DELINEATION OF SPRING PROTECTION AREAS AT FIVE, FIRST-MAGNITUDE SPRINGS IN NORTH-CENTRAL FLORIDA

Prepared For The

Suwannee River Water Management District
Live Oak, Florida

By

SDII Global Corporation
Tampa, Florida

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Cover Photograph

Madison Blue Spring, located on the Withlacoochee River in eastern Madison County, Florida, during a river flood.

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This report was prepared by the following individuals on behalf of SDII Global Corporation and under contract No. 03/04-058 with the Suwannee River Water Management District.

Sam B. Upchurch, Ph.D., P.G.
Florida License No. 4
Vice President and Principal Geologist

Kyle M. Champion, P.G.
Florida License No. 2044
Senior Hydrogeologist

Date: ______________________________

Disclaimer

The contents of this report were prepared by SDII Global Corporation for the possible use of the Suwannee River Water Management District. The contents of this report do not reflect opinions or policies of the District. The report is provided for possible guidance to District staff while considering implementation of spring protection zones.

INTRODUCTION

There is considerable concern about the quantity and quality of water discharging from Florida springs (Florida Springs Task Force, 2000). Concerns about water quality deal largely with trends of increasing nitrate concentrations through time. The quantities of water discharged from some Florida springs have also declined. As a result, the Suwannee River Water Management District (District) has determined to establish spring protection areas in order to assist in protecting water supplies and water quality at key springs within the District. Initial efforts for spring protection have focused on five, first-magnitude springs within the District. These springs (Manatee, Fannin, Ichetucknee, Troy, and Madison Blue) are located within Florida state parks and represent important economic, ecological, and water resources to the citizens of the District and state. Because of their close proximity and uncertainties as to the location of the ground-watershed between the two springs, the springsheds of Manatee and Fannin springs are treated as one basin in this report.

Spring protection areas are sub-areas of the ground- and surface-water basins of each spring, or spring system, that supply water to the springs and within which human activities, such as waste disposal or water use, are most likely to have negative impacts on the water discharging from the spring. Spring protection areas are likely to require special water-management efforts because

- Aquifers are highly vulnerable to contamination,
- There are direct connections between the protection area and the spring as a result of cavern development,
- The protection area is in close proximity to the spring, or
- Water withdrawals are likely to have direct impacts on spring discharge.

When one or more of these, or similar, conditions exist and a protection area has been developed, adverse conditions at the spring as a result of land use within the protection area can be minimized through use of

- Land-use management and zoning by county or municipal government,
- Adoption of minimum flows and levels (MFLs),
- Adoption of best management practices (BMPs),
- Development of an informed and environmentally sensitive public,
- Engineered waste-management or water-use solutions obtained through cooperative efforts, such as assistance grants and agency cooperative programs, and
- If necessary, regulatory action.

On March 11, 2004, the District retained SDII Global Corporation (SDII) to develop a strategy for delineating protection areas for the ground- and surface-water basins (springsheds) of the five first-magnitude springs under contract number 03/04-058. In addition to methodology development, proposed interim protection areas were to be delineated for these springsheds for District consideration. Finally, this preliminary spring-protection-area delineation will provide a basis for the proposed interim springshed management plans that are being developed by the District (Upchurch et al., 2001).

Florida Statutes (Chapter 373.042 F.S.) require that each water management district establish minimum flows and levels (MFLs) for first magnitude springs in order to protect them from adverse withdrawals that will cause "significant harm." The District is in the process of developing MFLs for a number of springs, including these five springs. After analysis and establishment of the MFLs is complete, final protection areas may be adopted by the District to assist in managing the MFLs.

This report is divided into three major sections:

- Rationale and Methods, which explains the bases for protection area delineation;
- Spring Protection Areas, introduce the protection areas for each of the springsheds; and
- Protection Area Implementation, which suggests ways to implement the protection areas.

RATIONALE AND METHODS

On-Going Monitoring

The District is currently intensively monitoring the five springsheds, resulting in high-resolution data, including potentiometric surface determinations, as well as other hydrologic, water-quality, climate, and biological data (Upchurch et al., 2001). This data collection effort was intended by the District to be utilized for

- Characterizing the hydrology of the springsheds and hydrology and environmental quality of the springs,
- Development of spring protection areas, and
- Development of management plans for each springshed.

These efforts are well underway and sufficient data have been collected to develop the preliminary protection areas. The data consist of high-resolution data on aquifer potentials and ground-water quality as well as data on spring discharge and stage, spring water quality, and spring ecological conditions.

As part of this effort, the potentiometric-surface and nitrate-concentration data from all five springsheds have been subjected to geostatistical analysis and potentiometric surface maps have been prepared at a 1-foot contour interval (Upchurch and Champion, 2003b, 2003c, 2004a, 2004b). These maps and the data developed as part of the springshed delineation efforts form the bases for the preliminary springshed protection area delineations presented in this report.

Previous Work on Spring Protection Area Delineation

There have been at least two earlier attempts at springshed protection area delineation within the District. Both deal with the Ichetucknee Springs basin (North Central Florida Regional Planning Council, 1978; Upchurch and Champion, 2002). The North Central Florida Regional Planning Council (1978) report was prepared for the Columbia County Commission without benefit of the District's high-resolution monitoring program. The North Central Florida Regional Planning Council report utilized topography and flooding estimates combined with existing data on the hydrologic regime. The report by Upchurch and Champion (2002) was developed based on prior investigations of the karst of the

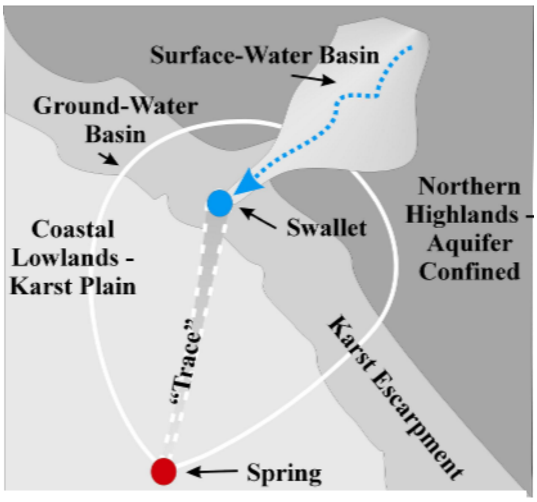

Figure 1 - Hypothetical springshed bounded by a karst escarpment.

Ichetucknee basin (Lawrence and Upchurch, 1976; Upchurch and Lawrence, 1984; Karst Environmental Services, 1997; Upchurch, 2002; and others).

Since these projects were completed, an analysis of water sources for the springs in the Ichetucknee spring complex has been completed (Upchurch and Champion, 2003a) and the first round of high-resolution monitoring has been completed for the five spring systems. Review of the existing, high-resolution water-quality and Floridan aquifer potentiometric data indicates that interim protection area delineation is now possible in the five basins.

Models for Protection Areas

Preliminary review of the high-resolution potentiometric data for the five springsheds indicates that there are at least two different springshed types represented in the five spring systems. These suggest somewhat different protection strategies, as discussed below.

