HYDROGEOLOGY OF MARION COUNTY, ORANGE LAKE SUBSURFACE, AND DYE TRACING

ORANGE CREEK BASIN INTERAGENCY WORKING GROUP
HYDROGEOLOGY WORKSHOP 11/05/2015

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TOPICS

1. MARION COUNTY HYDROGEOLOGY

2. ORANGE LAKE SUBSURFACE

3. SILVER SPRINGS NUTRIENT PATHWAY DYE TRACE STUDY

MARION COUNTY HYDROGEOLOGY

HYDROSTRATIGRAPHIC UNITS

A **Hydrostratigraphic Unit** is a body of rock (or sediment) distinguished and characterized by its porosity and permeability. *

- Unit is laterally extensive enough to be mapped.
- Unit can be sufficiently permeable to produce water and allow flow.
- Unit can have low permeability and retard flow or provide confinement.
- Unit does not have to conform to lithostratigraphic boundaries.
- Unit has to be recognizable.

It's all about the connectivity of water in the rocks

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* Modified from The Geology of North America, Vol. O-2 Hydrogeology, The Geological Society of North America, 1988

HYDROSTRATIGRAPHIC UNIT - LITHOSTRATIGRAPHIC UNIT COMPARISON

LITHOSTRATIGRAPHIC UNIT
Undifferentiated sand, silt, clay, and shell
Cypresshead Formation
Hawthorn Group, Coosawhatchie Formation
Hawthorn Group, Undifferentiated
Ocala Limestone
Avon Park Formation
Oldsmar Formation

HYDROSTRATIGRAPHIC UNIT

SURFICIAL AQUIFER SYSTEM (SAS)

INTERMEDIATE CONFINING UNIT (ICU)

UPPER FLORIDAN AQUIFER (UFA)

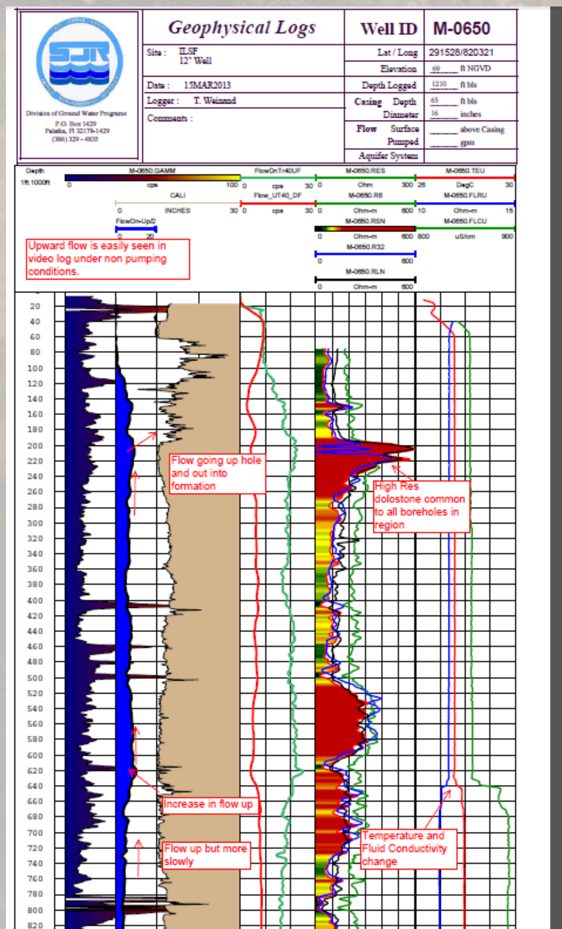
MIDDLE CONFINING UNIT I OR II
(MCU I OR MCU II)

LOWER FLORIDAN AQUIFER (LFA)

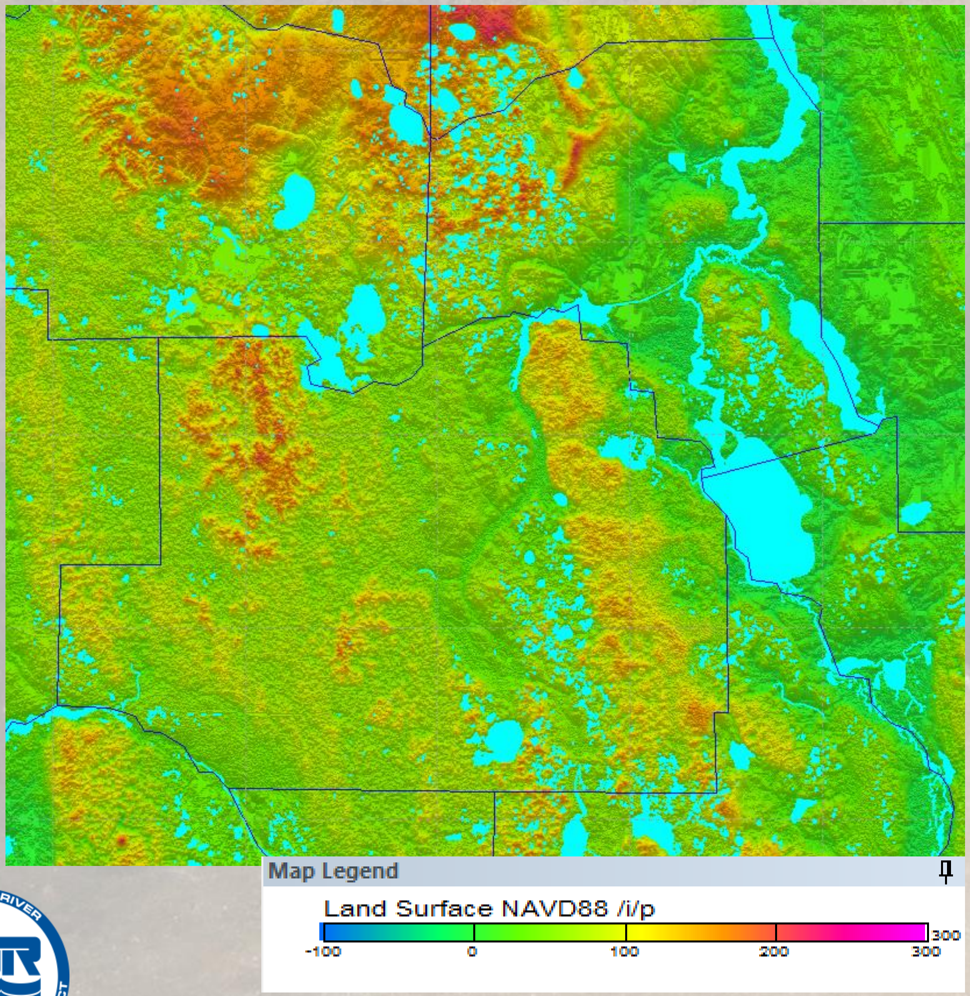
FLORIDAN AQUIFER SYSTEM

SUBSURFACE EXPLORATION

GEOPHYSICAL LOGS
 RUN IN BOREHOLES
TO SEE WHAT IS
UNDERGROUND

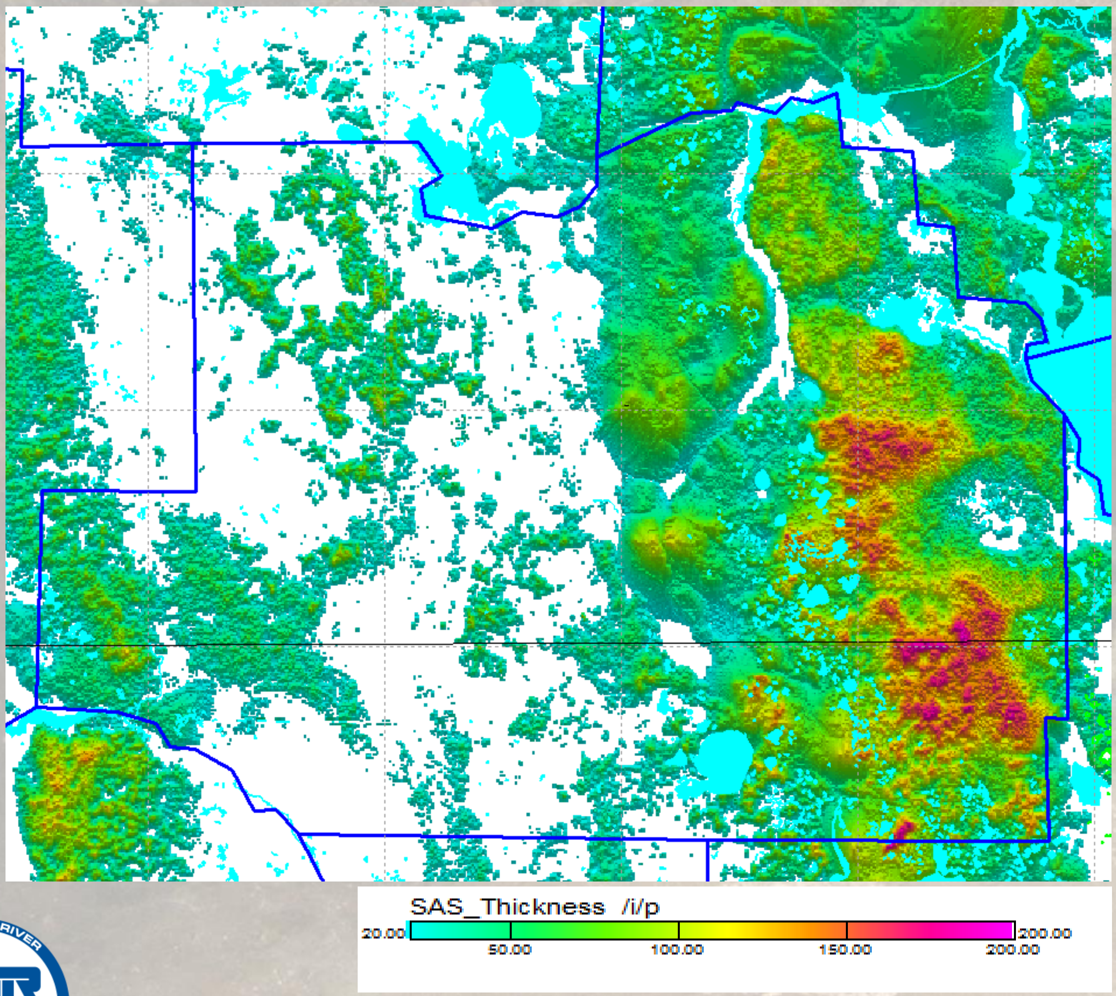


LAND SURFACE ELEVATION (aka TOP OF SURFICIAL AQUIFER (SAS))



- GENERALLY NOT USED EXTENSIVELY FOR PRODUCTION.
- MOST VULNERABLE TO CONTAMINATION AND FLUCTUATING WATER LEVEL BASED ON RAINFALL.

SURFICIAL AQUIFER THICKNESS (WHITE AREAS LESS THAN 20' THICK)

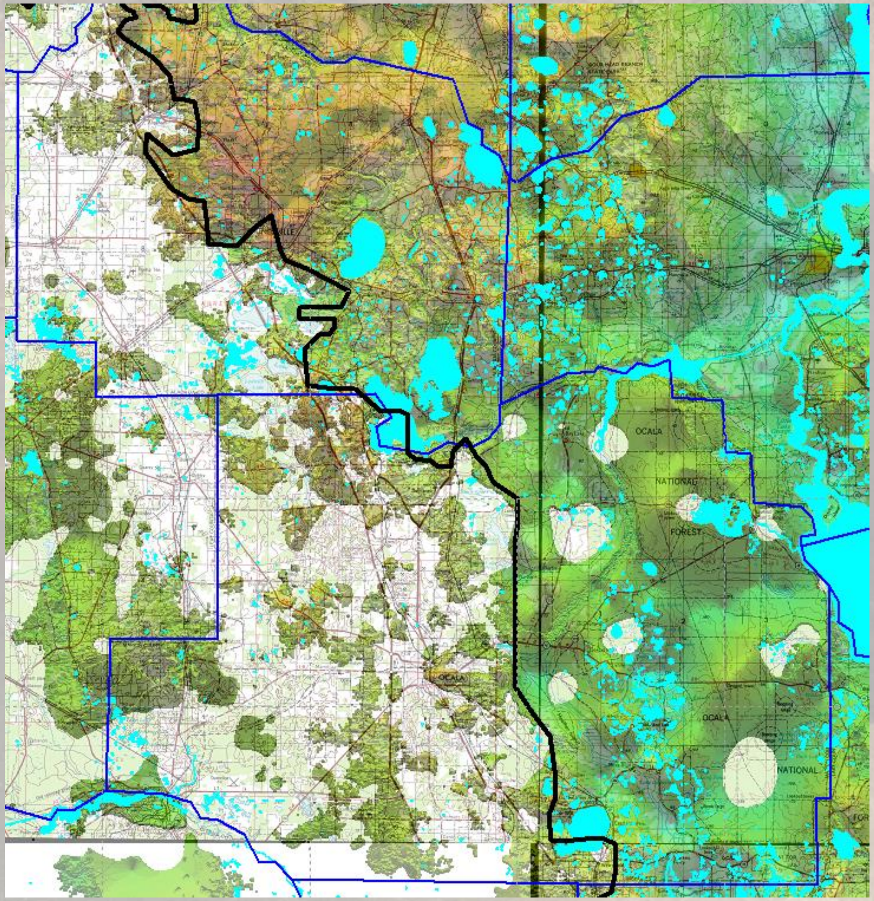


- SAS IS THIN OR ABSENT IN MUCH OF MARION COUNTY.
- WHERE SAS IS PRESENT IT MAY CONTAIN SIGNIFICANT AMOUNTS OF CLAY.

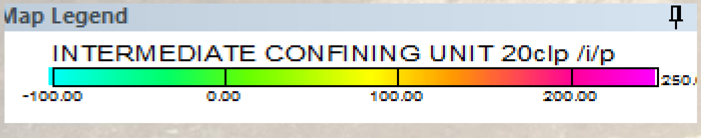
INTERMEDIATE CONFINING UNIT

- Comprised of multiple intervals of varying hydraulic properties.
- Some intervals may produce water and others are very confining.
- The entire “package” of ICU rocks and sediments acts as a confining unit to the Floridan aquifer system (FAS).
- Some intervals may produce water and others are very confining.
- Hydraulic properties of individual intervals are not laterally continuous.
- Erosion has removed or thinned the ICU in many areas. These areas can provide pathways for direct recharge to the FAS.

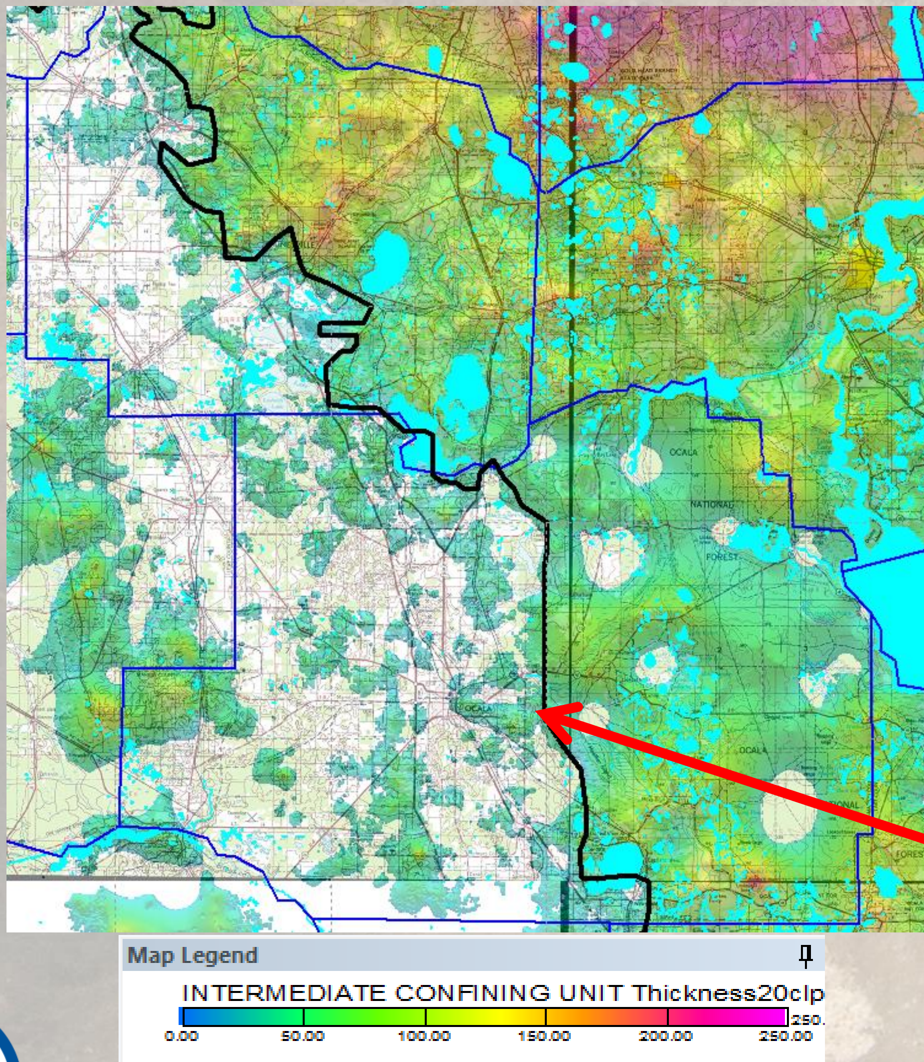
ELEVATION OF INTERMEDIATE CONFINING UNIT (ICU)



- SURFACE IS CLIPPED WHERE THICKNESS OF ICU IS LESS THAN 20'
- NOTE THERE ARE MORE WATER BODIES PRESENT WHERE THE ICU IS PRESENT.
- THERE ARE SIGNIFICANTLY MORE CAVES AND SINKHOLES IN THE WESTERN AREA.
- DIRECT RECHARGE TO THE FAS IN THE WEST.
- ELEVATION RANGES FROM -70' TO 173'



THICKNESS OF THE ICU (clipped to >20' thick)

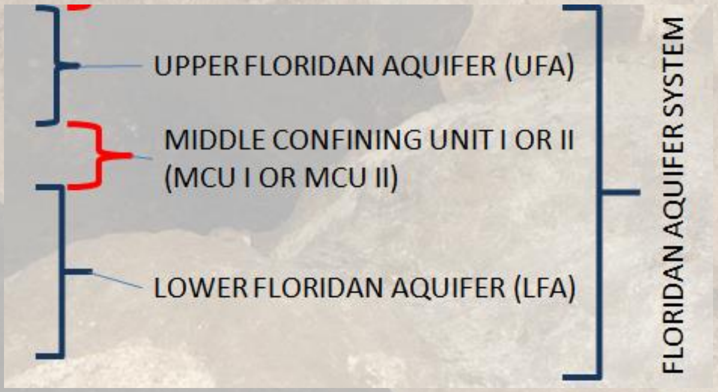


- Thin or absent in western Marion County. (Ocala Platform)
- Thickens to the northeast and south.
- Patches of ICU in the west provide localized confinement but considered as unconfined regionally.

