

***REVISED DRAFT***

***Priority Focus Area for Fanning and Manatee Springs***

**Division of Environmental Assessment and Restoration**

**Florida Department of Environmental Protection**

**March 2017**

DRAFT

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***More Information***

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## ***Introduction***

Under the Florida Springs and Aquifer Protection Act, the Florida Department of Environmental Protection (department) is required to delineate priority focus areas (PFA) for all Outstanding Florida Springs that are identified as impaired. According to the Florida Springs and Aquifer Protection Act, adopted by the Florida Legislature in 2016 (Chapter 373, Part VIII, F. S.), “*‘priority focus area’ means the area or areas of a basin where the Floridan Aquifer is generally most vulnerable to pollutant inputs where there is a known connectivity between groundwater pathways and an Outstanding Florida Spring, as determined by the department in consultation with the appropriate water management districts, and delineated in a basin management action plan. Using the best data available from water management districts and other credible sources, the department, in coordination with the water management districts, shall delineate priority focus areas for each Outstanding Florida Spring or group of springs that contains one or more Outstanding Florida Springs and is identified as impaired in accordance with s. 373.807. In delineating priority focus areas, the department shall consider groundwater travel time to the spring, hydrogeology, nutrient load, and any other factors that may lead to degradation of an Outstanding Florida Spring. The delineation of priority focus areas must be completed by July 1, 2018, shall use understood and identifiable boundaries such as roads or political jurisdictions for ease of implementation, and is effective upon incorporation in a basin management action plan.*”

Factors to consider in establishing these geographically bounded areas include:

- Groundwater travel time to the spring, which could be based on empirical data from tracer studies and/or predicted travel time from modeling, if such data or studies are available.
- Hydrogeology, which includes the spring’s estimated groundwater contributing area (or springshed), the amount of confining material protecting the Floridan Aquifer, the aquifer recharge characteristics, the capacity for the aquifer to transmit water, and other characteristics that help determine the aquifer vulnerability and the likelihood of adverse water quality impacts to springs.
- Nutrient load to the spring, which includes actual measured load in the water discharging from the spring as well as the potential nutrient load based on land uses in specific regions that would most probably influence water quality in the spring.
- Other factors, which include soil characteristics that are favorable for pollutant leaching to the aquifer in the springshed and the presence or absence of pollutant sources in the area.
- Identifiable boundaries, which include roads, natural boundaries, and political jurisdictions.

Delineation of the combined PFA for both Fanning and Manatee Springs (due to their proximity to one another) is described in the following section.

## ***Steps in Delineating Fanning and Manatee PFA***

The PFA for Fanning and Manatee Springs was developed using geographic information system (GIS) tools, spring-specific data, and published information to help identify the portion of the springs' contributing area that is most important from both the water quality restoration and protection perspectives. The following steps were taken to develop a draft PFA for review and input by stakeholders. The overlap of mapped characteristics that express high vulnerability, high potential for pollutant mobility, and likely pollutant sources provide the best assurance that the PFA includes the areas of greatest concern for water quality restoration and protection.

Step 1. Establish the springshed for the priority spring(s). The estimated combined springshed for Fanning and Manatee Springs used for this evaluation was created by SDII Global Corporation for Suwannee River Water Management District (SRWMD) in 2004.<sup>1</sup> The combined Fanning-Manatee Springs springshed and the proposed PFA are shown in **Figure 1**. This map also shows the groundwater elevation contour map for the Floridan aquifer for May 2010. Groundwater flow gradients were in part basis for the delineation of the springshed.

Step 2. Identify regions within the contributing area where greatest recharge occurs. Several GIS coverages developed by the USGS and water management districts delineate areas of high, medium, and low recharge to the Floridan aquifer system as well as areas of aquifer discharge. The areas to be considered in the PFA delineation are the areas of highest recharge to the aquifer, which could occur as diffuse infiltration through permeable geological material as well as focused recharge to sinkholes that breach confining layers. Pollutant sources in high recharge areas have the greatest potential for causing adverse impacts to the groundwater and springs because water is impeded and attenuated the least as it infiltrates to the aquifer from the ground surface. In high recharge areas, recharge is 10 inches per year (in/yr) or greater. The area of high recharge shown in **Figure 2** is from a GIS coverage developed for a 2002 USGS model.<sup>2</sup>

To help further refine the recharge regime for priority setting, another recharge map, which was developed by the Florida Natural Areas Inventory (FNAI) for state land acquisition priority ranking, was also considered. This layer identifies areas of potential recharge important for natural systems and human use based on features that contribute to aquifer vulnerability as well as areas within springshed protection zones in proximity to public water supply wells.<sup>3</sup> In this coverage, higher priority areas are those with greatest recharge to the Floridan aquifer. The FNAI recharge coverage is shown in **Figure 3**.

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<sup>1</sup> SDII Global Corporation, September 13, 2014. Delineation of Spring Protection Areas at Five, First-Magnitude Springs in North-Central Florida. Prepared for the Suwannee River Water Management District under Project No. 3008033.

<sup>2</sup> Sepulveda, N. 2002. Simulation of Ground-Water Flow in the Intermediate and Floridan Aquifer Systems in Peninsular Florida. USGS Water Resources Investigation Report 02-4009.

<sup>3</sup> Florida Natural Areas Inventory, December 2000. Florida Forever Conservation Needs Assessment Summary Report to the Florida Forever Advisory Council.

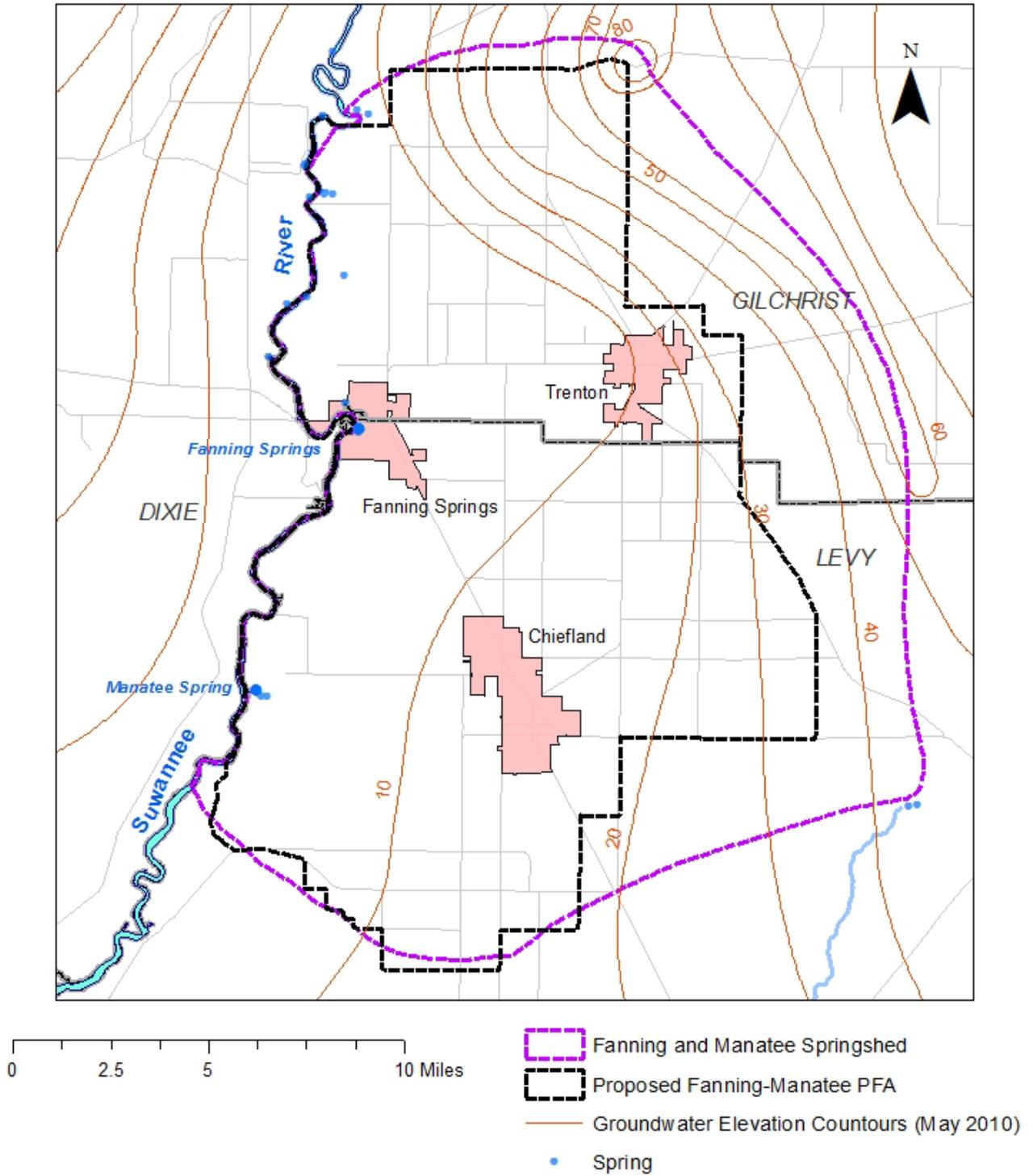


Figure 1. Combined Fanning-Manatee Springs springshed and proposed priority focus area

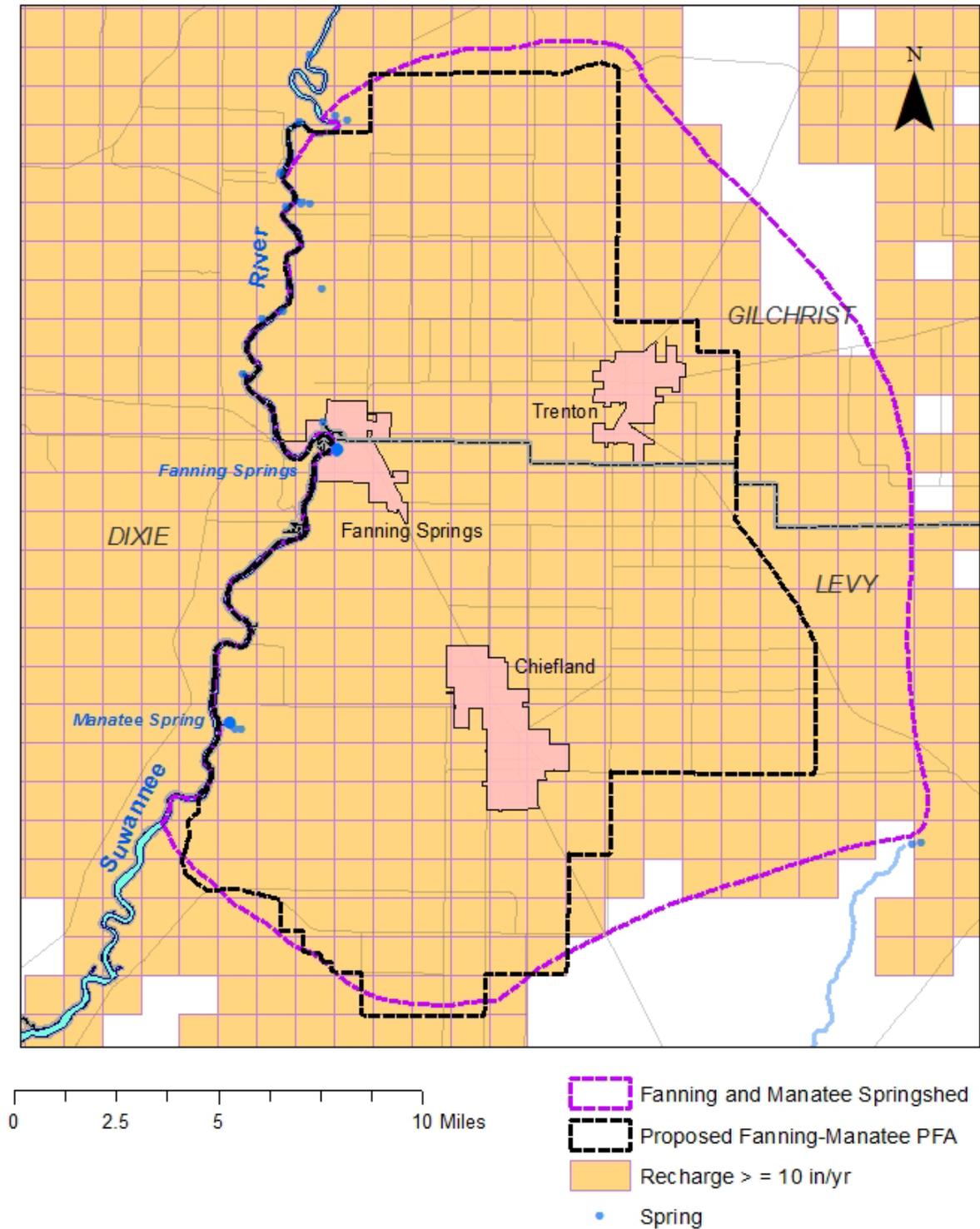


Figure 2. Areas of high recharge to Floridan aquifer ( $\geq 10$  inches/year) based on USGS 2002 methodology and proposed priority focus area

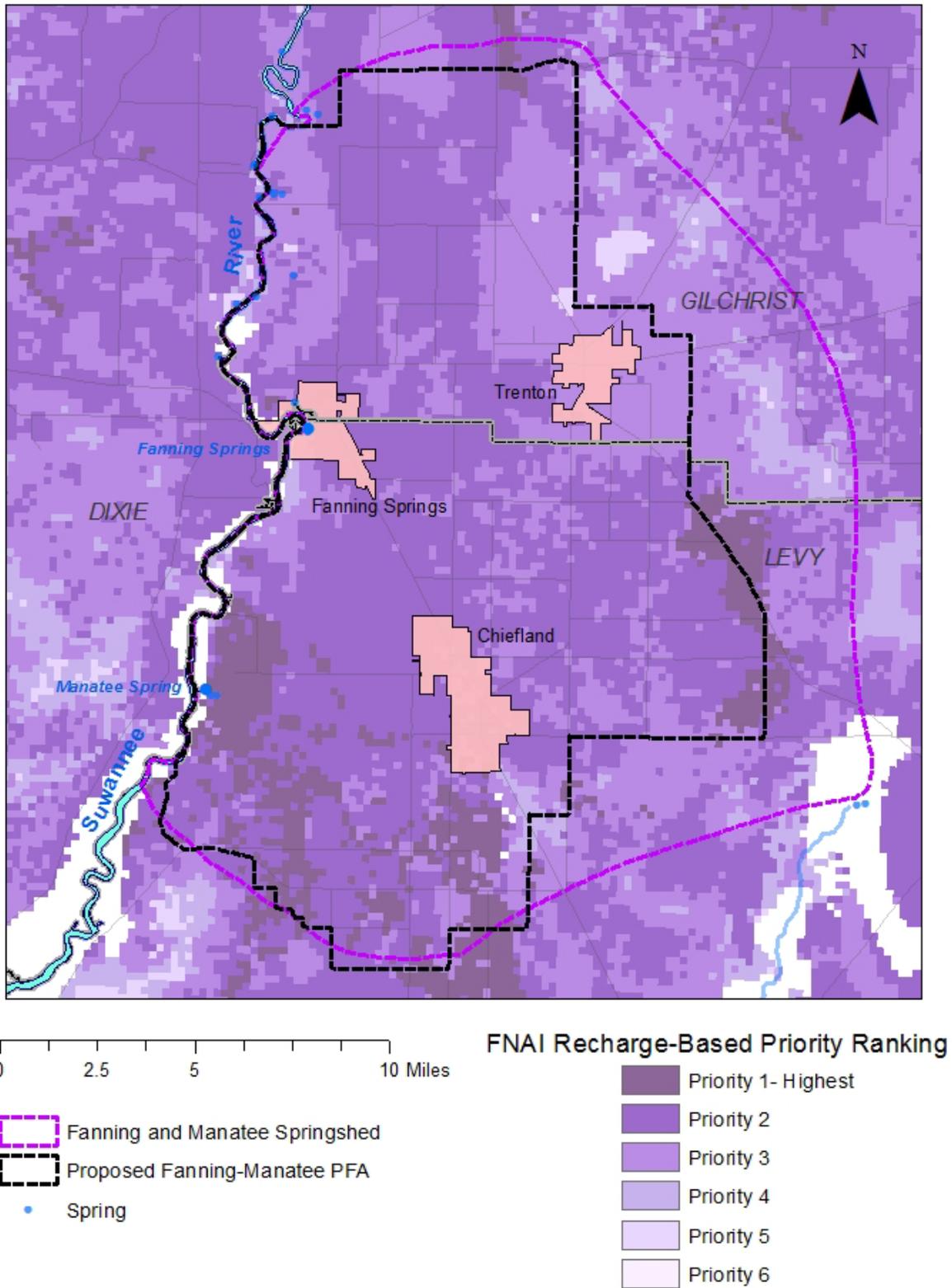


Figure 3. Florida state lands recharge-based prioritization coverage and proposed priority focus area

Step 3. Identify regions within the springshed where the Floridan Aquifer is most vulnerable.

The FGS developed the Florida Aquifer Vulnerability Assessment (FAVA) model to provide a spatial coverage of aquifer vulnerability ranges across an area.<sup>4</sup> According to the statewide FAVA model for the Floridan aquifer system, the entire combined springshed of Fanning and Manatee Springs lies within the “more vulnerable” category. As a further refinement, the vulnerability of the aquifer to local points of recharge through sinkholes and linear karst features was evaluated by using the statewide Digital Elevation Model (DEM) that is based on the Light Imaging, Detection, and Ranging (LIDAR) remote sensing method. In this area, most closed topographic depressions form as solution or collapse sinkholes and water flowing into these features can more rapidly reach the aquifer and erode and enlarge conduits in the limestone and can be expressed in linear arrays across the landscape. Dry or intermittent stream traces, shown in the coverage, can have associated subterranean conduit networks. Some sink features, known as “swallets” provide a direct conduit for surface water discharge into the aquifer. Swallets are sinkholes that capture stream flow. In 2007, the FGS completed a project to map all known swallets in the state and produced a GIS layer that includes their locations. The DEM map (2009), outlines of closed depressions and swallets in the Madison Blue Spring area region are shown in **Figure 4**.

Step 4. Consider nitrogen load. Nitrate-nitrogen has become known as the major nutrient of concern in Florida’s spring systems due to its pervasive nature in groundwater, its mobility, and its availability for uptake by aquatic flora when it is discharged from springs. Excess concentrations of nitrate nitrogen in the spring water have contributed to biological impairment at Fanning and Manatee Springs. The source of flow from these two springs is groundwater in the Floridan aquifer system and its source is local precipitation that recharges the aquifer within the springshed area. The nitrate originates from atmospheric deposition and anthropogenic sources in the springshed. Recent nitrate concentrations based on 1/6/2017 readings from nitrate sensors in Fanning and Manatee Springs were 5.52 milligrams per liter (mg/L) and 2.40 mg/L, respectively.<sup>5</sup> These concentrations are 16 and 7 times greater, respectively, than Florida’s numeric nitrate criterion for spring vents (0.35 mg/L). The load of nitrogen from Fanning and Manatee Springs depends on concentration and flow. Using the 1/6/2017 nitrate concentrations from the real-time monitoring stations and 1/2/2017 mean flows of 52 cubic feet per second (cfs) and 141 cfs from USGS monitoring stations at Fanning and Manatee Springs, respectively, estimated daily loads of nitrate nitrogen for the two springs were 1,553 and 1,825 pounds N per day, respectively, in early January 2017. Using these data, an estimated total nitrogen load (as nitrate) from the two springs would be about 1.2 million pounds per year (lb/yr), assuming flow or concentrations did not fluctuate significantly.

