largely been based on land use. However, the NSILT takes this process a step further.

The nitrogen input to the land surface for anthropogenic sources is estimated based on detailed methods specific to each nitrogen source category. These main categories include atmospheric deposition, septic tanks, WWTFs, fertilizers (urban and agricultural), livestock waste, and any additional source category relevant to the specific area. After the nitrogen input is estimated, environmental attenuation is considered. This attenuation is specific for each source category and related to land application and other factors. The final step in the process is evaluating the influence of groundwater recharge, which varies depending on hydrogeology and soil characteristics. The final DEP NSILT report contains a series of pie charts that illustrate the estimated percent contribution of each loading category in a BMAP area.

This process is constantly being improved on and tailored for each specific area as new data become available. Stakeholder involvement is a critical aspect of this process and has been very helpful in NSILT development. DEP recognizes that no two BMAP areas are the same and tries to account for these differences in its estimates so that the end product is representative of the hydrogeology, anthropogenic inputs, and nitrogen attenuation in a BMAP-designated area.

Chapter 5: Determination of Loading Capacity

DEP often uses hydraulic and water quality models to simulate loading and the effects of loading in a given waterbody. However, there are other appropriate methods to develop a TMDL that are just as credible as a modeling approach. Such an alternative approach was used to estimate existing mean concentrations and calculate the TMDLs for Wacissa River and Springs.

5.1 Determination of Loading Capacity

Typically, the target loading and existing loading for a stream or watershed are based on hydrologic and water quality modeling. Many of these models depend on the relationship between flow and surface water drainage area, as well as the relationship between land use, soils, and pollutant delivery.

The predominant source of nutrient loading to the Wacissa River is groundwater discharged at the springs. In most of the contributing area of the river in Florida, recharge to the aquifer can readily occur. Rainwater percolates directly through the soil profile, and surface drainage flows toward sinkholes and closed depressions, where it infiltrates and reaches the Wacissa River via groundwater discharged from the spring vents. Thus, a direct relationship between surface water loadings in the watershed is not appropriate. This diffuse loading situation requires the use of an alternative approach for establishing the nutrient TMDLs.

Existing spring loading can be estimated by multiplying the measured spring flow by the measured pollutant concentrations in the spring. To estimate the pollutant loading this way, synoptic flow and concentration data measured at the outlet of each spring vent under assessment are required. These data were not available when the TMDLs were developed. Therefore, the nitrate loads were not explicitly calculated, nor were they needed, since the TMDL targets for these waters are being established as concentrations.

Percent reductions required to achieve the nitrate concentration targets for Wacissa River and Wacissa Springs were calculated using the following formula:

[(existing mean concentration – target concentration)/existing mean concentration] x 100

5.2 Unique Nature of the Wacissa River

The Wacissa River is a spring-run stream with clear water, a shallow bottom, and a low flushing rate under typical conditions. For most of its reach, the river is wide (greater than 75 to 150 meters), shallow (less than 2 meters deep in most areas), and choked with aquatic vegetation that reduces flow velocity. Reduced light penetration, a low rate of water flushing, and a longer residence time for nutrients are the greatest concern in these areas. The upper river between the headsprings and county park and Big Blue Spring Run are most heavily used for recreation and may be most stressed by boat traffic and the use of aquatic herbicides for controlling invasive aquatic vegetation.

As mentioned previously, this area is also where the highest nitrate concentrations occur in the river water column and springs (**Figure 2.6**). Coincidentally, this portion of the river is the most significantly affected by the growth of benthic macroalgae. Reductions of nitrogen in the water discharging from the springs should help reduce macroalgal accumulation by slowing the growth rate of macroalgae (Stevenson et al. 2007). Therefore, this TMDL document establishes appropriate maximum allowable nitrogen concentrations in water delivered to the Wacissa River by the springs and in the river itself to help reduce the growth of algae.

5.3 Critical Conditions/Seasonality

Establishing the critical condition for nitrogen inputs that affect algal growth in a waterbody depends on many factors, including the presence of point sources and the land use pattern in the contributing area. The critical condition for point source loading to a waterbody usually occurs during periods of low flow, when dilution is minimized. Typically, the critical condition for nonpoint source loading to a surface water is a period of rainfall-related flushing preceded by an extended dry period. During the wet weather period, rainfall mobilizes nitrogen that has accumulated on the land surface and in the soil under dry conditions, resulting in higher pollutant concentrations. However, significant nonpoint source contributions can also appear under dry conditions without any major surface runoff event. Also, there can be a lag time between nitrogen inputs into groundwater and discharge from the spring vents.

However, for Wacissa Springs and Wacissa River, there appears to be no significant correlation between nitrate concentrations, potential loading events in response to rainfall, or changes in spring or river flow. **Figure 5.1** shows the plotted nitrate concentrations in Wacissa Spring #2 compared with the measured flow in the upper Wacissa River. **Table 5.1** summarizes the monthly nitrate-nitrite averages for springs in WBID 3424Z. The highest monthly average was 0.39 mg/L during October.

Table 5.2 summarizes the monthly averages for nitrate in WBID 3424. For the river, there was no apparent seasonal influence on nitrate concentrations. River data for nitrate were mostly collected on a quarterly schedule and are somewhat sparse for some months compared with the springs. The confidence level in identifying months with higher or lower concentrations is greater for months with more data. The data indicate that no samples were collected in April, and only one sample was collected during January. The highest concentration measured in WBID 3424 occurred in a sample collected in January (0.80 mg/L). However, this single sample was not considered representative of all the Januaries during the verified period. Instead, December was selected, with 6 samples collected and the highest monthly average of 0.33 mg/L.

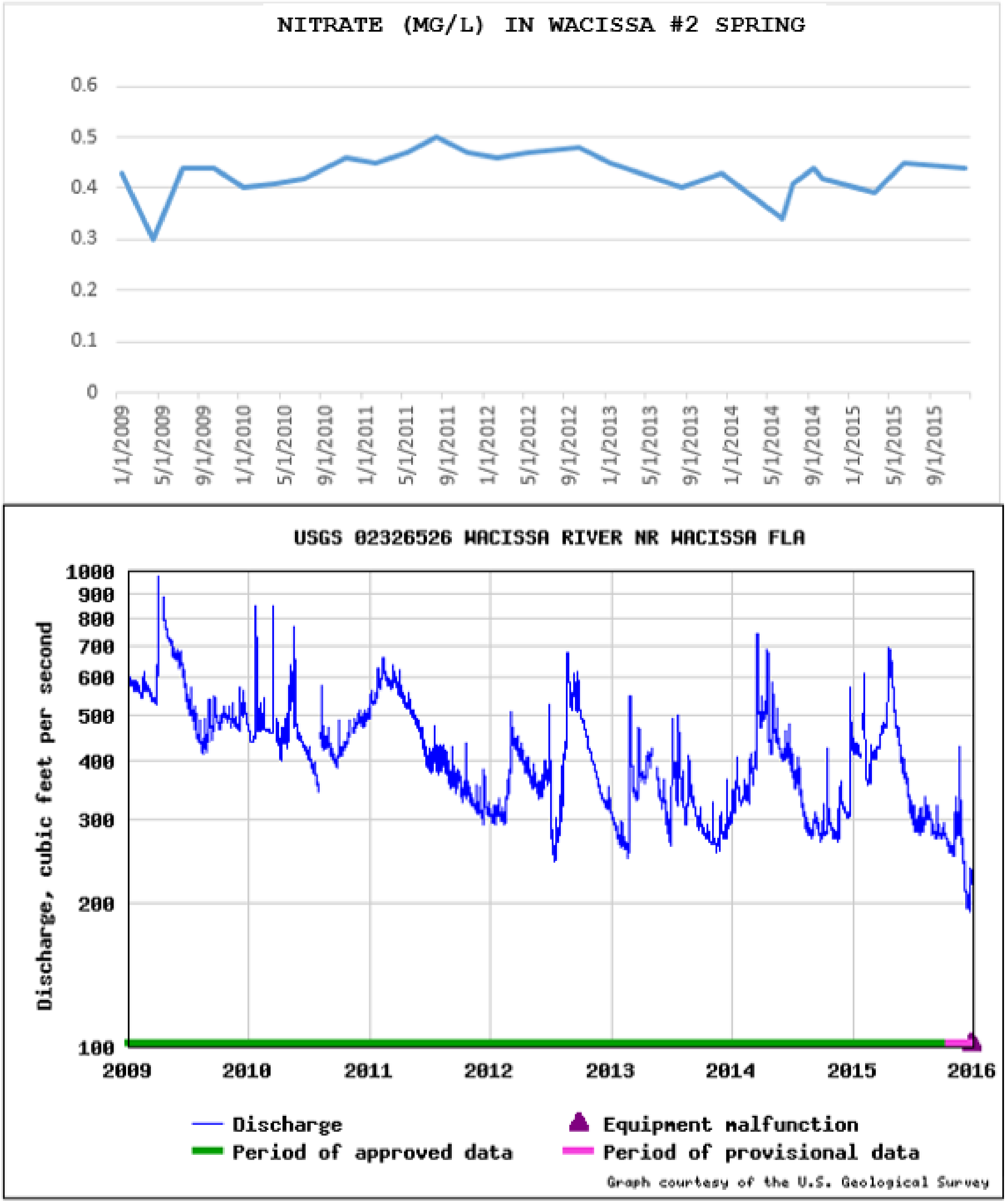

Figure 5.1. Comparison of nitrate in Wacissa #2 Spring to discharge in upper Wacissa River

