SEGS Field Trip Guidebook 47

Karst Hydrogeology of Florida's Santa Fe River Basin

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Gainesville, Florida

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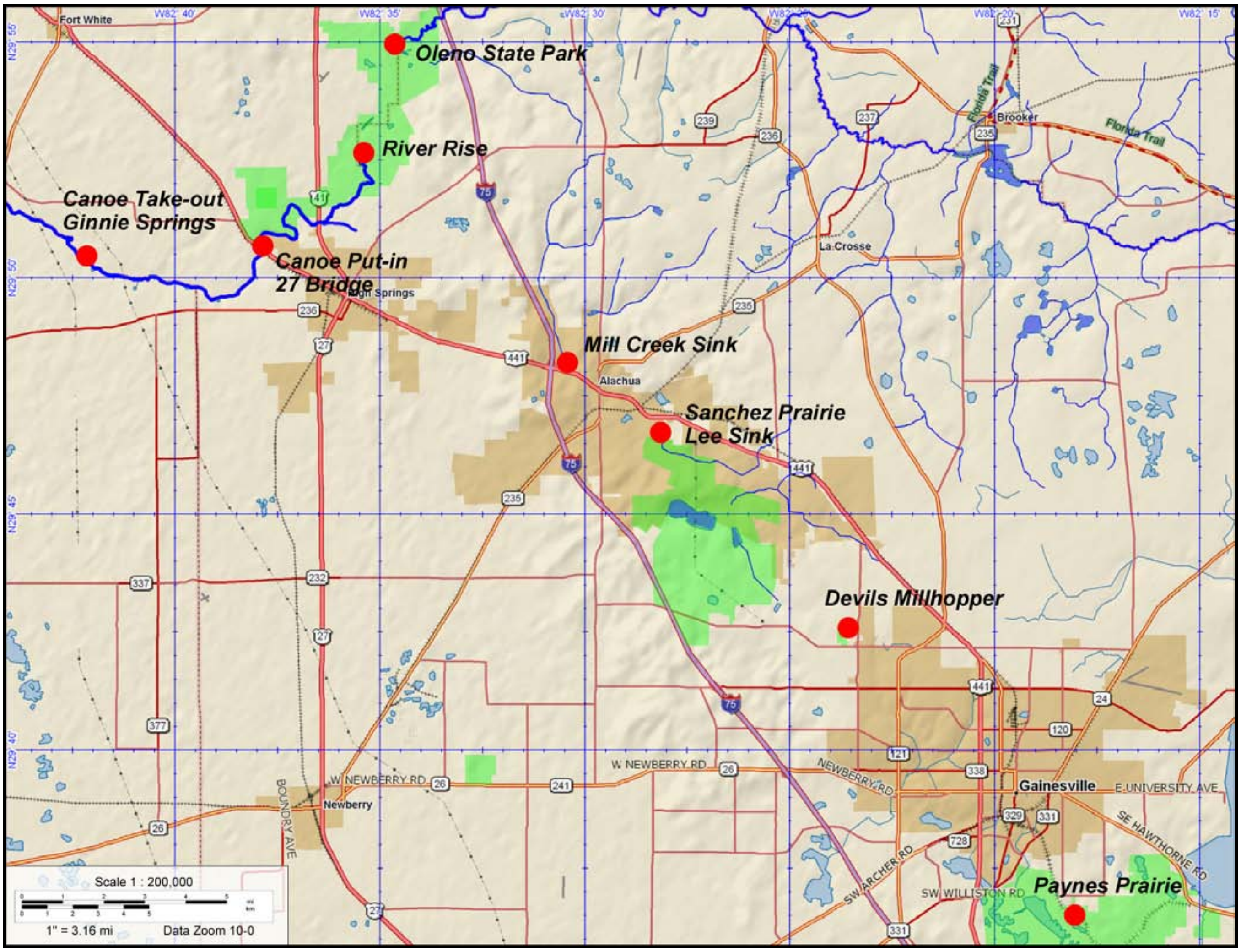
Field Trip Itinerary

Time	Objective / Discussion Topics
0800	Meet in parking lot of the Best Western Gateway Grand Hotel 4200 NW 97th Blvd, Gainesville, Florida
0800 - 0815	Vans will leave for 1st stop: Payne's Prairie State Park, Gainesville
0815 – 0900	Payne's Prairie State Park: Florida's geologic layers, aquifer recharge, the Hawthorn confining unit, and the disappearance of Alachua Lake
0900 – 0915	Drive to Devil's Millhopper State Geological Park
0915 – 1000	Devil's Millhopper State Geological Park: Sinkhole formation and examples of the three key geologic layers in north-central Florida
1000 – 1020	Drive to O'leno State Park (HWY 441 north of High Springs)
1020 – 1145	O'leno State Park: Hiking tour to O'leno Sink and intervening sinks between O'leno & the River Rise / Disappearing streams & rivers, sinkhole formation
1145 – 1215	Lunch at O'leno State Park (box lunches provided)
1215 – 1230	Drive to Santa Fe River Rise
1230 – 1300	Santa Fe River Rise: Cave exploration at the River Rise, problems with mapping groundwater flow paths in karst
1300 – 1315	Drive to Canoe Launch (HWY 441 Bridge on Santa Fe River)
1315 – 1800	Canoe trip with stops at: Lilly, Poe, Blue, Devil's Ear, and Ginnie Springs
1800 – 1830	Take out canoes and return to Vans at HWY 27 Bridge
1830 – 1900	Vans will return to the Best Western Gateway Grand

Dress Suggestions:

- *Shorts or pants depending on the season*
- *Light weight shirt and jacket depending on the season, comfortable walking shoes*
- *Swimming suit, mask, towel, sun screen*
- *Just in Case …*
    - *Rain jacket*
    - *Extra set of dry clothes for the drive home*

Orientation Map



<u>Potential Field Trip Stops</u>

1) *Paynes Prairie*
2) *Devil's Millhopper*
3) *Sanchez Prairie – Lee Sink*
4) *Mill Creek Sink & Cave System*
5) *O'leno State Park (Lunch)*
6) *Santa Fe River Rise*
7) *Canoe put-in (HWY 27 Bridge)*
8) *Canoe take-out (Ginnie Springs)*

Introduction

What Makes the Santa Fe River Basin Special?

The Santa Fe River Basin (SFRB) occupies approximately 3,500 km^2 of north central Florida and is a major tributary basin of the Suwannee River. The basin is made hydrogeologically interesting by the fact that it has been extensively karstified, spans part of a transition zone between confined and unconfined regions of the Floridan aquifer system, and contains numerous opportunities to observe and study the effect of karstification and confinement on groundwater / surface water exchange. More generally however, the SFRB is a unique and, many would say, "special" place because of the number of often crystal clear springs that discharge along its western reach between the River Rise and the confluence with the Suwannee River.

The Santa Fe River (SFR) generally flows from east to west. It originates in Northern and Central Highlands of the eastern part of the basin where the Floridan aquifer system is confined and overlain by clay and limestone sediments of the Hawthorn Group that create an intermediate aquifer system and upper confining unit, and variably thick sands that create a discontinuous surficial aquifer system. From there, it flows onto the Gulf Coastal Lowlands where the Floridan aquifer system is unconfined and either exposed at the land surface or overlain only by variably thick sands. Evidence of karstification becomes significantly more apparent in the transition zone, where the SFR and all of the River's mapped tributaries disappear underground, and in the western section of the basin, which contains several resurgences including that of the SFR, numerous springs and sinkholes, many dry and saturated (underwater) caves, and a marked decrease in overland drainage. Within this one basin, it is therefore possible to observe numerous examples of karstic controls on groundwater flow and recharge and how the localization of the karst features is effected by the presence, thickness, and integrity of the Hawthorn semi-confining layer.

Problems confronting the Basin

Like most of Florida, the SFRB is experiencing environmental problems associated with land use changes and population growth. The area that, until recently, was occupied by relatively disperse low-intensity agriculture and rural populations, is becoming increasingly urbanized, encroached upon by suburban sprawl from Gainesville, and increasingly utilized for higher-intensity agricultural operations including confined animal feeding operations (CAFOs). One result of these land-use changes has been increased nutrient loading in groundwater and surface waters that correlates to increased algae and decreased water clarity in the once crystal-clear SFR springs. Contributions from agriculture are particularly exacerbated because the Department of Environmental Protection (DEP) has limited jurisdiction over agricultural operations. The DEP has therefore encouraged landowners to implement "Best Management Practices" (BMPs) that are designed to reduce nutrient loading to groundwater through a voluntary approach.

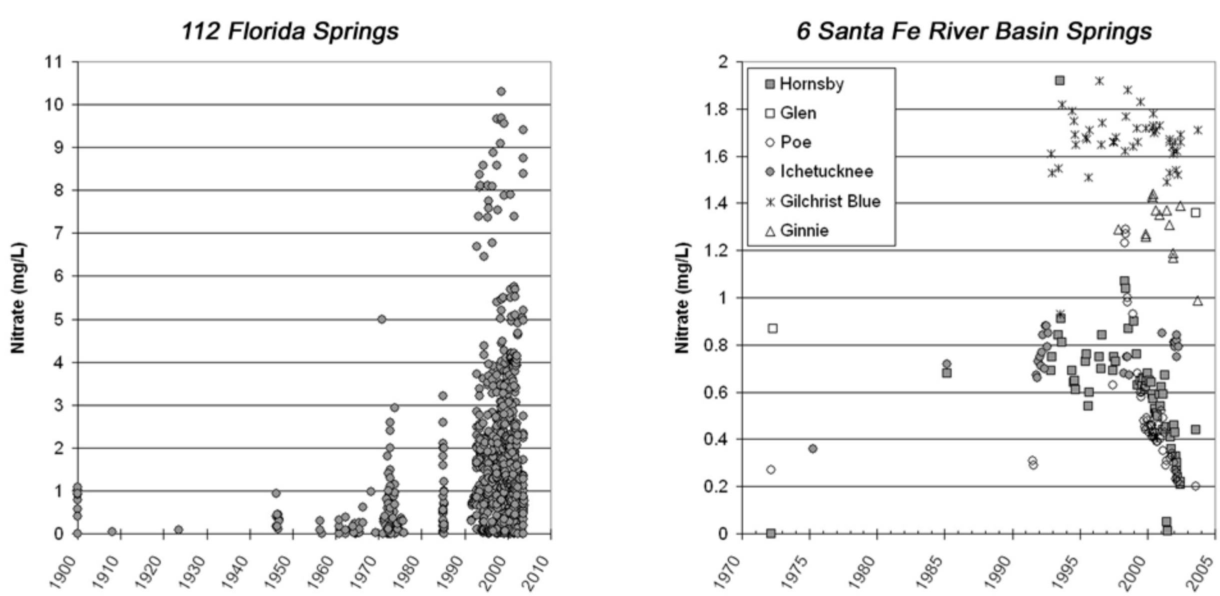


Figure 1. Nitrate concentrations in Florida springs. Data compiled by Strong (2004).