Scarp-Bounded Springshed Model - Figure 1 illustrates an hypothetical springshed located in proximity to a karst escarpment. This model is based on conditions in the Ichetucknee Springs basin. Of importance in this model are:

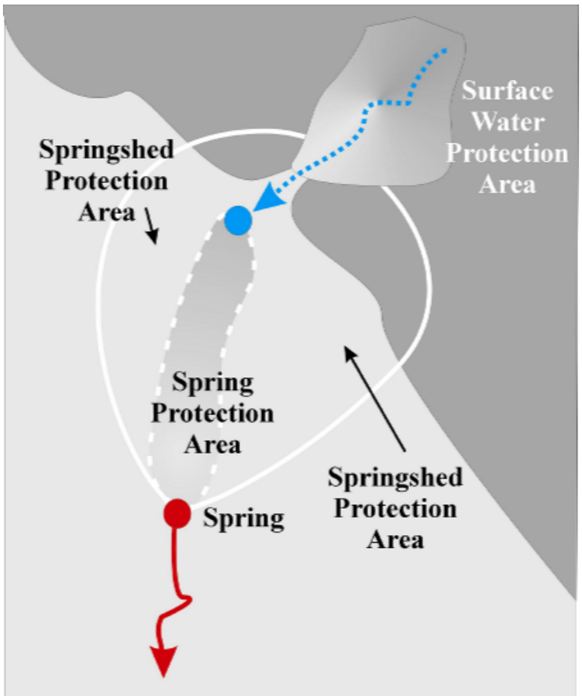

Figure 2 - Hypothetical spring protection areas in a scarp-bounded springshed.

1. A ground-water basin that includes confined aquifer conditions under a northern highlands-like geomorphic province;

2. A karst escarpment (i.e., the Cody Scarp) with large sinkholes and focused recharge originating from rainfall within the scarp and from runoff from the adjacent highlands;

3. Sinking streams that may originate outside of the ground-water basin;

4. A "trace" or relict stream/cavern system associated with a well-developed cave system; and

5. A karst plain characterized by relatively small sinkholes and localized recharge.

Because of the differences in permeability and recharge amounts in this scenario, the potentiometric surface of the underlying aquifer responds to these features in terms of elevation and slope.

Given the combination of circumstances shown in Figure 1, the springshed can be logically subdivided into two ground-water protection areas and one surface-water protection area, as shown in Figure 2. These areas, tentatively designated the Spring Protection Area, the Springshed Protection Area, and the Surface Water Protection Area, represent the following threats to the ground water and discharge from the spring(s):

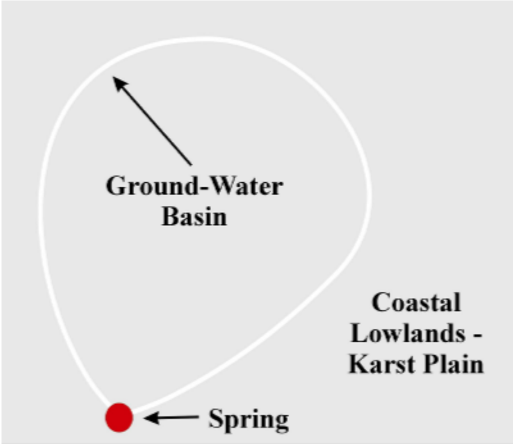

Figure 3 - Hypothetical unconstrained springshed.

1. **Spring Protection Area** – The Spring Protection Area constitutes that part of the springshed characterized by close proximity to the spring and its cavern system (the caverns associated with the trace) where dilution and attenuation of pollutants is limited because of rapid transit times to the spring and a propensity for conduit flow. In addition, the surface-water component within the trace is included because of rapid recharge through swallets and potential for bypassing of interactions with soils that might otherwise remove or retard contaminants.

2. **Springshed Protection Area**– The Springshed Protection Area includes the remainder of the springshed where the aquifer system is either unconfined or semi-confined but that include longer transport times and distances so dilution and retardation of contaminants are probable.

3. **Surface Water Protection Area** – The Surface Water Protection Area includes surface watersheds that drain directly to swallets. These surface water drainage basins are included as Spring Protection Areas because of the possibility of contaminant spills and other releases that are likely to enter the cavern system that connects with the springs without benefit of sufficient dilution or retardation.

Unconstrained Springshed Models - Other springsheds are not obviously controlled by the presence of escarpments and highlands with confined aquifers and significant swallet systems. These springsheds appear to be relatively simple (Figure 3) and unconstrained by major changes in hydrogeologic conditions within the aquifer system. In this type of unconstrained springshed selection of protection areas is more difficult because of the absence of significant spatial changes in the hydraulics and potentiometric surfaces of the ground-water basin. The Madison Blue Springs springshed appears to be such a basin.

The same spring protection area classification (Spring Protection Area, Springshed Protection Area) is used in areas where unconstrained springsheds exist.

Since the aquifer is not confined within the springshed, streams that drain to swallets are of minor importance and the Surface Water Protection Area is not likely to be utilized.

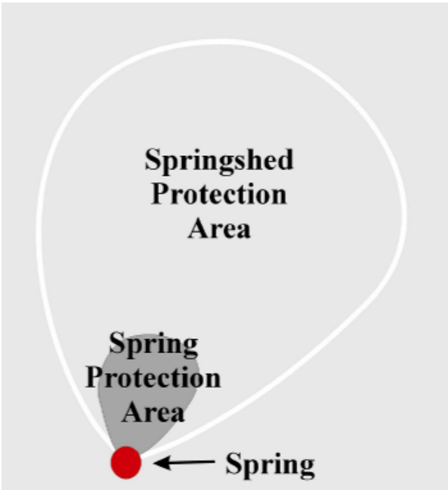

Figure 4 - Hypothetical spring protection areas in an unconstrained springshed.

Figure 4 illustrates possible protection areas for this unconstrained, Madison Blue-type springshed. Here, the protection areas depend on knowledge of the ground-water flow system, travel times, and potential dilution and retardation estimates. This is the more difficult springshed to with respect to delineation of protection areas.

Criteria For Protection Area Identification

The criteria utilized for the delineation of protection areas in this report are discussed by springshed type. Critical data for delineation of the protection areas include

- Spatial topographic data, including locations and spatial characteristics of sinkholes and escarpments;
- High resolution potentiometric surface data and the location of the springshed ground-water basin;
- Knowledge of cavern system locations, such as cave maps and fracture trace maps;
- Spatial extents of surface water basins that drain into swallets within the springshed;
- Knowledge of the locations of swallets and, where possible, dye traces that connect the swallets with the spring system; and
- Spatial data indicating conditions of confinement of the aquifer.

Spring Protection Areas

Spring Protection area boundaries enclose the area that is most vulnerable to rapid movement of contamination to the spring and ground-water withdrawals from the spring or cavern system. The boundaries were drawn to include the following

- The spring or spring system if there are multiple vents,
- Known cavern systems and/or traces, and
- All areas predicted by the available ground-water flow model(s) to be within a distance over which water can flow to the spring within 20 years, or less.

Springshed Protection Areas

Springshed Protection Areas include all unconfined or semi-confined portions of the springshed that are not within the Spring Protection Areas. Therefore, the inner boundaries are the Springshed Protection Area boundaries and the other boundaries are the margins of the springshed (unconstrained model) or approximate location where the aquifer becomes more-or-less confined.

Practical Delineation of the Protection Areas

Practical delineation of spring protection areas depends on available data. While the criteria listed above were utilized in delineation of the proposed protection areas, the behavior of the Floridan aquifer potentiometric surface and mapped cave segments were most useful. Mapped cave areas, locations of known sinkholes, and near-spring potentiometric surface data were utilized for location of the spring protection areas. Springshed protection areas were primarily based on potentiometric surface data from within the springsheds. Figure 5 is a hypothetical cross section that illustrates the rationale for selection of springshed protection areas, and Figure 6 illustrates a hypothetical map showing a springshed protection zone based on increased gradient in the Floridan aquifer potentiometric surface.