Generalized boundary where the Floridan Aquifer is unconfined based on where ICU is less than 20' thick.

EXAMPLE WHERE NO ICU IS PRESENT. SOME CLAY ZONES IN THE SAS MAY PROVIDE SOME MINIMAL CONFINEMENT TO THE FLORIDAN.

FLORIDAN AQUIFER SYSTEM (FAS)



- Predominately limestone and dolostone but may contain beds of peat, lignite, sands, clay, chert, and gypsum.

- Primary porosity up to 30-40%. Secondary porosity up to 100% (caves).

- Secondary porosity from dissolution and fracturing can greatly affect permeability (caves, conduits).

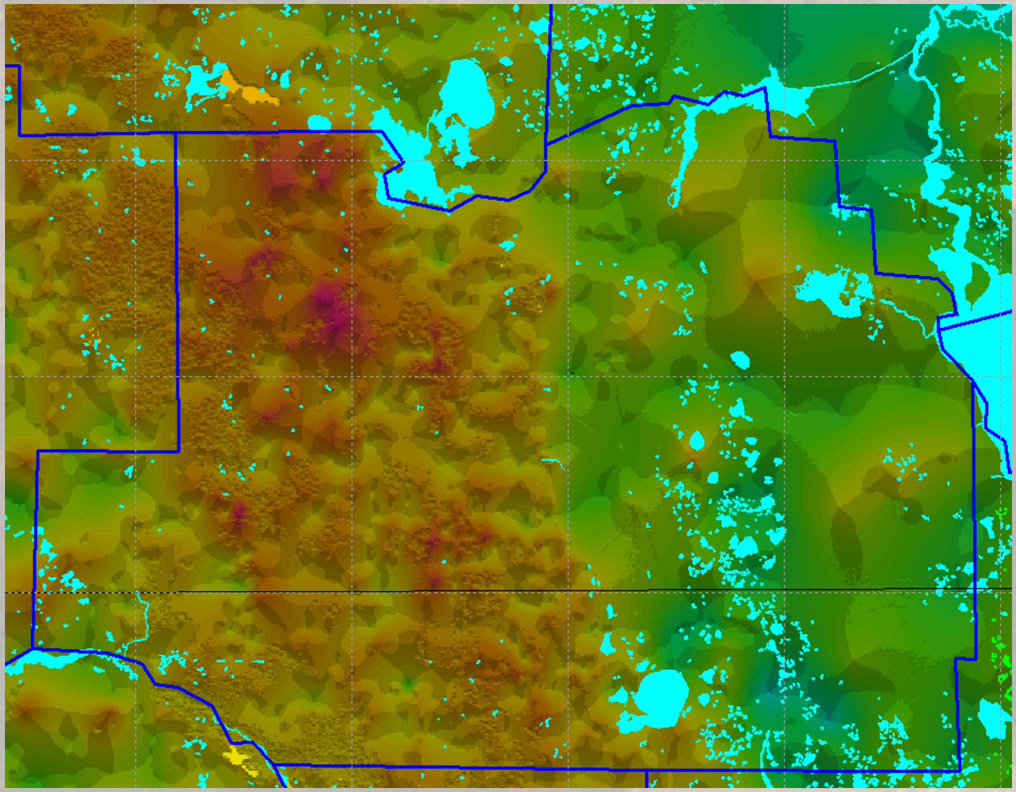
- Individual intervals can have very low porosity and permeability forming confining units within the system.

- The cumulative effect of multiple low permeable intervals divides the system into the Upper and Lower Floridan aquifers with distinct hydraulic properties.

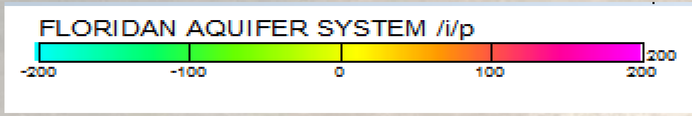
FLORIDAN AQUIFER SYSTEM (FAS)

- **Covers an area of over 100,00 square miles in Florida, Georgia, Alabama, South Carolina and extends offshore.**
- **Maximum age of the water has been dated to 26,000 years.**
- **One of the most productive aquifers in the world.**
- **May be thousands of feet thick however not all is productive.**

ELEVATION OF THE UPPER FLORIDAN AQUIFER (UFA)

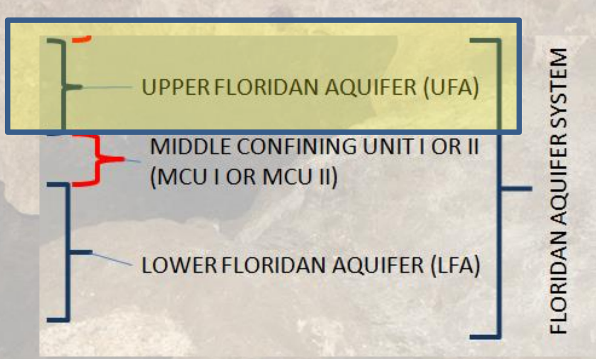


- Elevation increases to the west.
- Elevation ranges from a low of about -200 to a high of about 150 In this area.
- Karst features greatly influence the hydrologic characteristics.



UPPER FLORIDAN AQUIFER

HIGHLY VARIABLE BUT GENERALLY MORE PERMEABLE THAN UNDERLYING UNITS



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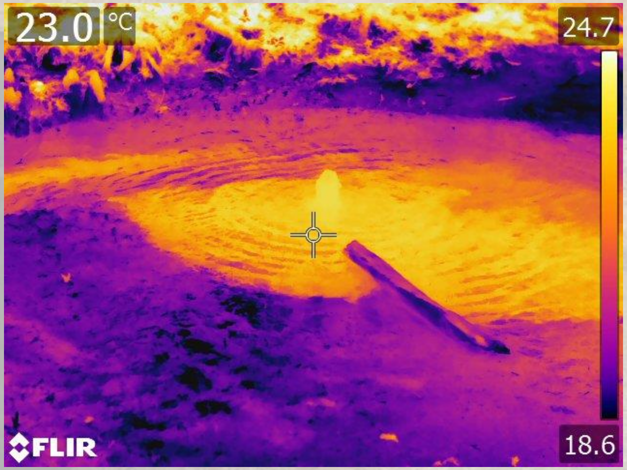
UPPER FLORIDAN AQUIFER

• WATER IN THE UPPER FLORIDAN MAY BE UNDER ARTESIAN CONDITIONS AND CAN FLOW AT LAND SURFACE.

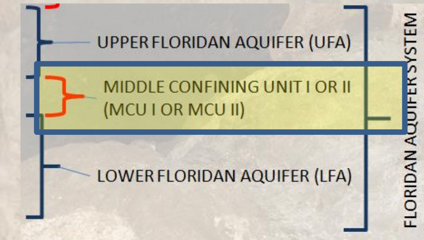
• MAY BE EXPOSED AT LAND SURFACE OR COVERED BY HUNDREDS OF FEET OF SEDIMENT.



• CAVES, DISSOLUTION ENLARGED FRACTURES, AND HIGH POROSITY AND PERMEABILITY ARE COMMON FEATURES.

• INTERVALS WHERE PERMEABILITY IS VERY HIGH OR LOW CAN BE MAPPED REGIONALLY.

MIDDLE CONFINING UNITS



EXTREMELY LOW VERTICAL CONDUCTIVITY (Kh)

LOW VERTICAL CONDUCTIVITY (Kh)

HIGH VERTICAL CONDUCTIVITY (Kh)

EXTREMELY LOW VERTICAL CONDUCTIVITY (Kh)

MULTIPLE LAYERS, EACH WITH DIFFERENT Kh
BUT THE CUMULATIVE EFFECTS OF ALL LIMIT CONNECTION BETWEEN THE UPPER FLORIDAN AND LOWER FLORIDAN AQUIFERS

MIDDLE CONFINING UNITS

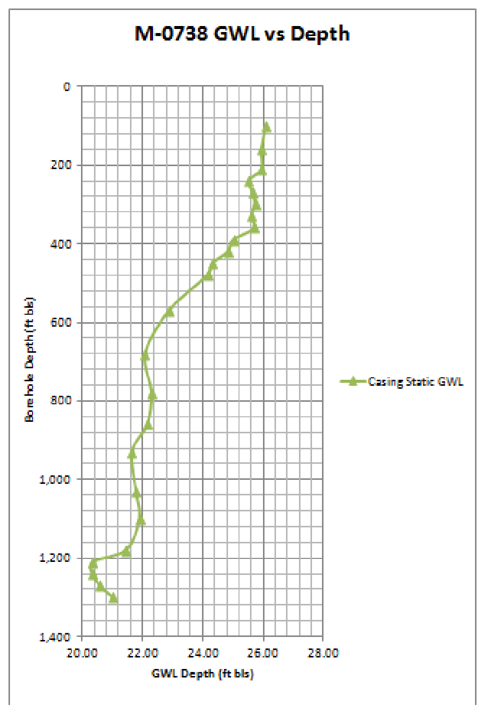
- SEPARATES THE UFA FROM THE LFA.

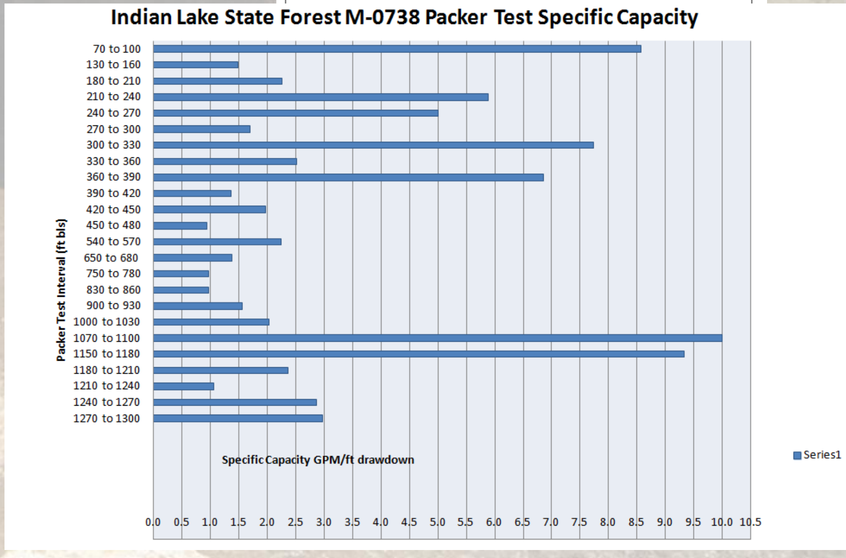
- BOUNDARIES CAN BE DIFFICULT TO IDENTIFY.

- GEOPHYSICAL LOGS, CORES, PACKER TESTS, AND WATER LEVEL CHANGES DURING DRILLING AND TESTING.

- ROCK TYPE CAN BE A GOOD INDICATOR BUT FRACTURES OR OTHER SECONDARY FEATURES CAN PROVIDE HYDRAULIC CONNECTION WITH THE UFA.

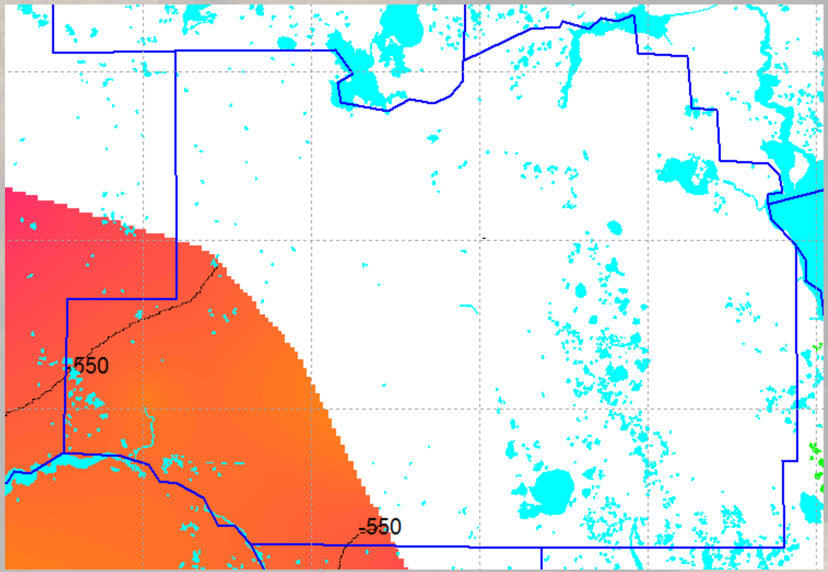
THIN, ABSENT, OR DIFFICULT TO RECOGNIZE TO THE WEST. NEED MORE DRILLING TO REFINE.



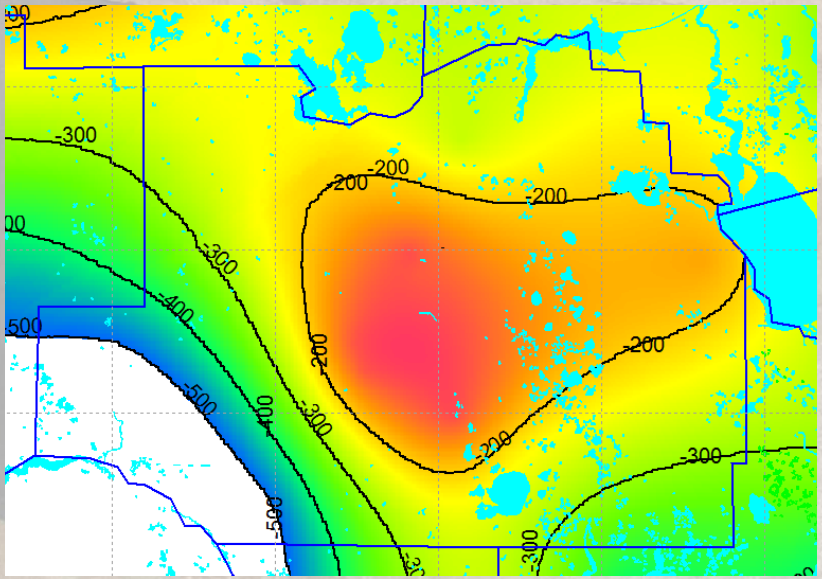


ELEVATION AND EXTENT OF MCU I AND MCU II MARION COUNTY

MCU II EXTENT



MCU I EXTENT



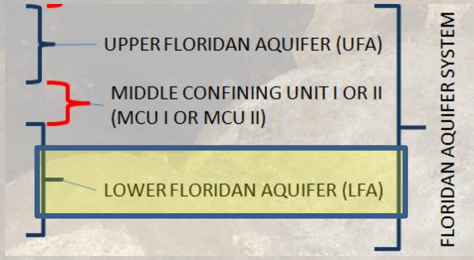
Note – efforts are underway to update these surfaces with additional data from other WMDs so there may be refinements in the near future.

LOWER FLORIDAN AQUIFER

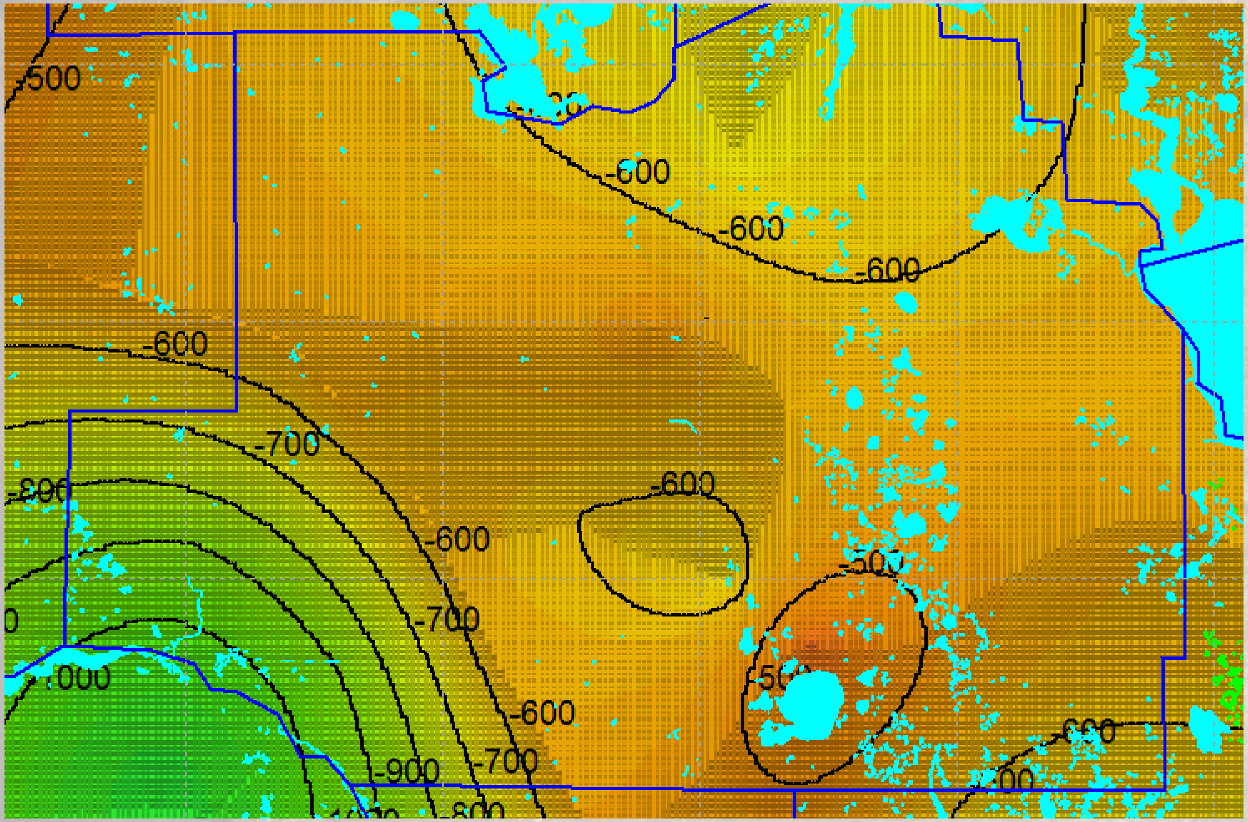
• SJRWMD maps this as the first regionally extensive permeable zone below the middle confining units.

• May be recognized by changes in water level, packer tests during drilling, geophysical log response, and rock type.

• Not always well defined or sharp boundary.