In addition to the water quality impacts, population growth, intensified agricultural activities, and a growing water bottling industry are placing increasing demands on groundwater supplies. All of these users withdraw water from the basin's water budget much like one withdraws money from a bank account. If the rate of withdrawal exceeds the rate of replenishment then the account will be diminished and some or all users will suffer shortages. In this light, the springs can be thought of as simply one of the user groups that withdraw water from the aquifer to create their flows.

If we broaden the concept of the "basin" to include the region contributing all water (surface water and groundwater) to the SFR, then the total available water to all users is the amount of rainfall in the basin minus the amount that evaporates back into the atmosphere. Some of this water flows overland into the creeks, streams, and rivers that drain into the SFR and some of it infiltrates through the ground to provide recharge to the Floridan aquifer system from which the springs receive their water. Ultimately all of the water flows to the SFR, which empties into the Suwannee River and leaves the basin. This process is described as the hydrologic cycle, which reflects the fact that the total available water is that which is constantly flowing from input as rainfall to output as river discharge.

All of the springs in the basin collectively collect and discharge the majority of the groundwater flow into the SFR. Because of this, any groundwater extractions in the basin will reduce the spring flows by an amount essentially equal to the total withdrawal minus any water that is returned to aquifer. For instance, extractions for public and private water supplies return water to the system through sewage and septic discharges. Agricultural extractions return water to the system via irrigation that is not utilized by the crops. Though both of these returns present problems for water quality management, their returns significantly reduce the impact of the usage on groundwater supplies and thus spring flows. The fundamental problem therefore lies in knowing the available water budget, how much each usage extracts from the system, and how much it returns. Currently, we have a very poor understanding of any of those three variables despite exponential increases in demand.

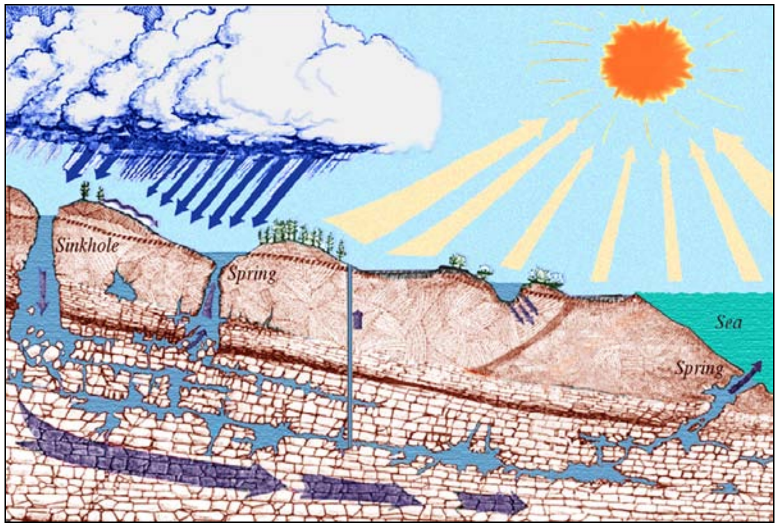


Figure 2. Hydrologic cycle in a hypothetical karst setting such as the Santa Fe and Suwannee River Basins.

Purpose

The purpose of this field trip and field guide is primarily to elevate public awareness of the significant hydrologic features in the SFRB and their vulnerability to contamination and water level decline associated with irresponsible development within the basin boundaries. This guide is designed to provide an overview of the hydrogeologic setting in which the SFRB is located and the key features that control groundwater / surface water interactions and groundwater flow patterns. Particular focus is directed on the western section of the SFRB between O'leno Sink and Ginnie Springs and the transition zone between that region and the eastern part of the basin where the Floridan aquifer system is confined or partially confined by the Hawthorn Group. Special focus on these regions stems from the density of springs and siphons along that section of the river, and the effect of the confining layer on aquifer recharge and groundwater / surface water exchange. Not all of the features and locations described in the guide will be visited on the field trip but maps and references are provided at the end of the document to direct interested readers to more in-depth discussions of the region and its hydrologic processes and to some of the significant features that cannot be visited due to time constraints.

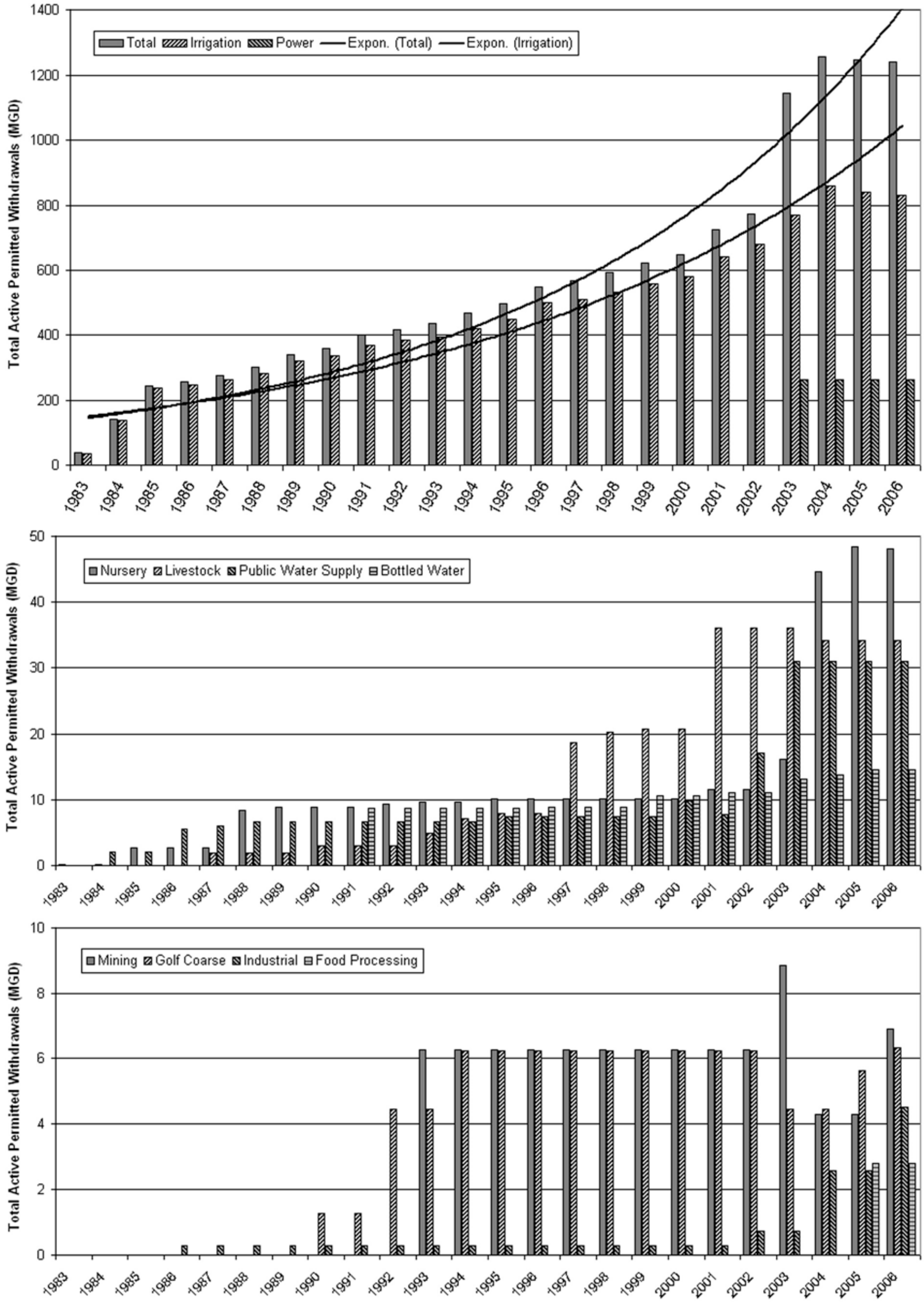


Figure 3. Groundwater usage in the Santa Fe River Basin between 1983 and 2006 compiled from data provided by the Suwannee River Water Management District.

Hydrogeologic Setting

Floridan Aquifer System

The Floridan aquifer system is aerially extensive underlying all of Florida, nearly half of Georgia and South Carolina, and part of Alabama and is regarded as one of the most productive aquifers in the United States. In the SFRB, the Floridan aquifer system consists of several hundred meters of limestone and dolostone but only the upper 100 - 250 m yield potable water (Hunn and Slack, 1983). The stratigraphic units constituting the upper part of the aquifer are, from oldest to youngest, the: Eocene Ocala Limestone, the Oligocene Suwannee Limestone, and the limestones at the base of the Miocene Hawthorn Group (Figure 4). The Hawthorn Group is significant to the hydrogeology because, where present (in the eastern part of the SFRB), thick sequences of clay form a confining layer that inhibits recharge except where it is breached by sinkholes or fractures. Variably thick carbonate lenses interbedded within the clays create a moderately productive intermediate aquifer that can provide adequate private water supplies (Hunn and Slack, 1983). Variably thick surficial sediments cap the sequence throughout most of the basin and are sufficiently thick in the eastern part of the basin to create a surficial aquifer. Figures 4 and 5 provide a stratigraphic sequence and geologic cross-section that mark the relationship of these units in the SFRB.