In areas where the Floridan is confined or semi-confined, the potentiometric surface is generally high, largely because of lower permeability of the limestone where karst development has not been widespread (Upchurch, 2002). In unconfined areas of the Floridan aquifer, permeability is better developed and the potentiometric surface is relatively flat and at a lower elevation than under confined areas. The transition zone between these two environments is characterized by a steepened slope of the potentiometric surface (Figures 5 and 6). In many of the springsheds, the springshed protection area boundary was, therefore, limited by springshed divides and the change in slope of the Floridan aquifer potentiometric surface near confined portions of the springshed.

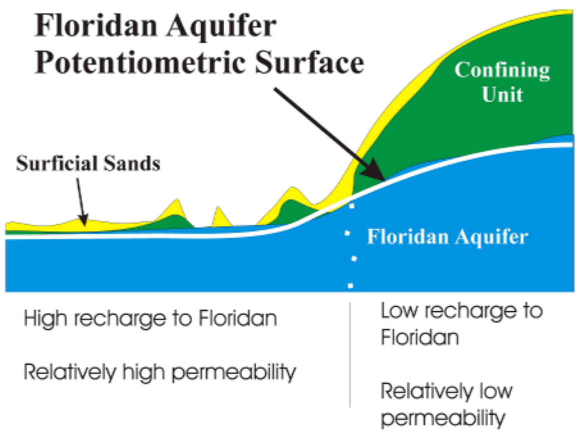

Figure 5 – Schematic illustrating the relationship of the Floridan aquifer potentiometric surface to changes in aquifer permeability and degree of confinement.

There was no attempt to correlate the boundaries of the protection areas with political or natural boundaries that would allow for effective management. We recommend that the boundaries that are presented herein be redrawn to be inclusive of the natural boundaries but be described in terms of political or natural boundaries. For example, a 2-mile radius from a spring has meaning based on the estimated time required for water to flow to a spring but this line is a boundary that is not easily identified on the ground. A land description bounded by rivers, roads, or township and range designators will be more easily managed.

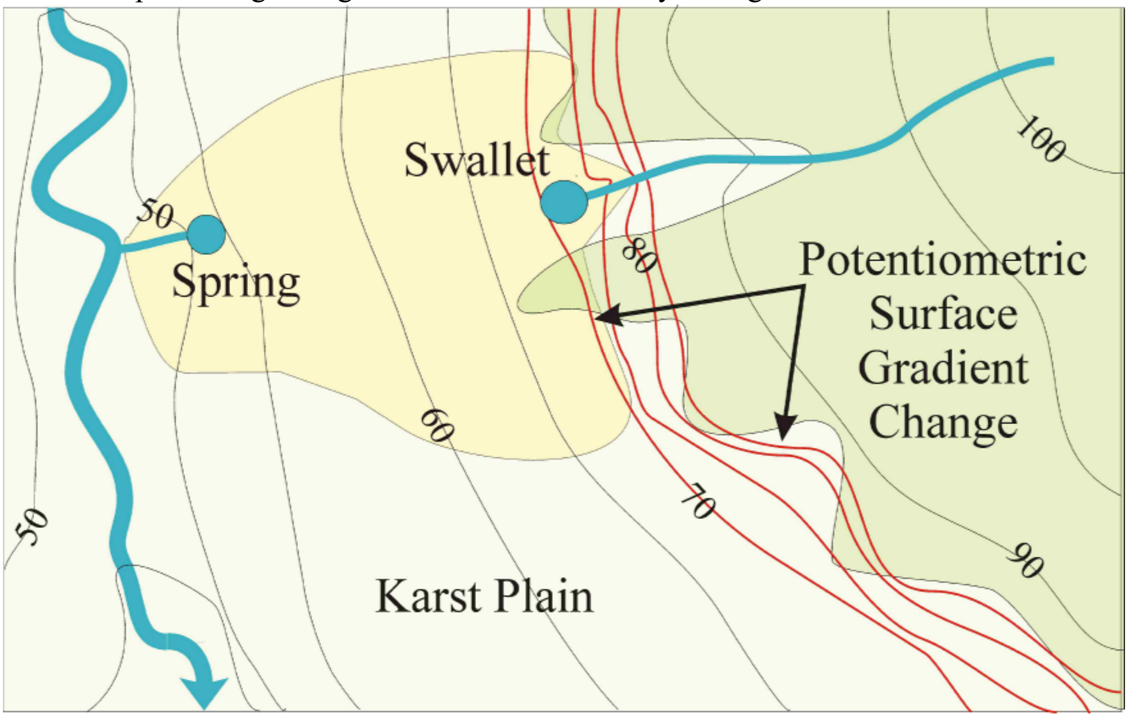

Figure 6. - Hypothetical potentiometric-surface map showing the steepened gradient (red isopotential lines) and a springshed protection area (yellow) bounded in the up-gradient direction by the semi-confined portions of the aquifer and the resulting steepened gradient.

In many cases the locations of cavern systems are known to cave divers, but data are not available for public use. It is recommended that these data be obtained and the known locations of cavern system be outlined in the Spring Protection Areas in the same fashion as the Ichetucknee Trace and swallets were incorporated in this preliminary delineation exercise.

MFLs are being developed by the District for each of the springs. It is recommended that final protection area delineations be made in conjunction with the MFLs in order to utilize the delineations as part of the MFL management strategy, if appropriate.

SPRING PROTECTION AREAS

This section introduces the proposed Springshed and Spring Protection Areas for each of the five first-magnitude springs. They are discussed in order from north to south (Figure 7).

Madison Blue Spring

Figures 8 and 9 illustrate the preliminary, recommended protection area delineations for the Madison Blue springshed and cavern system. MFLs for the spring are nearing finalization by the District, and a preliminary, ground-water flow model for the Madison Blue Spring springshed has been developed for MFL development. The potentiometric surface up gradient of the spring is relatively uniform in gradient (Upchurch and Champion, 2004b). In the absence of significant potentiometric slope changes that indicate changes in permeability and/or recharge rates, (1) the potentiometric surface, (2) locations of significant karst features (sinkholes), and (3) the known location of the cavern system were utilized to identify the Spring Protection Area.

Madison Blue Spring has a well-developed cavern system with preferential flow to the spring through this feature. The extent of the cavern system is depicted in Figure 9. The cavern system runs generally east to west and crosses below Highway 6 several times. The known extent of the western end of the cavern begins under a large uvala (large sinkhole formed by the coalescence of several smaller sinks) to the west of Madison Blue Spring. A protection zone around this large sinkhole and along either side of the cavern system should be used to provide an additional level of protection to the cavern and spring.

The Spring Protection Area encompasses the cavern/uvala buffer zone as well as areas within 2,500 feet of Highway 6 (Figure 9). This area extends from the Withlacoochee River westward toward County Road 414 (Old Blue Road).

The Springshed Protection Area includes all of the mapped springshed outside of the Spring Protection Area (Figure 8). The head of the springshed lies near Cherry Lake within the Northern Highlands Physiographic Province to the north and northwest of the spring. In this region, the Floridan aquifer is semi-confined and ground-water flow is sluggish. The Springshed Protection Area for Madison Blue Spring lies in the portion of the springshed that is characterized by well-developed karst features, which enhance rapid recharge to the Floridan aquifer.

Troy Spring

Figure 10 illustrates the recommended protection areas for the Troy Spring springshed. The Troy Spring springshed has many characteristics of the scarp-bounded springshed (Figure 1). As shown in Upchurch and Champion (2004a), there is a significant slope break in the Floridan aquifer potentiometric surface 2 to 4 miles from the spring. Here, the potentiometric surface flattens and sinkhole development is pronounced, which indicates that there is an increase in recharge rates and permeability.

