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Southeastern Geological Society

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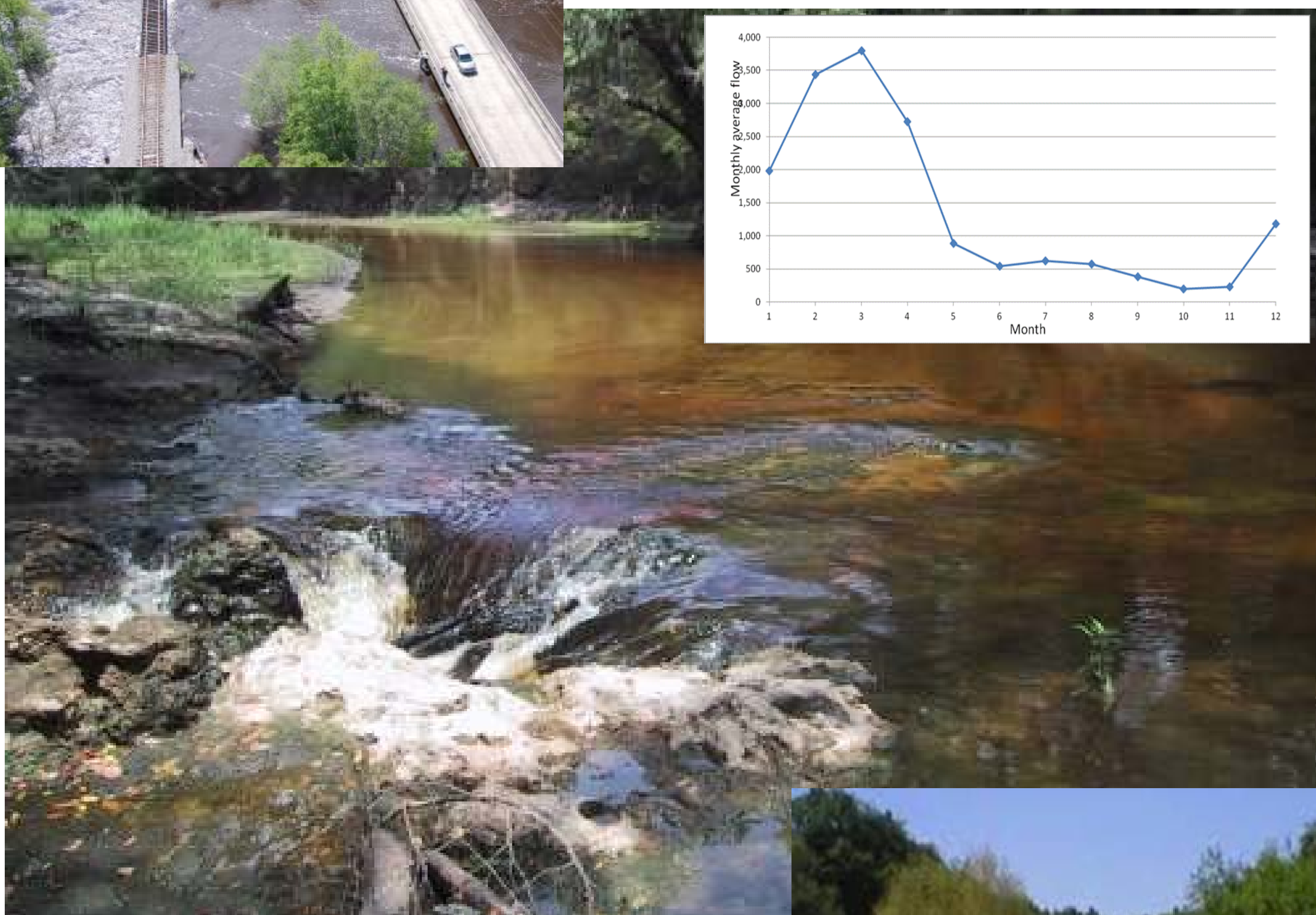
KARST HYDROGEOLOGY OF THE UPPER SUWANNEE RIVER BASIN, ALAPAHA RIVER AREA HAMILTON COUNTY, FLORIDA



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Compiled by Andrew Lawn

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Acknowledgments

The Southeastern Geological Society (SEGS) would like to acknowledge a number of individuals who contributed time and effort in planning and organizing this logistically challenging field trip. We thank Edwin McCook with the Suwannee River Water Management District for his assistance in helping gain access to a number of karst features on District land and for providing maps. We would also like to thank Craig Liney, park manager for the Suwannee River State Park who provided permission to access karst features on State Park lands. Thanks go to Clint Kromhout with the Florida Geological Survey (FGS) for agreeing to give a talk on ongoing karst mapping being conducted by the FGS and for providing maps and logistical support. The SEGS is also indebted to those members who serve on various committees that oversee the planning of field trips. We would also like to thank our corporate sponsor, HSW Engineering, for providing assistance in putting the field trip guidebook together and getting it ready to be printed. And finally we would like to thank the organizers and attendees of the 1981 SEGS field trip to this same area. That field trip was one of the most successful field trips ever organized by the SEGS and provides the current organizers with a lofty goal – to make this trip even more successful than the last.

Cover photo credits

U.S. Geological Survey, Florida Fish and Wildlife Conservation Commission and Super Motors

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The Field Trip Notification with plans and Stop descriptions and a map of the Spirit of Suwannee Music Park is included at the back of the guidebook.

The following presentations were produced for the Friday evening dinner meeting:

SEGS
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POST OFFICE BOX 1636 TALLAHASSEE FLORIDA 32302 www.SEGS.org

Alapaha River/Cody Scarp Area
SEGS Field Trip Plans for November 8, 2014

Following our Friday afternoon/evening technical presentations (starting at 4:00) and buffet dinner in the Spirit Lodge at the Spirit of the Suwannee Music Park and Campground, we'll **meet near the Park entrance at U.S 129 at 8:30 AM** (look for SEGS signs). We will check everyone in, confirming receipt of payment and indemnification forms with everyone's cell numbers and designation of carpool drivers and groups. Please let us know by Friday if you have a high-clearance vehicle with room for some passengers; all others please have your gear packed and ready to carpool. Note that you should wear long pants and be aware of thorny plants, and poison ivy. We plan to **drive out of the Music Park at 9:30**.

We'll **meet near the Suwannee Music Park and Campground entrance at U.S 129 at 8:30 AM** (look for SEGS signs). We will check everyone in, confirming receipt of payment and indemnification forms with everyone's cell numbers and designation of carpool drivers and groups. Please let us know by Friday if you have a high-clearance vehicle with room for some passengers; all others please have your gear packed and ready to carpool. Note that you should wear long pants and be aware of thorny plants, and poison ivy. We plan to **drive out of the Music Park at 9:30**.

Stop #1 - Law Sink; 9:30 to 10:30

We'll head north (left) on U.S. 129 into Jasper then turn west onto U.S. 41. We'll slowly cross the bridge over the Alapaha River for a quick view of the dry riverbed, then proceed to a right turn marked with an SEGS sign into Zellwin farms property along the edge of row crops to **Law Sink**, a very large ponor/sink that's hidden behind dense overgrowth and great live oaks. We'll drive past huge center-pivot, 3-phase powered irrigation guns and other big farming equipment until we hear water falling into this 80 ft deep sink. Your SEGS reconnaissance crew cleared a path into the woods to a precipice for viewing the falls. Due to uncertain footing beneath

heavy vegetation, we must use caution, staying in the cleared areas. We won't be rappelling the cliffs; we'll have other opportunities for close encounters with waterfalls.
Discussion leaders: Ron Ceryak and Rick Copeland

Stop #2 - Jennings Bluff Cemetery and River Vista, 10:30 to 11:30

We'll go back to U.S. 41, south (left) and immediately turn left onto NW 72nd Place toward **Jennings Bluff Cemetery** where headstones date from the 1700s, and enjoy very nice river vistas. We'll also see a spring that early settlers harnessed by installation of piping and likely blasting of overburden to funnel the flow.
Discussion leaders: Tom Scott and Ron Ceryak

Stops #3 - Alapaha River and #4 - Dead River Ponor/Sink, about 11:30 to 2:00, including lunch

We'll backtrack a few hundred yards to a northward turn at a dirt road into SRWMD gated property. We'll drive in (see SRWMD New Access Map to Dead River) toward the river and stop where we'll have a couple hundred feet walk to the **Alapaha River** at the head of the Dead River's distributary. We'll observe silicified oyster beds and have an opportunity to collect river rock and quartz gravel (please leave oyster beds intact). You will choose to either hike back through the woods or down the Dead River or riverbank (about a 20 minute hike) to the ponor/sink. We'll all meet at the end of the distributary - the **Dead River Ponor/Sink** to relax and enjoy our box lunches.
Discussion leaders: Tom Scott, Sam Upchurch and Andy Lawn

Stop #5 - Alapaha River Rise Confluence with the Suwannee, about 2:00 to 3:30

After lunch, we'll head back south on Hwy 41 to a right on South Hwy 6 then a left onto CR 249 south and park under the river bridge at Gibson Park where restrooms are available. We'll hike up the Suwannee River bank to the **Alapaha River Rise confluence with the Suwannee**. The Rise is a First Magnitude spring; its water is tannic and believed to be a resurgence of the Alapaha River. We'll observe echinoids in Suwannee limestone along the river bank. We have mailed requests for access to the owner of the Rise headwater, but have not to-date received a response.

Discussion leaders: Harley Means and Dave DeWitt

Stop #6 - Holton Creek, about 3:30 to 4:30

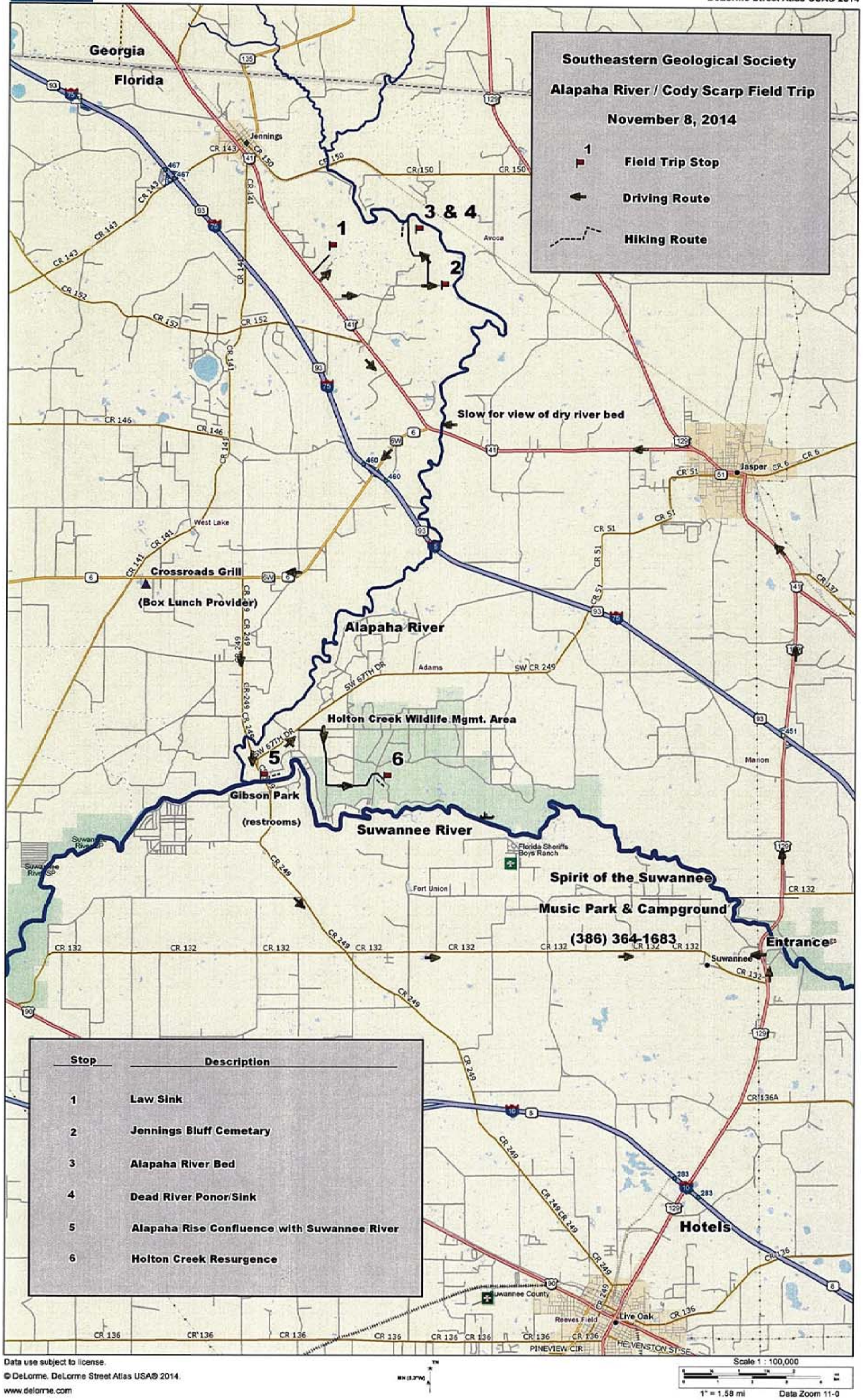
We'll drive back north a few hundred feet and head east on SW 67th Drive to an entrance of the **Holton Creek** Wildlife Management Area. On our drive through the area to Holton Creek we'll see numerous karst depression features. Well drive to the Creek and walk up to the head, which is another resurgence similar to the Rise, and view a beautiful Champion cypress. The tree is thought to possibly be the oldest cypress in Florida since we lost the 3500+ year old "Senator" in Longwood two years ago due to human-caused fire.

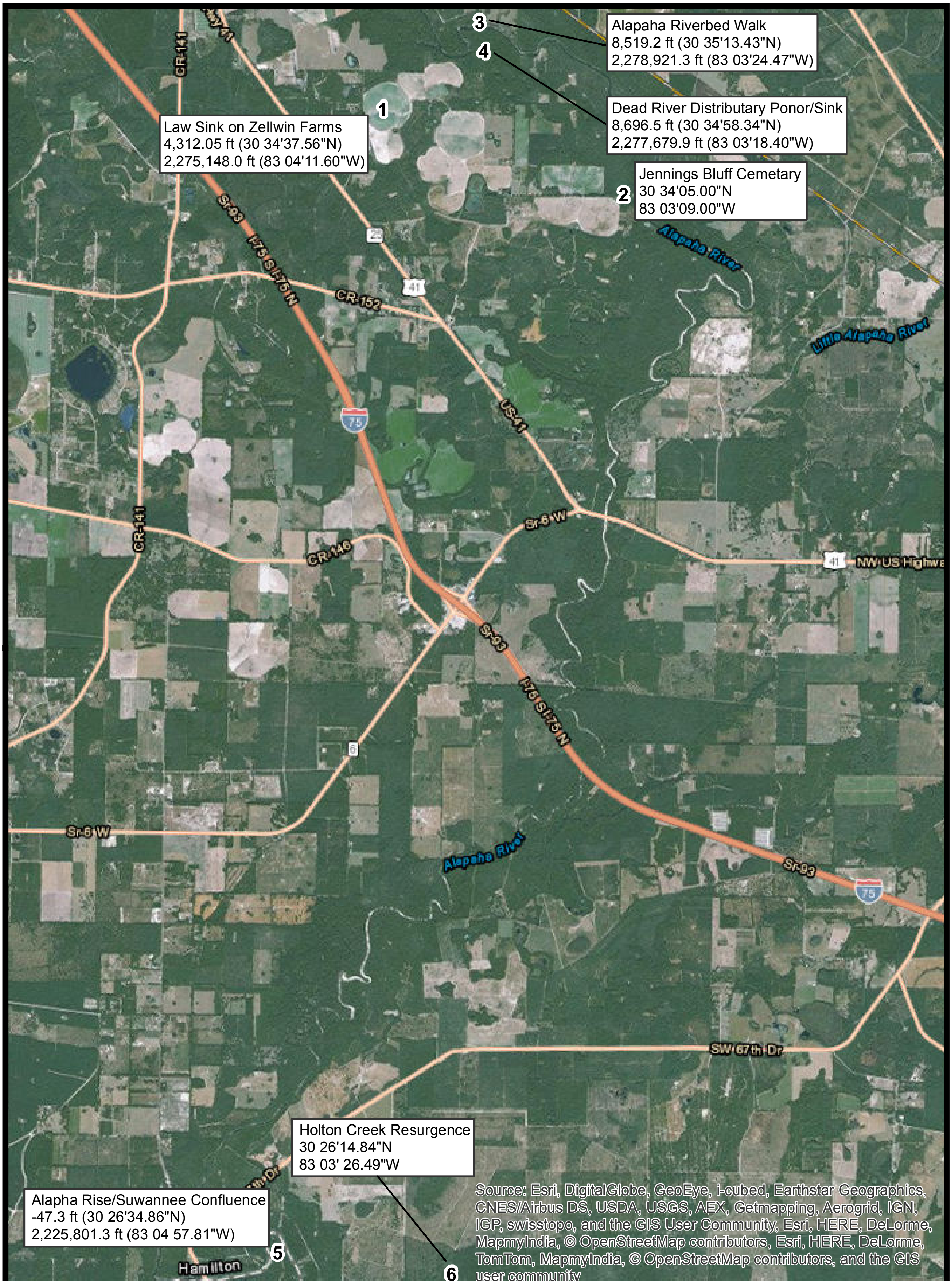
Discussion leaders: Sam Upchurch and Wink Winkler

Return to the Music Park for buffet dinner around 6:00 and Band at 7:00

After leaving the Holton Creek area we'll go back west on SW 67th Drive to CR 249 south (left) to CR 132 east (left) to US 129 north (left) to our Music Park entrance. We'll have time to relax and clean up before dinner at 6:00 and enjoy our Irish Band Kanapaha at 7:00.

DeLorme Street Atlas USA® 2014





0 3,000 6,000 Feet

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SEGS Field Trip Stops

Alapaha River / Cody Scarp 11/8/14

HSW Engineering, Inc.

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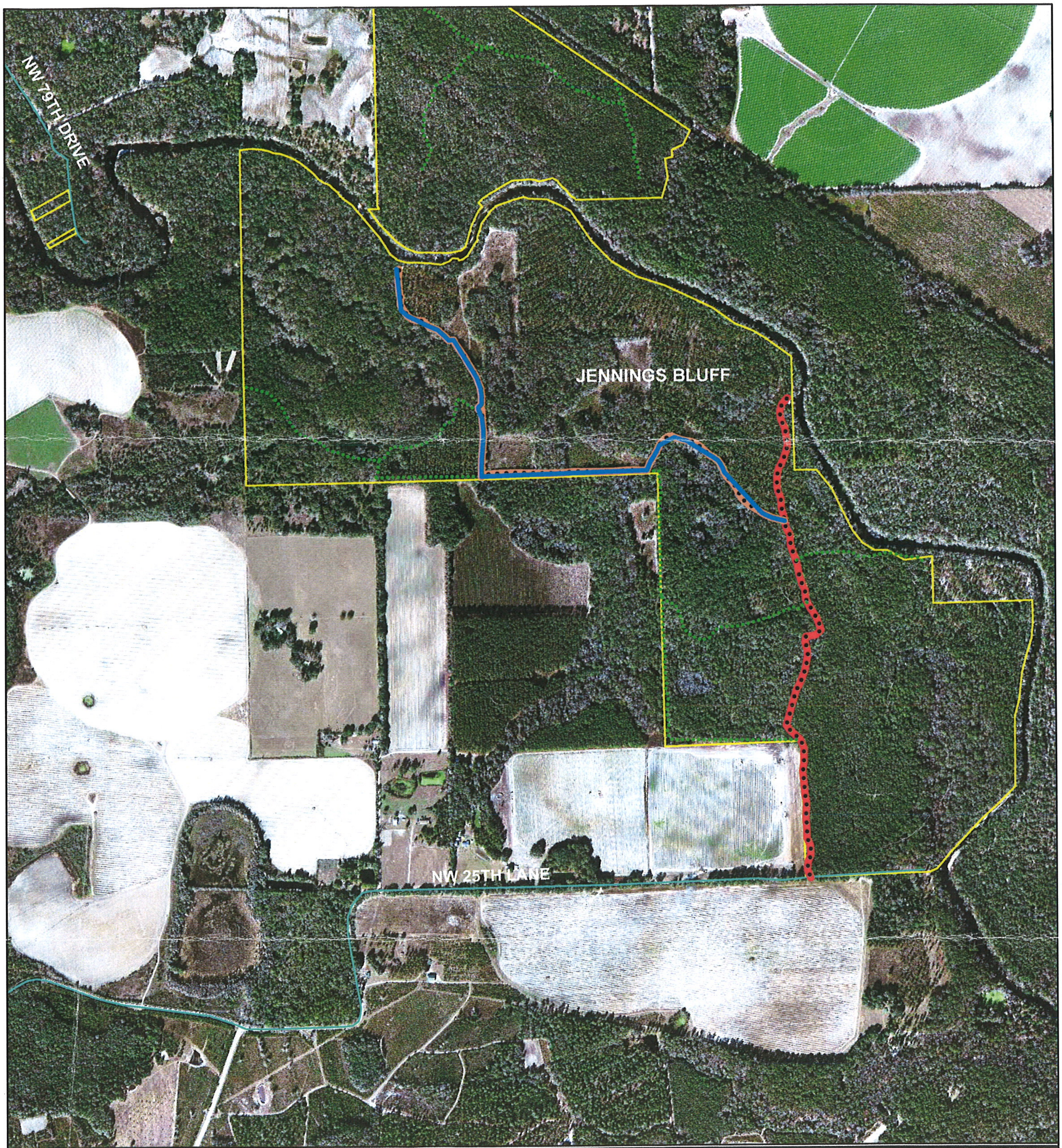

New Access Map to Dead River
Jennings Bluff Tract
Hamilton County, FL

Legend

- SUA Access Route

District Roads

- Administrative
- Secondary
- Public
- Highways
- District Lands

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Note: This map was created by the Suwannee River Water Management District (SRWMD) to be used for planning purposes only. SRWMD shall not be held liable for any injury or damage caused by the use of data distributed as a public records request regardless of their use or application. SRWMD does not guarantee the accuracy, or suitability for any use of these data, and no warranty is expressed or implied. For more information please contact the SRWMD at 386-362-1001.
Map Created on 3/29/2013

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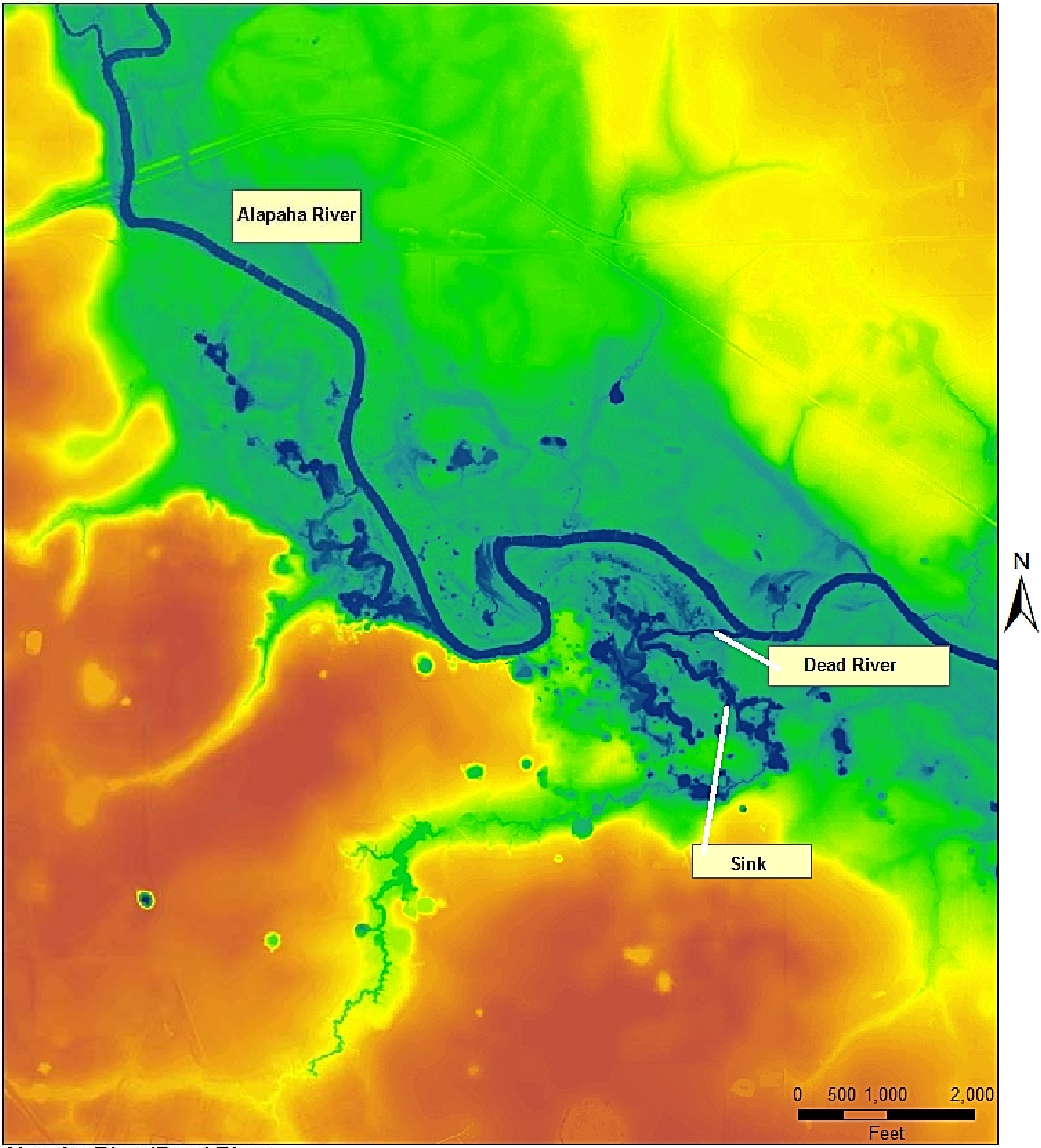