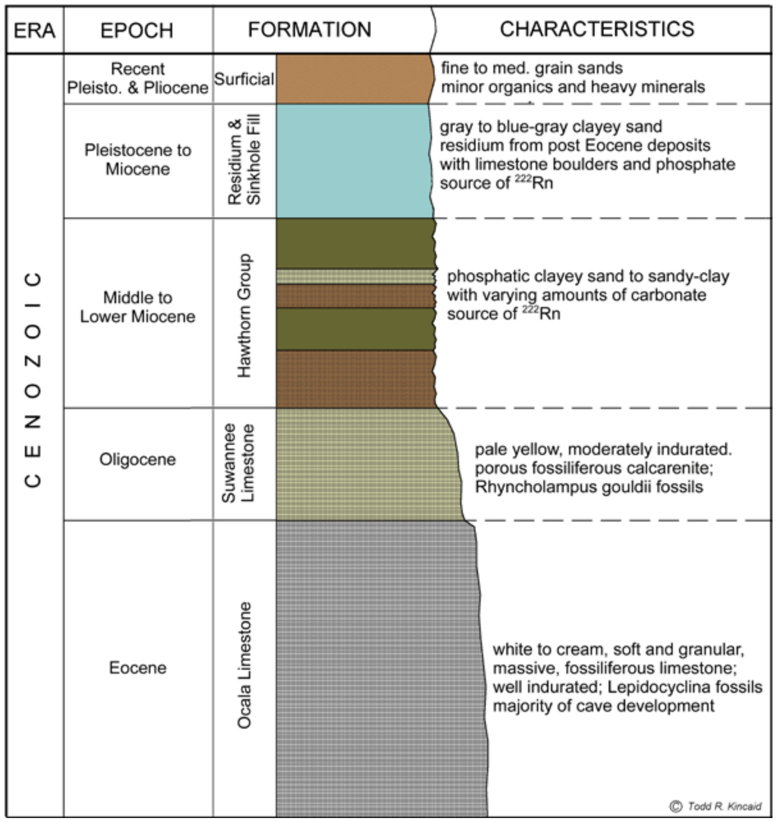


Figure 4. Stratigraphic sequence underlying the Santa Fe River Basin, north-central Florida.

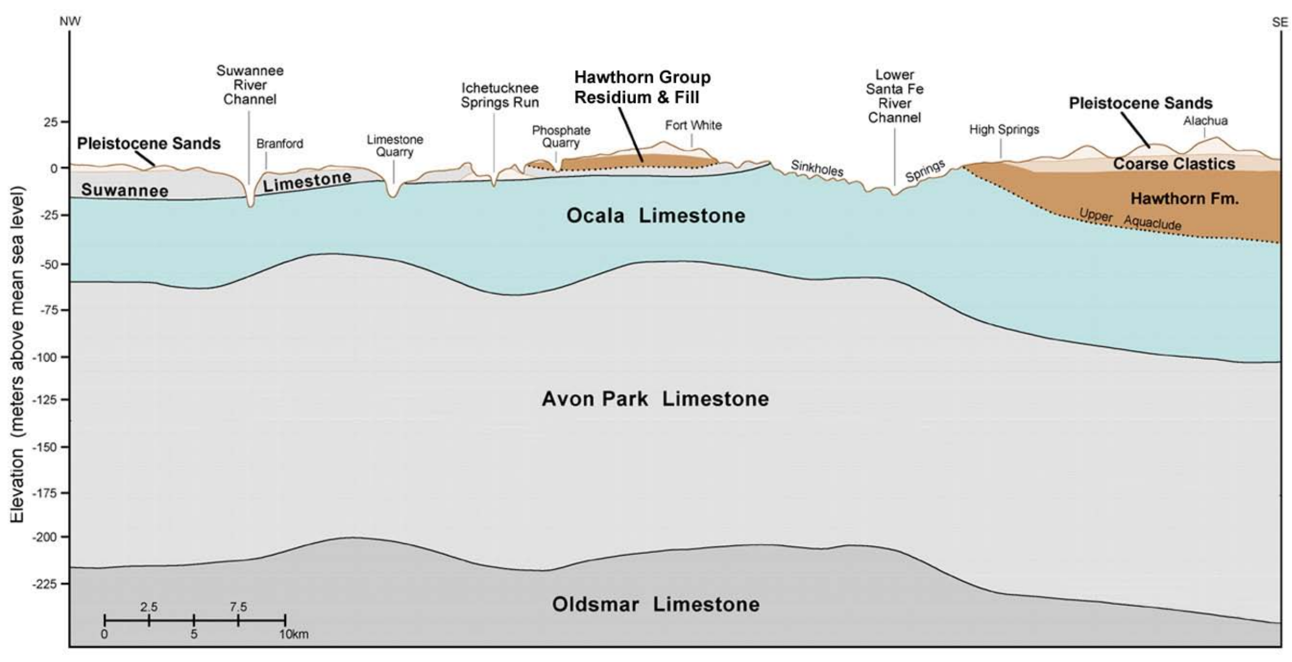


Figure 5. Geologic cross-section across the Santa Fe River Basin from northwest to southweast.

The Hawthorn Group is thought to have once covered much of the Florida platform (Scott, 1988) but has been eroded off from the west leaving a fairly pronounced topographic scarp along the present-day western margin. The eastern side of the margin is characterized as highlands (the Northern Highlands) with topographic elevations that range from 45 – 60 m. By contrast, the western side of the margin is characterized as lowlands (the Gulf Coastal Lowlands) with topographic elevations averaging about 15 m or less. From a hydrogeologic perspective, the margin itself is a transition zone that separates confined and unconfined regions of the Floridan aquifer system. The position of the margin and the thickness of the clay sediments behind it create one of the most important variables controlling aquifer vulnerability because of the resulting influence on aquifer recharge.

In the SFRB, the erosional boundary of the Hawthorn Group coincides with the topographically defined Cody Scarp (Puri and Vernon, 1964; White, 1970; Crane, 1986), which has given rise to an association between the Cody Scarp and the hydrogeologic transition zone. That correlation does not hold however in other parts of Florida because the Cody Scarp was defined on a purely topographic rather than a geologic or hydrogeologic basis. In some regions, such as the Woodville Karst Plain, that association has led to significant confusion regarding the variables controlling aquifer vulnerability.

The Floridan aquifer system is highly productive as is demonstrated by more than 300 springs that discharge an average of 360 m^3/sec to Florida's major rivers (Fernald and Patton, 1984). Of the 78 largest springs on the North American continent, 27 discharge more than 272 m^3/sec from the Floridan aquifer system (Lane, 1986). Within the SFRB, spring discharges reach as much as 10 m^3/sec (Scott et al, 2004; SWRMD, 1998), pumping tests have revealed transmissivities that range from 3,000 - 50, 000 m^2/day, and well yields range between 0.1 – 0.3 m^3/sec (Hunn and Slack, 1983).

Karstification

Karstification is ubiquitous in the limestones that comprise the Floridan aquifer system wherein sinkholes, such as the famous Winter Park sinkhole in central Florida are the most common surface expressions. Many of these sinkholes have at least partially filled with water and constitute most of the over 7,700 freshwater lakes in Florida that are larger than 40,000 m^2 (Spangler, 1981). In terms of hydrogeology, karstification becomes significantly more pervasive and exerts a stronger control on groundwater flow patterns throughout the unconfined section of the aquifer that arcs from the Gulf Coast near Tampa up through the peninsula and terminates in the panhandle near Tallahassee. The region is termed the "*karst belt*" of Florida (Figure 6) because pervasive sinkholes and caves characterize the region.

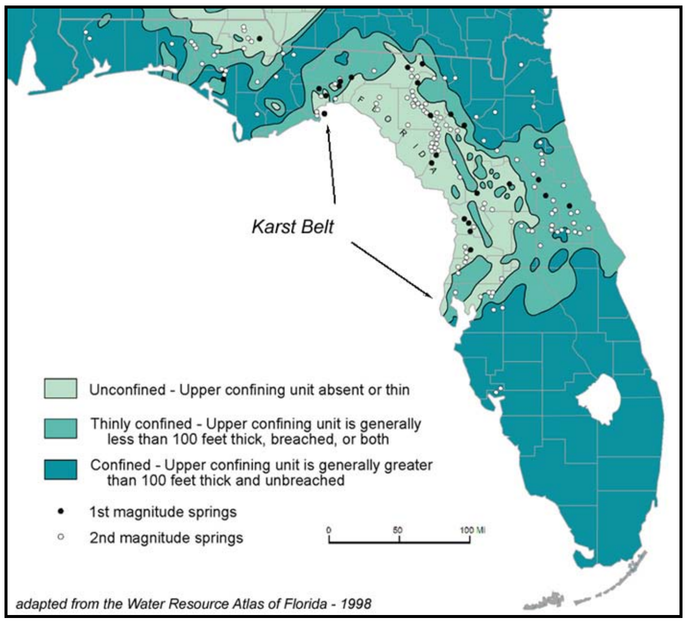


Figure 6. Distribution of confining layers over the Floridan aquifer and the location of 1st and 2nd magnitude springs.

Sinkholes, swallets, springs, dry caves, and underwater caves are all common in the western part of the SFRB but become progressively less common moving east across the transition zone into the confined section of the aquifer. Map 1 (attached) shows the locations of springs, swallets, and underwater caves relative to the position of confining layer within the SFRB.

Dry caves such as those found in Florida Caverns State Park in Marianna, Florida are exposed in regions where the limestones and dolostones are unsaturated and facilitate infiltration to the water table. Warren Cave and Bat Cave are two of the most well known dry caves in the SFRB. Much more significant are the regionally extensive cave systems that occur in the limestones beneath the water table. These saturated cave systems are of particular hydrogeologic interest because they collect and transmit large quantities of water to springs in Florida's major rivers such as the Suwannee, St. Johns, Santa Fe, Oklawaha, and Withlacoochee. All of the 27 first magnitude springs (discharge >= 2.8 m^3/sec) in Florida discharge from saturated cave systems. The ground water discharge from these springs is, in each case, between one and three orders of magnitude greater than the largest well yields. The distribution and magnitude of these spring discharges demonstrate that saturated karst conduits provide the major ground water flow pathways in the

Floridan aquifer system. Devil's Ear, Old Bellamy, Horsby, Ginnie and Blue Hole are the most well known saturated caves in the basin.

Sinkholes and swallets provide point sources of aquifer recharge where swallets are typically sinkholes that receive all or part of a stream's flow and direct it into saturated caves or smaller saturated conduits. Sinkholes distant from streams are not necessarily connected to caves or conduits, which can be seen by evaluating water temperatures in the sinkholes during cold winter periods. Those that are readily connected to conduits will contain water at or near the regional groundwater temperature (~21°C) whereas those that are not will contain significantly colder water. Though they receive rainfall and sheet-flow during floods, not all sinkholes therefore provide point sources of elevated recharge and the overall distribution of sinkholes is not necessarily demonstrative of underlying conduit formation or trends.