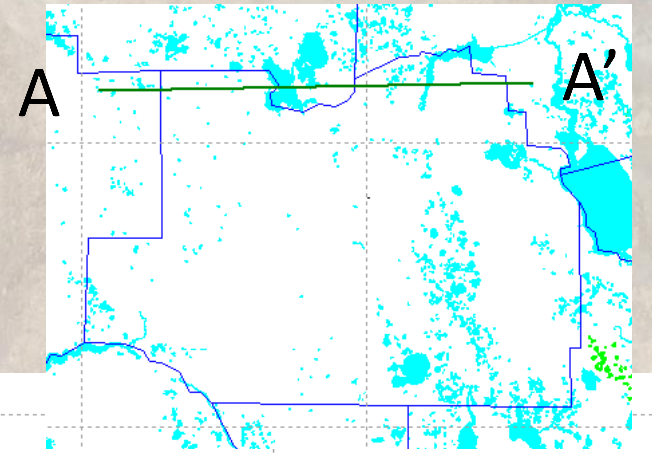


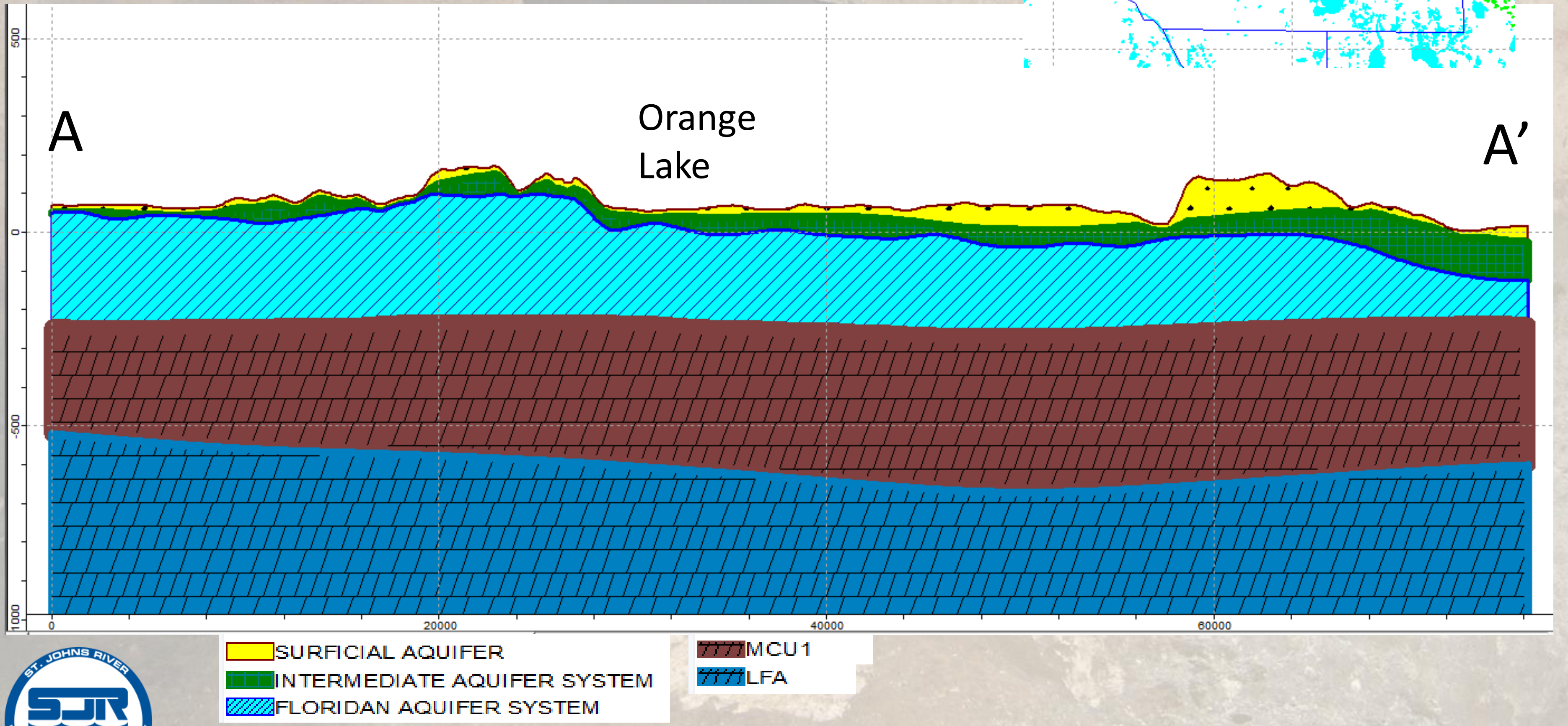
GENERALIZED TOP ESTIMATION OF THE LOWER FLORIDAN AQUIFER IN MARION COUNTY



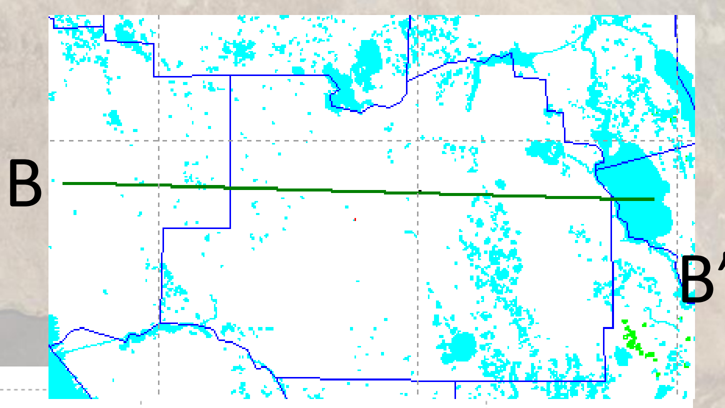
Elevation in feet NAVD88,

WEST TO EAST HYDROGEOLOGIC CROSS SECTION A-A’

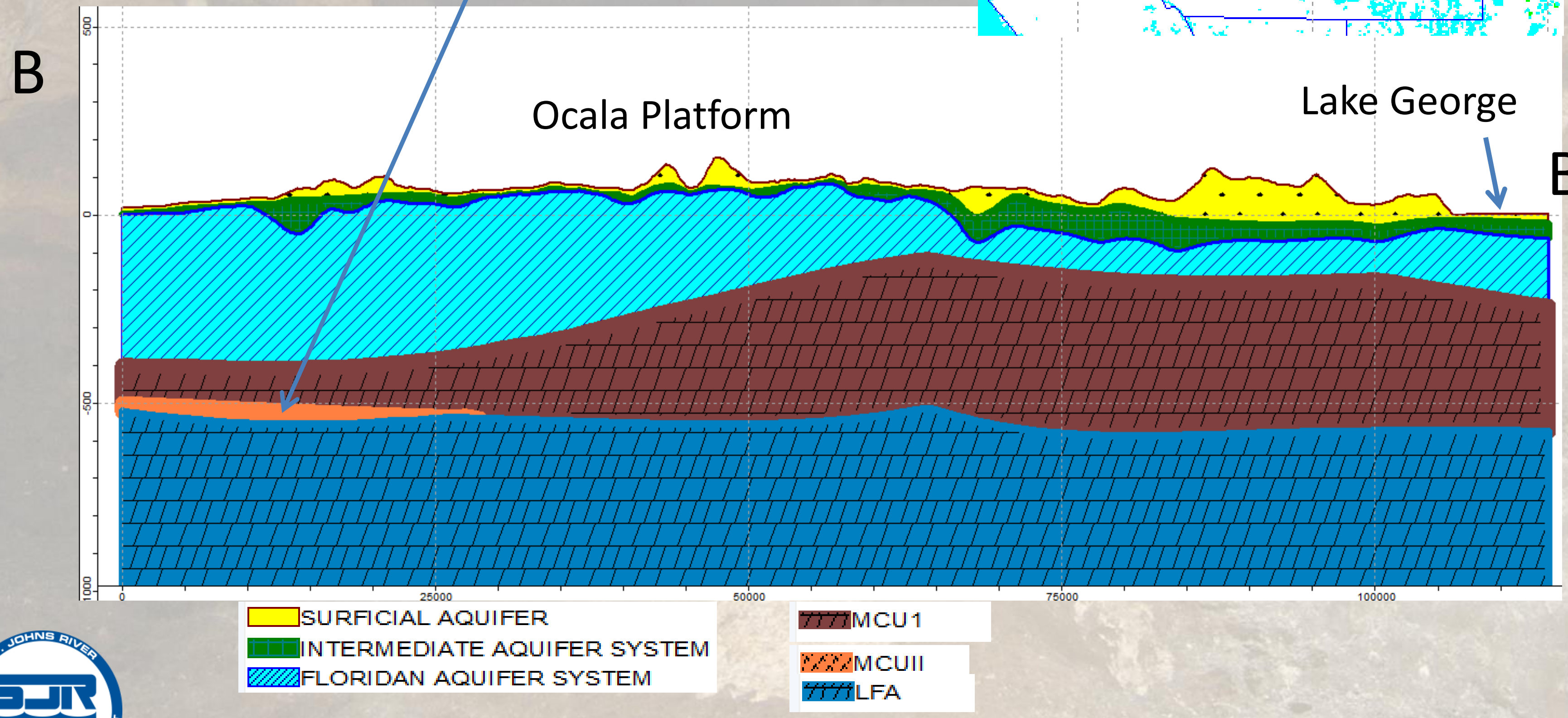




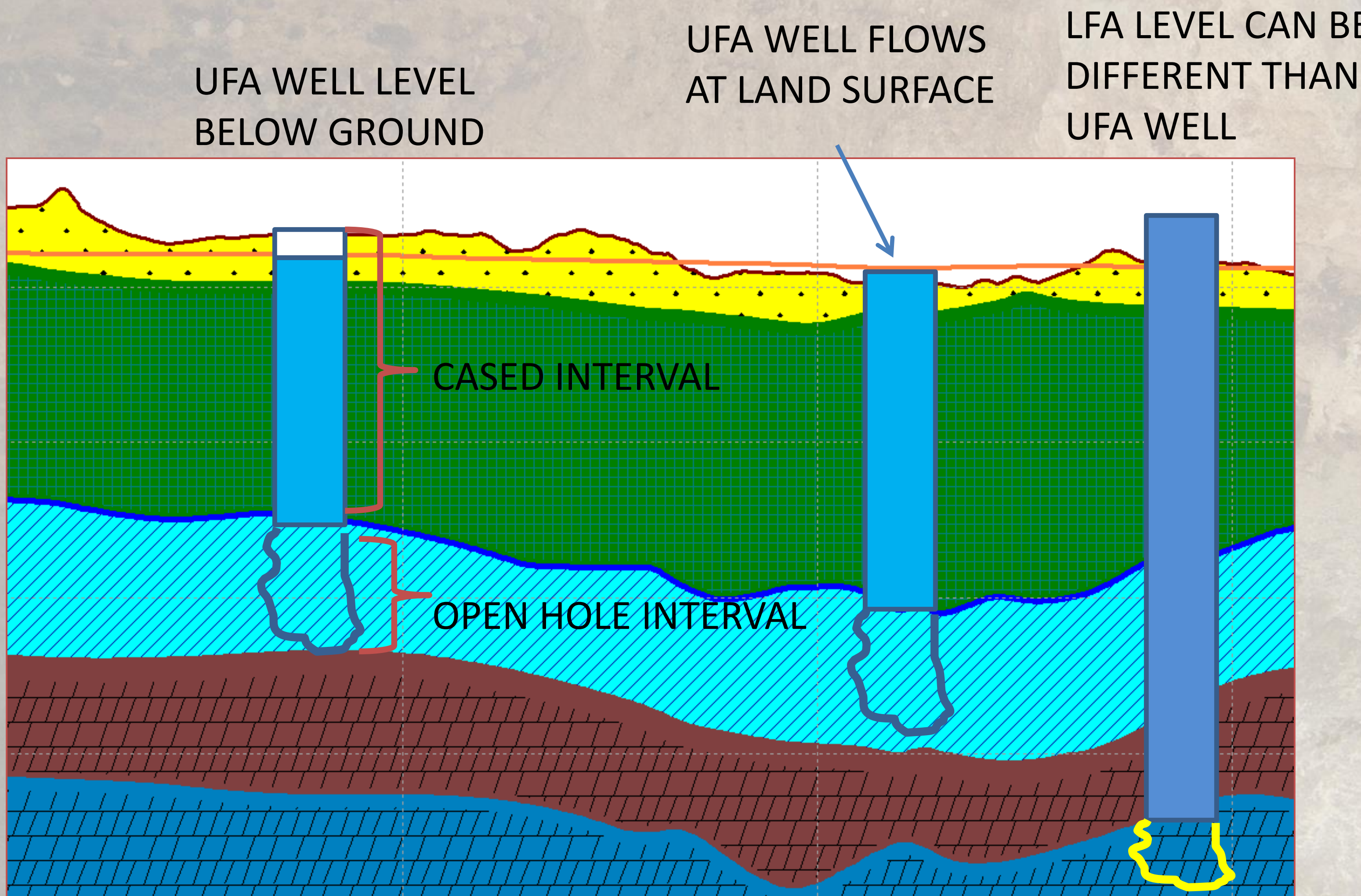
WEST TO EAST HYDROGEOLOGIC CROSS SECTION B-B'



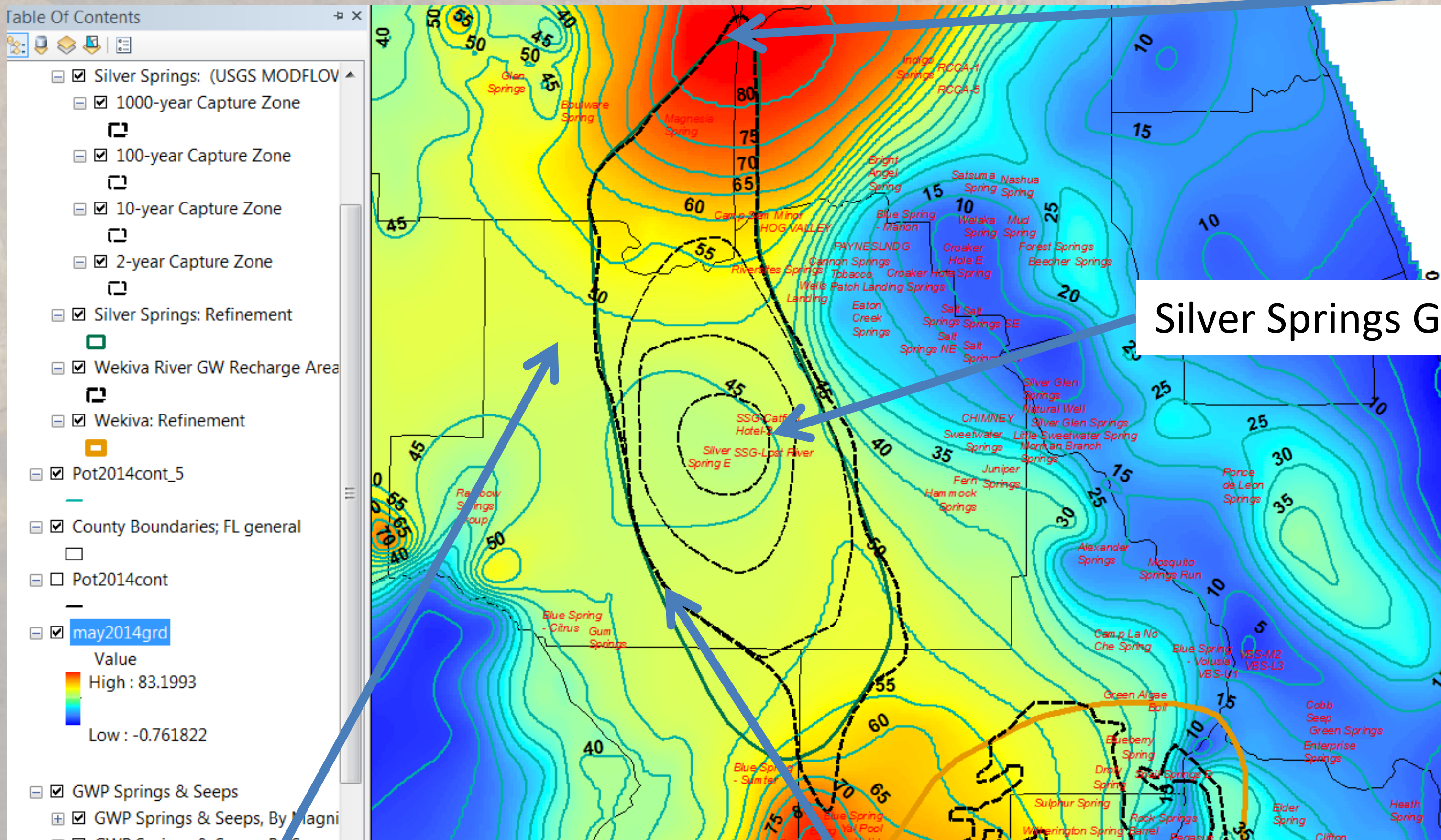
Note – MCUI thins to west and MCUII present



POTENTIOMETRIC SURFACE – THE LEVEL TO WHICH WATER WILL RISE IN A TIGHTLY CASED WELL



EXAMPLE POTENTIOMETRIC SURFACE MAP OF UPPER FLORIDAN AQUIFER



Recharge

Silver Springs Group discharge

Low relief or poorly defined gradient

Springshed boundary and 2, 10, 100, 1000 year capture zones (USGS MODFLOW)

The Lower Floridan Aquifer has it's own potentiometric surface that can be above, below, or equal to the Upper Floridan Aquifer potentiometric surface.