Alapaha River/Dead River
Hamilton County FL

Location of Distributary and where it goes underground
Elevation range 38.5' to 150' NGVD
Orange is highs

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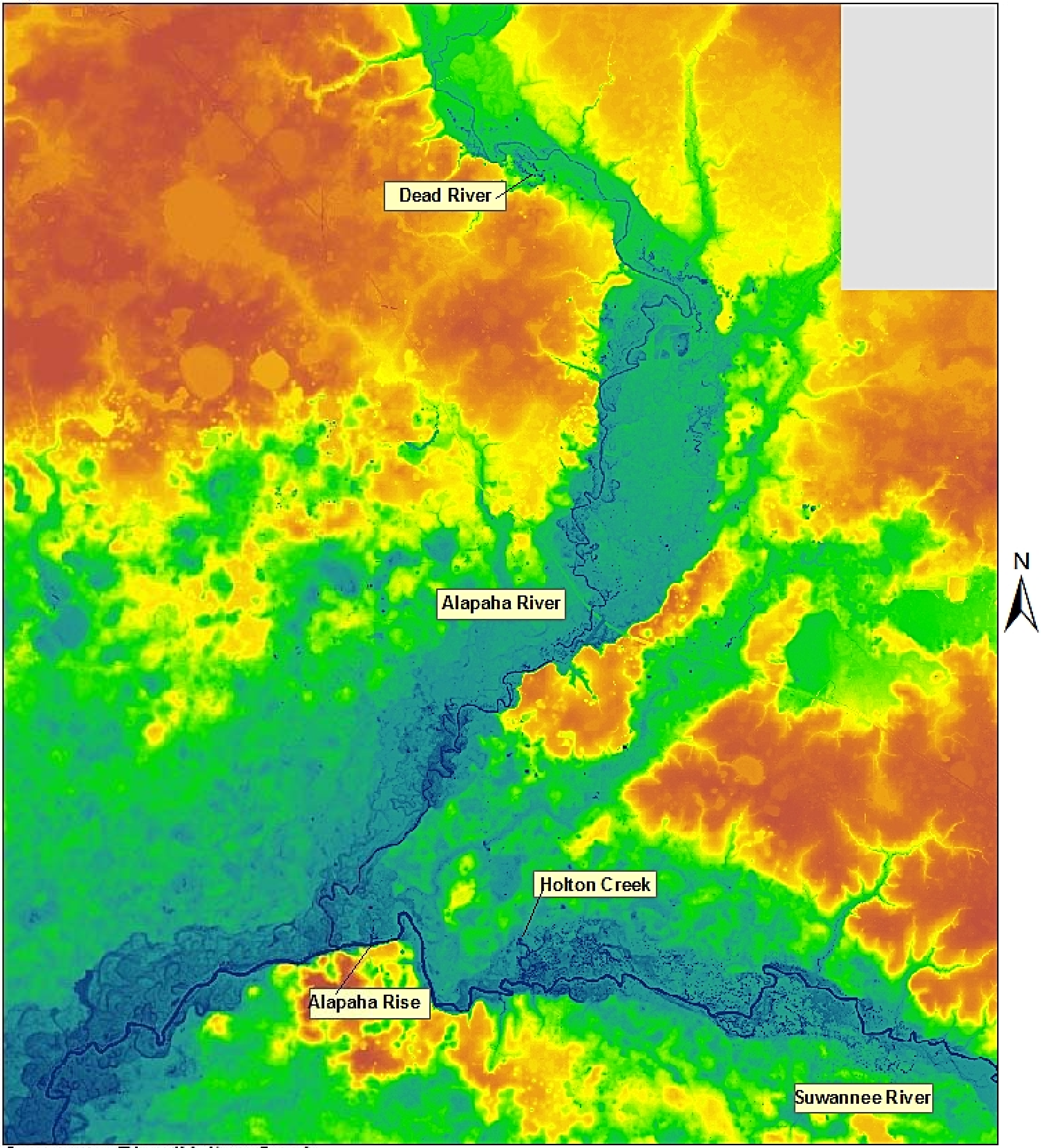

Suwannee River/Holton Creek
Hamilton County FL

Suwannee River/Holton Creek
Another possible resurgence of the Alapaha R.
Elevation Range 28' to 174'

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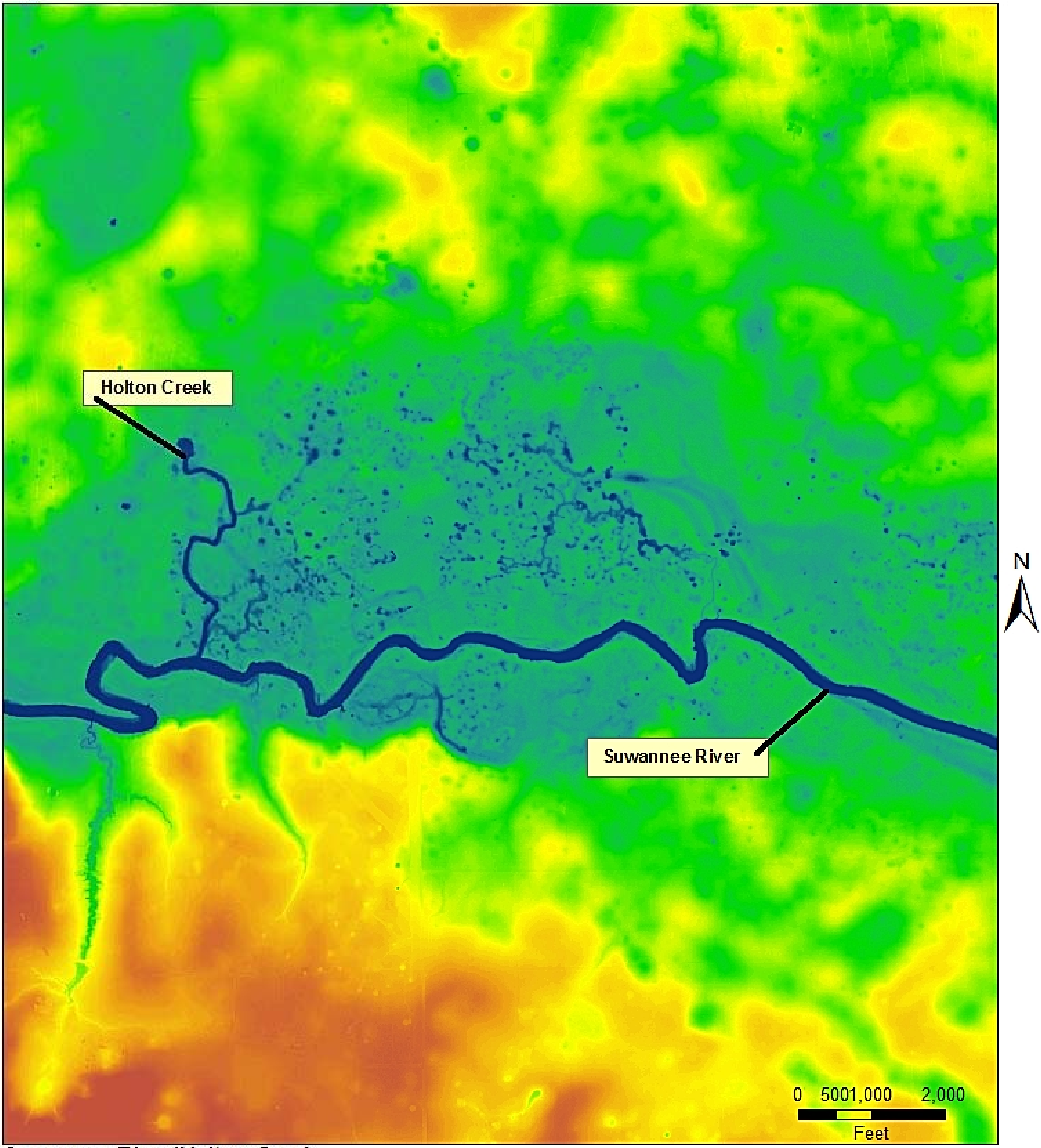
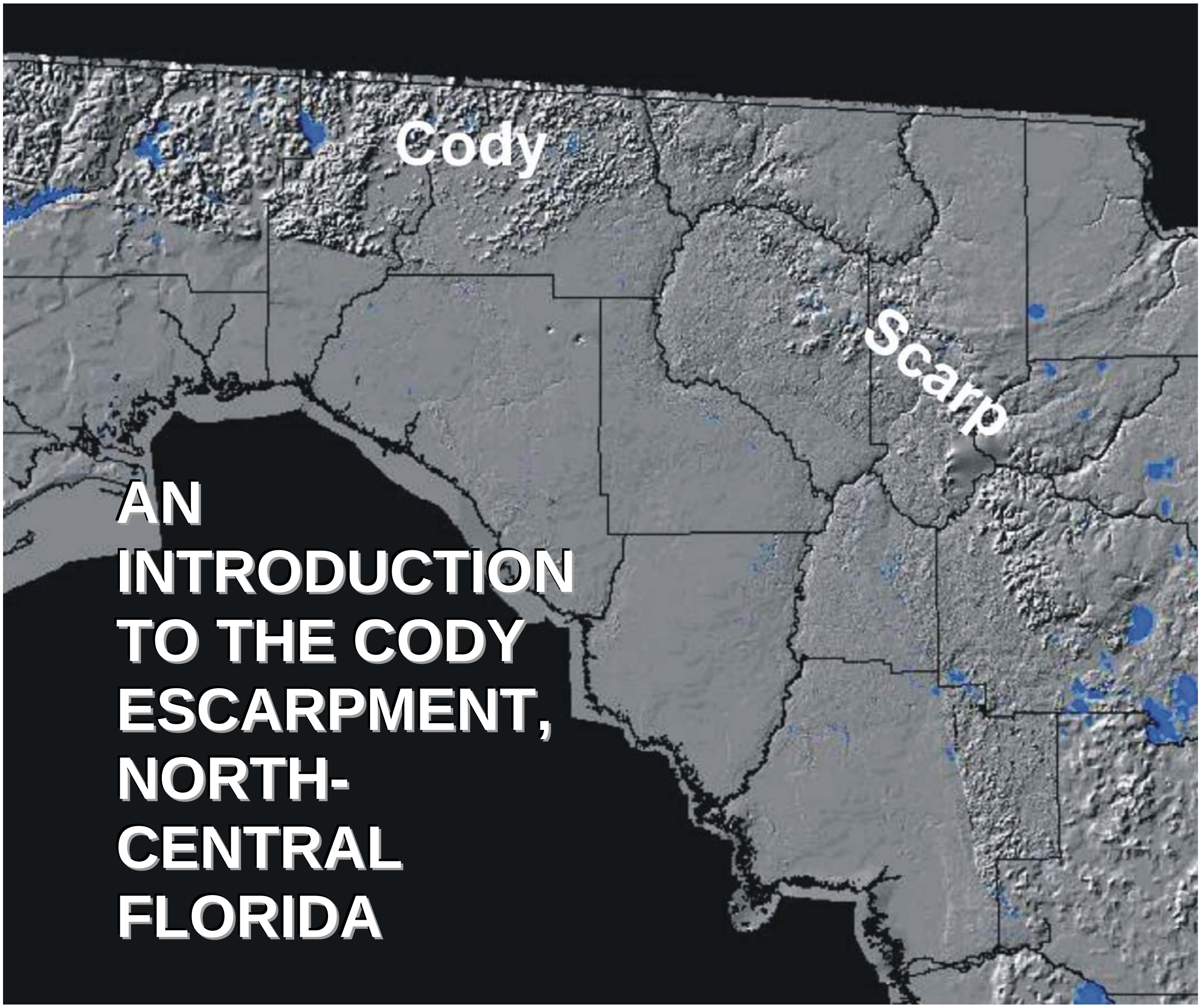


Suwannee River/Holton Creek
Hamilton County FL

Suwannee River/Holton Creek
Another possible resurgence of the Alapaha R.



AN INTRODUCTION TO THE CODY ESCARPMENT, NORTH-CENTRAL FLORIDA

Prepared for the
Suwannee River Water Management District
Live Oak, Florida

by

Sam B. Upchurch
SDII Global Corporation
4509 George Road
Tampa, Florida 33634

September, 2007

Cover: Digital terrain map of north-central Florida illustrating the hilly terrain of the Cody Scarp and Tallahassee Hills. (Image courtesy of the U.S. Geological Survey and Suwannee River Water Management District)

Endorsement

This report was prepared for the Suwannee River Water Management District by SDII Global Corporation under contracts to Water Resource Associates, Inc. for minimum flows and levels development in the Lower Santa Fe River Basin. All work contained in this report was performed under the supervision of the undersigned.

SDII Global Corporation

______________________________ October, 30, 2007

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

SDII Global Corporation Project Number

3009080

Important Definitions

Carbonate rock – A rock composed of carbonate minerals, such as calcite ($CaCO_3$) or dolomite ($CaMg(CO_3)_2$).
Dolostone - A carbonate rock composed primarily of the mineral dolomite ($CaMg(CO_3)_2$).
Fluvial – Related to, or derived from stream or river processes.
Limestone – A carbonate rock composed primarily of calcite ($CaCO_3$).
Karst – A Serbo-Croatian word that refers to the landforms associated with dissolution of carbonate rock or sediments. Examples of karst landforms include sinkholes, sinking streams, pinnacled limestone, caves, and springs.
Polje – A Serbo-Croatian term that refers to a large, flat-bottomed uvala that has been filled by lake or fluvial sediment.
Resurgence – A spring formed when surface water that has been captured by a siphon or swallet re-emerges from the aquifer.
Sinking stream – A stream that goes underground through a sinkhole (swallet or siphon).
Sinkhole – A depression in the land surface created when sediment or rock migrates into voids in the underlying limestone or dolostone. The voids are created by dissolution of the carbonate rock.
Siphon – An in stream sinkhole that captures portions of the stream flow.
Spring – A place where the potentiometric surface of an aquifer intersects the land surface. Groundwater discharges at the point of intersection to form the spring.
Swallet – A sinkhole that normally captures all, or most, of a sinking stream. During high runoff events, the swallet may not be able to take all of the runoff in which case the excess runoff flows overland along a normally dry streambed.
Trace – A term local to the Cody Scarp of Florida that refers to a relict stream valley associated with the retreat of the scarp. A trace is characterized by elongated sinkholes, swallets, and periodic flooding during extreme runoff events.
Uvala – A large sinkhole complexes formed by the coalescing of multiple individual sinkholes.

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AN INTRODUCTION TO THE CODY ESCARPMENT, NORTH-CENTRAL FLORIDA

Introduction

The Cody Scarp (Escarpment) is a classic example of a karst escarpment with numerous poljes, uvalas, sinkholes, sinking streams, siphons, springs, and other karst features along its length.[1] It extends from near Gainesville, in Alachua County, to west of Tallahassee in Leon County (Figure 1).

The Cody Scarp was first named by Puri and Vernon (1964), who attributed the formation of the scarp to a combination of Plio-Pleistocene shoreline development and fluvial/karst erosion. The segment of the scarp within the Suwannee River Water Management District (District) is predominantly a karst escarpment (White, 1970) that has been modified in many areas by marine shoreline processes.

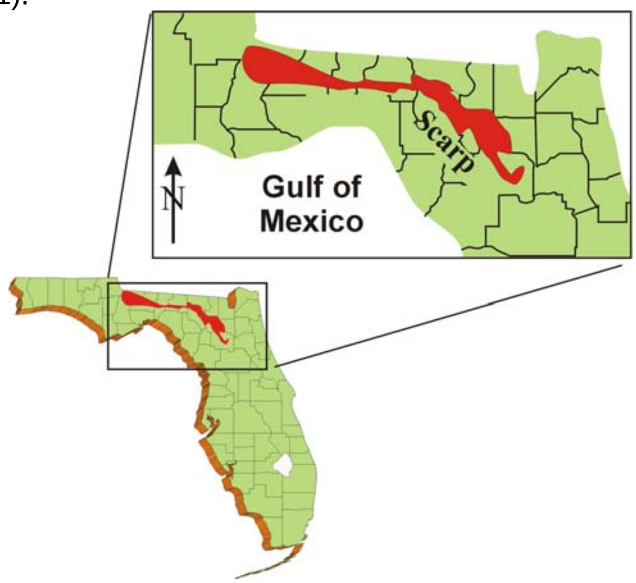

Figure 1. Approximate location of the Cody Scarp.

The Cody Scarp is important to understanding the hydrology of the Suwannee River Basin and other areas of north-central Florida because the processes that have formed it greatly affect rivers, groundwater, land forms, and water quality throughout the region (Copeland, 2005).

Geomorphology

The Cody Scarp is a topographic break (Cover; Figures 2a, b) with up to about 100 feet of relief. Within the District, the scarp is characterized by sinking streams, springs, and large sinkholes (Figure 2b). The sinkholes are large because of the thickness of sand and clay cover that remains over the limestone between these large sinkhole features. Plio-Pleistocene marine terrace deposits commonly form elevated ridges at the top of the scarp. The "peak" under the word scarp in Figure 2 is an example.

The scarp is the topographic break between the Northern Highlands Physiographic Province to the north and east and Gulf Coastal Lowlands Province to the west and south of the scarp (Figure 2; White, 1970). The Northern Highlands are underlain by a thick sequence of erosion-resistant sand, clay, and carbonate sediments of the Miocene Hawthorn Group. More easily eroded limestone and dolostone of the Eocene Ocala Limestone and Oligocene Suwannee Limestone characterize the shallow sediments of the adjacent Gulf Coastal Lowlands. The scarp is a result of marine, fluvial, and karst-related erosion of the Hawthorn Group sediments of the Highlands.

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[1] See definitions of these terms on page i.

Note in Figure 2b that streams drain to the south and southeast across the Northern Highlands. These streams have well-developed drainage systems with dendritic (tree-like) drainage patterns. As the streams cross the scarp (the region where the contour lines "bunch up" indicating steep slopes), they flow into poljes, such as Paynes Prairie, Kanapaha Prairie, and uvalas. Smaller streams flow into isolated sinkholes (swallets) or uvalas.

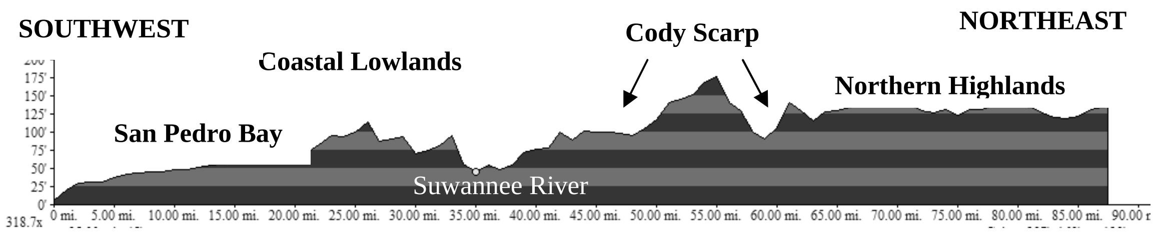


Figure 2a. - Topographic profile of the Cody Scarp from Taylor (Baker County) to Dekle Beach on the Gulf of Mexico.

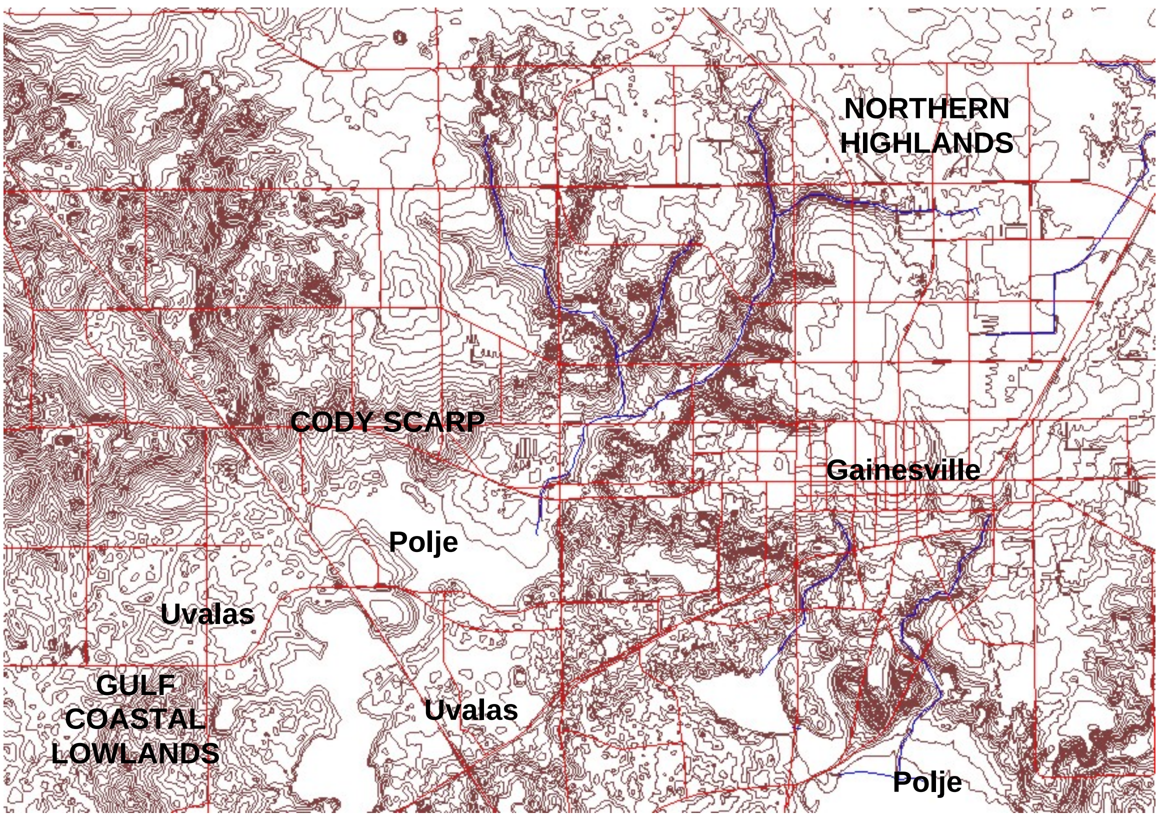
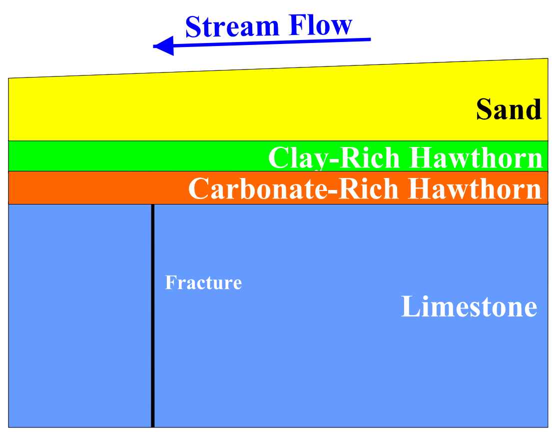


Figure 2b. Topographic map of the area near Gainesville showing the Cody Scarp.
Contour interval is 5 feet.

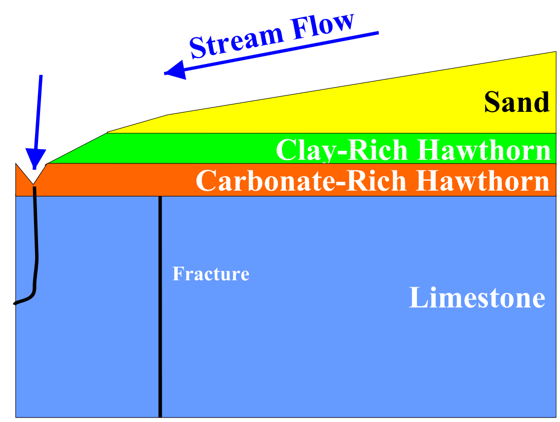
Origin of the Cody Scarp

As noted above, the Cody Scarp is predominantly a karst escarpment. Karst escarpments develop because of a combination of headward erosion by streams and dissolution of carbonate rocks by streams and groundwater. The difference between a karst escarpment and any other topographic scarp is that the toe of the scarp is characterized by limestone or dolostone that is dissolved by the surface- and groundwater as the scarp retreats. Figure 3 illustrates the process of headward erosion on the Cody Scarp.



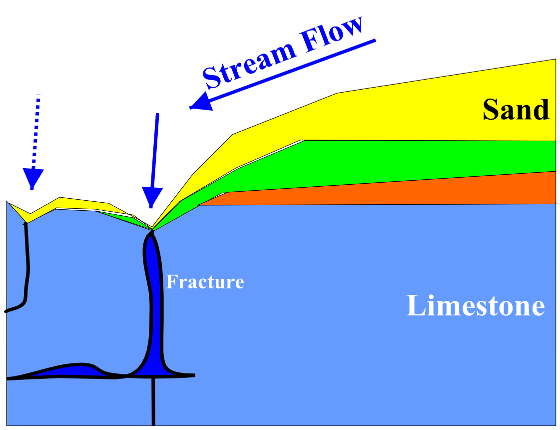
Time Step 1

Figure 3a. – Initial stage of scarp retreat.



