TECHNICAL REPORT

MFL ESTABLISHMENT
FOR THE
LOWER SUWANNEE RIVER & ESTUARY,
LITTLE FANNING, FANNING,
&
MANATEE SPRINGS

OCTOBER 2005

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CERTIFICATION

This Technical Report was prepared for the use of the Suwannee River Water Management District for the establishment of Minimum Flows and Levels for the Lower Suwannee River and Estuary, Little Fanning, Fanning and Manatee Springs by the undersigned.

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Date: 10/31/05

Technical Report

MFL Establishement for the
Lower Suwannee River & Estuary,
Little Fanning, Fanning & Manatee Springs

SUWANNEE RIVER WATER MANAGEMENT DISTRICT

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1.0 Introduction

This Minimum Flows and Levels for the Lower Suwannee River and Estuary – Technical Report (Report) presents the data and analyses which provide technical support for the establishment and adoption of Minimum Flows and Levels (MFLs) for the Suwannee River Estuary ("Lower Suwannee River"), Manatee Springs, and Fanning Springs. The goals for these MFLs are:

- To implement the intent and policy of the Governing Board of the Suwannee River Water Management District;
- To satisfy the requirement of state water law and policy.

1.1 State of Florida Law Pertaining to the Establishment of MFLs

Chapter 373.042, F.S:

(1) Within each section or the water management district as a whole, the Department (Florida Department of Environmental Protection) or the district Governing Board shall establish the following:

(a) Minimum flow for all surface watercourses in the area. The minimum flow for a given watercourse shall be the limit at which further withdrawals would be significantly harmful to the water resources or ecology of the area.

(b) Minimum water level. The minimum water level shall be the level of groundwater in an aquifer and the level of surface water at which further withdrawals would be significantly harmful to the water resources of the area.

Subsequent language in the statute (Chapter 373.042(1), F.S.) provides guidance that the Governing Board shall use the "best information available", and that the Board may consider "seasonal variations" and the "protection of nonconsumptive uses" in establishing MFLs.

Additional policy guidance is provided in the State Water Resources Implementation Rule regarding MFLs (Chapter 62-40.473, Florida Administrative Code [F.A.C.]), indicating that ". . . consideration shall be given to the protection of water resources, natural seasonal fluctuations in water flows or levels, and environmental values associated with coastal, estuarine, aquatic, and wetlands ecology. . . ." These environmental values may include:

a) Recreation in and on the water;
b) Fish and wildlife habitats and the passage of fish;
c) Estuarine resources;
d) Transfer of detrital material;
e) Maintenance of freshwater storage and supply;
f) Aesthetic and scenic attributes;
g) Filtration and absorption of nutrients and other pollutants;
h) Sediment loads;
i) Water quality; and
j) Navigation.

These requirements constitute the statutory framework and the outline for the scope of work required to develop the MFLs for the Lower Suwannee River including Manatee Spring and Fanning Springs.

1.2 Project Scope

In September 1994, the Governing Board of the Suwannee River Water Management District (District) initiated the effort to develop MFLs for the Lower Suwannee River. The study area (Fig. 1.1) included the Lower Suwannee River from Fanning Springs to the river mouth, and including the estuary of the river (the region including Suwannee Sound, Horseshoe Cove, Cedar Key, and the nearshore waters of the Gulf of Mexico influenced by freshwater discharge from the river). Note that the study area, which is termed the Lower Suwannee River in this report, is the tidal portion of the Lower Suwannee hydrologic unit as identified by the U.S. Geological Survey (USGS; Kenner, et al., 1967).

As the Lower Suwannee River MFL was being developed, it became evident that the two major springs on the Lower Suwannee River (Fanning and Manatee Springs), which are also on the District's list for MFL development, would play a significant role in MFLs for the river. This is due to the fact that the Suwannee River has an integral relationship to the MFLs for each spring as a contributing flow back into the springs and as a dilution factor for thermal effects of the spring discharges which impacts manatee refuge. Therefore, it was decided that the three sets of MFLs would be established simultaneously.

1.3 Water Body Regulatory Designations

The Suwannee River is widely regarded as a river system with high conservation value. In a study using data from the National Rivers Inventory (NRI), Benke (1990) identified the Suwannee as one of 42 "large, intact" river drainages remaining in the U.S. He defined these as rivers with more than 124.2 miles (200 km) of length that are unaffected by any major dams, flow diversions, or navigation projects. These 42 river systems cumulatively represented only 2% of the total length of river reaches in the NRI database. Based largely on Benke's work, Noss et al. (1995) designated large intact streams and rivers in the U.S. as "Endangered Ecosystems", which they defined as those ecosystem types which have experienced an 85-98% decline in the existence of high-quality, intact examples. In similar fashion, a report on U.S. river ecosystems by The Nature Conservancy (Master et al., 1998) classified the Suwannee/Santa Fe drainages as "critical watersheds to protect freshwater biodiversity." Moreover, the federal government has designated portions of the Suwannee River as Critical Habitat for Gulf sturgeon, a federally threatened species. Existing state designations recognize the Suwannee as a river system of both regional and statewide importance. The Suwannee is recognized as a system having high conservation and recreational value, through designations such as Outstanding Florida Water (OFW) and Aquatic Preserve.

The Suwannee River, including the Lower Suwannee River MFL study area, is designated an Outstanding Florida Water (Chapter. 62-302.700[9][i][34], F.A.C.). This designation is conferred to waters of the state with "exceptional recreational or ecological significance" (Chapter 62-302.700[3], F.A.C.).

Figure 1-1 Map showing the Lower Suwannee River MFL study area.

A substantial portion of the MFL study area also lies within the Big Bend Seagrasses Aquatic Preserve. Aquatic Preserves are established by the State Legislature "…for the purpose of being preserved in an essentially natural or existing condition so that their aesthetic, biological and scientific values may endure for the enjoyment of future generations." (Chapter 18-20.001[2], F.A.C.). The Big Bend Seagrasses Aquatic Preserve was created in 1985 and includes the Lower Suwannee River from Fanning Springs to the mouth and all of the coastal waters of the Suwannee estuary.

The Lower Suwannee River study area also includes a number of important conservation areas, including two National Wildlife Refuges (Lower Suwannee and Cedar Keys NWRs), two State Parks (Fanning Springs and Manatee Springs), a state Wildlife Management Area (Andrews

WMA) and numerous parcels of Water Management District lands. These lands provide important ecological services as well as public recreation benefits (hiking, swimming, fishing, hunting, kayaking, etc.).

The springs play an integral role in the ecological and health and hydrology of the Lower Suwannee system. Manatees move freely from the river to the springs to find refuge if winter months and the river provides a carbon source to the spring biota for maintenance of the spring ecosystem.

Fanning Springs is a State Park. The spring is classified as a 1st magnitude spring but the flow no longer meets 1st magnitude flow requirements of 100 cfs median flow. Based on review of available discharge data, Fanning Springs has not ever met the criteria for 1st magnitude classification (mean or median discharge of 100 cfs or greater). The spring does experience intermitting discharge greater than 100 cfs. The spring is currently being renovated and is a popular swimming and picnicking area. Attendance at the spring for fiscal year 2003/2004 was recorded at 249,565.

Manatee Springs is a popular State Park that boasts a 1st magnitude scenic spring and spring run, swimming area, manatee viewing, and cave diving, among other activities. Attendance at the spring for fiscal year 2003/2004 was recorded at 129,661 (FDEP- 2004).

1.4 Relevant Water Resource Values

As noted in Section 1.1, Chapter 62-40.473, F.A.C. provides policy guidance regarding establishment of MFLs. In particular, this section of Florida's Water Policy lists 10, specific environmental and water resource values that should be considered in setting MFLs. As part of the MFL establishment process, Chapter 62-40.473, F.A.C. environmental and water resource values evaluation matrices are prepared to allow the MFL evaluators the opportunity to identify potential target values that may be the limiting factors for the proposed MFLs (Tables 1-1 thru 1-3). This process helps to focus the evaluation and shape the types of analyses needed to complete the MFL. This ranking process is initiated after compilation of all available data and review by the MFL evaluators. The rankings represent the professional opinion of the WRA team of experts based upon their collective experience in the development of MFLs after reviewing available data for each waterbody. Each ranking is based upon the collective experience of the evaluation team in establishing MFLs and review of the available data. Target values have the highest probability of limiting the amount of water available for the water body without causing significant harm. As an example, if the fish passage criterion requires the most water flow to avoid significant harm to the water body, then that value becomes the limiting factor for the proposed MFL since all other values would require less flow to avoid significant harm. This value ranking procedure is not inflexible and new target criteria can emerge in the evaluation process, but in most cases the initial determinations are accurate

The relevance of each, and how they were incorporated into the establishment of MFLs for the Lower Suwannee River, Fanning Springs and Manatee Springs, is discussed below:

a. <u>Recreation in and on the water</u>. This water resource value is considered relevant to the Lower Suwannee River and its springs. The Outstanding Florida Water designation of the river is in part based on the recreational significance of the Suwannee system. Uses include swimming, boating, water skiing, recreational fishing, kayaking and canoeing. The District and the Florida Department of Environmental Protection (FDEP) are currently engaged in creating the "Suwannee Wilderness Trail"; a 207-mile canoe trail on the Suwannee River, linked with a network of camping and cabin facilities located on State and District lands. In establishing MFLs for the Lower Suwannee River and

Estuary, general information was considered on the economic value of ecotourism, recreational fishing, and related activities.

Similarly, recreation is a major use of Fanning and Manatee springs. Both are popular and heavily utilized. Maintaining an acceptable spring discharge for recreation was considered for each.

b. Fish and wildlife habitats and the passage of fish. This water resource value is considered relevant for the Lower Suwannee River MFLs. Fish passage is not as much an issue in the river channel itself, due to the general lack of shallow shoal areas in the MFL study area, but it may be considered as a component of adequate water depths on the floodplain and tidal marshes. A major focus of the studies conducted to support the Lower Suwannee River MFLs was on the major wetland and aquatic habitats of the lower river and estuary (see Chapter 4 in this report), and how hydrologic conditions structure those habitats.

   The springs are both secondary refuges for the West Indian Manatee (Warm Water Task Force, 2004). Consideration was given to providing acceptable refuge for manatees during cold months as well as for fish passage and wildlife habitat in general.

c. Estuarine resources. This water resource value is considered relevant for the Lower Suwannee River. The estuary of the river is the largest and most extensive river estuary in the Big Bend region of the Florida Gulf Coast (Mattson, 2002a); it is part of the Big Bend Seagrasses Aquatic Preserve, an OFW, and it supports extensive recreational and commercial fisheries. To support establishment of the Lower Suwannee River MFLs, relationships between stream flow and estuarine salinity dynamics were investigated, and studies of important estuarine habitats were conducted to evaluate the effects of freshwater inflow and salinity on those habitats. The results of these were incorporated into the Lower Suwannee River MFLs.

   The spring flows did not in themselves merit consideration as having impacts on the estuarine resources but consideration was given to the contribution of spring discharge to overall discharge of the river below Wilcox (Fanning Springs).

d. Transfer of detrital material. It has been well-established that a principal food base in aquatic and wetland ecosystems is decaying plant material, collectively termed “plant detritus” or simply detritus. Transport of this material from the river floodplain wetlands to the river channel is an important source of food material for riverine invertebrates, and transport of material from the river to the estuary is similarly a vital component of maintenance of the food base for estuarine consumers. This water resource value is relevant to the Lower Suwannee River MFLs, and existing data in the scientific literature were used to assist in determination of MFLs for the Lower Suwannee River.