Table 5.1. Monthly average nitrate-nitrite concentrations (mg/L) for springs in Wacissa Springs (WBID 3424Z) for the period of record (January 1, 2005–December 31, 2015)

* Highest monthly average

Month	Number of Samples	Mean	Maximum	Minimum	30-Year Monthly Average Rainfall (inches) in Monticello
Jan	11	0.31	0.46	0.06	4.68
Feb	9	0.27	0.46	0.04	4.71
Mar	6	0.09	0.39	0.01	5.35
Apr	6	0.38	0.49	0.24	3.37
May	6	0.26	0.47	0.00	2.80
June	8	0.25	0.45	0.01	6.36
July	9	0.34	0.47	0.00	6.16
Aug	11	0.27	0.5	0.00	6.74
Sept	10	0.19	0.44	0.00	4.82
Oct	14	**0.39***	0.48	0.08	3.39
Nov	7	0.23	0.47	0.03	3.50
Dec	7	0.32	0.44	0.10	3.88

Table 5.2. Monthly average surface water nitrate-nitrite concentrations (mg/L) for Wacissa River (WBID 3424) for the period of record (January 1, 2005–December 31, 2015)

* Highest monthly average

Month	Number of Samples	Mean	Maximum	Minimum	30-Year Monthly Average Rainfall (inches) in Monticello
Jan	1	0.80	0.80	0.80	4.68
Feb	8	0.28	0.41	0.14	4.71
Mar	7	0.22	0.29	0.12	5.35
Apr	0	0.00	0.00	0.00	3.37
May	11	0.24	0.48	0.02	2.80
June	9	0.27	0.38	0.03	6.36
July	4	0.30	0.41	0.03	6.16
Aug	7	0.28	0.40	0.09	6.74
Sept	10	0.29	0.43	0.13	4.82
Oct	13	0.28	0.46	0.02	3.39
Nov	4	0.25	0.35	0.17	3.50
Dec	6	**0.33***	0.45	0.20	3.88

5.4 TMDL Development Process

5.4.1 Use of Site-Specific Information

The proposed nitrate water quality target concentrations for Wacissa River and Springs are based on a combination of site-specific historical documentation of algal mats, laboratory studies, and field surveys. These values are considered more appropriate than the statewide nitrate criterion for springs. The statewide spring nitrate (or NO_3+NO_2-N) standard for freshwater spring vents is 0.35 mg/L as an annual geometric mean (AGM), not to be exceeded more than once in any 3 consecutive calendar years.

In many cases, this criterion is appropriate to serve as the concentration-based TMDL target for spring waters. However, TMDLs can also serve as site-specific alternative criteria where an alternative threshold is more appropriate based on waterbody-specific information. One factor that led DEP to work toward an alternative target was that algal growth was an issue in areas where existing nitrate concentrations were already lower than the standard. A combination of factors, such as slow flushing conditions resulting in apparently long residence times, and the shallow depth to bottom and clear water conditions, influence the nutrient budget in these systems and can affect the site-specific quality of spring waters.

5.4.2 Biological Study of Wacissa Springs and River

Nuisance algal growth has been observed in many springs and is associated with increases in anthropogenic activities and nutrients (Stevenson et al. 2007). Several studies described in this section evaluated the growth of *Lyngbya* sp. in response to nutrients in Florida springs. These studies were performed in the laboratory under different flow regimes and were used in the development of Florida's nitrate standard of 0.35 mg/L for free-flowing freshwater springs.

From 2012 through 2014, the DEP Groundwater Management Section collected water quality data and biological measurements at 5 spring stations (Thomas, Log, Wacissa #2, Cassidy, and Big Blue Springs) and 4 surface water stations (WR-1, WR-2, WR-3, and WR-4) in the upper reach of the Wacissa River, including the most impacted area. Surface water sites were sequentially numbered from 1, near the headspring, to 4, downstream of Big Blue Spring Run. For each sampling event, the station was located using a global positioning system (GPS) unit (Trimble Juneau SB), water quality samples were collected, and the river bottom at each station was photographed (Nikon Coolpix AW100 underwater camera) and a 360º panorama underwater video was recorded (Aqua-Vu Micro 5 with DVR). The stations were visited on May 2, 2012; December 11, 2013; March 26, 2014; June 12, 2014; July 30, 2014; September 3, 2014; and October 22, 2014.

Photo interpretation of the underwater imagery of the river bottom was conducted using a rectangular quadrat computer screen overlay divided into 10 equally measured blocks (1 0% intervals). The imagery was analyzed to determine the following: (1) filamentous % community, (2) SAV % community, (3) dominant plant species, (4) dominant % community, (5) co-dominant plant species, (6) co-dominant % community, (7) minor plant species, and (8) minor % community.

The dominant plant species was defined as a single taxon and comprises a clear, overwhelming majority of the areal coverage of plants. A co-dominant plant species was assigned where there are two taxa that are abundant and it is unclear that one taxon is definitively more abundant than the other. A minor plant species was recorded when a -taxa was identified and it was less than or equal to 20 % of the plant community.

In the Wacissa River adjacent to Log, Thomas, Wacissa #2, and Cassidy Springs, and at surface water stations WR-1, WR-2, and WR-3 through the survey period, *Lyngbya sp.* comprised 10 % to 20 % of the plant community during the winter, 10 % to 40 % during the spring, peaked to 60 % to 100 % during the summer, and then dropped to 10 % to 60 % during the fall, with further decreases back to the winter minimum.

However, for surface water station WR-4 during the survey period, *Lyngbya sp.* made up 10 % of the plant community during the winter and spring, peaked to 50 % (co-dominant with *Vallisneria*), and then fell back to 20 % during the fall, with further decreases back to the winter minimum. Throughout the entire study period, *Vallisneria* was the dominant plant and/or co-dominant plant species at WR-4. At one spring station in Big Blue Spring Run, diatoms (*Eunotia sp.* and *Aulacoseira granulata*) dominated. Diatoms in this spring run are not particularly sensitive to nitrate concentration and are apparently related to the spring's unique water chemistry.

Figure 5.2 shows the range in percent benthic algal coverage and corresponding mean nitrate concentrations at the spring and river stations. **Table 5.3** lists in greater detail the seasonal variation in nitrate concentrations, algal coverage, and coverage of nonalgal SAV for each monitoring station. **Appendix C** provides a more complete summary of the Wacissa vegetative survey.

Florida uses a tool known as the Rapid Periphyton Survey (RPS) to quantify the extent (coverage) and abundance (thickness) of attached algae (periphyton). The RPS is used to quantify the abundance of nuisance algal growth and evaluate if an imbalance of flora exceeds the NNC standard in Paragraph 62-302.531(1)(c), F.A.C. The methodology to quantify the extent of algal growth using the RPS is very similar to the approach taken in the Wacissa River vegetative study. As described in Florida's NNC support document, an imbalance of flora in a stream segment is defined as finding algal coverage of >25 % during 2 consecutive, temporally independent samplings (>3 months apart). Where algal coverage is <20 % in a stream segment, the algal composition is deemed acceptable (DEP 2013). Based on this metric, the algal coverage at Wacissa River station WR-4, which was 20 % or less on 5 out of 6 temporally independent measurement dates, would be representative of background conditions and not exceed the NNC for floral imbalance. **Figure 5.3** shows the algal coverage percentages at the headspring and four river stations monitored.