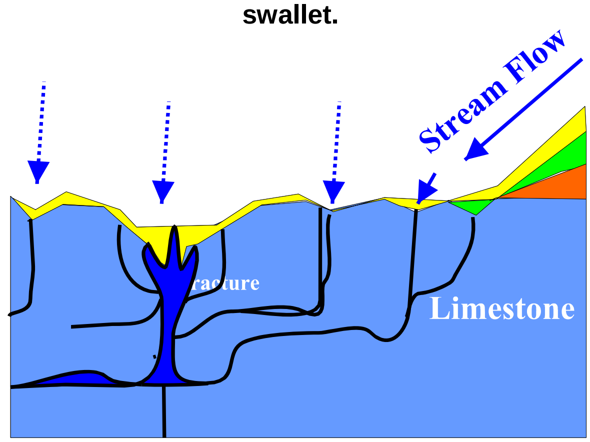
Time Step 2

Figure 3b. – Headward erosion exposes limestone and stream is captured by a swallet.



Time Step 3

Figure 3c. – Scarp continues to retreat and stream capture by a new swallet strands the original one.



Time Step 4

Figure 3d. Scarp retreat results in a series of former swallets and a trace, or relict stream channel connecting the swallets.

In Step 1 of the scarp retreat (Figure 3a), a stream has developed on the Northern Highlands. The stream flows from right to left (east to west) and slowly erodes the surficial sands, clays, and carbonate-rich strata of the Hawthorn Group away. At some point, the stream cuts headward and downward, deep enough to intersect a limestone stratum. The streams of the Northern Highlands and groundwater of the surficial aquifer (the water table aquifer contained within the sand mantle that overlies the Hawthorn in the Northern Highlands) are typically acidic, so the limestone is attacked by the water as soon as the water and rock are in contact. The water finds a fracture, joint, or other pathway into the limestone and cavern development begins as dissolution of the rock occurs (Figure 3b)

As the scarp continues to retreat (Figure 3c), the limestone is weathered to form a karst terrain with swallets that can capture the surface- or groundwater as it flows off the Highlands. This process continues for many thousands of years, resulting in a string of active and inactive swallets (Figure 3d) along the retreating stream valley. Often, the former path of the stream can still be seen on the land surface as linear depressions, vegetation and soil tonal patterns, and, of course, the string of sinkhole swallets.

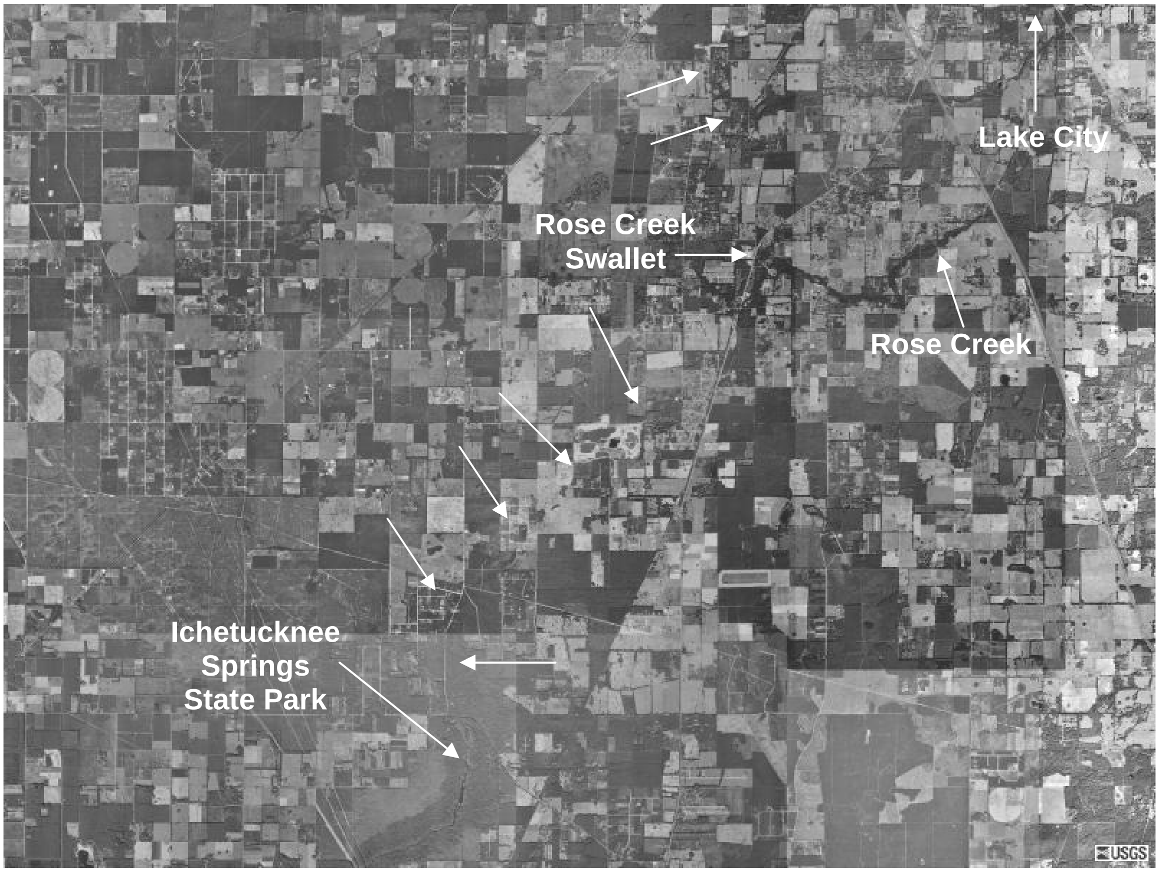


Figure 4. The Ichetucknee Trace, which extends from near Lake City to the Ichetucknee Spring Group.

Arrows follow the path of the Trace. Rose Creek drains off the Highlands into a swallet (Rose Creek Swallet) within the Trace.

These relict stream areas are locally known as "traces" (Figure 4). Traces are characterized by a linear, low area with numerous sinkholes. Many traces, such as the Ichetucknee Trace (Figure 4), flood when the volume of water in the tributary stream exceeds the ability of the swallets to capture surface water.

Features of the Cody Scarp

Table 1 summarizes some of the properties of the Cody Scarp and the adjacent Northern Highlands and Gulf Coastal Lowlands provinces. When the sizes and shapes of closed depressions are compared, the Cody Scarp is immediately obvious (Figure 5). The following summarizes the size and shape of sinkholes in each geomorphic area:

- The Northern Highlands are relatively flat. There may be small depressions that are either developed as part of the Plio-Pleistocene marine terraces or minor sinkholes developed on shallow carbonate strata of the Hawthorn Group.

Table 1. Some Properties of the Cody Scarp and Associated Physiographic Provinces (Based on Upchurch, 2002).

Feature	Characteristic
Topography	
Northern Highlands	Relatively flat, minor depressions
Cody Scarp	Hilly, large, closed depressions
Gulf Coastal Lowlands	Relatively flat but characterized by many, small, closed depressions
Surface Drainage	
Northern Highlands	Well developed streams, swamps, lakes
Cody Scarp	Sinking streams, large lakes
Gulf Coastal Lowlands	Internal drainage, few lakes or streams
Surficial Aquifer Flow Systems	
Northern Highlands	Local flow systems, aquifer well developed
Cody Scarp	Generally absent
Gulf Coastal Lowlands	Mostly absent; limestone aquifer is the water table aquifer
Intermediate Aquifer System	
Northern Highlands	Localized aquifers (carbonate and siliciclastic) well developed; clay-rich strata form aquitards and confine the underlying Floridan aquifer
Cody Scarp	Aquifers absent or very local, local clay-rich strata are present
Gulf Coastal Lowlands	Absent
Upper Floridan Aquifer	
Northern Highlands	Porosity development varies; flow often sluggish
Cody Scarp	Secondary porosity well developed by karst processes, flow very dynamic
Gulf Coastal Lowlands	Secondary porosity well developed by karst processes, flow very dynamic
Recharge to Upper Floridan Aquifer	
Northern Highlands	Limited and slow
Cody Scarp	Rapid, includes runoff from Highlands
Gulf Coastal Lowlands	Rapid, localized by small catchments of sinkholes
Karst Development	
Northern Highlands	Limited to interstratal karst within Hawthorn Group carbonate strata
Cody Scarp	Well developed; vertical conduits dominate
Gulf Coastal Lowlands	Well developed; horizontal conduits highly developed

- The Gulf Coastal Lowlands are characterized by numerous small sinkholes superimposed on a relatively flat platform.

- The Cody Scarp is characterized by large sinkholes (including uvalas and poljes; Figure 5) that produce a distinctly hilly appearance to the terrain (Cover; Figure 2).

The large sizes of sinkholes in the Cody Scarp are a result of thick cover over the limestone. This cover consists of erosional remnants of the intact Hawthorn Group sediments of the Northern Highlands plus residua and sediment derived from erosion and transport of Hawthorn sediments created by scarp retreat. The thicker the cover, the larger the sinkholes will be. Cover is thin in the Gulf Coastal Lowlands, so sinkholes are small and separated into individual depressions (Figure 5).

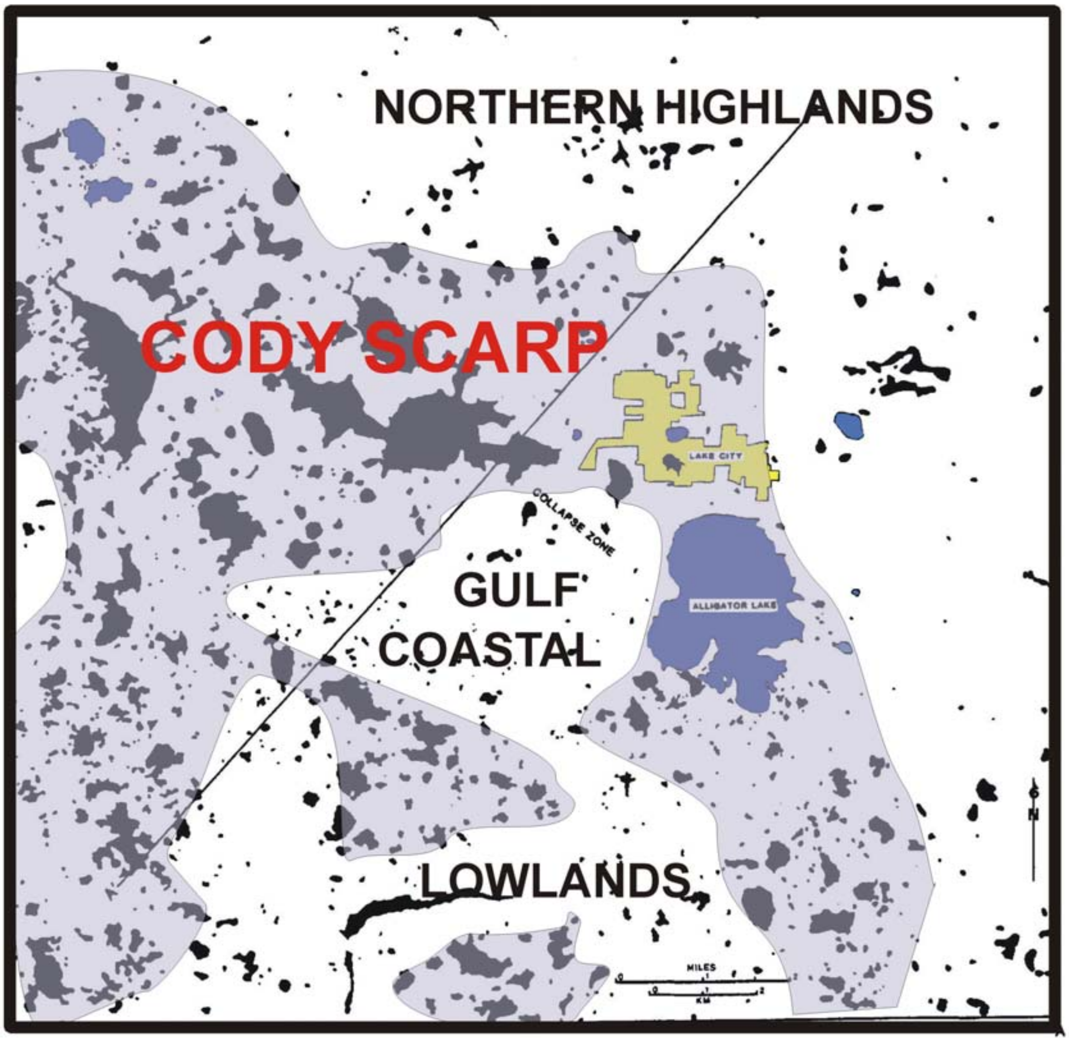


Figure 5. – Closed depressions within a four township (144 mi.^{2}) area near Lake City, Florida.

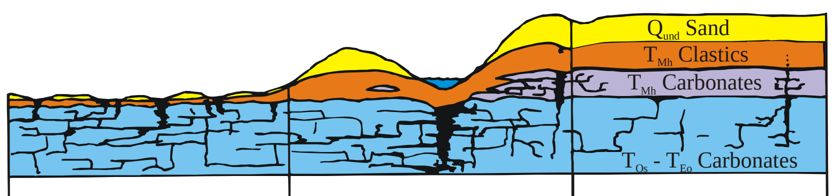
Black shapes represent closed depressions (sinkholes, uvalas, poljes), and blue areas are lakes. The pale blue shaded area that encloses the largest of the closed depressions is the topographic extent of the Cody Scarp in the study area. lakes. The northeast to southwest line represents a cross section that is summarized by Figure 6. Modified from Lawrence and Upchurch (1976 and Upchurch and Lawrence (1984).

Karst development is limited in the Northern Highlands. Limestone and dolostone beds within the Hawthorn Group may develop localized caverns and sinkholes that are limited to the thin Hawthorn strata. This form of karst (interstratal karst) results in minor aquifer development, and it has little effect on the hydrology of the Cody Scarp area.

Because of the localized recharge by streams entering swallets along the scarp, karst is very well developed on the Cody Scarp. Recharge tends to result in vertical karst conduits, both under the large sinkholes and in association with swallets and siphons that capture runoff from the Northern Highlands. As the groundwater flow turns to move to the south and east, away from the scarp, horizontal passages develop. These processes result in the siphon/resurgence systems that characterize many of the streams and rivers.

Groundwater Quality

Lawrence and Upchurch (1976, 1982) subdivided the Cody Scarp region into three groundwater "domains" (Figure 5). These domains were refined by Upchurch and Lawrence (1984) and Upchurch (2002). The Northern Highlands are underlain by the Upland Domain. The Cody Scarp is termed the Scarp Domain and the Gulf Coastal Lowlands are the Lowlands Domain (Figures 6). Each domain has different groundwater quality states and forms of karst (Figure 6).



GROUND-WATER DOMAINS	LOWLAND DOMAIN	SCARP DOMAIN	UPLAND DOMAIN
SATURATION STATES		**Zone of Colloidal Transport**	
Calcite	undersaturated	OVER SATURATED	saturated to sl. undersat.
Dolomite	undersaturated	undersaturated	undersat. to saturated
Quartz	undersaturated to saturated	OVER SATURATED	SUPERSATURATED
Hydroxylapatite	undersaturated	SUPERSATURATED	undersaturated
KARST DEVELOPMENT			
Vertical Conduits			
Horizontal Conduits			
Intrastratal Karst			
Solution Doline Development			
Collapse Sinks			
Uvala/Polje Development			
Paleokarst Reactivation			
RECHARGE PATTERNS	**DISPERSED RECHARGE**	**LOCAL, MAJOR RECH.**	**MINOR RECHARGE**

Figure 6 - Model for Cody Scarp retreat with summary of geologic processes in each geomorphic domain.

(Modified from Upchurch 2002)

Water flowing off of the Northern Highlands is typically mildly acidic and contains dissolved phosphate. Because of the clay content of the confining beds of the Hawthorn, there is little chemical buffering to reduce the water acidity, and the mildly acid water moves toward the scarp as either surface water or within the surficial or intermediate aquifers. There is little recharge to the underlying upper Floridan aquifer and karst development in the upper Floridan is very limited in the Highlands Domain

(Figures 5, 6) because of relatively low hydraulic conductivities in the aquifer. Flow in the upper Floridan aquifer is relatively stagnant, so the groundwater is hard and contains sulfide and sulfate. Limited recharge from the surface results in little or no Floridan aquifer vulnerability, and water quality issues, such as elevated nitrate concentrations, are not of concern. Because recharge and permeability are limited, extraction of high volumes of upper Floridan aquifer water in the Northern Highlands tends to cause large and regionally extensive cones of depression.

Upon reaching the vicinity of the Cody Scarp, the acidic, surficial and groundwater begins to contact carbonate rocks of the Hawthorn Group as a result of down-cutting in stream valleys (Figure 3). Karst development is initiated within Hawthorn carbonate beds at this stage in scarp retreat (Figures 3b, 5). Interaction of the acidic water with the carbonate rocks begins to buffer the water, resulting in an increase in pH. As the lower Hawthorn carbonates are dissolved away, residual sand and clay accumulate and sinkholes allow access of the still acidic water to the underlying Floridan aquifer. Sediments in transport in the streams are swept into the aquifer and landscape development changes from fluvial to karst near the toe of the scarp. The groundwater of the Scarp Domain is highly vulnerable to contamination because of the sinking streams and large drainage basins associated with the large scarp sinkholes (Figure 5). Nitrate and other contaminants are likely to first occur within the Scarp Domain. Since the scarp is not conducive to large-scale agricultural practices, contaminant sources are largely related to urban and suburban sources. Contact with alkaline water and carbonate rocks in the lower Hawthorn and Floridan aquifers may result in precipitation of phosphate as carbonate hydroxylapatite (Florida's "hard rock phosphate deposits"; Upchurch, 1992), so orthophosphate concentrations in Floridan aquifer water are limited by aquifer

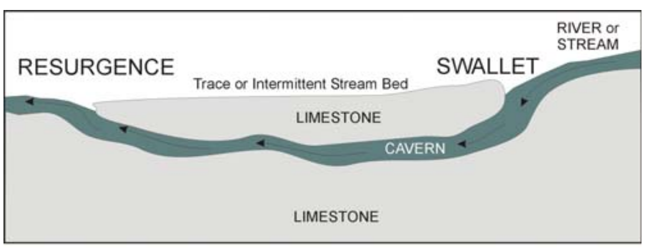


Figure 7a – Cross section of a swallet-resurgence system.
The stream goes underground and then re-emerges at resurgence. During periods of excessive runoff, ability of the swallet to take runoff may be exceeded in which case the trace or intermittent stream is flooded.

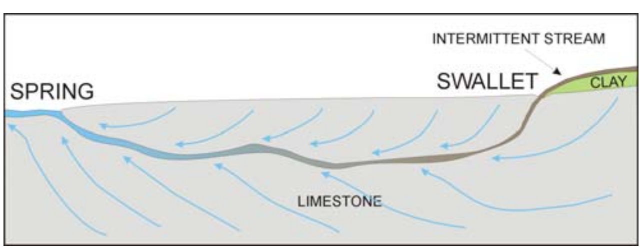


Figure 7b – Cross section of a swallet-to-spring system fed by an intermittent stream.
Normal spring discharge is regional groundwater.

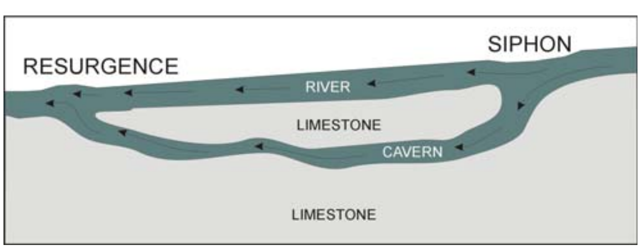


Figure 7c - Cross section of a siphon - resurgence system.
The stream partially goes underground and then re-emerges at a resurgence.

chemistry.

After the scarp has retreated from an area, the Lowlands Domain prevails. The area is pockmarked by numerous sinkholes that make the aquifer vulnerable to contamination. Soils are highly conducive to agriculture, and contamination by nitrate and related constituents is widespread. Because of high alkalinity, phosphate concentrations are limited in the Lowlands Domain.

Stream Behavior At The Cody Scarp

Streams that cross the Cody Scarp are typically associated with swallets and/or siphons. In fact, White (1970) pointed out that, with the exception of the Suwannee River, all of the streams that cross the Scarp go underground. Water captured by the swallets and/or siphons typically emerges from the aquifer as springs or resurgences (Figure 7).

Swallets - Swallets are associated with all sized streams from rivers to small, intermittent streams. Since they normally capture the flow of a stream, there is often a dry stream segment down gradient from the swallet.

Figure 8a – The Santa Fe Sink at O'Leno State Park near High Springs, Florida.
The Santa Fe River flows into a large swallet and goes completely underground here. The light green Duckweed floating on the surface defines a slow gyre over the drain.

Figure 8b – The Santa Fe Rise at River Rise State Preserve, near High Springs, Florida.
Here, the Santa Fe River emerges from a cavern system connected to the River Sink (Figure 8b). Note that the water emerging through the resurgence is stained by dissolved organics even though there is a groundwater contribution to the discharge. The actual resurgence is in the center foreground.

The Santa Fe River example is the largest swallet-to-resurgence system (Figure 7a) in Florida. The Santa Fe River totally goes under ground at the River Sink in O'Leno State Park near High Springs, Florida (Figure 8a), and it emerges at a resurgence (Figure 8b) known as the at River Rise State Preserve after traveling several miles underground.

Swallets that capture small streams may not have a directly identifiable resurgence. Rather, the surface water that is captured in the swallet simply becomes incorporated in the regional groundwater system (Figure 7b). The groundwater is likely to discharge down gradient at a spring, and discharge from many of the springs near the Cody Scarp has been connected to swallets by dye tracing. During periods between rainfall events, the streams may be very small or dry. When this occurs, the water that discharges from the associated spring is groundwater with little surface water contribution. High runoff events may alter this pattern and the spring water may become discolored. The water of Wakulla Spring in Wakulla County, Florida, is notorious for turning brown during high runoff events.

Figure 9a illustrates a small swallet known as Rose Creek Swallet. It captures runoff in Rose Creek (Figure 4). This captured surface water is diluted by regional groundwater flow, and it is rare that the springs that discharge this water becomes discolored. Rose Creek Swallet is one of many in the Ichetucknee Trace. Water captured in the swallets of the trace discharge through the springs of the Ichetucknee Spring Group (Figure 9b). Many of the flow systems associated with these swallets have been connected to the springs through dye tracing (Karst Environmental Services, 1997; Butt and Murphy, 2003, Butt et al., 2006).

Figure 9a – Rose Creek Swallet, a swallet located at the terminus of Rose Creek, Columbia County, Florida.
This creek flows off the Northern Highlands and goes underground in this sink (Figure 4). When discharge is greater than the capacity of the sink, water flows to the next sink down-gradient on the Ichetucknee Trace.

Figure 9b – The Ichetucknee Head Spring, Ichetucknee State Park, Florida (Figure 4).
Hydraulic connections between Rose Sink Swallet and the Ichetucknee springs have been established by dye tracing (Karst Environmental Services, 1997). Note that while water entering the system through swallets may be colored, spring water is clear because of the dominance of groundwater rather than surface water in spring discharge.

Siphons – Figure 7c illustrates a cross section of a siphon-resurgence system. Siphons differ from swallets in that they only partially capture the flow of the source stream. The resurgences associated with the siphons are often nearby. While the resurgences are considered springs by many, most appear to be part of the flow system of the river.

Downstream from the River Rise resurgence, portions of the Santa Fe River go under ground at several siphons and emerge at resurgences. For example, Figure 10a illustrates a siphon near High Springs on the Santa Fe River. This and other siphons capture water from the Santa Fe and transport it about 1,100 feet west to discharge at a large spring known as Columbia Spring (Figure 10b). Two known siphons account for about 42 percent of the discharge from Columbia Spring. The connections between these siphons and the spring have been confirmed by cave divers (Butt et al., 2007).

Figure 10a – Columbia Siphon (North Bank). Butt et al. (2007) identified two siphons on the Santa Fe River that drained water into a cavern system that discharges at Columbia Spring, a large spring near High Springs, Florida. Hornsby and Ceryak (1998) estimated that the siphon was taking about 60 cubic feet per second (cfs) in early 1998. The siphon on the south bank was thought to be taking about 70 cfs, for a total capture from the river of about 130 cfs.

Figure 10b – Columbia Spring. This spring is the resurgence associated with the Columbia Siphons (Figure 10a; Butt et al., 2007). In early 1998 Hornsby and Ceryak (1998) measured discharge at 306 cubic feet per second, so the two siphons described above accounted for about 42 percent of the flow from this spring.

Conclusions

The Cody Scarp is a prominent topographic escarpment that extends in an arc from Alachua County to the southeast to Leon County in the northwest. It is characterized by large sinkholes, sinking streams, springs and resurgences, and profound changes in groundwater quality in the upper Floridan aquifer. The adjacent uplands (the Northern Highlands) are not typically karstic and well-developed stream systems are developed. The lowlands (Gulf Coastal Lowlands) are characterized by numerous, small sinkholes and a thin sand mantle over the Floridan aquifer limestone.

The clay-rich strata of the Miocene Hawthorn Group under the Northern Highlands confine the underlying Floridan aquifer, which results in relatively low permeability, sluggish flow systems, and low aquifer vulnerability. In contrast the scarp is a region of developing karst conduits and elevated aquifer permeability. The Gulf Coastal Lowlands are characterized by little or no cover over the limestone aquifer and a mature karst flow system. The Floridan aquifer under the scarp and lowlands is highly vulnerable and contamination by pollutants, such as nitrate, is widespread.