Recharge

Aquifer recharge in the SFRB occurs through diffusive infiltration through the sediments covering the limestones that comprise the aquifer and through swallets that deliver runoff and stream flow directly into the aquifer. As such, the swallets are points where the aquifer is extremely vulnerable to contamination. Swallet-spring connections are most readily marked by tea-colored discharge during high flow periods. Inflow rates through the swallets are determined by the size of the connecting conduits and can be inferred by the magnitude of water level fluctuations in the swallet basins and their drainage rates. Table 1 provides a list of the major swallets in the basin and an estimate of their drainage area and inflow rates.

Table 1. Major swallets in the Santa Fe River Basin.

Swallet	Drainage Area (km^2)	Inflow Rate (m^3/sec)
Rose Creek Complex		
Alligator Lake	24	0.8
Rose Sink	70	2.8
Clay Hole Sinks	67	2.8
San Felasco Complex		
Mill Sink	36	2.8
Lee Sink		0.4
Burnetts Lake	28	0.6
Turkey Creek	32	0.4
Blues Creek	20	0.4

Discharge

Springs constitute the primary form and locations of groundwater discharge in the SFRB. Table 2 lists all springs in the basin documented by the Suwannee River Water Management District along with their location and maximum recorded discharge. Note that there are nine springs that rank as first magnitude (discharge > 2.8 m^3/sec). In order to use the flow data to determine the groundwater budget however, the challenge is to determine for each spring how much of the flow is attributable to groundwater flow and how much is attributable to swallet recharge. That remains an important task to tackle.

Table 2. Springs in the Santa Fe River Basin documented by the Suwannee River Water Management District.

Spring	County	Lat (DD)	Lon (DD)	Flow (m3/sec)	Spring	County	Lat (DD)	Lon (DD)	Flow (m3/sec)
Santa Fe Rise	Columbia	29.8739	82.5916	12.52	COL1012971	Columbia	29.8569	82.7300	0.42
ALA112971	Alachua	29.8547	82.6029	11.50	GIL729971	Gilchrist	29.8894	82.8750	0.38
GIL1012973	Gilchrist	29.8562	82.7329	10.48	COL930971	Columbia	29.8312	82.6567	0.38
Hornsby	Alachua	29.8504	82.5932	9.97	Pickard	Gilchrist	29.8305	82.6621	0.33
Columbia	Columbia	29.8541	82.6120	8.66	COL1012972	Columbia	29.8565	82.7317	0.29
Devil's Ear	Gilchrist	29.8353	82.6966	5.85	COL101974	Columbia	29.8340	82.6767	0.28
COL61981	Columbia	29.9344	82.5306	4.25	Grassy Hole	Columbia	29.9681	82.7598	0.28
July	Columbia	29.8362	82.6964	3.31	COL917971	Columbia	29.9248	82.7720	0.27
Blue Hole	Columbia	29.9805	82.7584	3.01	Trail	Gilchrist	29.8984	82.8667	0.27
Mission	Columbia	29.9762	82.7579	2.40	GIL101971	Gilchrist	29.8323	82.6784	0.23
Gilchrist Blue	Gilchrist	29.8299	82.6829	2.26	GIL1012972	Gilchrist	29.8560	82.7327	0.23
ALA930972	Alachua	29.8447	82.6309	1.98	GIL99972	Gilchrist	29.9309	82.8024	0.20
GIL1012974	Gilchrist	29.8645	82.7401	1.98	Sawdust	Columbia	29.8400	82.7035	0.19
Rum Island	Columbia	29.8335	82.6798	1.72	COL101972	Columbia	29.8336	82.6753	0.17
Devil's Eye	Suwannee	29.8352	82.6966	1.70	Deer	Gilchrist	29.8412	82.7073	0.14
Ginnie	Gilchrist	29.8363	82.7001	1.65	GIL99974	Gilchrist	29.9186	82.7717	0.14
Poe	Alachua	29.8257	82.6490	1.43	COL928971	Columbia	29.8862	82.7515	0.14
Sunbeam	Columbia	29.9281	82.7698	1.29	Jamison	Columbia	29.9258	82.7701	0.12

Spring	County	Lat (DD)	Lon (DD)	Flow (m^3/sec)	Spring	County	Lat (DD)	Lon (DD)	Flow (m^3/sec)
Ichetuckenee	Columbia	29.9842	82.7619	1.20	SUW917971	Suwannee	29.9324	82.8008	0.08
Devil's Eye	Gilchrist	29.8352	82.6966	1.17	Coffee	Suwannee	29.9595	82.7753	0.08
Lilly	Gilchrist	29.8297	82.6612	1.12	COL101971	Columbia	29.8322	82.6694	0.07
Wilson	Columbia	29.9001	82.7585	1.10	Betty	Suwannee	29.9148	82.8400	0.07
GIL107971	Gilchrist	29.8910	82.8742	0.85	COL428981	Columbia	29.8535	82.6055	0.07
GIL107972	Gilchrist	29.8990	82.8663	0.85	Little Devil	Gilchrist	29.8346	82.6970	0.06
COL428982	Columbia	29.8273	82.6460	0.71	GIL917971	Gilchrist	29.9114	82.8424	0.05
Mill Pond	Columbia	29.9667	82.7600	0.65	GIL928971	Gilchrist	29.8756	82.7519	0.03
Dogwood	Gilchrist	29.8381	82.7018	0.58	Oasis	Gilchrist	29.9258	82.7804	0.03
ALA930971	Alachua	29.8279	82.6408	0.57	COL61982	Columbia	29.9383	82.5304	0.03
GIL1012971	Gilchrist	29.8559	82.7322	0.57	GIL928972	Gilchrist	29.8805	82.7533	0.02
SUW107971	Suwannee	29.9129	82.8452	0.57	COL101975	Columbia	29.8338	82.6782	0.02
Twin	Gilchrist	29.8400	82.7058	0.55	GIL99971	Gilchrist	29.9213	82.8241	0.01
COL928972	Columbia	29.8578	82.7339	0.49	GIL729973	Gilchrist	29.9134	82.8367	0.01
Cedar Head	Columbia	29.9833	82.7587	0.47	GIL729972	Gilchrist	29.9128	82.8368	0.01
Darby	Alachua	29.8526	82.6060	0.42	SUW917972	Suwannee	30.0327	83.0135	0.00

Saturated Caves

Saturated caves in the SFRB can be classified by the recharge mechanism responsible for delivering water to the caves. Caves that receive water primarily from the aquifer matrix (autogenic recharge) consistently deliver crystal clear water to the springs at a relatively constant rate. They tend to be smaller in diameter and trend up-gradient into the aquifer from the springs to which they connect in a dendritic or braided pattern. Caves that primarily receive water from sinking streams (allogenic recharge) on the other hand carry water of varying clarity at highly variable flow rates. They tend to be larger in diameter and longer and connect the springs to which they connect to one or more swallets and sinkholes in a dendritic pattern. A third type of system includes caves that have developed parallel or sub-parallel to the Santa Fe River and circulate water between springs and siphons in the river channel. Table 3 lists six of the best known caves in the SFRB that represent each of the three types.

Table 3. Majors caves in the Santa Fe River Basin

Cave	Type	Length (m)
Old Bellamy	Allogenic	15,387
Devil's Ear	River	7,179
Hornsby	Allogenic	5,680
Rose Sink	Allogenic	1,299
Mill Creek	Autogenic	1,115
Ginnie	Autogenic	348

Groundwater / Surface Water Exchange

The Santa Fe River provides one of the best localities in the world to observe and study groundwater / surface water interactions. In this region, the river is actually the top of the Floridan aquifer system, that is, there is no confining layer separating the aquifer from the land surface and the rocks beneath the river are completely saturated. Groundwater and surface water are readily exchanging (aquifer – river – aquifer) along the entire reach of the Santa Fe down to its confluence with the Suwannee River.

Beyond the obvious groundwater inputs at the numerous springs along the trip from HWY 27 to Ginnie Springs, there are also several points where the river looses water to the aquifer via well-developed cave systems. There are two basic mechanisms for the river water intrusion. Where the aquifer is confined or partially confined, rising river stages drive water into the aquifer through the spring vent. (Figure 7, A & B). This is the situation at most of the springs along the Suwannee River.

The second mechanism is active in regions where the aquifer is unconfined and the river forms the top of the aquifer (Figure 7, C & D). In these regions, rising river stage drives river water into the aquifer directly along the river floor causing an increase in spring discharge, albeit dark water. This is the situation at most of the Santa Fe River springs. One place where this is happening is Columbia spring, which is actually a resurgence of river water that sinks approximately 100 yards upstream at a siphon often strong enough to hold a canoe in place.

Another, better known point of exchange is the Devil's Ear cave system (Table 3), which is an anastomosing network of underwater conduits that trend parallel and sub-parallel to the river. The main conduit in the cave system trends east for over 4,500 ft upstream from the entrance at Devil's Ear spring at a depth of approximately 30 m below the water surface. Three springs (July, Devil's Eye, and Devil's Ear) discharge water from the cave to the river that consists of groundwater (autogenic recharge) and recirculated river water. Water clarity in the conduits is typically clear but becomes turbid during higher stages of the river or after flood events. During periods of turbid water discharge at the three springs, cave divers report that clear water enters the main passage from the northern conduits and mixes with turbid water from the southern conduits producing the turbid water discharge visible at the surface. Reverse flow, a common situation at many springs in Florida where spring discharge is reversed and river water flows into a cave system through the spring opening, has never been reported at the Devil's Ear cave system.

Figure 8 is a map of Devil's Ear cave colored to reflect the results of sampling experiments carried out by the author between 1991 and 1993 (Kincaid, 1994; Kincaid, 1998). In short, numerous water samples were collected from points throughout the cave system and measured for Radon gas, which emanates from the rocks that comprise the aquifer but is almost immediately lost to the atmosphere once the water discharges. Water samples with high Radon concentrations are indicative of groundwater from the aquifer whereas water samples with low Radon concentrations are indicative of surface water. Using a two-component mixing model, the measured concentrations were converted to the relative percentages of river water shown on the map.