   Transport of detrital material is not a consideration with respect to spring discharge. During periods of high discharge in the river, the springs perform as estevelles. That is, they backflow and transport humic substances and minor detritus from the river into the cavern systems that feed the springs. No data exist as to the importance of this process or how it specifically impacts these springs.

e. Maintenance of freshwater storage and supply. This water resource value is considered relevant to the Lower Suwannee River MFLs, and it is considered in more detail in

Chapters 3. Establishment of an MFL for a water body implicitly establishes potential availability of that water. This water resource value refers to the long-term maintenance (i.e., sustainability) of water storage and supply capability of the water body. The result of the protection of this value by MFL establishment is to ensure that, over time, the ability of the water body to serve as a supply source for existing and future legal permitted users is preserved without causing "significant harm" to the water resource or ecology of the area.

f. Aesthetic and scenic attributes. This water resource value is closely linked with the first one pertaining to recreation, in that part of the recreational value of the Lower Suwannee River is the aesthetic experience.

Aesthetic and scenic attributes are considered relevant to the establishment of MFLs for the Lower Suwannee River, and were incorporated as an important characteristic along with recreation.

Both springs are in state parks and are considered to have high aesthetic and scenic value. MFL consideration included acceptable maintenance of these attributes through provisions for a full spring bowl, minimization of black water reversal from the river and maintenance of stage in the spring runs.

g. Filtration and absorption of nutrients and other pollutants. This water resource value is considered relevant to the Lower Suwannee River MFL. The role of wetlands in maintenance of water quality is well-established (Mitsch and Gosselink, 1986). By allowing for settlement of suspended particulates, uptake of nutrients by plants, and sequestration of heavy metals and other contaminants in sediments, wetlands help protect water quality. Data from the scientific literature on nutrient cycling and other biochemical functions of wetland were taken into consideration in establishing MFLs, with the assumption that maintaining an acceptable level of ecological integrity for wetland ecosystems of the Lower Suwannee River would maintain this particular function.

Both spring systems have records of increasing nitrate concentrations. The spring systems, however, have little nutrient sorption capability. Submerged aquatic vegetation (SAV) provides minor sorption because of the short residence time of water in the spring systems.

h. Sediment loads. This water resource value is considered relevant to the Lower Suwannee River MFL. Available evidence indicates that the Suwannee River carries substantially lower sediment loads than similar-sized rivers along the northern Gulf Coast (USDA, 1977). This is primarily due to the physiography and soil types present in the basin. Despite this fact, the presence of alluvial features in the floodplain of the river and the existence of an estuarine delta indicates that the river does carry some sediment, which is important in the maintenance of these geomorphic features and their associated ecological communities. It is probable that most of the river's sediment load is carried at higher flows. General information from the literature on riverine fluvial dynamics was considered in setting the MFLs.

Transport of sediment loads is not considered to be an issue with respect to the springs. Both spring systems are sediment starved.

i. Water quality. This water resource value is considered relevant to setting MFLs on the Lower Suwannee River. The main water quality consideration was salinity variation in the estuary in relation to freshwater inflow and its effects on important estuarine habitats and fauna.

   While increasing nitrate concentrations in the springs is a concern, the increases are not related to levels or flows. They are related to land use within the springsheds. Water quality was not considered in MFL development for the springs.

j. Navigation. This water resource value was considered not relevant to the Lower Suwannee River MFLs, in that the system is not a waterway which supports commercial shipping or barge traffic. Passage by recreational vessels, canoes, etc. was considered under the “Recreation in and on the water” value, above.

   Neither spring has a navigable run. Canoeing and swimming were considered as recreational and scenic/aesthetic criteria.

SUWANNEE RIVER WATER MANAGEMENT DISTRICT

Table 1-1 MFL DECISION MATRIX: FANNING SPRINGS

Potential Criteria	Resource at Risk	Resource Value	Legal Factors	Rank	Available Data	Preliminary Data Analysis: Related to Flow/Level?	Limiting Criterion?
Notes	1	2	3	4	5	6	7
Recreation in and on the water	3	3	2	8	2	Y	N
Fish and wildlife habitats and the passage of fish	3	3	3	9	4	Y	Y
Estuarine resources	1	1	1	3	4	Y	N
Transfer of detrital material	1	1	1	3	1	N	N
Maintenance of freshwater storage and supply	2	3	1	6	6	Y	N
Aesthetic and scenic attributes	3	3	3	9	1	Y	N
nutrients and other pollutants	1	1	1	3	1	N	N
Sediment loads	1	1	1	3	1	N	N
Water quality	3	2	1	6	3	N	N
Navigation	1	1	1	3	1	N	N

Notes:

1. Evaluation of the level to which the resource is potentially at risk. 1 = low risk, 2 = medium risk, 3 = high risk
2. Evaluation of importance of the criterion with respect to resource. 1 = low importance, 2 = medium importance, 3 = highly important
3. Legal constraints on resource, such as endangered species, Outstanding Florida Water, etc. 1 = low, 2 = medium, 3 = high
4. Sum of columns 1, 2, and 3. Indicates overall importance of criterion to MFL development.
5. Evaluation of available data for use in development of MFL based on the criterion. 0 = no data available, 8 = abundant and relevant data available
6. Evaluation as to whether criterion is related to flow or level in resource. (Yes or No)
7. Evaluation as to whether criterion is potentially limiting for MFL development. (Yes or No)

Table 1-2 MFL DECISION MATRIX: MANATEE SPRINGS

Potential Criteria	Resource at Risk	Resource Value	Legal Factors	Rank	Available Data	Preliminary Data Analysis: Related to Flow/Level?	Limiting Criterion?
Notes	1	2	3	4	5	6	7
Recreation in and on the water	3	3	2	8	2	Y	N
Fish and wildlife habitats and the passage of fish	3	3	3	9	4	Y	Y
Estuarine resources	1	1	1	3	4	Y	N
Transfer of detrital material	1	1	1	3	1	N	N
Maintenance of freshwater storage and supply	2	3	1	6	6	Y	N
Aesthetic and scenic attributes	3	3	3	9	1	Y	N
nutrients and other pollutants	1	1	1	3	1	N	N
Sediment loads	1	1	1	3	1	N	N
Water quality	3	2	1	6	4	N	N
Navigation	1	1	1	3	1	N	N

Notes:

1. Evaluation of the level to which the resource is potentially at risk. 1 = low risk, 2 = medium risk, 3 = high risk
2. Evaluation of importance of the criterion with respect to resource. 1 = low importance, 2 = medium importance, 3 = highly important
3. Legal constraints on resource, such as endangered species, Outstanding Florida Water, etc. 1 = low, 2 = medium, 3 = high
4. Sum of columns 1, 2, and 3. Indicates overall importance of criterion to MFL development.
5. Evaluation of available data for use in development of MFL based on the criterion. 0 = no data available, 8 = abundant and relevant data available
6. Evaluation as to whether criterion is related to flow or level in resource. (Yes or No)
7. Evaluation as to whether criterion is potentially limiting for MFL development. (Yes or No)

Table 1-3 MFL DECISION MATRIX: LOWER SUWANNEE RIVER

Potential Criteria	Resource at Risk	Resource Value	Legal Factors	Rank	Available Data	Preliminary Data Analysis: Related to Flow/Level?	Limiting Criterion?
Notes	1	2	3	4	5	6	7
Recreation in and on the water	3	3	1	7	1	Y	N
Fish and wildlife habitats and the passage of fish	3	3	3	9	8	Y	Y
Estuarine resources	3	3	3	9	8	Y	Y
Transfer of detrital material	2	2	1	5	1	Y	N
Maintenance of freshwater storage and supply	2	3	2	7	4	Y	N
Aesthetic and scenic attributes	2	2	3	7	1	Y	N
nutrients and other pollutants	3	2	1	6	1	N	N
Sediment loads	1	1	1	3	1	N	N
Water quality	3	3	3	9	8	N	Y
Navigation	2	1	1	4	1	N	N

Notes:

1. Evaluation of the level to which the resource is potentially at risk. 1 = low risk, 2 = medium risk, 3 = high risk
2. Evaluation of importance of the criterion with respect to resource. 1 = low importance, 2 = medium importance, 3 = highly important
3. Legal constraints on resource, such as endangered species, Outstanding Florida Water, etc. 1 = low, 2 = medium, 3 = high
4. Sum of columns 1, 2, and 3. Indicates overall importance of criterion to MFL development.
5. Evaluation of available data for use in development of MFL based on the criterion. 0 = no data available, 8 = abundant and relevant data available
6. Evaluation as to whether criterion is related to flow or level in resource. (Yes or No)
7. Evaluation as to whether criterion is potentially limiting for MFL development. (Yes or No)

SECTION 2

2.0 Introduction to the Suwannee River Basin and Study Area

2.1 Suwannee River Basin

2.1.1 Physical Setting of the Suwannee Basin

The Suwannee River Basin encompasses 9,950 mi^2 (25,770 km^2) in Florida and Georgia (Figure 2-1; Franklin et al., 1995). It is the second largest river system in Florida by drainage area and mean annual flow (Table 2-1). Major tributaries of the river are the Withlacoochee and Alapaha Rivers, which are mostly located in Georgia, and the Santa Fe River in Florida. In total, approximately 57% of the basin is in Georgia. The Suwannee is a low-gradient stream, with an average gradient of 0.4 feet per mile. The following discusses general characteristics of this complex river system.

Table 2-1. Descriptive data on the Suwannee River and its major sub-basins (Franklin et al., 1995, and Berndt et al., 1996).

	Basin Area (mi^2)	Total Length (miles)	Florida Length (miles)	Gradient (ft/mile)	Average Flow (ft^3/sec)
Suwannee River**	9,950	235	206.7	0.42	10,540**
Withlacoochee River	2,360	120	30.0	2.32	1,714
Alapaha River	1,840	130	22.6	1.80	1,674
Santa Fe River	1,360	79.9	79.9	1.90	1,608

** - includes contributions of the Withlacoochee, Alapaha and Santa Fe sub-basins

The physiographic setting of the basin (Allan, 1995; Berndt et al, 1996), acting in conjunction with regional climatic characteristics controls the basic water chemistry and hydrologic characteristics of the river. The river basin lies entirely within the Southeastern Coastal Plain (Berndt et al., 1996). Major physiographic provinces in Florida include the Northern Highlands and Gulf Coastal Lowlands physiographic regions (White, 1970; Ceryak et al., 1983; Figure 2-2).

Characteristics of the Northern Highlands include gently rolling topography, generally from 100-200 feet above mean sea level (msl). Soils typically range from sand to clayey sand. Clayey sediments in the subsurface serve as a base for a surficial aquifer and retard infiltration of rainwater into the underlying Floridan Aquifer System. The result is abundant surfacewater features (streams, lakes and ponds) throughout the Highlands.