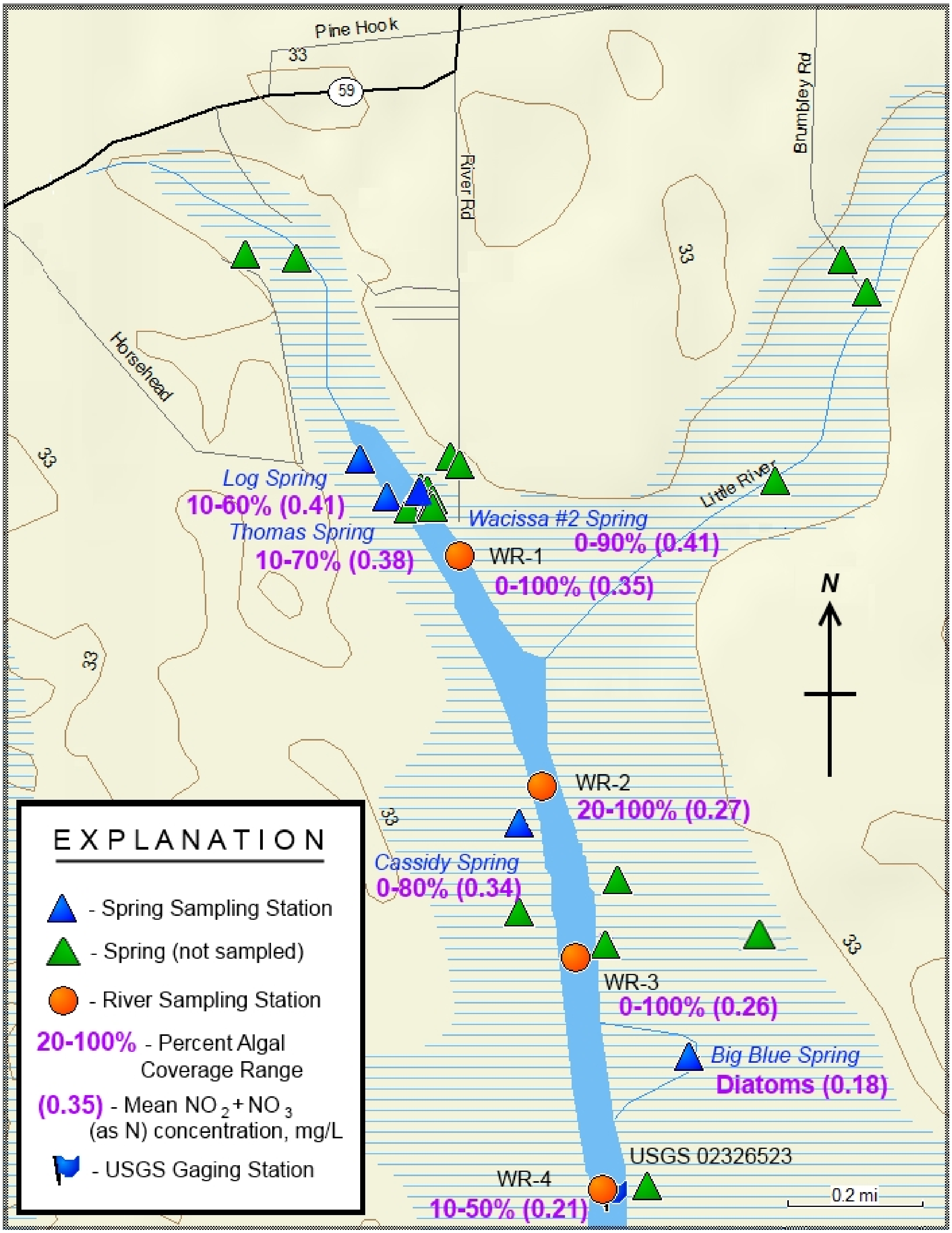

Figure 5.2. Range in filamentous algae coverage and mean NO_3+NO_2 concentrations at vegetation survey stations

Table 5.3. Wacissa vegetation survey summary results by season for spring and river stations

Station	Distance from Wacissa #2 (feet downriver)	Observations	Jan–Mar	Apr–Jun	Jul–Sep	Oct–Dec	Average NO_3+NO_2 from All Events (mg/L)
Log Spring	-446	Average of Nitrate (mg/L)	0.33	0.41	0.42	0.45	0.42
Log Spring		Average of Filamentous % Community	20	55	30	15	
Log Spring		Average of SAV % Community	80	45	70	85	
Thomas Spring	-75	Average of Nitrate (mg/L)	0.28	0.34	0.42	0.42	0.39
Thomas Spring		Average of Filamentous % Community	20	70	20	10	
Thomas Spring		Average of SAV % Community	80	30	80	90	
Wacissa #2 Spring	0	Average of Nitrate (mg/L)	0.37	0.41	0.43	0.43	0.39
Wacissa #2 Spring		Average of Filamentous % Community	10	65	90	25	
Wacissa #2 Spring		Average of SAV % Community	90	35	10	75	
WR-1	605	Average of Nitrate (mg/L)	0.27	0.34	0.37	0.41	0.35
WR-1		Average of Filamentous % Community	0	60	95	10	
WR-1		Average of SAV % Community	100	40	5	90	
WR-2	2,517	Average of Nitrate (mg/L)	0.28	0.27	0.28	0.27	0.27
WR-2		Average of Filamentous % Community	40	100	90	20	
WR-2		Average of SAV % Community	0	0	0	0	
Cassidy Spring	2,859	Average of Nitrate (mg/L)	0.35	0.31	0.39	0.36	0.33
Cassidy Spring		Average of Filamentous % Community	0	25	80	30	
Cassidy Spring		Average of SAV % Community	100	25	20	25	
WR-3	3,878	Average of Nitrate (mg/L)	0.29	0.19	0.26	0.32	0.25
WR-3		Average of Filamentous % Community	40	100	90	25	
WR-3		Average of SAV % Community	0	0	0	0	
Big Blue Spring	4,777	Average of Nitrate (mg/L)	0.18	0.16	0.2	0.18	0.16
Big Blue Spring		Average of Filamentous % Community	0	80	10	10	
Big Blue Spring		Average of SAV % Community	100	20	90	90	
WR-4	5,700	Average of Nitrate (mg/L)	0.22	0.17	0.26	0.22	0.2
WR-4		Average of Filamentous % Community	10	20	50	15	
WR-4		Average of SAV % Community	90	80	50	85	