Streams on the Highlands are characterized by dendritic drainage patterns and interaction with the surficial aquifer and, to a limited extent, permeable zones in the intermediate aquifer system. When streams cross the Cody Scarp, they commonly go underground and reappear as resurgences or springs.

It is necessary to understand the origin of the Cody Scarp and how it affects the MFL water bodies of the Suwannee River Water Management District that are adjacent to the scarp in order to determine what can be achieved by setting MFLs and why different forms of MFLs are recommended for different water bodies.

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November, 2014

To the readers of this guidebook, an update to geomorphic terminology is needed. In a previous SEGS Guidebook, I contributed an article, “Mature Karst Features in North Central Florida” (Copeland, 1981). I used geomorphic terminology of the time as defined by Puri and Vernon (1964), White (1970), and modified slightly by Lawrence and Upchurch (1976). By 2005, the terminology was updated (Scott, 2005). In the table below, the left-hand column lists the previous terminology, while the right-hand column lists updated versions in terms as defined by Scott.

Rick Copeland, P.G.

Table 1. Comparison of Geomorphic Terminology for Units in SEGS Guidebook # 63 Area

Terminology – SEGS Guidebook #23	**Terminology – SEGS Guidebook #63**
Northern Highlands	Madison Hills – W. of Alapaha River Northern Okeefenokee – E. of Alapaha River
Gulf Coastal Lowlands	Branford Karst Plain
Transition Region	Alachua Karst Hills

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Hydrogeology of the Swallet and Resurgence System in the Alapaha River, Hamilton County, Florida

By

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Abstract

The Alapaha River originates in south Georgia, and only a small part of the basin is located in Florida. In Florida, the Alapaha encounters karstic limestone and dolostone for the first time. At low flow, the river is entirely captured by a series of swallets in the river mainstem and a large blind valley and swallet off the mainstem. This captured water emerges through two resurgences: the Alapaha Rise and Holton Creek Rise, where it then joins the Suwannee River. At high flow, river discharge exceeds the capacity of the swallet system to capture water and excess water flows to the Suwannee River via a normally dry stream channel.

Hydrographs of river flow were generated and utilized to estimate the amount of water captured by the swallet system, the discharge threshold below which all river water is captured by the swallets, and relationship of stream capture in the river and discharge at the river resurgence, the Alapaha Rise.

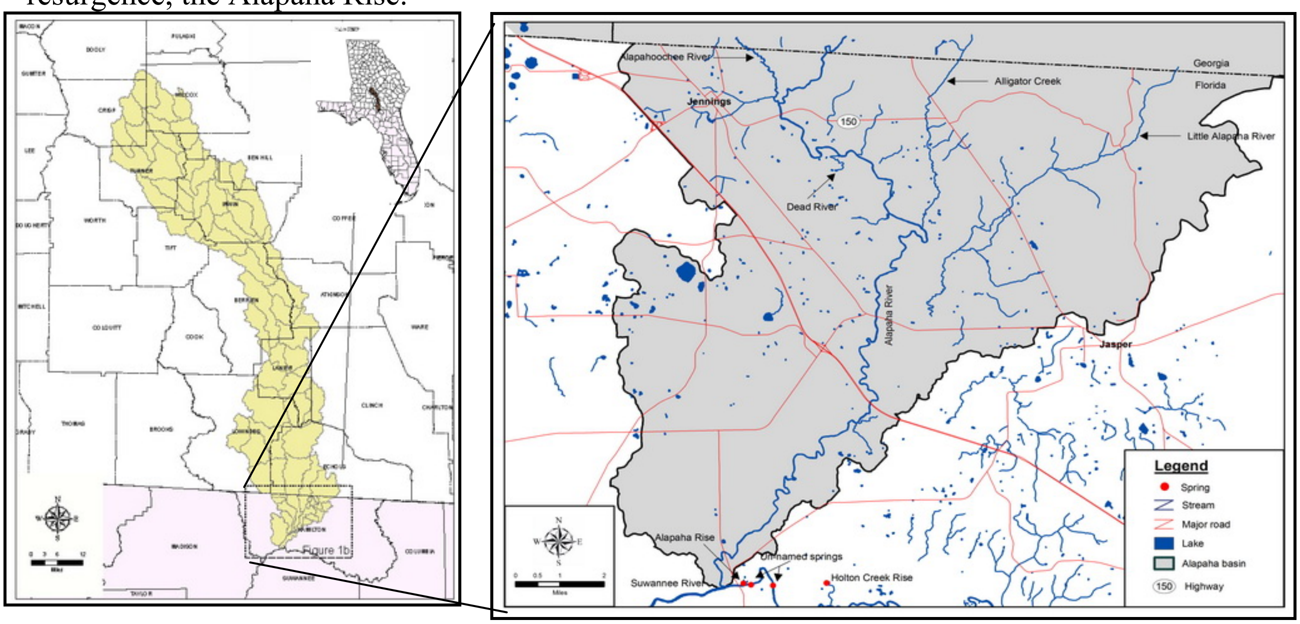

Figure 1. Location of the Alapaha River and important features in the drainage basin in Florida.

Introduction

This paper presents an overview of the drainage system of the Alapaha River in Florida and a context for modeling the dynamics of water capture at a series of swallets in and off the river's mainstem. Many of the streams that cross the karst escarpment known as the Cody Scarp (Puri and Vernon, 1964) go underground for a portion of their flow across the scarp. The Santa Fe and Alapaha rivers are the best known of these streams. Thanks to work by Jon Martin and his colleagues at the University of Florida, much is known about the Santa Fe's underground flow system. In contrast, little is known about the Alapaha's.

Sufficient data exist for modeling of the capture mechanism at the swallets and determination of the discharge threshold beyond which the swallets are less efficient at stream capture and overland flow begins. The water captured in the Alapaha swallet system discharges through two resurgences that flow directly into the Suwannee River. There are sufficient data to model the response of the larger of the two resurgences, the Alapaha Rise, to discharge events in the Alapaha and stage of the Suwannee River. This paper summarizes the results of this modeling.

Acknowledgements, Photographs, and Investigation Context

In 2007, the author's team was tasked with developing a technical-basis report for the purpose of establishing minimum flows and levels (MFLs) for the Alapaha River in Florida by the Suwannee River Water Management District. This paper presents a portion of the results in that document. Details of the statistics used to establish the flow regimes for the Alapaha River will be published elsewhere, and the basis document prepared for the District is public record and should be available upon request from the District. The MFLs have not been adopted by the District because so much of the Alapaha River drainage basin is within Georgia (Figure 1) and beyond regulatory authority in Florida.

Jim Schneider and Kyle Champion provided much of the technical expertise required for this study. The Suwannee River Water Management District provided support and encouragement for the study. John Good, Kirk Webster, and David Hornsby were especially important to the study.

The black and white images used to illustrate this paper were taken on the 1981 SEGS Alapaha fieldtrip or at approximately the same time. Look for old friends with bushy, 1980s hair and beards.

Alapaha River Drainage Basin

The Alapaha River Basin (Conover and Leach, 1975) encompasses roughly 100 mi.^{2} of central Hamilton County (Figure 1). This area represents less than 10 percent of the Alapaha drainage basin, which covers approximately 1,700 mi.^{2} and extends northward nearly 100 mi. into southern Georgia. The portion of the Alapaha River Basin within Florida contains approximately 15 sub-basins, some of which are internally drained, karst basins that do not contribute direct runoff to the Alapaha River.

Figure 2. Rock-bound channel at shoals area north of the SR 150 Bridge.

Figure 3. Rock shoals approximately 1 mi. upstream of the SR 150 bridge.

Figure 4. View of the Alapaha River looking north (upstream) from the SR 150 bridge.

Figure 5. Sinkhole in the bed of the Alapaha River near the mouth of the Dead River blind valley.

The Alapaha River begins in southern Georgia near the town of Cordele (Figure 1). From its headwaters, the river flows southeast through agricultural lands of the Southeastern Plains of Georgia before turning southward across the Okefenokee Plains (Griffith et al., 2001) or Northern Highlands (White, 1970). As the Alapaha flows southward, the river passes through forested areas and wetlands that skirt the western boundary of the Okeefenokee Swamp. The Alapaha River enters Florida near the town of Jennings (Figure 1).

South of State Route (SR) 150 (Figure 1), the river is incised into a rock-bound channel (Figure 2) with rock shoals (Figure 3) and a narrow floodplain. The shoals are primarily composed of dolostone and sedimentary opal (opal-CT) of the Miocene Hawthorn Group (McFadden, 1982).

Figure 6. One of the Alapaha's in-stream swallets.

Downstream from the shoals, the floodplain broadens (Figure 4) for a short distance. It then enters a reach where swallets begin to capture a significant amount of surface flow to the underlying Floridan aquifer. The development of swallets results from the thinning of the Hawthorn Group semi-confining beds by erosion as the river flows south (Ceryak, 1977, 2005).

During low to moderate flows in the river, surface-water discharge diminishes until it is entirely captured by swallets (Figures 5 and 6) in the bed of the river southeast of Jennings (south of the SR 150 bridge) and in a "blind valley."

A major swallet is located at the terminus of a "blind valley" known as Dead River. Blind valleys are karst features characterized by flow of surface water that is diverted from the mainstem of a river into a stream channel that terminates in a sinkhole/swallet, through which surface water recharges the underlying, carbonate aquifer. Figures 7 and 8 depict Dead River and its swallet, respectively.

Overland flow in the Alapaha River reaches the Suwannee River only during high flows and floods, when discharge upstream at Jennings is about 350 to 500 ft.^{3}/s (cfs). About 50 % of the time, the lower river is dry owing to the capture of discharge from the upper river at the swallets about 3 river mi. south of the SR 150 Bridge.

Figure 7. Dead River during a drought.

Figure 8. Dead River swallet.

Figure 9. View looking downstream in the dry Alapaha River bed at the mouth of the Dead River blind valley.

Figure 10. View of the dry Alapaha River bed downstream of the swallet system.

Figure 11. Mouth of the Alapaha River as seen from the Suwannee at moderate low flow.

Figure 12. The Alapaha Rise on the north bank of the Suwannee River.

When the lower Alapaha River is dry, large, sandy bed forms are exposed (Figure 9 and 10). Lawn (1989) showed that these sand bars are mobile during episodes of flooding, and a small "delta" of sand extends from the mouth of the river into the Suwannee River (Figure 11).

The river water that enters the aquifer at Dead River and the swallets in the river bed discharges to the Suwannee River through two resurgences (Ceryak, 1977). These resurgences are the Alapaha Rise (Figure 12), which drains directly to the Suwannee River and Holton Creek Rise (Figure 13), which drains to the river through Holton Creek.

The water that drains into the underlying upper Floridan aquifer can be identified within the aquifer because of color, odor, and iron content. Ceryak (1977) showed that this water spreads over an area of about 50 square miles in the aquifer.

Discharge from the Alapaha Rise is usually discolored by humic substances. Therefore, it reflects primary capture of river water at the swallets. At low flow, discharge from Holton Rise is limited and constitutes relatively clear Floridan aquifer water. This resurgence appears to serve as an “overflow” route for water that is unable to discharge at the Alapaha Rise.

Figure 13. Holton Spring and the head of Holton Creek.

Topography, Physiography, Recharge, and Drainage

Topography

The topography of the Alapaha River Basin in Florida varies. Land-surface elevations range from less than 50 ft. above sea level near the confluence with the Suwannee River to elevations in excess of 150 ft. in upland areas along the Florida-Georgia state line. In the immediate vicinity of the Alapaha River, however, elevations are generally less than 100 ft.

Physiography

The Alapaha River Basin lies largely within the Northern Highlands/Okeechobee Plains physiographic province (White, 1970; Griffith et al., 2001, respectively). In Florida, its entire reach is within the Cody Scarp (Puri and Vernon, 1964) and near its mouth the river enters the Gulf Coastal Lowlands.

The Northern Highlands is an upland area (typically greater than 75 ft. above sea level). The Gulf Coastal Lowlands lie adjacent to the Northern Highlands and is an area of subdued topography, underlain by a thin veneer of sandy cover over karstic limestone of the upper Floridan Aquifer System. The Gulf Coast Lowlands (typically between 25 and 75 feet above sea level) is a mature karst plain Sinkholes in the Coastal Lowlands are typically small in area, but they are numerous (Upchurch, 2002).

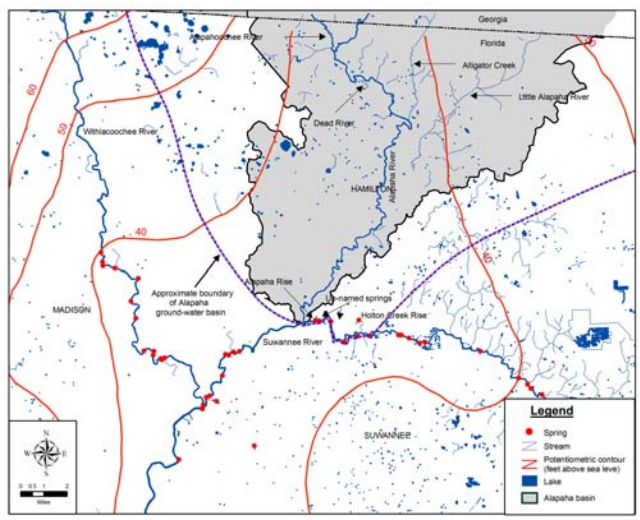

Figure 14. Potentiometric surface of the Floridan aquifer and approximate location of the Alapaha ground-water basin in the vicinity of the Alapaha River in Florida. Data modified from SRWMD (1995)

Drainage

The Alapaha River surface-water basin is interesting in that it is somewhat asymmetrical (Figure 14). On the east, the Hawthorn Group, which underlies the Northern Highlands Province and Okefenokee Plains, prevents significant groundwater recharge and a dendritic pattern of tributary streams has developed. Note, however, that many of the streams that are considered tributaries of the Alapaha go underground through swallets before reaching the Alapaha River. The Little Alapaha River, for example, enters the Floridan aquifer approximately 1.2 mi. east of the Alapaha through a large, complex swallet (Figure 15).

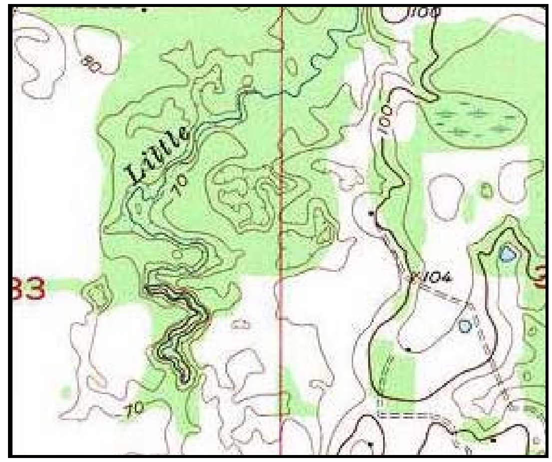

Figure 15. Topographic map of the lower reaches of the Little Alapaha River and swallet.

On the west, the Hawthorn Group has been penetrated by numerous sinkholes, and surface-water drainage is almost entirely internal. Only the Alapahoochee River, which lies in part in a collapsed cavern system, enter the Alapaha River from the west. As such, the Alapaha River surface-water drainage basin identified by Florida agencies includes a true surface-water system on the east and little direct drainage to the river on the west.

The groundwater basin is characterized by flow toward the river (Figure 14) from the east and west. In Florida, the basin abuts the Suwannee River groundwater basin on the east and the Withlacoochee River groundwater basin on the west (Figure 14).

Recharge

The abundance of sinkholes and closed depressions (Figure 16) along the southern margin of the Northern Highlands (i.e., the Cody Scarp of Puri and Vernon, 1964) has created a landscape that favors large internally drained basins, which greatly increase the relative amount of recharge to the Floridan aquifer system. The internally drained basins that lie along the western side of the Alapaha River watershed (Figure 16), therefore, contribute very little, if any, surface-water runoff to the Alapaha River.

Other factors affecting recharge rates include the development of surface-water drainage, variations in water-level gradients between surface water, the surficial aquifer and the Floridan aquifer, and aquifer permeability. Low recharge rates occur where confining materials overlying the aquifer retard downward vertical movement of water, or where an upward gradient exists between the Floridan and surficial aquifers. Recharge to the Floridan aquifer is directly related to the confinement of the Floridan aquifer system and karst. The highest recharge rates occur where the Floridan is unconfined or poorly confined as in those areas where the aquifer is at or near land surface. Recharge may also be high in areas where the confining layers are breached by karst features, such as sinkholes in the Cody Scarp (Figure 15) and the sinkhole swallets within the Alapaha River near Dead River.

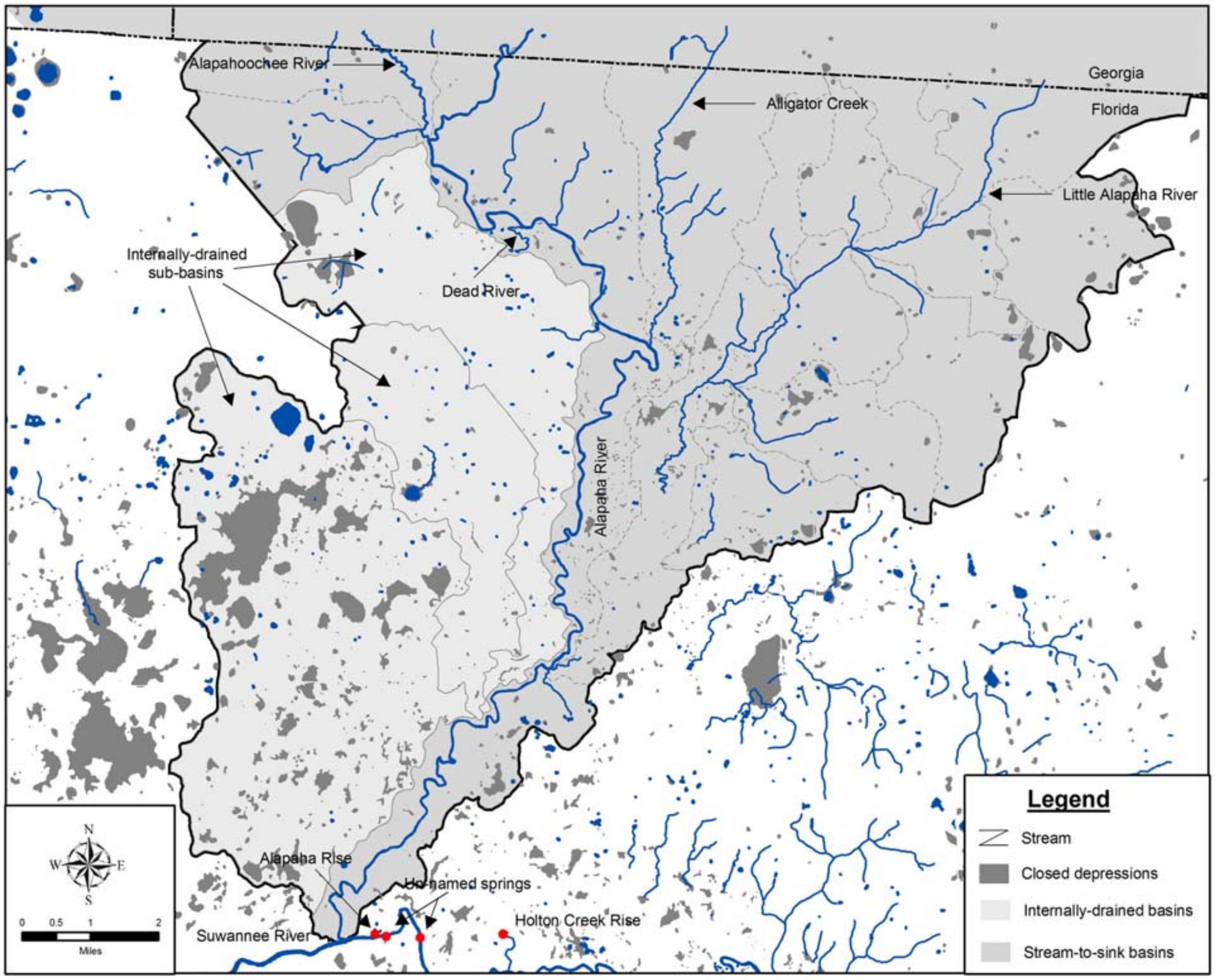

Figure 16. Closed depressions and internally drained basins within the Alapaha River watershed in Florida.

Karst in the Alapaha Basin

The lower Alapaha River Basin (Cody Scarp and Gulf Coastal Lowlands) is an area of intensive karst development, characterized by numerous sinkholes (Figure 16), lack of surface-water. drainage, and undulating topography. In karst areas, dissolution has created enlarged cavities along fractures in the limestone, which eventually collapse or reach the surface and form sinkholes. Sinkholes capture surface-water runoff and funnel it underground, which promotes further dissolution of limestone. This dissolution leads to progressive integration of voids beneath the surface over time and allows increasingly larger amounts of water to be transported through the ground-water system.

Groundwater may flow rapidly through conduits and passages with the limestone or slowly through minute pore spaces within the rock matrix. Dye-trace studies in Columbia County show that ground water near Ichetucknee Springs may travel approximately one mile per day in active conduits in the Floridan aquifer (Karst Environmental Services, 1997). Similar velocities were recorded near Sulphur Springs in Hillsborough County (Stewart and Mills, 1984). Studies such as these clearly indicate show that ground water has the potential to flow rapidly and traverse great distances in a short amount of time in karst environments near major springs. Because the flow in these karst conduits is rapid and direct, dispersion, dilution, and retardation of contaminants is likely to be minimal and the springs are vulnerable to contamination.

The calculated lag time between a recharge event in the Alapaha River near Dead River and the Alapaha Rise varies from about 2 to 21 days depending on discharge at the Jennings gage. The lag reflects a period of time sufficient for water to enter storage in the aquifer and migrate to the resurgences (Alapaha and Holton Rises). Ceryak (1977) showed that river water invaded a very large area of the aquifer (≈ 50 $mi.^2$), so it is apparent that flow to the resurgences is not entirely by a single conduit system. The dispersion of colored, river water in the aquifer is evidence that the conduit system is complex and has a strong lateral as well as longitudinal flow network as it works its way to the resurgences.

On a smaller scale, the Alapaha has abundant evidence of karst activity, including development of karren (Figures 17 and 18). Epikarst and karren structures are best developed in the Suwannee Limestone near the mouth of the Alapaha (Figures 11 and 18).

Figure 17. Small-scale karren and vugs in the Statenville dolostone near the junction of Dead River and the Alapaha.

Figure 18. Karren and epikarst in the Suwannee Limestone near the Alapaha Rise.

Hydrologic Analysis of the Swallets and Resurgence

Data Quality

Stage and/or discharge data exist for four gages in the Alapaha River Basin (Figure 19). Large gaps exist in these data sets. However, where data gaps exist at one station, excellent data exist at another, which enables synthesis of discharge and stage data to fill the missing data gaps at each station.

The quality of the data used for the regressions had the following issues:

- Excellent discharge and stage data for the Alapaha River near Statenville, GA;
- Spotty stage and discharge data for the Alapaha River near Jennings;
- Spotty data, including long periods with zero discharge, at the Jasper gage;
- Very limited discharge data for the Alapaha Rise; Limited discharge data for the Holton Creek Rise; and
- Gaps in long-term, stage and discharge data for gages on the Alapaha River in Florida.

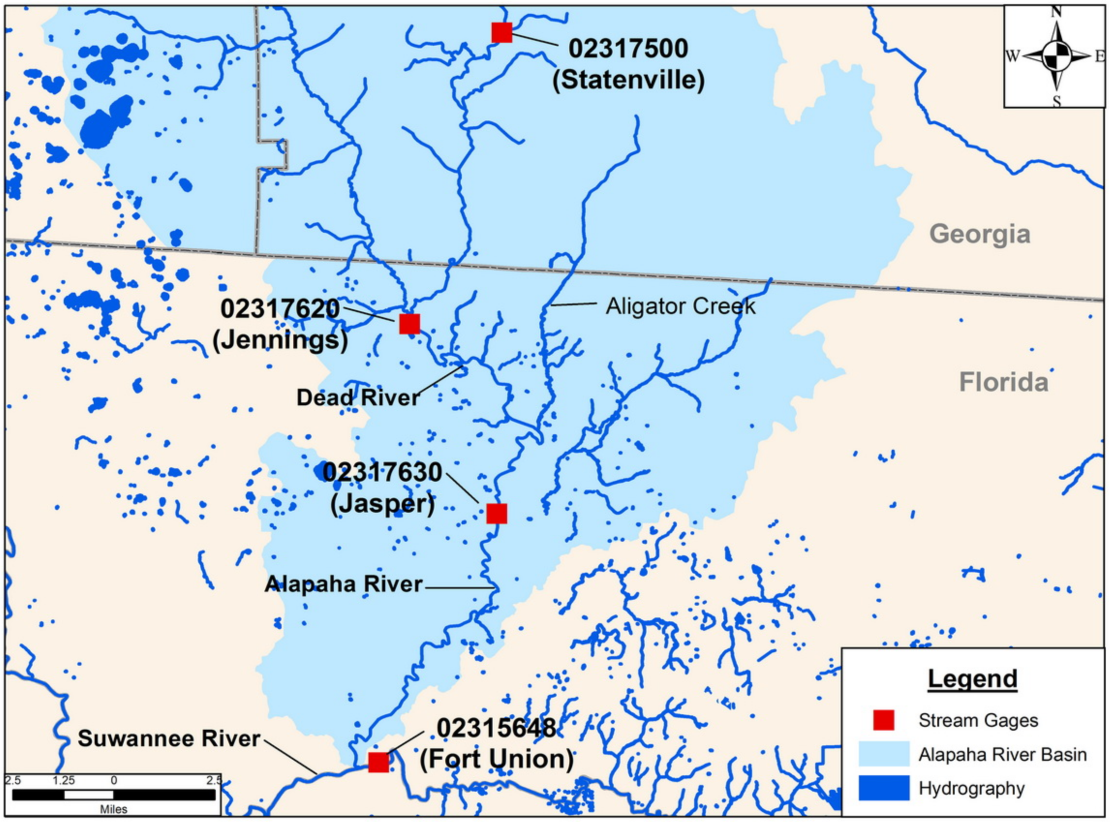

Figure 19. Locations of stream stage and discharge data to fill data gaps.