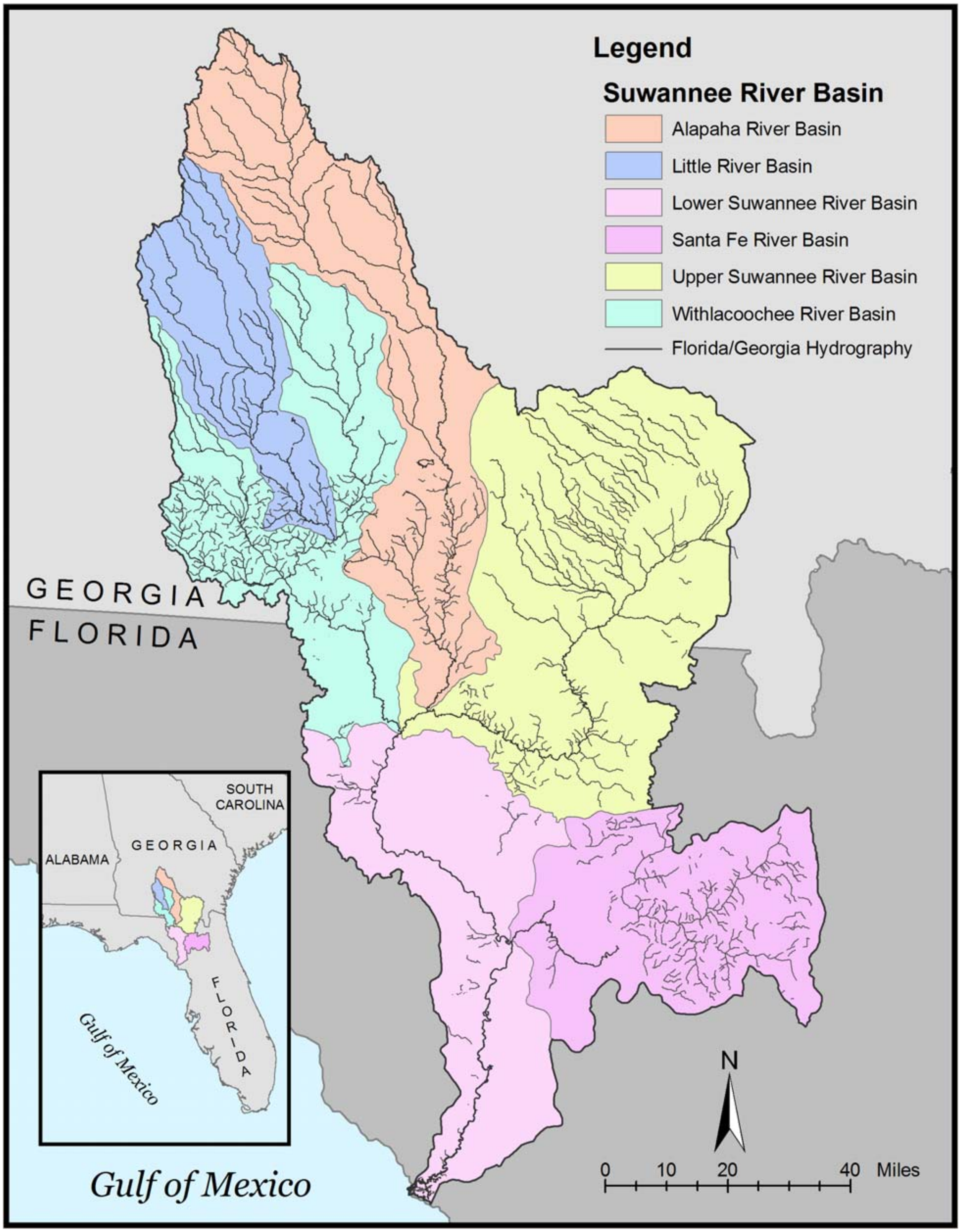

Figure 2-1. Suwannee River Basin in Florida and Georgia. Basins shown are USGS hydrologic units (Kenner et al., 1967).

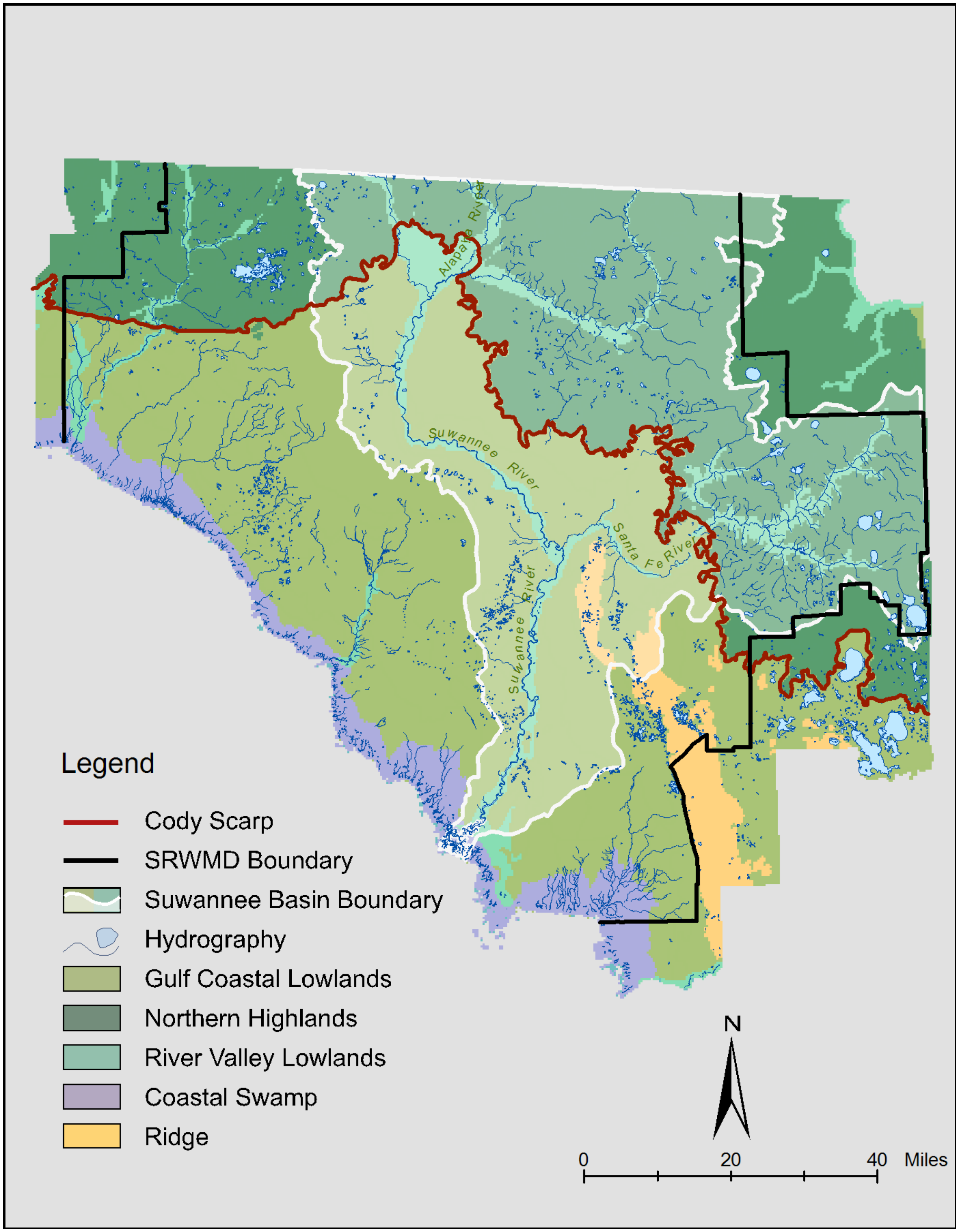

Figure 2-2. Physiographic regions in the SRWMD and regional hydrography in relation to the Suwannee River Basin in Florida. Data sources include White (1970); Ceryak et al. (1983); SRWMD data.

The Gulf Coastal Lowlands are characterized by elevations from sea level to about 100 feet above msl. The Lowlands feature low relief, karstic topography, and shallow sandy soils with muck in many wetland areas. Karst landforms are widespread in the lowlands, with abundant features such as sinkholes, sinking streams and springs, and a high degree of interconnection between surfacewater and groundwater systems. Carbonate rock (limestone, dolostone) is at or near land surface throughout the Lowlands. Whereas the surfacewater features in the Highlands reflect the water table of the surficial aquifer, those in the Lowlands represent the water table in the upper Floridan aquifer.

A significant geologic region separating the two major provinces is the Cody "Scarp," or Escarpment (Figure 2-2; depicted as a line for illustrative purposes), the most persistent topographic break in Florida (Puri and Vernon, 1964). There can be as much as 80 feet of relief along the Scarp. It is a karst escarpment that has been highly modified by marine shoreline processes. The Scarp region is characterized by active sinkhole formation, large uvalas, poljes and lakes, springs, sinking streams, and river rises (Ceryak et al., 1983). During average and lower flows, the Santa Fe and Alapaha Rivers are completely captured by sinkholes as they cross the Scarp and re-emerge down-gradient as river rises. The Withlacoochee River is partly captured as it crosses the Scarp near Valdosta, Georgia. Due to its size, the Suwannee is the only stream that is not significantly captured by a sink feature. Upgradient of the Scarp, surficial drainage has developed, with numerous small creeks branching off the upper Suwannee and its tributaries (Figure 2-2). Below the Scarp, drainage is predominantly internal and streams that are tributary to the Suwannee are rare.

Ridges, such as Bell Ridge and the Brooksville Ridge, are prominent features in the southern part of the District (Figure 2-2). These ridges were formed by a combination of karst scarp retreat and marine terrace development.

Relict marine terraces are important features of the Suwannee basin in Florida. These terraces were established by different stands of sea level during the Pleistocene (and possibly Pliocene) Epoch. The terraces stair-step from the Gulf to the Highlands, and the marine and coastal processes that created the terraces were responsible for deposition of the surficial sands that mantle the region (Healy, 1975; Schmidt, 1997). The progression of these terraces from the coast inland and upward includes (Figure 2-3):

Terrace	Approximate Elevation
Silver Bluff Terrace	1-10 feet above mean sea level (msl)
Pamlico Terrace	8-25 feet msl
Talbot Terrace	25-42 feet msl
Penholoway Terrace	42-72 feet msl
Wicomico Terrace	70-100 feet msl
Sunderland Terrace	100-170 feet msl
Coharie Terrace	170-215 feet msl
Hazlehurst Terrace	215-320 feet msl

The terraces from Silver Bluff to Wicomico occur primarily in the Gulf Coastal Lowlands physiographic region, while the Sunderland, Coharie, and Hazlehurst terraces are found in the Northern Highlands.