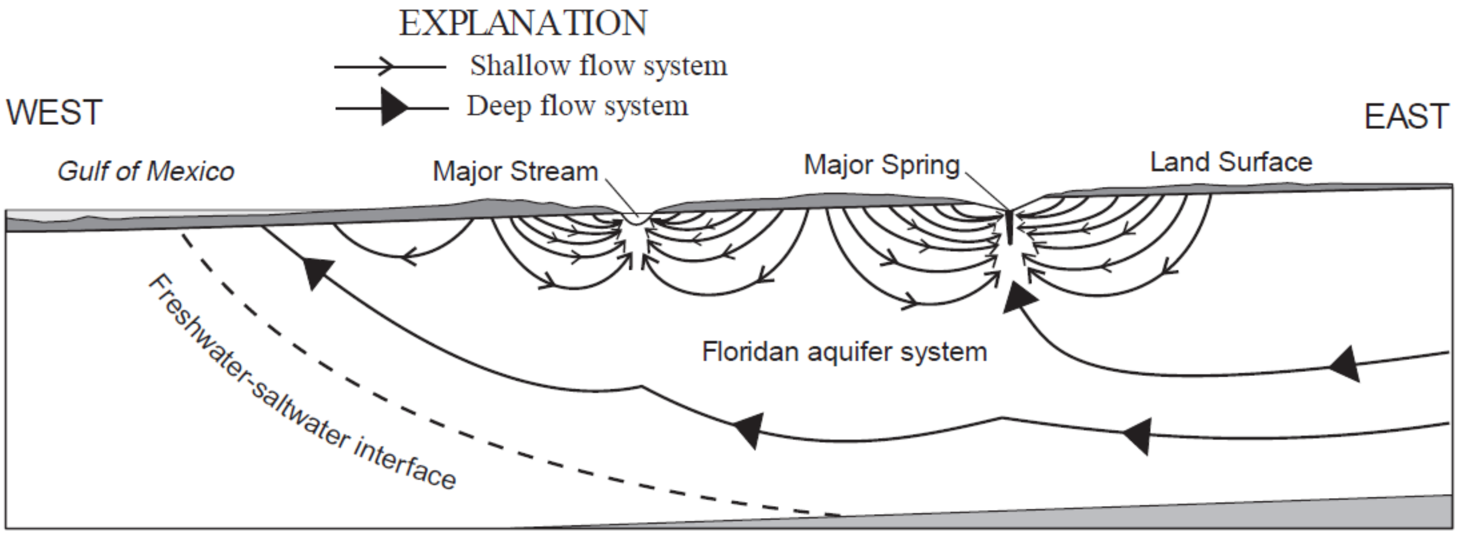
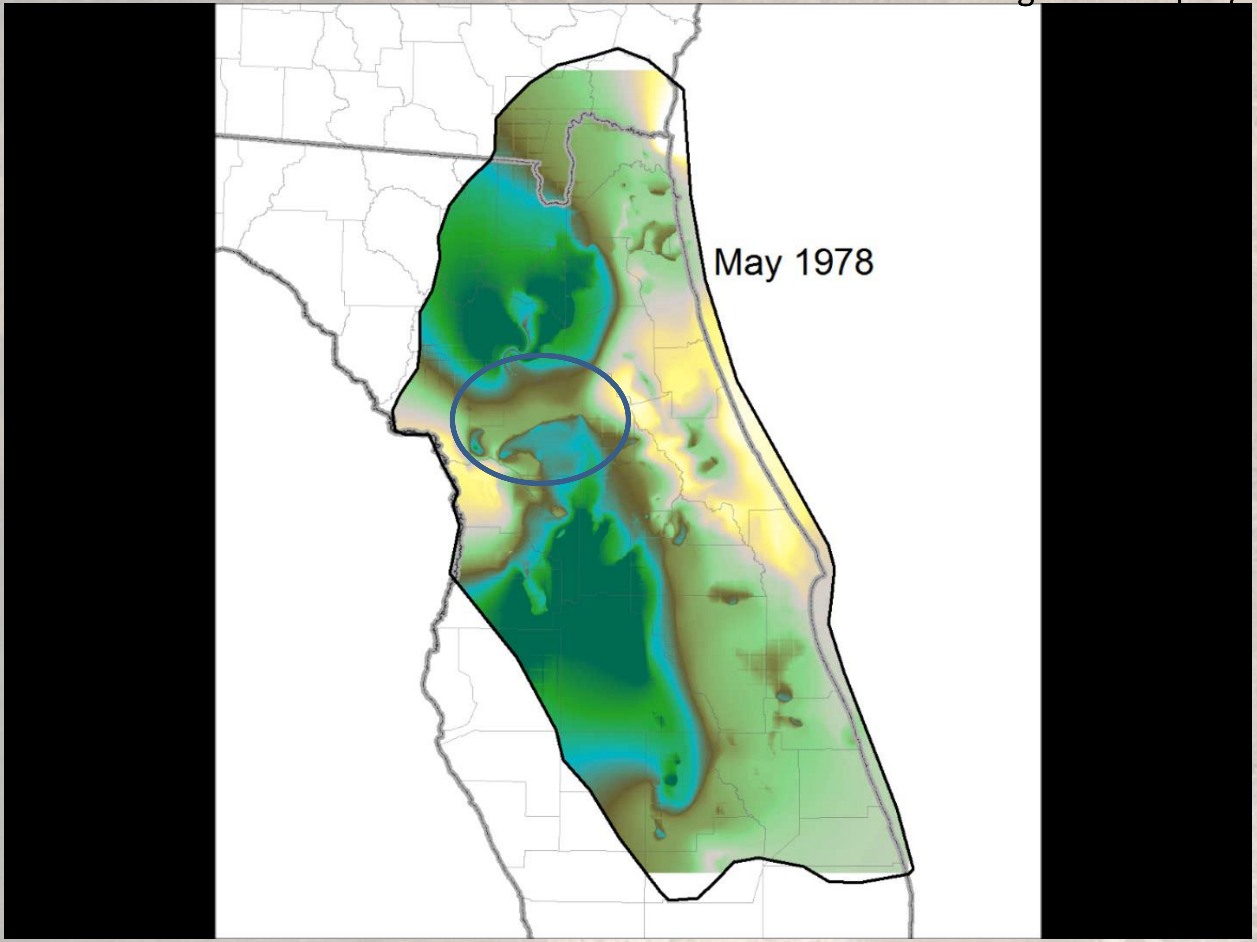


Figure 5. Idealized flow patterns in the Upper Floridan aquifer between north-central Florida and the Gulf Coast. (Modified from Bush and Johnston, 1988.)

From : Geochemical and Isotopic Composition of Ground Water with Emphasis On Sources of Sulfate in the Upper Floridan Aquifer in Parts of Marion, Sumter, and Citrus Counties, Florida. Laura A. Sacks, USGS Water-Re sources Investigation Report 95-4251

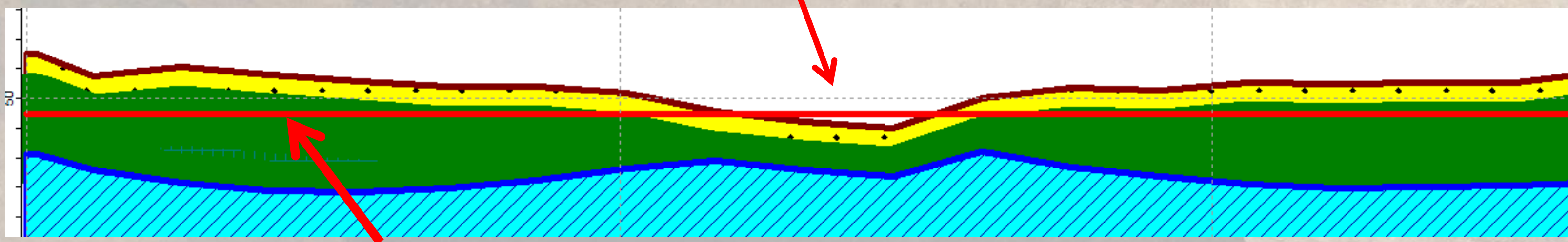
ANIMATION OF UPPER FLORIDAN POTENTIOMETRIC SURFACE
MAY 1978- SEPTEMBER 2010

(CLICK IMAGE TO START ANIMATION – movie file needs to be in directory of presentation and will not work if viewing this as a pdf)

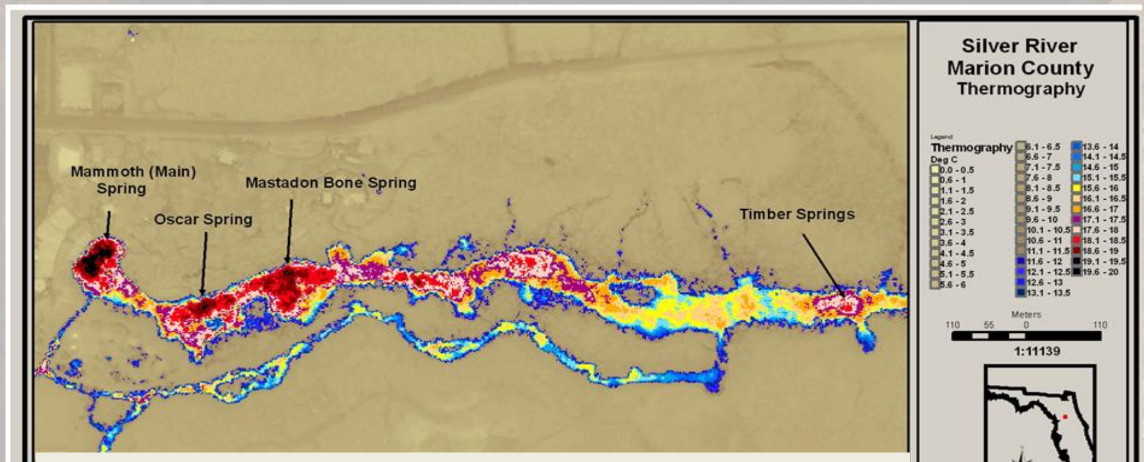


Test animation made by Jill Stokes, GIS analyst, SJRWMD

SILVER SPRINGS FLOWS BECAUSE THE POTENTIOMETRIC SURFACE IS HIGHER THAN LAND SURFACE AND THERE ARE PATHWAYS THROUGH THE CONFINING UNIT



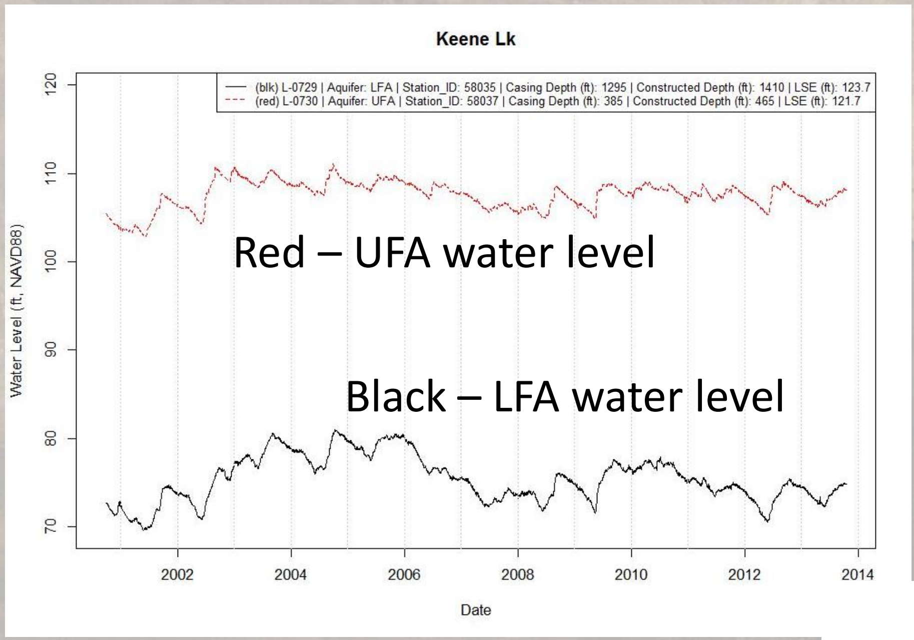
1995 UFA potentiometric surface (red line)



Thermal imagery showing discharge locations

SOME DISCHARGE FROM UFA AND SOME FROM LFA

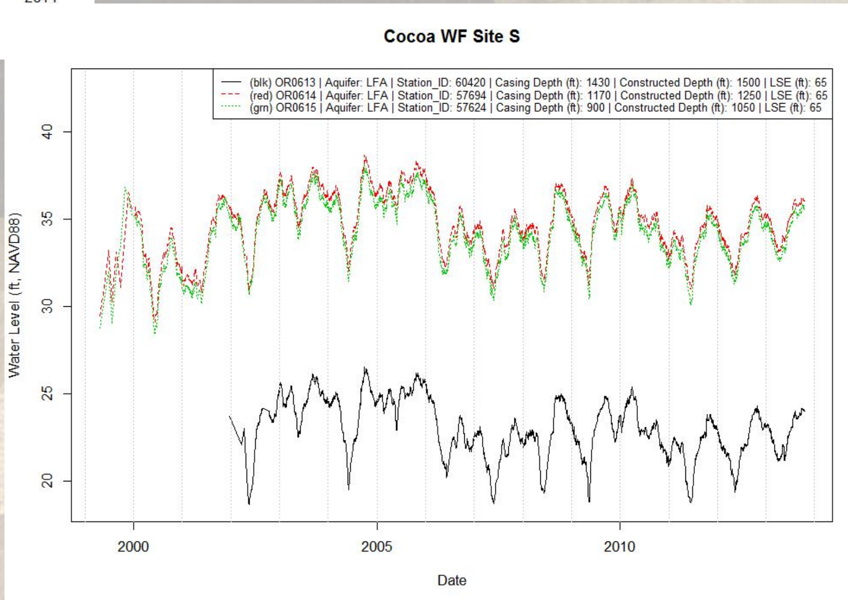
HYDROGRAPHS ARE MADE FROM MEASURING WATER LEVEL IN WELLS FOR A TIME INTERVAL



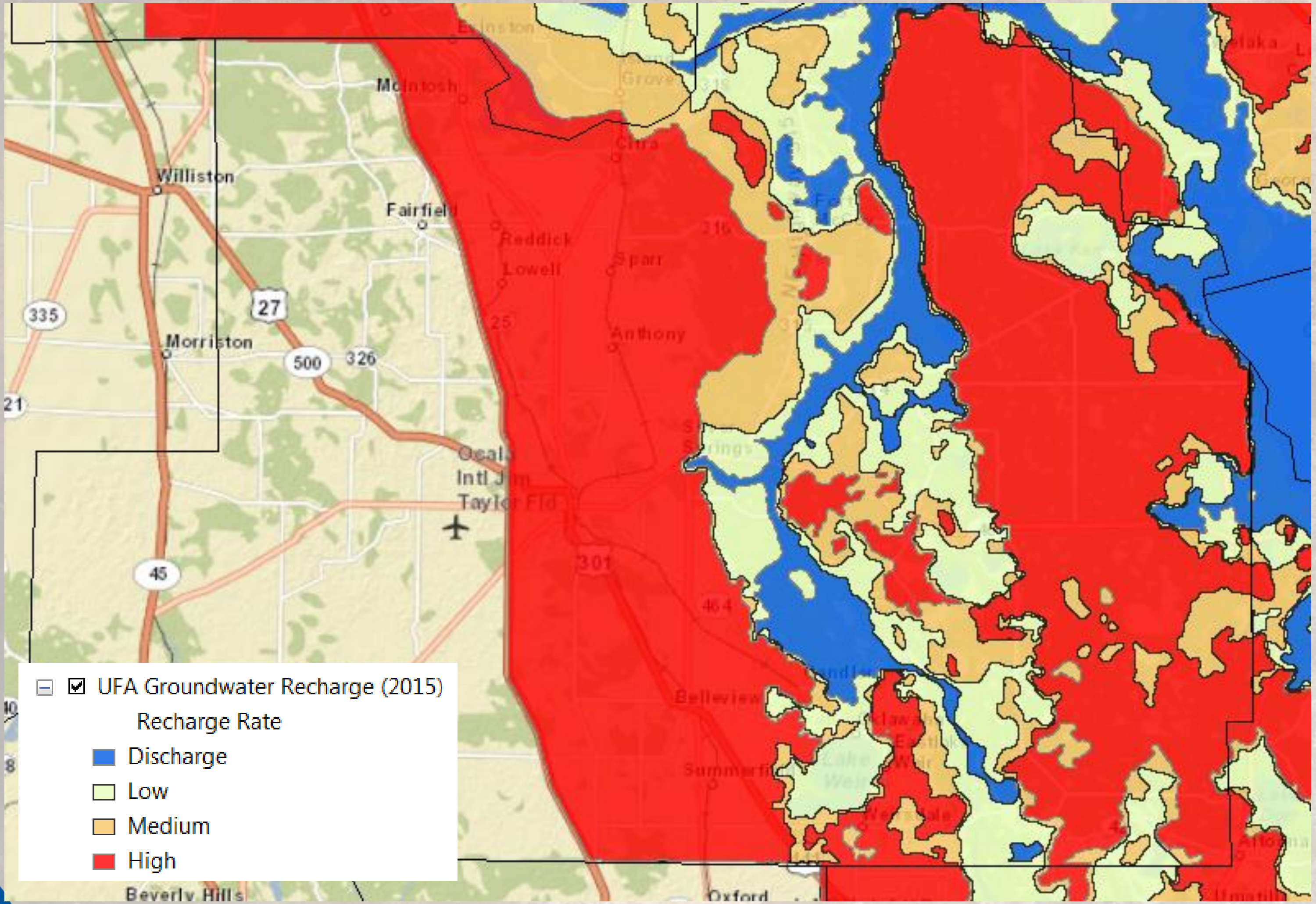
A HYDROGRAPH CAN SHOW THE GRADIENT BETWEEN UPPER FLORIDAN AND LOWER FLORIDAN POTENTIOMETRIC SURFACE.

AT THIS SITE THERE IS OVER 35' DIFFERENCE IN WATER LEVEL ELEVATION BETWEEN THE TWO AQUIFERS SO WATER WOULD FLOW DOWN FROM UFA TO LFA IF A PATHWAY WAS PRESENT.

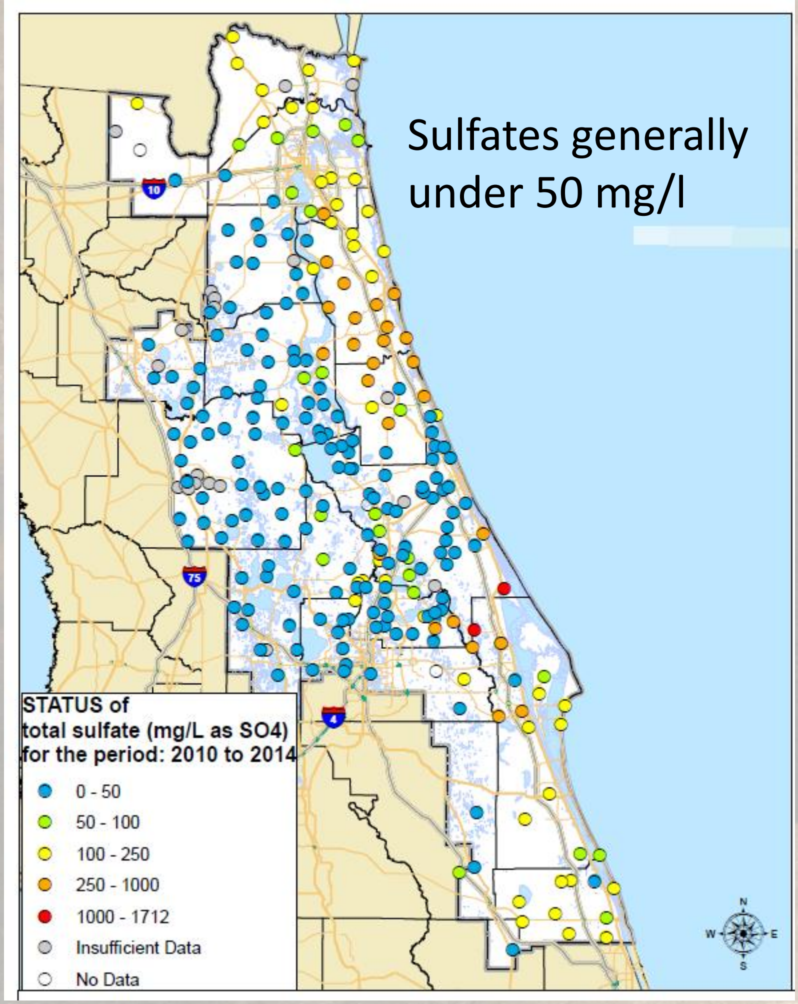
HYDROGRAPHS CAN ALSO SHOW WATER LEVEL CHANGES FROM DIFFERENT ZONES AT THE SAME SITE IN THE UPPER OR LOWER FLORIDAN.