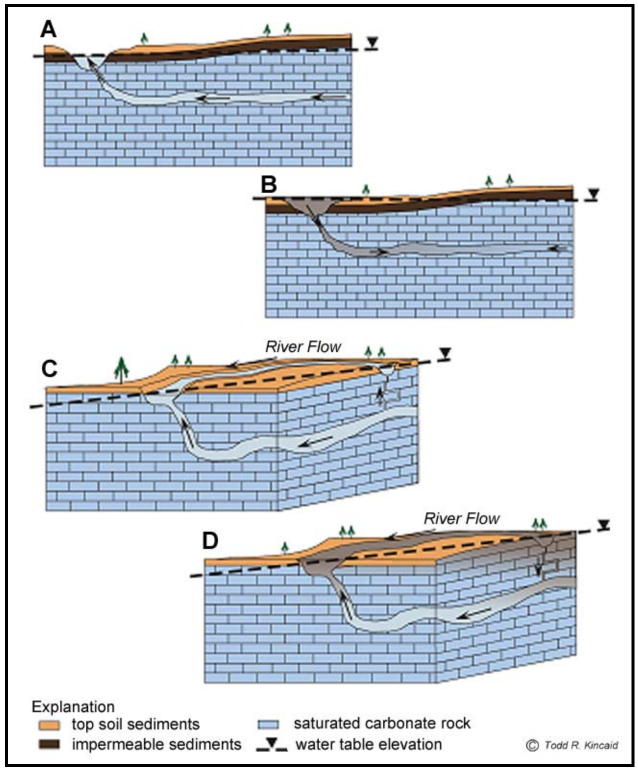


Figure 7. Mechanisms for river water intrusion to spring cave systems in the Santa Fe and Suwannee River Basins.

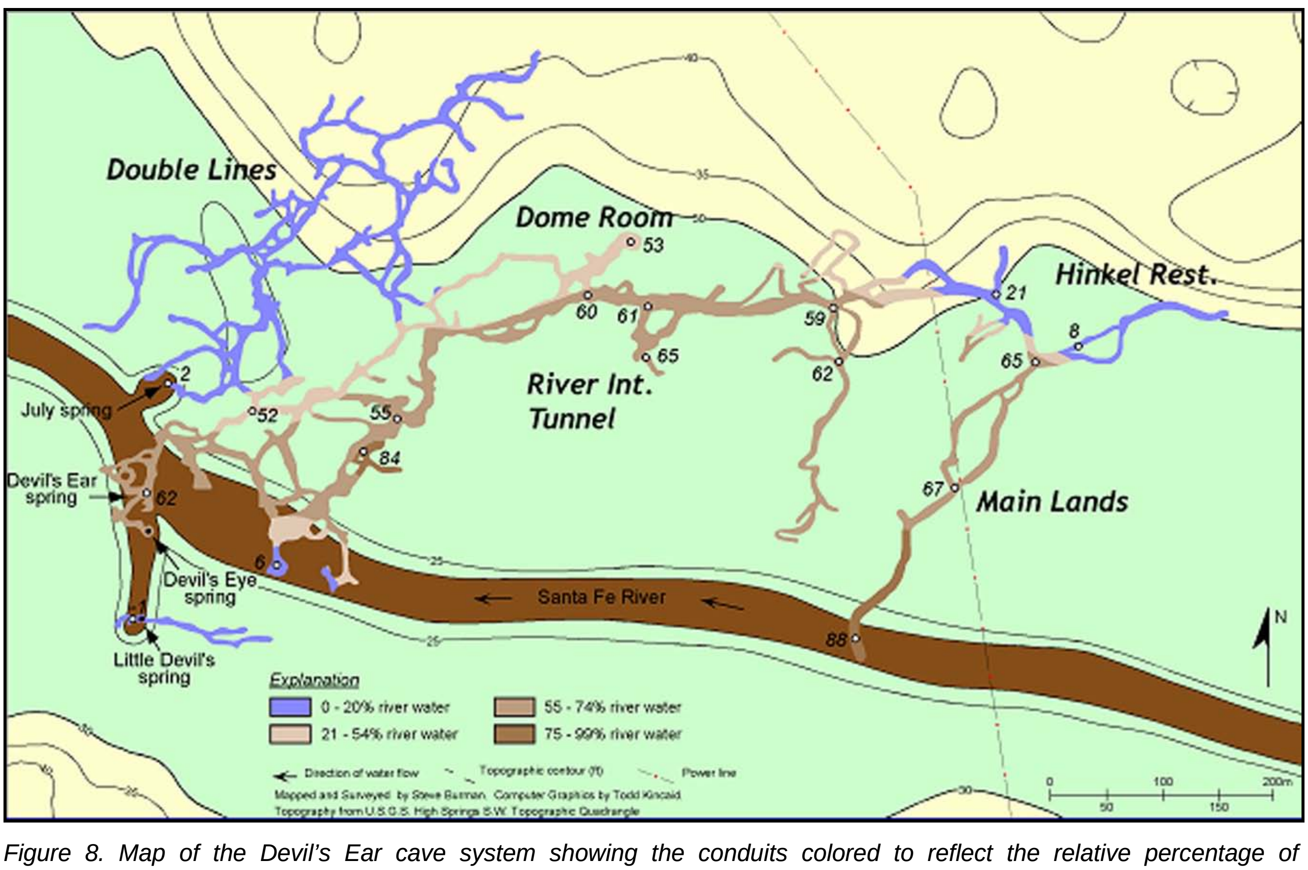


Figure 8. Map of the Devil's Ear cave system showing the conduits colored to reflect the relative percentage of groundwater and recirculated river water flowing toward the springs.

As expected, water samples collected from points directly beneath the river have higher river water percentages than samples collected from the upstream sections of the cave north of the river. However, samples collected during the lower flow stage unexpectedly revealed higher percentages of river water. Comparison to local and regional rainfall data revealed that, rather than being controlled by river stage, the quantity of river water intrusion is controlled by the magnitude and distribution of recharge.

When precipitation is concentrated on the Northern Highlands where the Santa Fe River is not in hydraulic connection with the Floridan aquifer, the water accumulates in the river as overland flow and the flood pulse moves downstream onto the unconfined part of the aquifer. The subsequent increase in river stage produces a downward hydraulic gradient causing large amounts of river water to invade the cave (See A at Right). Observations of water clarity reductions in the cave after large flood events originating in the highlands of the upper SFR reveal that river water intrusion to the aquifer can occur in as little as one or two days.

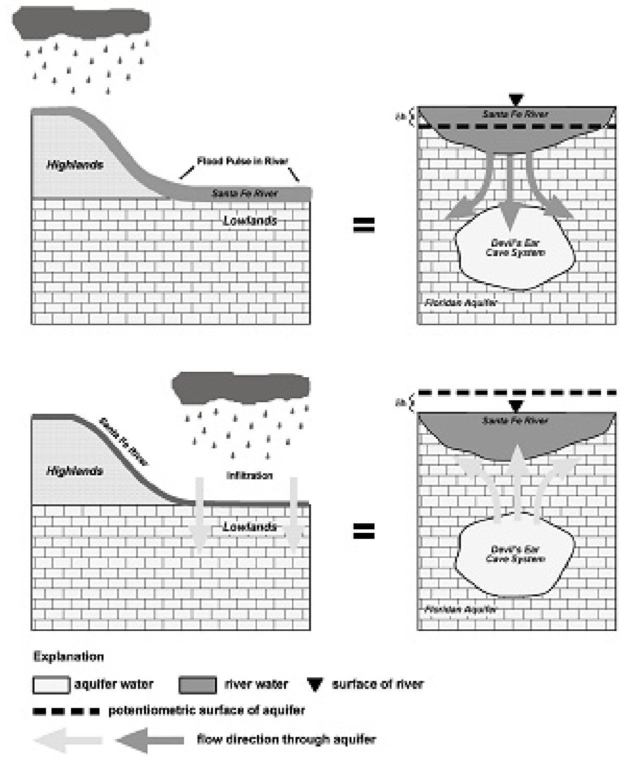


Figure 9. Rainfall mechanisms responsible for river water intrusion to the Devil's Ear cave system.

Conversely, when precipitation is concentrated over the lowland regions where the Floridan aquifer system is unconfined, recharge to the aquifer results from direct infiltration with no resulting flood wave in the river. The hydraulic head in the cave rises above that of the river where a rising river stage is caused only by increased spring discharge. The resulting upward hydraulic gradient results in flow from the cave to the river (See B at Right). The water in the cave will clear as the tannin surface water from the Santa Fe River is flushed up and out through the aquifer.

Selected Field Trip Stop – Paynes Prairie Preserve State Park

Disappearing Lake

Paynes Prairie was once known as Alachua Lake. From 1873 to 1891 Paynes Prairie was a lake centered at Alachua Sink, which funnels water down into the Floridan aquifer system. The sink apparently became plugged and in 1873 there was enough water on the prairie for boats to travel. People became used to the 3 to 5 foot deep lake and even used steamers to haul citrus from Micanopy to Gainesville. Alachua Lake persisted for about eighteen years and then the levels fell, gradually at first and then, finally, the sink (which was deeper than the rest of lake) drained at the rate of 8 feet in only 10 days. Initially, there were great fish fries followed a few days later by a tremendous stench as thousands of stranded fish rotted.

History

Paynes Prairie became Florida's first state preserve in 1971 and is designated as a national natural landmark. This site possesses exceptional values as an illustration of the nation's natural heritage and contributes to a better understanding of the environment. The prairie basin and surrounding uplands have been a center for man's activities in Florida for many centuries. Human occupation dates back to 12,000 BP (Before Present). During the late 1600's, the largest cattle ranch in Spanish Florida operated here. In 1774, William Bartram described the basin as "the Great Alachua Savannah." The Seminole were the native inhabitants and the prairie is thought to have been named after King Payne, a Seminole Chief. Several raids and skirmishes were fought in the vicinity during the Second Seminole War.

In 1871, heavy rains began to flood the basin. By 1873, the flooded marsh was large enough to be considered Alachua Lake. Steam-powered boats traveled across the lake to transport lumber, goods and passengers to landings along the shoreline. In 1891, Alachua sink, the main drain for the basin, became unclogged allowing the water to drain. By 1892, the character of the marsh had returned. In 1903, William Camp began cattle operations on the lush, green grasses of the prairie.