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<sup>4</sup> Arthur, J. D., Wood, H. A. R., Baker, A. E., Cichon, J. R., Raines, G. L., 2007, Development and Implementation of a Bayesian-based Aquifer Vulnerability Assessment in Florida: Natural Resources Research, Vol. 16, No. 2., P. 93-107. Also for more information go to <http://www.dep.state.fl.us/geology/programs/hydrogeology/fava.htm>.

<sup>5</sup> Source: Suwannee River Water Management District Water Data Portal at <http://www.srwmd.state.fl.us/index.aspx?NID=345>

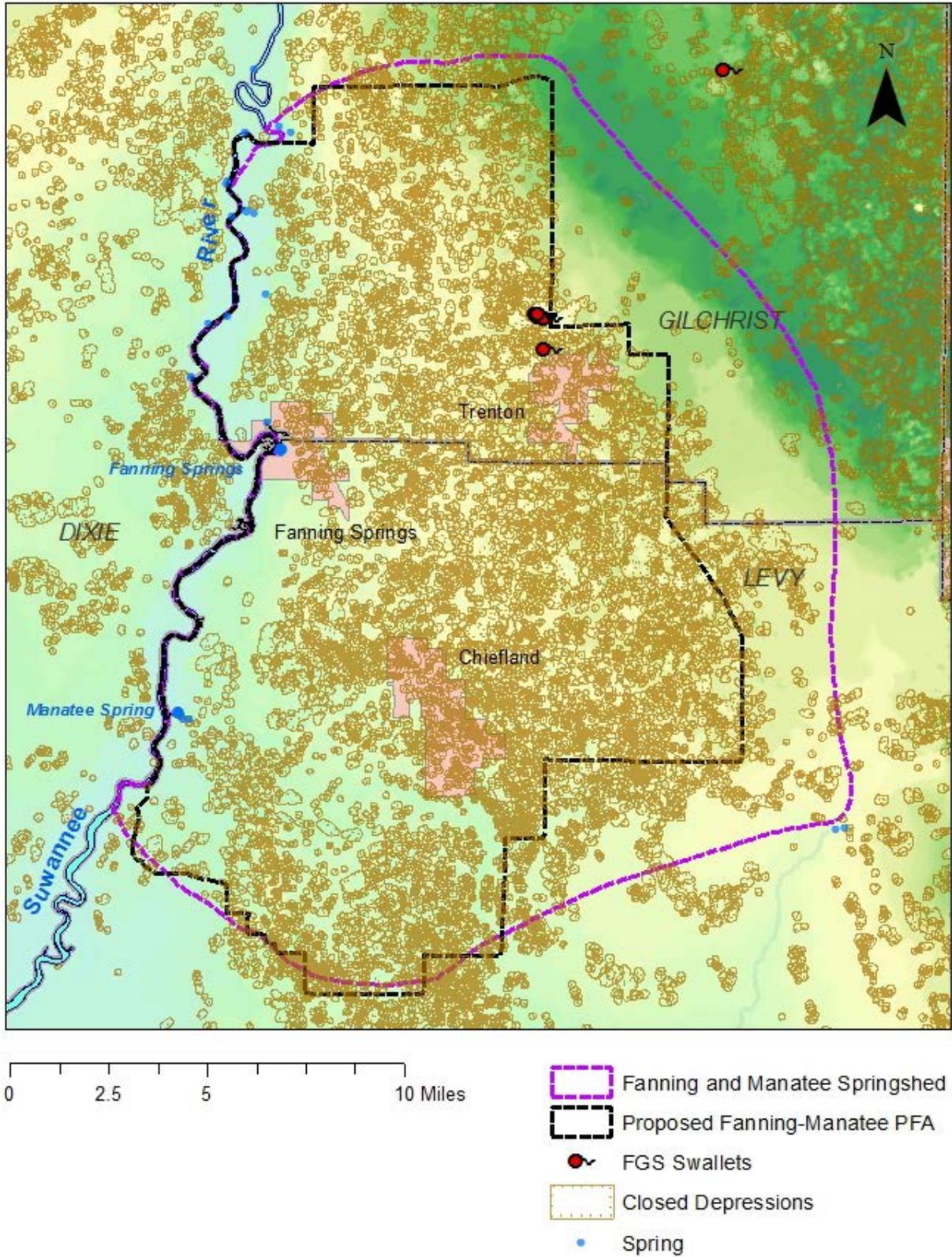


Figure 4. Digital elevation model project with closed depressions and swallets

The department is developing a nitrogen source inventory for the Fanning-Manatee Springs contributing area to serve as a tool for developing remediation strategies and projects for reducing nitrogen loads to the springs. Typical sources of nitrogen in spring contributing areas include inorganic fertilizer, livestock waste, onsite treatment and disposal systems (OSTDS or septic systems), treated domestic wastewater, and atmospheric deposition. According to the draft inventory, the main sources of nitrogen loading to the groundwater in the Fanning-Manatee Springs springshed are agricultural fertilizer and livestock waste from dairies.

Step 5. Consider groundwater travel time in creating PFA boundaries. To the extent possible, PFAs should include parts of contributing areas that have demonstrated or anticipated short travel times to the springs. Springs occur in areas of karst terrain where surface and subsurface erosion of the limestone can result in the development of complex networks of solution channels and conduits in the aquifer material. In parts of these areas, groundwater can move rapidly from points where the water enters the aquifer to the spring vents. The Fanning and Manatee Springs springshed includes areas of more dynamic flow where infiltrating water has caused dissolution and creation of sinkholes, pipes and conduits in the limestone matrix and areas where the limestone might be semi-confined by layers of lower permeability material that inhibit the erosion of the limestone by percolating water. Where karst features are less prevalent, groundwater movement occurs within intergranular pore spaces in the limestone and is slower.

In 2009, DEP contractors conducted a dye tracer test to evaluate groundwater flow rates to Manatee Spring.<sup>6</sup> In this test, rhodamine dye was introduced into Chiefland Sink, a sinkhole used for stormwater disposal located 7.4 miles east of Manatee Spring. The dye injection was immediately followed by a major precipitation event and dye arrival at the spring occurred in less than 8 days. Travel time under these conditions was approximately 1 mile per day, however under low or more typical rainfall conditions the rate of travel could be somewhat lower. Considering that development of karst features is common throughout the springshed, it is safe to assume that groundwater transport to the springs could be very rapid from many points in the springshed. Development of these features may be more extensive in the areas of locally greater recharge.

Step 6. Identify regions within the contributing area where soil conditions are most favorable for leaching of nitrogen from surface sources. Nitrogen has been identified as the target nutrient for spring restoration. Research has shown that nitrogen removal in the soil zone through denitrification and its tendency to leach can be related to soil drainage class.<sup>7</sup> Denitrification is lowest and leaching of nitrogen is highest in areas with soils that are excessively drained, somewhat excessively drained, or well drained. Leaching may occur in areas with moderately well drained soils and leaching of nitrogen is least likely to occur in areas where soils are poorly

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<sup>6</sup> URS Corporation, December 4, 2009. Manatee Springs Dye Trace Levy County, Florida, June-September, 2009. Prepared for Florida DEP under Contract WM946.

<sup>7</sup> Otis, R. J., 2007. Estimates of Nitrogen Loadings to Groundwater from Onsite Wastewater Treatment Systems in the Wekiva Study Area, Task 2 Report Wekiva Onsite Nitrogen Contribution Study. Prepared by Otis Environmental Consultants for Florida Department of Health.

Hofstra, N. and Bowman, 2005. Denitrification in Agricultural Soils: Summarizing Published Data and Estimating Global Annual Rates. *Nutrient Cycling in Agroecosystems* (2005) 72: 267-278.

drained, somewhat poorly drained or very poorly drained because of their greater potential for denitrification. The portions of the contributing area where soil conditions are more favorable for nitrogen leaching can be mapped using the U. S. Department of Agriculture Natural Resources Conservation Service soil survey geographic (SSURGO) database for Florida.<sup>8</sup> These excessively to well drained soils tend to occur in areas where aquifer recharge is highest and vulnerability is greatest. **Figure 5** shows the area where soil conditions are most favorable for nitrogen leaching, which includes soils in the excessively drained, somewhat excessively drained and well drained SSURGO drainage classes. The figure also shows areas of moderately well drained soils where leaching of nitrogen could also be significant. The areas of higher soil drainage are somewhat similar to the FNAI higher groundwater recharge priority areas shown in **Figure 3**.

Step 7. Identify regions within the contributing area to exclude or include based on land use and potential for pollutant sources to occur. Conservation lands, wetlands, and undeveloped open land that are protected from development are land areas that in some cases may be excluded from the PFA if there is no expectation that they would include pollutant sources affecting springs in the foreseeable future and they are under protection. However, most of the conservation land area in the Fanning-Manatee Springs springshed includes SRWMD-managed lands and privately owned conservation easements along the Suwannee River corridor that should reasonably be included in the PFA as a protection measure. In addition to the district-managed lands, larger public owned conservation lands within the proposed PFA include Fanning Springs State Park, Manatee Springs State Park, Hart Springs County Park, and Andrews Wildlife Management Area (WMA). Conservation lands from the Florida Natural Areas Inventory Conservation Lands (FNAI Managed Areas) GIS layer are shown in **Figure 6**.

The Fanning-Manatee Springs springshed includes a large aggregate area in agricultural land uses and scattered areas of urban land use (mostly residential and commercial). Delineation of the PFA includes consideration of areas with significant potential for nitrogen leaching to groundwater based on the sources of nitrogen that occur there. Agricultural lands can include fertilizer use and livestock operations that can result in significant nitrogen inputs to land surface. Urban lands can include higher densities of OSTDS, domestic wastewater and urban fertilizer use, all of which can be sources of nitrogen to the aquifer and springs. Mapped urban and agricultural lands (based on the 2013-2014 SRWMD land use-land cover GIS coverage) are shown in **Figure 7**.

Onsite treatment and disposal systems can be potentially significant sources of nutrients to be considered when delineating the PFA. OSTDS in the area are shown in **Figure 8**. Their locations are based on a GIS coverage developed as part of the Florida Department of Health's Florida Water Management Inventory Project (<http://www.floridahealth.gov/environmental-health/onsite-sewage/research/flwmi/index.html>).

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<sup>8</sup> SSURGO Soil Survey Geographic Database is a digital soil survey developed by the National Cooperative Soil Survey. The dataset includes georeferenced digital map data and computerized attribute data. Metadata can be found at this link: <https://catalog.data.gov/dataset/soil-survey-geographic-ssurgo-database-for-various-soil-survey-areas-in-the-united-states->

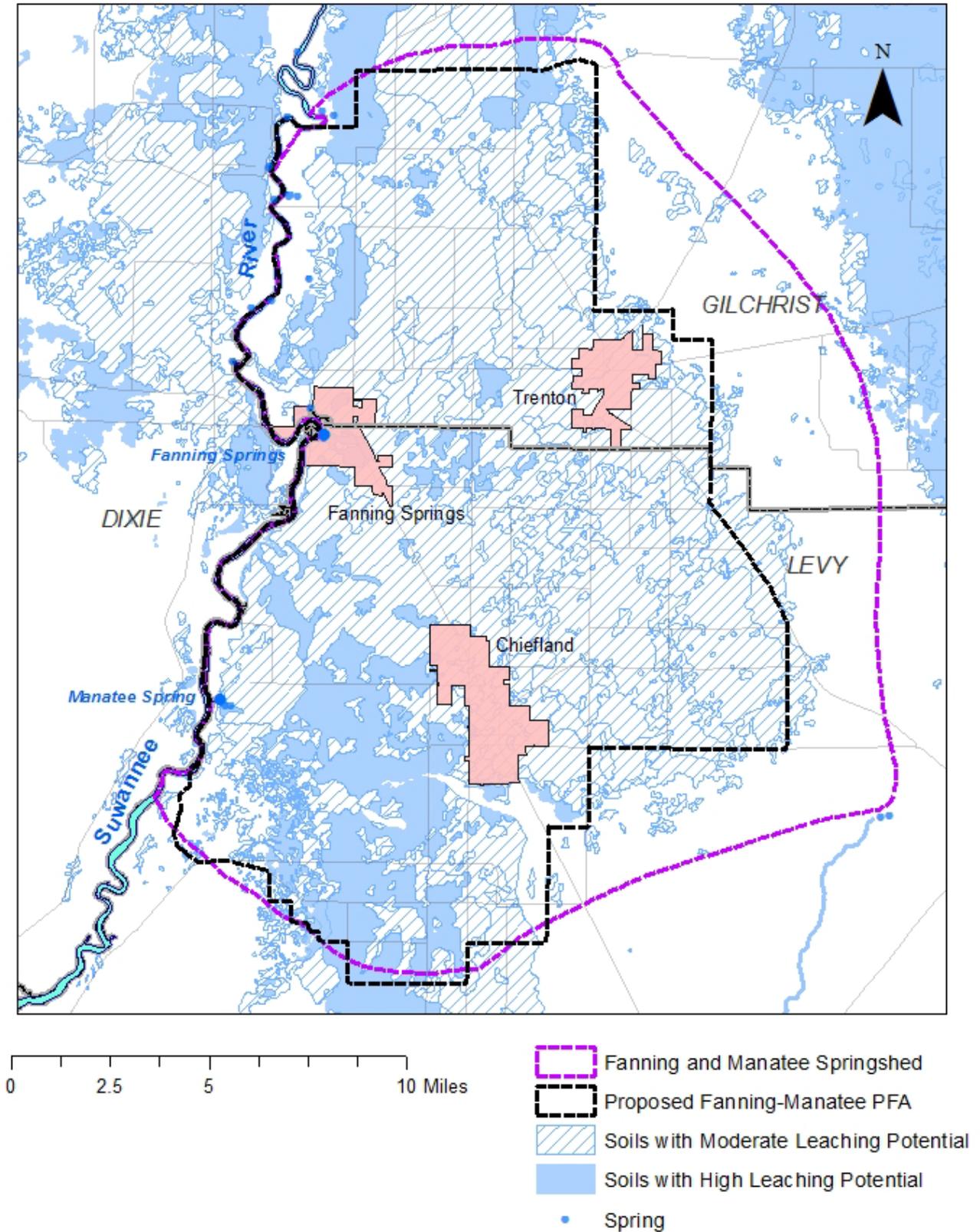


Figure 5. Areas of high nitrogen leaching potential soils and proposed priority focus area