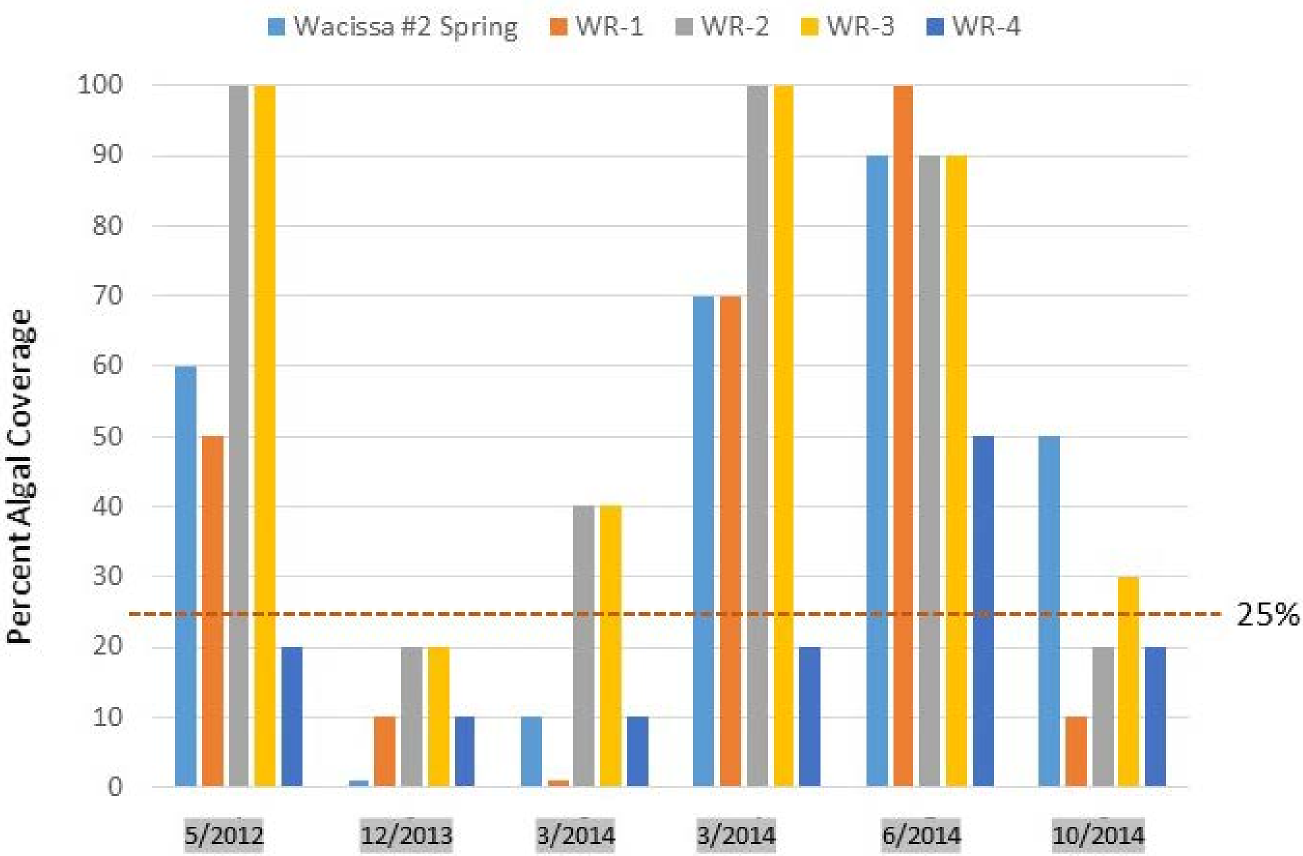

Figure 5.3. Range in algal growth percentages at Wacissa #2 Spring and Wacissa River monitoring stations

5.5 Setting Water Quality Targets for Nitrate in Wacissa River and Springs

Wacissa River water quality stations included in the vegetation survey had nitrate concentrations ranging from 0.26 to 0.41 mg/L over 6 measurement periods spanning more than 2 years. The biological survey results from the 6 measurement events for the river monitoring stations indicated that floral imbalance occurred at all the river stations upstream from WR-4, which is located 5,700 feet downstream from the headsprings.

According to the NNC for streams, floral imbalance exists when 2 or more consecutive temporally independent RPS surveys show algal coverage of >25 %. Higher percentages of algal coverage at these stations correlate with higher nitrate concentration. At Station WR-4, the percent coverage of benthic filamentous algae was 20 % or less on all but one survey date, and corresponding nitrate concentrations were significantly lower than those at the upstream stations on most occasions (**Table 5.4**). The average nitrate concentration at WR-4 for the study period was 0.21 mg/L.

Based on evidence from the vegetative survey, there is a relationship between nutrient concentrations and percent algal coverage, suggesting that the reduction of nitrate concentrations in the water column will cause algal coverage to decrease. As a result, additional restoration activities will become more effective and efficient. The results of the biological survey indicate that nitrate concentrations lower than 0.21 mg/L are needed to reduce the coverage of algae on the river bottom of the upper Wacissa River (where floral imbalance occurs) to acceptable levels (<20 % algal coverage or less). Therefore, to reduce filamentous algae, the selected maximum allowable nitrate target concentration limit for the Wacissa River is 0.20 mg/L.

Table 5.4. Filamentous algal coverage and nitrate concentrations for Wacissa River Station WR-4

Survey Date	Season	NO3+NO2 concentration (mg/L)	% Filamentous Algal Coverage
5/2/2012	Spring	0.13	20 %
12/11/2013	Winter	0.16	10 %
3/26/2014	Spring	0.22	10 %
6/12/2014	Spring	0.20	20 %
9/3/2014	Summer	0.26	50 %
10/22/2014	Fall	0.27	20 %
Averages		**0.21**	**21.6 %**

A concentration of 0.20 mg/L nitrate was selected as the water quality target for the Wacissa River. Concentrations at the nearby surface water sampling station, WR-1, exhibit a strong and significant positive relationship with spring concentrations (r square = 0.58, p value < 0.05) (**Figure 5.4**).

Using this methodology, a nitrate target concentration of 0.20 mg/L for surface water sampling station WR-1 translates to a nitrate target concentration of 0.24 mg/L for Wacissa #2 using the following regression equation:

WACISSA RIVER WR-1 = -0.02 + 0.90*WACISSA SPRING#2

The reduction in nitrate over this distance is attributable to dilution and to biological uptake in the river. Nitrate is readily available for uptake by phytoplankton and benthic organisms (Woods Hole Group 2007). Nitrate concentrations in water discharged from the springs are also decreased by dilution. The same relationship may not be representative of the relationship found in the springs and spring runs outside the headsprings area, but it does provide the maximum protection for these other areas by being more conservative. A reduction in nitrate at Wacissa #2 Spring is expected to be accompanied by a similar reduction in the river.

These nitrate water quality target concentrations for WBIDs 3424 and 3424Z as maximum monthly averages, not to be exceeded, will be submitted to the EPA for approval as site-specific (Hierarchy 1) interpretations of the narrative nutrient criterion for these waterbodies, as stated in Rule 62-302.531, F.A.C.

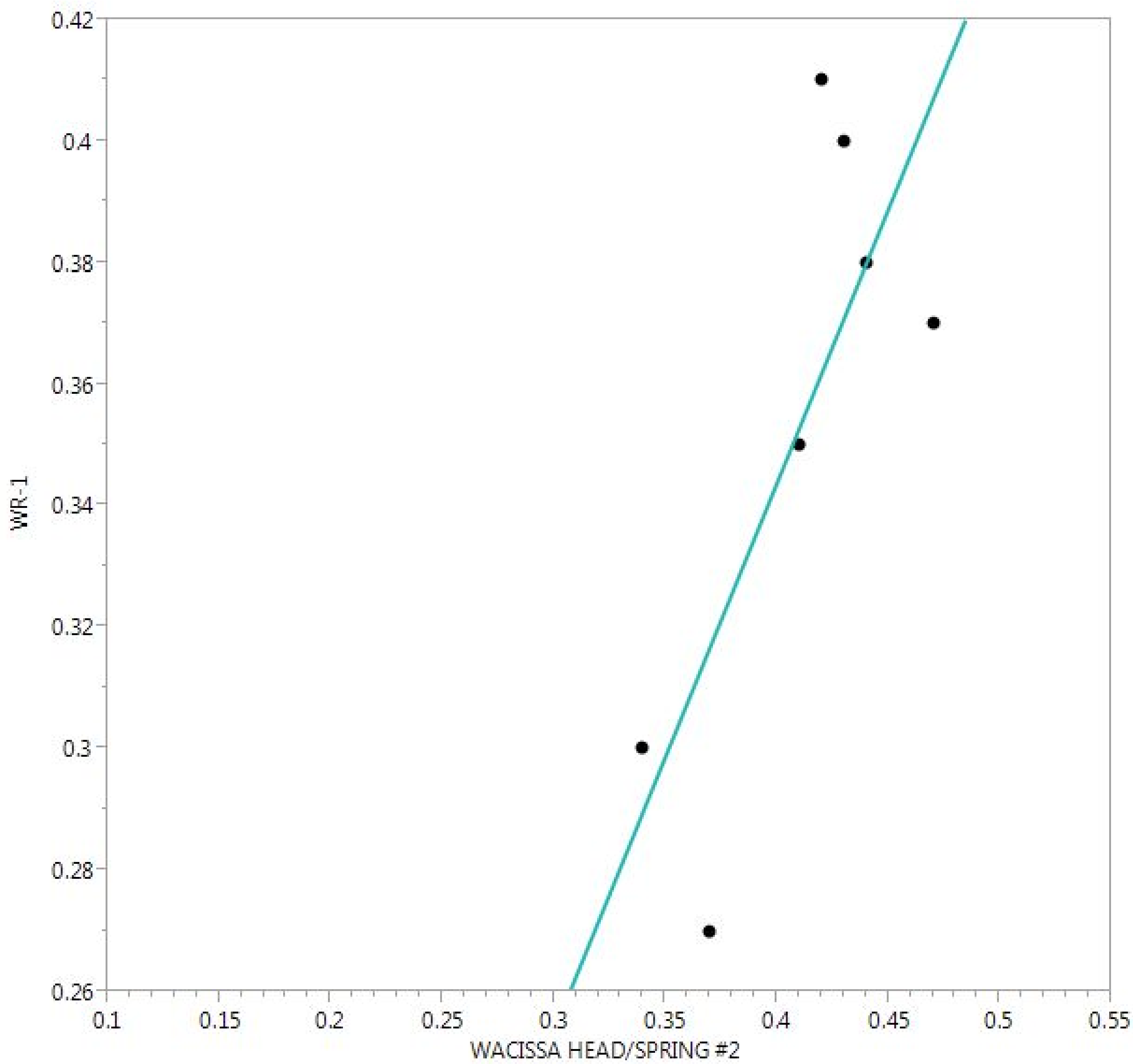

Figure 5.4. Nitrate attenuation and dilution of Wacissa Spring vs. Wacissa River (concentrations in mg/L)