Geology

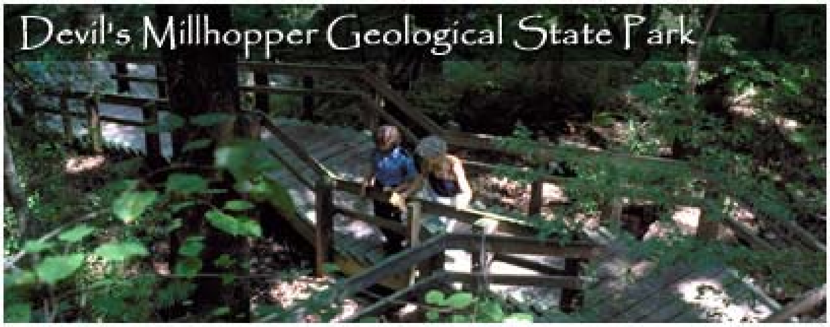
Paynes Prairie can be described as a "Solution basin," being the central and largest of several located in Alachua County. Underground dissolution is responsible for the reduction of the original surface level. It covers an area of eight miles long and varies from one and a half to four miles wide, containing about 12,000 acres. Low divides separate this basin from Kanapaha and other prairies on the west, from Levy, Ledwith, and smaller lakes on the south, and from Newnan's Lake on the northeast.

The principal stream, entering this basin, is a creek flowing from Newnan's Lake that empties into two sinkholes collectively called Alachua Sink. During heavy rains, this stream carries water more rapidly than the sinks can transmit. Under these conditions, the basin fills and temporarily becomes a lake. At times the sinks become completely clogged, and the prairie becomes a lake, often for several years.

Sources

http://www.floridastateparks.org/paynesprairie

Selected Field Trip Stop - Devils Millhopper



Facts

- The sinkhole is about 120 feet deep.
- At the top, the sinkhole is 500 feet across from rim to rim.
- Geologists estimate that the sinkhole collapsed approximately 10,000 to 14,000 years ago.
- There are 236 steps that go down into the Devil's Millhopper.
- Deer Run Creek flows into the Devil's Millhopper and recharges the Floridan aquifer system through fissures in the limerock in the bottom of the sinkhole.
- The reason the Devil's Millhopper does not fill up is because the fissures, or cracks in the limerock at the bottom are large enough to handle the volume of water flowing into the sinkhole. Occasionally, a heavy rainfall will briefly cause a pool to form at the bottom; however, this usually only lasts for a few hours.
- The deepest the pool has been is 35 feet deep, which occurred in February 1998, during a heavy rain event. It took about a week to drain down.

History

Devil's Millhopper gets its unique name from its funnel-like shape. During the 1880's, farmers used to grind grain in gristmills. On the top of the mill was a funnel-shaped container called a "hopper" that held the grain as it was fed into the grinder. Because fossilized bones and teeth from early life forms have been found at the bottom of the sink, legend has it that the millhopper was used to feed bodies to the devil. Hence, Devil's Millhopper.

Geology

All three of the key hydrostratigraphic units are present and visible in the walls of the sinkhole. Discharge from the surficial and intermediate aquifers results in the falling water along the sinkhole walls and demonstrates recharge to the Floridan aquifer system via sinkholes that cut down through the confining layer.

In general, sinkholes such as the Devil's Millhopper form by dissolution of limestones by weak acids in the infiltrating water. Rainwater becomes a weak carbonic acid thru contact with carbon dioxide in the air. As it soaks into the ground, passing through the dead plant material on the surface, the acid becomes even stronger. When this acidic water reaches the limestone layer, small cavities form as the rock is slowly dissolved away. A large cavern is formed as this process continues over a long period of time. Eventually the ceiling of the cavern becomes so thin that it cannot support the weight of the earth above it. When the ceiling collapses, a sinkhole is formed.

Researchers have learned a great deal about Florida's natural history by studying fossil shark teeth, marine shells and the fossilized remains of extinct land animals found in the sink. Map 2 (attached) shows the location of Devils Millhopper relative to the extent of the confining layer and mapped and traced caves.

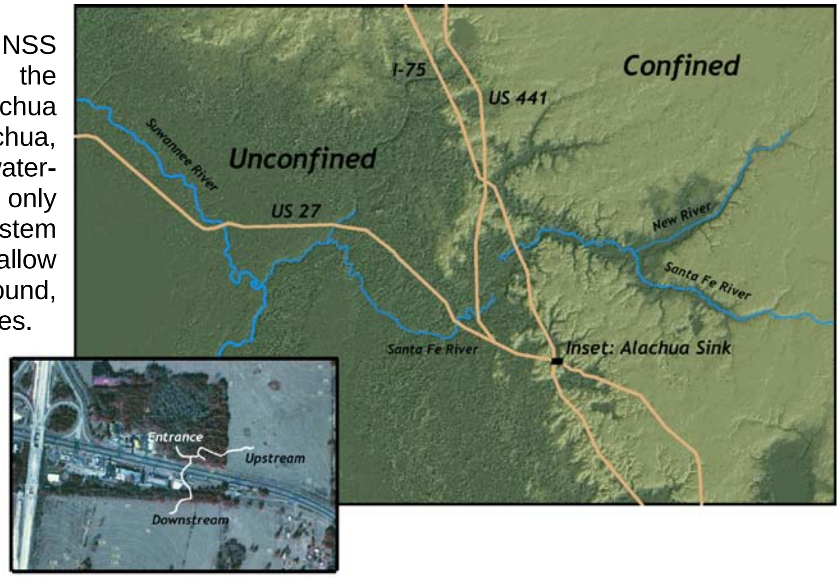
Sources

http://www.floridastateparks.org/devilsmillhopper/history.asp

Selected Field Trip Stop – Mill Creek Sink

<u>Background</u>

In late 1992 and early 1993, the NSS completed negotiations to accept the donation of Mill Creek Sink (aka Alachua Sink), located in the city of Alachua, Florida. Mill Creek is a completely water-filled cave where the sink is the only access point. The surface stream system is dissected by more than 10 swallow holes, which divert water underground, draining a basin of over 70 square miles.



Alachua Sink is managed by the NSS Cave Diving Section. A fence and locked gate is maintained around the sink. Access to the cave is permitted to only the highest qualified cave divers because of the nature and complexity of the underwater cave system. Visitation is permitted for research, data collection, water sampling, and survey/mapping. Training is not allowed.

<u>Geology</u>

Alachua Sink is located along the Cody Scarp, which marks the transition zone between confined and unconfined conditions in the Floridan aquifer system *(See Map Above)*. The Alachua Sink cave system is the up-gradient most extensive underwater cave that has been found in this region. The upstream section leads east toward the highland province under the confining layer. The downstream section trends southwest toward the lowland limestone plateaus where the aquifer is unconfined and tantalizingly close to the Hornsby Spring cave system. Map 2 (attached) shows the location of the Mill Creek cave system relative to the extent of the confining layer and traced conduit flow paths.

<u>Sources</u>

http://www.nsscds.org/divesites.html

Selected Field Trip Stop – O'leno State Park & River Rise

History

From the 1500's through the 1700's, there was a natural bridge area that served as a crossroad between the Santa Fe River Sink and the River Rise. Still in existence today, this is a place where the river disappears underground, and then comes back up several miles away. This natural bridge was traveled by Spanish explorers, Indians and settlers alike.

The famous road of 1824, known as Bellamy Road, was named for its builder, John Bellamy who was a wealthy plantation owner. The road was the first in Florida to be funded by federal money. The Bellamy Road ran from east to west, crossing the St. John's River, going from Pensacola to Tallahassee to St. Augustine.

Geology

O'Leno State Park is located on the banks of the scenic and unique Santa Fe River, a tributary of the Suwannee River. Within O'Leno, the Santa Fe River disappears and flows underground for more than three miles before it rises back to the at the River Rise.

After disappearing underground, tracer tests have shown that the river flows through a series of intervening sinkholes on its path to the River Rise and that the river becomes approximately 40% larger by the time it reaches the Rise due to groundwater flow converging into the rivers underground channel (Hisert, 1994). Map 3 (attached) shows the location of Oleno Sink and the River Rise relative to the Old Bellamy and Hornsby cave systems and some of the springs and siphons along the western Santa Fe River.

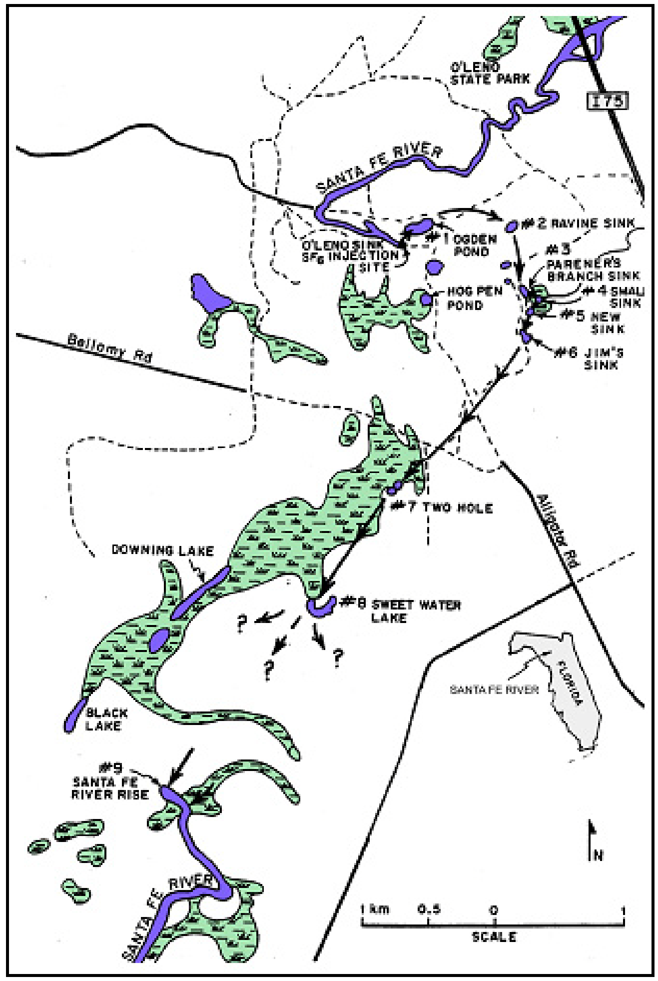


Figure 10 (right). Map of O'leno State Park showing the underground section of the Santa Fe River and the intervening sinkholes through which the river flows.

Sources

http://www.floridastateparks.org/oleno

http://www.abfla.com/parks/Oleno/oleno.html

Selected Field Trip Stop – Santa Fe River HWY27 – Ginnie Springs

Background

For its first eighteen miles, the Santa Fe River is a tiny meandering stream that is not navigable. At Worthington Springs it becomes minimally canoeable for the very determined, and at S.R. 241, just a few miles above O'Leno State Park, it becomes a pleasant stream for even the novice paddler. At O'Leno, the river goes underground in a lazy whirlpool and follows subterranean passageways for some three miles to River Rise State Preserve. When the Santa Fe returns, it is as a generously sized river some 75 to 100 feet wide. From there to the confluence of the Suwannee, the Santa Fe is said to have over three-dozen springs, many of them of the first magnitude.