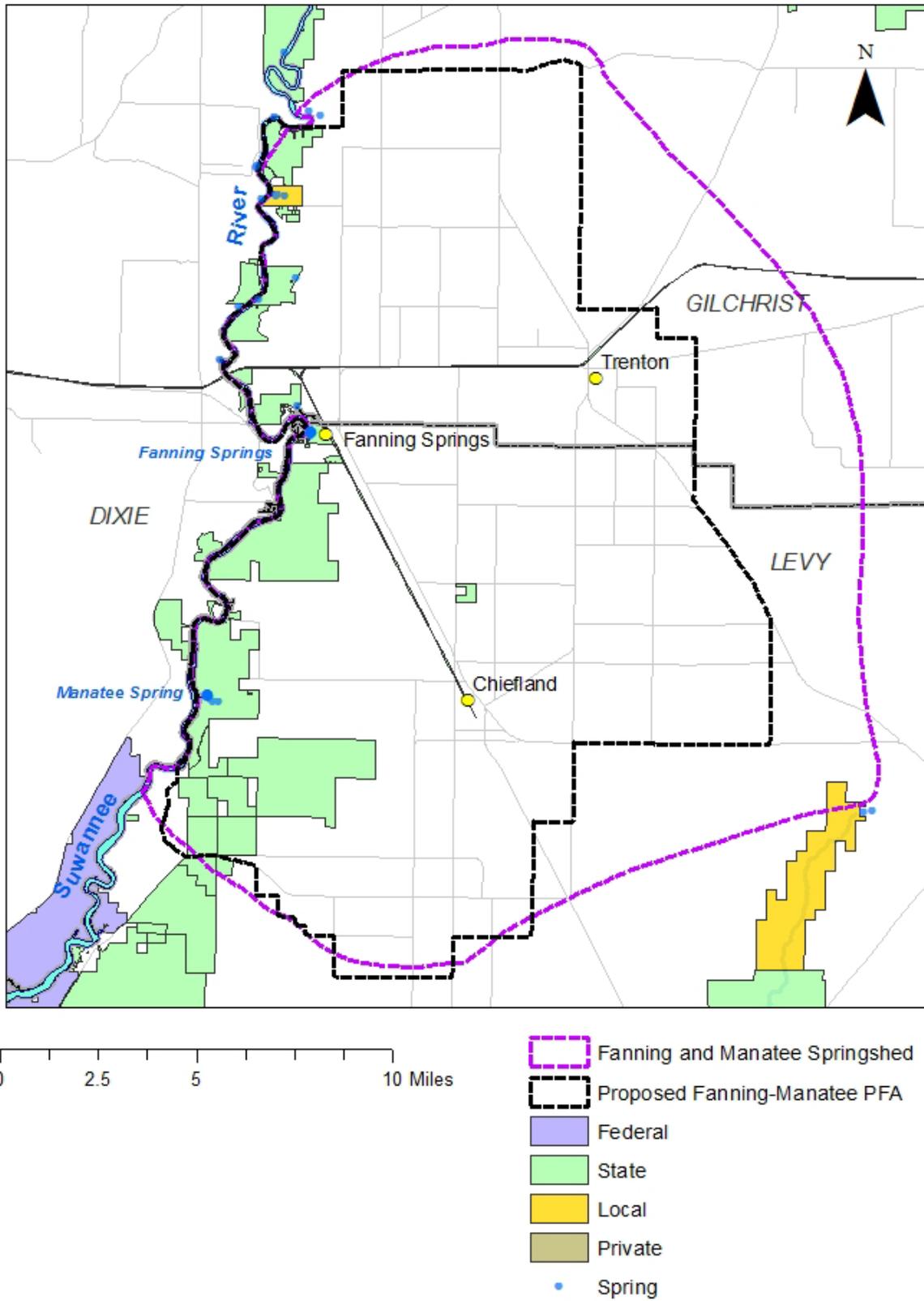


Figure 6. Conservation lands and proposed priority focus area

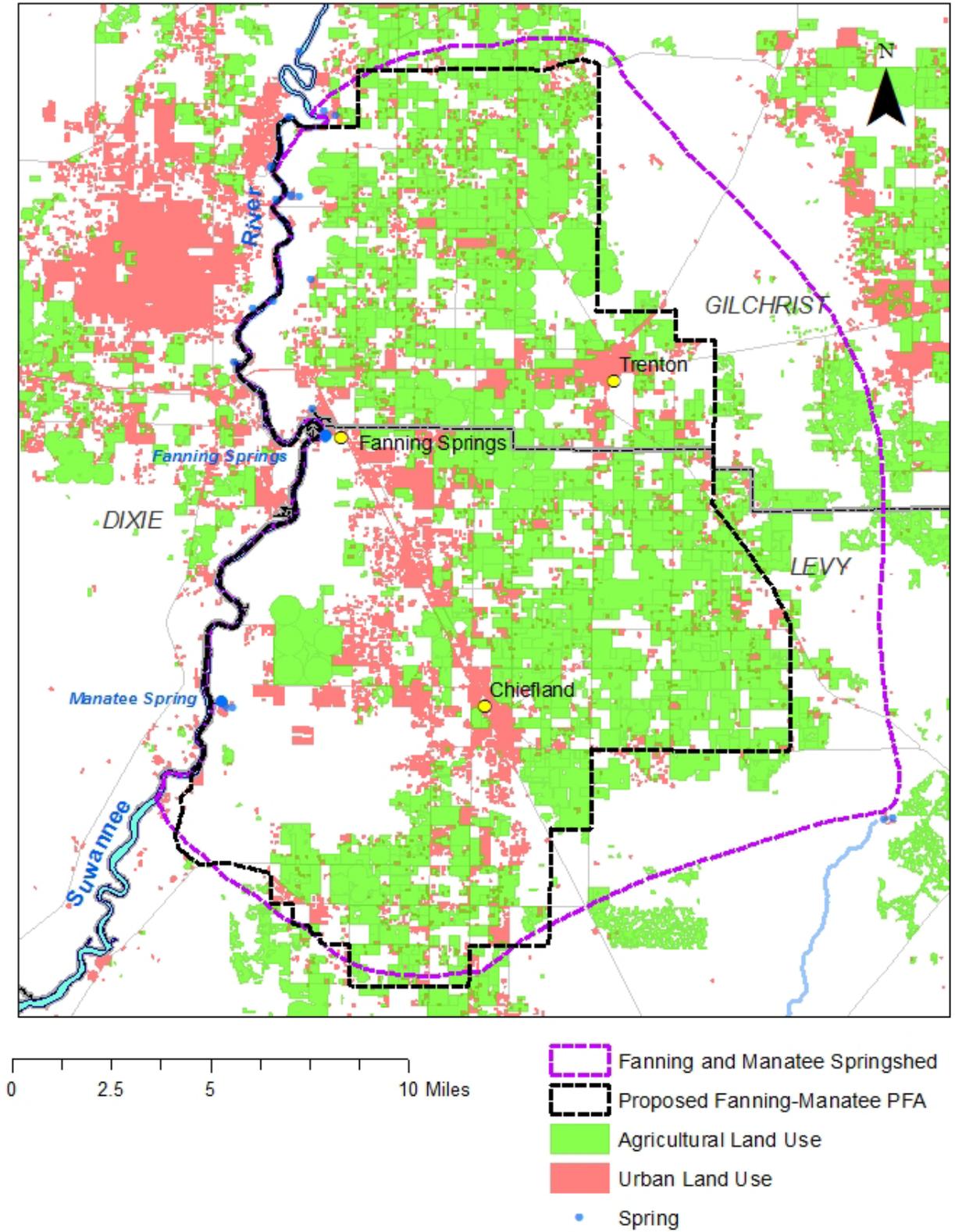
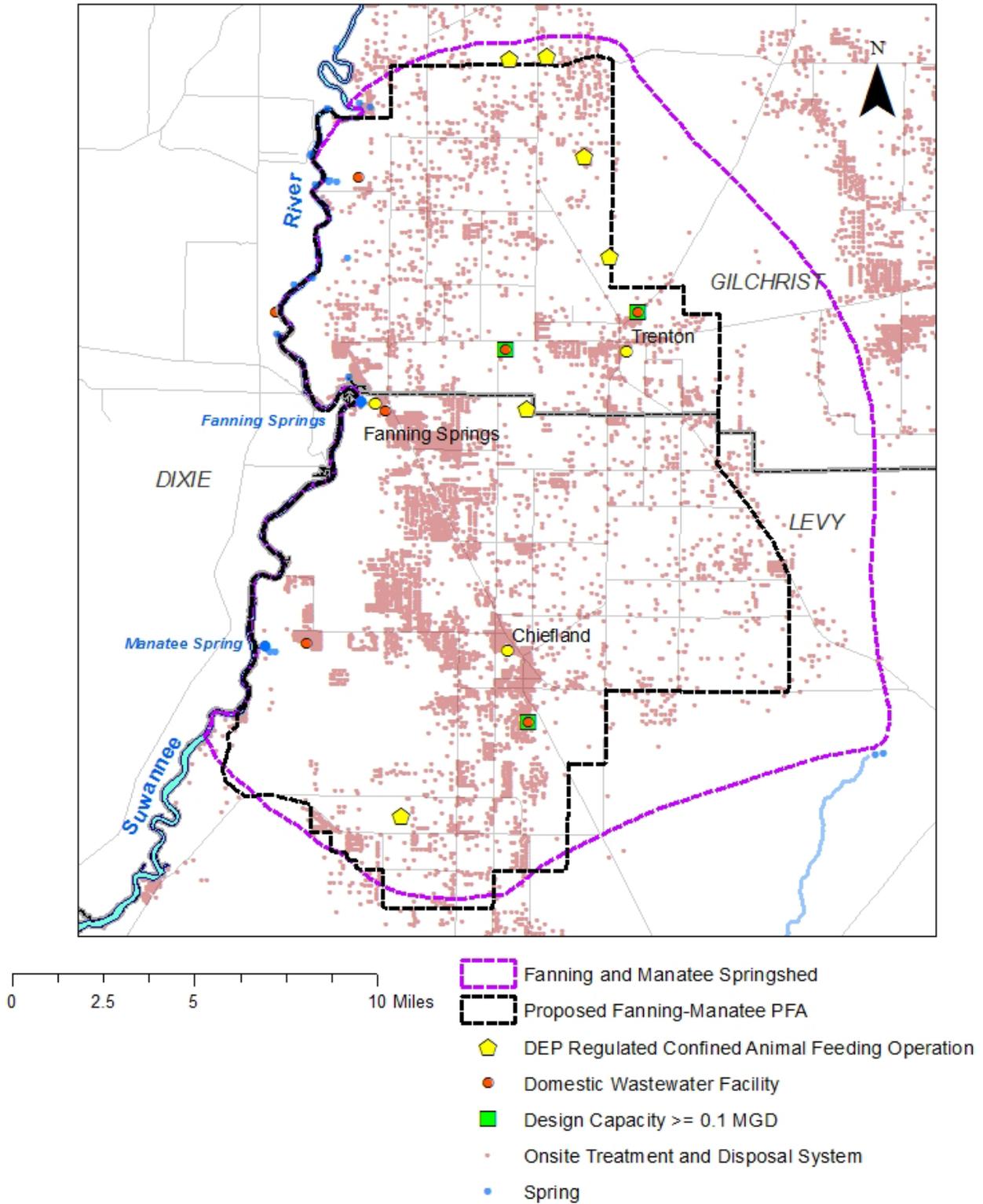


Figure 7. Urban and agricultural land use areas and proposed priority focus area



**Figure 8. Onsite treatment and disposal systems, domestic wastewater treatment facilities, DEP regulated confined animal feeding operations, and proposed priority focus area**

Department-regulated wastewater facilities can also be significant nutrient sources to be considered. Existing domestic wastewater facilities, including those with design flows greater than or equal to 0.1 million gallons per day (mgd), are shown in **Figure 7** because they also have potential for contributing nitrogen to groundwater. Larger wastewater treatment facilities include those operated by the City of Trenton, the City of Chiefland, and Lancaster Correctional Institution. The figure also includes locations of department-regulated confined animal feeding operations (CAFO), which in this area are large dairy operations, that can also have significant inputs of nitrogen. Department regulated wastewater facility information for the two springsheds was obtained from the department's wastewater facility regulation (WAFR) information management system.

Step 8. Create PFA boundaries that correspond with understood and identifiable boundaries.

For stakeholders to implement restoration and protection actions described in the ones within the PFAs, the boundaries must be clearly defined and associated with features easily recognizable on a map. For that reason, the proposed boundary of the Fanning-Manatee Springs PFA that would be used for planning and restoration was made to conform to easily recognizable natural features, roads, political boundaries, and major survey boundaries.

### ***PFA Boundary for Fanning and Manatee Springs***

The PFA boundary shown in **Figure 9** was developed by considering GIS coverages of recharge, vulnerability, soils, conservation lands, and potential contaminant nitrogen source information. The PFA includes a region including most of the combined springshed. This area includes high groundwater recharge/vulnerability conditions and soil conditions that tend to leach nitrogen. It includes potential areas of higher nitrogen loading from agriculture and urban land uses. It also includes an area within the springshed over which groundwater travel to the springs could occur rapidly. The PFA also includes interconnected areas of agricultural land use, urban development, areas of OSTDS, domestic wastewater facilities, and CAFOs which all have potential to contribute to nitrogen enrichment in the aquifer and springs.

The proposed PFA is in Gilchrist and Levy Counties. It includes the following cities: Fanning Springs, Chiefland, and Trenton. It also includes the Lancaster Correctional Institution (maximum population of 732 inmates). The proposed PFA also includes Fanning Springs State Park, Manatee Springs State Park, Hart Springs Park, a corridor along the Suwannee River of SRWMD managed state land and conservation easements and state managed wildlife management areas. Conservation land boundaries, natural features, political boundaries, roads, and survey boundaries in the area were also considered in the development of a readily identifiable boundary.



# *Priority Focus Area for Madison Blue Spring*

**Division of Environmental Assessment and Restoration  
Florida Department of Environmental Protection**

**August 2017**

**2600 Blair Stone Road, MS 3575  
Tallahassee, FL 32399-2400**

**[www.dep.state.fl.us](http://www.dep.state.fl.us)**



## **More Information**

For more information about the priority focus area for Madison Blue Spring, contact the following individuals:

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## Introduction

Under the Florida Springs and Aquifer Protection Act, the Florida Department of Environmental Protection (DEP) is required to delineate priority focus areas (PFAs) for all Outstanding Florida Springs identified as impaired. According to the Florida Springs and Aquifer Protection Act, adopted by the Florida Legislature in 2016 (Chapter 373, Part VIII, Florida Statutes [F.S.]):

" 'Priority focus area' means the area or areas of a basin where the Floridan Aquifer is generally most vulnerable to pollutant inputs where there is a known connectivity between groundwater pathways and an Outstanding Florida Spring, as determined by the department [DEP] in consultation with the appropriate water management districts, and delineated in a basin management action plan. Using the best data available from water management districts and other credible sources, the department, in coordination with the water management districts, shall delineate priority focus areas for each Outstanding Florida Spring or group of springs that contains one or more Outstanding Florida Springs and is identified as impaired in accordance with s. 373.807. In delineating priority focus areas, the department shall consider groundwater travel time to the spring, hydrogeology, nutrient load, and any other factors that may lead to degradation of an Outstanding Florida Spring. The delineation of priority focus areas must be completed by July 1, 2018, shall use understood and identifiable boundaries such as roads or political jurisdictions for ease of implementation, and is effective upon incorporation in a basin management action plan."

Factors to consider in establishing these geographically bounded areas include the following:

- Groundwater travel time to the spring, which could be based on empirical data from tracer studies and/or predicted travel time from modeling, if such data or studies are available.
- Hydrogeology, which includes the spring's groundwater contributing area (or springshed), the amount of confining material protecting the Floridan aquifer, the aquifer recharge characteristics, the capacity for the aquifer to transmit water, and other characteristics that help determine the aquifer vulnerability and the likelihood of adverse water quality impacts to springs.
- Nutrient load to the spring, which includes the actual measured load in the water discharging from the spring as well as the potential nutrient load based on land uses in specific regions that would most probably influence water quality in the spring.

- Other factors, including soil characteristics that are favorable for pollutant leaching to the aquifer in the springshed and the presence or absence of pollutant sources in the area.
- Identifiable boundaries, including roads, natural boundaries, and political jurisdictions.

## Steps in Delineating the PFA for Madison Blue Spring and Related Springs

The PFA delineated for Madison Blue Spring also includes related springs downstream along the Withlacoochee River. It was developed using geographic information system (GIS) tools, spring-specific data, and published information to help identify the portion of the springs' contributing area that is most important from both water quality restoration and protection perspectives. The steps listed below were taken to develop a draft PFA for review and input by stakeholders. The consideration of mapped characteristics that express high vulnerability, a high potential for pollutant mobility, and likely pollutant sources provides the best assurance that the PFA includes the areas of greatest concern for water quality restoration and protection.

**Step 1. Establish the springshed for the priority spring(s).** SDII Global Corporation created a springshed boundary for Madison Blue Spring for the Suwannee River Water Management District (SRWMD) in 2004.<sup>1</sup> In 2016 DEP and the SRWMD expanded the springshed boundary to include the contributing area for spring vents downriver that were confirmed by cave exploration and dye trace work to share a common conduit system with Madison Blue Spring. **Figure 1** shows the Madison Blue Springshed, the Madison Blue/Pott/Tanner combined springshed, and the PFA boundary. The map also shows the groundwater elevation contour map for the Floridan aquifer for May 2010. Groundwater flow gradients were part of the basis for the springshed delineation.

**Step 2. Identify regions in the contributing area where the greatest recharge occurs.** Several GIS coverages developed by the U.S. Geological Survey (USGS), the water management districts (WMDs), and others delineate areas of high, medium, and low recharge to the Floridan aquifer system as well as areas of aquifer discharge. The PFA delineation considers areas with the highest recharge to the aquifer, which could occur as diffuse infiltration through permeable geological material as well as focused recharge to sinkholes that breach confining layers. Pollutant sources in high-recharge areas have the greatest potential to cause adverse impacts to groundwater and springs because water is impeded the least as it infiltrates to the aquifer from the surface. In high-recharge areas, recharge is 10 inches per year (in/yr) or greater.

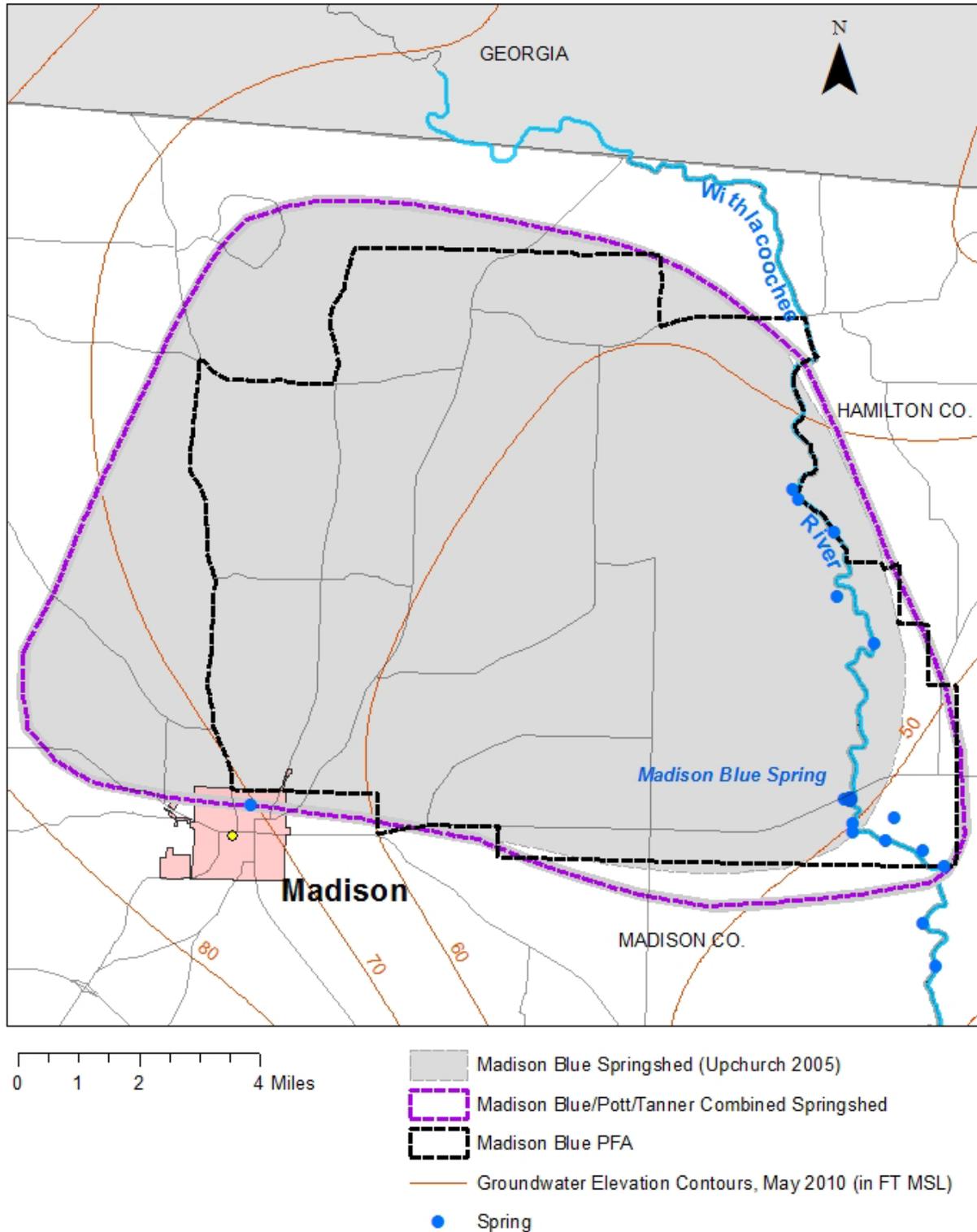
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<sup>1</sup> SDII Global Corporation. September 13, 2014. *Delineation of spring protection areas at five, first-magnitude springs in north-central Florida*. Prepared for the SRWMD under Project No. 3008033.

Unfortunately, available WMD or USGS recharge coverages do not include most of the Madison Blue Springs area. However, another GIS coverage, developed by the Florida Natural Areas Inventory (FNAI) for state land acquisition priority ranking, identifies areas of potential recharge important for natural systems and human use, based on features that contribute to aquifer vulnerability and springshed protection zones near public water supply wells.<sup>2</sup> In this coverage, higher priority areas are those with the greatest recharge to the Floridan aquifer. **Figure 2** shows the FNAI recharge coverage.