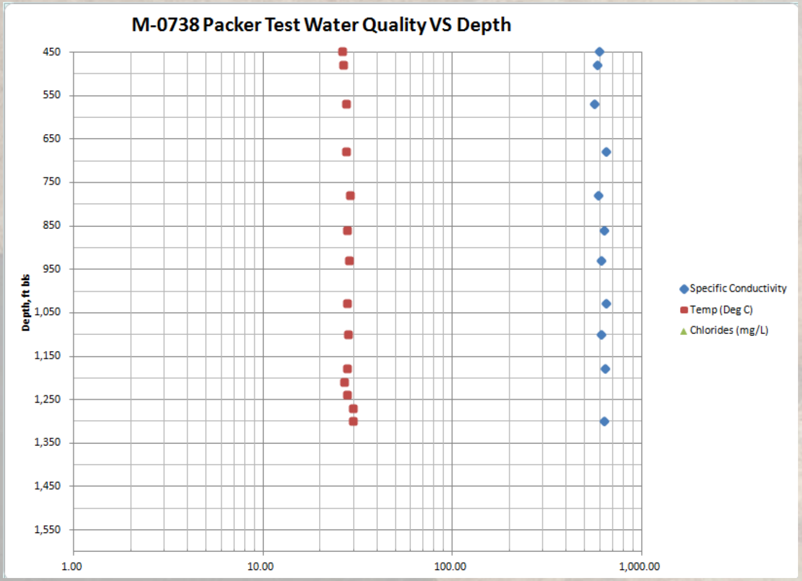


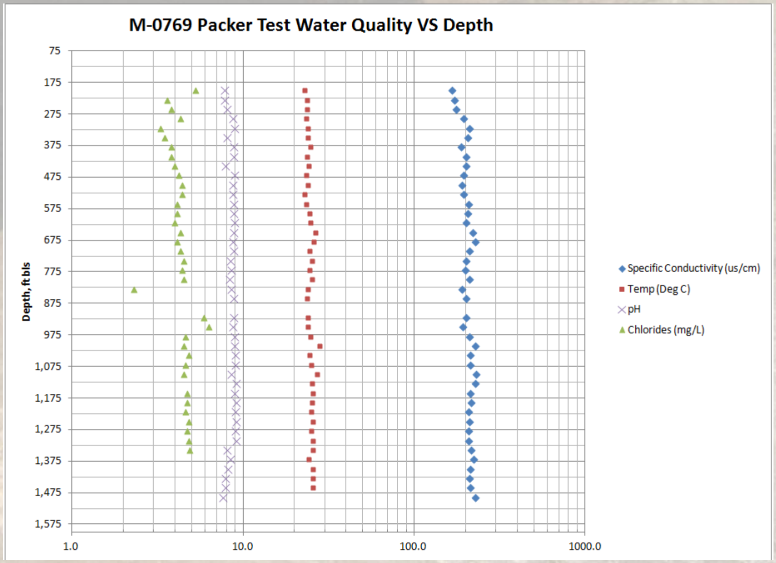
RECHARGE AND DISCHARGE IN THE SJRWMD



WATER QUALITY FAIRLY CONSISTENT WITH DEPTH







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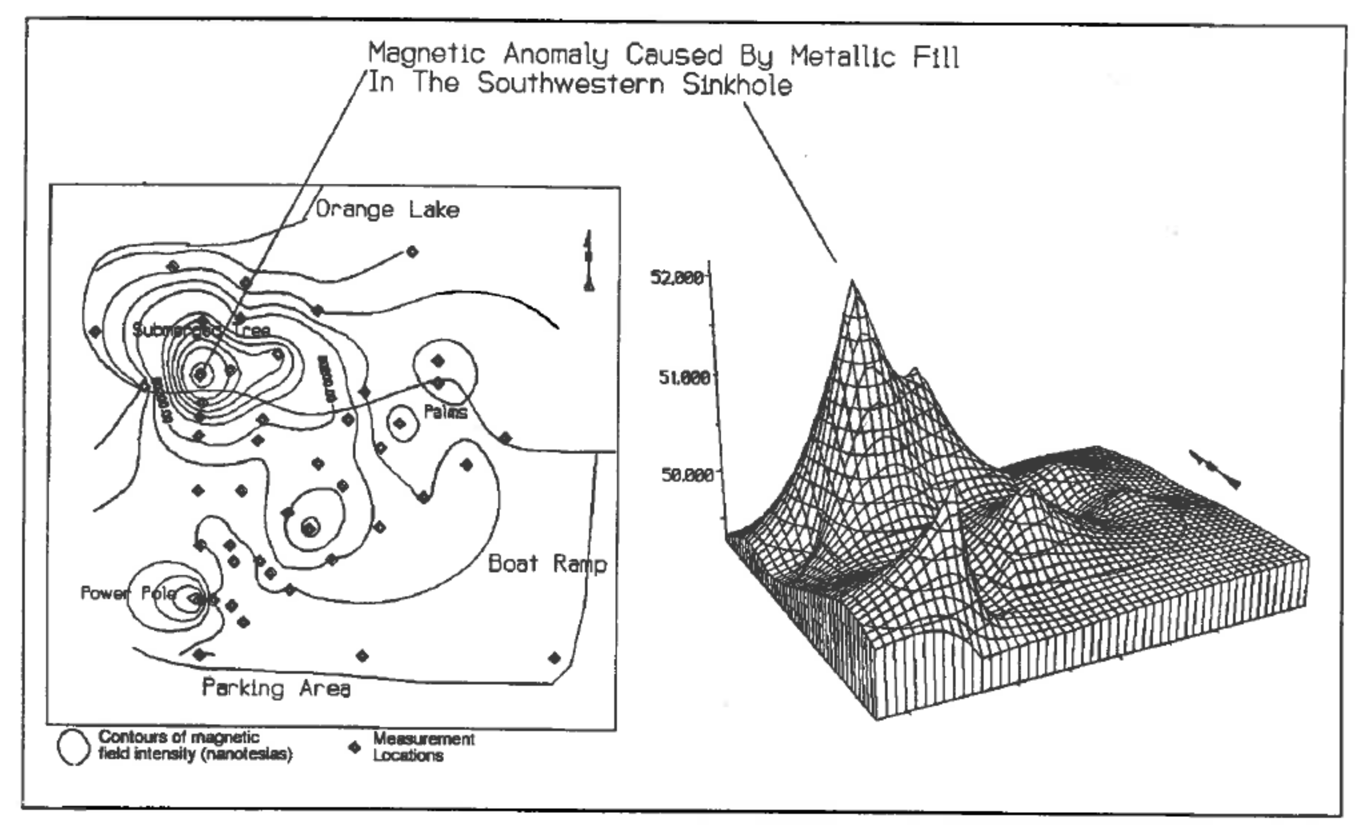
LET'S LOOK BELOW ORANGE LAKE

GEOPHYSICAL INVESTIGATIONS OF THE ORANGE LAKE AREA SUBSURFACE

- HIGH RESOLUTION SINGLE CHANNEL SEISMIC REFLECTION.
- MAGNETOMETER.
- GROUND PENETRATING RADAR.

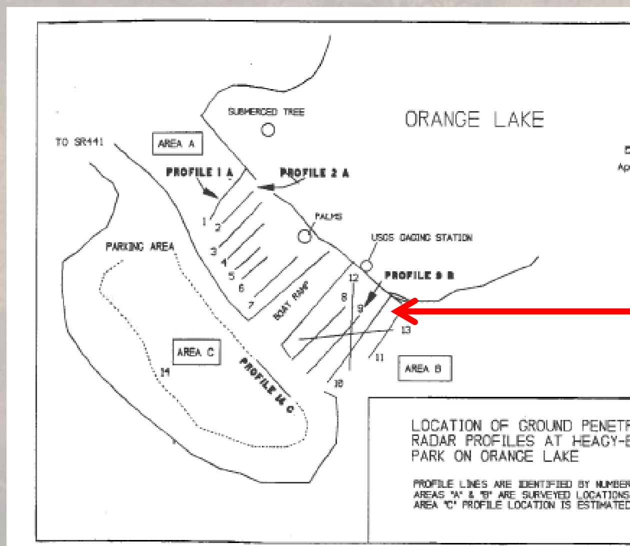
MAGNETIC FIELD INTENSITY AT THE HEAGY-BURY PARK, MARION COUNTY

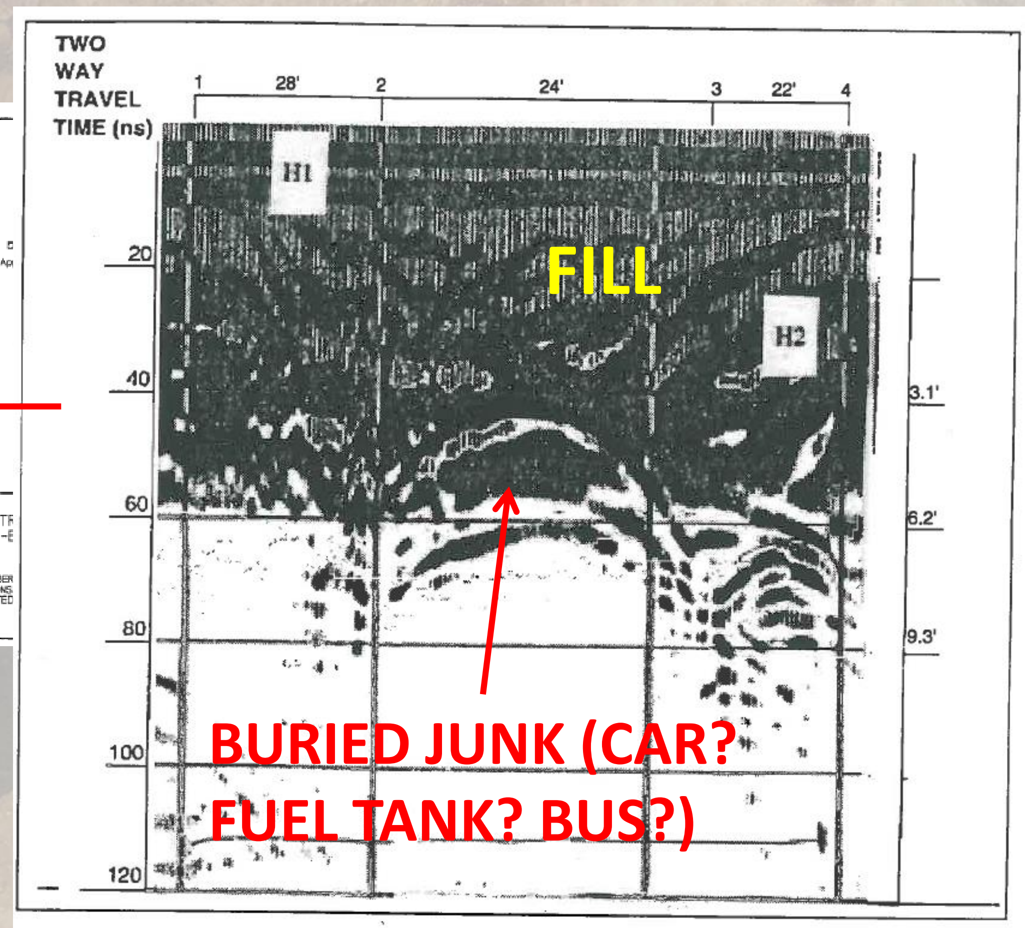
ANOMALIES IN THE MAGNETIC FIELD INTENSITY INDICATE WHERE VEHICLES AND OTHER DEBRIS WERE PLACED IN 1964



From: Davis, J. B. 1996, Geological and Karstic Features That May Impact the Surface Water to Ground Water Interactions at Orange Lake, Alachua County, Florida. Masters Thesis, University of Florida, Gainesville, Florida, 125p.

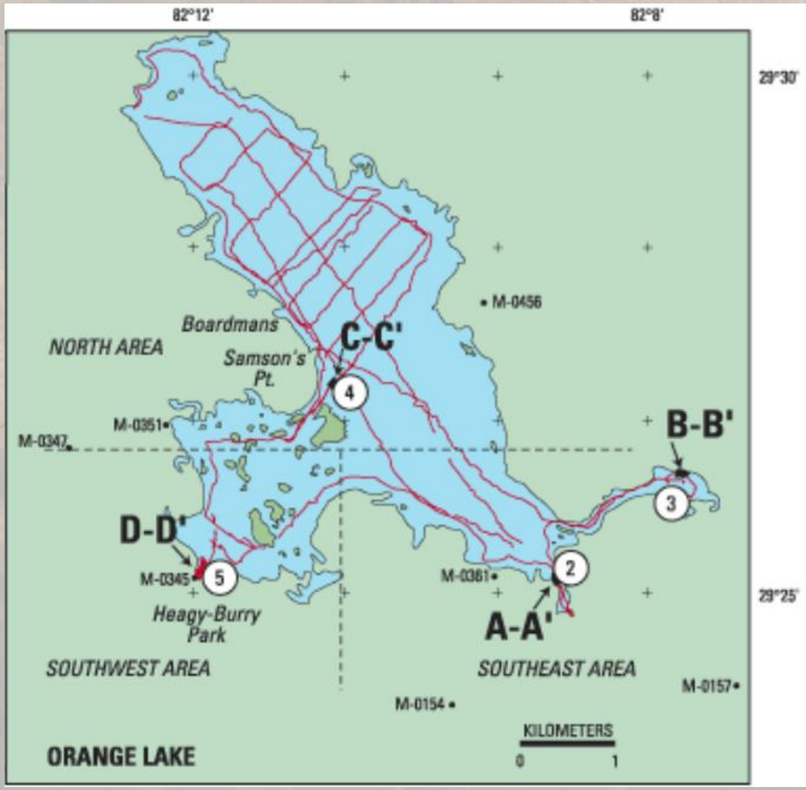
GROUND PENETRATING RADAR EXAMPLE (OLD STYLE ANALOG) AT THE HEAGY-BURRY PARK BOAT RAMP



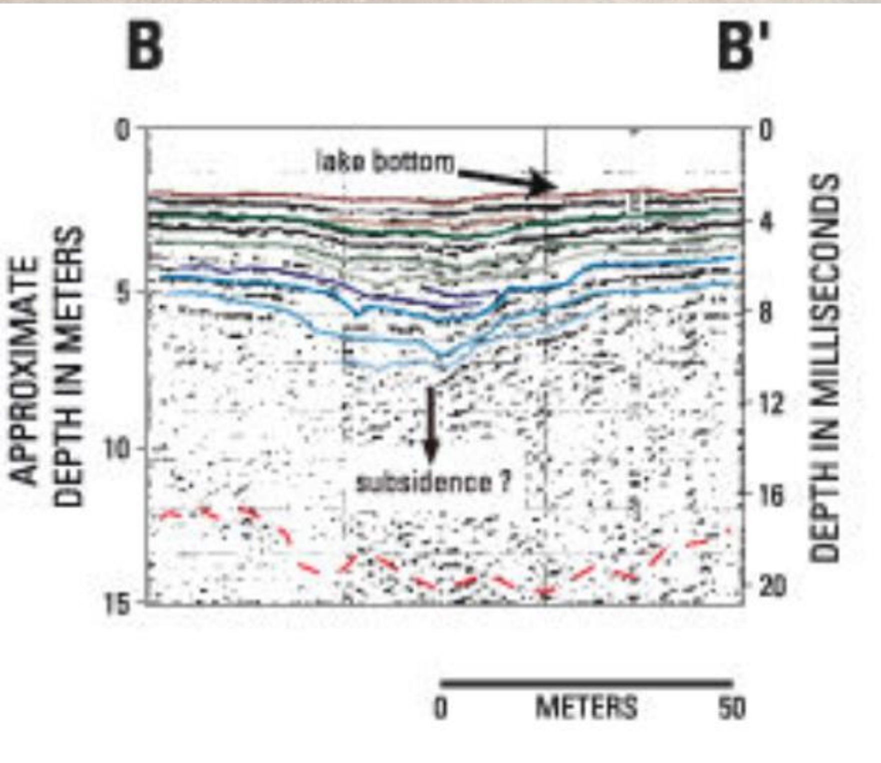


From: Davis, J. B. 1996, Geological and Karstic Features That May Impact the Surface Water to Ground Water Interactions at Orange Lake, Alachua County, Florida. Masters Thesis, University of Florida, Gainesville, Florida, 125p.

HIGH RESOLUTION SINGLE CHANNEL SEISMIC REFLECTION (HRSP)



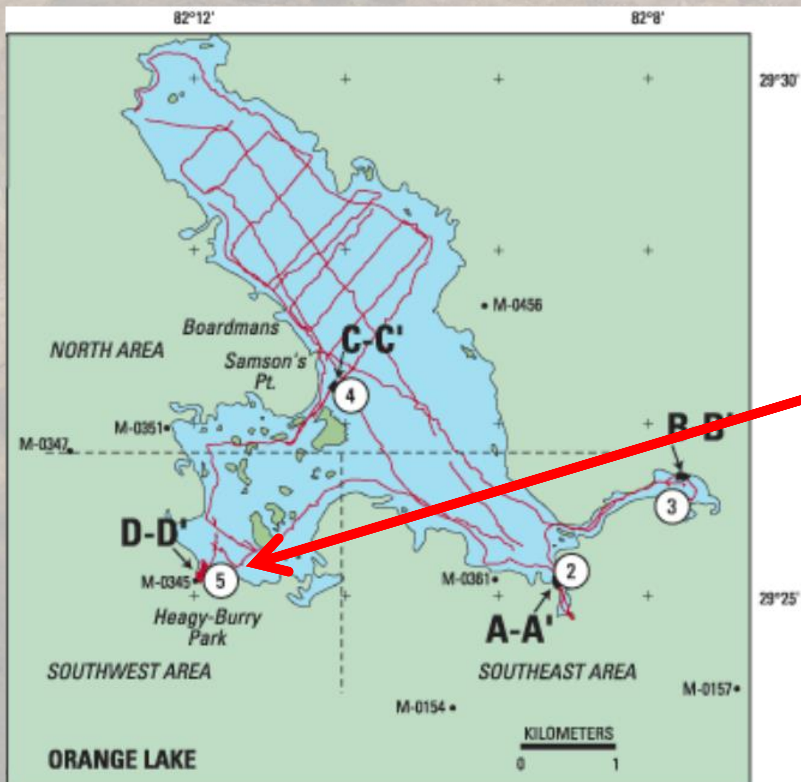
Track lines limited by aquatic vegetation



Example of a subsidence feature that does not breach the confining unit over the Floridan.