Trip Description

This section of the river is very popular with canoeists and divers because of the vast array of beautiful springs. The river is occasionally shallow and the occurrence of rocky shoals makes it undesirable for large motorboats. In addition, low swampy terrain makes it unsuitable for housing developments and, for the time being, it is one of the loveliest spots in Florida.

Allen Spring is located on the right bank about one and one-half miles downstream from U.S. 27, and at low-water level, a number of small, unnamed springs may also be seen. Across the river, on the left bank, a quarter of a mile downstream, is Poe Spring. A large spring boil flowing from a horizontal cavern with several smaller boils nearby, this spring forms a circular pool about 90 feet in diameter. It is connected to the river by a 175 foot run. At one time there was commercial development here but no evidence of it remains. It is still a popular swimming and picnicking spot, however. Poe Spring marks the beginning of lowland and swampy areas along the banks that are spotted with small springs.

Lilly Spring is located less than a mile from Poe Spring on the left bank. Jonathan Spring will be on the right bank just before reaching an island in the river. At the end of the island, watch the right bank for Rum Island Spring. The Blue Spring run will be seen entering the river from the left bank. Paddle 500 feet up the run to the spring. This is a privately owned area and canoes are not permitted to paddle over the spring vent. Nearby, in the swamp around Blue Spring are Little Blue Spring, Johnson Spring, and Naked Spring.

Less than three miles down river are July Spring on the right bank and Devil's Eye and Devil's Ear springs on the left. The Devil's Ear cave system is the largest on this part of the river with more than 10,000 feet of underwater passages. Devil's Eye and Devil's Ear are connected with July Spring across the river.

Just a quarter of a mile further is Ginnie Spring, a large oval pool that is 50 feet deep and connects to an extensive cave system with some 1,000 feet of passages, though a grate installed in the cavern that prevents access. The area from July and the Devil springs to below Ginnie Spring is owned by the Ginnie Spring Corporation. There is an extensive private campground, boardwalks, and facilities for swimmers, tubers, scuba divers, and cave divers.

Map 4 (attached) shows the section of the river between HWY 27 and Ginnie Springs and marks the position of most of the features described above.

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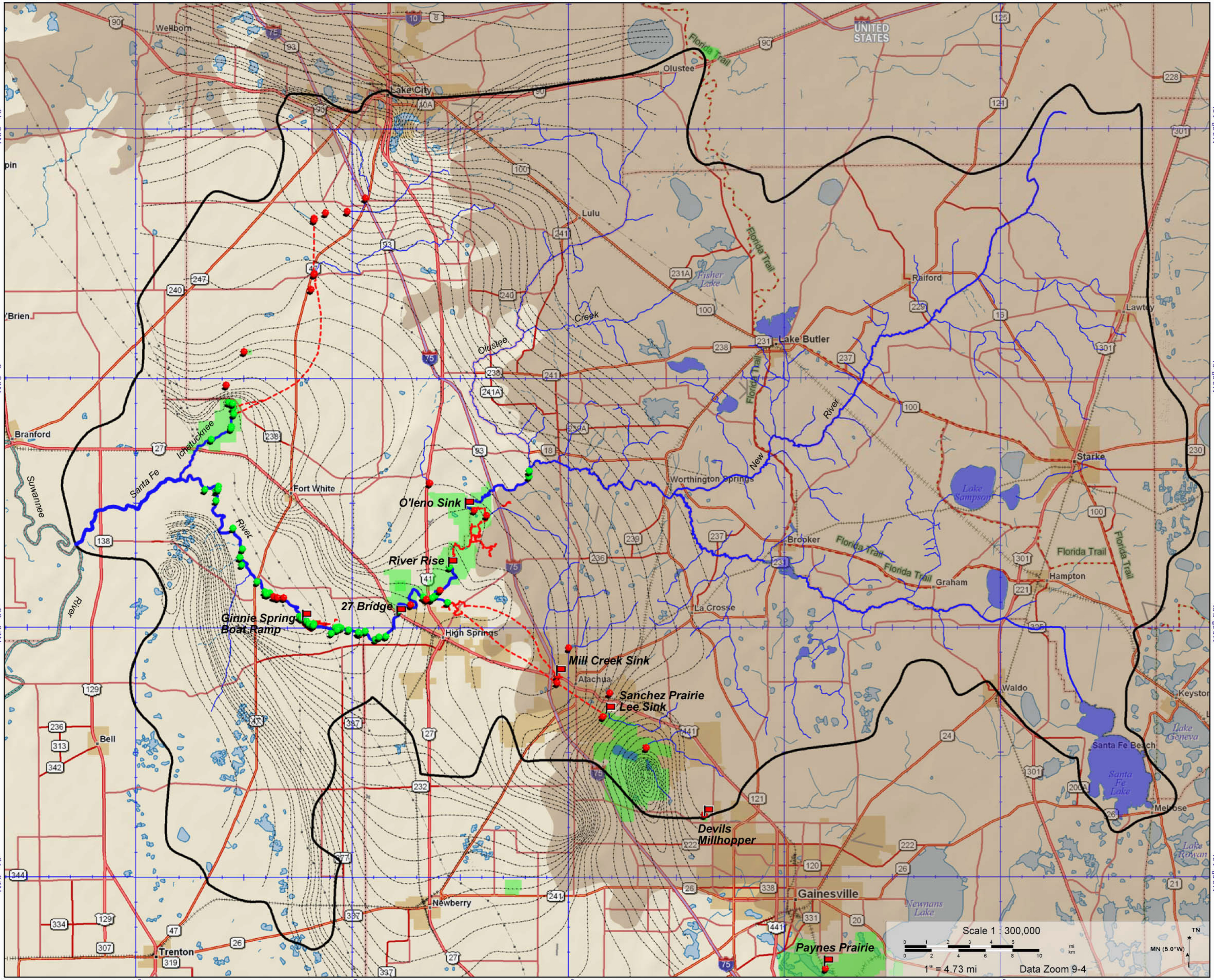
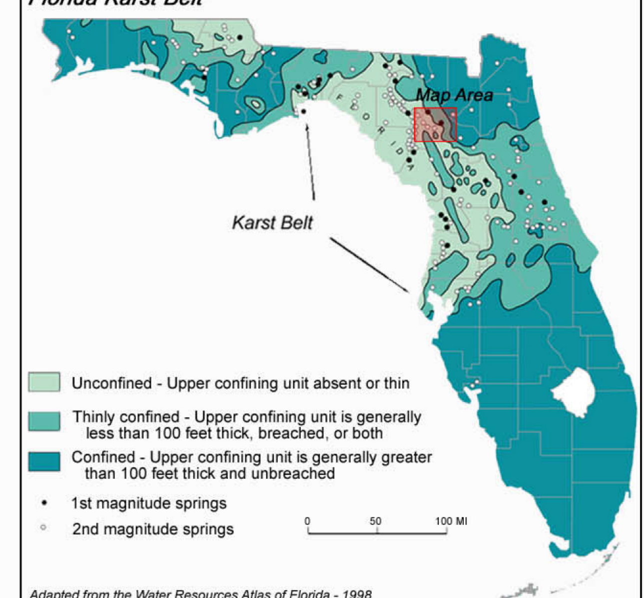


Santa Fe River Basin North-Central Florida

Explanation

- possible field trip stop
- spring
- swallet (sinking stream)
- estimated floridan aquifer water table - 2005
- approximate Santa Fe River Basin boundaries
- traced conduit flow path
- mapped underwater cave
- incorporated area
- state parks
- confined region
- unconfined region