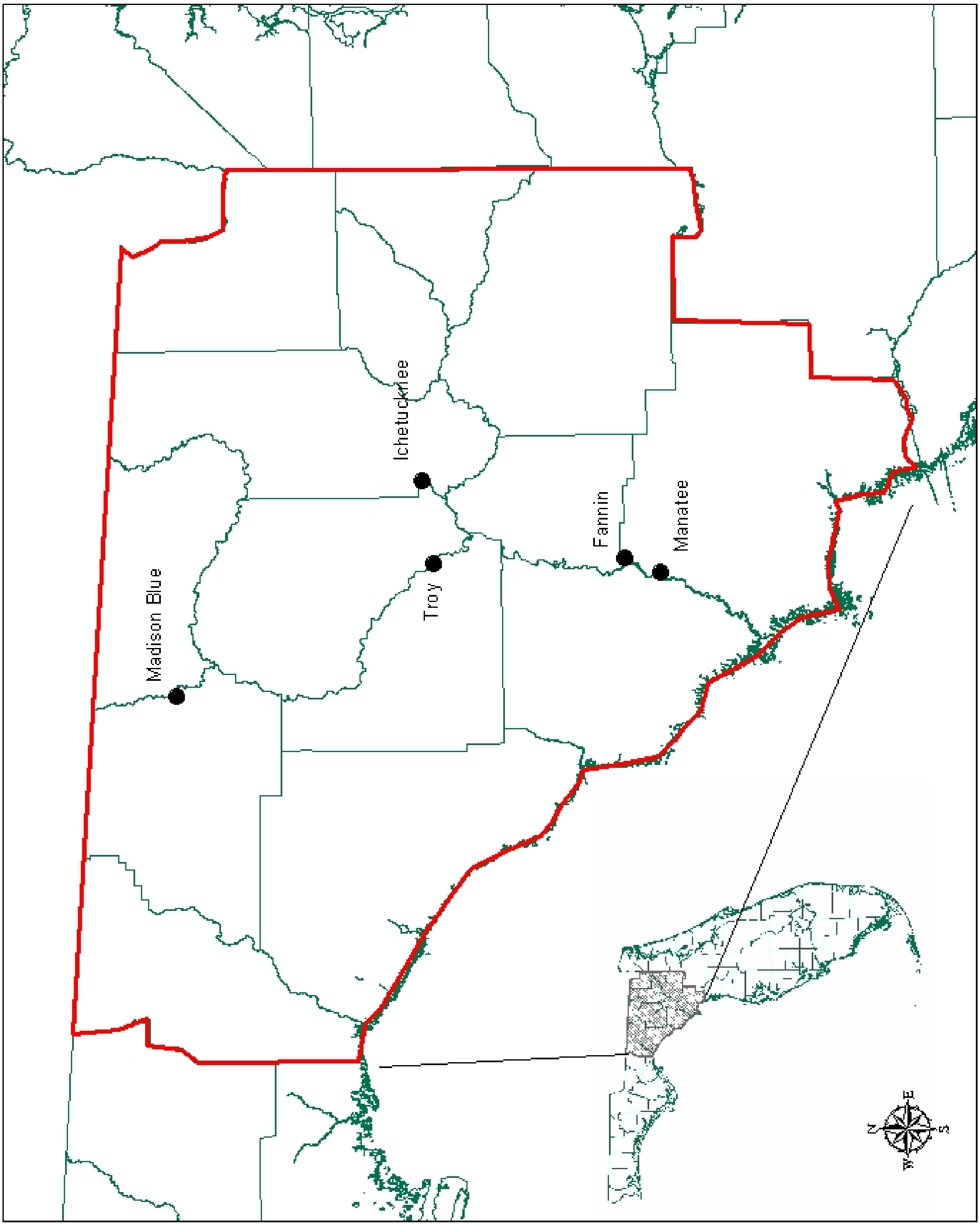

Figure 7. Location of first-magnitude springs in the Suwannee River Water Management District.

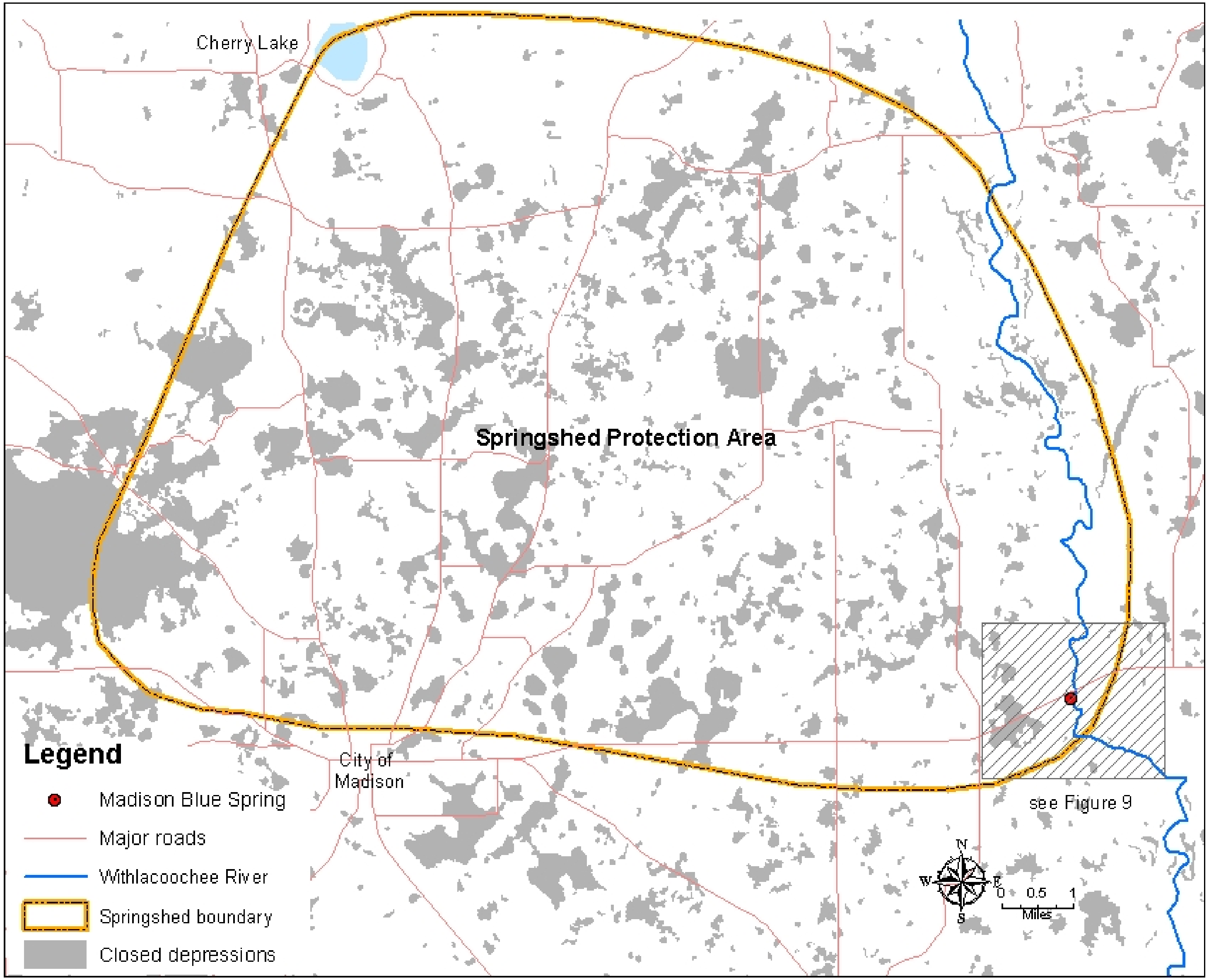

Figure 8. Springshed Protection Area for Madison Blue Spring.

* This figure was prepared for planning purposes only and is intended to assist the District in the development of spring protection strategies.