The most complete and extensive data set was from the Alapaha River near Statenville, GA gage (Figure 19), which was provided by the Georgia USGS. The data set for the Alapaha River near Jennings spanned roughly 25 years, though one large gap (~10 years) and numerous smaller gaps existed. The gage on the Alapaha River near Jasper had never been continuously monitored, but there were many discharge and/or stage data points scattered through time. Limited discharge data for the Alapaha Rise were also available. The discharge data from Holton Rise and Creek were too sparse to allow for data synthesis.

Modeling Methods

It was possible to synthesize stage and discharge data for all gages except Holton Rise/Creek through simple linear and multiple regressions between stage and discharge measurements at pairs of gages and nearby Floridan aquifer monitoring wells. Time lags between events at different measurement stations were determined by cross-correlation and factored into the regressions as necessary.

The goodness of fit of the regressions varied with the amount of available data and complexity of the flow system being modeled. In general, regressions were excellent and captured a large proportion of the data variability with coefficients of determination (R^2) greater than 0.90. Regressions between Alapaha River flow and stage and lagged discharge at the Alapaha Rise had R^2 values greater than 0.70.

Discharge and stage time-series data were modeled using the lagged endogenous variable method, beginning upstream with the best data - the Statenville gage data. Daily Statenville data were used to model daily discharge and stage data at Jennings, the gage just above the swallets.

Then the Jennings data were used to model discharge at Jasper, the gage below the swallets, and, finally, discharge from the Alapaha Rise was modeled using the reconstructed data from all three riverine gages and water levels in nearby Floridan aquifer monitoring wells.

There are backwater effects in the lower Alapaha River caused by high stages in the Suwannee River. As a result, discharge and stage data were compared to stage in the Suwannee River at the Ellaville gage, the first gage downstream from the mouth of the Alafia. Similarly, the modeled discharge of the Alapaha Rise was compared to Suwannee River stage at Ellaville.

Modeling to Fill Data Gaps

Lag times between flood events at all three gages on the Alapaha River were approximately 1 day, which were included in the discharge and stage regression models for data reconstruction.

As an example of use of regression to fill time-series data gaps, Figure 20 compares the measured and modeled discharge of the Alapaha River at Jennings. Note that the low to medium flows and stages were accurately accounted for but high flow events were not always captured in the simulation. Extreme high flow events were both under- and over-estimated.

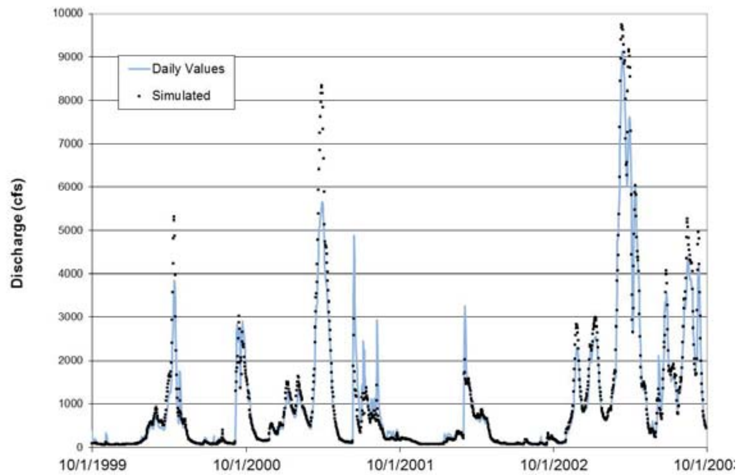

Figure 20. Comparison of modeled and measured discharge of the Alapaha River at the Jennings gage.

Similar results were obtained for all data sets. Even so, the ability to fill data gaps and reproduce flow and stage regimes was excellent.

Discharge Captured by the Swallet System

Figure 21, which compares measured discharge at Jennings, upstream from the swallets, and Jasper, which is downstream, provides insight as to capture of water in the swallets.

The regression is excellent with a R^2 of 0.95. Note the discharge downstream from the swallet system does not begin until discharge above the swallets (at Jennings) is approximately 300 - 500 cfs (the intercept of the regression line is 291 cfs). This indicates that the swallets capture up to about 350 to 500 cfs of the

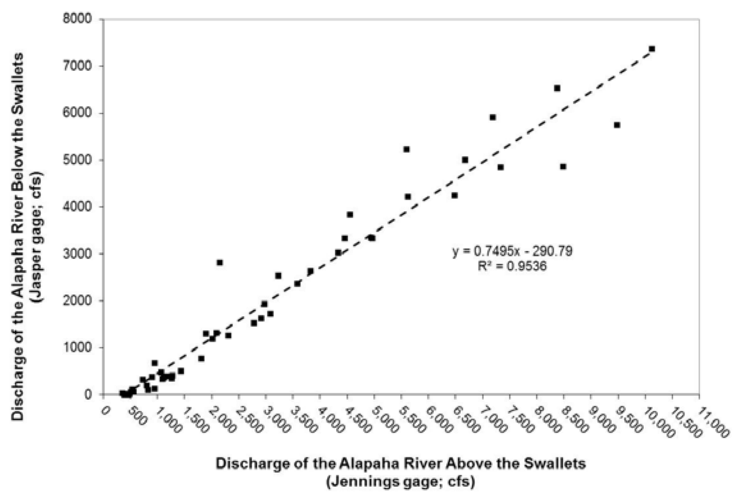

Figure 21. Comparison of the measured discharge of the Alapaha River at Jasper with measured or modeled discharge at the Jennings gages.

river flow at low flow and that there is no river discharge below the swallet area. The slope coefficient of the regression line equation (Figure 20) also suggests that, when the river is flowing at Jasper, its flow is about 75% of the flow at Jennings.

Figure 22 presents another the comparison of discharge above and below the swallets in the Alapaha, Here, a log-log discharge graph using modeled data for times when the Alapaha River at Jasper was flowing provides additional insight into the dynamics of stream capture by the swallets. The model suggests that little or no flow occurs near Jasper when discharge at Jennings is 300 cfs, or less. The graph also suggests that, when discharge at Jennings approaches 10,000 cfs, similar discharge measurements are observed at Jasper. In other words, water capture by the swallet system is completely overwhelmed and the amount of water captured is insignificant compared to the flood.

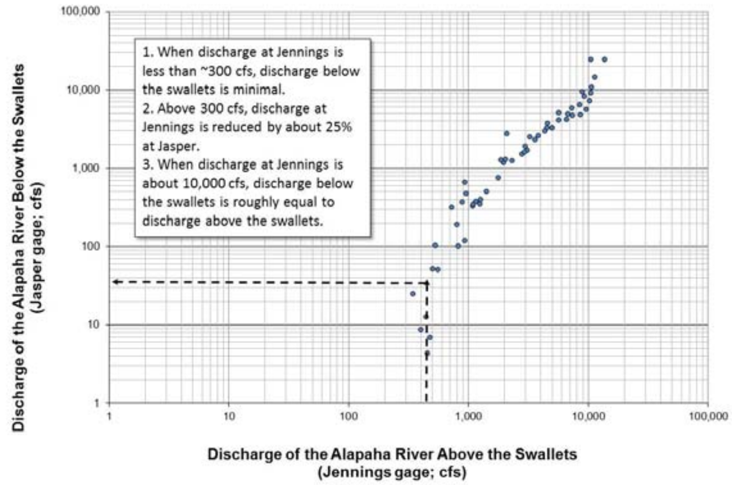

Figure 22. Comparison of discharge above and below the swallet system using modeled data.

Alapaha Rise Hydrogeology

In order to model discharge at the Alapaha Rise, it was important to account for a significant lag time between recharge of the Floridan aquifer at the swallets and discharge at the resurgence. Cross correlation analysis indicated that the lag time is, in part, dependent with flood stage in the Alapaha River. The lag times are as follows:

- When Q < 500 cfs at Jennings, the lag time of the flood peak at the Alapaha Rise is 3 - 6 days (Figure 23) and
- When Q > 500 cfs at Jennings, the peak lag at the Alapaha Rise is 18 - 21 days (Figure 24).

These lag times and stage of the Suwannee River at Ellaville, the nearest downstream gage, were included in modeling of discharge at the Alapaha Rise. This difference in lag times is instructive because it demonstrates the efficiency of the conduit network between the swallet system and resurgence and dependence on flood stage in the river.

The analysis of discharge in the river indicated that the in-stream swallet system captures all flow up to about 300 to 500 cfs. It appears that the Dead River swallet doesn’t function until the in-stream swallets are essentially at capacity. Using a <500 cfs threshold for capture for in-stream and blind-valley swallets, the movement of water to the resurgence is relatively efficient. This relative efficiency suggests a moderately well-developed network. However, when discharge in the river is above 500 cfs, the discharge peak develops slower and over a longer time (18-21 days). This increased lag is a result of the increased complexity of the conduit system required to store recharged water and backwater effects caused by the Suwannee River in flld. Thus, high flow into the aquifer causes the flow system to access less efficient conduits

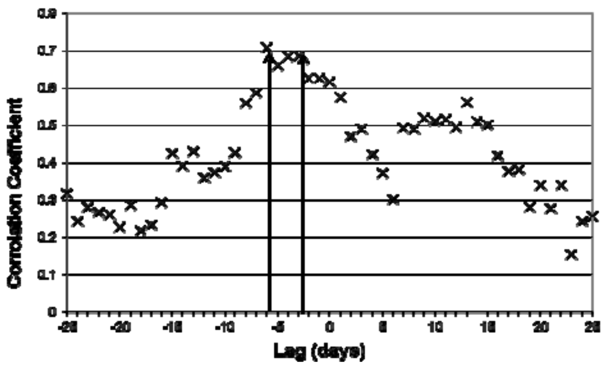

Figure 23. Cross-correlation analysis of lag time between discharge at the Jennings gage on the Alapaha River with discharge at the Alapaha Rise when discharge at Jennings in < 500 cfs. The peak discharge ranges from 3 to 6 days.

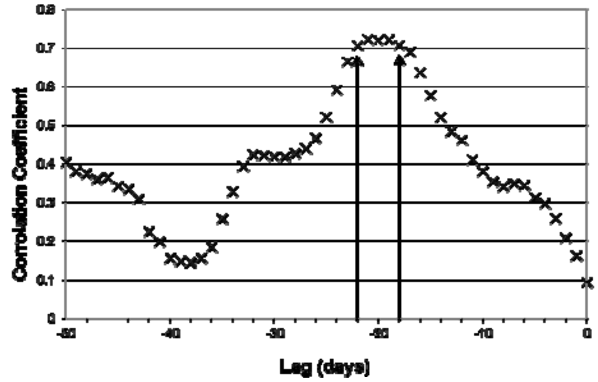

Figure 24. Cross-correlation analysis of lag time between discharge at the Jennings gage on the Alapaha River with discharge at the Alapaha Rise when discharge at Jennings in > 500 cfs. The peak discharge ranges from 18 to 21 days.

Alapaha Rise Hysteresis

Figure 12 was taken from the mouth of the run of the Alapaha Rise. The proximity of the Rise to the Suwannee indicates that there is a significant correlation of Suwannee River stage to discharge of the resurgence. Figure 25 illustrates the relationship of modeled discharge at the Alapaha Rise to discharge in the Alapaha River at Jennings. Clearly, there is a linear relationship between the two variables up to a river discharge of about 300 cfs at Jennings. When Alapaha discharge exceeds 300 cfs, the relationship begins to break down. When the flow in the Alapaha River is less than 300 cfs, flow is low in the Suwannee and the stage of the Suwannee has little effect on discharge at the resurgence. When flow increases in both rivers, the relationship loses predictability because the stage of the river begins to interact with resurgence discharge.

One way to evaluate this effect is to investigate the relationship of river stage to resurgence discharge. Figure 26 illustrates this relationship. Note that the relationship of resurgence discharge to river stage forms broad loops, known as hysteresis loops. These loops reflect backwater, storage, and estavelle processes at springs and resurgences.

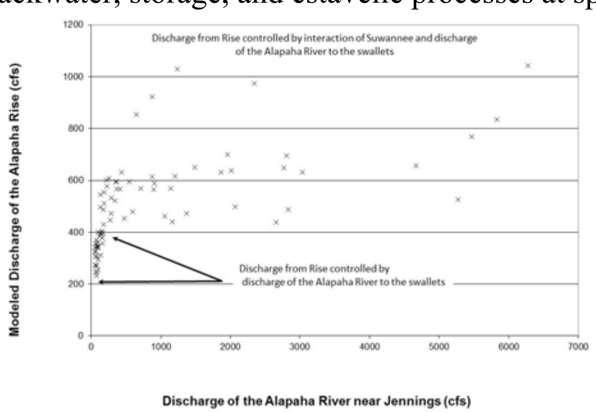

Figure 25. Modeled relationship between discharge in the Alapaha River at Jennings and at the Alapaha Rise.

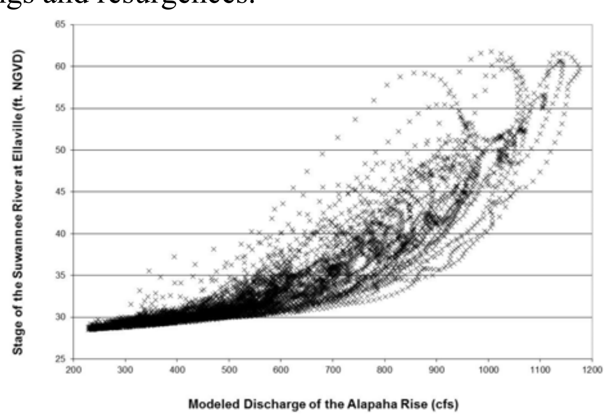

Figure 26. Relationship of modeled discharge from the Alapaha Rise and stage of the Suwannee River at Ellaville.

To simplify interpretation of these hysteresis loops, Figure 27 illustrates one loop that developed during a regional flood from February 11, 1986, to March 31, 1986. The arrows indicate the passage of time. As the river stage began to increase, modeled discharge at the resurgence also increased. These increases reflect the onset of the precipitation that caused the flood. Note that the top of the hysteresis loop is nearly horizontal, indicating that the discharge from the Rise remained relatively constant as the stage of the river began to decline. This delay in response of the Rise to the river stage is a result of backwater effects and storage of groundwater in the aquifer. Finally, discharge from the Rise began to decline as river stage continued to decline. However, the discharge from the Rise is substantially higher than it was at comparable river stage because of release of water backed up, and stored, in the aquifer. The difference in resurgence discharge between rising and falling river stage also hints that the Rise may serve as an estavelle during high river stages.

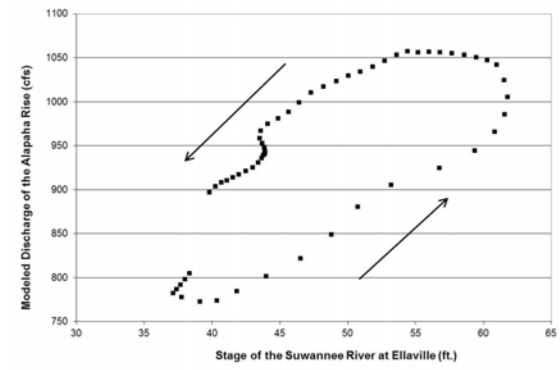

Figure 27. Hysteresis loop at the Alapaha Rise for the Suwannee River flood of February 11 through March 31, 1986.

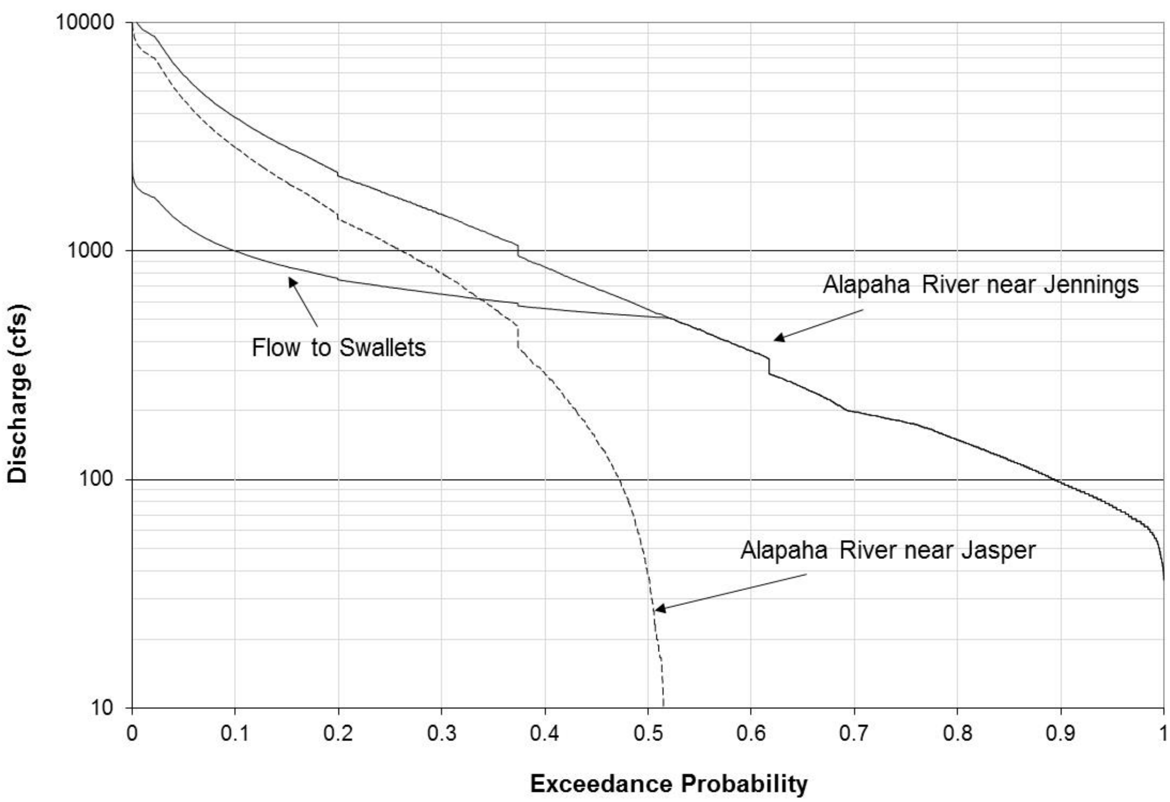

Figure 28. Flow-duration curves for the Alapaha River above and below the swallets and, by difference, flow into the swallet system.

Flow Duration Curves and Capture Thresholds

Modeling of discharge and stage data to fill data gaps results in incorporation of some uncertainty, especially at extreme high flows. Assuming accuracy of the measured and simulated data, it is possible to create flow-duration curves that display the interaction of the Alapaha River with its swallet system. Figure 28 depicts the combined flow-duration curves above and below the swallet system.

Table 1 summarizes the flow duration curves shown in Figure 28. The swallet system captures all of the flow in the Alapaha River at Jennings at low flow, including the 25th percentile (Q_{25}) discharge. In fact, flow is less than 10 cfs at Jennings 51 percent of the time (Figure 28). Even at median flow, the swallets capture a little over 90 percent of the river discharge (Table 1). As flow increases, however, more and more water bypasses the swallets. So that at maximum recorded flood stage for the period of record and including simulated data, the swallets were only capturing about 18 percent of the flow.

Table 1. Comparison of modeled discharge above and below the swallet system on the Alapaha River and calculated losses to the swallet system near Dead River.

	Minimum	Q_{25}	Median	Q_{75}	Maximum
Discharge at the Jennings Gage (cfs)	36	178	555	1,750	13,600
Discharge at the Jasper Gage (cfs; includes days with 0 discharge)	0	0	39	1,060	11,200
Discharge Captured by the Swallet System (cfs)	36	178	517	690	2,400
Percentage of Flow Captured by Swallets	100	100	93	39	18

Conclusions

The Alapaha River is one of several streams and rivers that go underground as they cross the Cody Scarp. The Alapaha goes underground through a series of swallets in the mainstem of the river and by way of a blind valley, known as Dead River, which diverts flow off the mainstem of the river. Portions of the water captured by the swallets are discharged through two resurgences. The Alapaha Rise is located on the bank of the Suwannee River while Holton Rise is connected to the river by a short run known as Holton Creek.

Three stream gages on the river provide stage and discharge data. The upstream gage, located at Statenville, GA, has excellent data, while the downstream gages have sporty data. Discharge and stage data were simulated by regression methods using upstream and monitoring well data in order to fill the data gaps from the two downstream gages. These gages, near Jennings and Jasper, are just upstream and downstream from the swallet system.

Use of time-series data, including simulated data to fill gaps, allowed for estimation of the amount of water captured by the swallet system and the flow threshold above which flow passes the swallets and arrives at the Jasper gage. All of the flow is captured by the swallets about 49 percent of the time. The discharge at the Jennings gage that allows for flow past the swallets is approximately 500 cfs based on flow-duration curve analysis and between 300 and 500 cfs based on comparison of flows using simple data comparisons.

There was sufficient data to model the discharge from the Alapaha Rise. The time lag between peak flows in the Alapaha River at Jennings and at the Rise varied from 3 to 6 days when the flow in the river at Jennings was less than 500 cfs and 18 to 21 days when flow exceeded 500 cfs. Discharge at the Alapaha Rise is influenced by stage of the Suwannee River. This interaction results in hysteresis curves that indicate that high water in the Suwannee backs up water in the aquifer and interferes with discharge from the Rise. The data suggest that the Rise may by an estavelle that takes flow from the Suwannee at high river stages.

There were insufficient data to allow simulation of discharge from Holton Rise.

Modeling capture of water by the swallets provides information as to the hydrodynamics of capture during low and high flow conditions. By comparison with the discharge of the Alapaha Rise, a picture of a complex network of conduits in the subsurface. At low flow in the Alapaha, water is transported fairly efficiently to the Rise. However, at high flow combined with high stage in the Suwannee, water remains stored in the Floridan aquifer and release is controlled by the larger, more complex conduit system and Suwannee River stage.

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Excerpts from a 1988 USF Geology Program Master's Thesis

Sedimentology of a Low Sinuosity Meander within the Alapaha River Hamilton County, Florida

Andrew M. Lawn, M.S., P.G.

Thesis Advisors:
Dr. Bruce Nocita, P.G.
Dr. Richard A. Davis, P.G.
Dr. Sam B. Upchurch, P.G.

The lower Alapaha River is a low-sinuosity, low-gradient, intermittent, bed-load river that has characteristics of both meandering and braided rivers. Discharge within the lower Alapaha River is highly variable, ranging from zero flow to over 500 cms (17,700 cfs), in response to great fluctuations in seasonal discharge as well as base-flow capture by a group of sinkholes a few miles south of the Florida-Georgia border at the Cody Scarp. Bed-load sediment, which is composed primarily of sub-rounded to rounded, medium to very coarse quartz sand, accumulates as point, lateral and transverse bars.

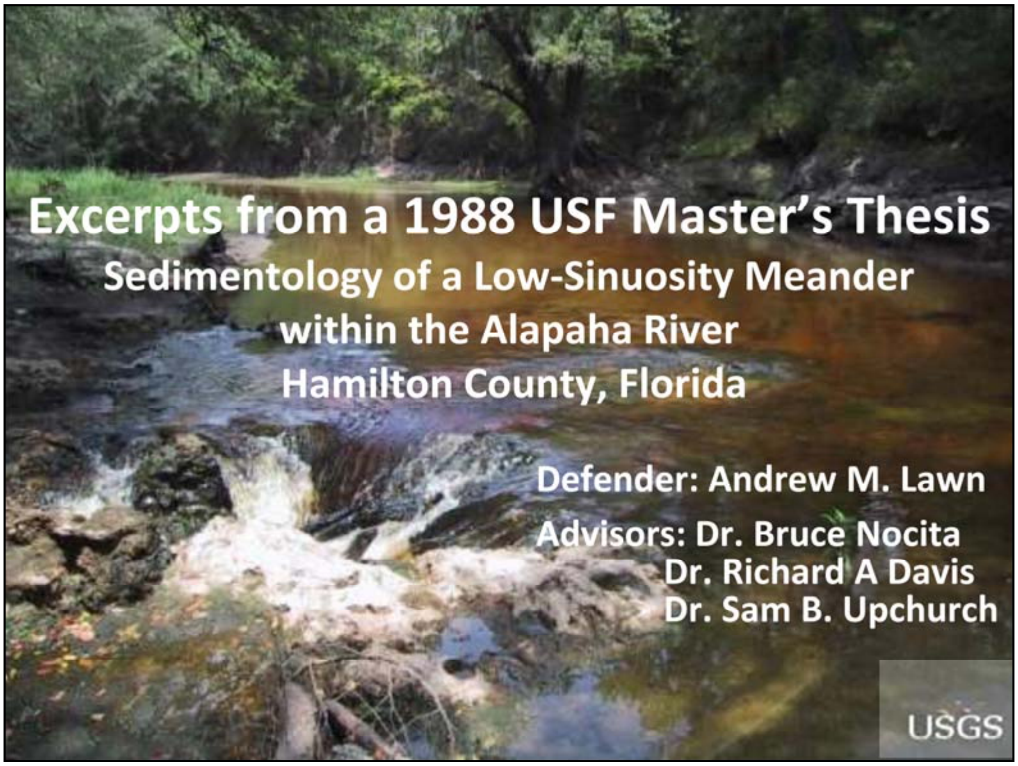
Sediment is transported downriver in the form of ripples, megaripples, plane beds and migrating bars during flood-stage flow as well as during intermittent periods of low flow. Bedforms migrate over the channel floor near the convex banks of meanders where water depths are shallower and flow velocities are lower than those occurring within the thalweg. Bars are developed as sediment is deposited by migrating bedforms that stack vertically.