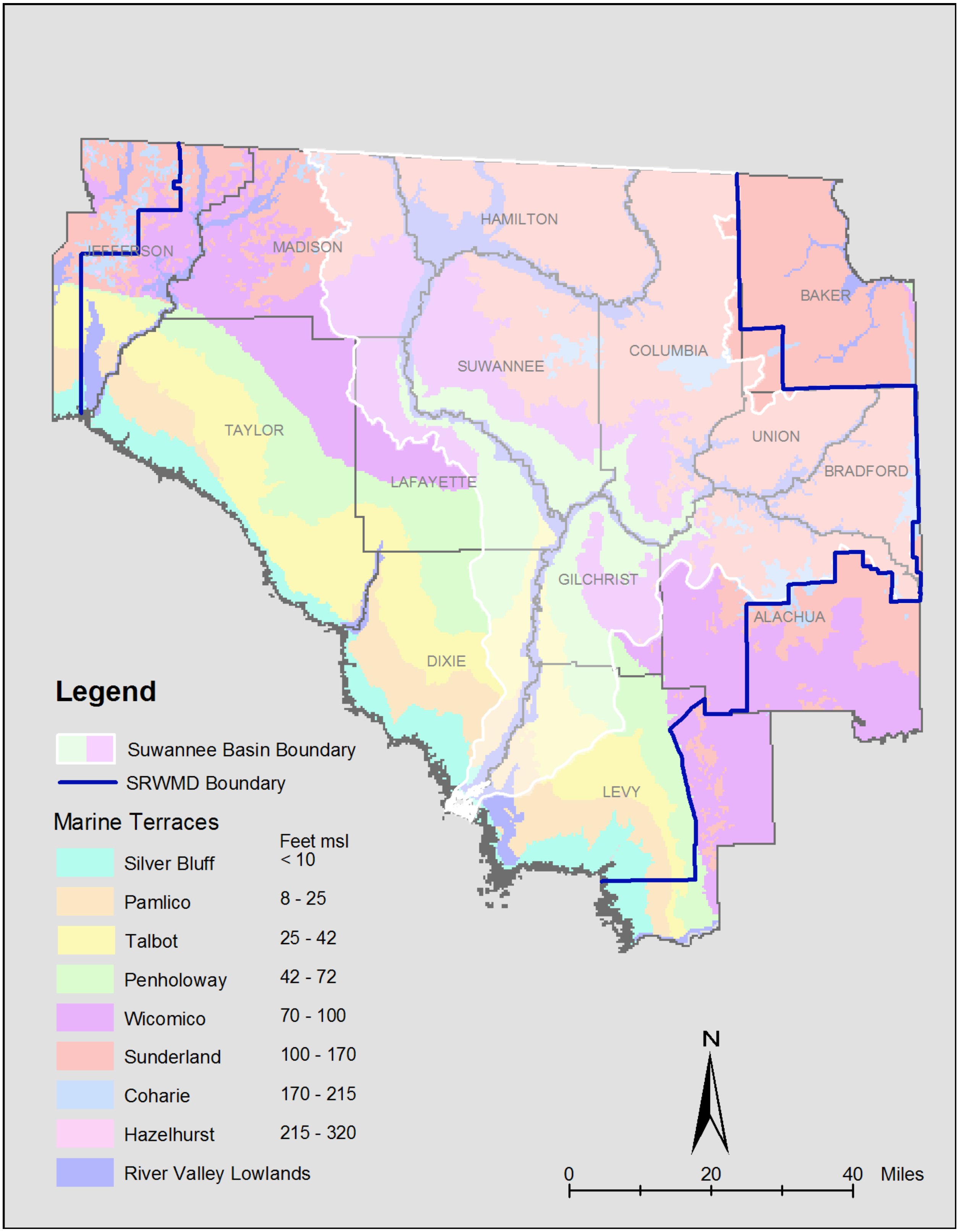

Figure 2-3. Marine terraces in the SRWMD in relation to the Suwannee River Basin. Data sources: USGS topographic GIS data and Healy, (1975).

2.1.2 Climate of the Suwannee River Basin

Climate is a description of aggregate weather conditions, including all statistical weather information for a region (Lutgens and Tarbuck, 1989). The climate of the Suwannee River basin can be described as a mixture of warm temperate and subtropical conditions. Mean annual temperature in the Florida portion of the basin is 68.6 °F (NOAA, 2002). The maximum and minimum average monthly temperatures are 81.3 °F (in July) and 54.2 °F (January), respectively.

Precipitation and evapotranspiration (ET) are the climatic features most significant to long-term hydrologic conditions in the Suwannee Basin. Average annual rainfall in the Basin is approximately 53.4 inches (NOAA, 2002) but varies spatially from 46 inches in the upper basin to over 60 inches near the Gulf coast (Figure 2-4). This precipitation gradient is largely controlled by the range in latitude of the basin (equivalent to approximately 200 miles) and the proximity of the lower third of the basin to the Gulf of Mexico (NOAA, 1972).

Year-to-year rainfall is rarely comparable to the average annual spatial differences. In the area covered by the NOAA North Florida Climatic Division, annual (calendar year) rainfall has varied from a low of 35.5 inches (1955) to a high of 77.9 inches (1964). Figure 2-5 shows the long-term (104 year) rainfall conditions for the north Florida region. The data were smoothed with a LOESS-type smoothing algorithm as implemented in TableCurve 2D (AISN Software, 2000). As shown, the smoothed curve suggests that a drier period existed in the first half of the 20th Century, with wetter conditions subsequently prevailing through the 1990's.

The month-to-month variation in rainfall is as important to understanding the Suwannee's hydrology as annual rainfall. Figure 2-4 shows the typical monthly rainfall pattern at three locations in the Suwannee Basin. As with annual rainfall, there is a gradient in seasonal climatic conditions from the northern to southern regions of the basin. The seasonal pattern is strongest in the south where a pronounced wet season occurs in the summer months (June through September). In this area, summer rainfall is associated with localized, convectional thunderstorms or periodic tropical weather systems (hurricanes, tropical storms). The pattern weakens in the middle and northern parts of the basin (compare Usher Tower to the Jasper and Tifton insets, Figure 2-4). More northerly portions of the basin are characterized by lower average annual rainfall, and a weakened seasonal pattern with precipitation that is more evenly distributed between the warmer and cooler months. Winter rainfall to the north is somewhat higher than to the south. Winter precipitation events are due to mid- latitude frontal weather systems with individual rainfall events that are usually more widespread.

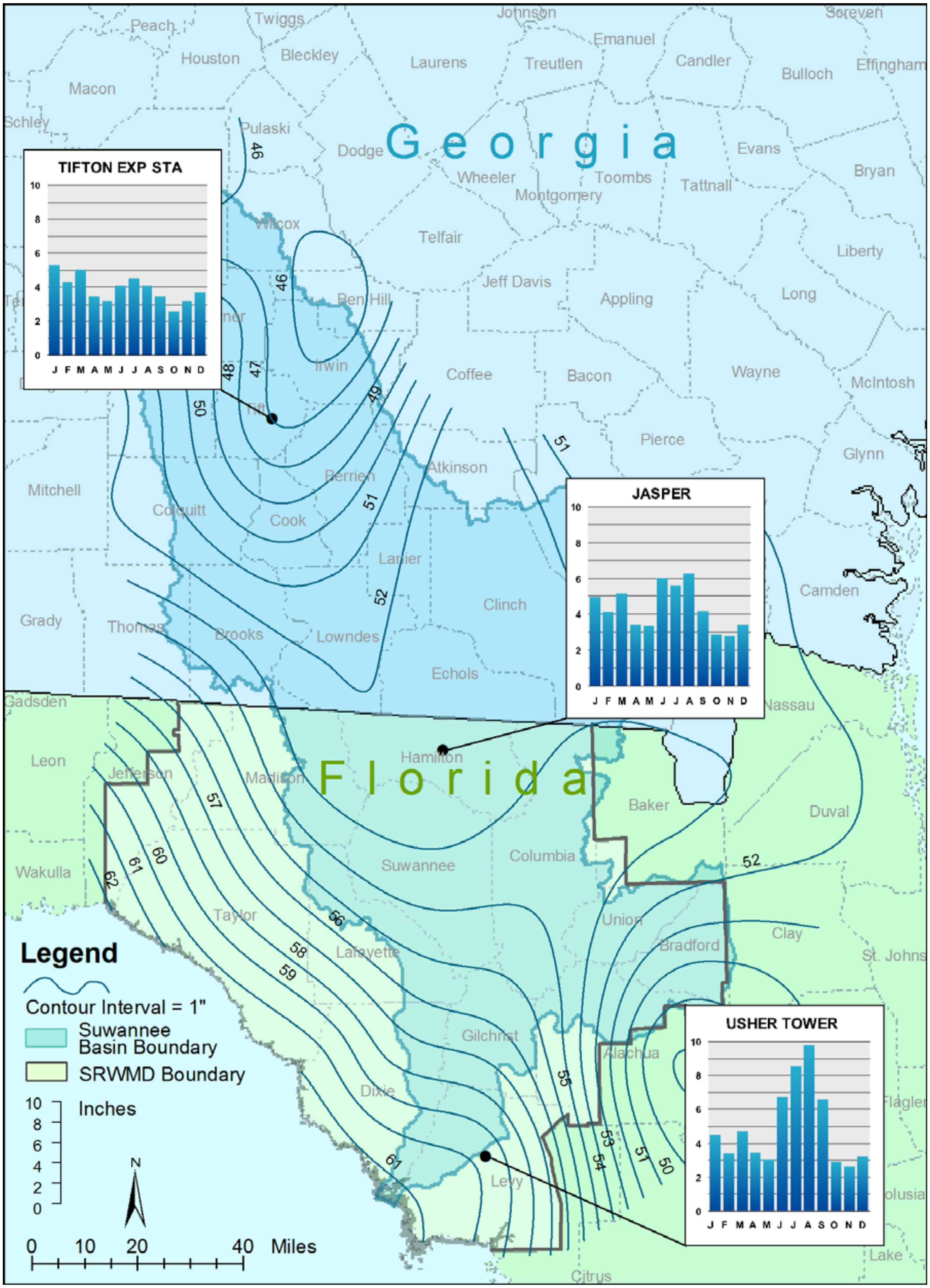

Figure 2-4. Average annual and monthly rainfall patterns in the Suwannee River Basin (Data: NOAA, 2002).

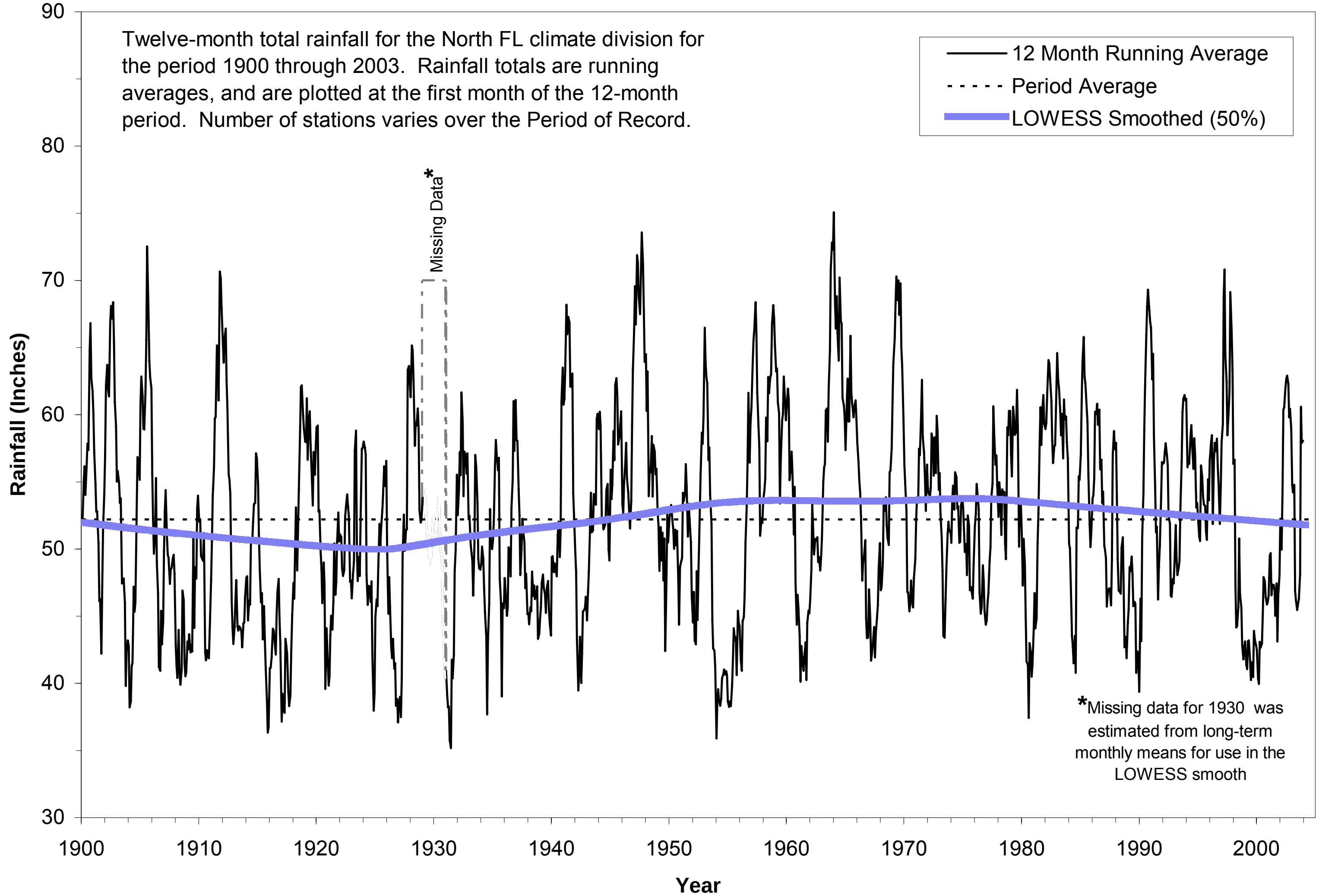

Figure 2-5. Twelve-month total rainfall for the North Florida climate division for the period 1900 to 2003. Rainfall totals are running averages, and are plotted at the first month of the 12-month period Data: NOAA (2005).