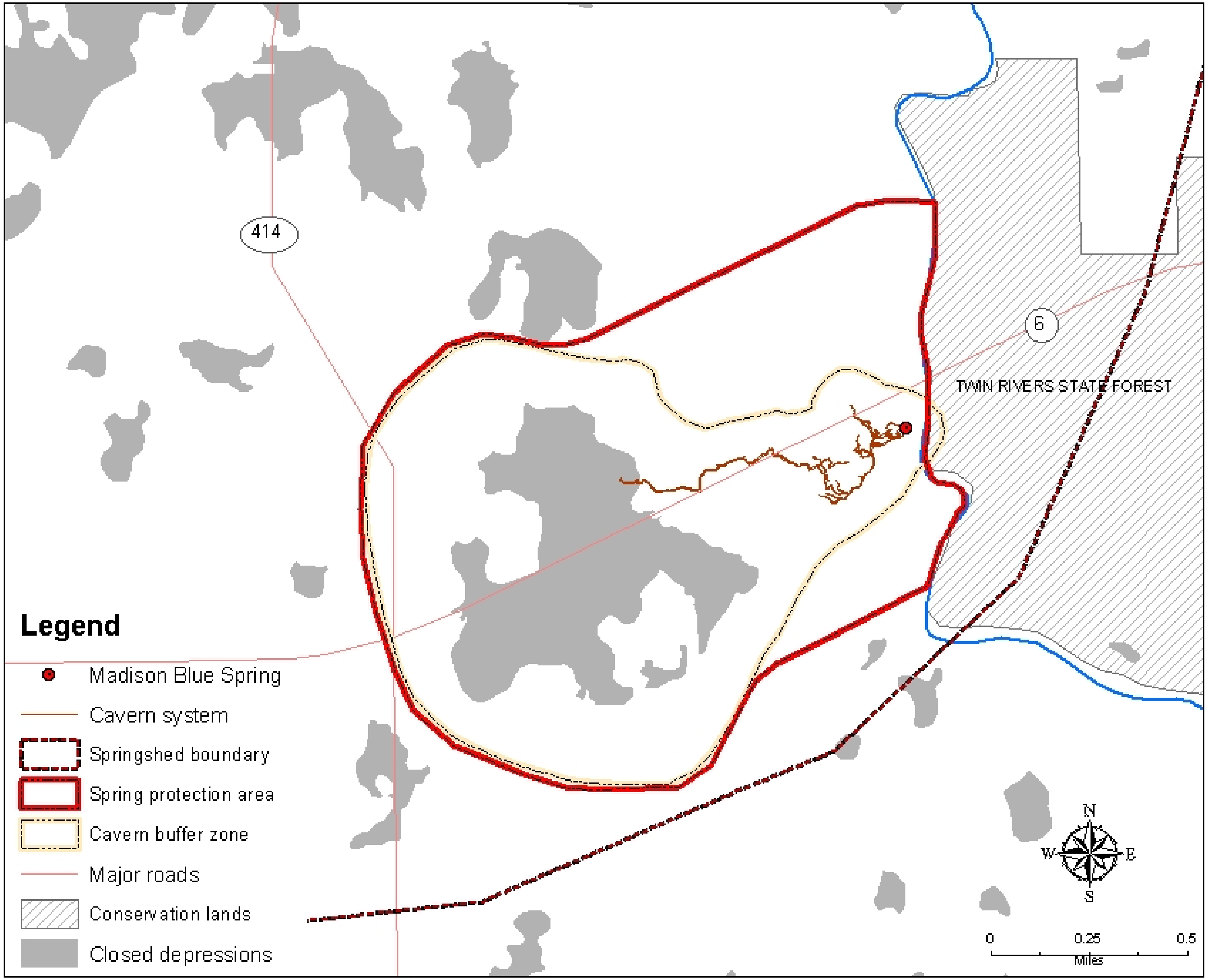

Figure 9. Spring Protection Area and Cavern Buffer Zone for Madison Blue Spring.

* This figure was prepared for planning purposes only and is intended to assist the District in the development of spring protection strategies.

These karst features result in increased ground-water velocities and enhanced aquifer vulnerability. The Spring Protection Area was drawn to include this portion of the aquifer.

The Springshed protection area extends from the Spring Protection Area to the head of the Cody Scarp, which is northern-most extent of large karst features as shown on Figure 9. The Spring Protection Area encompasses several miles of the Suwannee River along the Lafayette and Suwannee County lines.

Ichetucknee Springs

Figure 11 depicts the recommended protection areas for the Ichetucknee Springs springshed. This is the best-known system, and more detail can be added to the protection-area delineations. The Ichetucknee Springs springshed is also the only basin with mapped surface water protection areas.

The Spring Protection Area was drawn to include the area immediately around the springs, the Ichetucknee River, the Ichetucknee Trace, and the surface-water basins within the central portions of the springshed that empty directly into swallets known to recharge water discharging from the springs. The area near the springs includes a portion of the potentiometric surface where slope increases as flow converges on the springs. Dye tests in Rose Sink and ground-water quality studies (Upchurch and Champion, 2003a) clearly connect karst features in the Ichetucknee Trace with discharge at the springs. The dye trace data (Karst Environmental Services, 1997) show that travel times are rapid (up to a mile per day) within the cavern system that connects the swallets to the springs. Therefore, the trace and a one-half mile buffer on each side are included in the Spring Protection Area. The Spring Protection Area extends to Cannon Sink and includes Clay Hole sink, Rose Creek Sink and Swallet, and other surface-water recharge areas.

The Springshed Protection Area includes that portion of the springshed characterized by low potentiometric surface gradients and well-developed karst features (sinkholes, etc.). It extends to the top of the Cody Scarp and includes the steepened potentiometric surface gradient and large sinkholes within the Cody Scarp.

Surface Water Protection Areas include the drainage basins of the three major streams that discharge to swallets in the Trace. These basins (Cannon Creek, Clay Hole Creek, and Rose Creek) discharge storm water directly to the cavern system under the Trace, so protective measures should be taken to avoid discharge of deleterious constituents to the swallets.

Manatee and Fannin Springs

Figures 12 and 13 illustrate the proposed Spring Protection Areas and Cavern Buffer Zone for the Manatee and Fannin springsheds. Because the two springsheds abut each other and the ground-water divide between the two springsheds is not distinctive, the springsheds have been combined. The two springsheds correspond with the scarp-bounded springshed model.