Disturbances within the riverbed, produced by the addition of fallen trees, slumped bank material or the addition or removal of man-made structures, can lead to reformation of the channel bed topography. Any change in bed topography at one locality will inevitably have an effect on downstream bed configuration. This reactionary effect, coupled with the dynamic discharge and lack of cohesion of coarse sediments that make up the bars results in the lack of any long term stability of individual bars and bedforms.

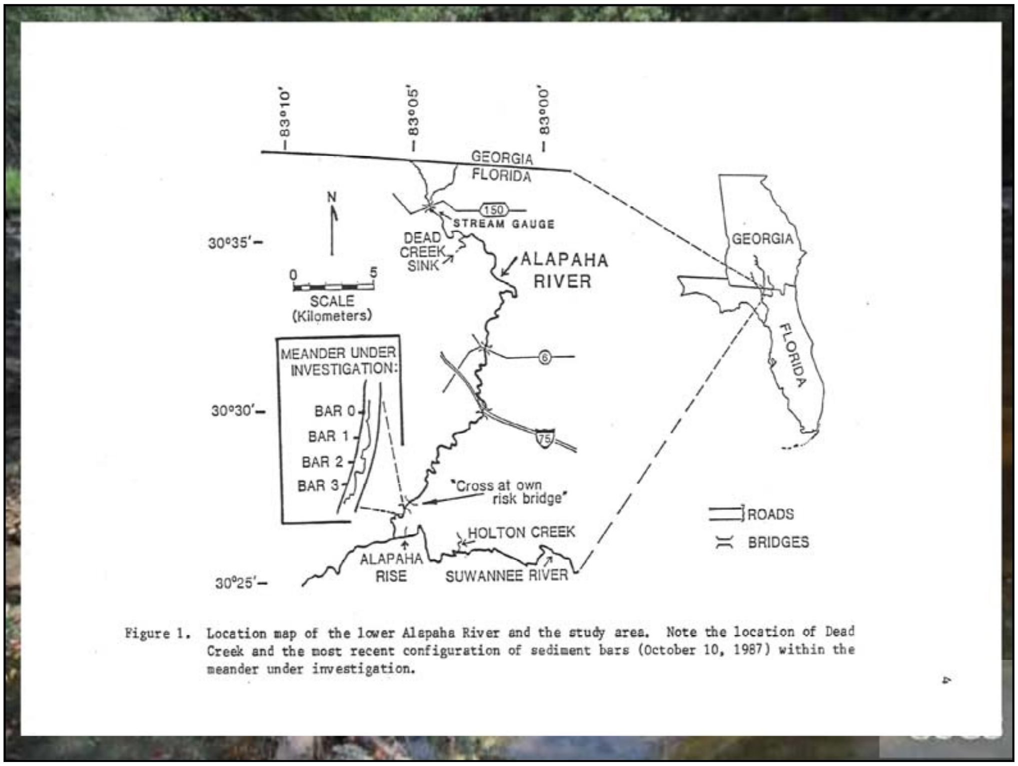
The depositional history of migrating bars within the Alapaha River can be interpreted by time-series topographic mapping and internal investigation of sedimentary structures of exposed bars. Five vertical facies elements including the: 1) gravelly facies, (G), 2) horizontal sand and gravel facies (SGh), 3) trough cross-bedded sandy facies (Scb), 4) ripple cross-laminated sand facies (Scl) and stained sand and mud drape facies (SMs) were distinguished for interpretation of depositional and erosional events. The development of these facies is dependent upon processes associated with the river's dynamic discharge regime.

Facies (G) is deposited as channel lag and exists only within the present thalweg or in areas where the thalweg may have existed in the past. Facies (SGh) is formed between trough cross-sets by deposition of relatively coarse-grained sediment at the base of cross-bed foresets. Facies (Scb) is formed by migrating megaripple deposition and is the most prominent facies constituting the observed bars. Facies (Scl) is formed by migrating ripple deposition during periods of low current velocity and discharge. Facies (SMs) develops as mud and organic material settle out of suspension from pond water during periods of very low or zero river discharge.

Cross-stratified deposits, similar to facies Scb, found within the cut-banks of the river, indicate that preservation can occur where the channel meanders migrate. However, most of the Alapaha River channel is incised in bedrock which inhibits meander migration. Preservation potential is low due to the channel incision below base level.



You might have heard the adage: you learn a little about a lot during college, a lot about a little during grad school and almost everything about almost nothing pursuing a doctorate. You're about to learn almost everything about one small river meander; and all I got out of what seemed to be a tremendous amount of work, was a master's degree. Kidding aside, that degree from USF, which by the way has the most advanced geology curriculum, funding and equipment in Florida, helped me advance my career to being a Principal and part owner of an engineering company, with my own branch office employing engineers and scientists. // I used the excellent USGS photo of the famous Dead River swallet for my slide background.



I started college with a double major in pre-med and graphic arts, planning to be a textbook illustrator for Gray's Anatomy. My mechanical skills and penchant for brute force and ignorance landed me a job in the rock crushing and slicing lab making thin sections from boulders and I fell in love with earth sciences. Those graphics skills came in handy when I found myself sketching many depictions of sedimentology for this thesis. You'll recognize this map compared to your 11 x 17 trip map, but note! – my scale is in kilometers. We scientists have been trying to convert the U.S to the metric system, but I think that when NASA and Lockheed Martin fouled up a mission and lost the $125M Mars orbiter due to a mixup of metric vs English units, the effort suffered a setback. // Several of our six stops are illustrated – Dead Creek Sink (the cover photo), the River, the Rise and Holton Creek. Note my study area – one little meander near cross-at-your-own-risk bridge.

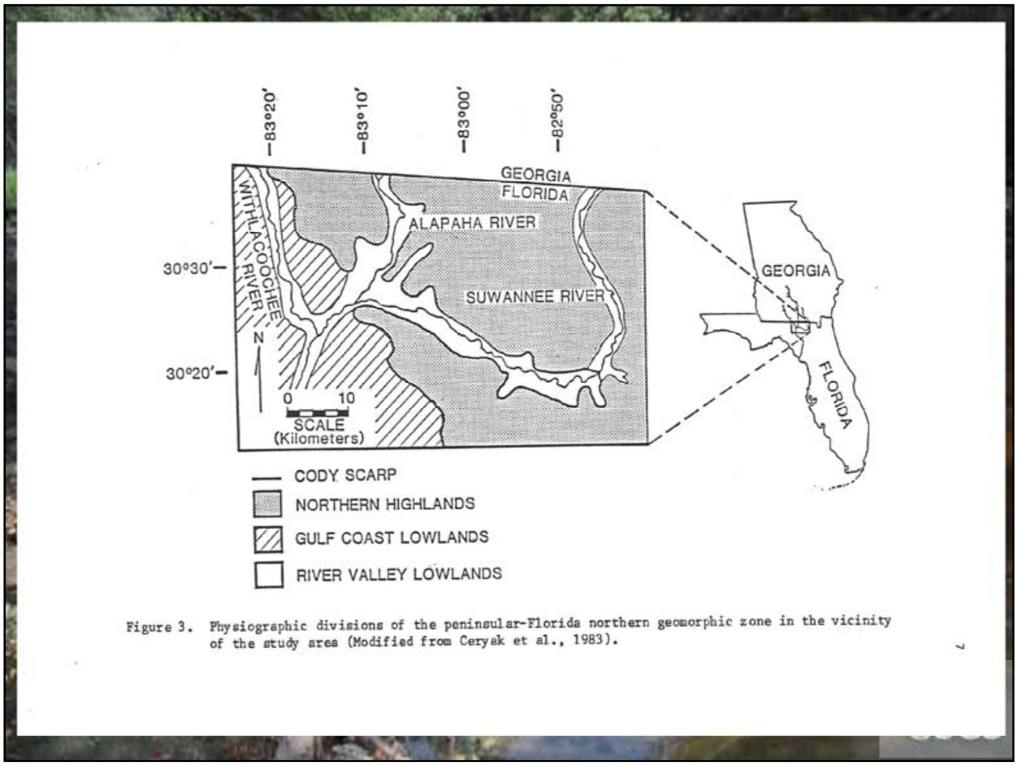
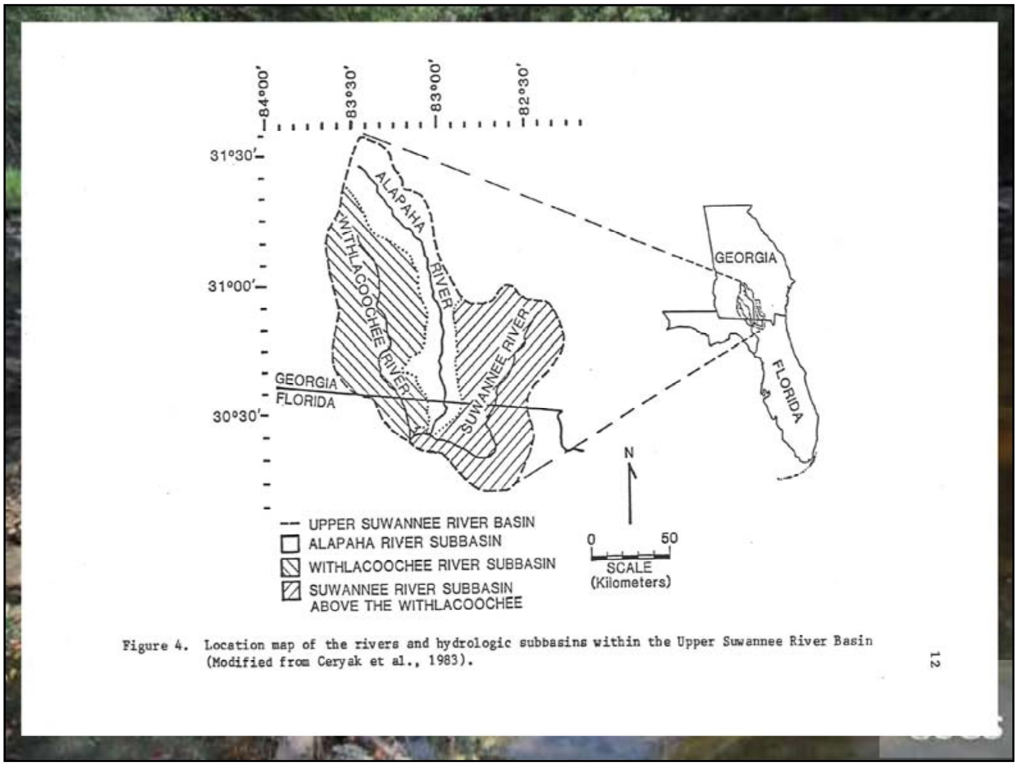


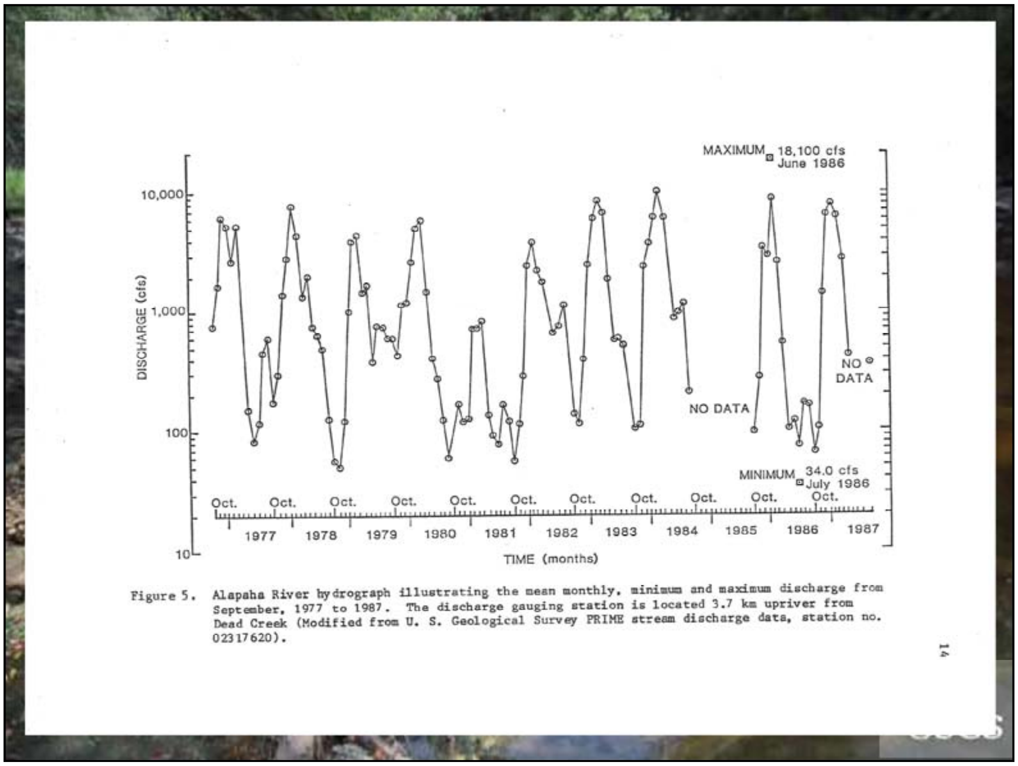
Figure 3. Physiographic divisions of the peninsular-Florida northern geomorphic zone in the vicinity of the study area (Modified from Ceryak et al., 1983).

Another hand drawn figure, but I don't recall if it was my artwork; note that credit is given to SEGS member Ron Ceryak, retired SRWMD Hydrogeologist. // Please raise a hand Ron, so folks know you're one of the present experts. Again, scale in Kilometers; also note the fine-labels made with a Kroy machine. It was an industrial-sized version of the label-making tool you that you may have seen your Mom use.



This map illustrates watershed basins. Note the location of the northern Withlacoochee River; this is one of the top 3 best locations for collecting Florida's State stone. Do any of you college students know what Florida's State Stone is? Agatized Coral, which can be collected in the Northern Withlacoochee River during low flow (now thru the Holidays), or at Caladesi Island on the Treasure coast or at Ballast Point in Tampa – specimens known as Ballast Point Diamonds. Show of hands, who knows what Florida's State Flower is – orange blossom, State bird – Mockingbird, tree – sabal palm, motto – in God We Trust, nickname – the Sunshine State; animal – panther, freshwater fish – largemouth bass, mammal – manatee or porpoise; reptile-gator, shell – horse conch; soil – Myakka soil, gem – moonstone – not found in Fl, but designated after Apollo 11 from Cape Canaveral landed on the moon; pie – key lime, all right last one; song – The Suwannee River aka Old folks at Home by Stephen Foster

And here are some photos of our state stone. These are my lovely daughters filling my truck with coral pilfered from the seawall at Ben T. Davis beach. Swinging my sledgehammer, I knew I was at risk of being kicked out, but with happy girls like that I was willing to take the risk. The coral has many colors and textures; the common botrioidal texture is in the middle. Our Indian predecessors harvested the coral, which is silica opal, chert, flint, etc for making tools. For the record, it is a felony to collect human artifacts from state lands and waterways, so if you find a point, show a trip leader, take a photo and throw it into the woods.



Back to the Alapaha; this hydrograph shows seasonal fluctuations over 10 years. We in the water resources business appreciate this consistency because our industry is constantly pressured to predict water availability. That reminds me of quote from USF professor Mark Stewart, who teaches modeling, that prediction is very difficult, especially when you're talking about the future.

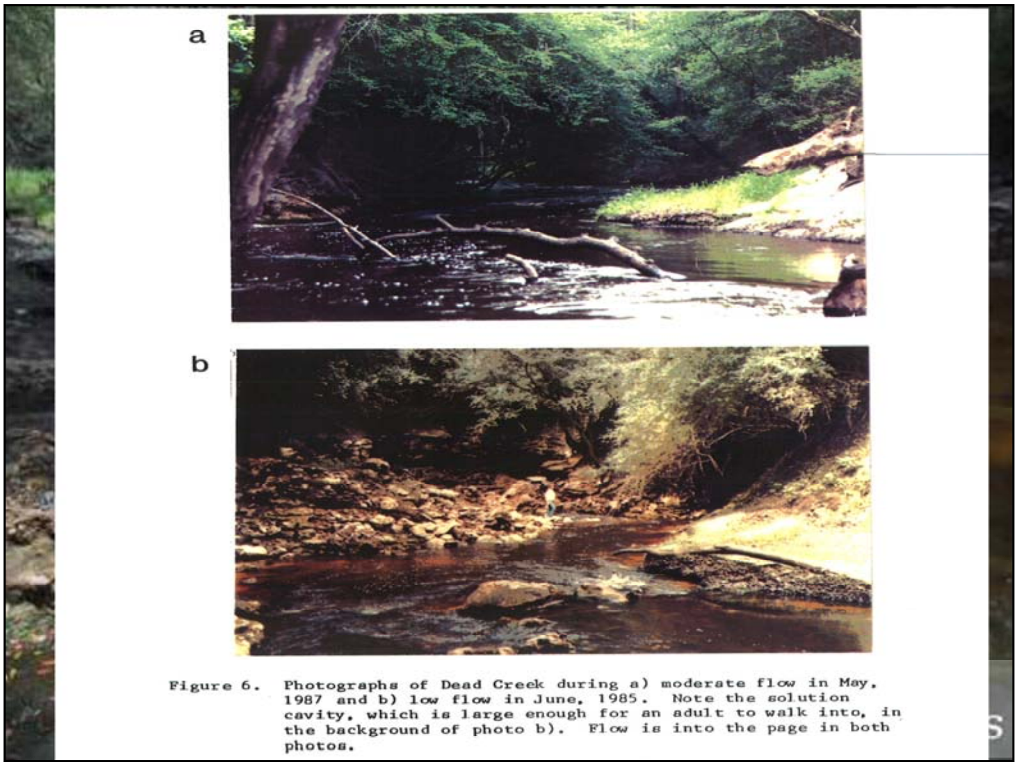


Figure 6. Photographs of Dead Creek during a) moderate flow in May, 1987 and b) low flow in June, 1985. Note the solution cavity, which is large enough for an adult to walk into, in the background of photo b). Flow is into the page in both photos.

Here are more photos of the Dead Creek sink at moderate and low flow. Incidentally, at high flow, there is no surface evidence of the tremendous flow into the bowels of the earth.

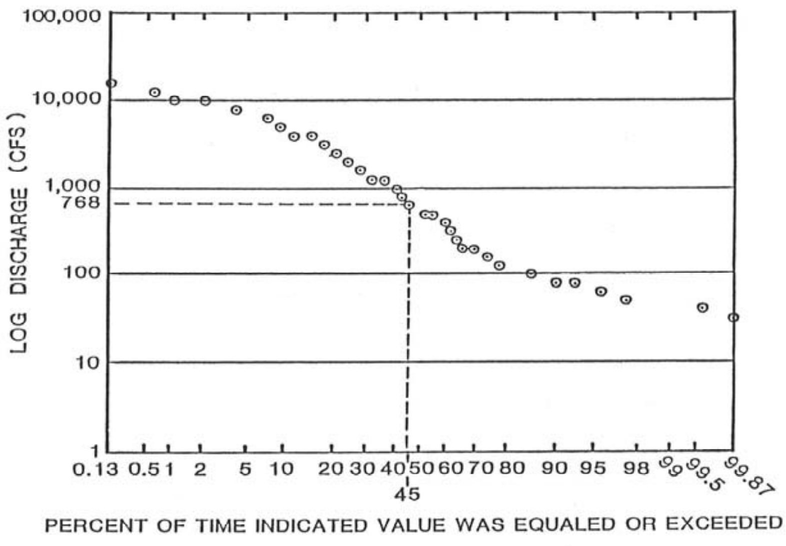


Figure 2. Duration graph of daily discharge data for the Alapaha River near Jennings, Florida (upriver from Dead Creek). Note that discharge exceeded 21.8 cms (768 cfs) approximately 45% of the year (Modified from U. S. Geological Survey WATSTORE daily values retrieval program no. G490).

Of course my thesis was heavy on data evaluation. This graph indicates that the Alapaha river discharge exceeded the volume that flows into the ground at Dead River 45% of the time.

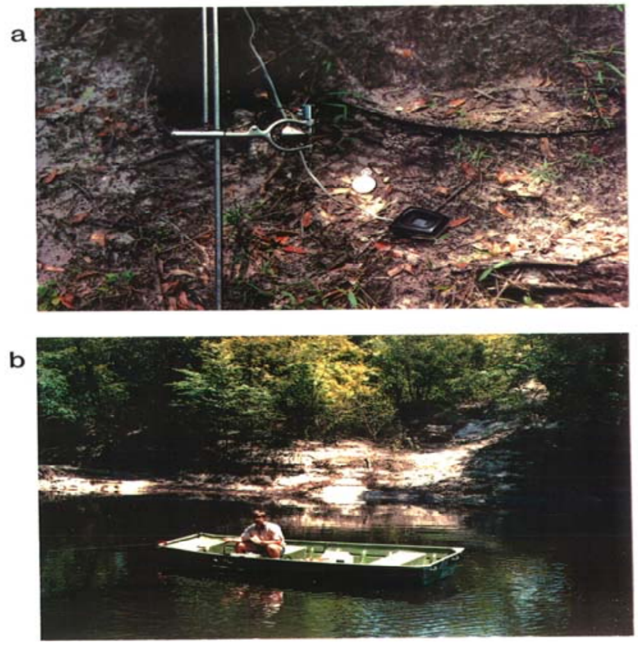
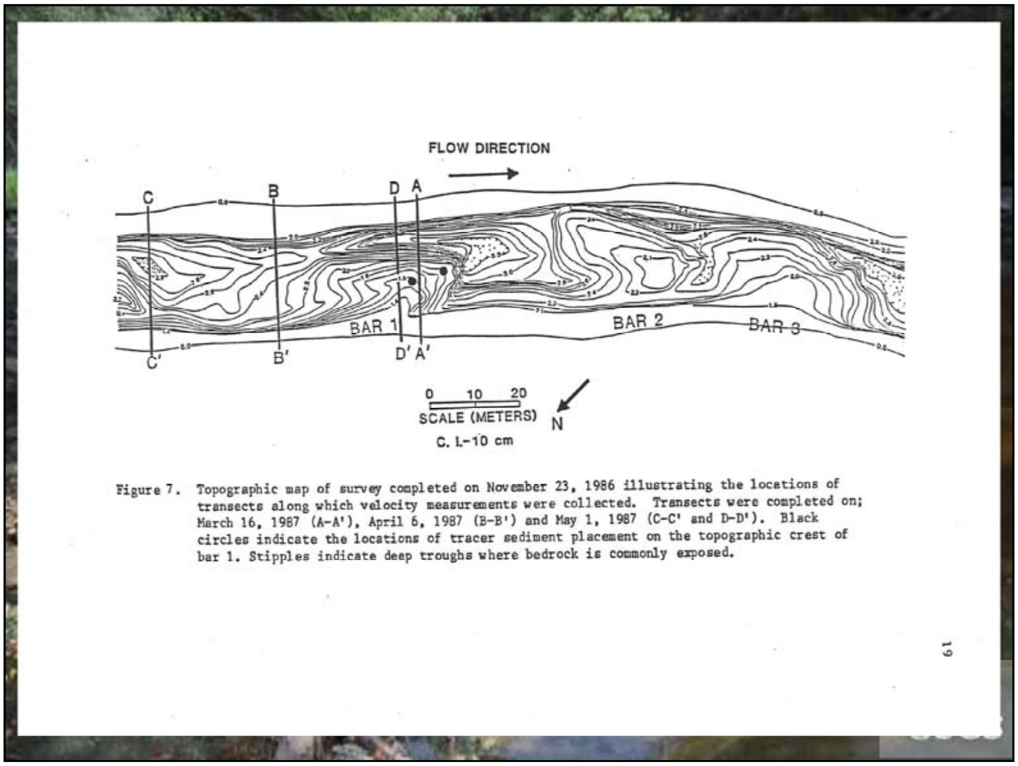
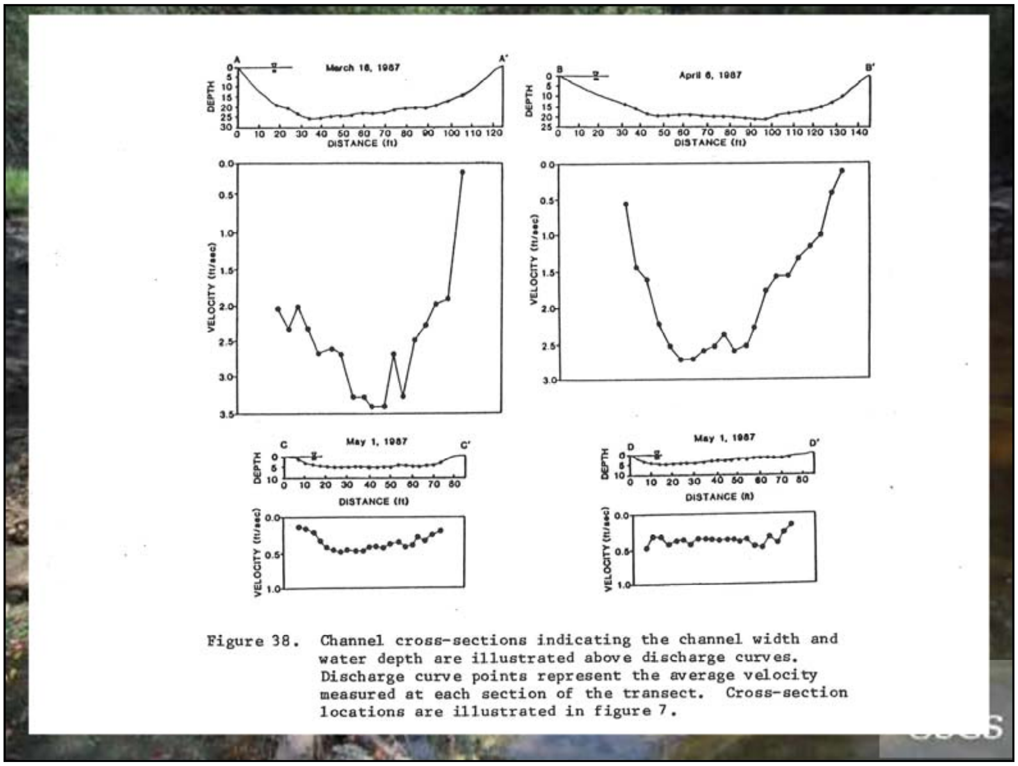


Figure 8. Photographs of a) Price AA current meter, stopwatch and earphone and b) current meter, jonboat and cross-channel wireline. Photograph b) was taken during the low-discharge measurement of May 1, 1987.