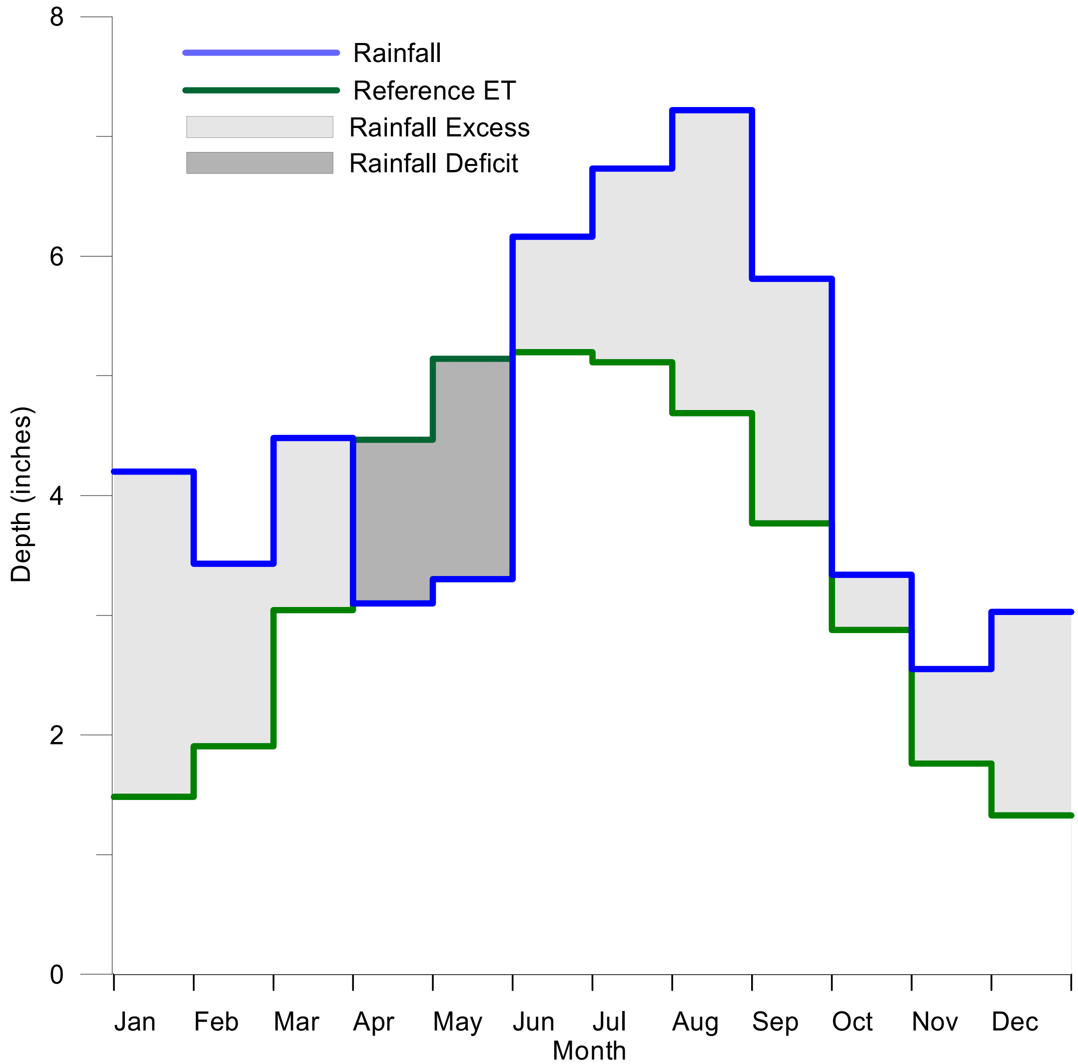

Figure 2-6. Mean monthly rainfall and reference evapotranspiration in the north Florida region. Data: NOAA (2002); Jacobs and Dukes (2004); Jacobs and Satti (2001).

Rates of evapotranspiration (ET) in the region have been estimated with a variety of direct measurements and/or computational methods. The average annual ET pattern shown in Figure 2-6 is estimated from computed reference ET for Gainesville (Jacobs and Dukes, 2004) multiplied by monthly crop coefficients for pasture (Jacobs and Satti, 2001). Reference ET is the potential ET from a short, well-watered grass crop. The resulting mean annual ET is 40.8 inches, with the largest mean monthly value of 5.20 inches in June and a minimum of 1.3 inches in December. The monthly rainfall values in Figure 2-6 are the North Florida Climatic Division means (NOAA, 2002).

Figure 2-6 indicates potential months of net rainfall surplus and/or deficit. During the cooler winter months, a water surplus can exist that serves to recharge the groundwater system. During late spring, a rainfall deficit can occur. Utilization of soil moisture (Fernald and Purdum, 1998) and late frontal systems can offset this effect. In the summer, the situation reverses, with rainfall typically exceeding ET. However, for climate-affected activities, such as agriculture, the scattered nature of summer convective rainfall events combined with excessive- to well-drained soils often result in site conditions that require supplemental irrigation.

2.1.3 Geology of the Suwannee Basin

The Suwannee River Basin lies in the Coastal Plain Physiographic Province of the United States (Hunt, 1974). The highly productive Floridan aquifer (Miller, 1997) underlies the region. It is capable of producing thousands of gallons of water per minute to wells. This section describes the geologic and groundwater systems of the Suwannee River Basin. Note that the lower Suwannee MFL study area is described in more detail in Section 2.3.

Carbonate rock (limestone and/or dolostone) as much as 5,000 feet thickness exists in the subsurface of the basin. These strata, which are primarily Tertiary in age, make up the Florida Platform. The Floridan aquifer is found within these strata and in similar strata in Georgia, the Carolinas, and portions of Alabama. The permeable portion of this carbonate-rock platform ranges from about 600 feet to 1700 feet in thickness (Miller, 1982).

The extent and elevation of the upper surface of the limestone are depicted in Figure 2-7. The upper surface of the Tertiary limestone ranges from sea level to 90 feet msl throughout most of the basin. The limestone begins dipping to the northeast in the northeastern corner of the District. This dip is about 20 feet per mile, and the top of the limestone reaches a depth of about 300 feet below sea level in the eastern corner of the District (Figures 2-7 and 2-8). Figure 2-8 illustrates details of the elevation of the top of the Tertiary limestone within the District and the Suwannee Basin.

Table 2-2 presents the lithostratigraphic (geologic formation) as well as the hydrostratigraphic (aquifer system) nomenclature used to characterize the shallow geologic and hydrogeologic units in the District.

The uppermost geologic unit consists of the Pliocene- and Quaternary-aged (Pleistocene/Holocene) surficial sand deposits. These deposits are undifferentiated and may include shell and clay horizons. They were primarily formed by deposition associated with marine terraces and by erosion and chemical weathering of pre-existing strata.

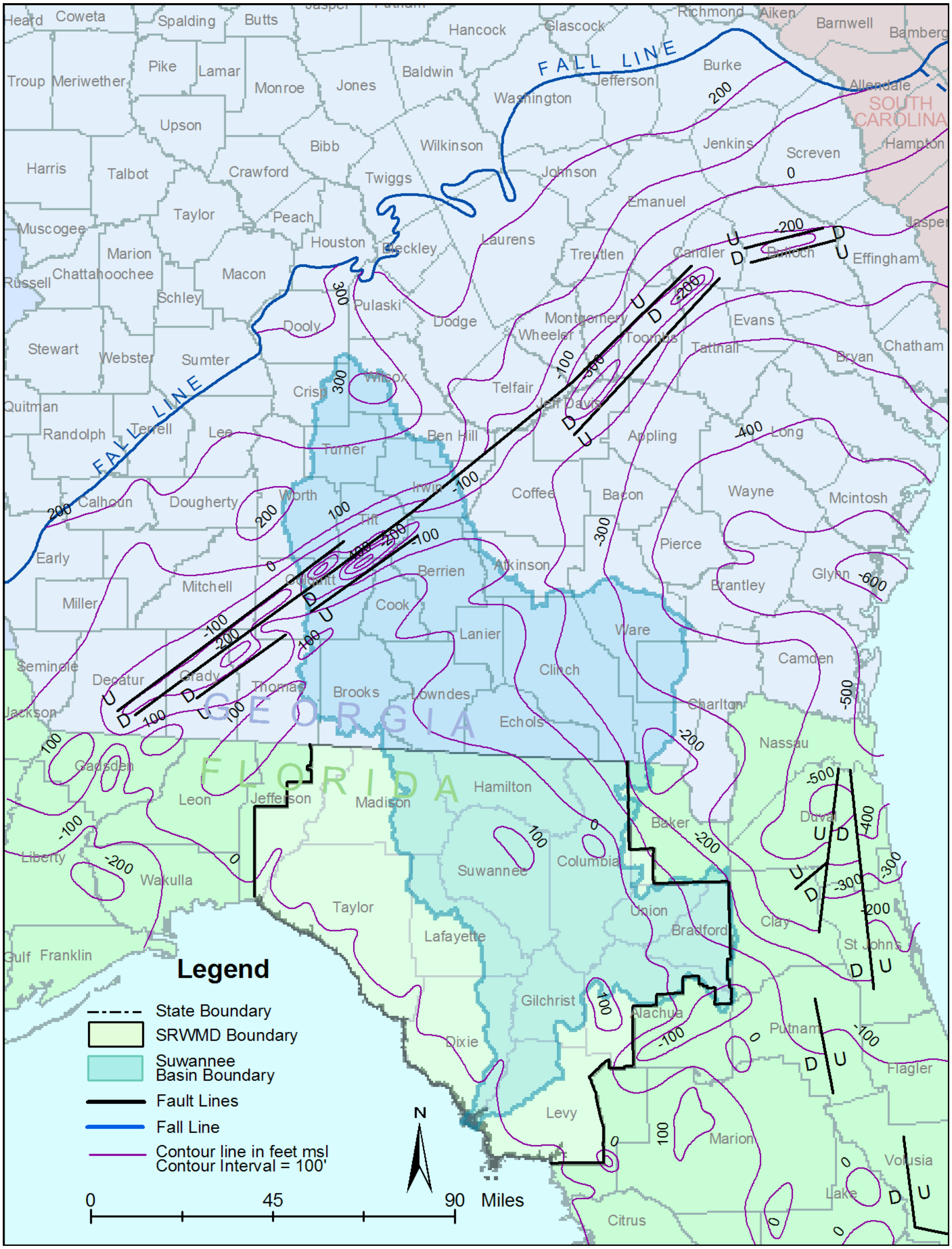

Figure 2-7. Extent of the limestone unit bearing the Floridan aquifer in the southeastern U.S. Fault line labels indicate: U = Uplift; D = Downlift. Adapted from Miller (1982).