From: Kindinger, J. L., Davis, J. B., and Flocks, J. G. 1994, High-Resolution Single-Channel Seismic Reflection Surveys of Orange Lake and Other Selected Sites of Northern Florida: U S Geological Survey Open-File Report 94-616, 48 p

HIGH RESOLUTION SINGLE CHANNEL SEISMIC REFLECTION AT THE HEAGY-BURRY PARK



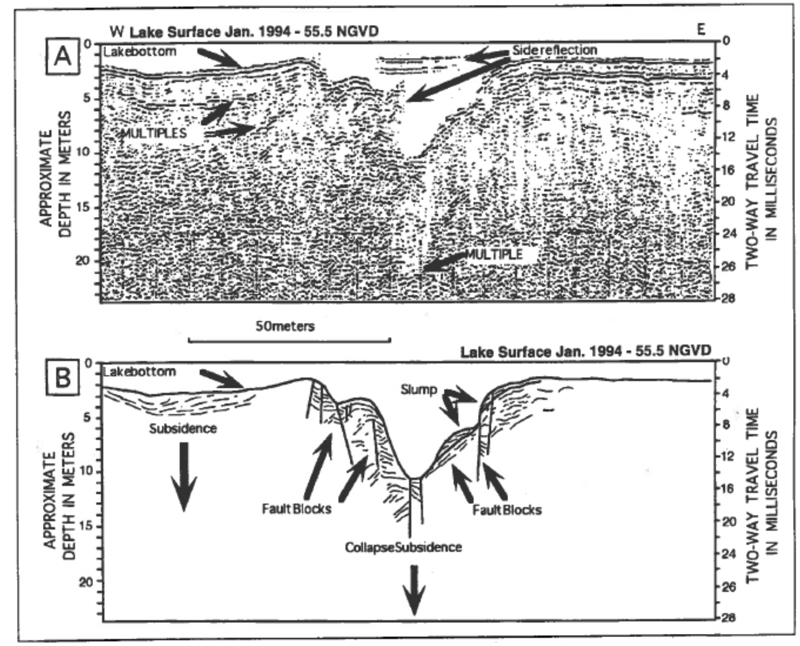
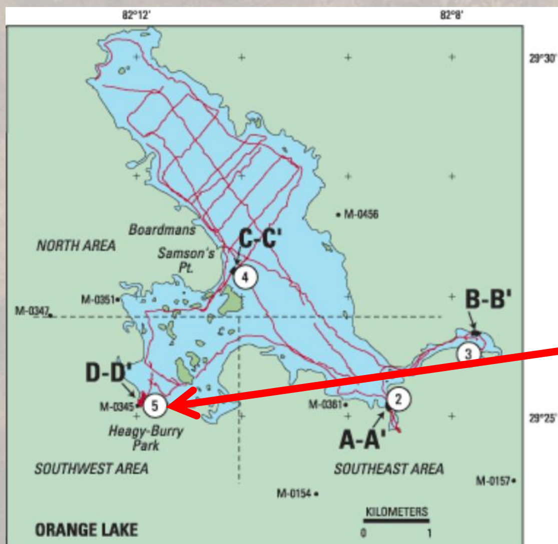


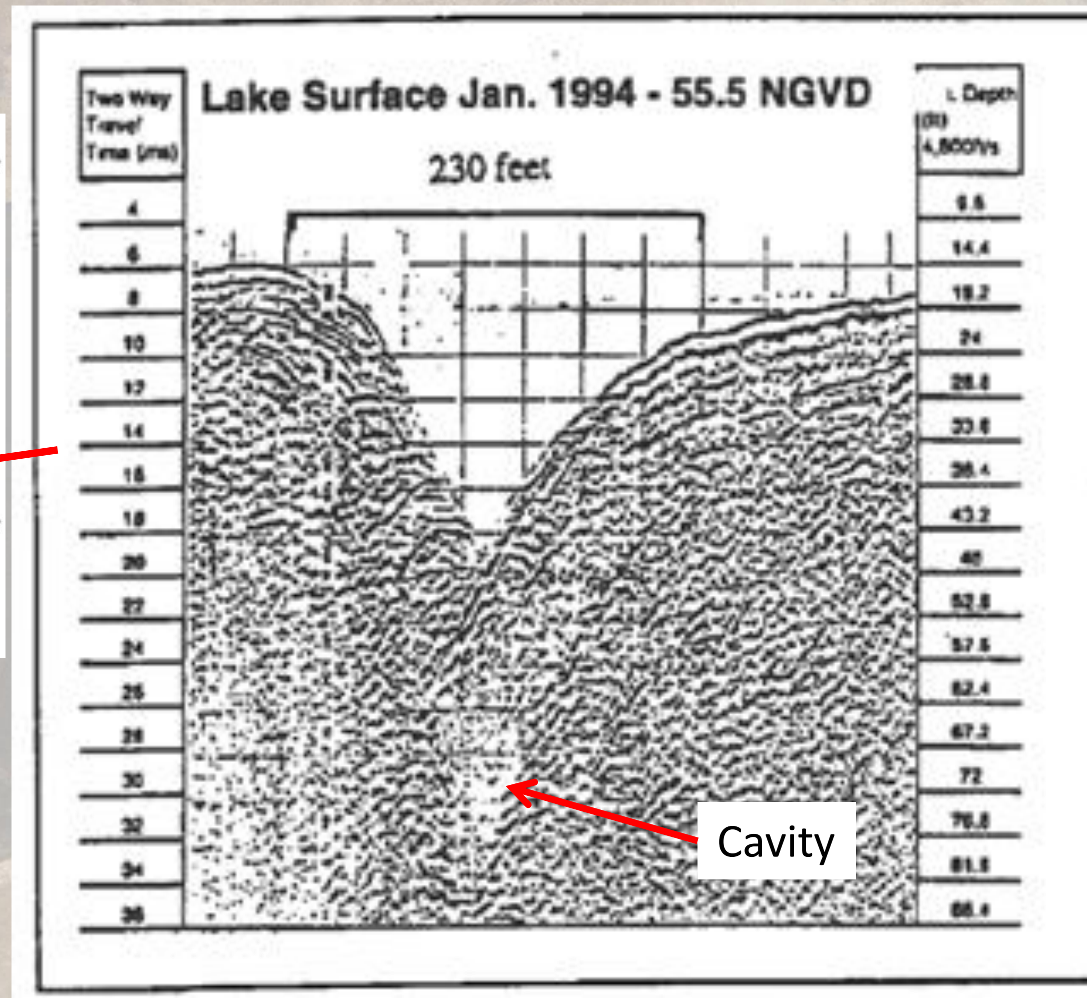
Figure 6-17. Seismic data and line drawing interpretation from the west collapse sinkhole at the Heagy-Burry park site. See Figure 6-7 for location.
a) Seismic data. Note the reflections caused by the seismic signal reverberating from the walls of the sinkhole.
b) Line drawing interpretation. Faulted blocks are identified by grouping parallel reflectors. These blocks have shifted into the sinkhole. The faults represent a local discontinuity of the sinkhole and are not indicative of any regional trend.

Example of a collapse sinkhole with blocks
Slumping into the sink.

From: Kindinger, J. L., Davis, J. B., and Flocks, J. G. 1994, High-Resolution Single-Channel Seismic Reflection Surveys of Orange Lake and Other Selected Sites of Northern Florida: U S Geological Survey Open-File Report 94-616, 48 p

HIGH RESOLUTION SINGLE CHANNEL SEISMIC REFLECTION AT THE HEAGY-BURRY PARK





From: Kindinger, J. L., Davis, J. B., and Flocks, J. G. 1994, High-Resolution Single-Channel Seismic Reflection Surveys of Orange Lake and Other Selected Sites of Northern Florida: U S Geological Survey Open-File Report 94-616, 48 p

HIGH RESOLUTION SINGLE CHANNEL SEISMIC REFLECTION SOUTHERN ORANGE LAKE

MUCK ON THE BOTTOM CAUSES PROBLEMS BUT CERTAIN FEATURES CAN STILL BE DISCERNED

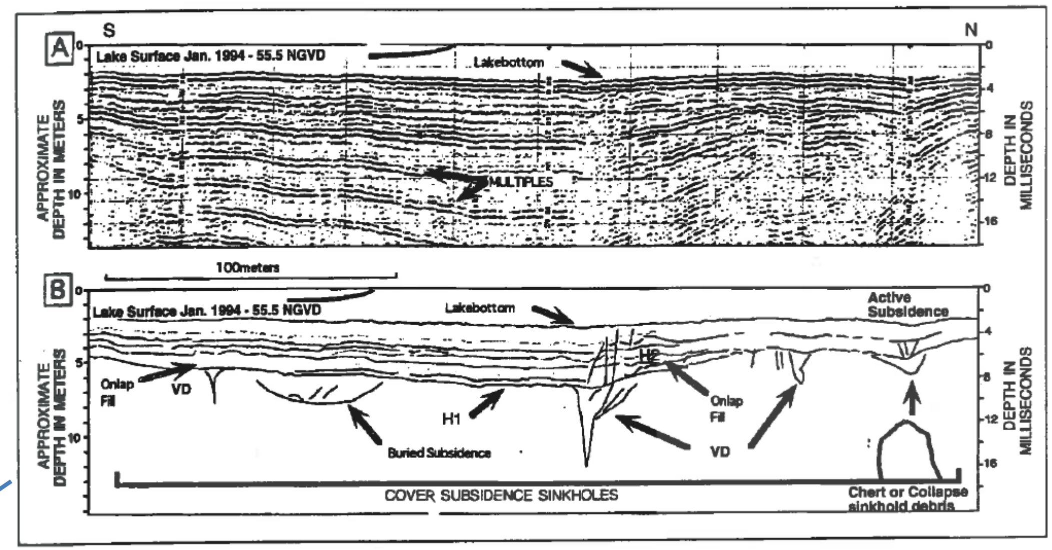
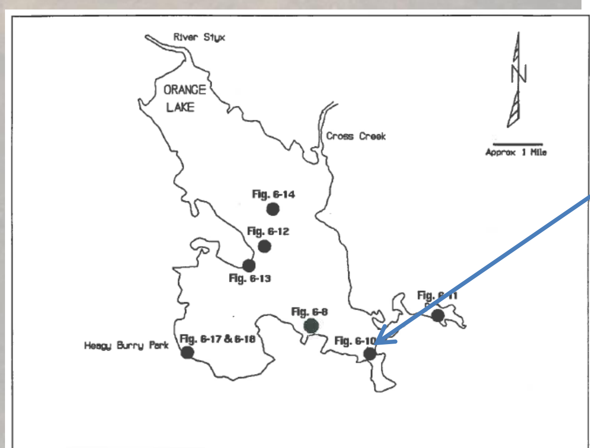


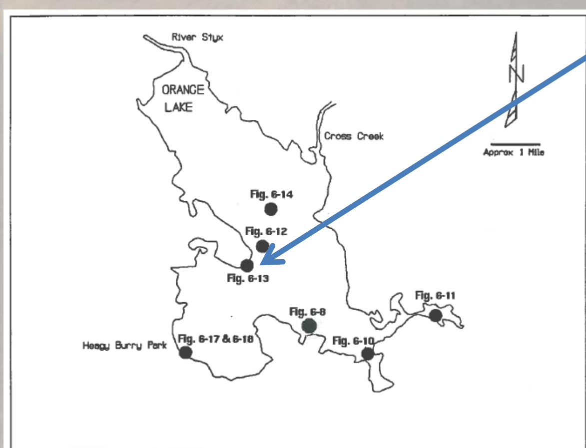
Figure 6-10. Seismic data and line drawing interpretation from the central part of the southeast region of Orange lake.
a) Seismic data.
b) Line drawing interpretation. Note large subsidence features with associated smaller sinkholes and vertical discontinuities (VD).
Source: Modified from Kindinger, Davis and Flocks, (1994).



From: Davis, J. B. 1996, Geological and Karstic Features That May Impact the Surface Water to Ground Water Interactions at Orange Lake, Alachua County, Florida. Masters Thesis, University of Florida, Gainesville, Florida, 125p.

HIGH RESOLUTION SINGLE CHANNEL SEISMIC REFLECTION NEAR SAMSONS POINT

Vertical discontinuity through confining unit



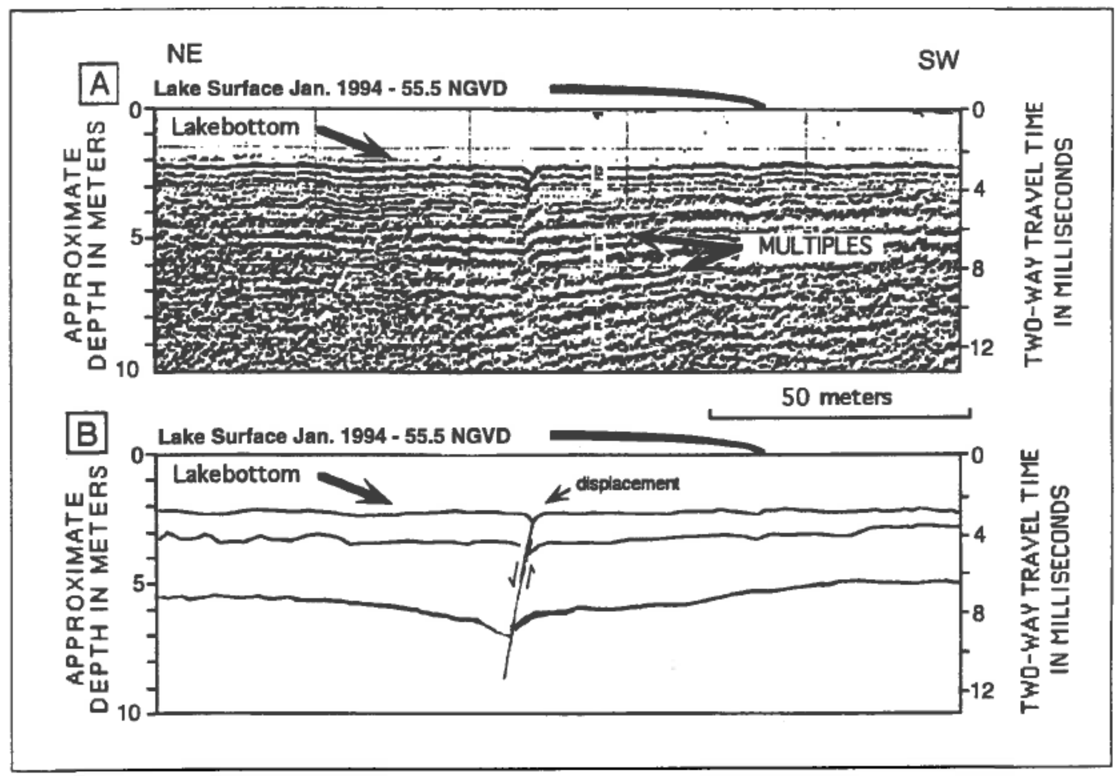
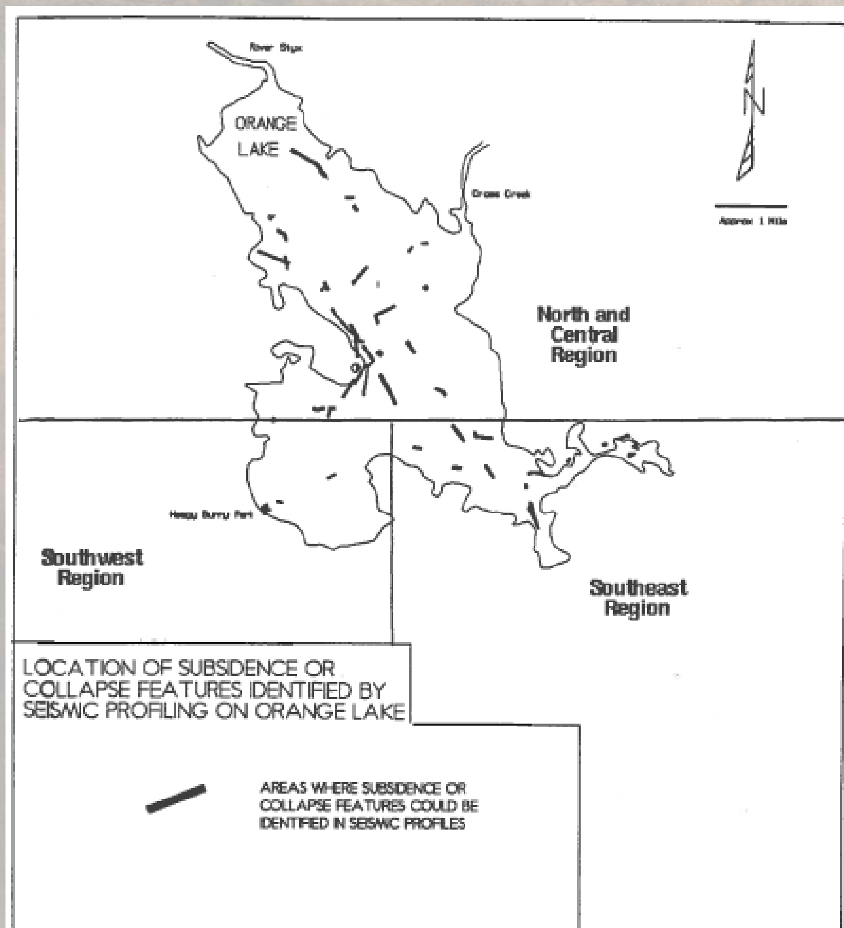


Figure 6-13. Additional seismic data and line drawing interpretation from the north-central region of Orange Lake. See figure 6-7 for location.
a) Seismic data.
b) Line drawing interpretation. This shows an isolated vertical discontinuity (VD) in the semiconfining unit. Evidence of vertical displacement through the lake bottom can also be seen.
<u>Source</u>: Modified from Kindinger, Davis and Flocks, (1994).

From: Davis, J. B. 1996, Geological and Karstic Features That May Impact the Surface Water to Ground Water Interactions at Orange Lake, Alachua County, Florida. Masters Thesis, University of Florida, Gainesville, Florida, 125p.