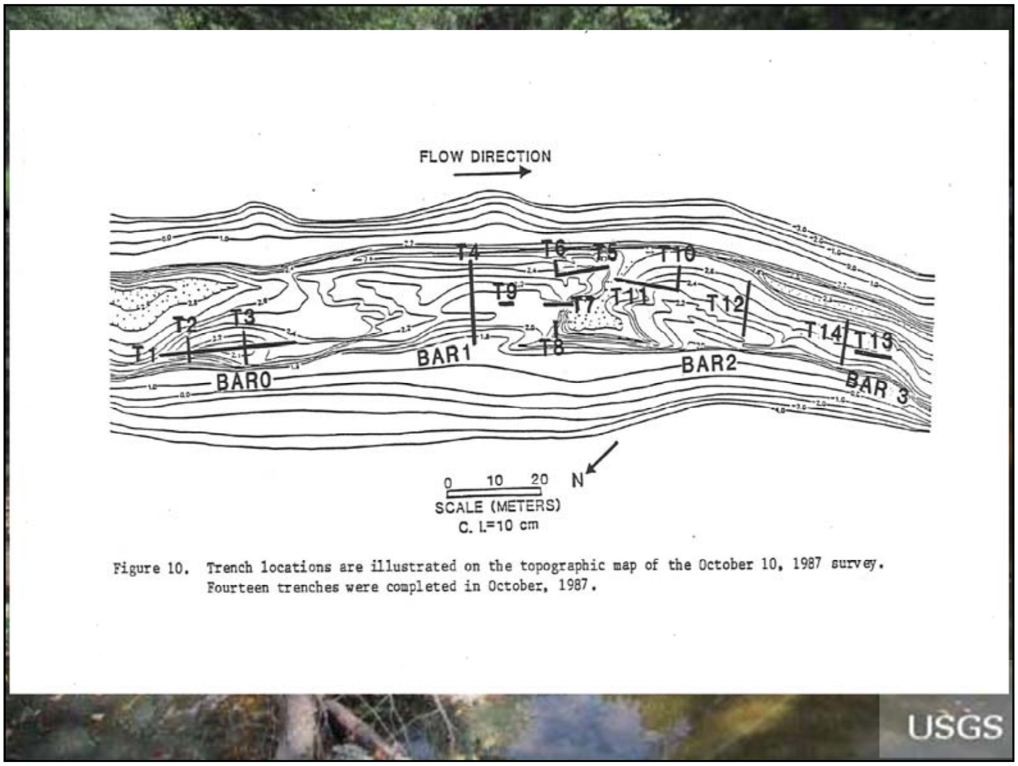
We used a velocity flow meter to measure flow at transects across the river. That's me in the boat – photo by Dave, if it was Dave in the photo, his long yellow hair would have been obvious. These photos, by the way, were actually taped onto pages of my original thesis, which is on the 5th floor of the USF library. I remember when my daughter Maggie insisted on seeing my thesis one day I brought her to the geo alumni dinner. I said, nah, it's gotta be on microfiche by now. She said micro what??? To my surprise all the theses in their ugly green binders were there on the fifth floor. I looked thru colleague these while Maggie read mine. About 15 minutes passed and she looked up, after reading the entire work, and said that is really cool work Dad.



This is one of my first topo-graphics of the meander that I dissected. Credit to Dave DeWitt for helping my survey, map, trench and pay great attention to detail. Dave, please raise your hand as a known expert on this trip.



I mapped velocity vs depth to evaluate impact on bed load migration.



We did many trench dissections to map sedimentological facies and determine formation processes that should be communicable to interpretations one can make by viewing the rock record.

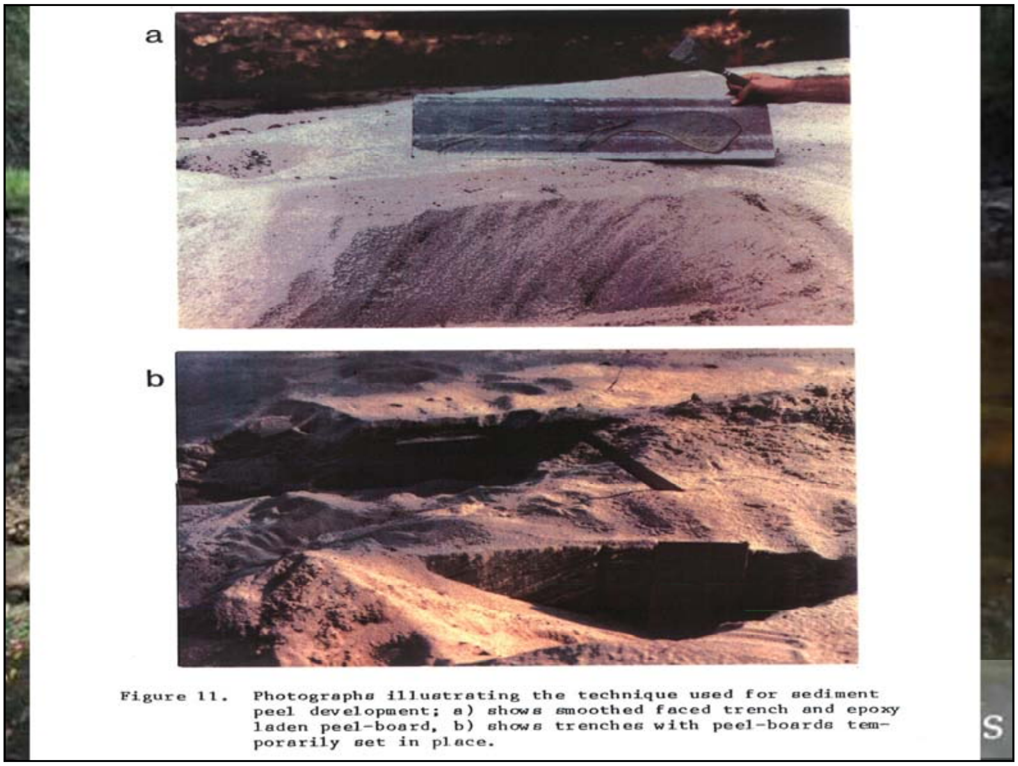


Figure 11. Photographs illustrating the technique used for sediment peel development; a) shows smoothed faced trench and epoxy laden peel-board, b) shows trenches with peel-boards temporarily set in place.

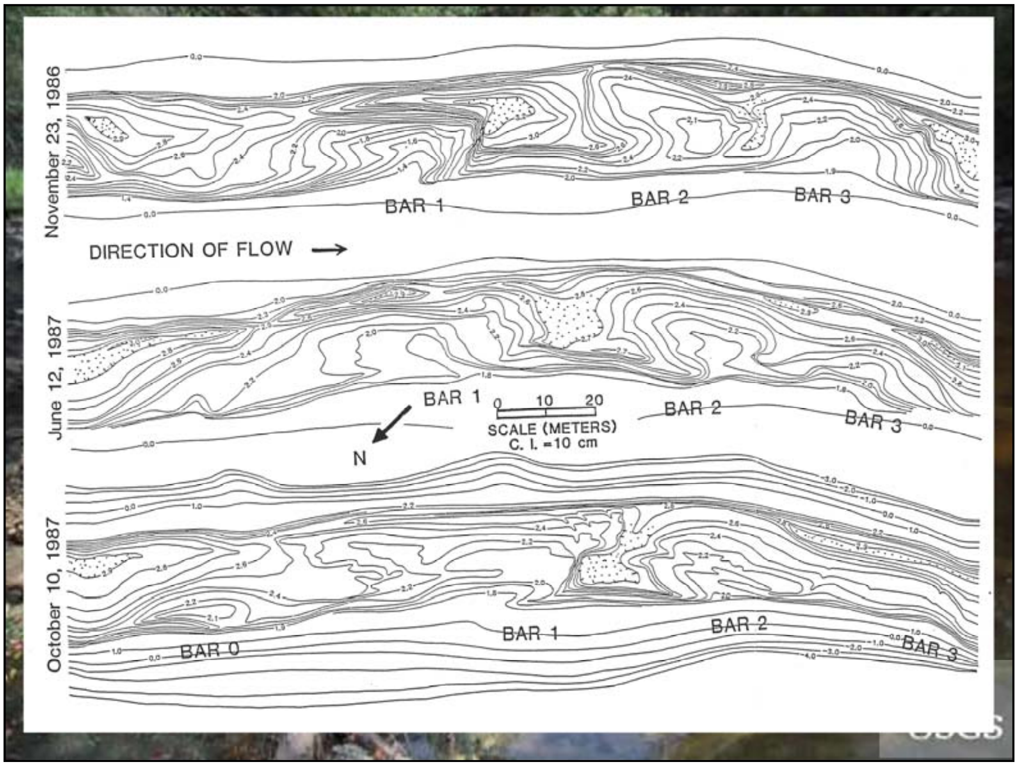
These photos show how we made peels of trench cuts by coating plywood with epoxy, pressing them against the trenches and peeling them off for some cool unconsolidated rock art.

Figure 12. Photograph taken in October, 1987 illustrating megaripple crests which slope off the thalweg flank of bar 1 and shallow chutes which developed across the laterally extended crests. Note the deposition of mud on the bar near ponded water. Flow direction is toward the bottom left corner of the photograph. 1.5 m shovel for scale.

This photo illustrates what we termed mega-ripples, which were a form of sediment transport during high flow.

Figure 13. Photograph taken in October, 1987, illustrating megaripples and troughs filled with accumulated leaves, sticks and other organic debris. Flow direction is toward the bottom of photograph. Stadia rod is 2 m long.

You can see how megaripples would accumulate organic matter – a process that, on a larger scale could lead to interpretation of hydrocarbon deposits.



I made topo maps of the meander at different times to document that this environment is very much non-static. This is primarily due to the fact that the sediment exists within a limestone channel, as opposed to a completely unconsolidated environment.

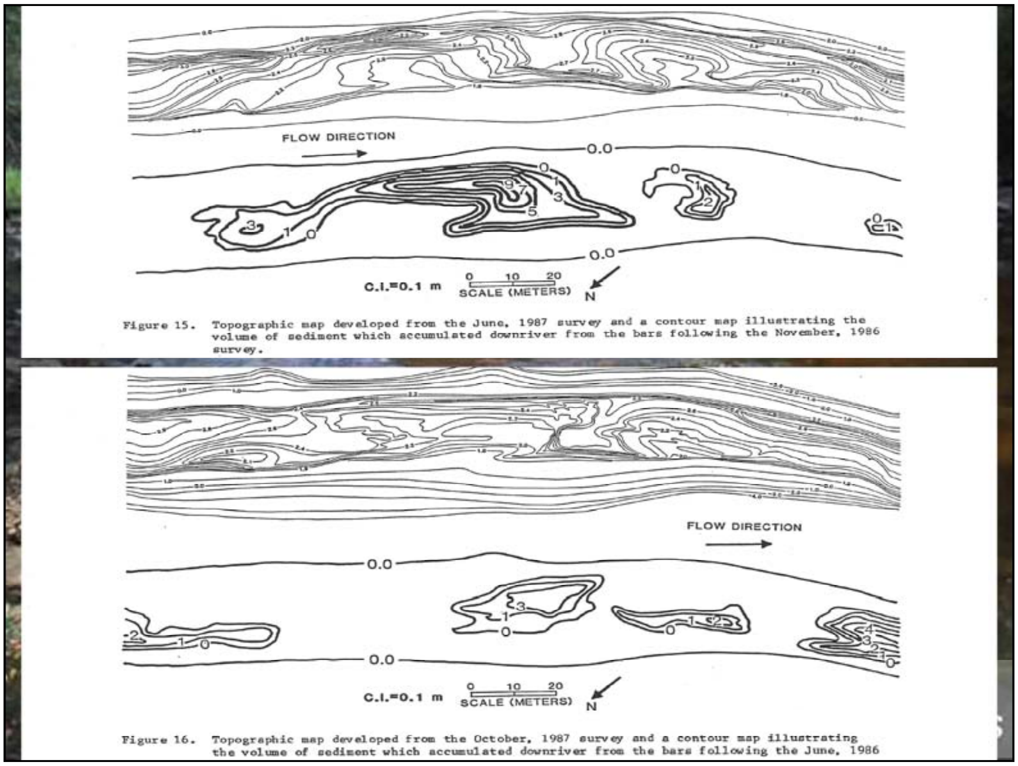


Figure 15. Topographic map developed from the June, 1987 survey and a contour map illustrating the volume of sediment which accumulated downriver from the bars following the November, 1986 survey.

Figure 16. Topographic map developed from the October, 1987 survey and a contour map illustrating the volume of sediment which accumulated downriver from the bars following the June, 1986

I documented changes based on topography and sediment thickness.

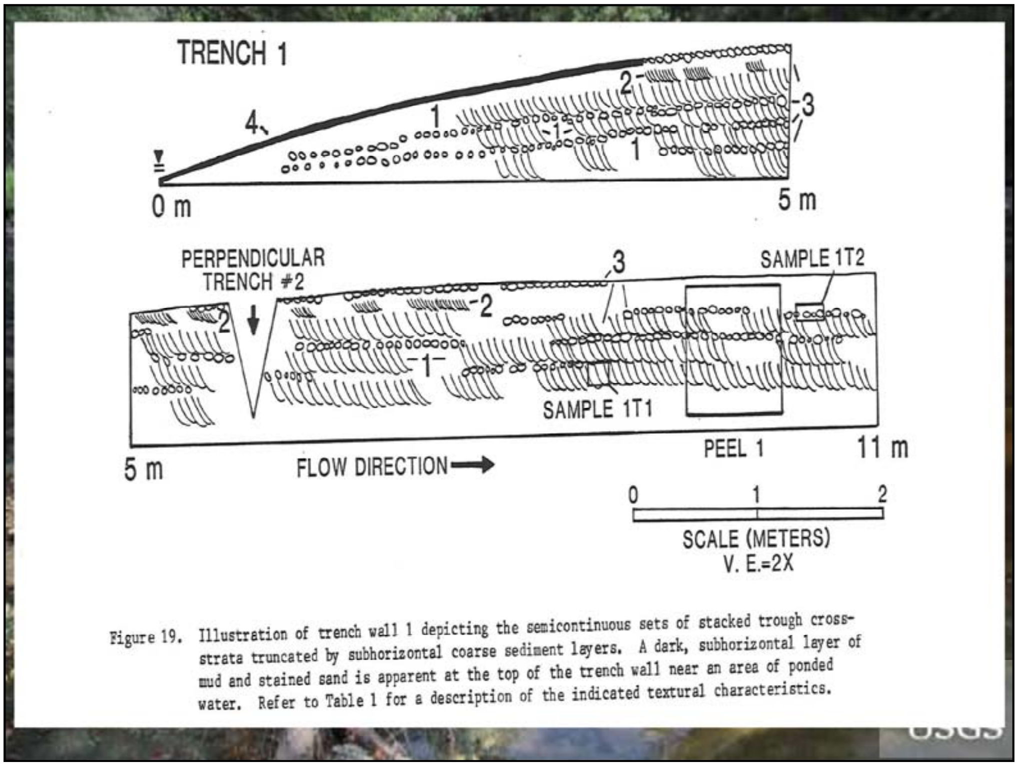


Figure 19. Illustration of trench wall 1 depicting the semicontinuous sets of stacked trough cross-strata truncated by subhorizontal coarse sediment layers. A dark, subhorizontal layer of mud and stained sand is apparent at the top of the trench wall near an area of ponded water. Refer to Table 1 for a description of the indicated textural characteristics.

The trench descriptions and peels helped me describe depositional facies and determine geologic processes that lead to their formation.

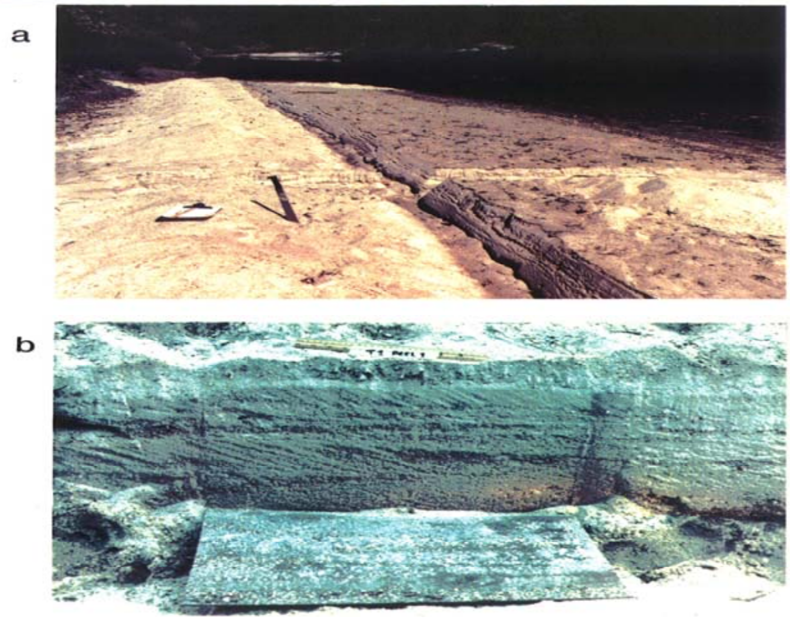
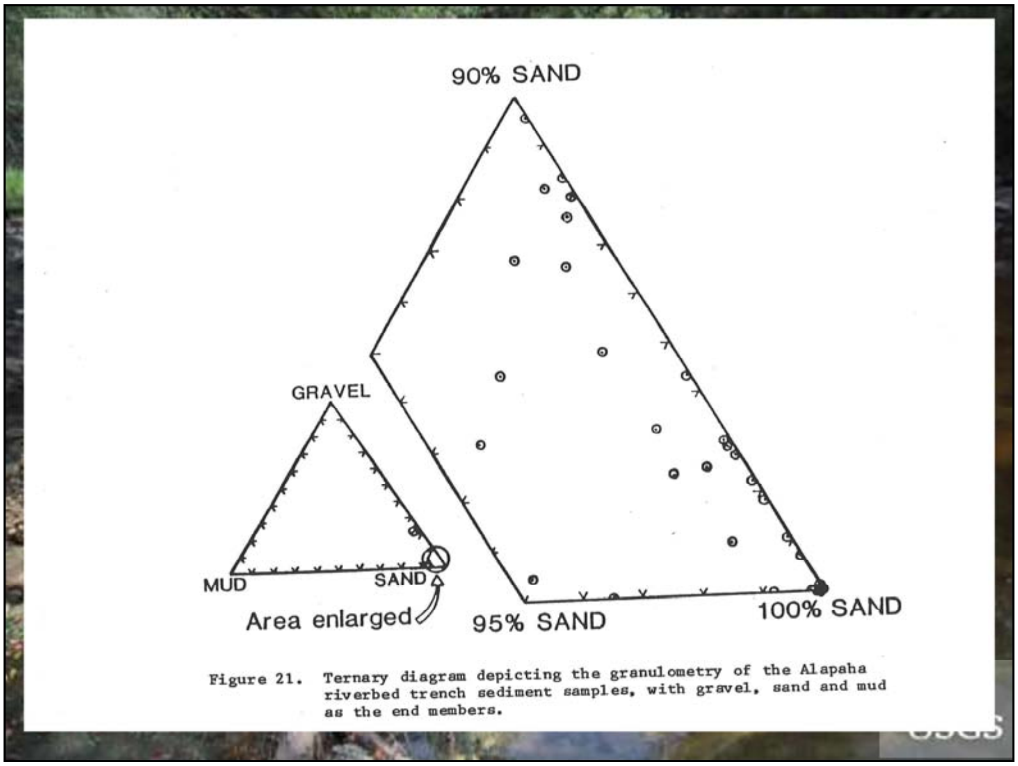
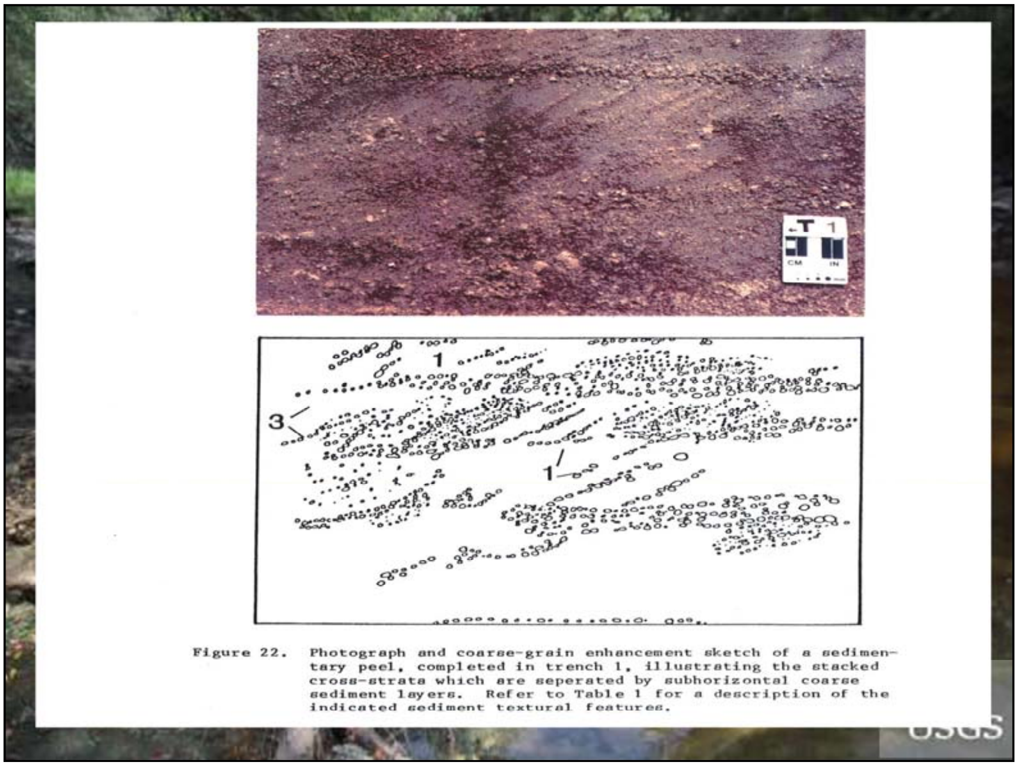


Figure 20. Photographs illustrating a) the orientation of trenches 1, 2 and 3 (flow is out of the page) and b) a section of trench wall 1 following the attempted development of a sedimentary peel. Stacked cross-strata seperated by subhorizontal layers of coarse sediment are apparent.

Here are a couple shots with different light conditions. The course-grained nature of indigenous sands lended to really neat differentiation, much more so than you get by trenching beach sand.



Of course we did some statistical analyses such as this ternary diagram depicting granulometry to hone in on our fascies descriptions.



I took time to provide artistic renderings of some of the really nice peels to document my facies interpretations and depositional processes and environments.

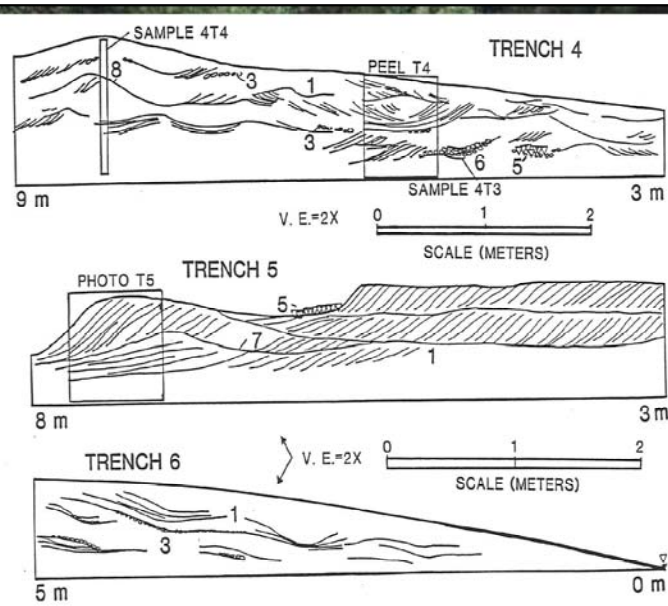


Figure 24. Illustration of trench wall 4 showing a flow-perpendicular, cross-sectional view of trough cross-strata and truncating coarse sediment layers. Trenches 5 and 6 were completed in a recently-developed extension of bar 1. Stacked trough cross-strata without well-developed, truncating subhorizontal layers of coarse sediment were the norm in this area. Refer to Table 1 for a description of the indicated sediment textural features.