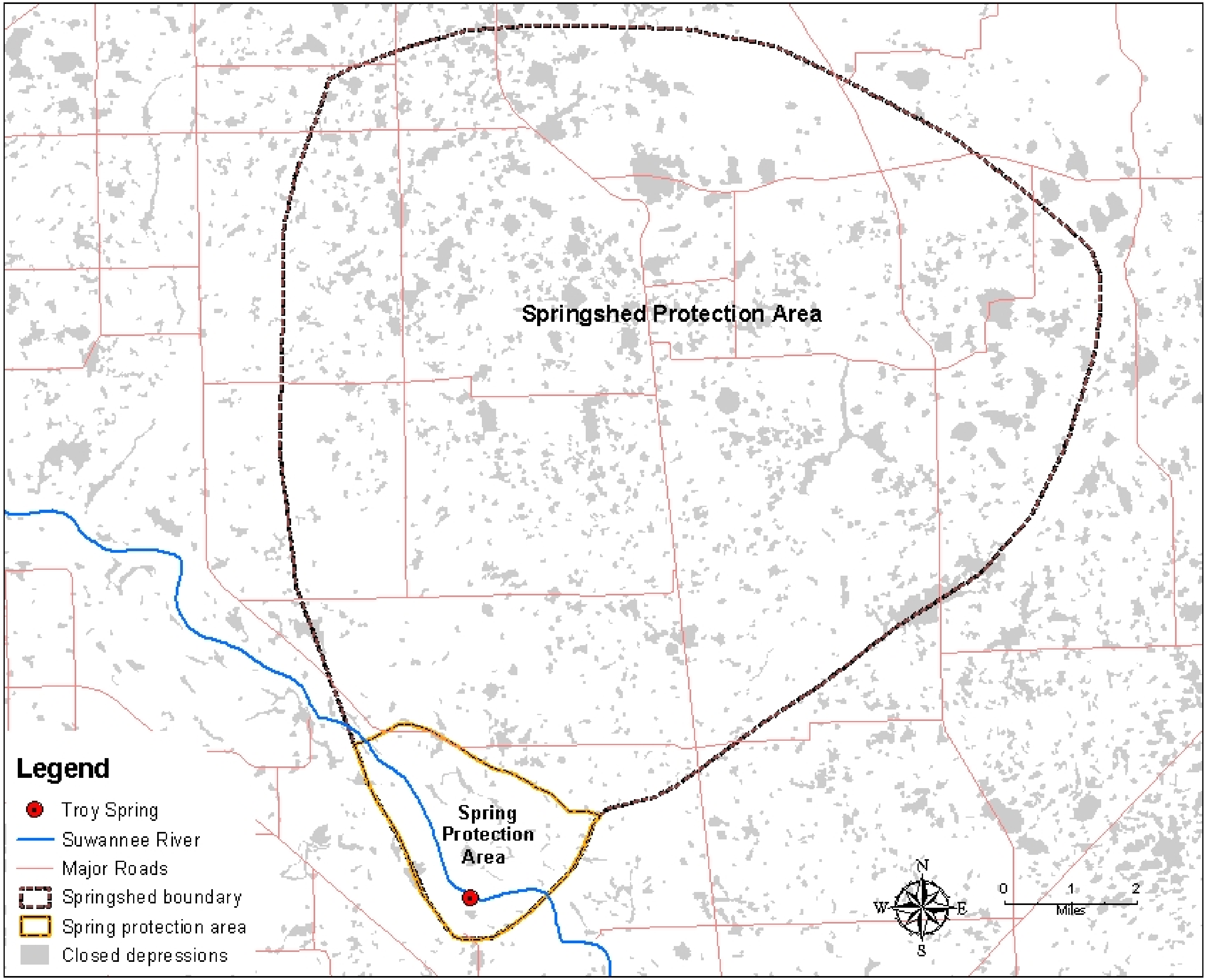

Figure 10. Springshed Protection Area for Troy Spring.

* This figure was prepared for planning purposes only and is intended to assist the District in the development of spring protection strategies.

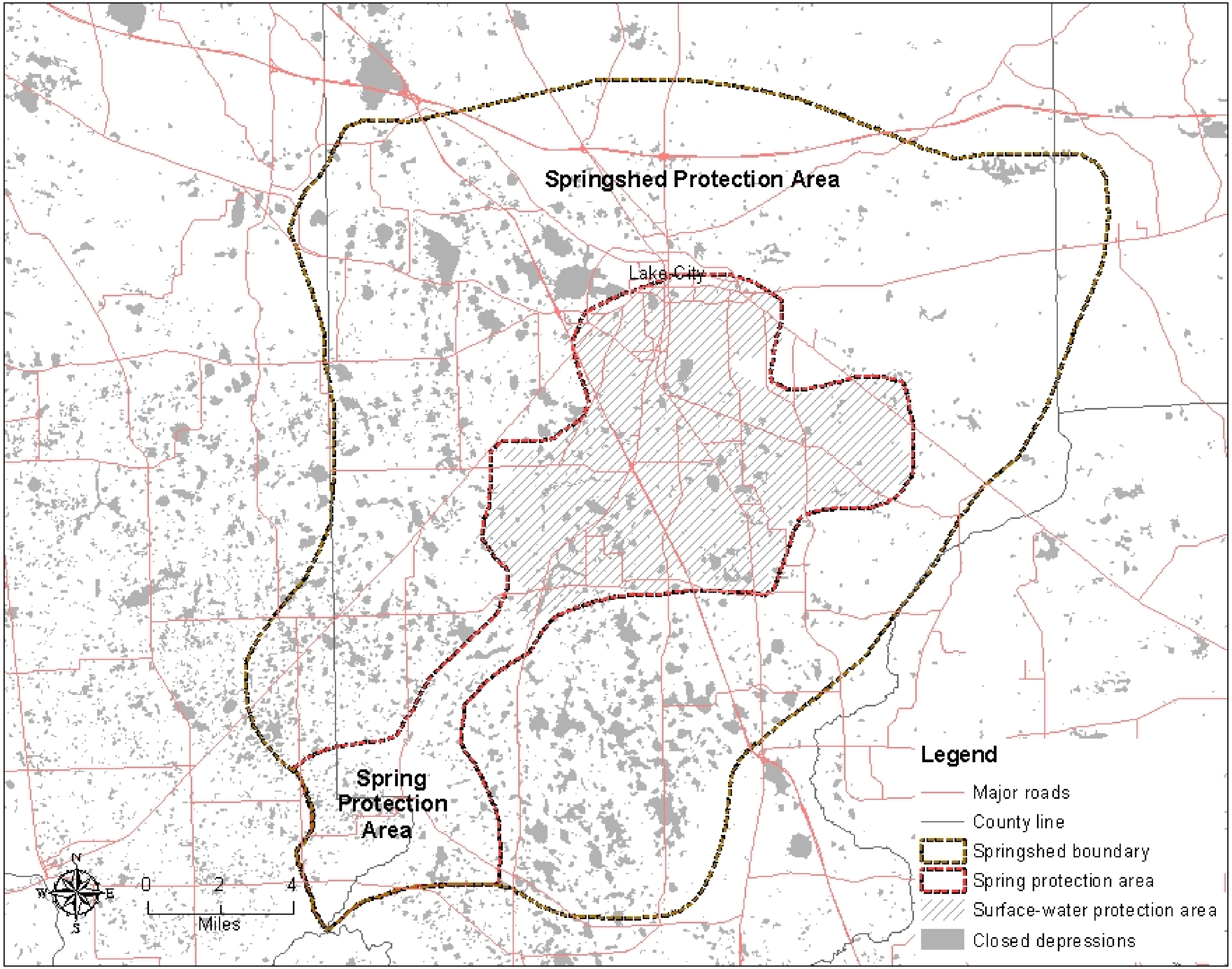

Figure 11. Protection zones in the Ichetucknee Springs springshed.

* This figure was prepared for planning purposes only and is intended to assist the District in the development of spring protection strategies.

The Spring Protection Areas include regions where the slope of the potentiometric surface indicates converging flow near the springs (see Upchurch and Champion, 2003b). In the case of Manatee Spring, this converging flow is closely associated with the cavern system known to lie to the southeast of the Spring (Figure 13). It is proposed that, much like Madison Blue Spring, this cavern system be afforded an additional level of protection through the designation of a Cavern Buffer Zone along either side of the cavern.

The cavern system under Fannin Spring has not been explored. The cavern system under Manatee is being actively explored at the present time. The mapped and projected extent of the cavern system under Manatee Spring appears to lie within a 2-mile radius of the Spring. A two-mile radius was chosen on the basis of the District's ground-water flow model has recently been developed for the Lower Suwannee Basin by the U.S. Geological Survey (the model and report had not been released to the public by the Survey at the time of preparation of this report). The model was run under steady state conditions and travel times estimated for ground water near the springs. Based on the model, water takes 20 years or less to flow to the spring from 2 miles away. This travel time does not account for flow through the cavern systems that serve each spring, so it is felt that this distance is protective of the spring and yet not restrictive of land uses in general. This travel time coincides with areas where the Floridan aquifer potentiometric surface flattens, indicating rapid flow times and enhanced aquifer vulnerability.