5.6 Protection of Downstream Waters

An imbalance of flora occurring in the upper Wacissa River is attributable to elevated nitrate concentrations in the river water. The elevated nitrate in the river is due to elevated nitrate concentrations in water coming from the headsprings (Wacissa Springs). When the nitrate concentration thresholds established for Wacissa River and Wacissa Springs are met, algal growth that contributes to the floral imbalance will be reduced so that algal coverage will be at background levels (<20 % algal coverage). Since the cause of the imbalance in the river is elevated nitrate from the headsprings in the upper part of the Wacissa River system, decreasing the nitrate concentration from the headsprings will reduce nitrate, and will correspondingly reduce TN, in downstream waters. TN concentrations in downstream waters are currently below the NNC for Panhandle East streams. Therefore any nitrogen contributions from Wacissa Springs are not preventing the Wacissa River from attaining the NNC for TN in the existing condition. Decreasing the nitrate concentrations stands to only improve the existing condition and will ensure the river attains its designated uses when the nitrate concentrations in water from the headsprings and Wacissa River achieve the TMDLs.

5.7 Setting the TMDL Monthly Arithmetic Average Concentration for Nitrate

A target concentration of 0.20 mg/L nitrate (based on average monthly concentrations) is an appropriate and conservative TMDL for the Wacissa River (WBID 3424), and 0.24 mg/L nitrate (based on average monthly concentrations) is an appropriate and conservative TMDL for Wacissa Springs (WBID 3424Z). Monthly average targets are most appropriate because algal growth does not respond to instantaneous changes in nutrient concentration. Therefore, a short-term exceedance of the target concentration should not produce negative or positive biological or ecological effects.

Natural processes such as competition between other periphyton and plants, grazing from aquatic animals, removal effects from the shearing force of stream flow, and light attenuation from changing water color in natural systems such as Wacissa Springs and Wacissa River could significantly influence the response of algae to changes in water column nitrate concentrations. For these reasons, treating the nitrate concentration as an instantaneous value is not necessary. It is more appropriate to treat the target value as an average concentration over a certain period. DEP established the nitrate TMDLs for Blue Spring and Blue Spring Run (Volusia); the Wekiva, Suwannee, and Wakulla Rivers; and Silver and Rainbow Springs as a monthly average target. Expressing the target as a monthly average provides a margin of safety because restoration activities designed to address the highest monthly average nitrate concentrations should help to ensure that average nitrate concentrations over the rest of the year are even lower.

5.8 Calculation of TMDL Percent Reduction

For Wacissa River and Springs, the percent reductions required to meet the TMDLs were calculated using the monthly arithmetic average concentrations for nitrate calculated for each year over the most recent verified period (January 1, 2005–June 30, 2012) plus more recently (2013–15). To ensure that the monthly average concentrations would meet the concentration targets even under the worst-case scenario, the maximum monthly average for each WBID was then considered in calculating its target for the percent reduction (**Tables 5.1** and **5.2**). The use of the maximum monthly average concentrations in setting the TMDLs is considered a conservative assumption for establishing reductions and provides assurance that the TMDLs are protective.

The maximum monthly average nitrate concentrations for Wacissa Springs and River were observed during October and December and are 0.39 and 0.33 mg/L, respectively. These TMDL target concentrations for Wacissa Springs and River will be submitted to the EPA for approval as site-specific (Hierarchy 1) interpretations of the narrative nutrient criterion for these waterbodies, as stated in Rule 62-302.531, F.A.C.

To obtain percent reductions that are reasonably representative of Wacissa Springs and River and that will be adequately protective by using the largest datasets, the maximum monthly average nitrate concentrations were used. The percent reductions required to achieve the water quality targets were calculated using the following formula:

[(existing mean concentration – target concentration)/existing mean concentration] x 100

Percent Reduction Calculations:

- **Wacissa River (WBID 3424):**

  [(0.33 mg/L – 0.20 mg/L) / 0.33 mg/L] * 100

  Equals a 39.4 % reduction in nitrate.

- **Wacissa Springs (WBID 3424Z):**

  [(0.39 mg/L –0.24 mg/L) /0.39 mg/L] * 100

  Equals a 38.4 % reduction in nitrate.

Reductions in nitrate concentrations of 39 % in Wacissa River and 38 % in Wacissa Springs are proposed because they are protective values that, when achieved, will cause filamentous algae biomass and phytoplankton productivity to decrease. Once the target concentrations are consistently achieved, both WBIDs will be reevaluated to determine if nitrogen continues to contribute to an imbalance of flora due to algal smothering. If such a condition still exists, the waterbodies will be reassessed as part of DEP's watershed assessment cycle. The TMDL target concentrations may be changed if DEP determines that further reductions in nitrogen concentrations are needed to address the imbalance. The purpose of a TMDL is to set a pollutant reduction goal that, if achieved, will result in the attainment of designated uses for that waterbody.

Chapter 6: Determination of the TMDL

6.1 Allocation of the TMDL

The objective of a TMDL is to provide a basis for allocating acceptable loads among 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 any uncertainty concerning the relationship between effluent limitations and water quality:

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

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

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

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

This approach is consistent with federal regulations (40 CFR § 130.2[I]), which state that TMDLs can be expressed in terms of mass per time (*e.g.*, pounds per day), toxicity, or **other appropriate measure**. The TMDLs for Wacissa River and Springs are expressed in terms of the nitrate concentration that the river and springs can assimilate and maintain healthy levels of algal growth that do not contribute to an ecological imbalance (**Table 6.1**). The TMDLs are also represented as the percent reduction in existing nitrate concentrations required to achieve the nitrate targets. The existing nitrate concentrations used for the river and springs are conservative and based on worst-case water quality conditions from the TMDL period of record. The percent reductions assigned to all the nonpoint source areas (LAs) are the same as those defined for the TMDL percent reductions.

Table 6.1. TMDL components for Wacissa River (WBID 3424) and Wacissa Springs (WBID 3424Z)

N/A = Not applicable
[1] Nutrient concentrations represent monthly averages, not to be exceeded.
[2]-Applies to future NPDES discharges, if they occur.

Waterbody (WBID)	Parameter	TMDL[1] (mg/L)	TMDL % Reduction	Wasteload Allocation for Wastewater	Wasteload Allocation for NPDES Stormwater % Reduction[2]	Load Allocation % Reduction	MOS
Wacissa River (WBID 3424)	Nutrients (Nitrate)	0.20	39 %	N/A	39 %	39 %	Implicit
Wacissa Springs (WBID 3424Z)	Nutrients (Nitrate)	0.24	38 %	N/A	38 %	38 %	Implicit

6.2 Wasteload Allocation (Point Sources)

6.2.1 NPDES Wastewater Discharges

Currently, no NPDES wastewater facilities discharge directly into the Wacissa River. Any new potential discharger is expected to comply with the Class III criterion for nutrients and with nitrate limits consistent with this TMDL. If it is determined that any of the wastewater facilities discharge into the Wacissa River, they will be subject to the assigned WLA.

6.2.2 NPDES Stormwater Discharges

Table 6.1 lists the NPDES stormwater percent reductions, which represent the allowable nutrient loads that would result in ecosystem improvement. There are no MS4 permittees in the contributing area. It should be noted that any future 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.