You can see some really extreme variability that made for a nice project. Note that I numbered different sediment types to develop facies relationships.

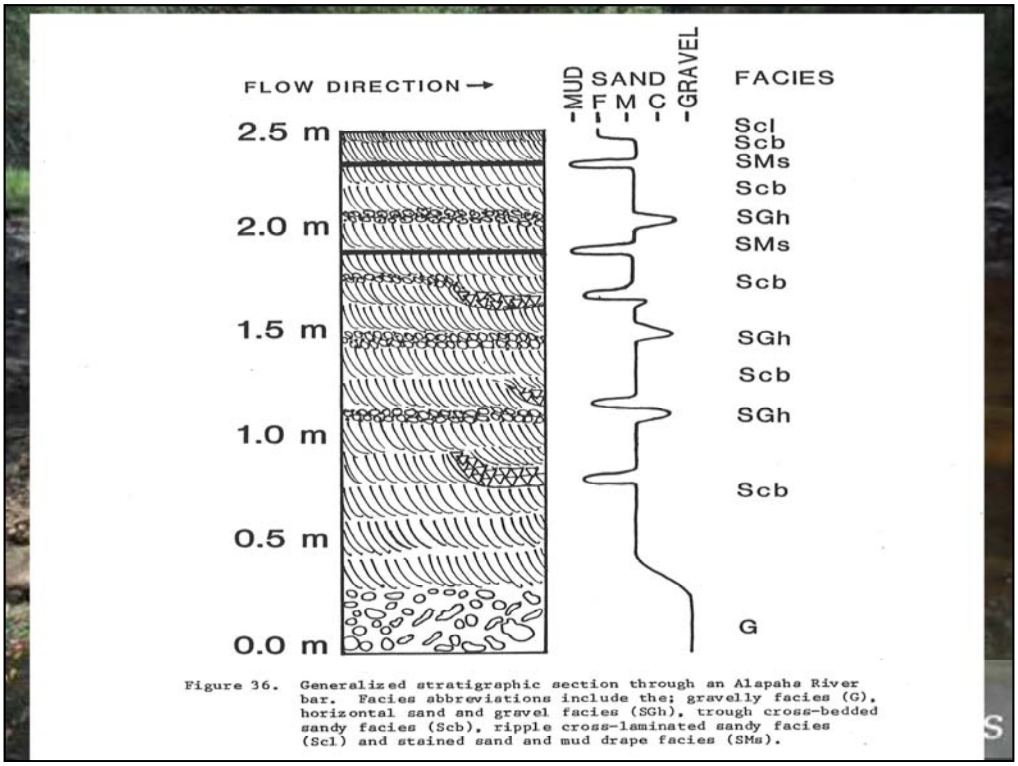


Figure 36. Generalized stratigraphic section through an Alapaha River bar. Facies abbreviations include the; gravelly facies (G), horizontal sand and gravel facies (SGh), trough cross-bedded sandy facies (Scb), ripple cross-laminated sandy facies (Scl) and stained sand and mud drape facies (SMs).

After determining facies, I described them in cross-section, so you could essentially determine depositional environment with a core. I defined facies called gravelly facies (G), horizontal sand and gravel facies (SGh), trough cross-bedded sandy facies (Scb), ripple cross-laminated sandy facies (Scl) and stained sand and mud drape facies (SMs).

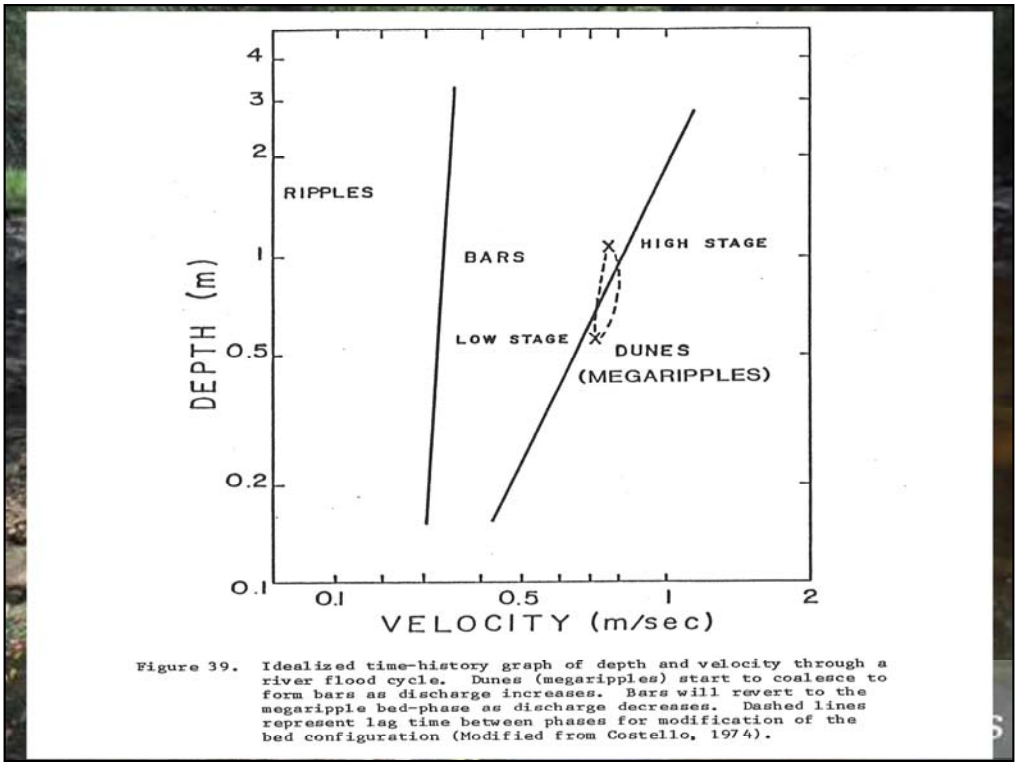


Figure 39. Idealized time-history graph of depth and velocity through a river flood cycle. Dunes (megaripples) start to coalesce to form bars as discharge increases. Bars will revert to the megaripple bed-phase as discharge decreases. Dashed lines represent lag time between phases for modification of the bed configuration (Modified from Costello, 1974).

And determined geomorphology relative to flow velocities and depth.

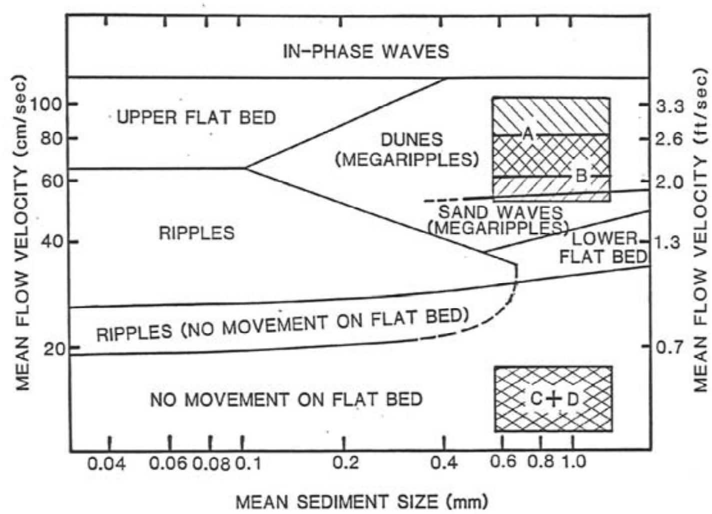
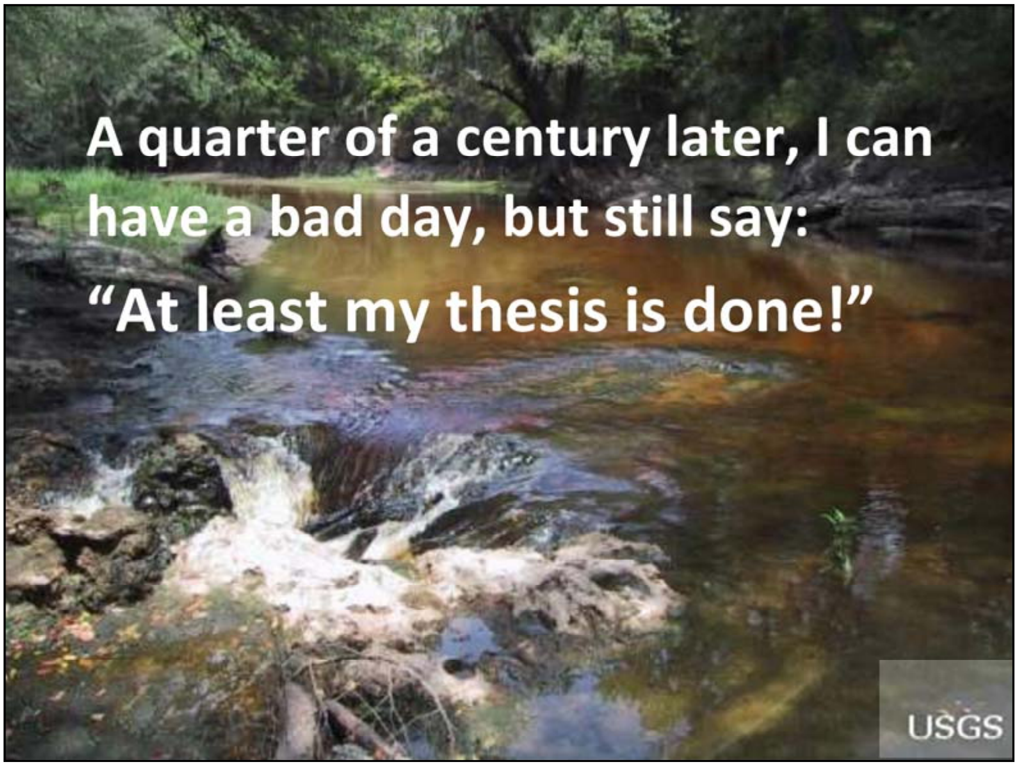


Figure 37. Highly schematic size-velocity diagram for a flow depth of approximately 20 cm, derived from depth-velocity sections drawn using flume data from several sources (modified from Harms et al., 1982). The boxes represent ranges of mean sediment sizes and mean flow velocities measured in lines of discharge on 3/16/87 (A), 4/6/87 (B) and 5/1/87 (C and D). It is clear that migrating megaripples were the dominant bedform phase during the high-discharge stage of March and April, 1987. Flow velocities were too low for development or migration of bedforms during the receeding flow of May, 1987.

I correlated facies based on grain sizes to water depths and flow velocities.

For a closing slide, I thought I'd show you a classic Suwannee Limestone specimen that I collected from the Alapaha River. These are a challenge to carry out, so I made a couple sleds because I really enjoy educating folks on geo and hydrogeology and can explain that our water in Florida comes from dissolved rock like this, and rock like this is sometimes responsible for sinkhole formation.



And in closing…

SYNOPSIS OF 1981 SEGS FIELD TRIP GUIDEBOOK
KARST HYDROGEOLOGY AND MIOCENE GEOLOGY
OF THE UPPER SUWANNEE RIVER BASIN
HAMILTON COUNTY FLORIDA
10/23/81 and 10/24/81

Friday, October 23

The first day of the 1981 SEGS field trip will feature and 8-mile canoe trip on the Suwannee River. The Alapaha Rise, artesian Floridan Aquifer springs, sandbars, and Oligocene and Miocene outcrops will be visited. Terry Burnson, Suwannee River Water Management District (SRWMD) hydrogeologist will guide the trip.

Participants in the canoe trip will leave the Telford House Hotel in White Springs at 10:30 AM. The route to the put-in spot follows SR 136 west into Live Oak for 15 miles, then northwest 12 miles on SR 249 to the river (county map, facing page). At this point, Terry Burnson will present an overview of the hydrology of the Upper Suwannee River Basin.

The group will return to the hotel around 5:00 PM. The annual banquet will begin at 7:00 PM.

Following the meal there will be a presentation by Dave Fisk, Director, Department of Water Resources, SRWMD, concerning the development of sinkholes, springs, and caves in the field trip area. A review of previously mapped lineaments, fracture traces, and regional structural features when compared to the dominant trends of subsurface cave development establishes close correlation between karst development and structure in the area. Dave's presentation will show photographic examples of solution along vertical joints or fractures and horizontal bedding planes in local underwater caves. Several planametric maps of local underwater caves will be presented to reinforce the correlation to regional structural trends.

Saturday, October 24

Buses will leave ·the Telford House at 8:00 AM on Saturday. **Stop 1** is 27 miles northwest of White Springs off US 41. This stop features a steep-sided sinkhole on Hamilton Turpentine Company property. Mike Knapp, hydrogeologist with South Florida Water Management District will discuss the geologic setting of this area. Rick Copeland, hydrogeologist with the SRWMD will; discuss the mature karst features that will highlight the day's trip.

The sinkhole is approximately 80 feet deep and displays the Hawthorn section. Prior to descending into the sink, Tom Scott, geologist with the Florida Bureau of Geology will describe the characteristics of the Hawthorn Formation in the field trip area.

From the sinkhole, we will travel 1 mile to the banks of the dry Alapaha River. **Stop 2** is a 1 ½ mile hike down the dry river bed.

There are numerous streamsinks in the river bed. The hike veers down Dead River for ½ mile. Dead River is a distributary of the Alapaha that ends in a streamsink on the property of Ronald Mathis (**Stop 3**). Dead River exposes an excellent section of basal Hawthorn. This streamsink accepts up to 750 CFS 485 MGD) of Alapaha River water.

We will lunch at **Stop 3**.

From here we will travel 8 miles southeast along US 41 and SR 6 to Tiger Creek (**Stop 4**), a disappearing stream on Billy Pennington's property. This is a fine example of a surf ace stream in the Highlands that descends the Cody Scarp and goes underground at the toe of the scarp. At this stop, Ron Ceryak, hydrogeologist with the SRWMD will discuss how the Cody Scarp is a transition zone between the hydrogeologic units in this area. Dennis Price, a geologist with Occidental Chemical Company, will expound on paleo-karst features that he encounters while mining phosphate in Hamilton County.

From Tiger Creek *we* travel 10 miles along back roads to the Alapaha Rise, the alleged resurgence of the Alapaha River (**Stop 5**). This resurgence is a first magnitude spring with a range of flow from 294 to 1043 CFS(190 to 675 MDG). Terry Burnson will summarize the hydrology in the Upper Suwannee River Basin at this stop. Following Terry's talk will be a presentation by Sheck Exley. Sheck is a highly experienced certified cave diver who has dived sinks and springs throughout the United States and abroad. He has dived in every spring, sink, or resurgence in North Florida that has been available and has been 240 feet deep in the Alapaha Rise.

The Alapaha Rise is the final stop of the trip. A 27 mile return ride to White Springs will get us back to the Telford House.

The following is a list of the papers included in the 1981 GUIDEBOOK #23, KARST HYDROGEOLOGY AND MIOCENE GEOLOGY OF THE UPPER SUWANNEE RIVER BASIN, HAMILTON COUNTY, FLORIDA.

Contents are available for download on SEGS.org:

GENERAL INFORMATION

- **General Policy:** Your job is to enjoy the park. Our job is to help you. If we both do our job, this park will quickly become what it aspires to be: the most outstanding music-oriented facility in the world. If we may be of further assistance, please do not hesitate to ask. We hope there are no strangers here, only friends we haven't met. Park admission Fee $2.00 per person and $5.00 per vehicle.
- **Bicycles:** We ask you not to ride your bicycle after dusk unless you have it properly equipped with lights and you are dressed in reflective clothing. This is a must during special events as well as all times when vehicle traffic is heavy.
- **Check-Out:** 12:00 noon. Please re-register before this time if you would like to extend your stay. Rental units check-out is 11:00 a.m. Please return key to the office.
- **Quiet Time:** In general the park should be quiet after 11:00 p.m. Occasionally, however, musicians may want to "jam" a little longer, and should feel free to do so as long as they aren't disturbing sleeping campers.
- **Campfires:** Should be attended at all times and extinguished before retiring for the night. Do not cut standing trees or bushes.
- **Messages:** Telephone messages will be posted on message board - unless there is an emergency, in which case the staff will deliver the messages as quickly as possible.
- **Picnic Tables:** Picnic tables are available throughout the park.
- **Sewer Sites:** State law requires each camping unit to use a "donut" to seal sewer hose into sewer line. When disconnecting replace cover to sewer line connection.
- **Dump Station:** Free to campers. $10.00 + tax fee for non-campers.
- **Hiking Trails:** Four trails currently open. No Guide.
- **Pets:** Keep all pets on a leash. The owner is responsible for clean-up after pet. Pets are not to be left alone in the park. **No pets in any rental units. $100 penalty.**
- **Respect Nature:** We love our trees, shrubs, flowers, deer, gophers, turtles, birds and other plants and animals. Please help us to preserve these wonderful gifts of God. Please do not attach any appurtenance or accessories to trees, shrubs or structures within the park (e.g. clotheslines). Please no guns, bows and arrows, sling shots or fireworks. *Take nothing but pictures, leave nothing but footprints.* $100 fine per tree damaged or cut down.
- **Pool:** Hours are 9:00 a.m.-dusk daily. These are seasonal hours. We do not have a lifeguard. Children should be accompanied by a responsible adult. Please observe all posted rules.
- **Trash/Cigarettes:** All trash should be placed in trash bags and into the dumpsters or trash barrels. Please do not leave trash bags outside your camping rig overnight.
- **Vehicles:** Display car passes at all times. The park speed limit is 10 M.P.H.
- **Rental Facilities:** For a fee you may reserve the various park buildings and pavilions for private or corporation group functions.
- **River Swimming:** The river is unpredictable and you should not swim in it - if you do so - it will be at your own risk.
- **Solicitation:** No soliciting or selling of any items without the manager's permission.
- **Campers (visitors) are responsible for any physical damage to park property.**
- **Golf Carts:** All member golf carts must have a current park registration. Golf carts are subject to Florida motor vehicle laws. Trail Fee applies to non-rentals. Proof of liability coverage is required to drive golf cart in park. Golf cart policy enforced.
- **Alcohol:** Alcoholic beverages are confined to your campsite. Alcohol purchases are available in licensed areas of the park.
- **Horses:** Horses are allowed on trails and in the horse camping area. No horses in the concert vending areas or roadways. Negative Coggins required for all horses. For additional rules/regulations see office. Health certificate required by Agriculture Inspection station, along with coggins, for out-of-state. Must be current.
- **Country Store:** Rentals of golf carts, camping gear and bicycles. Sales of food items, ice, wood and full line of beverages and more. (386) 364-4841.
- **Canoe Outpost:** Rentals - guided canoe trips (386) 364-4991. Closed during January and Wednesdays.
- **SOS Café & Music Hall:** Fine Food, Catering, TV's for sports games. (386) 364-1703.

THINGS TO DO @ SOSMP

Swim in our Pool – 10am – Dark
Shop at our Craft Village
Visit our Bat House - They usually come out at dusk
Sit on our Observation Decks in the 80 Acres
Walk our Trails
Fish in our Lake – Catch and Release Only
Dine at Our Full Service Restaurant – 386-364-1703
Enjoy a Cold Treat at Our Kosmic Kream Shoppe – 386-364-6550
Handmade Pizza, Subs, Ice Cream & More
Shop the Country Store – 386-364-4841
*Rent Golf Carts & Bicycles*Disc Golf *Shuffle Board*
*Groceries*Beer*Ice*Camping Supplies* Souvenir* Fire Wood*
Go to the Canoe Outpost – 386-364-4991
Tubing*Canoeing*Kayaking
Talk with our Tropical Birds "Mango" & "Tie-Dye"
Enjoy the Bird Sanctuary
Ride the Horse Trails and Stable Your Horse
Play at our Big New Playground
Relax at our Suwannee River Beach
Pick at the Pickin' Shed - Saturday nights @ 6pm
Stay in a Rental - *Treehouse*1 & 2 bedroom or Loft Park Models*
Plan a *Wedding*Reception*Reunion*Private Party*
*Company Party @ Grande Hall or Pavilions
Explore with Geocaching
Attend Church Services @ Spirit Lodge/ Sun. @ 9am
Enjoy our New Game Room – Located by the pool

Cafe'- 386-364-1703
Sun - Closed
Mon – Closed
Tues – 11am – 5pm
Wed – 11am – 2pm
Thur – 11am – 5pm
Fri – 11am – 5pm
Sat – 7:30am – 5pm

Ice Cream & Pizza Shop – 386-364-6550 Open daily 11am – 6pm

Music Hall – 386-364-1703
Sun – Closed
Mon – Closed
Tues – 5pm – 10pm
Wed – Closed
Thurs – 5pm – 10pm
Fri - 5pm – 11pm
Sat – 6pm – 11pm

Canoe Outpost – 386-364-4991
9am – 3pm (Closed Wednesdays)

Country Store – 386-364-4841
Sun – 9am – 5pm
Mon – Thurs – 9am – 6pm
Fri – Sat – 9am – 8pm
Propane Exchanges and sales and Non –Ethanol Gasoline available n

Spirit Lodge Church Service – Sun @ 9am

The Southeastern Geological Society
Field Trip Notification
Alapaha River/Cody Scarp Area

Friday, November 7, 2014, 4:00 PM - gathering for several technical presentations and southern-style chicken buffet dinner with peach cobbler in the Spirit Lodge at the:

Spirit of the Suwannee Music Park and Campground

at 3075 95th Dr., Live Oak, Fl 32060 (on U.S 129 between I-75 and I-10) ***386-364-1683***

We recommend that you arrive at the music park early Friday to experience a variety of amenities this renowned venue has to offer. http://www.musicliveshere.com/content/

Saturday, November 8, 2014, 9:00 AM - departure via carpool to view 6 locations exhibiting unique karst geomorphology and enjoy technical information by several geologists with hands-on knowledge of the area. Box lunches and drinks provided.

Saturday, November 8, 2014, 6:00 PM - following the field trip, you're invited to a gathering of peers at the Music Park's lake-front screened pavilion for a pulled pork buffet dinner with apple cobbler and entertainment by Irish band Kanapaha.

Sunday, November 9, 2014, 10:00 AM - depending on interest, we are hoping to enjoy a canoe trip down the Suwannee River from the Florida Sherriff's Boys Camp to the Suwannee River State Park to get a better view of 5 Sinks - about a 5 hour trip.

DESCRIPTION: This trip is setup to be tech-info heavy because a similar expedition was done in 1981 and several of the original attendees will be present to share their knowledge. The Friday gathering will start early to encourage folks to experience the Music Park during the day and enjoy several technical presentations before, during and after our buffet dinner in the Spirit Lodge. Presenters will include Andy Lawn, Clint Kromhout, Dr. Sam Upchurch, Dr. Tom Scott, Dr. Rick Copeland and potentially more.

We will examine karst geomorphology in the Cody Scarp Area, the largest topographic break in Florida. A variety of features can be observed within Hamilton County, courtesy of property access granted by the Florida Park Service, the Suwannee River Water Management District and private property owners. We'll see striking examples of surface water - groundwater interaction in this mature karst terrain. Planned sites include:

- Jennings Bluff Cemetery - a 100+ foot bluff over the Alapaha River and headstones dating back to the 1700s
- Dead River Ponor - a giant swallow that drains the entire Alapaha River during this time of year

- The Alapaha Riverbed - we plan to hike a mile or so up the riverbed to observe exposed karst features and intermittent river, coarse-grained sedimentology
- Law Sink - an exposed multi-tributary sinkhole
- Five Sinks - sinkholes along the river in the Suwannee River State Park
- The Alapaha Rise (or Holton Creek) where the Alapaha's subterranean flow re-emerges at a large spring adjacent to the Suwannee River.

Site visit plans may be adjusted following an October 25, 2014 reconnaissance trip, after which we'll send an update on trip rigors with driving and hiking paths on our map.

PLEASE BRING: Safety equipment including closed-toed footwear, sunscreen, bug repellant, sunglasses and orange vests (it's hunting season). SEGS will provide box lunches and hydration fluids on Saturday. The optional Sunday canoe trip is on your own.

COST OPTIONS: Costs for various participation are listed below. SEGS members must have 2014 dues paid ($35) and may bring a guest. Students are welcome, but encouraged to pay student SEGS member dues ($25).

$20 for guidebook and Saturday field trip with box lunch and hydration fluids;
$10 for students for above ($10 grants available by registering while they last).

$35 for above plus Friday dinner and technical presentations in Spirit Lodge;
$20 for students for above ($20 grants available by registering while they last).

$50 for all of the above plus Saturday dinner at the Lake Pavilion and band;
$35 for students for all of the above.

Sunday canoeing and box lunches to be purchased individually.

OVERNIGHT LODGING SUGGESTIONS: Everyone is encouraged to enjoy Friday and Saturday night at the *Spirit of the Suwannee Music Park and Campground.* Please call the park 386-364-1683 or Carol's cell 386-365-0070 and reserve a campsite or cabin. Cabins that sleep 4 cost about $120 per night; half cabin duplexes that sleep 3 cost about $100; campsites cost $22 to $44; golf carts are $50/day. Alternatively, hotels are available about 4 miles south of the camp at I-10 and U.S. 129 (north of Live Oak): Holiday Inn 386-362-2600 $119; Quality Inn 386-362-6000 $89; Econolodge 386-363-7459 $69.

REGISTRATION: The trip fee must be paid with your registration and mailed to the SEGS at PO Box 1636, Tallahassee, Florida 32302. The attached waiver and release form must be returned with registration for attending the field trip. Early registration is requested so we plan enough food. For more information contact Andy Lawn at ALawn@HSWEng.com or Greg Mudd at gmudd@cfl.rr.com.