LOCATION OF SUBSIDENCE AND COLLAPSED FEATURES IDENTIFIED BY SEISMIC PROFILING



- **North and Central – Isolated, solitary features with breaches through the ICU. Multiple features around Samsons Point. Poor data quality in the central area**

- **Southwest – Mostly covered with vegetation. Active sinks identified.**

- **Southeast – gently sloping bowl shaped features with evidence of differential subsidence rates and infilling. Coalesced sinks.**

From: Davis, J. B. 1996, Geological and Karstic Features That May Impact the Surface Water to Ground Water Interactions at Orange Lake, Alachua County, Florida. Masters Thesis, University of Florida, Gainesville, Florida, 125p.

DYE TRACING TO IDENTIFY FLOW DIRECTION AND ESTIMATE GROUNDWATER VELOCITY

Silver Springs Nutrient Pathway Characterization Project

FROM: Mcgurk, B.E., Davis, J. B., Stokes, J. A., Toth, D.J., Colona, W., Butt, Pete, 2011, Silver Springs Nutrient Pathway Characterization Project Final Report Prepared for the Florida Department of Environmental Protection, St. Johns River Water Management District Special Publication SJ2012-SP2

http://floridaswater.com/technicalreports/spubs1.html Go to SJ2012-SP2 for download

Silver Springs Nutrient Pathway Characterization

This project is funded by the Florida Department of Environmental Protection using funds provided by the U. S. Environmental Protection Agency from the American Reinvestment and Recovery Act of 2009 (ARRA).

The project objectives are to 1) identify dominant groundwater flow pathways and travel times between specific locations and Silver Springs and 2) identify potential sources of nutrient inputs to the groundwater flow system that appear to be directly connected to the Silver Spring Discharge vents.

RECOVERY.GOV

Florida Department of Environmental Protection

Springs Initiative

St. Johns River Water Management District

Funded by the American Reinvestment And Recovery Act of 2009

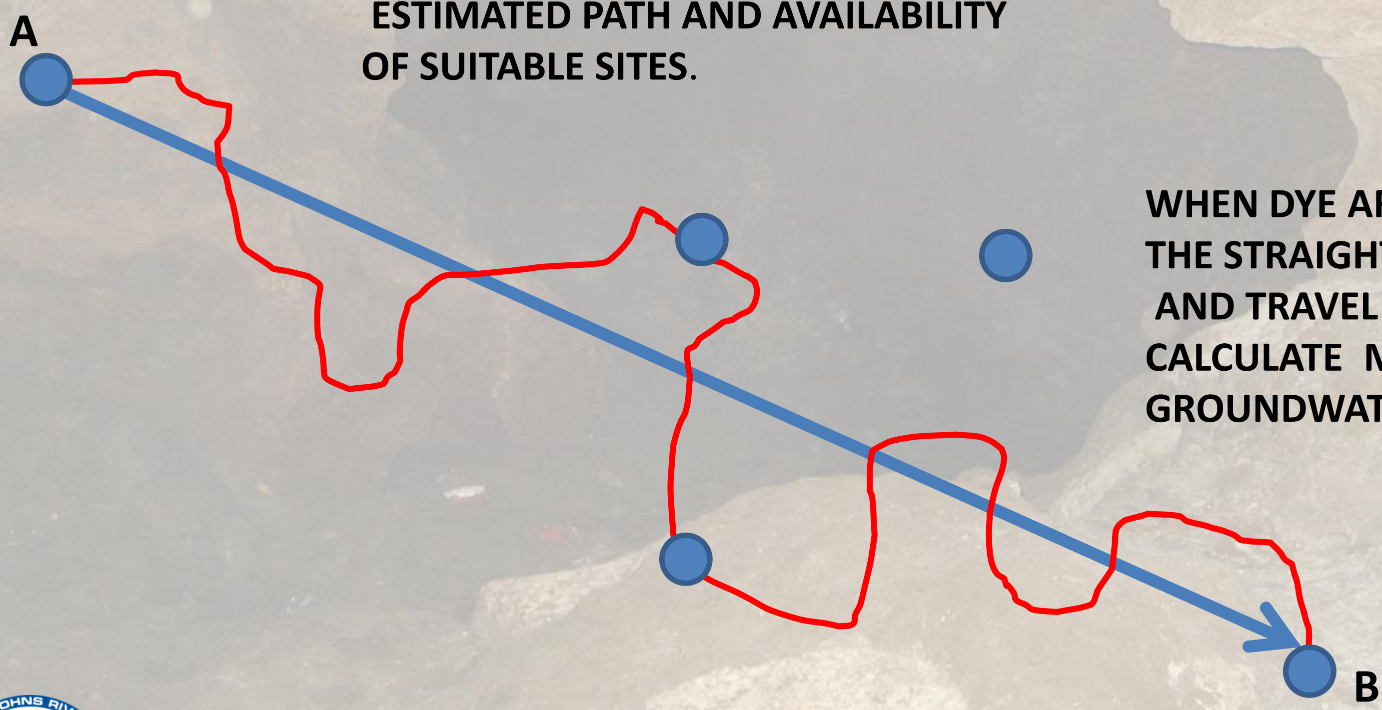
URS

Karst Environmental Services

DYE TRACE CONCEPT

DYE INJECTED
AT POINT "A"

SAMPLING LOCATIONS BASED ON
ESTIMATED PATH AND AVAILABILITY
OF SUITABLE SITES.



WHEN DYE ARRIVES AT "B"
THE STRAIGHT LINE DISTANCE
AND TRAVEL CAN BE USED TO
CALCULATE MINIMUM
GROUNDWATER VELOCITY.

ACCURACY IS LIMITED BY SAMPLE FREQUENCY SO IF SAMPLES ARE WEEKLY
THEN THE ARRIVAL TIME COULD BE ON DAY 1 OR DAY 7 OF THE WEEK

KEY ELEMENTS OF A SUCCESFUL DYE INJECTION

- **Injection and sampling sites need to be located to maximize the chance of reaching the target site. This can be difficult to predict.**
  - **Up-gradient based on potentiometric surface. Remember the low gradient areas in the potentiometric surface slide? Not good for dye trace.**
  - **Natural features present (sinkhole, cave, lineaments) that would suggest site is part of a flow path.**

- **Site has sufficient water flow to insure dye gets into the system (water filled sinkhole, drainage well, retention pond, manual injection). Rainfall is good!!**

- **Sufficient sampling frequency to insure the event is captured.**

- **Baseline sampling to insure no interference.**

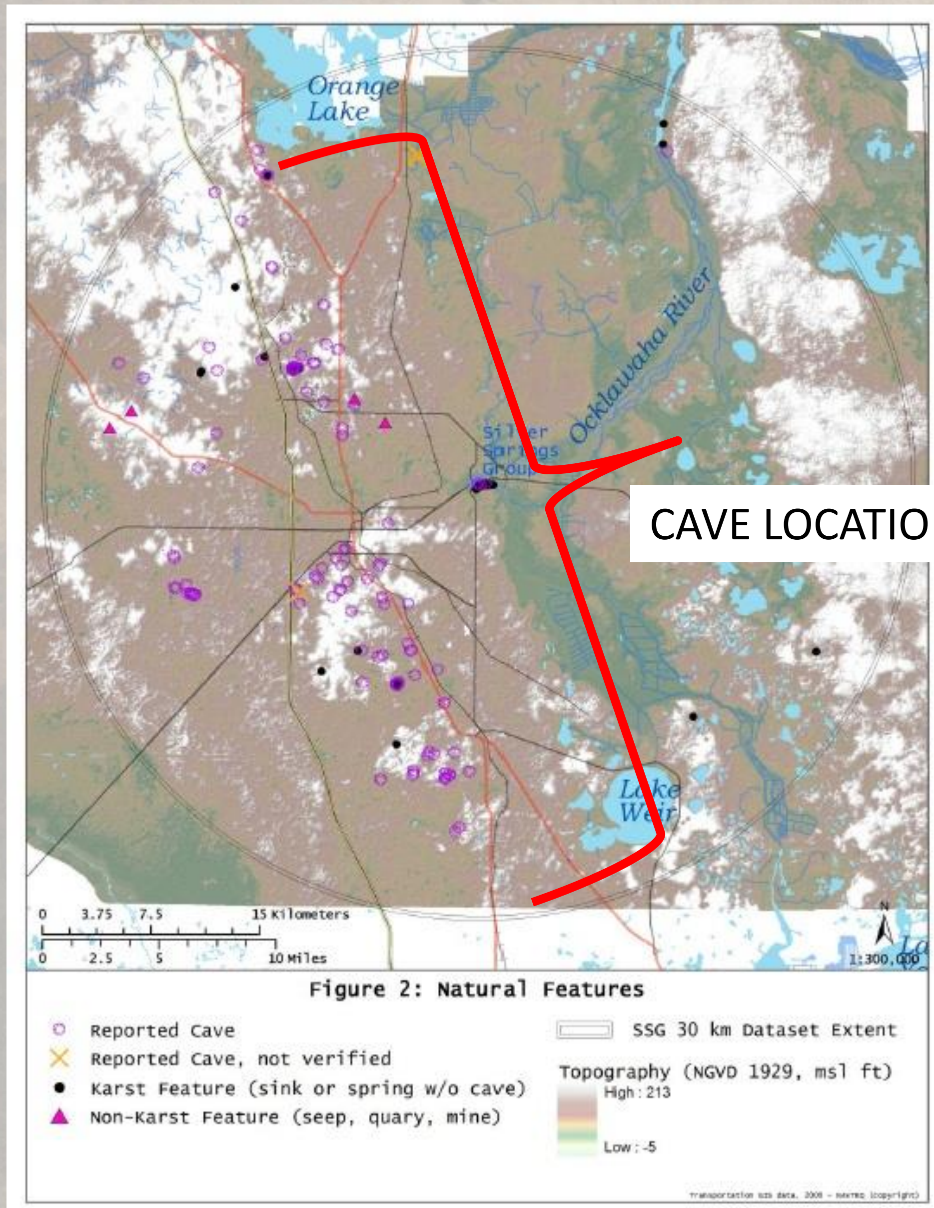


Figure 2: Natural Features

CAVE LOCATIONS

NATURAL FEATURES SUCH AS CAVES MAY INDICATE A PREFERRED GROUNDWATER FLOW PATHWAY

Types of Tracer Dyes

- Fluorescein (Uranine, Fluorescent yellow)
- Rhodamine WT ("red fluorescent dye")
- Eosine (D&C red 22)
- Sulforhodamine B (Pontacyl Brilliant Pink B)
- Pyranine (Solvent Green 7)

- All are usually in powder form, except Rhodamine WT is liquid.

SAMPLING

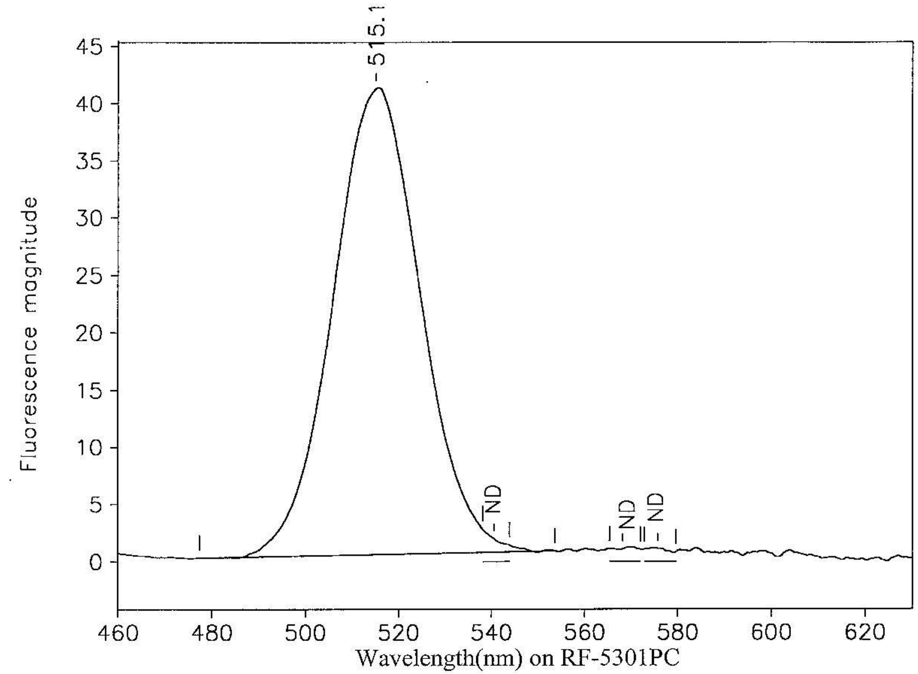
- SAMPLES COLLECTED ON ACTIVATED CHARCOAL PACKETS STRATEGICALLY PLACED.

- SAMPLES ARE TAKEN FREQUENTLY AT FIRST THEN LESS FREQUENTLY AS TIME GOES ON

- SAMPLES SENT TO A LAB THAT SPECILAIZES IN DYE TEST ANALYSIS.

- ANALYSIS SHOWS FLURESENCE MAGNITUDE AND WAVELENGHT SO THE TYPE OF DYE CAN BE IDENTIFIED. EACH DYE HAS A UNIQUE SIGNATURE SO MULTIPLE DYES CAN BE INJECTED AT DIFFERENT SITES.

Ozark Underground Laboratory



Station 59: IFAS Plant Science Unit Well D
OUL number: T9766 Analyzed: 06/25/10
Matrix: Elutant
Placed: 04/29/10 1629 Collected: 05/06/10 1541

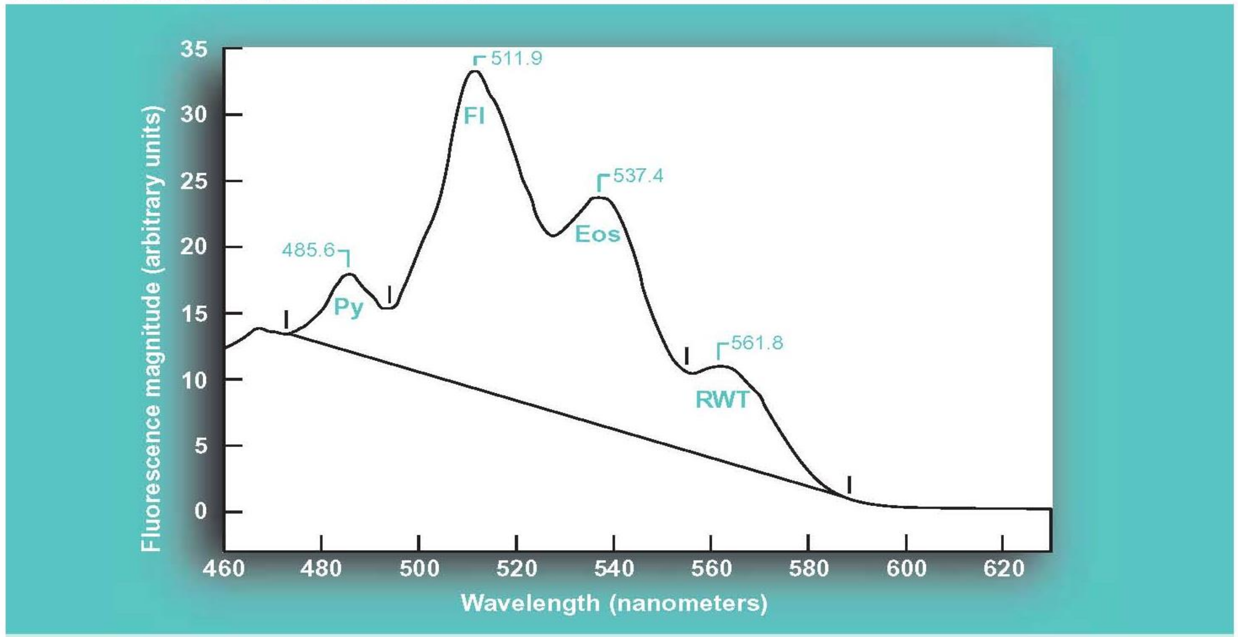
Peaks within the normal range of tracer dyes:

Peak nm	Left X	Right X	Height	Area	H/A	Conc.
515.1	477.4	553.5	40.70	892.06	0.05	26.7
540.5	538.1	543.9	0.00	0.00	0.00	ND
568.2	565.4	572.0	0.00	0.00	0.00	ND
575.7	572.8	579.6	0.00	0.00	0.00	ND

Peaks close to the normal range of tracer dyes:

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT

COMPARISON OF RESPONSE FROM DIFFERENT DYES



Station 8: Tsultan Rising

OUL number: H1996
Date placed: 03-24-1998
Time placed: 1420

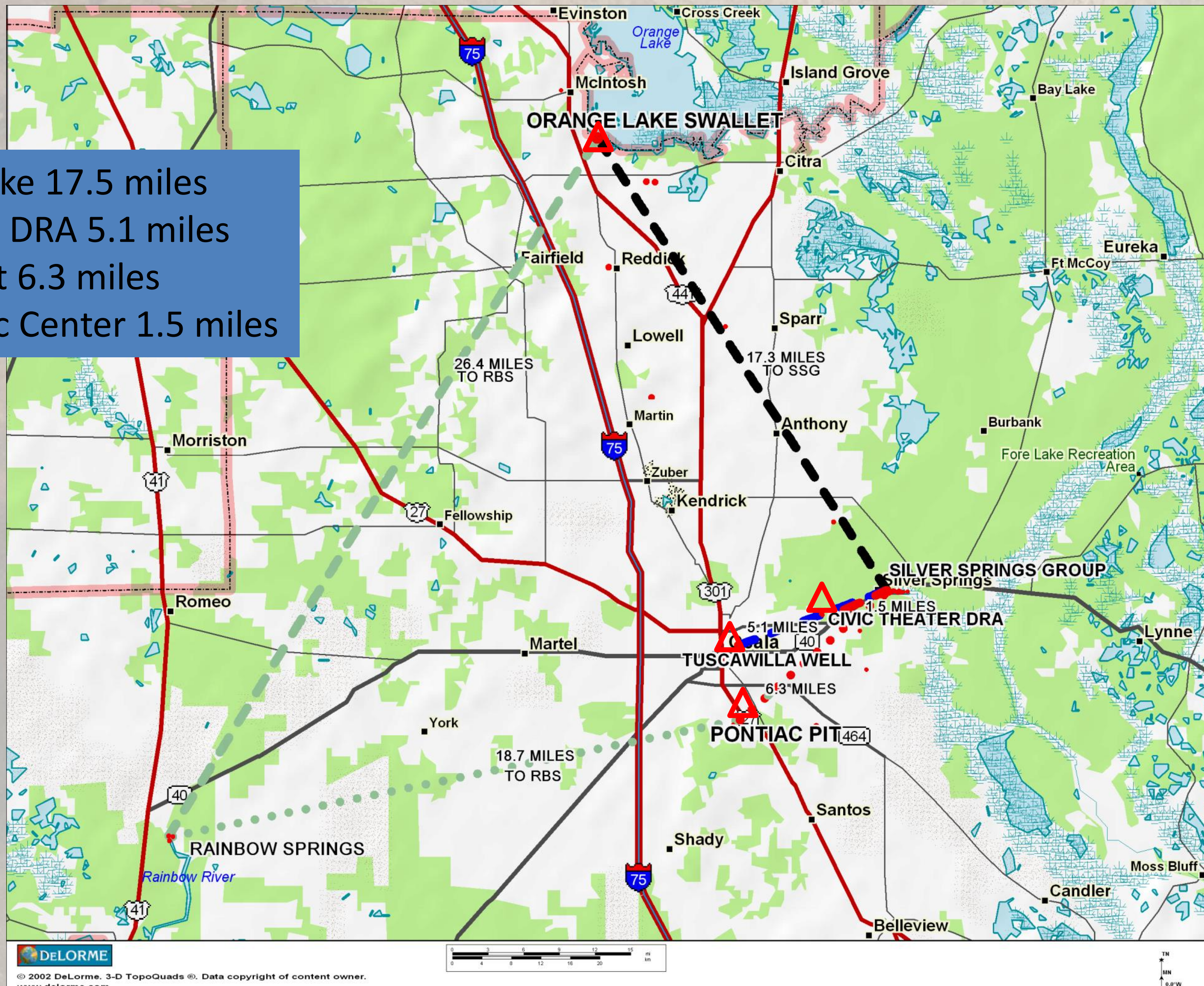
Charcoal Analyzed: 04-15-1998
Date recovered: 04-02-1998
Time recovered: 1330