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<sup>2</sup> FNAI. December 2000. *Florida Forever conservation needs assessment summary report to the Florida Forever Advisory Council.*



**Figure 1. Madison Blue Springshed, Madison Blue/Pott/Tanner combined springshed, and PFA boundary**

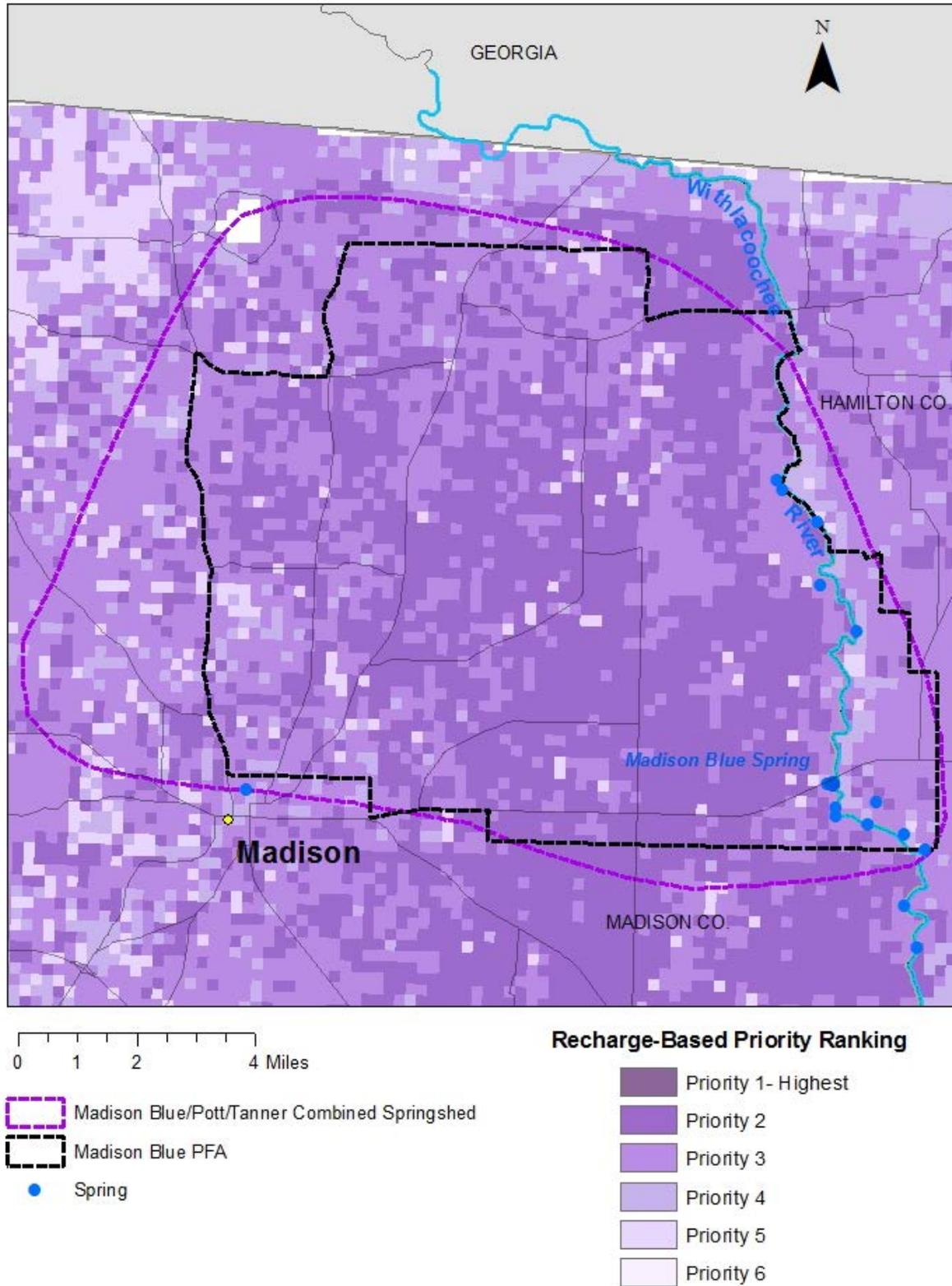


Figure 2. Florida state lands recharge-based prioritization coverage and PFA boundary

**Step 3. Identify regions in the springshed where the Floridan aquifer is most vulnerable.**

The Florida Geological Survey (FGS) developed the Florida Aquifer Vulnerability Assessment (FAVA) model to provide spatial coverage of aquifer vulnerability ranges across an area of interest.<sup>3</sup> According to the statewide FAVA model for the Floridan aquifer system, the entire springshed is in the "more vulnerable" category (**Figure 3**).

As a further refinement, the vulnerability of the aquifer to local points of recharge through sinkholes and linear karst features was evaluated by using the statewide Digital Elevation Model (DEM), which is based on the light imaging, detection, and ranging (LIDAR) remote sensing method. In this area, most closed topographic depressions form as solution or collapse sinkholes, and water flowing into these features can more rapidly reach the aquifer and erode and enlarge conduits in the limestone, and can be expressed in linear arrays across the landscape. Dry or intermittent stream traces, shown in the coverage, can have associated subterranean conduit networks. Some sink features, called "swallets," provide a direct conduit for surface water discharge into the aquifer. Swallets are sinkholes that capture stream flow. In 2007, the FGS completed a project to map all known swallets in the state and produced a GIS layer that includes their locations. **Figure 4** shows the DEM map (2009) with outlines of closed depressions and swallets in the Madison Blue Spring region.

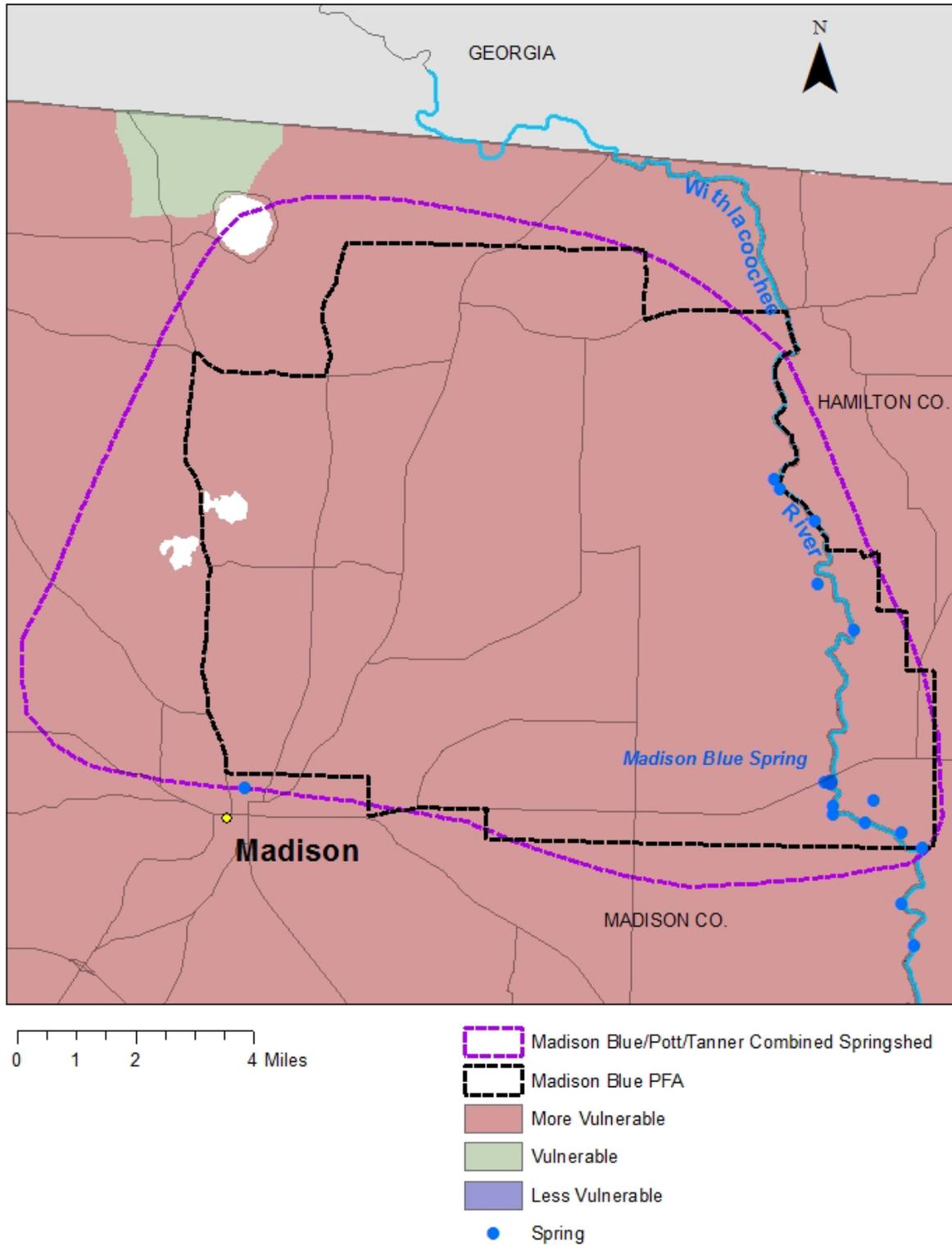
**Step 4. Consider nitrogen load.** Nitrate-nitrogen is the major nutrient of concern in Florida's spring systems because of its extensive use and presence on the land surface, its mobility, and its availability for uptake by aquatic flora when it is discharged from springs. Excess concentrations of nitrate-nitrogen in the spring water have contributed to biological impairment in Madison Blue Spring. Groundwater from the Floridan aquifer system comprises the source of flow from the spring. This groundwater comes mainly from local precipitation that recharges the aquifer in the springshed area. The nitrate originates from atmospheric deposition and anthropogenic sources in the springshed. A recent nitrate concentration of 1.39 milligrams per liter (mg/L) was measured on January 17, 2017, by a nitrate sensor installed at the USGS real-time monitoring station at Madison Blue Spring.<sup>4</sup> This concentration is almost 4 times higher than Florida's numeric nitrate criterion for spring vents (0.35 mg/L).

The nitrogen load from the spring vent depends on concentration and flow. Using the January 1, 2017, mean flow value of 85 cubic feet per second measured at the USGS station and the nitrate concentration on the same date, the nitrogen load from the Madison Blue Spring vent was 636 pounds per day. Using this daily calculation, 0.23 million pounds of nitrogen (as nitrate) would discharge per year.

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<sup>3</sup> Arthur, J.D., H.A.R. Wood, A.E. Baker, J.R. Cichon, and G.L. Raines. 2007. Development and implementation of a Bayesian-based aquifer vulnerability assessment in Florida. *Natural Resources Research* 16(2): 93–107. For additional information, see the DEP [FAVA website](#).

<sup>4</sup> SRWMD [Water Data Portal](#).



**Figure 3. Floridan aquifer vulnerability based on the statewide FAVA model**

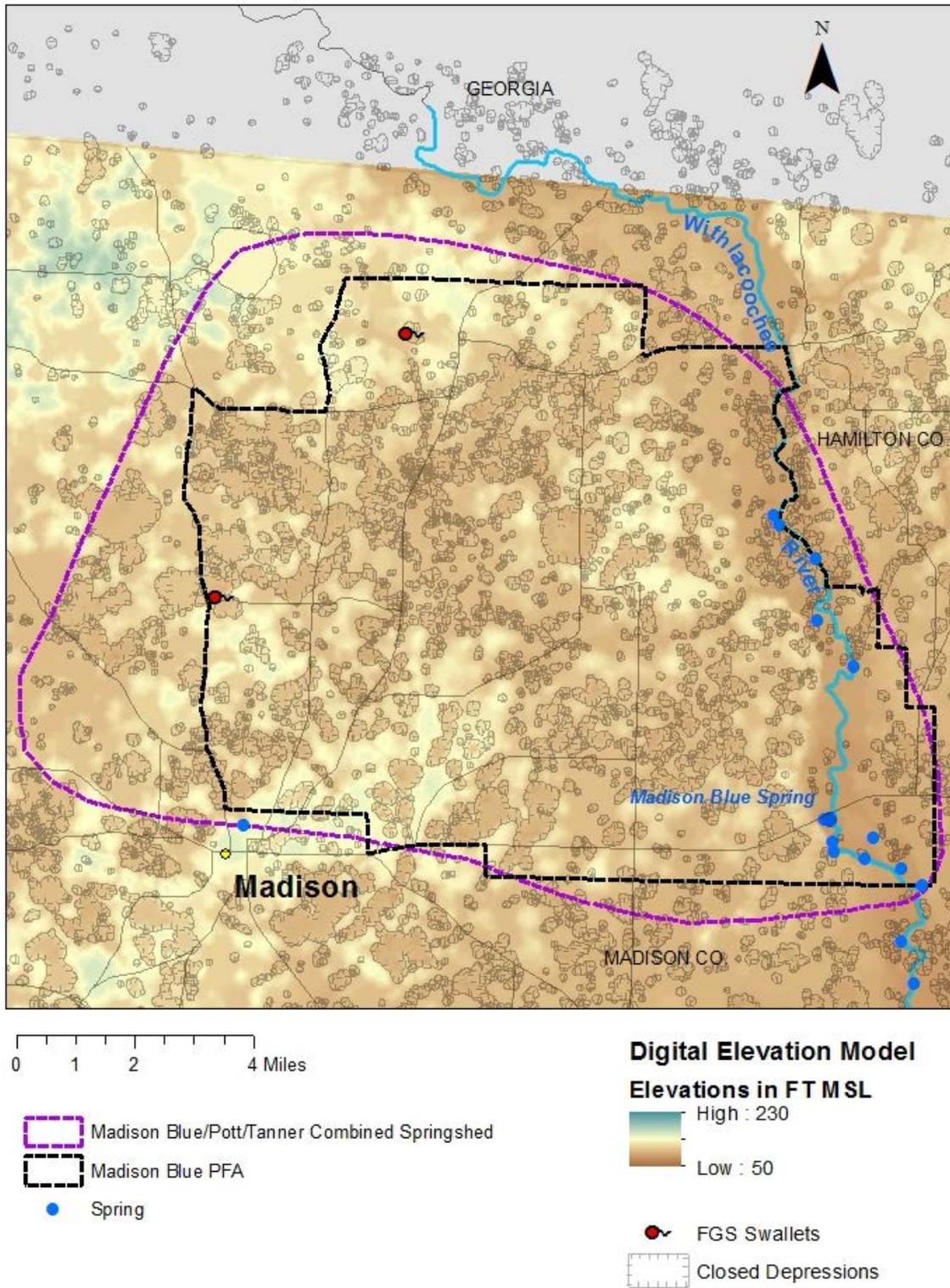


Figure 4. DEM projection with closed depressions and swallets in the combined springshed

DEP is developing a nitrogen source inventory for the contributing area of Madison Blue and related springs to serve as a tool for developing remediation strategies and projects for reducing nitrogen loads to the springs. Typical sources of nitrogen in spring contributing areas include inorganic fertilizer; livestock waste; onsite treatment and disposal systems (OSTDS), or septic systems; treated domestic wastewater; and atmospheric deposition. According to the draft inventory, the main source of nitrogen loading to groundwater in the Madison Blue Springshed is agricultural fertilizer.

**Step 5. Consider groundwater travel time in creating PFA boundaries.** To the extent possible, PFAs should include parts of contributing areas that have demonstrated or anticipated short travel times to the springs. Springs occur in areas of karst terrain where surface and subsurface erosion of the limestone can result in the development of complex networks of solution channels and conduits in the aquifer material. In these areas, groundwater can move rapidly from points where water enters the aquifer to the spring vents. One study documented the transport of dye from an injection point just downstream from the Madison Blue Spring vent to Pot Spring, located along the Withlacoochee River 0.8 miles to the southeast, within 24 hours. The tracer reached Tanner Spring farther downstream (2 miles to the southeast) in less than 96 hours.<sup>5</sup>

The Madison Blue Spring/Pott/Tanner combined springshed includes areas of dynamic flow potential where infiltrating water has caused the dissolution and creation of sinkholes, pipes, and conduits in the limestone matrix and areas where the limestone may be semi-confined by layers of lower permeability material that inhibit the erosion of the limestone by percolating water. Where karst features are less prevalent, groundwater movement occurs in intergranular pore spaces in the limestone and is slower. However, in areas where conduit development has been extensive, the rate of groundwater movement can be very rapid.

Considering that the development of karst solution features is common throughout much of the springshed, it is safe to assume that groundwater transport to the springs is very rapid from many points in the springshed and that recharge areas are shared. The development of these features is prevalent along the Withlacoochee River and may be more extensive in areas of locally greater recharge.

**Step 6. Identify regions in the contributing area where soil conditions are most favorable for nitrogen to leach from surface sources.** Nitrogen has been identified as the target nutrient for spring restoration. Research has shown that nitrogen removal in the soil zone through denitrification and its tendency to leach are related to soil drainage class.<sup>6</sup> Denitrification is

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<sup>5</sup> SDII Global Corporation. March 30, 2005. *Ground water chemistry and origin of water discharging from Manatee and Fanning Spring, Troy Spring, Madison Blue Spring*. Prepared for the SRWMD.

<sup>6</sup> Otis, R.J. 2007. *Estimates of nitrogen loadings to groundwater from onsite wastewater treatment systems in the Wekiva Study Area, Task 2 report, Wekiva Onsite Nitrogen Contribution Study*. Prepared by Otis Environmental Consultants for the Florida Department of Health (FDOH).

lowest and nitrogen leaching is highest in areas with soils that are excessively drained, somewhat excessively drained, or well drained. Leaching may occur in areas with moderately well-drained soils and nitrogen leaching is least likely to occur in areas where soils are poorly drained, somewhat poorly drained, or very poorly drained because of the greater potential for denitrification where drainage is poor. The portions of the contributing area where soil conditions are more favorable for nitrogen leaching can be mapped using the U.S. Department of Agriculture Natural Resources Conservation Service Soil Survey Geographic (SSURGO) Database for Florida.<sup>7</sup> These excessively to well-drained soils tend to occur in areas where aquifer recharge is highest and vulnerability is greatest.

**Figure 5** shows the area where soil conditions are most favorable for nitrogen leaching. This includes soils in the excessively drained, somewhat excessively drained, and well-drained SSURGO drainage classes. The figure also shows areas of moderately well-drained soils where nitrogen leaching could be significant. The mapped areas of higher soil drainage are often the same as the areas of higher groundwater recharge shown in **Figure 2**.

**Step 7. Identify regions in the contributing area to exclude or include based on land use and the potential for pollutant sources to occur.** Conservation lands, wetlands, and undeveloped open land protected from development may be excluded from the PFA if there is no expectation that they would include pollutant sources affecting springs in the foreseeable future and they are under protection. The conservation lands in the Madison Blue/Pott/Tanner Springshed include part of the Withlacoochee State Forest, located along the Withlacoochee River corridor. Portions of this forest in the Madison Blue Springshed are included in the PFA as a protection measure. The PFA boundary also includes Madison Blue Spring State Park, which contains the Madison Blue Spring vent. **Figure 6** shows the location of conservation lands from the FNAI Conservation Lands (Managed Areas) GIS layer.