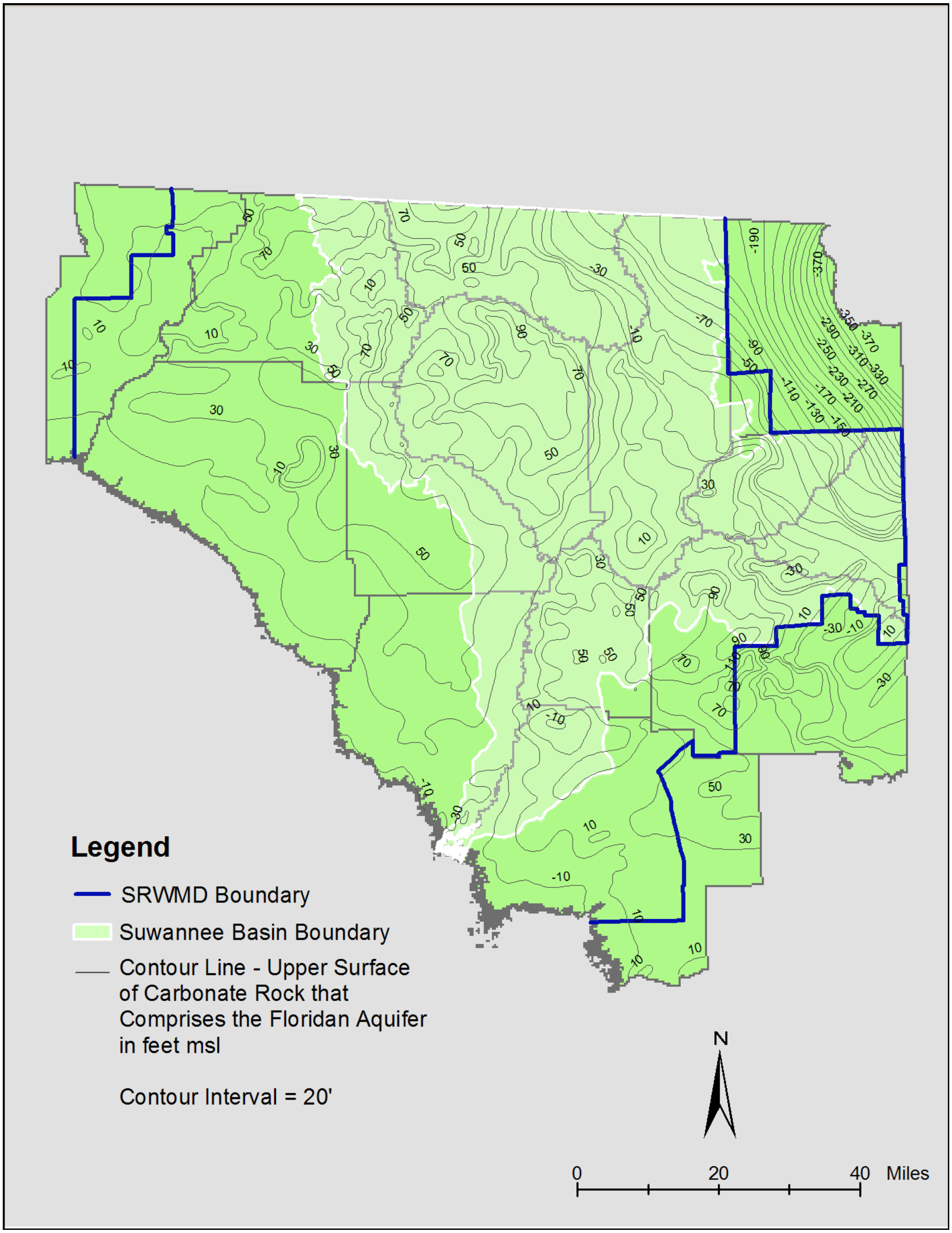

Figure 2-8. Elevation of the upper surface of the Tertiary limestone strata that constitute the Floridan aquifer within the District. Adapted from Allison et al. (1995).

Table 2-2. Generalized lithostratigraphic column and aquifer systems in the Suwannee Basin.

LITHOSTRATIGRAPHIC (ROCK) NOMENCLATURE			AQUIFER SYSTEM
SYSTEM	**SERIES**	**FORMATION**	
Quaternary	Holocene/Pleistocene	Undifferentiated Sands	Surficial
Tertiary	Pliocene	Undifferentiated Sands	Surficial
Tertiary	Miocene	Hawthorn Group St. Mark's Formation	Intermediate Aquifer System and Confining Beds
Tertiary	Oligocene	Suwannee Limestone	Upper Floridan
Tertiary	Eocene	Ocala Limestone Avon Park Limestone Oldsmar Limestone	Upper Floridan
Tertiary	Paleocene	Cedar Keys Formation	Mid-Floridan Confining Unit

The Miocene Hawthorn Group is present in the northern and northeastern portions of the District. It consists of interbedded clay, sand, and carbonate strata (Scott, 1988).

While the Miocene and Plio-Pleistocene strata are predominantly composed of siliciclastic materials (sand, clay, silt) interbedded with carbonate-rich strata, the underlying strata are predominantly composed of limestone and/or dolostone. These formations include (from top, or youngest, to bottom, or oldest) the Oligocene Suwannee Limestone, Eocene Ocala, Avon Park, and Oldsmar formations, and the Paleocene Cedar Keys Formation (Giller, 1997). These strata comprise the upper Floridan aquifer and, where present, the mid-Floridan confining unit. The Ocala Limestone, the uppermost section of the Floridan in the majority of the Basin, is also the source of the majority of ground water pumpage. The Suwannee Limestone overlies the Ocala in places, and ranks second in water production.

Figure 2-9 is a geologic east-west cross section that depicts the relationships of these formations. From the cross section, it is evident that, in the west, the Suwannee Limestone overlies the Ocala Limestone from the Gulf to the Suwannee River. The Suwannee Limestone is more dolomitic than the Ocala Limestone within the District. East of the Suwannee River, the Suwannee Limestone is generally missing. Note that the Hawthorn Group overlies the Ocala and thickens as the Ocala dips to the east.

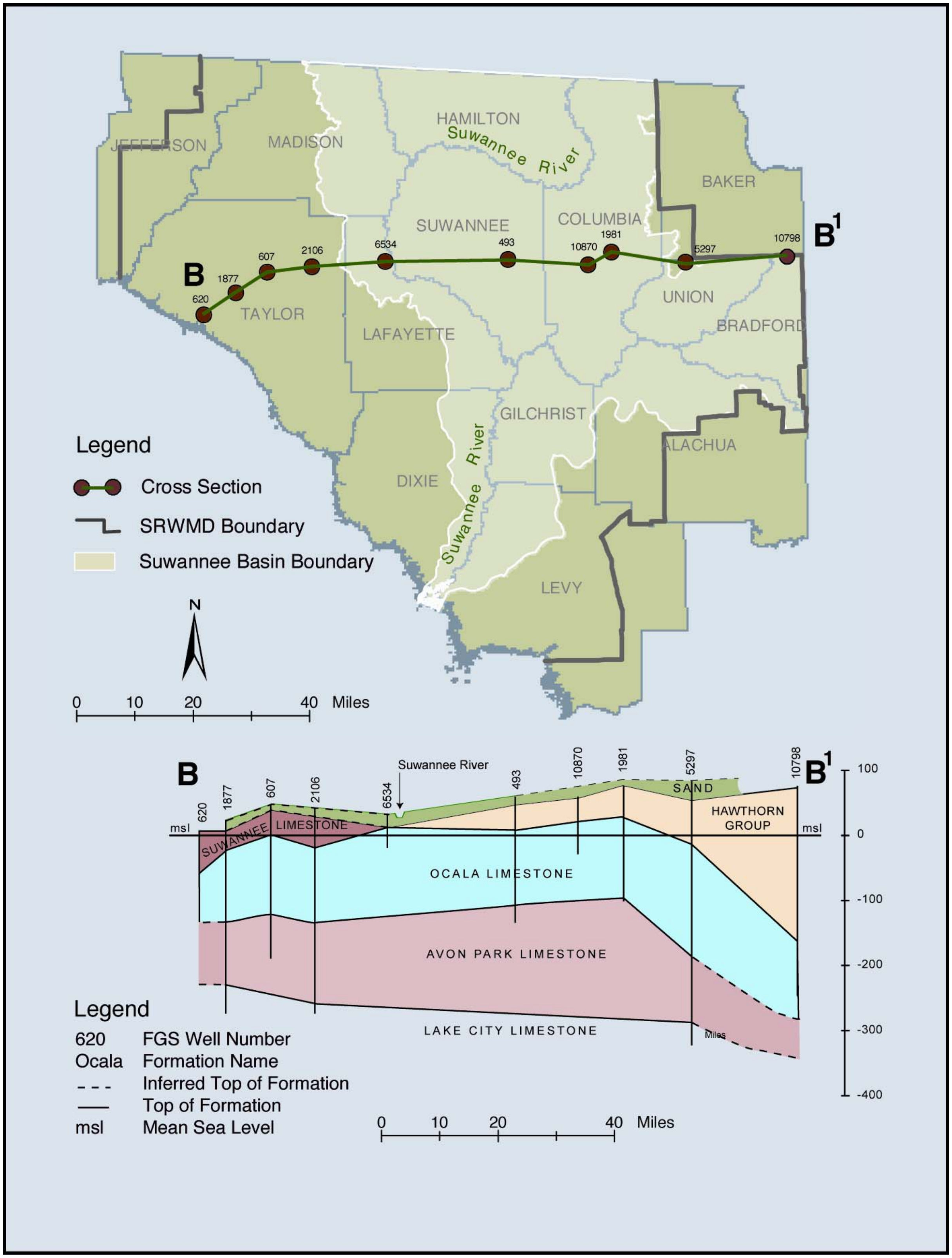

Figure 2-9. Generalized geologic cross section of the region. Adapted from Ceryak et al. (1983).

2.1.4 Regional Aquifer Systems

The uppermost aquifer within the District is the surficial aquifer (Table 2-2). The surficial aquifer occurs within the undifferentiated, Plio-Pleistocene, marine-terrace sands. This aquifer is only present in the northern and eastern parts of the District where the Hawthorn Group provides an effective aquitard under the surficial aquifer, which minimizes recharge to the underlying aquifer. The surficial aquifer is found locally in the Northern Highlands (Tallahassee Hills west of the Withlacoochee River) Province, and where water is perched over clays within the San Pedro/Mallory Swamp complex. The surficial aquifer is locally utilized for domestic well water. However, because of dissolved organics, color, odor, and iron problems, water quality is generally poor and undesirable.

The Hawthorn Group (Table 2-2) includes the Intermediate Aquifer and Confining Beds System. The strata act primarily as aquitards within the District, but thin layers of gravel, sand, and carbonate rock form localized aquifers that are capable of producing water to small-yield wells.

The upper Floridan aquifer extends throughout Florida, coastal plain Georgia and portions of the coastal plain in Alabama, North Carolina and South Carolina (Figure 2-7). The limestone unit begins along the Fall Line, where Coastal Plain sedimentary rocks lap against the metamorphic rocks of the Piedmont Province in central Georgia. The upper surface of the limestone dips easterly and southerly from the Fall Line. The rock surface elevation is about 300 feet above MSL along the Fall Line and dips to elevations lower than 600 feet below MSL in southeastern Georgia (Miller, 1982). Within the District, the top of the Upper Floridan aquifer ranges from approximately –100 to +100 feet MSL (Figure 2-8).