Florida Karst Belt

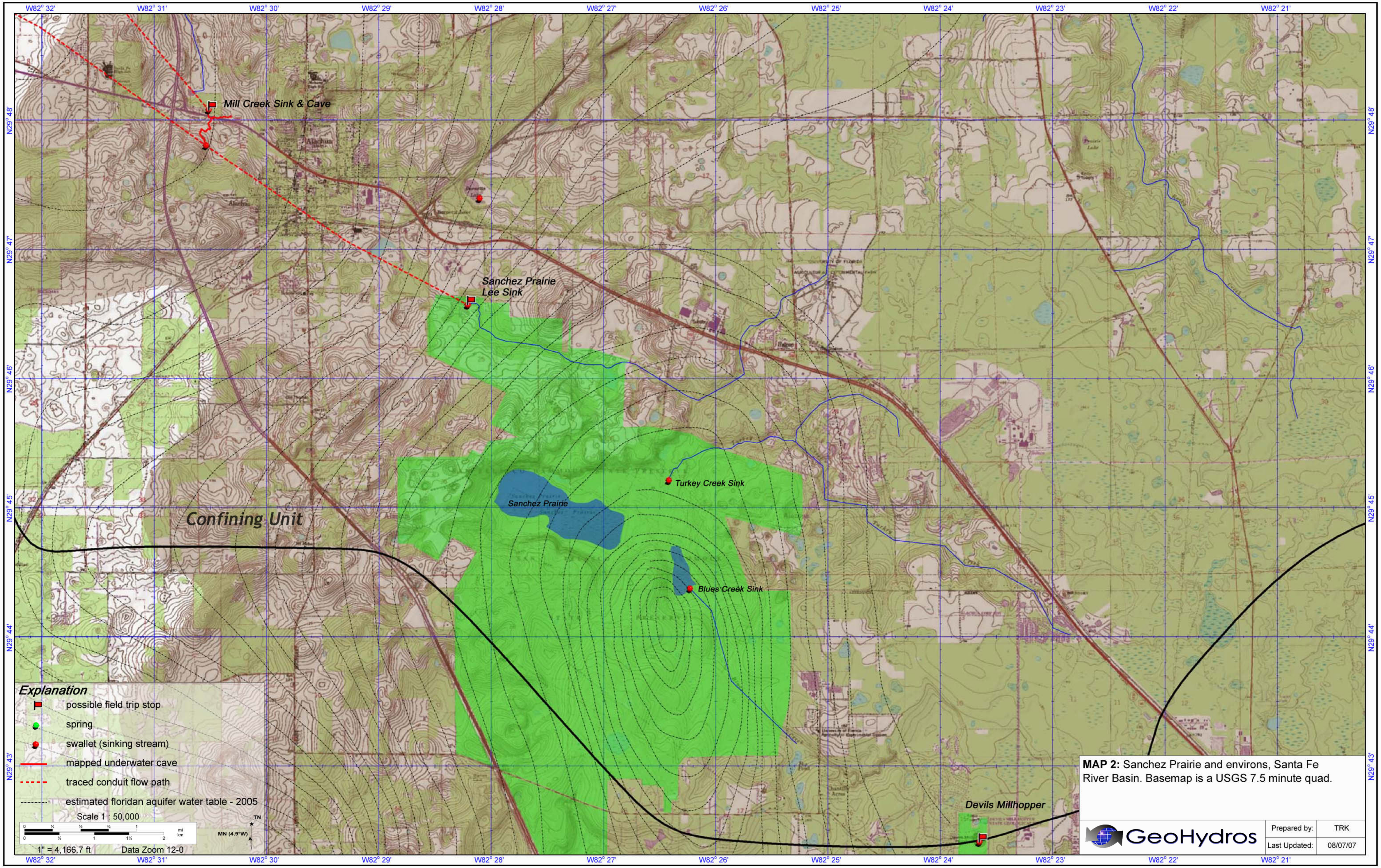


Adapted from the Water Resources Atlas of Florida - 1998

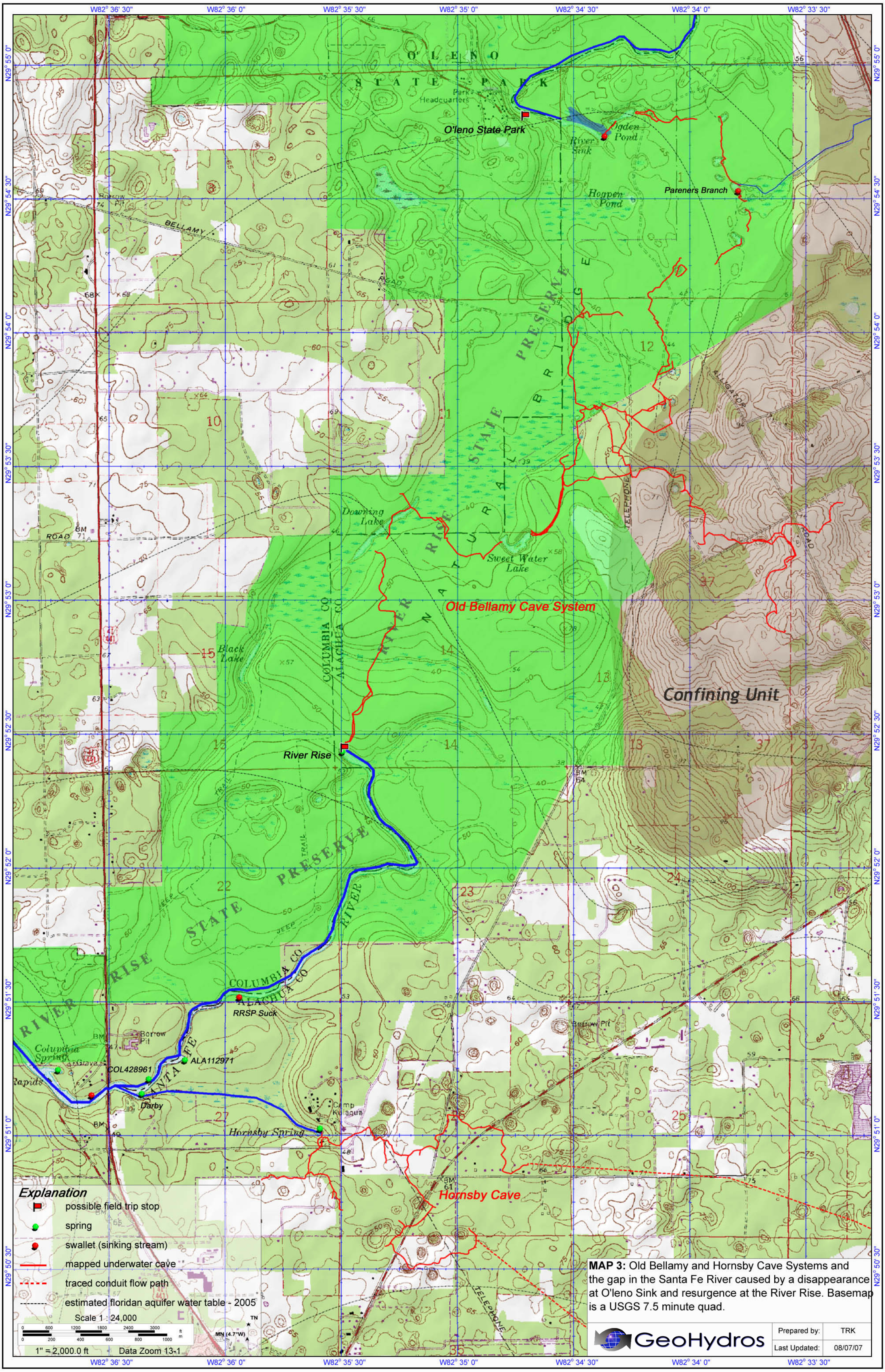
MAP 1: Map of the Santa Fe River Basin, north-central Florida showing the extent of the confining unit relative to drainage and karst features.

GeoHydros

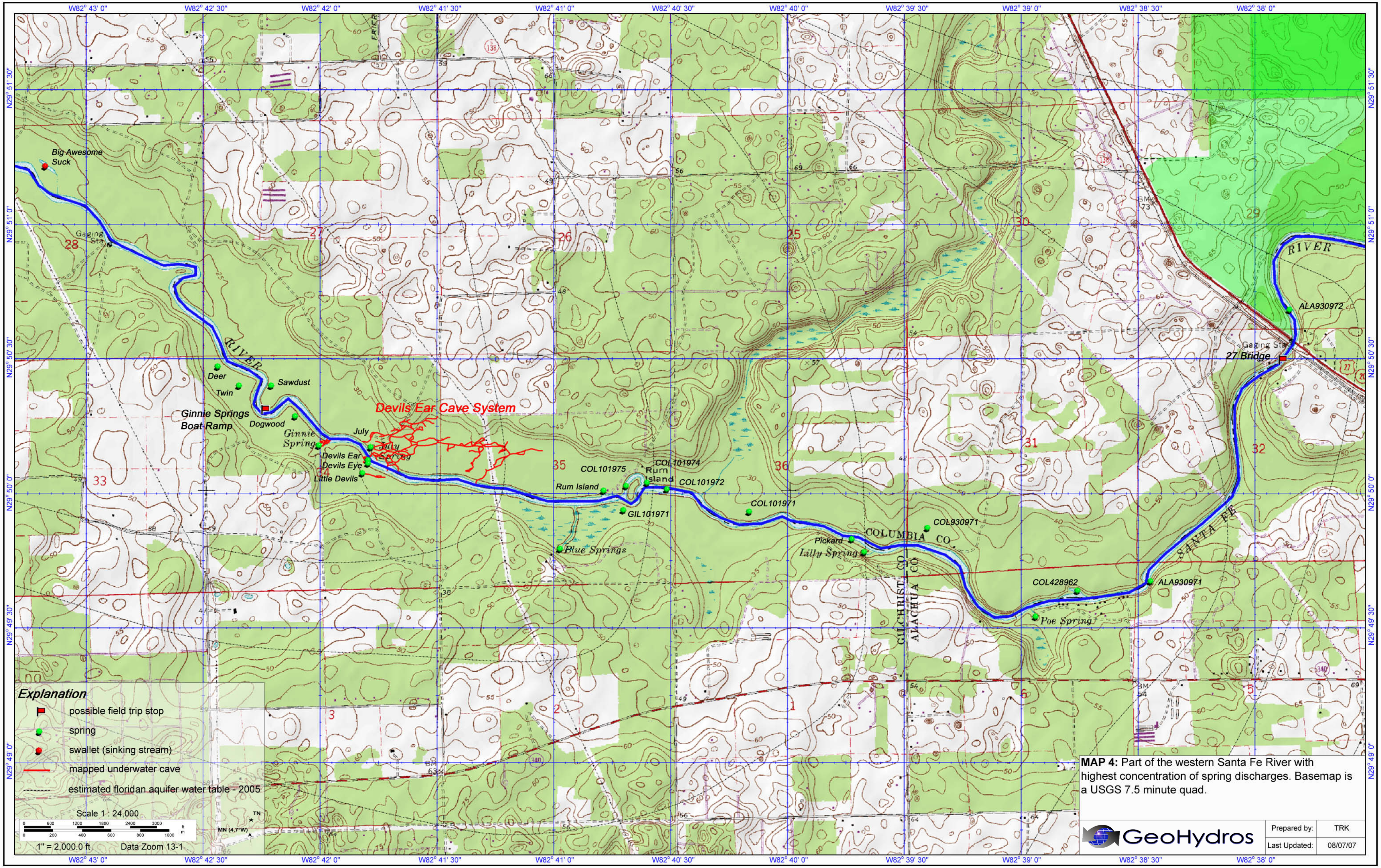
Prepared by:	TRK
Last Updated:	08/07/07



MAP 2: Sanchez Prairie and environs, Santa Fe River Basin. Basemap is a USGS 7.5 minute quad.



MAP 3: Old Bellamy and Hornsby Cave Systems and the gap in the Santa Fe River caused by a disappearance at O'leno Sink and resurgence at the River Rise. Basemap is a USGS 7.5 minute quad.


Big Awesome Suck
RIVER
Deer
Twin
Sawdust
Ginnie Springs Boat Ramp
Dogwood
Ginnie Spring
Devils Ear Cave System
July
Devils Ear
Devils Eye
Little Devils
Rum Island
COL101975
COL101974
COL101972
GIL101971
COL101971
Blue Springs
COL930971
Pickard
Lilly Spring
COLUMBIA CO
GILCHRIST CO
ALACHUA CO
COL428962
ALA930971
Poe Spring
SANTA FE
ALA930972
27 Bridge
Explanation
possible field trip stop
spring
swallet (sinking stream)
mapped underwater cave
estimated floridan aquifer water table - 2005
Scale 1 : 24,000
1" = 2,000.0 ft
Data Zoom 13-1
MAP 4: Part of the western Santa Fe River with highest concentration of spring discharges. Basemap is a USGS 7.5 minute quad.
GeoHydros
Prepared by: TRK
Last Updated: 08/07/07