The springshed includes a large aggregate area in agricultural land uses (31 % of the springshed area) and scattered areas of urban land use north of the City of Madison (7 % of the springshed). The PFA delineation includes areas with significant potential for nitrogen leaching to groundwater based on the nitrogen sources found there. Agricultural lands can include fertilizer use and livestock that may contribute significant nitrogen inputs. Urban lands can include areas with higher densities of OSTDS, domestic wastewater application sites, and areas of urban fertilizer use, all of which can be sources of nitrogen to the aquifer and springs. **Figure 7** shows the locations of mapped agricultural and urban lands (based on the 2013–14 SRWMD land use–land cover GIS coverage).

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Hofstra, N. and A.F. Bouwman. 2005. Denitrification in agricultural soils: Summarizing published data and estimating global annual rates. *Nutrient Cycling in Agroecosystems* 72: 267–278.

<sup>7</sup> The SSURGO Database is a digital soil survey developed by the National Cooperative Soil Survey. The dataset includes georeferenced digital map data and computerized attribute data. Metadata can be found [online](#).

OSTDS are potentially significant sources of nutrients to be considered when delineating the PFA. **Figure 8** shows the locations of OSTDS in the area. Their locations are based on GIS coverage developed as part of the FDOH [Florida Water Management Inventory Project](#).

DEP-regulated wastewater facilities can also be significant nutrient sources. **Figure 8** shows the locations of existing domestic facilities with design flows greater than or equal to 0.1 million gallons per day (mgd) because they also have the potential to contribute nitrogen to groundwater. There are currently no DEP-permitted wastewater facilities in the Madison Blue Springshed, based on information obtained from the DEP Wastewater Facility Regulation (WAFR) Database.

**Step 8. Create PFA boundaries that correspond with understood and identifiable boundaries.** For stakeholders to implement restoration and protection actions in a PFA, the boundaries must be clearly defined and associated with features easily recognizable on a map. For that reason, the PFA boundary conforms to easily recognizable natural features, roads, political boundaries, and major survey boundaries.

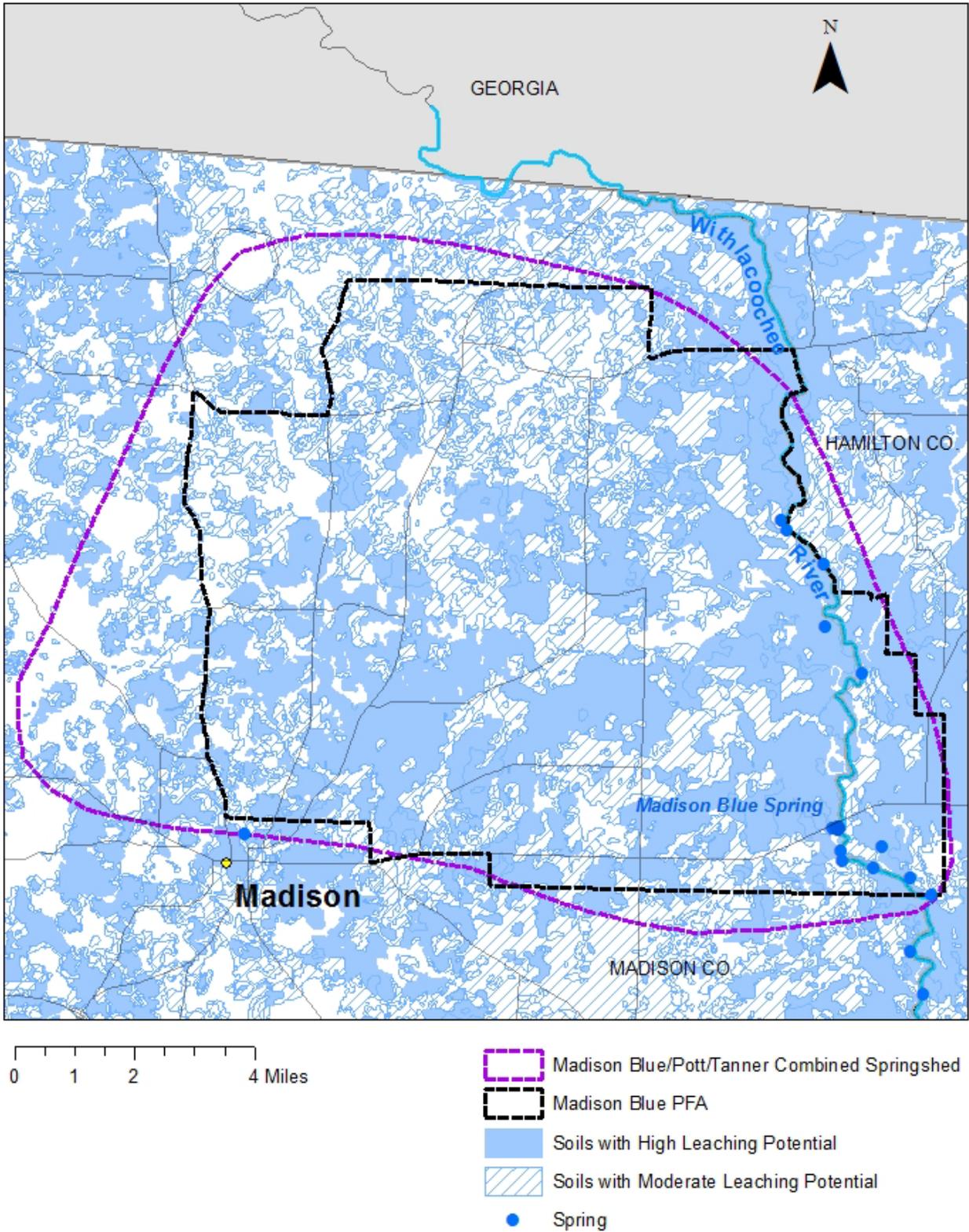


Figure 5. Areas of soils with high nitrogen leaching potential and PFA boundary

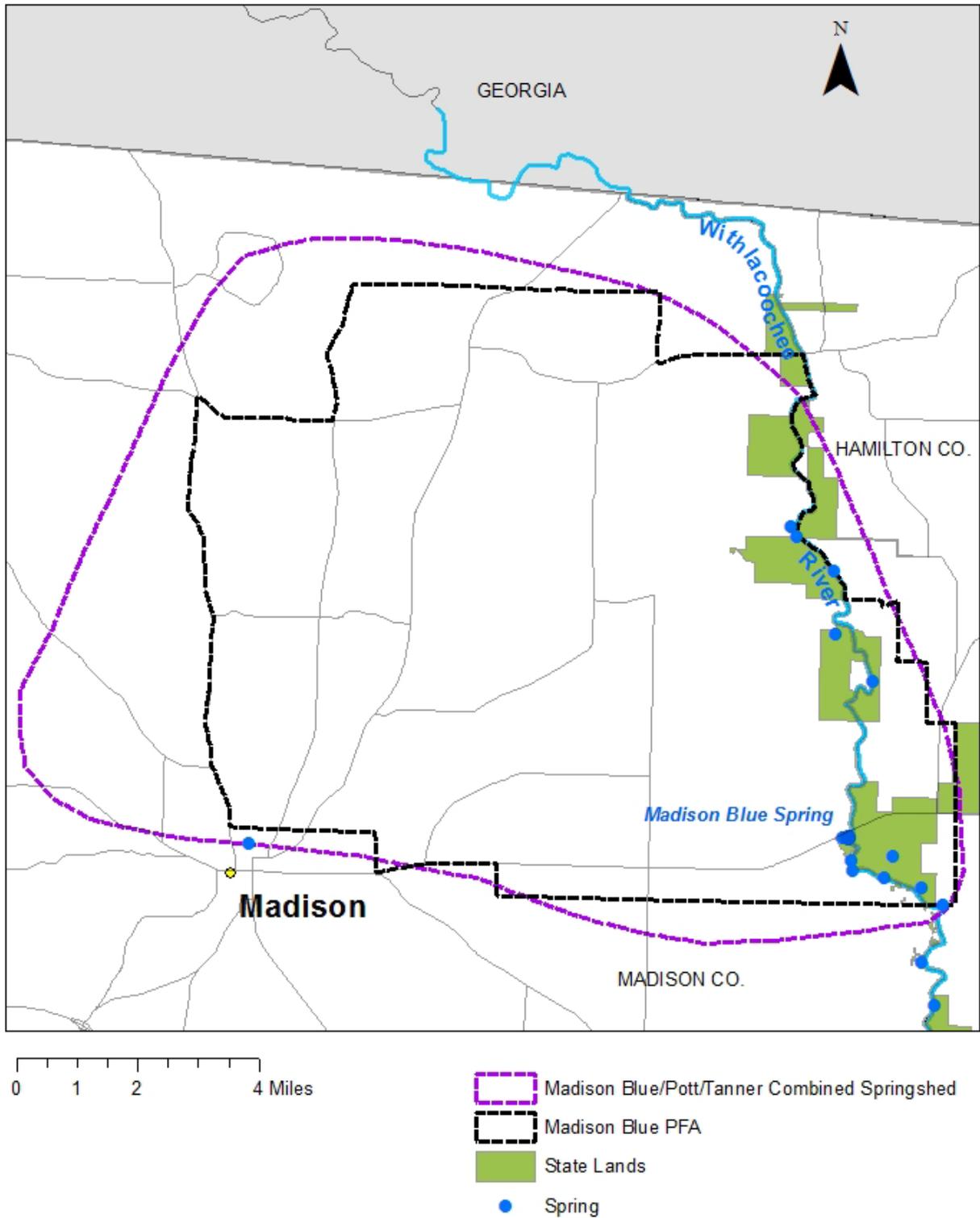


Figure 6. Conservation lands and PFA boundary

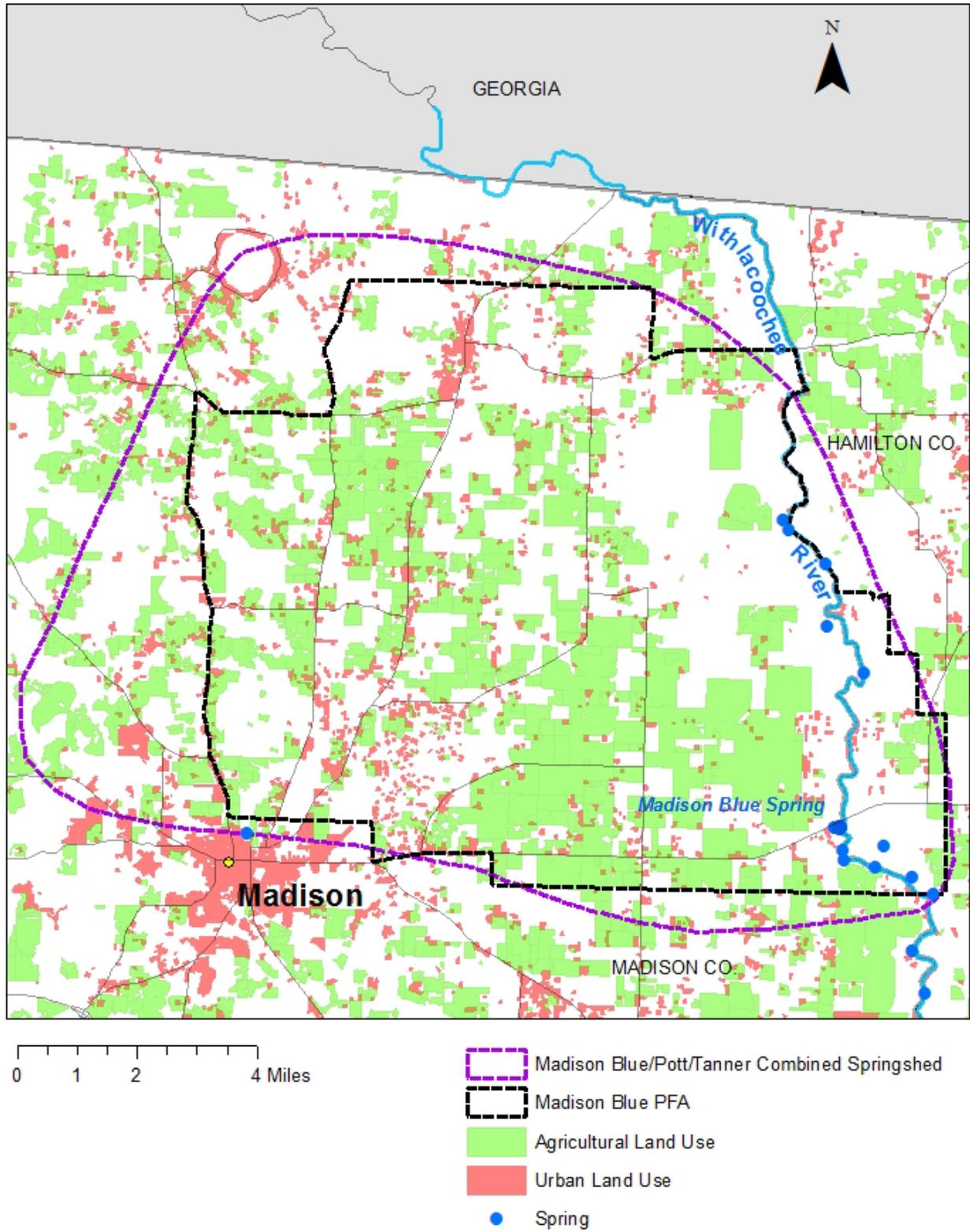


Figure 7. Agricultural and urban land use areas and PFA boundary

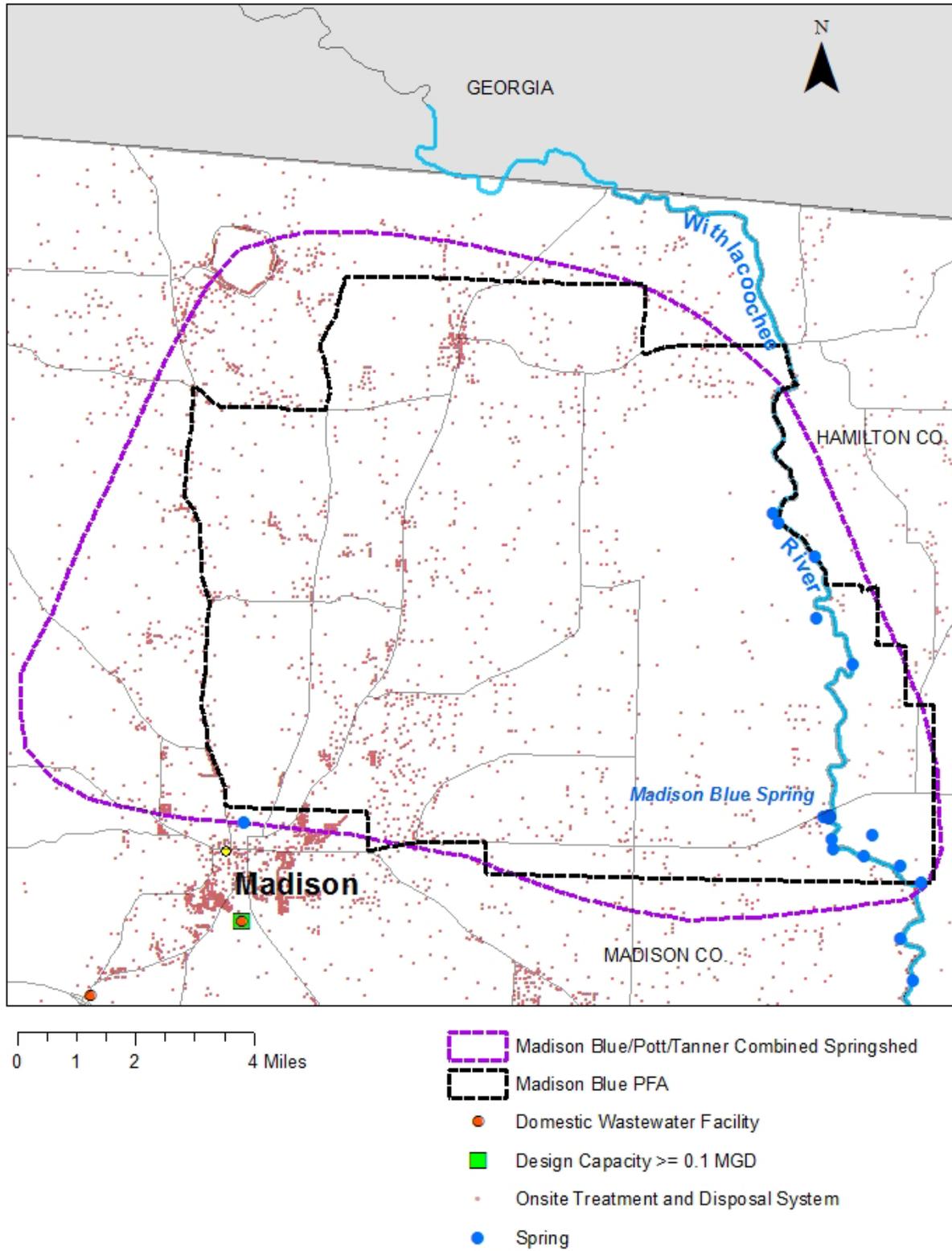
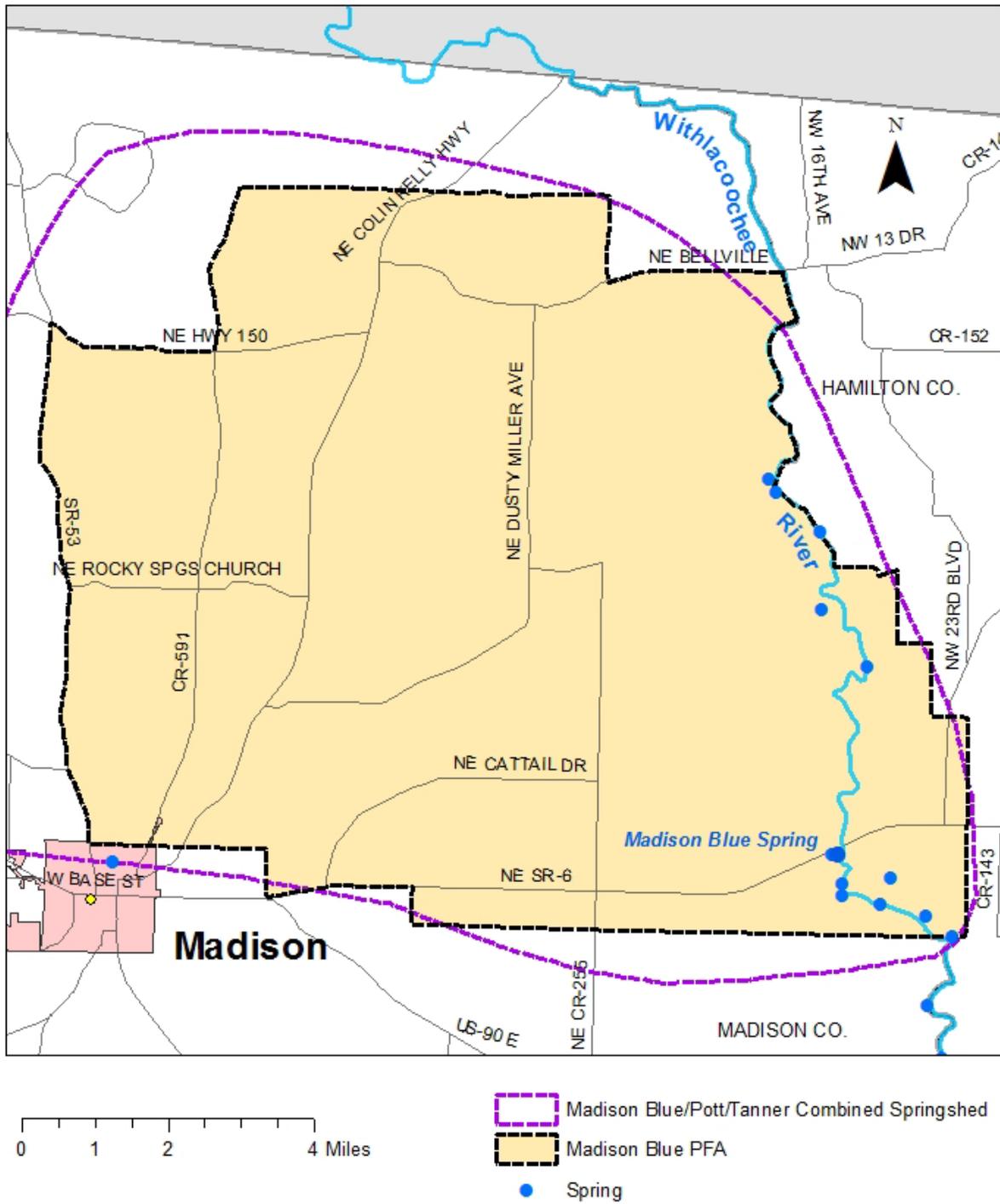


Figure 8. OSTDS, domestic WWTFs, and PFA boundary

## **PFA Boundary for Madison Blue Spring**

The PFA boundary shown in **Figure 9** was developed by considering GIS coverages of recharge, vulnerability, soils, conservation lands, and potential contaminant nitrogen source information. The PFA includes several important springs along the Withlacoochee River (such as Madison Blue, Rossiter, Pot, Tanner, and several other named springs) that contribute flow to the system and share the same springshed. This area includes high groundwater recharge/vulnerability conditions and soils that tend to leach nitrogen. It also includes potential areas of higher nitrogen loading from agriculture and urban land uses, as well as an area where groundwater travel to the springs could occur rapidly. In addition, the PFA includes areas of agricultural land use and urban development, where there is the potential for significant nitrogen contributions to the aquifer and springs.