Figure 2-10 depicts the regional potentiometric surface for the upper Floridan aquifer in the District in May 1976. The contour lines depict the elevation of the water table where the Floridan is unconfined and correspond to the elevation to which water would rise in wells where the aquifer is confined. The general direction of flow can be estimated by drawing flow lines that are perpendicular to the lines of equal potential from high to low potentials. The head pressure caused by elevation differences in the potentials drives movement of water in the aquifer. The average flow rate through the aquifer is estimated to be a few feet per day.

The Floridan aquifer is primarily composed of limestone and dolostone, and the movement of water through the aquifer is via both “conduit flow” (flow through fractures, caverns, etc.) and “diffuse flow” (flow through intergranular pore spaces in the rock). As such, water quality is generally excellent because of extensive dilution, chemical interactions with the rock matrix, and mechanical filtration.

The saltwater/freshwater transition zone is the wedge-shaped groundwater zone where fresh ground water flows seaward, up and over saline water related to the

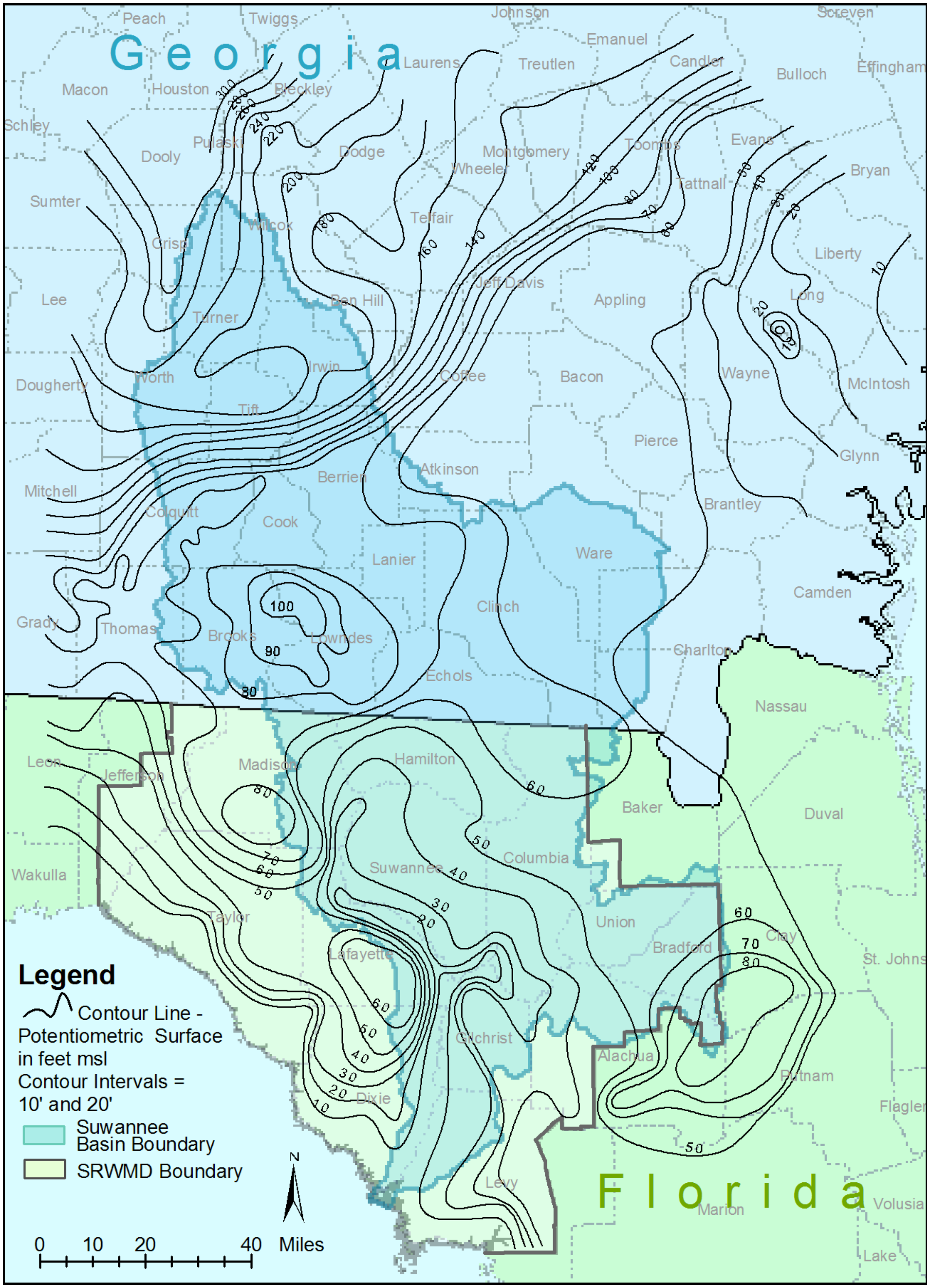

Figure 2-10. Potentiometric surface of the Floridan aquifer in May 1976. Adapted from Laughlin (1976); Rosenau and Meadows (1977); Fisk and Rosenau (1977).

Gulf of Mexico. The transition zone is characterized by upward movement and mixing of fresh water with saline water. The position of the transition has been roughly delineated by sodium and chloride data (Upchurch, 1990) along the Gulf of Mexico, and it has been defined by geophysics within a 20-kilometer radius around the mouth of the Suwannee River (Countryman and Stewart, 1997). Shallow aquifer water within about 5 miles of the Gulf coast tends to have relatively higher concentrations of sodium, chloride and potassium; however, chloride concentration does not exceed the 250 mg/L drinking water standard, (Copeland, 1987). Well depths in the larger coastal communities range from 85 feet to 170 feet without a significant increase in sodium, chloride or sulfate concentrations.

The degree of confinement of the upper Floridan aquifer is a critical factor in aquifer dynamics. Poorly confined areas tend to be rapidly recharged, while highly confined areas may receive minimal recharge on an annual basis. The District has compiled a hydrogeologic classification based on the degree of confinement of the Floridan aquifer (Figure 2-11) by combining and evaluating the physiography, geology, and hydrogeology (SRWMD, 1982). The classes of confinement are as follows.

Class 1 – Unconfined. Class I conditions exist where the Floridan is unconfined, is the only aquifer present, and the carbonate rock is at or near land surface. Where it is not exposed, the Floridan is usually covered by porous sand. The limestone is porous and permeable, exhibiting a high degree of secondary porosity that has been enhanced by a fluctuating water table. Due to the porous nature of the rock and sand, rainwater recharges the aquifer directly. Recharge rates in this region range from 16 to 31 inches annually (Grubbs, 1998). Surface water features usually represent exposures of the water table in the Floridan aquifer.

Class II - Semi-confined. Class II conditions exist where the Floridan aquifer is semi-confined on top by discontinuous, leaky, clay beds. The Class II area in Gilchrist, Alachua and Levy counties coincides with the Waccasassa Flats and the Class II area in Madison, Taylor, Dixie and Lafayette counties coincides with the San Pedro Bay/Mallory Swamp region. Because of reduced recharge, there are streams that drain the Waccasassa Flats and the San Pedro Bay, and there are lakes on the edges of these features. The Class II area that extends southeast from Suwannee County to Columbia County is the transition zone that parallels the Cody Scarp. This area is characterized by sinking streams, sinkhole lakes that periodically drain into the Floridan, and numerous steep-sided sinkholes. Recharge rates to the Floridan in this region are variable (Grubbs, 1998) and highly focused in location.

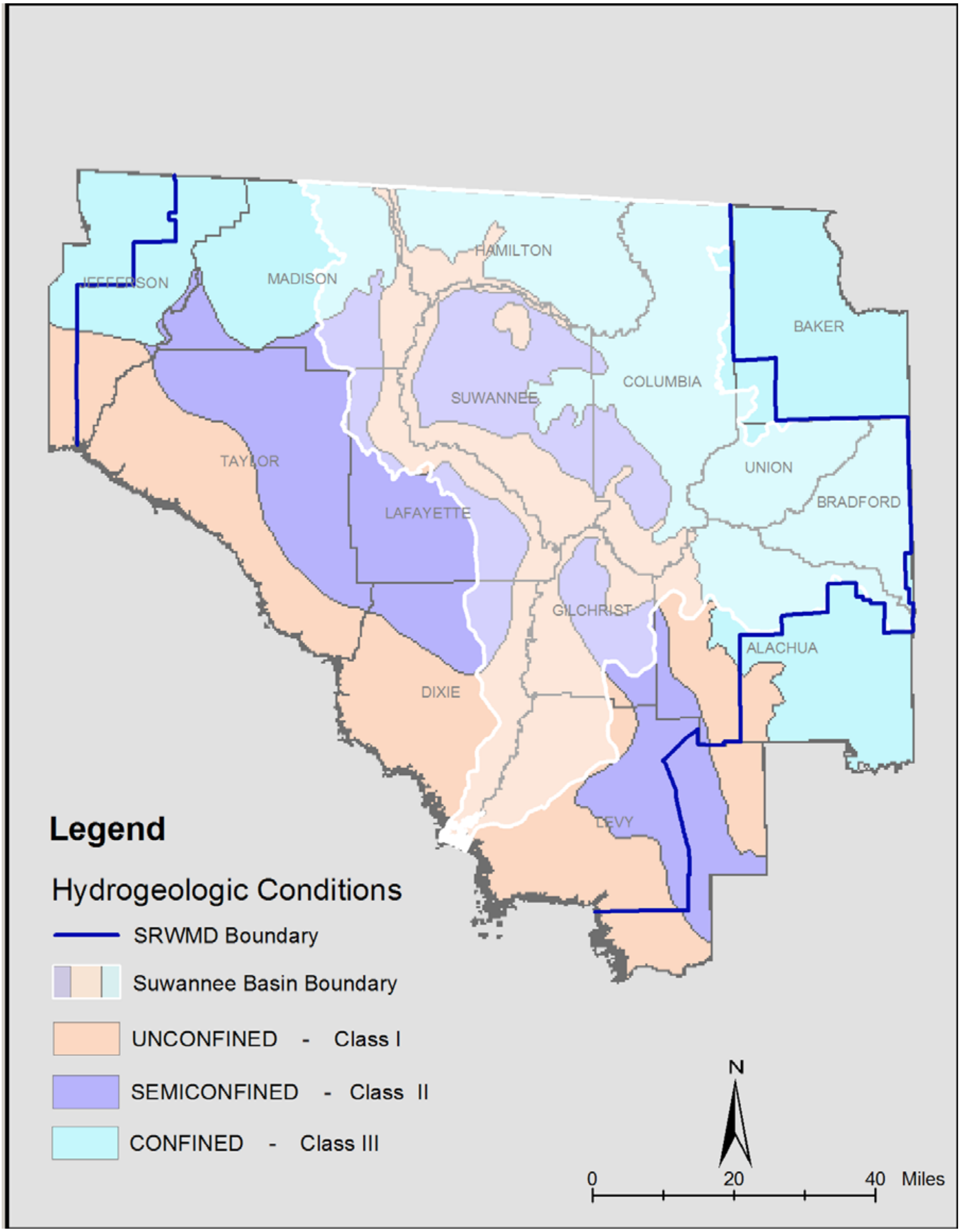

Figure 2-11. Confinement conditions of the Floridan aquifer in the region. Adapted from SRWMD (1982).