6.3 Load Allocation (Nonpoint Sources)

Reductions in nitrate concentrations of 39 % in Wacissa River and 38 % in Wacissa Springs are needed from the nonpoint source areas contributing to these impaired waters. The target monthly average nitrate concentrations and the percent reductions represent estimates of the maximum reductions required to meet the targets. It may be possible to meet the targets before achieving the percent reductions. It should be noted that the LA could also include loading from stormwater discharges regulated by DEP and the water management district that are not part of the NPDES Stormwater Program (see **Appendix A**).

6.4 Margin of Safety (MOS)

Consistent with the recommendations of the Allocation Technical Advisory Committee (DEP 2001), an implicit MOS was used in the development of this TMDL, and was provided by the conservative decisions associated with a number of assumptions and the development of assimilative capacity. Also, when estimating the required percent reduction to achieve the water quality target, the highest monthly average of measured nitrogen concentration in the 10-year data period (2005–12) was used instead of the average of the monthly averages. Due to the minimal seasonal variation of the nitrate concentrations for Wacissa River and Springs, the percent reductions were established based on the data for the month with the highest monthly average concentration. This will also be protective for all seasons, adding to the implicit MOS. Both of these will make estimating the required percent load reduction more conservative and therefore add to the MOS. The 39 % and 38 % reductions were derived based on maximum monthly average concentrations of 33 mg/L and 39 mg/L for Wacissa River and Wacissa Springs, respectively.

Chapter 7: Next Steps: Implementation Plan Development and Beyond

7.1 Basin Management Action Plan

Following the adoption of these TMDLs by rule, DEP will determine the best course of action regarding their implementation. Depending on the pollutant(s) causing the waterbody impairment and the significance of the waterbody, DEP selects the best course of action leading to the development of a plan to restore the waterbody. Often this is accomplished cooperatively with stakeholders by creating a basin management action plan, referred to as the BMAP.

BMAPs are the primary mechanism through which TMDLs are implemented in Florida (see Subsection 403.067[7], F.S.). A single BMAP may provide the conceptual plan for the restoration of one or many impaired waterbodies. A BMAP can take into account the sources of nitrogen in the contributing area, including legacy loads from past land use activities, as well as the complexity of the aquifer system that conveys pollutants to the impaired waters.

If DEP determines that a BMAP is needed to support the implementation of these TMDLs, it will be developed through a transparent, stakeholder-driven process intended to result in a plan that is cost-effective, is technically feasible, and meets the restoration needs of the applicable waterbodies.

Once adopted by order of the DEP Secretary, BMAPs are enforceable through wastewater and municipal stormwater permits for point sources and through BMP implementation for nonpoint sources. Among other components, BMAPs typically include the following:

- Water quality goals (based directly on the TMDLs).
- Refined source identification.
- Load reduction requirements for stakeholders (quantitative detailed allocations, if technically feasible).
- A description of the load reduction activities to be undertaken, including structural projects, nonstructural BMPs, and public education and outreach.
- A description of further research, data collection, or source identification needed in order to achieve the TMDLs.
- Timetables for implementation.
- Implementation funding mechanisms.
- An evaluation of future increases in pollutant loading due to population growth.

- Implementation milestones, project tracking, water quality monitoring, and adaptive management procedures.
- Stakeholder statements of commitment (typically a local government resolution).

BMAPs are updated through annual meetings and may be officially revised every five years. Completed BMAPs in the state have improved communication and cooperation among local stakeholders and state agencies; improved internal communication within local governments; applied high-quality science and local information to the management of water resources; clarified the obligations of wastewater point source, MS4, and non-MS4 stakeholders in TMDL implementation; enhanced transparency in DEP's decision making; and built strong relationships between DEP and local stakeholders that have benefited other program areas.

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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 (ERP) 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) 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 Clean Water Act Reauthorization. This section of the law amended the scope of the federal NPDES permitting program to designate certain stormwater discharges as "point sources" of pollution. The EPA promulgated regulations and began implementing the Phase I NPDES Stormwater Program in 1990 to address, stormwater discharges associated with industrial activity," which includes 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 the Florida Department of Transportation throughout the 15 counties meeting the population criteria. DEP received authorization to implement the NPDES stormwater program in October 2000. DEP 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

Waterbody Information	Description of Waterbody and Location
Waterbody name	1. Wacissa River 2. Wacissa Springs (river headsprings)
Waterbody type(s)	Stream, springs
Waterbody ID (WBID)	WBIDs 3424, 3424Z (See **Figures 1.3** and **1.4** of this TMDL report)
Description	The Wacissa River is in southern Jefferson County, Florida, just south of the town of Wacissa. The river extends for approximately 12 miles from the headsprings area to the river's confluence with the Aucilla River. The Wacissa River headsprings include several spring vents: Wacissa #1, Wacissa #2, Wacissa #3A and 3B, Log, and Thomas Springs. The surface area of the spring group is 1.5 acres. The average depth of the spring group is 6 feet.
Specific location (latitude/longitude or river miles)	The center of the headsprings area (known as Wacissa Springs in this document, WBID 3424Z) is N 30^{0} 20'22.87''/W-83^{0} 59'28.81''. The Wacissa River (WBID 3424) extends from the headsprings area approximately 12 river miles to the south.
Map	**Figure 1.1** of this TMDL report shows the general location of the Wacissa River and Wacissa Springs, and **Figure 4.1** shows land uses in the contributing area. Land use is predominately forest/rural/open (43 %), wetlands (37 %), and agriculture (12 %). Urban land use is less than 3 % of the area.
Classification(s)	Class III Freshwater
Basin name (Hydrologic Unit Code [HUC] 8)	Aucilla River (03110103)

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

Numeric Interpretation of Narrative Nutrient Criterion	Parameter Information Related to Numeric Interpretation of Narrative Nutrient Criterion
NNC summary: Default nutrient watershed region or lake classification (if applicable) and corresponding NNC	Per Rule 62-302.531, F.A.C., the applicable numeric nutrient thresholds for streams in the Panhandle East region are 0.18 mg/L of TP and 1.03 mg/L of TN, as AGMs not be exceeded more than once in any 3-calendar-year period. For spring vents, the applicable nutrient criterion is 0.35 mg/L of nitrate-nitrogen (or NO_3+NO_2-N) as an AGM, not to be exceeded more than once in any 3-calendar-year period.
Proposed Nitrate+Nitrite (magnitude, duration, and frequency)	DEP selected nitrate thresholds of 0.20 and 0.24 mg/L for Wacissa River and Springs, respectively, expressed as monthly average. These are based on a vegetative survey conducted over a 3-year period in the river that measured the nitrate concentration and vegetative growth at different stations over several seasons. **Chapter 5** of this document describes the approach. These targets were selected because they would be protective of Class III designated use. Reducing the growth rate of macroalgae through nitrate reduction will decrease filamentous algae biomass and growth rate and achieve floral balance (<20 % algal coverage per NNC). **Section 5.5** discusses target setting for nitrate and floral metrics. The nitrate water quality targets will be established as NNC and will be expressed as a monthly arithmetic average not to be exceeded. A monthly arithmetic average was chosen due to the length of time that algal growth would be anticipated to occur, as described in **Section 5.7**.
Period of record used to develop the numeric interpretations of the narrative nutrient criterion for nitrate+nitrite	To ensure that the proposed nitrate TMDL was developed based on current conditions and that recent trends in spring water quality were adequately captured, monitoring data from the seven-year Cycle 2 verified period (January 1, 2005–June 30, 2012) and more recent data (2012–15) were used to develop the TMDL and nutrient criteria.