The PFA is mainly located in Madison County, with a smaller portion along the Withlacoochee River in Hamilton County. It includes Madison Blue Spring State Park and a part of the Withlacoochee State Forest that forms a corridor along the Withlacoochee River. Conservation land boundaries, natural features, political boundaries, roads, and major survey boundaries in the area were used in the development of a readily identifiable boundary.



**Figure 9. PFA boundary for Madison Blue Spring that also protects related downstream springs**

## Appendix A: Important Links

### Cover Page:

DEP website – [www.dep.state.fl.us](http://www.dep.state.fl.us)

### More Information:

Email address for Terry Hansen – [terry.hansen@dep.state.fl.us](mailto:terry.hansen@dep.state.fl.us)

Email address for Rick Hicks – [richard.w.hicks@dep.state.fl.us](mailto:richard.w.hicks@dep.state.fl.us)

### Step 7:

Florida Department of Health (FDOH) Florida Water Management Inventory Project website – <http://www.floridahealth.gov/environmental-health/onsite-sewage/research/flwmi/index.html>

### Footnotes:

DEP FAVA website – <http://www.dep.state.fl.us/geology/programs/hydrogeology/fava.htm>

SRWMD water data portal – <http://www.srwmd.state.fl.us/index.aspx?nid=267>

SSURGO Database metadata website – <https://catalog.data.gov/dataset/soil-survey-geographic-ssurgo-database-for-various-soil-survey-areas-in-the-united-states->

***REVISED DRAFT***

***Priority Focus Area for Troy, Peacock, Lafayette Blue and  
Falmouth Springs***

**Division of Environmental Assessment and Restoration**

**Florida Department of Environmental Protection**

**January 2017**

2600 Blair Stone Road, MS 3575  
Tallahassee, Florida 32399-2400  
[www.dep.state.fl.us](http://www.dep.state.fl.us)



***More Information***

The following individuals can provide more information about the priority focus area for Troy, Peacock, Lafayette Blue and Falmouth Springs:

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## ***Introduction***

Under the Florida Springs and Aquifer Protection Act, the Florida Department of Environmental Protection (department or DEP) is required to delineate priority focus areas (PFA) for all Outstanding Florida Springs that are identified as impaired. According to the Florida Springs and Aquifer Protection Act, adopted by the Florida Legislature in 2016 (Chapter 373, Part VIII, F. S.), “‘priority focus area’ means the area or areas of a basin where the Floridan Aquifer is generally most vulnerable to pollutant inputs where there is a known connectivity between groundwater pathways and an Outstanding Florida Spring, as determined by the department in consultation with the appropriate water management districts, and delineated in a basin management action plan. Using the best data available from water management districts and other credible sources, the department, in coordination with the water management districts, shall delineate priority focus areas for each Outstanding Florida Spring or group of springs that contains one or more Outstanding Florida Springs and is identified as impaired in accordance with s. 373.807. In delineating priority focus areas, the department shall consider groundwater travel time to the spring, hydrogeology, nutrient load, and any other factors that may lead to degradation of an Outstanding Florida Spring. The delineation of priority focus areas must be completed by July 1, 2018, shall use understood and identifiable boundaries such as roads or political jurisdictions for ease of implementation, and is effective upon incorporation in a basin management action plan.”

Factors to consider in establishing these geographically bounded areas include:

- Groundwater travel time to the spring, which could be based on empirical data from tracer studies and/or predicted travel time from modeling, if such data or studies are available.
- Hydrogeology, which includes the spring’s groundwater contributing area (or springshed), the amount of confining material protecting the Floridan Aquifer, the aquifer recharge characteristics, the capacity for the aquifer to transmit water, and other characteristics that help determine the aquifer vulnerability and the likelihood of adverse water quality impacts to springs.
- Nutrient load to the spring, which includes actual measured load in the water discharging from the spring as well as the potential nutrient load based on land uses in specific regions that would most probably influence water quality in the spring.
- Other factors, which include soil characteristics that are favorable for pollutant leaching to the aquifer in the springshed and the presence or absence of pollutant sources in the area.
- Identifiable boundaries, which include roads, natural boundaries, and political jurisdictions.

Delineation of the combined PFA for Troy, Peacock, Lafayette Blue, and Falmouth Springs (due to their proximity to one another and shared springshed areas) is described in the following section.

## ***Steps in Delineating Troy-Peacock-Lafayette Blue-Falmouth PFA***

The PFA for the Outstanding Florida Springs of the Middle Suwannee River Basin (Troy, Peacock, Lafayette Blue and Falmouth Springs) was developed using geographic information system (GIS) tools, spring-specific data, and published information to help identify the portion of the springs' contributing area that is most important from both the water quality restoration and protection perspectives. The following steps were taken to develop a draft PFA for review and input by stakeholders. The overlap of mapped characteristics that express high vulnerability, high potential for pollutant mobility, and likely pollutant sources provide the best assurance that the PFA includes the areas of greatest concern for water quality restoration and protection.

Step 1. Establish the springshed for the priority spring(s). The estimated combined springshed for these springs used for this evaluation was developed jointly by DEP and Suwannee River Water Management District (SRWMD) staff with input by the Florida Geological Survey (FGS). The combined springshed was based on flow path analysis of potentiometric surface contour maps developed by the U. S. Geological Survey (USGS) and FGS in cooperation with the water management districts. Flow pathways were compared for multiple dates to develop a contributing area accounting for seasonal variation in flow. In addition, results from dye traces and cave explorations documented by FGS and SRWMD contributed to the determination that one combined springshed was most appropriate for this area.<sup>1</sup> The combined Troy-Peacock-Lafayette Blue-Falmouth Springs springshed and the proposed PFA are shown in **Figure 1**.

Step 2. Identify regions within the contributing area where greatest recharge occurs. Several GIS coverages developed by the USGS and water management districts delineate areas of high, medium, and low recharge to the Floridan aquifer system as well as areas of aquifer discharge. The areas to be considered in the PFA delineation are the areas of highest recharge to the aquifer, which could occur as diffuse infiltration through permeable geological material as well as focused recharge to sinkholes that breach confining layers. Pollutant sources in high recharge areas have the greatest potential for causing adverse impacts to the groundwater and springs because water is impeded the least as it infiltrates to the aquifer from the surface. In high recharge areas, recharge is 10 inches per year (in/yr) or greater. The area of high recharge shown in **Figure 2** is from a GIS coverage developed for a 2002 USGS model.<sup>2</sup> Unfortunately this modeled area does not include the eastern edge of the springshed.

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<sup>1</sup> Greenhalgh, T., Kuersteiner, K., and White, K. February 2016. Middle Suwannee Basin Spring Recharge Area Delineation Project, Suwannee and Lafayette Counties, Florida, July 2014-November 2015. Florida Geological Survey report prepared for Suwannee River Water Management District under MOA 13/14-201.

<sup>2</sup> Sepulveda, N. 2002. Simulation of Ground-Water Flow in the Intermediate and Floridan Aquifer Systems in Peninsular Florida. USGS Water Resources Investigation Report 02-4009.

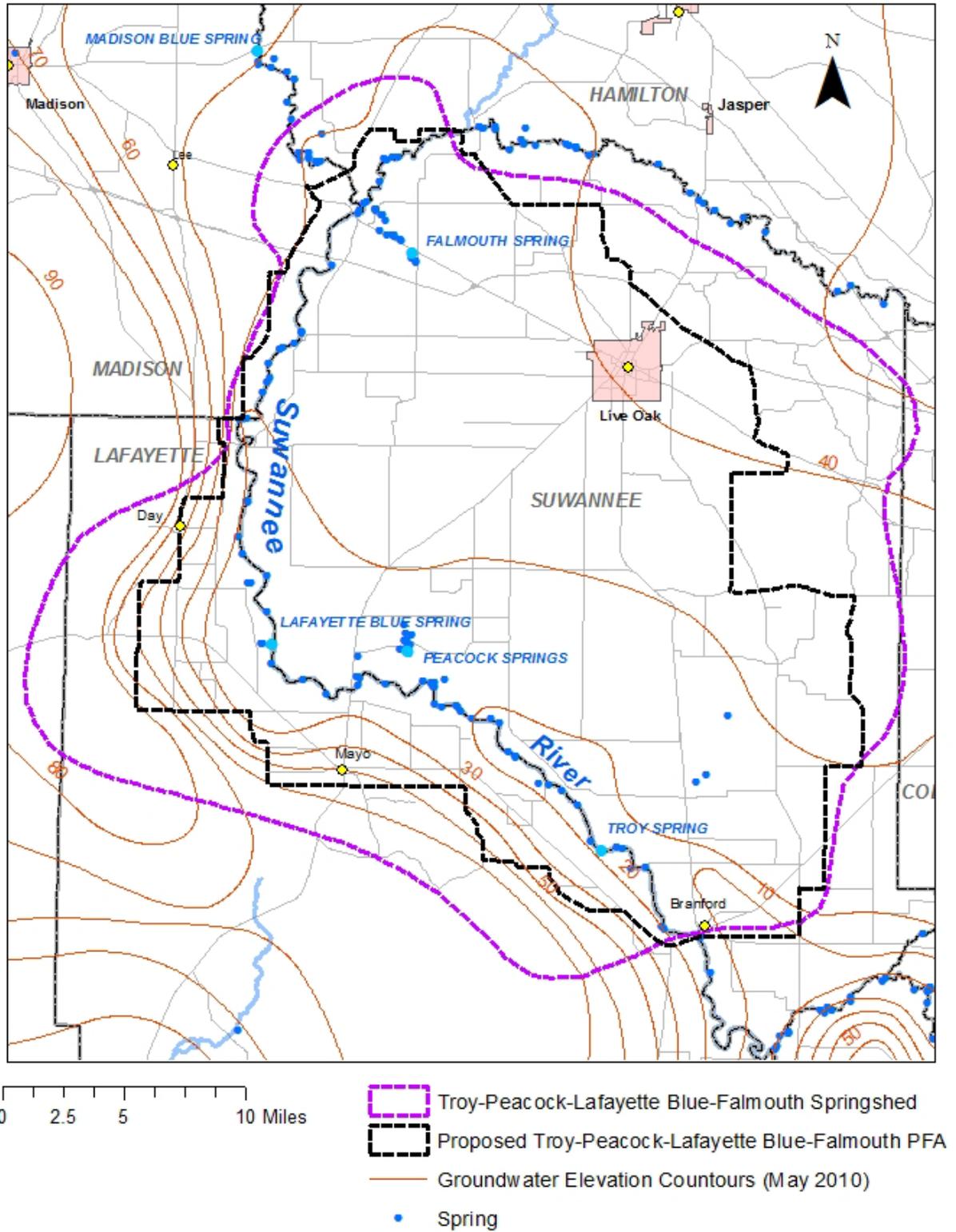


Figure 1. Combined Troy-Peacock-Lafayette Blue-Falmouth Springs springshed, proposed priority focus area, and groundwater elevation contours

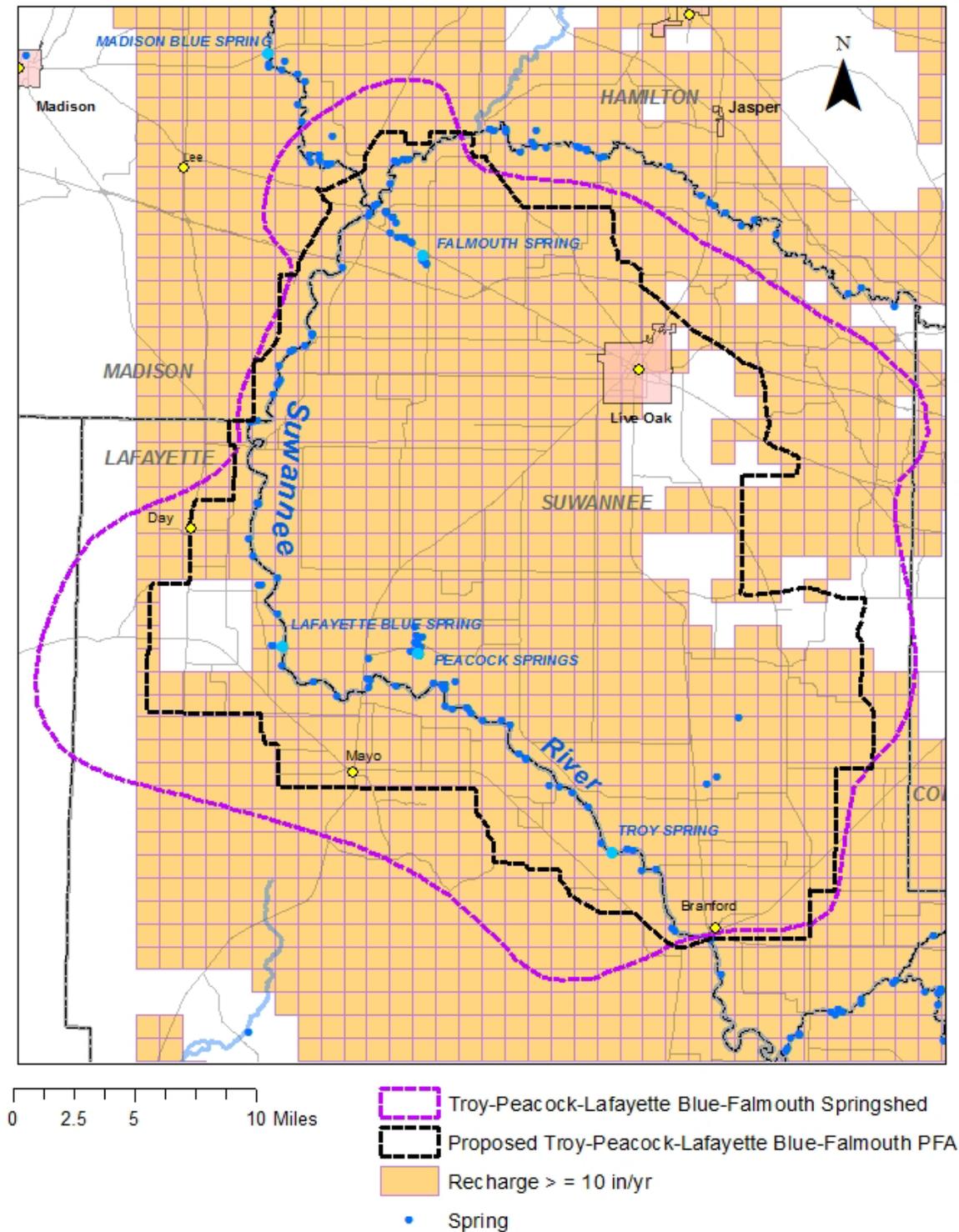


Figure 2. Areas of high recharge to Floridan aquifer ( $\geq 10$  inches/year) based on USGS 2002 methodology in Troy-Peacock-Lafayette Blue-Falmouth Springs area