The Springshed Protection Area (Figure 12) includes the relatively low gradient portions of the Floridan aquifer potentiometric surface and the steepened gradient areas on the flank of the potentiometric high under the Waccassa Flats to the northeast. The low-gradient areas are vulnerable to contamination because of high recharge rates, and ground-water withdrawals are likely to affect discharge from the springs. The western margin of the Waccassa Flats appears to function hydrologically much as the Cody Scarp. While no major surface-water streams that discharge to swallets have been identified, an investigation for such areas is warranted and surface-water protection areas may be necessary.

PROTECTION AREA IMPLEMENTATION

Implementation of spring protection areas is complex and largely unexplored as a water-management strategy. It will require an educated constituency and active cooperation between regulatory agencies, local government, industry, and residents of the springshed.

Three levels of management based on aquifer vulnerability and relative impact of ground-water withdrawals are suggested in this report. The most stringent is within the Spring Protection Areas, where we suggest either (1) that land uses that are most likely to affect spring water quality or quantity be avoided or, for existing uses, (2) that use of protective measures and a high level of monitoring be implemented. Within the Springshed Protection Areas, less stringent measures are suggested, but they remain protective. Suggested management measures in the Surface Water Protection Areas are similarly protective.

Development of MFLs for the five springs will assist in management of the protection areas, especially with respect to consumptive use of water. The protection areas should be refined during the MFL-development process and their extents modified as better data are obtained. Ultimately, the protection areas can be incorporated into the MFL process.

Table 1 summarizes the consequences of activities that may exist in a springshed and provides sample suggestions for management based on current understanding of the ground-water "plumbing" systems of springsheds and potentials for adverse impacts on springs as a result of contamination or water withdrawals.

The land uses, possible consequences, and management strategies within each protection area listed in Table 1 are not intended to be exhaustive or representative of the specific effects of any land use. The management strategies are intended to represent scenarios that illustrate some of the management options that might be adopted. The examples are intended to reflect the relative rigor required to protect springs and some possible management strategies.

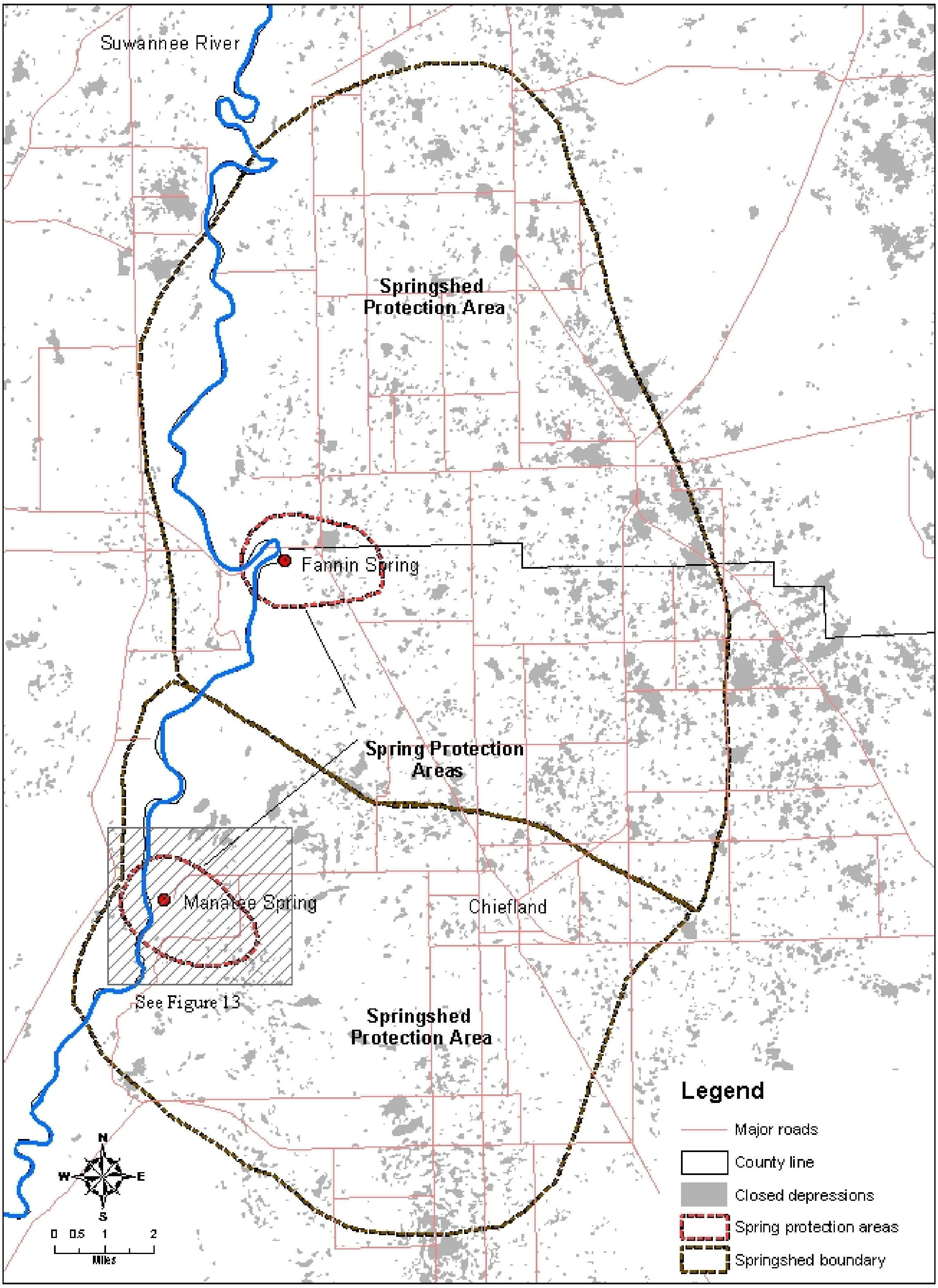

Figure 12. Protection zones in the Manatee-Fannin Springs study area.

*This figure was prepared for planning purposes only and is intended to assist the District in the development of spring protection strategies.