Numeric Interpretation of Narrative Nutrient Criterion	Parameter Information Related to Numeric Interpretation of Narrative Nutrient Criterion
Indicate how criteria developed are spatially and temporally representative of the waterbody or critical condition. **Are the stations used representative of the entire extent of the WBID and where the criteria are applied? In addition, for older TMDLs, an explanation of the representativeness of the data period is needed (e.g., have data or information become available since the TMDL analysis?). These details are critical to demonstrate why the resulting criteria will be protective as opposed to the otherwise applicable criteria (in cases where a numeric criterion is otherwise in effect, unlike this case).**	The data used were spatially representative of the waterbodies because the samples were collected at the spring vents and at river stations along the main stem of the Wacissa River. **Figure 2.3** shows the locations of the current and historical routine water quality sampling stations and biological stations represented by data collected by or provided to DEP for Wacissa River and Springs. To ensure that the nutrient TMDLs were developed based on current conditions and that recent trends in spring water quality were adequately captured, monitoring data were compiled for the seven-year Cycle 2 verified period (January 1, 2005–June 30, 2012) plus more recent (2012–15) data. The data used for the TMDLs are from samples collected mostly by DEP, with some collected by the SRWMD. **Figure 2.6** shows the nitrate monitoring results for these impaired springs during the Cycle 2 verified period (January 1, 2005–June 30, 2012) plus more recent (2012–15) data. **Tables 2.4a** through **2.4e** summarize the nitrate monitoring results for springs contributing flow to the Wacissa River and for the river. Establishing the critical condition for nitrogen inputs that affect algal growth in a given contributing area depends on many factors, including the presence of point sources and the land use pattern in the contributing area. The critical condition for point source loading to a waterbody typically occurs during periods of low flow, when dilution is minimized. Typically, the critical condition for nonpoint source loading is a period of rainfall-related flushing preceded by an extended dry period. During the wet weather period, rainfall mobilizes nitrogen that has accumulated on the land surface and in the soil under dry conditions, resulting in higher pollutant concentrations. However, significant nonpoint source contributions can also appear under dry conditions without any major surface runoff event. Also, there can be a lag between nitrogen inputs into groundwater and discharge from the spring vents. **Tables 5.1** and **5.2** summarizes the mean, maximum, and minimum nitrate concentrations in Wacissa River and Springs (for the verified period plus 2012–15), along with the 30-year monthly average rainfall for a station in the spring contributing area. Based on the nitrate data available, nitrate concentrations in the river and springs do not appear to respond consistently to rainfall. In general, there does not appear to be any significant period when higher loading occurs.

Table B-3. Designated use, verified impairment, and approach to establish protective restoration targets

Designated Use Requirements	Information Related to Designated Use Requirements
History of assessment of designated use support	These springs were listed as impaired by nutrients because of their elevated concentrations of nitrate and the corresponding evidence in the upper river and vicinity of the headsprings of imbalances in flora and fauna caused by algal smothering. This information was used in the determination of impairment for the 2012 Verified List of impaired waters. **Table 2.1** lists the waterbodies on the Cycle 2 Verified List addressed in this report.
Basis for use support	DEP selected the nitrate criteria based on a waterbody-specific vegetation study described in **Chapter 5** of this report. Nitrate is the most abundant form of nitrogen available in Wacissa Springs and in the impaired portion of the upper Wacissa River. The targets for the river and springs were selected at levels that were demonstrated to be protective of Class III designated use. Reducing the growth rate of macroalgae (including *Lyngbya* and *Chaetomorpha*) through nitrate reduction will decrease the growth rate and coverage of filamentous algae.
Summarize approach used to develop criteria and how it protects uses	The numeric interpretations for nitrate+nitrite were based on a study conducted in the Wacissa River for the specific purpose of identifying appropriate algal growth thresholds in response to nitrate concentrations. The approach involved the measurement of vegetation type and nitrate concentration at multiple stations along the river and at spring vents over a three-year period. Target nitrate levels were established to represent conditions where algal coverage was within acceptable ranges (<20 % coverage per the NNC for floral imbalance). These targets were selected because they would be protective of Class III designated use. Reducing the growth rate of macroalgae (including *Lyngbya* and *Chaetomorpha*) through nitrate reduction will decrease the growth rate and coverage of filamentous algae.
Discuss how the TMDL will ensure that nutrient-related parameters are attained to demonstrate that the TMDL will not negatively impact other water quality criteria. These parameters must be analyzed with the appropriate frequency and duration. If compliance with 47(a) is not indicated in the TMDL, it should be clear that further reductions may be required in the future.	Reductions in nitrate concentrations of 39 % in Wacissa River and 38 % in Wacissa Springs are proposed because they will result in in-stream nitrate levels that have been demonstrated to be protective (when achieved, filamentous algae biomass decreases). The proposed reductions in nutrient inputs will further improve water quality. Once the target concentrations are consistently achieved, each WBID will be re-evaluated to determine if nitrate continues to contribute to an imbalance of flora in the upper river as a result of excessive algal coverage. If such a condition still exists, the waterbodies will be reassessed as part of DEP's watershed assessment cycle. The TMDL target concentrations may be changed if DEP determines that further reductions in nitrate concentrations are needed to address the imbalance. The purpose of a TMDL is to set a pollutant reduction goal that, if achieved, will result in the attainment of designated uses for that waterbody.

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

Downstream Waters Protection and Monitoring Requirements	Information Related to Downstream Waters Protection and Monitoring Requirements
Identification of downstream waters: List receiving waters and identify technical justification for concluding downstream waters are protected	Wacissa Springs are the headsprings that contribute flow and have a significant influence in the Wacissa River. The Wacissa River merges with the Aucilla River 12 miles from the headsprings. The Aucilla River continues to the Gulf of Mexico. The established nitrate water quality targets were determined to be protective; therefore, setting targets for the headwaters should be protective of downstream waters.
Summarize existing monitoring and assessment related to the implementation of Subsection 62-302.531(4), F.A.C., and trend tests in Chapter 62-303, F.A.C.	DEP performed most of the spring water quality sampling and analysis, and the SRWMD contributed data for some springs and the Wacissa River. The frequency of sampling of these waterbodies meets minimum sampling requirements for future assessments, including trend tests.

Appendix C: Wacissa River Vegetation Survey Summary Information

FALGM = Filamentous algal mats

Date	Site	Season	Nitrate (mg/L)	Filamentous % Community	SAV % Community	Dominant Plant Species	Dominant % Community	Co-Dominant Plant Species	Co-Dominant % Community	Minor Plant Species	Minor % Community
5/2/2012	Big Blue	2	0.13	80 %	20 %	FALGM	80 %	No co-dominant	0 %	*Hydrilla*	20 %
12/11/2013	Big Blue	4	0.18	20 %	80 %	*Hydrilla*	80 %	No co-dominant	0 %	FALGM	20 %
3/26/2014	Big Blue	1	0.18	0 %	100 %	*Hydrilla*	90 %	No co-dominant	0 %	Coontail	10 %
6/12/2014	Big Blue	2	0.19	80 %	20 %	FALGM	80 %	No co-dominant	0 %	*Hydrilla*	20 %
9/3/2014	Big Blue	3	0.2	10 %	90 %	*Hydrilla*	90 %	No co-dominant	0 %	FALGM	10 %
10/22/2014	Big Blue	4	0.18	0 %	100 %	*Hydrilla*	80 %	No co-dominant	0 %	Coontail	20 %
5/2/2012	Cassidy	2	0.23	50 %	50 %	FALGM	50 %	*Hydrilla*	50 %	No minor	0 %
12/11/2013	Cassidy	4	0.34	0 %	10 %	*Hydrilla*	10 %	No co-dominant	0 %	No vegetation	0 %
3/26/2014	Cassidy	1	0.35	0 %	100 %	*Hydrilla*	90 %	No co-dominant	0 %	Coontail	10 %
6/12/2014	Cassidy	2	0.38	0 %	0 %	Human disturbance no vegetation	0 %	Human disturbance no vegetation	0 %	Human disturbance no vegetation	0 %
9/3/2014	Cassidy	3	0.39	80 %	20 %	FALGM	80 %	No co-dominant	0 %	*Hydrilla*	20 %
10/22/2014	Cassidy	4	0.37	60 %	40 %	FALGM	60 %	*Hydrilla*	40 %	No minor	0 %
5/2/2012	Log	2	0.48	50 %	50 %	FALGM	50 %	*Hydrilla*	40 %	*Vallisnaria*	10 %
12/11/2013	Log	4	0.45	10 %	90 %	*Hydrilla*	50 %	*Vallisnaria*	40 %	FALGM	10 %
3/26/2014	Log	1	0.33	20 %	80 %	*Hydrilla*	40 %	*Vallisnaria*	40 %	FALGM	20 %
6/12/2014	Log	2	0.34	60 %	40 %	FALGM	60 %	*Hydrilla*	20 %	*Vallisnaria*	20 %
7/30/2014	Log	3	0.4	20 %	80 %	*Vallisnaria*	50 %	*Hydrilla*	30 %	FALGM	20 %
9/3/2014	Log	3	0.43	40 %	60 %	FALGM	40 %	*Vallisnaria*	30 %	Hydrilla	30 %
10/22/2014	Log	4	0.44	20 %	80 %	*Hydrilla*	40 %	*Vallisnaria*	40 %	FALGM	20 %
12/11/2013	Thomas	4	0.43	10 %	90 %	*Hydrilla*	90 %	No co-dominant	0 %	FALGM	10 %
3/26/2014	Thomas	1	0.28	20 %	80 %	*Hydrilla*	80 %	No co-dominant	0 %	FALGM	20 %
6/12/2014	Thomas	2	0.34	70 %	30 %	FALGM	70 %	*Hydrilla*	20 %	*Vallisnaria*	10 %
9/3/2014	Thomas	3	0.42	20 %	80 %	*Hydrilla*	80 %	No co-dominant	0 %	FALGM	20 %
10/22/2014	Thomas	4	0.41	10 %	90 %	*Hydrilla*	90 %	No co-dominant	0 %	FALGM	10 %
5/2/2012	Wacissa #2	2	0.47	60 %	40 %	FALGM	60 %	*Hydrilla*	40 %	No minor	0 %
12/11/2013	Wacissa #2	4	0.43	0 %	100 %	*Hydrilla*	90 %	No co-dominant	0 %	Coontail	10 %
3/26/2014	Wacissa #2	1	0.37	10 %	90 %	Hydrilla	90 %	No co-dominant	0 %	FALGM	10 %