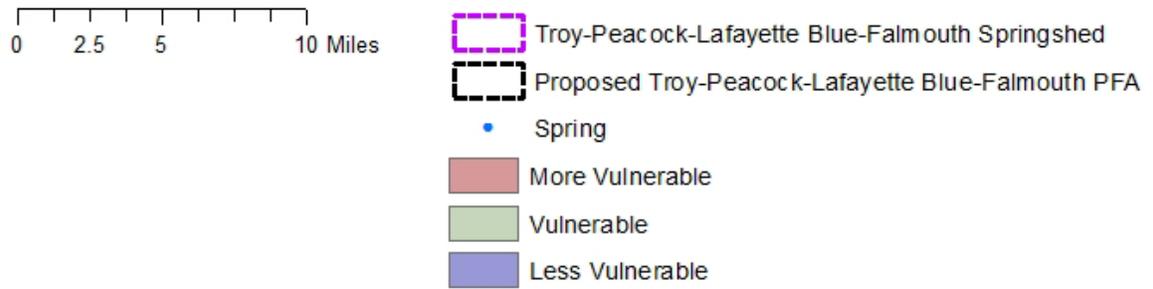
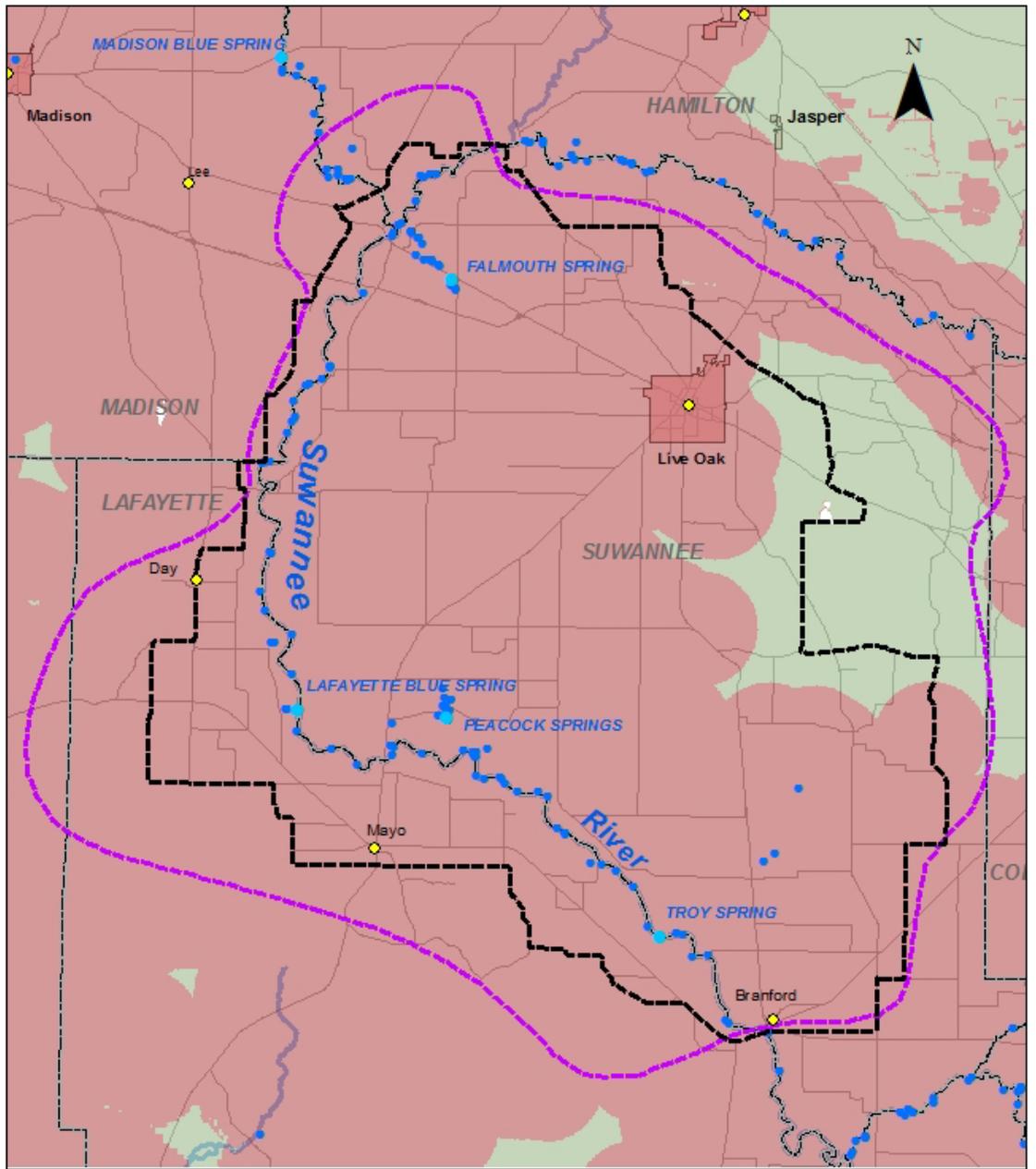
Step 3. Identify regions within the springshed where the Floridan Aquifer is most vulnerable.

The FGS developed the Florida Aquifer Vulnerability Assessment (FAVA) model to provide a spatial coverage of aquifer vulnerability ranges across an area.<sup>3</sup> According to the statewide FAVA model for the Floridan aquifer system, most of the combined springshed of Troy, Peacock, Lafayette Blue and Falmouth Springs lies within the “more vulnerable” category except for an area in the eastern part which is identified as “vulnerable” (**Figure 3**). As a further refinement, the vulnerability of the aquifer to local points of recharge through sinkholes and linear karst features was evaluated by using the statewide Digital Elevation Model (DEM) that is based on the Light Imaging, Detection, and Ranging (LIDAR) remote sensing method. In this area, most closed topographic depressions form as solution or collapse sinkholes and water flowing into these features can more rapidly reach the aquifer and erode and enlarge conduits in the limestone and can be expressed in linear arrays across the landscape. Dry or intermittent stream traces, shown in the coverage, can have associated subterranean conduit networks. Some sink features, known as “swallets” provide a direct conduit for surface water discharge into the aquifer. Swallets are sinkholes that capture stream flow. The FGS completed a project to map all known swallets in the state and produced a GIS layer that includes their locations. The DEM map (2009) and swallets in the Troy-Peacock-Lafayette Blue-Falmouth Springs region are shown in **Figure 4**.

Step 4. Consider nitrogen load. Nitrate-nitrogen is the major nutrient of concern in Florida’s spring systems due to its pervasive nature in groundwater, its mobility, and its availability for uptake by aquatic flora when it is discharged from springs. Excess concentrations of nitrate nitrogen in the spring water have contributed to excessive growth of algae in the Suwannee River and these springs. The source of flow from most springs in Florida is groundwater from the Floridan aquifer system. This groundwater comes mainly from local precipitation that recharges the aquifer in the springshed area. The nitrate originates from atmospheric deposition and anthropogenic sources in the combined springshed. Recent nitrate concentrations based on 1/16/2017 readings from nitrate sensors in Falmouth, Lafayette Blue, Peacock, and Troy Springs were 1.14, 2.86, 2.77, and 2.19 milligrams per liter (mg/L), respectively (and provisionally). These concentrations are between 3 to 8 times greater, roughly, than Florida’s numeric nitrate criterion for spring vents (0.35 mg/L). The load of nitrogen from these four springs depends on concentration and flow. Using the 1/16/2017 nitrate concentrations from the real-time monitoring stations and the latest measured flows at each of these springs of 38.2 cubic feet per second (cfs) 61.2 cfs, 2.4 cfs, and 142 cfs, respectively, estimated daily loads of nitrate nitrogen for the four springs were 235, 944, 36 and 1,677 pounds of nitrogen per day, respectively. Using these data, an estimated total nitrogen load (as nitrate) from the four springs combined would be about 1.05 million pounds per year (lb/yr).

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<sup>3</sup> Arthur, J. D., Wood, H. A. R., Baker, A. E., Cichon, J. R., Raines, G. L., 2007, Development and Implementation of a Bayesian-based Aquifer Vulnerability Assessment in Florida: Natural Resources Research, Vol. 16, No. 2., P. 93-107. Also for more information go to <http://www.dep.state.fl.us/geology/programs/hydrogeology/fava.htm>.



**Figure 3. Floridan aquifer vulnerability based on the statewide Florida Aquifer Vulnerability Assessment in Troy-Peacock-Lafayette Blue-Falmouth Springs area**

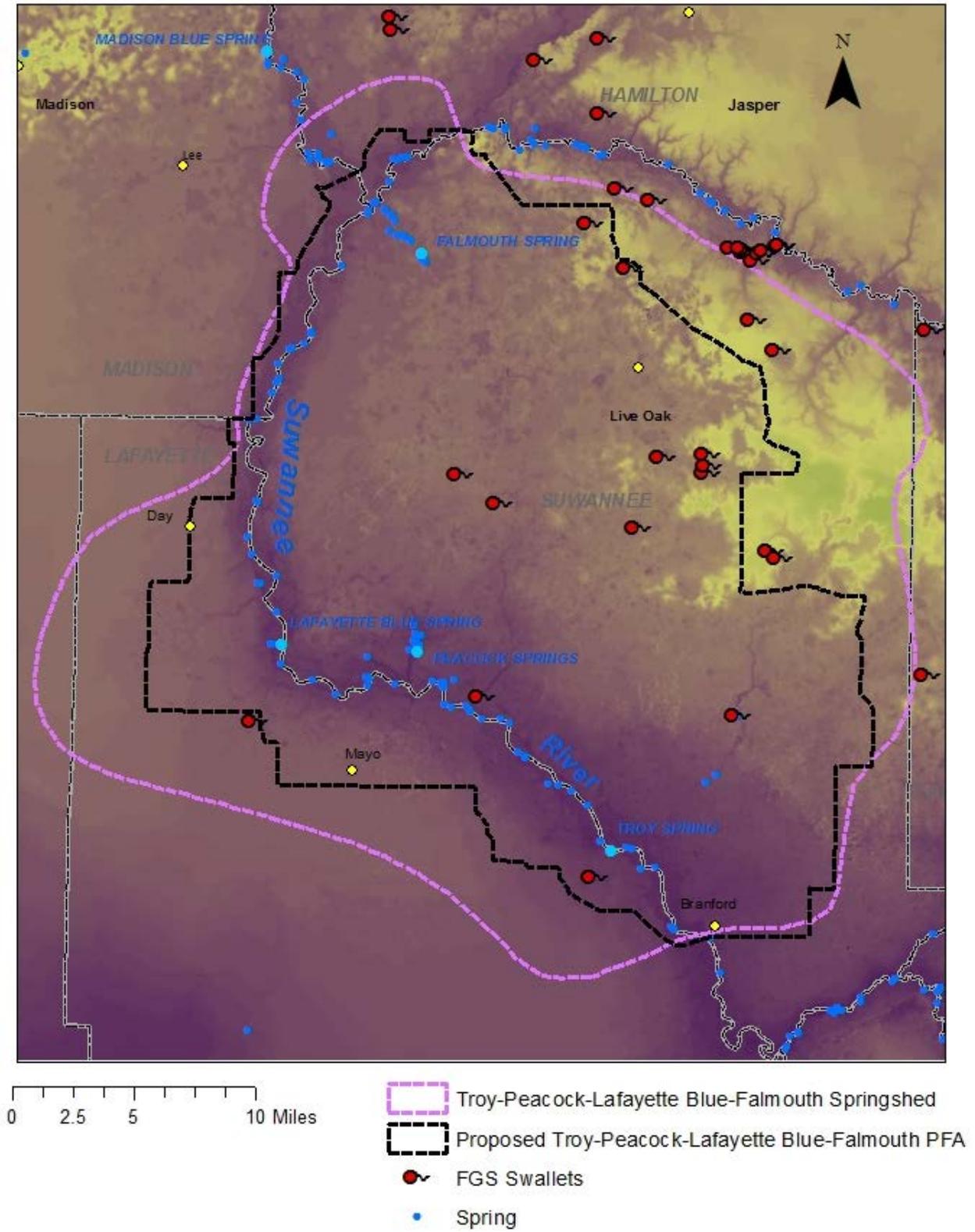


Figure 4. Digital elevation model and FGS swallets in Troy-Peacock-Lafayette Blue-Falmouth Springs area

DEP is developing a nitrogen source inventory for the Troy-Peacock-Lafayette Blue-Fallmouth Springs contributing area to serve as a tool for developing remediation strategies and projects for reducing nitrogen loads to the springs. Typical sources of nitrogen in spring contributing areas include inorganic fertilizer, livestock waste, onsite treatment and disposal systems (OSTDS or septic systems), treated domestic wastewater, and atmospheric deposition. The draft inventory shows that the main sources of nitrogen loading to the groundwater in the Troy-Peacock-Lafayette Blue-Falmouth Springs springshed are agricultural fertilizer and livestock waste from dairies.

Step 5. Consider groundwater travel time in creating PFA boundaries. To the extent possible, PFAs should include parts of contributing areas that have demonstrated or anticipated short travel times to the springs. Springs occur in areas of karst terrain where surface and subsurface erosion of the limestone can result in the development of complex networks of solution channels and conduits in the aquifer material. In parts of these areas, groundwater can move rapidly from points where the water enters the aquifer to the spring vents. The Troy-Peacock-Lafayette Blue Springs springshed includes areas of dynamic flow potential where infiltrating water has caused dissolution and creation of sinkholes, pipes and conduits in the limestone matrix and areas where the limestone might be semi-confined by layers of lower permeability material that inhibit the erosion of the limestone by percolating water. Where karst features are less prevalent, groundwater movement occurs within intergranular pore spaces in the limestone and is slower. However, in areas where development of conduits has been extensive the rate of groundwater movement can be very rapid.

As referenced previously, in 2014-2015, the FGS conducted dye traces to evaluate rate of groundwater flow and connectivity between springs in the system. In a trace originating at Falmouth Spring, dye was transported 2.6 to 2.8 miles westward to be detected at 4 springs along the Suwannee River at rates of 3,328 to 9,776 feet per day. To the south, a dye introduced into karst features along the Little River Trace was transported more than 10 miles southwestward to Troy, Mearson and Little River Springs along the Suwannee River, at rates ranging from 2,225 to 3,825 feet per day. Both dye traces confirmed that groundwater transport is rapid, multiple springs share common recharge areas, and that the Suwannee River does not form a flow boundary because contributing areas to individual springs include both sides of the river. Considering that development of karst solution features is common throughout much of the springshed, it is safe to assume that groundwater transport to the springs is very rapid from many points in the springshed and that recharge areas are shared. Development of these features is prevalent along the Suwannee River and may be more extensive in the areas of locally greater recharge.

Step 6. Identify regions within the contributing area where soil conditions are most favorable for leaching of nitrogen from surface sources. Nitrogen has been identified as the target nutrient for spring restoration. Research has shown that nitrogen removal in the soil zone through

denitrification and its tendency to leach can be related to soil drainage class.<sup>4</sup> Denitrification is lowest and leaching of nitrogen is highest in areas with soils that are excessively drained, somewhat excessively drained, or well drained. Leaching may occur in areas with moderately well drained soils and leaching of nitrogen is least likely to occur in areas where soils are poorly drained, somewhat poorly drained or very poorly drained because of their greater potential for denitrification. The portions of the contributing area where soil conditions are more favorable for nitrogen leaching can be mapped using the U. S. Department of Agriculture Natural Resources Conservation Service soil survey geographic (SSURGO) database for Florida.<sup>5</sup> These excessively to well drained soils tend to occur in areas where aquifer recharge is highest and vulnerability is greatest. **Figure 5** shows the area where soil conditions are most favorable for nitrogen leaching, which includes soils in the excessively drained, somewhat excessively drained and well drained SSURGO drainage classes. The figure also shows areas of moderately well drained soils where leaching of nitrogen could also be significant.

Step 7. Identify regions within the contributing area to exclude or include based on land use and potential for pollutant sources to occur. Conservation lands, wetlands, and undeveloped open land that are protected from development are land areas that in some cases may be excluded from the PFA if there is no expectation that they would include pollutant sources affecting springs in the foreseeable future and they are under protection. However, most of the conservation land area in the Troy-Peacock-Lafayette Blue-Falmouth Springs springshed includes SRWMD-managed lands and privately owned conservation easements along the Suwannee River corridor that should reasonably be included in the PFA as a protection measure. In addition to the district-managed lands, publicly owned conservation lands within the proposed PFA include Troy Springs State Park, Peacock Springs State Park, Lafayette Blue Spring State Park, and Suwannee River State Park. Conservation lands from the Florida Natural Areas Inventory Conservation Lands (FNAI Managed Areas) GIS layer are shown in **Figure 6**.

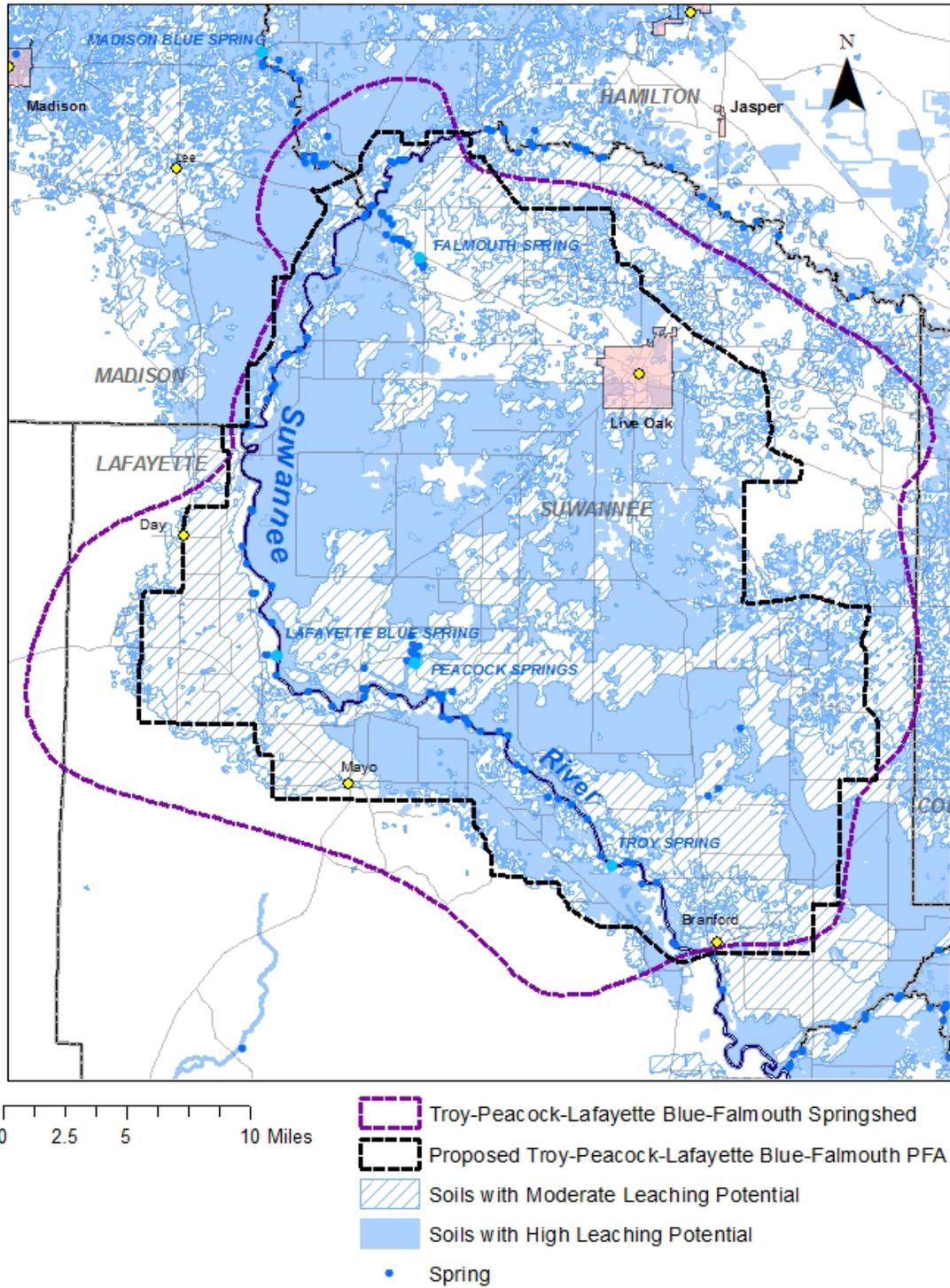
The Troy-Peacock-Lafayette Blue-Falmouth Springs springshed includes a large aggregate area in agricultural land uses and scattered areas of urban land use. Delineation of the PFA includes consideration of areas with significant potential for nitrogen leaching to groundwater based on the sources of nitrogen that occur there. Agricultural lands can include fertilizer use and livestock that can contribute significant nitrogen inputs. Urban lands can include higher densities of OSTDS, domestic wastewater and urban fertilizer use, all of which can be sources of nitrogen to the aquifer and springs. Mapped urban and agricultural lands (based on the 2013-2014 SRWMD land use-land cover GIS coverage) are shown in **Figure 7**.