Class III – Confined. The Class III area is characterized by deeper and confined portions of the Floridan aquifer. Confinement is a result of at least 80 feet of Hawthorn Group clay overlying the Floridan. Recharge rates to the Floridan in this region average 12 inches or less annually (Grubbs, 1998). Confinement creates artesian conditions, and water levels in wells that penetrate these aquifers usually rise to within 15 feet of land surface.

The surficial aquifer locally overlies the Floridan in the Class II and most of the Class III areas (Figure 2-11). The surficial aquifer consists of unconfined, saturated sand and ranges up to 55 feet in thickness. The water table is a subdued replica of the topography and is at, or near, land surface. It coincides with surface water levels observed in the swamps, lakes, and ponds. Streams in these areas drain the surficial aquifer in addition to removing surface runoff. The surficial aquifer is recharged directly by rainfall and water level fluctuations are directly related to the amount of rainfall.

As suggested by Figure 2-11, recharge to the Floridan is highly variable. In Class III areas recharge is limited. The Cody Scarp is an area of generally moderate to high recharge owing to the presence of sinking streams that flow off the confined, Class III areas (i.e., the Northern Highlands) of the District and the presence of large sinkholes. A similar pattern exists in the transition from Class II to Class I regions west of the Suwannee River and in eastern Levy County (Figure 2-11). Recharge is generally high in the Class I (Coastal Lowlands, etc.) because of the thin deposits that overlie the limestone of the Floridan and the presence of many sinkholes.

Areas defined by their high potentiometric surface elevations (Figure 2-10) vary in origin. In general, they reflect locations within the District where the hydraulic conductivity (permeability) of the Floridan is relatively low, and groundwater flow is, therefore, slow. The reduction in ability to effectively drain water from the aquifer results in the potentiometric highs in spite of the low relative recharge. Because of focused recharge on the Cody Scarp and the margins of other areas where recharge is limited, the margins of the potentiometric highs are supported by high recharge.

The lower Suwannee groundwater basin is characterized by flow toward the river (Figure 2-10) from the east and west. The groundwater basin boundary to the east is in central Levy and Gilchrist counties (Figure 2-10). There, a groundwater divide separates the Suwannee groundwater basin from the Waccasassa basin and the High Springs Gap groundwater flow system. The divide is located under the Waccasassa Flats and Bell and Brooksville Ridges. To the west, the groundwater basin is limited by the potentiometric surface high in Dixie and Lafayette counties (Figure 2-10).

The total fluctuation of the Floridan aquifer potentiometric surface in the basin ranges up to 40 feet in the Alapaha River Basin in the northern part of the Suwannee River Basin. There is less than 15 feet of total fluctuation in at least two-thirds of the District and there is less than 5 feet of total fluctuation along the coast. Average annual fluctuation is less than 4 feet for approximately two-thirds of the District.

2.1.5 Land and Water Use in the Basin

2.1.5.1 Land Use and Population Characteristics

A summary of land cover/land use conditions (based on 1994 aerial photography) in the Florida portion of the Suwannee basin is shown in Table 2-3. Major human land uses in the basin in Florida include managed pine forests and agriculture. Available information indicates that these two uses also dominate land cover in the Georgia portion of the basin (Berndt et al., 1996). Residential, commercial and industrial land uses collectively comprise less than 6% of the total land use in Florida. The other dominant land cover types in Florida are upland and wetland forests in a largely natural or relatively less-disturbed condition.

Population density in the basin averages 29.8 persons per square mile, which is well below the statewide average of 239 persons per square mile. The two largest private employment sectors are the forest products industry (pulp manufacturing, lumber milling, and related silvicultural activities) and phosphate mining and processing. The largest single source of employment in the region is government, with slightly over half of the total workforce in the region working for local, state, or federal governments. Major government employers include local school systems and county governments, the Florida Dept. of Corrections, the Florida Dept. of Transportation, and the federal Veterans Administration.

Most of the point source discharges to the river are located in Georgia. These point-sources are mostly municipal wastewater discharges. The three major point-source discharges are phosphate processing facilities, which discharge indirectly via Hunter and Swift Creeks on the upper Suwannee; a pulp mill located in Clyattville, GA, which discharges to the Withlacoochee River in Florida via Jumping Gulley Creek; and a poultry processing plant, which discharges directly to the Suwannee River near the Withlacoochee confluence.

Relative to other areas of Florida, urban non-point sources of water pollution are fairly low intensity and dispersed. The largest urban area in the drainage basin is Valdosta, GA, which lies adjacent to the Withlacoochee and Alapaha Rivers. In Florida, relatively urbanized areas along or adjacent to the river or its tributaries include the towns of White Springs, Dowling Park, Branford, Fanning Springs, Ft. White, and High Springs.

2.1.5.2 Water Use

Estimated water use in the District in 2000 (Table 2-4) was 314 million gallons/day (mgd; WRA, 2005), which equates to about 486 cfs. Water use patterns in the District somewhat mirror land use. Agricultural irrigation accounts for a large fraction of the existing and projected water use, although commercial/ industrial is also a large overall use, principally due to phosphate mining and processing and once-through cooling water for power generation (Marella, 2004; WRA, 2005). By 2020 and 2050, agriculture and industrial water uses are predicted to continue being the largest uses in the District (WRA, 2005). Total water use in the District is projected to be approximately 547 mgd in 2020 (which equates to about 846 cfs), and 895 mgd in 2050 (1385 cfs).

Spatial patterns in existing permitted water use are shown in Fig. 2-12. This indicates that a large proportion of the permitted water use in the District is within the Suwannee basin. Total 2000 water use for counties entirely or partly within the Suwannee River Basin in Florida was 259 mgd, which is 82% of the 314 mgd total District water use.

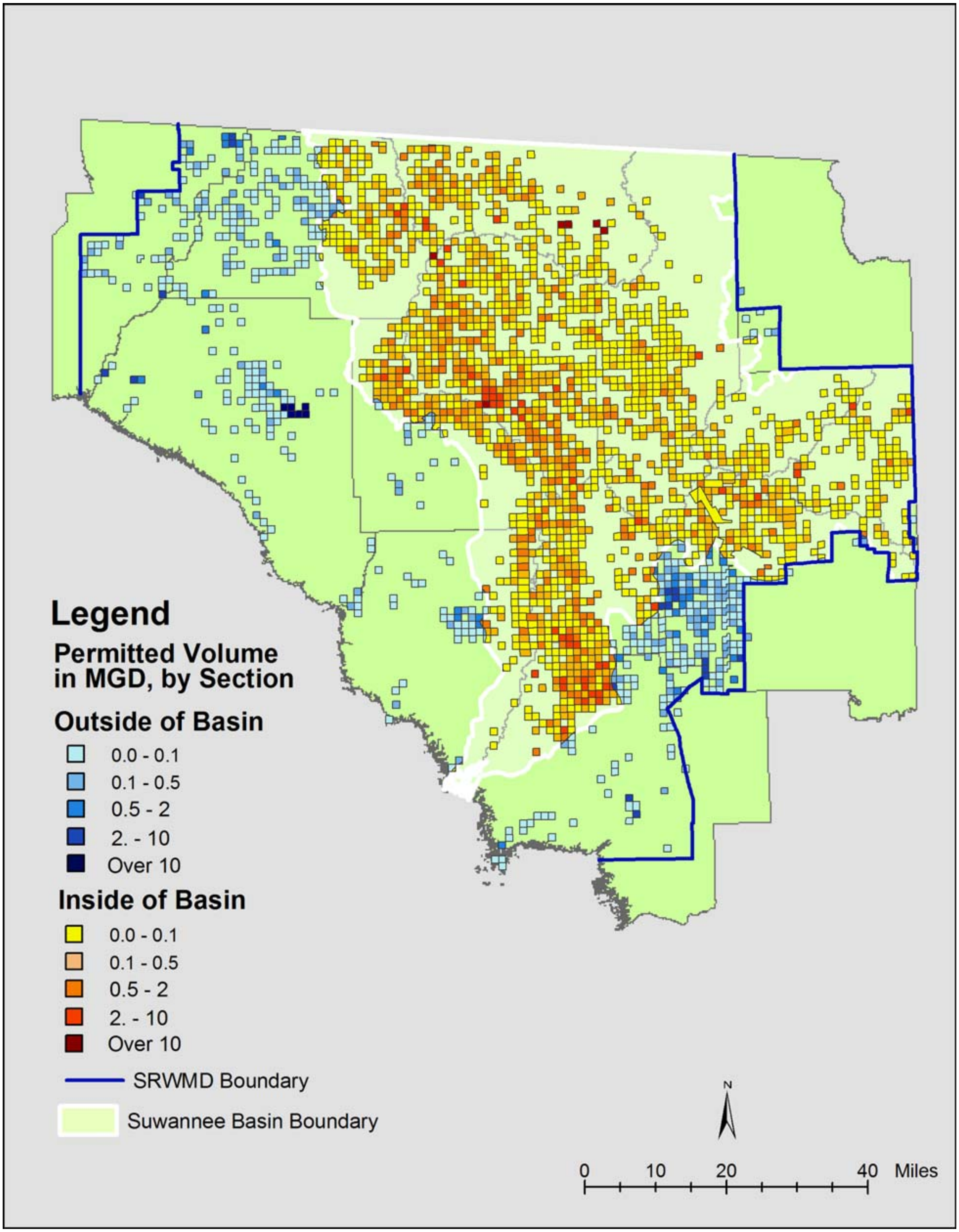

Figure 2-12. Map showing permitted water use patterns in the SRWMD. Each symbol represents the sum of the Average Daily Rate of Withdrawal (ADR) within each 1 mi.^{2} section.

Table 2-3. Land use/land cover conditions in the Florida portion of the Suwannee River basin, based on 1994 NAPP aerial photography (Source: SRWMD data).

CATEGORY	ACRES	%
Residential (all types)	153,324	5.5
Commercial (shopping, office parks, malls, motels, campgrounds, etc.)	6,186	0.2
Industrial	3,296	0.1
Mining	39,278	1.4
Institutional (prisons, military facilities, schools, churches, hospitals, etc.)	4,031	0.1
Recreational (golf courses, race tracks, marinas, parks, etc.)	2,409	0.1
Other developed uses (land being developed, cleared land in urban areas)	22,992	0.8
Agriculture (pasture and row crops)	584,754	20.9
Agriculture (groves)	4,751	0.2
Agriculture-other (dairy, poultry, hogs, nurseries, aquaculture, etc.)	21,408	0.8
Non-forested uplands (shrubland, coastal scrub, etc.)	32,106	1.1
Forested uplands	426,120	15.2
Managed pine forests	1,001,541	35.8
Streams and lakes	33,017	1.2
Artificial waterbodies (dug ponds, flooded rock pits, etc.)	5,822	0.2
Forested wetlands	420,265	15.0
Herbaceous wetlands	16,870	0.6
Disturbed lands	670	<0.1
Infrastructure (airports, powerline corridors, sewer and water treatment facilities, roads)	21,267	0.8

Table 2-4. Summary of current and projected water use in SRWMD (Sources: SRWMD data; WRA 2005).

Water Use Category	Existing (2000)	Projected (2020)	Projected (2050)
Public supply (utilities)	15.8 mgd	25.2 mgd	40.5 mgd
Domestic (self-supplied)	15.4	25.4	41.2
Commercial/Industrial**	190.1	311.7	505
Agriculture	91.1	182.2	305
Recreation	1.5	2.3	3.6
TOTAL	314 mgd	546.8 mgd	895.2 mgd

** - includes commercial, industrial, mining, and power generation