Date	Site	Season	Nitrate (mg/L)	Filamentous % Community	SAV % Community	Dominant Plant Species	Dominant % Community	Co-Dominant Plant Species	Co-Dominant % Community	Minor Plant Species	Minor % Community
6/12/2014	Wacissa #2	2	0.34	70 %	30 %	FALGM	70 %	No co-dominant	0 %	*Hydrilla*	30 %
7/30/2014	Wacissa #2	3	0.41	90 %	10 %	FALGM	90 %	No co-dominant	0 %	*Hydrilla*	10 %
9/3/2014	Wacissa #2	3	0.44	90 %	10 %	FALGM	90 %	No co-dominant	0 %	*Hydrilla*	10 %
10/22/2014	Wacissa #2	4	0.42	50 %	50 %	FALGM	50 %	*Hydrilla*	50 %	No minor	0 %
5/2/2012	WR-1	2	0.37	50 %	50 %	FALGM	50 %	*Hydrilla*	50 %	No minor	0 %
12/11/2013	WR-1	4	0.4	10 %	90 %	*Hydrilla*	90 %	No co-dominant	0 %	FALGM	10 %
3/26/2014	WR-1	1	0.27	0 %	100 %	*Hydrilla*	100 %	No co-dominant	0 %	No minor	0 %
6/12/2014	WR-1	2	0.3	70 %	30 %	FALGM	70 %	No co-dominant	0 %	*Hydrilla*	30 %
7/30/2014	WR-1	3	0.35	90 %	10 %	FALGM	90 %	No co-dominant	0 %	*Hydrilla*	10 %
9/3/2014	WR-1	3	0.38	100 %	0 %	FALGM	100 %	No co-dominant	0 %	No minor	0 %
10/22/2014	WR-1	4	0.41	10 %	90 %	*Hydrilla*	90 %	No co-dominant	0 %	FALGM	10 %
5/2/2012	WR-2	2	0.31	100 %	0 %	FALGM	100 %	No co-dominant	0 %	No minor	0 %
12/11/2013	WR-2	4	0.18	20 %	0 %	FALGM	20 %	No co-dominant	0 %	No minor	0 %
3/26/2014	WR-2	1	0.28	40 %	0 %	FALGM	40 %	No co-dominant	0 %	No minor	0 %
6/12/2014	WR-2	2	0.23	100 %	0 %	FALGM	100 %	No co-dominant	0 %	No minor	0 %
9/3/2014	WR-2	3	0.28	90 %	0 %	FALGM	90 %	No co-dominant	0 %	No minor	0 %
10/22/2014	WR-2	4	0.35	20 %	0 %	FALGM	20 %	No co-dominant	0 %	No minor	0 %
5/2/2012	WR-3	2	0.12	100 %	0 %	FALGM	100 %	No co-dominant	0 %	No minor	0 %
12/11/2013	WR-3	4	0.34	20 %	0 %	FALGM	20 %	No co-dominant	0 %	No minor	0 %
3/26/2014	WR-3	1	0.29	40 %	0 %	FALGM	40 %	No co-dominant	0 %	No minor	0 %
6/12/2014	WR-3	2	0.25	100 %	0 %	FALGM	100 %	No co-dominant	0 %	No minor	0 %
9/3/2014	WR-3	3	0.26	90 %	0 %	FALGM	90 %	No co-dominant	0 %	No minor	0 %
10/22/2014	WR-3	4	0.29	30 %	0 %	FALGM	30 %	No co-dominant	0 %	No minor	0 %
5/2/2012	WR-4	2	0.13	20 %	80 %	*Vallisnaria*	80 %	No co-dominant	0 %	FALGM	20 %
12/11/2013	WR-4	4	0.16	10 %	90 %	*Vallisnaria*	90 %	No co-dominant	0 %	FALGM	10 %
3/26/2014	WR-4	1	0.22	10 %	90 %	*Vallisnaria*	90 %	No co-dominant	0 %	FALGM	10 %
6/12/2014	WR-4	2	0.2	20 %	80 %	*Vallisnaria*	80 %	No co-dominant	0 %	FALGM	20 %
9/3/2014	WR-4	3	0.26	50 %	50 %	*Vallisnaria*	50 %	FALGM	50 %	No minor	0 %
10/22/2014	WR-4	4	0.27	20 %	80 %	*Vallisnaria*	80 %	No co-dominant	0 %	FALGM	20 %

Appendix D: List of Complete Web Addresses

Anderson, P.C. The pecan tree. https://edis.ifas.ufl.edu/hs229.

Florida Automated Weather Network. http://fawn.ifas.ufl.edu/data/reports/.

Florida Department of Environmental Protection:

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

Identification of Impaired Surface Waters Rule. http://www.dep.state.fl.us/legal/Rules/shared/62-303/62-303.pdf.

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

2016 Integrated Report. http://www.dep.state.fl.us/water/docs/2016-Integrated-Report.pdf.

Criteria for Surface Water Quality Classifications. https://www.flrules.org/gateway/ChapterHome.asp?Chapter=62-302.

Water Quality Status Report and Water Quality Assessment Report: Springs Coast. http://www.dep.state.fl.us/water/watersheds/assessment/basin411.htm.

Florida Springs. http://www.floridasprings.org/.

Biological and water quality assessment of the Wacissa River. ftp://ftp.dep.state.fl.us/pub/labs/lds/reports/9141.pdf.

DEP Standard Operating Procedure FS7420. http://www.dep.state.fl.us/water/sas/sop/sops.htm.

Florida Department of Health. OSTDS statistics. http://www.floridahealth.gov/environmental-health/onsite-sewage/ostds-statistics.html.

Gulf Coast Ecosystems (GCE). Chaetomoropha sp. A green macroalgae. http://marineplantbook.com/marinebookchaeto.htm.

Mylavarapu et al. UF/IFAS standardized fertilization recommendations for agronomic crops. https://edis.ifas.ufl.edu/ss163.

National Oceanic and Atmospheric Administration, National Centers for Environmental Information. Climate data for Monticello 3W and WTP Stations. https://www.ncdc.noaa.gov/cdo-web/search%3bjsessionid=1F03E1ED60E7CAE5E0A0A4DBC103D563.

Shukla et al. BMP recommended water and phosphorus inputs for tomato and watermelon can reduce environmental losses of phosphorus and save water. http://edis.ifas.ufl.edu/ae504.

U.S. Census Bureau. http://www.census.gov/.

U.S. Environmental Protection Agency:

Region 4: TMDLs in Florida. https://archive.epa.gov/pesticides/region4/water/tmdl/web/html/index-2.html.

National STORET Program. https://www.epa.gov/waterdata/storage-and-retrieval-and-water-quality-exchange.

U.S. Geological Survey:

Karst and the USGS. http://water.usgs.gov/ogw/karst/index.

Daily discharge data from USGS Gauging Station #02326526. http://waterdata.usgs.gov/fl/nwis/uv/?site_no=02326526&PARAmeter_cd=00065,00060.