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<sup>4</sup> Otis, R. J., 2007. Estimates of Nitrogen Loadings to Groundwater from Onsite Wastewater Treatment Systems in the Wekiva Study Area, Task 2 Report Wekiva Onsite Nitrogen Contribution Study. Prepared by Otis Environmental Consultants for Florida Department of Health.

Hofstra, N. and Bowman, 2005. Denitrification in Agricultural Soils: Summarizing Published Data and Estimating Global Annual Rates. *Nutrient Cycling in Agroecosystems* (2005) 72: 267-278.

<sup>5</sup> SSURGO Soil Survey Geographic Database is a digital soil survey developed by the National Cooperative Soil Survey. The dataset includes georeferenced digital map data and computerized attribute data. Metadata can be found at this link: <https://catalog.data.gov/dataset/soil-survey-geographic-ssurgo-database-for-various-soil-survey-areas-in-the-united-states>



**Figure 5. Areas of high nitrogen leaching potential soils in Troy-Peacock-Lafayette Blue-Falmouth Springs area**

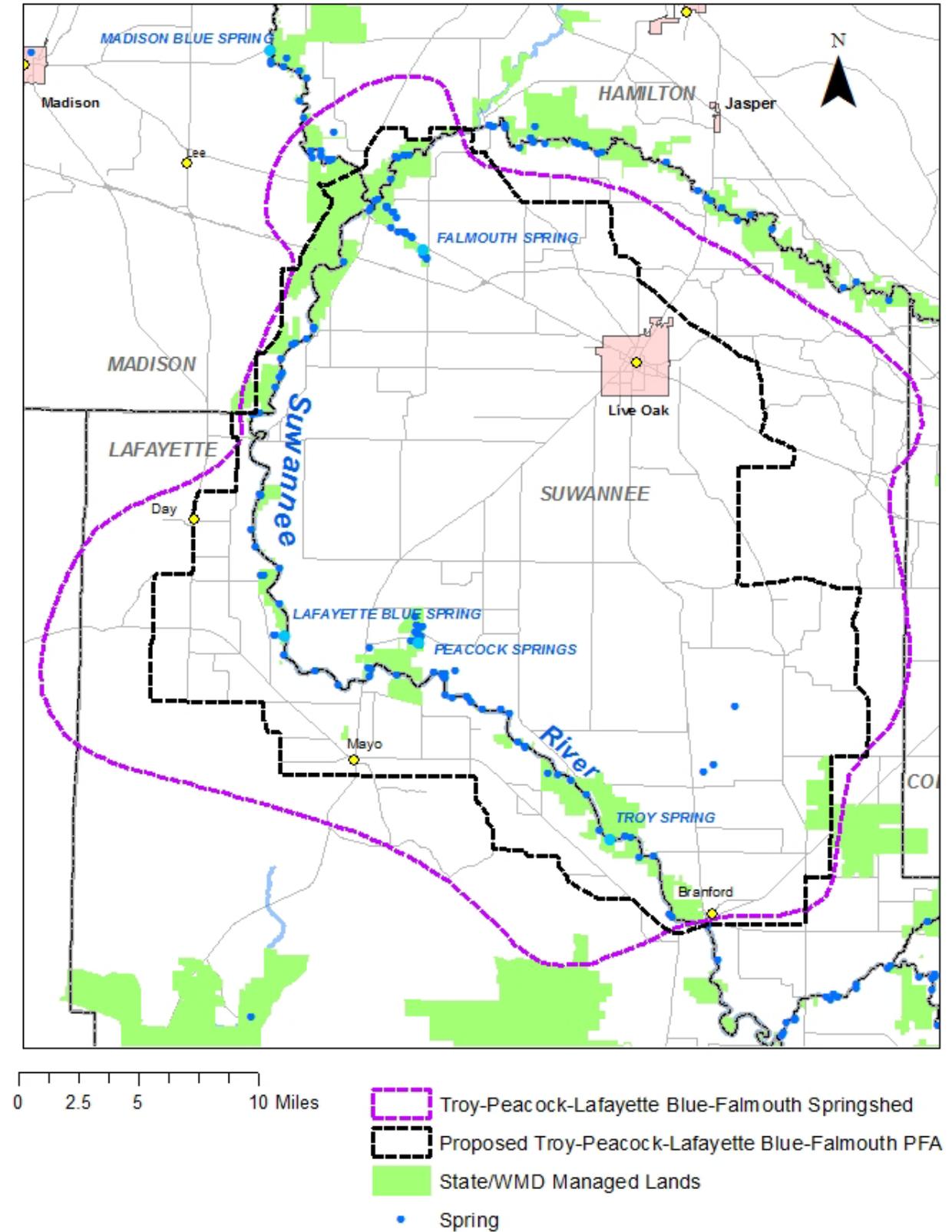


Figure 6. Conservation lands and proposed priority focus area

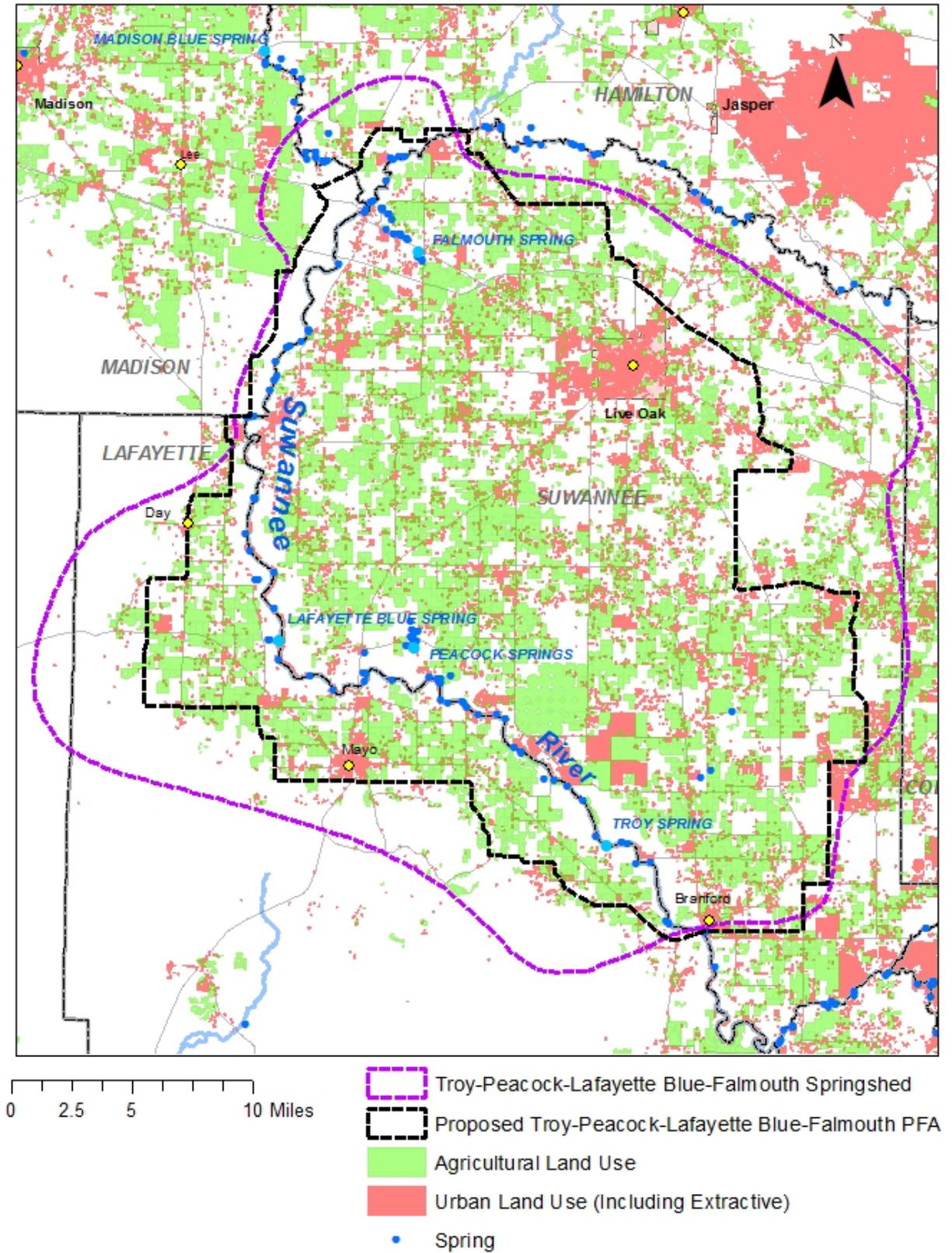


Figure 7. Urban and agricultural land use areas and proposed priority focus area

Onsite treatment and disposal systems can be potentially significant sources of nutrients to be considered when delineating the PFA. OSTDS in the area are shown in **Figure 8**. Their locations are based on a GIS coverage developed as part of the Florida Department of Health's Florida Water Management Inventory Project (<http://www.floridahealth.gov/environmental-health/onsite-sewage/research/flwmi/index.html>).

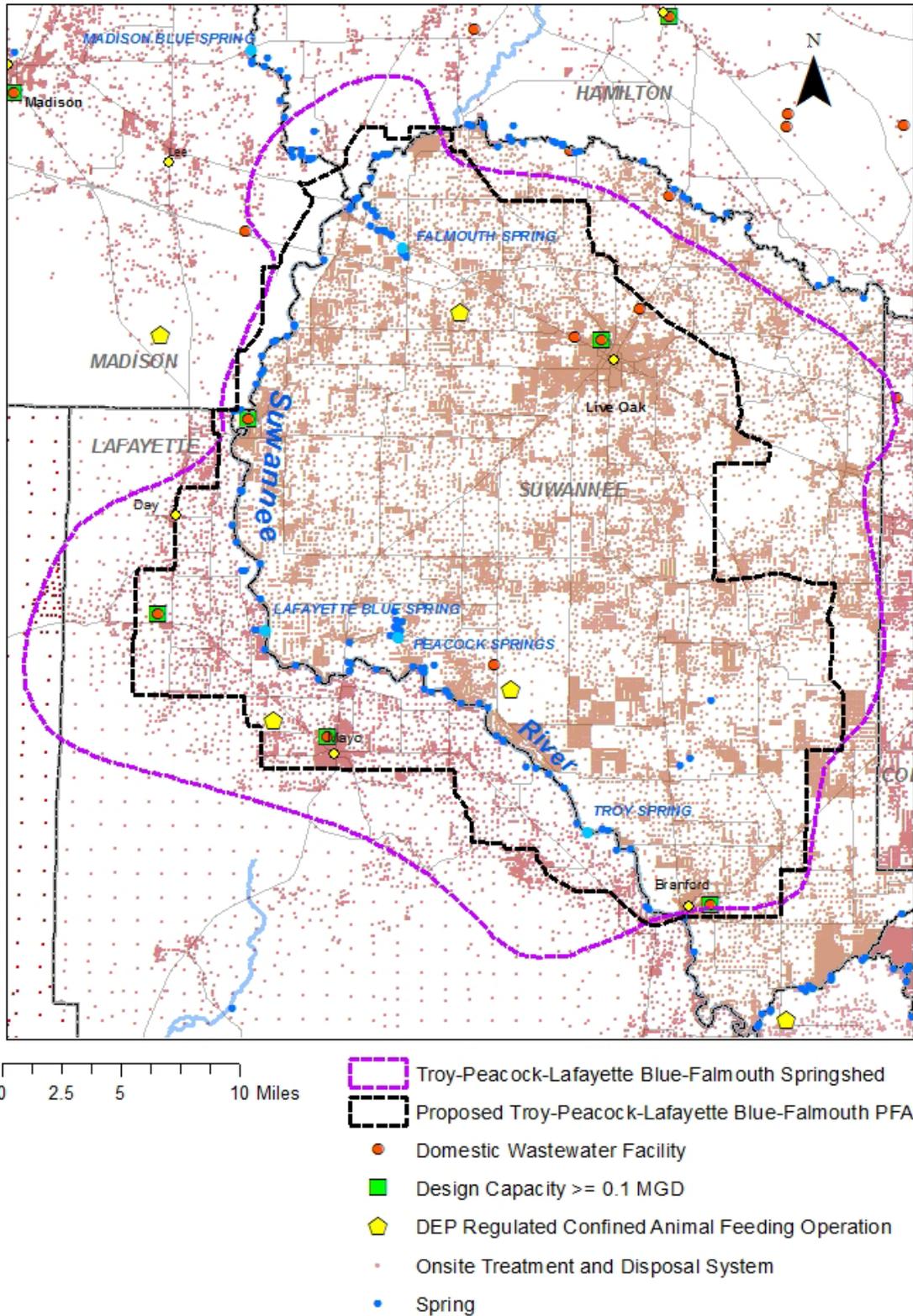
DEP-regulated wastewater facilities can also be significant nutrient sources to be considered. Existing domestic wastewater facilities, including large ones with design flows greater than or equal to 0.1 million gallons per day (mgd), are shown in **Figure 8** because they also have potential for contributing nitrogen to groundwater. The figure also includes locations of department-regulated confined animal feeding operations (CAFO), which in this area include several large dairy operations and one beef cattle operations. These facilities can also have significant inputs of nitrogen. DEP regulated wastewater facility information for the two springsheds was obtained from the department's wastewater facility regulation (WAFR) information management system.

Step 8. Create PFA boundaries that correspond with understood and identifiable boundaries. For stakeholders to implement restoration and protection actions in the PFAs, the boundaries must be clearly defined and associated with features easily recognizable on a map. For that reason, the proposed boundary of the Troy-Peacock-Lafayette Blue-Falmouth Springs PFA was made to conform to easily recognizable natural features, roads, political boundaries, and major survey boundaries.

### ***PFA Boundary for Fanning and Manatee Springs***

The PFA boundary shown in **Figure 9** was developed by considering GIS coverages of recharge, vulnerability, soils, conservation lands, and potential contaminant nitrogen source information. The PFA includes a region including most of the combined springshed. This area includes high groundwater recharge/vulnerability conditions and soil conditions that tend to leach nitrogen. It includes potential areas of higher nitrogen loading from agriculture and urban land uses. It also includes an area within the springshed over which groundwater travel to the springs could occur rapidly. In addition, the PFA also includes interconnected areas of agricultural land use, urban development, areas of OSTDS, domestic wastewater facilities, and CAFOs which all have potential to contribute to nitrogen enrichment in the aquifer and springs.

The proposed PFA is mainly in Suwannee County with smaller portions in Lafayette, Madison, and Hamilton Counties. It includes the city of Live Oak, portions of the towns of Branford and Mayo, and part of the community of Day. The proposed PFA also includes Troy Spring State Park, Peacock Springs State Park, Lafayette Blue Spring State Park, Suwannee River State Park, and a corridor along the Suwannee River of SRWMD managed state land and conservation easements. Conservation land boundaries, natural features, political boundaries, roads, and survey boundaries in the area were all considered in the development of a readily identifiable PFA boundary.



**Figure 8. Onsite treatment and disposal systems, domestic wastewater treatment facilities, DEP regulated animal feeding operations, and proposed priority focus area**

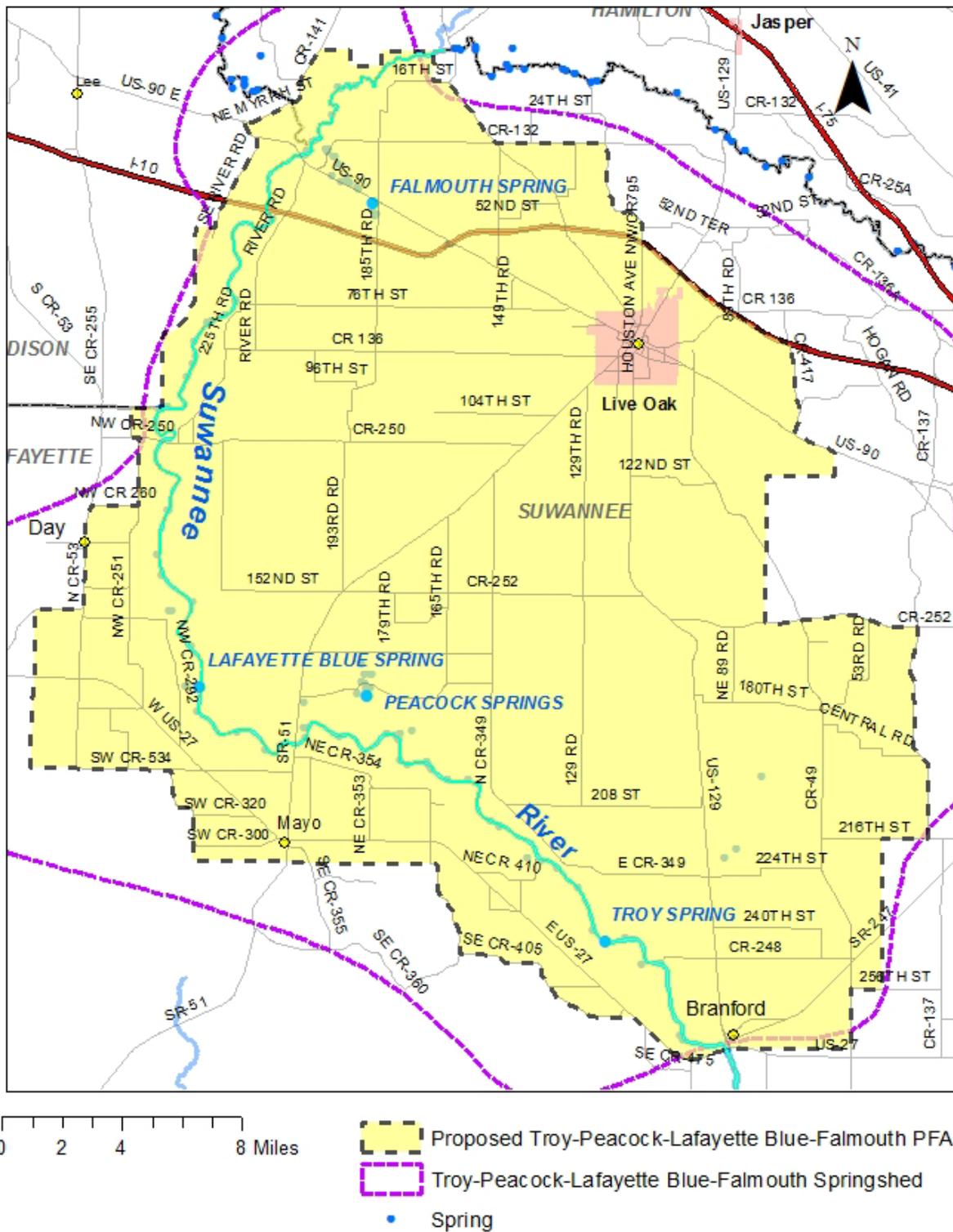


Figure 9. Proposed PFA boundary for Troy, Peacock, Lafayette Blue, and Falmouth Springs