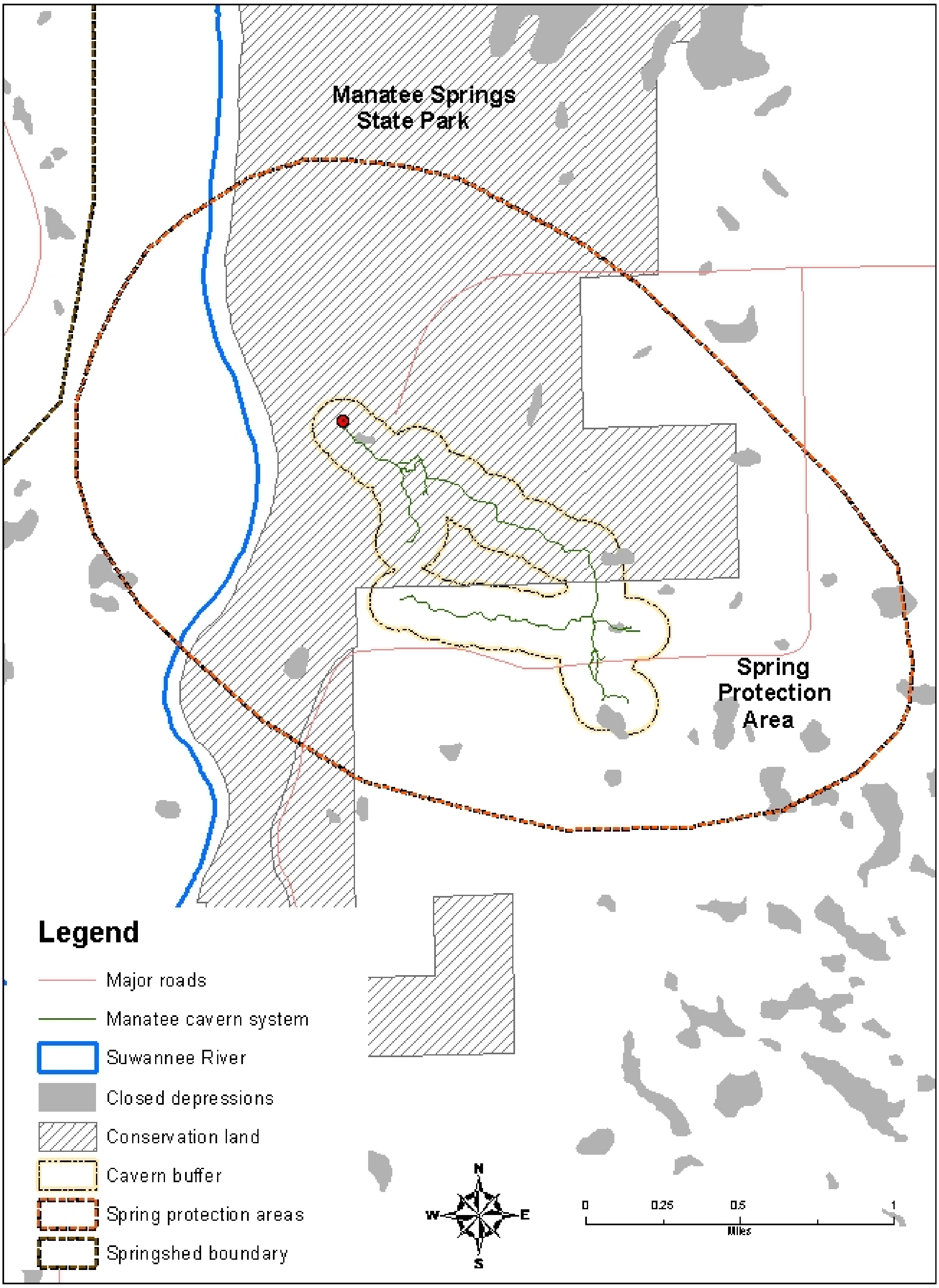

Figure 13. Extent of the Manatee Spring cavern system, and associated Spring Protection Area and cavern buffer zone.

* This figure was prepared for planning purposes only and is intended to assist the District in the development of spring protection strategies.

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Table 1 - Consequences and management strategies for spring protection.

Land-Use Activity	Potential Adverse Outcomes of Land Use on Spring	Protection Area Strategies: Spring Protection Areas	Protection Area Strategies: Springshed Protection Areas	Protection Area Strategies: Surface-Water Protection Areas
Crop production	Increased nutrient loads	• Best management practices	• Best management practices	• Best management practices
Animal and animal product production	Increased nutrient loads	• Area to avoid this use • Advanced waste management and spill protection	• Best management practices	• Best management practices
Landfill	Increased contaminant loads	• Area to avoid this use • Remove existing unlicensed landfills • Closely monitor shallow and deep ground-water at permitted facilities, install leachate collection facilities if necessary	• Best management practices	• Best management practices
Land-spreading sewage treatment facilities	Increased nutrient loads	• Area to avoid this use • Plug any conduits or sinkholes that lead to the Floridan aquifer and are within land application area • Advanced waste-water treatment to minimize potential contaminants	• Plug any conduits or sinkholes that lead to the Floridan aquifer and are within land application area • Advanced waste-water treatment to minimize potential contaminants	• Minimize direct discharge to area streams
Drainage wells	Increased metals and nutrient loads	• Remove all existing drainage wells • Dispose of runoff through percolation ponds that are hydraulically isolated from aquifer • In urban areas utilize lift stations to move storm water out of karst-dominated areas • Area to avoid this use	• Dispose of runoff through percolation ponds that are hydraulically isolated from aquifer with peak-flow capture in wells, if necessary	• Not applicable
Storm-water percolation ponds	Increased metals and nutrient loads	• Dispose of runoff through percolation ponds that are hydraulically isolated from aquifer • Plug all sinkholes and other penetrations that direct storm water to aquifer	• Dispose of runoff through percolation ponds that are hydraulically isolated from aquifer • Plug all sinkholes and other penetrations that direct storm water to aquifer	• Dispose of runoff through percolation ponds that are hydraulically isolated from aquifer • Plug all sinkholes and other penetrations that direct storm water to aquifer
Septic tanks	Increased metals and nutrient loads	• Connect to regional sewerage in urban areas • Limit septic tank	• Connect to regional sewerage in urban areas • Limit septic tank	• Develop best management practices for tank cleaning and drain

		Protection Area Strategies		
Land-Use Activity	**Potential Adverse Outcomes of Land Use on Spring**	**Spring Protection Areas**	**Springshed Protection Areas**	**Surface-Water Protection Areas**
		density to 1 tank (residence) per acre in rural areas • Develop best management practices for tank cleaning and drain field maintenance	density to 1 tank (residence) per acre in rural areas • Develop best management practices for tank cleaning and drain field maintenance	field maintenance
Domestic water wells	Potential minor losses of discharge	• Encourage public supply where housing densities are appropriate • Encourage best management and water conservation practices	• Encourage public supply where housing densities are appropriate • Encourage best management and water conservation practices	• Encourage public supply where housing densities are appropriate • Encourage best management and water conservation practices
Municipal and industrial withdrawals	Potential large losses of discharge	• Do not permit • For existing uses, encourage alternative water supplies or transfer of wellfields to Springshed Protection Areas • Require best management and water conservation practices • Limit production during water shortages	• Encourage best management and water conservation practices • Utilize permitting process to manage effects of pumpage and enforce water shortage rules	• Encourage best management and water conservation practices • Utilize permitting process to manage effects of withdrawals and enforce water shortage rules
Withdrawals for bottled water	Potential large losses of discharge	• Do not permit • For existing uses, encourage alternative water supplies or transfer of wellfields to Springshed Protection Areas • Require best management and water conservation practices • Limit production during water shortages	• Encourage best management and water conservation practices • Utilize permitting process to manage effects of pumpage and enforce water shortage rules	• Encourage best management and water conservation practices • Utilize permitting process to manage effects of withdrawals and enforce water shortage rules
Fuel handling facilities (including gas stations)	Potential contamination	• Do not permit • For existing facilities, require containment facilities, above-ground storage, and routine monitoring • Work with FDEP to ensure that monitoring is adequate	• Require containment facilities, above-ground storage, and routine monitoring	• Prevent offsite movement of storm water
Industry with chemical storage or permitted releases	Potential contamination	• Do not permit • For existing facilities, require containment facilities, above-ground storage, and routine monitoring	• Require containment facilities, above-ground storage, and routine monitoring, as appropriate	• Require containment facilities, above-ground storage, and routine monitoring, as appropriate

Land-Use Activity	Potential Adverse Outcomes of Land Use on Spring	Protection Area Strategies: Spring Protection Areas	Springshed Protection Areas	Surface-Water Protection Areas
		• Work with FDEP to ensure that monitoring is adequate		• Work with FDEP to ensure that discharge permits and monitoring are adequate
Mining (quarries, borrow pits)	Recharge of contaminated water, dewatering and loss of spring discharge	• Do not permit mining activities • For existing mines, utilize enhanced monitoring • Implement best water management practices	• Require appropriate monitoring • Implement best water management practices	• Require appropriate monitoring • Implement best water management practices