Peaks within normal range of tracer dyes:

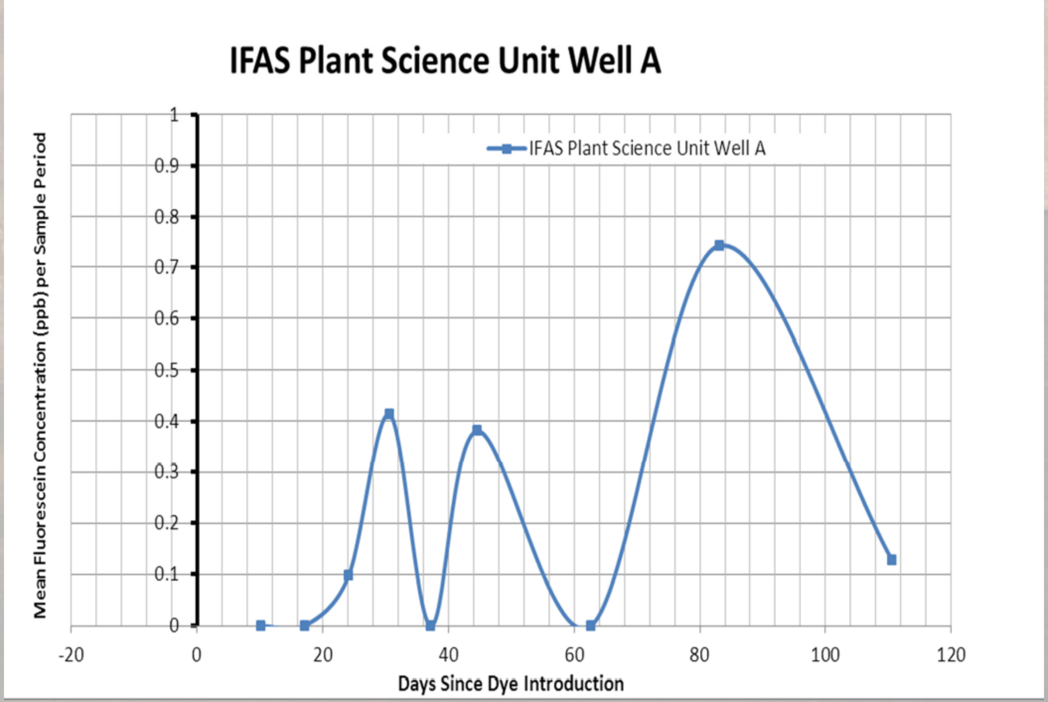
Peak nm	Left X	Right X	Height	Area	H/A	Conc.
511.9	494.0	528.2	24.17	539.32	0.04	4.64
537.4	528.2	555.2	17.36	350.95	0.05	11.2
561.8	555.2	588.4	7.12	135.54	0.05	34.1
Peaks close to normal range of tracer dyes:						
485.6	472.8	494.0	5.95	73.97	0.08	3.23

INJECTION SITES AND DISTANCE TO TARGET (SILVER SPRINGS)

Orange Lake 17.5 miles
Tuscawilla DRA 5.1 miles
Pontiac Pit 6.3 miles
Ocala Civic Center 1.5 miles



EXAMPLE RESULTS FROM A FLUORESCEIN DETECTION SITE



WELL SAMPLING

- Avoid exposure to chlorination.
- Don’t compromise water system or sanitation.
- Well sampling sites set up so when pump turned on, water trickled through the charcoal sampler.

DYE RELEASE; APRIL 23, 2010

SOMETIMES THE DYE NEEDS SOME HELP TO GET INTO THE SYSTEM.

ORANGE LAKE HEAGY-BURRY PARK DYE RELEASE

WATER IS ACTIVELY DRAINING INTO THE SINKHOLE IN ORANGE LAKE

ORANGE LAKE HEAGY-BURRY PARK INJECTION SITE TO AS FAR AS IT WAS RECORDED

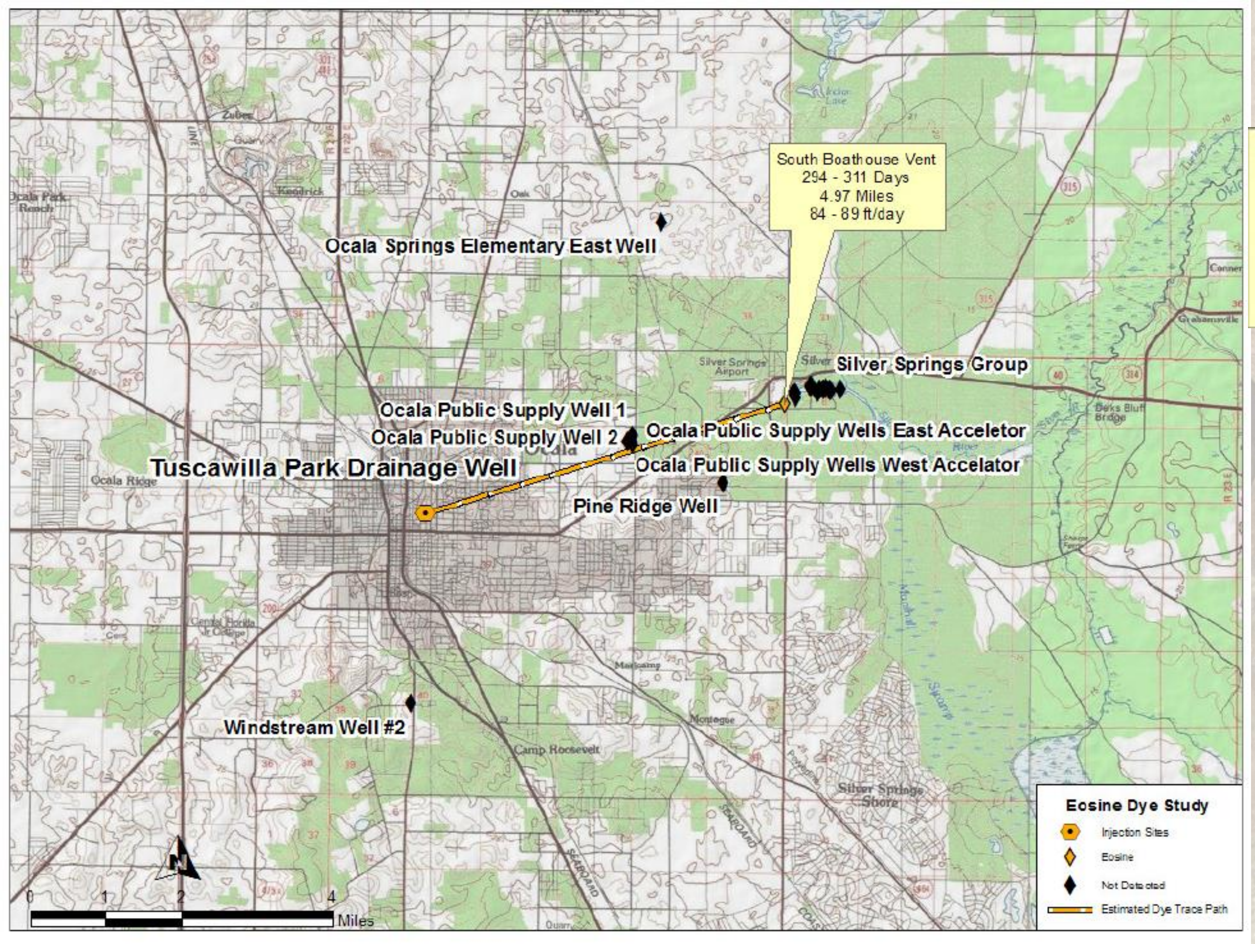
IFAS Well D
6-13 Days
2.1 Miles
850 - 1900 ft/day

Reddick Elementary
6 - 13 Days
4.2 Miles
1700 - 3600 ft/day

Marion Correctional Institution
181 - 194 Days
8.5 Miles
230 - 250 ft/day

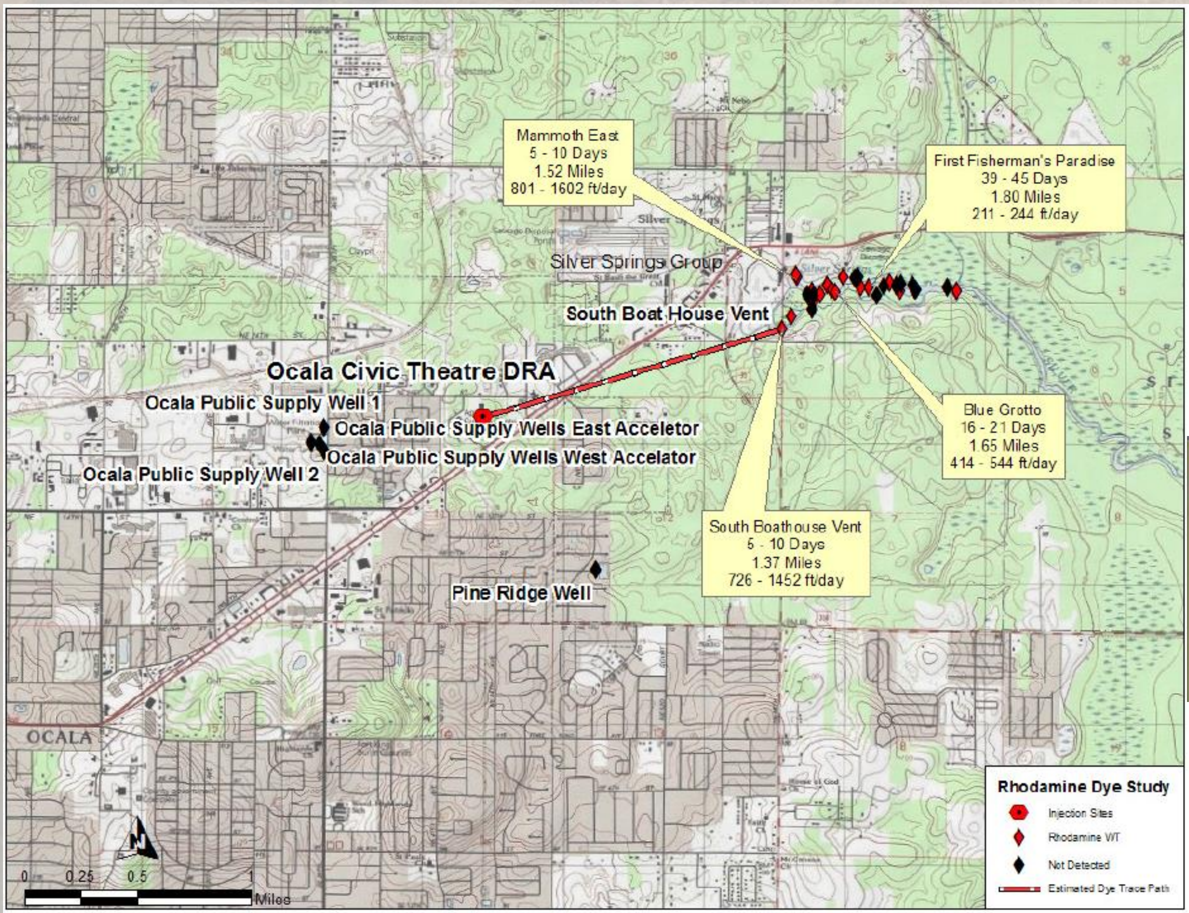
NO DETECTION IN THESE WELLS

TUSCAWILLA PARK DRAINAGE WELL INJECTION SITE TO SILVER SPRINGS GROUP



South Boathouse Vent
294 - 311 Days
4.97 Miles
84 - 89 ft/day

OCALA CIVIC THEATRE DRA INJECTION SITE TO SILVER SPRINGS GROUP



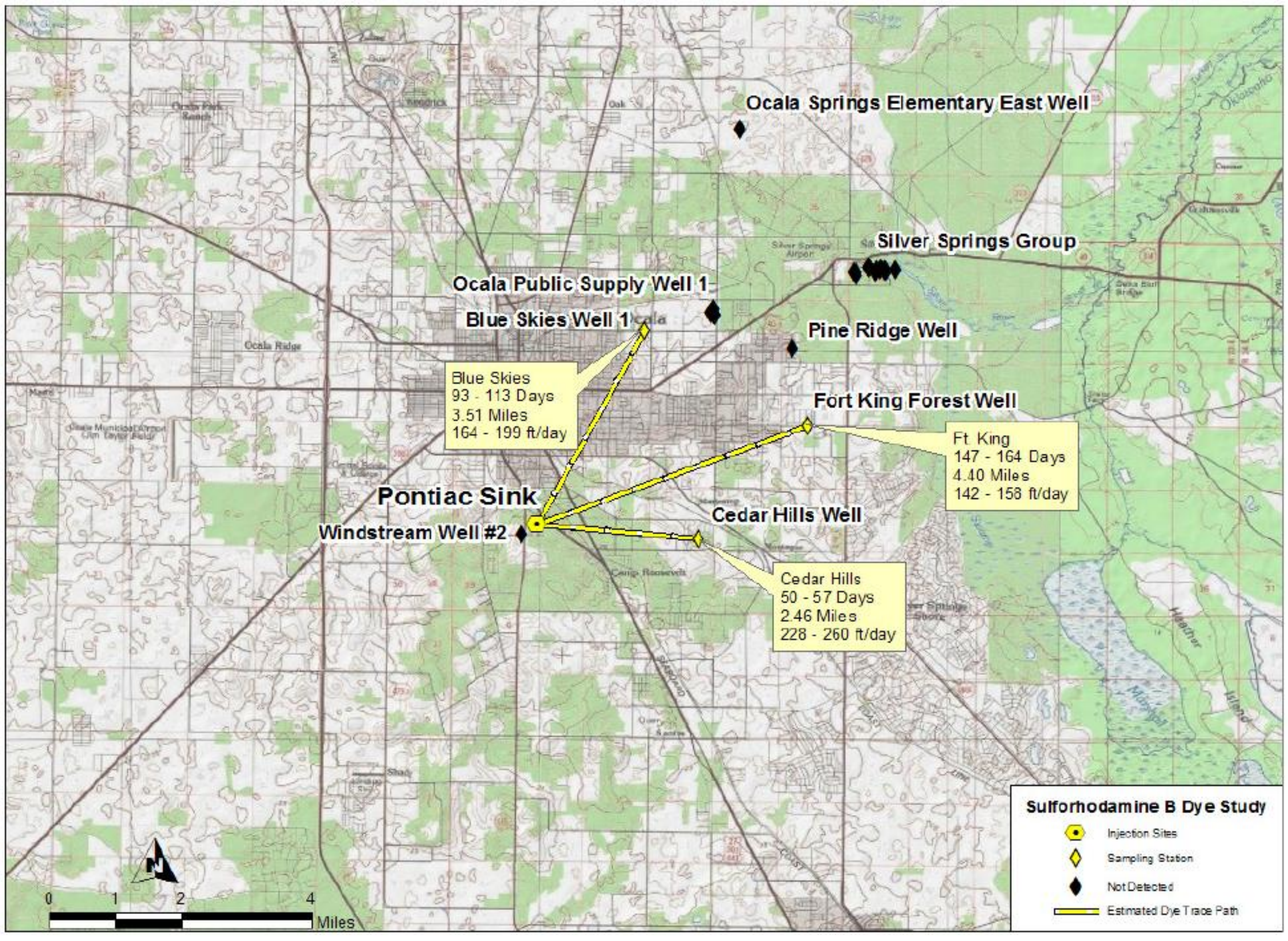
Mammoth East
5 - 10 Days
1.52 Miles
801 - 1602 ft/day

First Fisherman's Paradise
39 - 45 Days
1.80 Miles
211 - 244 ft/day

South Boathouse Vent
5 - 10 Days
1.37 Miles
726 - 1452 ft/day

Blue Grotto
16 - 21 Days
1.65 Miles
414 - 544 ft/day

PONTIAC PIT INJECTION SITE TO AS FAR AS IT WAS RECORDED



Blue Skies
93 - 113 Days
3.51 Miles
164 - 199 ft/day

Cedar Hills
50 - 57 Days
2.46 Miles
228 - 260 ft/day

Ft. King
147 - 164 Days
4.40 Miles
142 - 158 ft/day

TIME, DISTANCE, AND MEAN VELOCITY OF DYE

Introduction Location	Detection Station (Table 3 lists name and number)	Distance (ft)	Travel Time (days)	Mean Velocity (ft/day)
Heagy-Burry Sink	54 Reddick Elementary School Well 5	22,180	9.5	2,335
Heagy-Burry Sink	57 Marion Correctional Institution Well 1	44,880	187.5	245
Heagy-Burry Sink	58 IFAS Well A	11,620	23.5	495
Heagy-Burry Sink	59 IFAS Well D	11,090	9.5	1,165
Civic Theatre	SSG Stations 1, 4, 7, 9, 32, & 33	7,920	7.5	1,055
Civic Theatre	SSG Stations 2 & 5	7,920	13	610
Civic Theatre	SSG Stations 6, 10, 12, & 13	7,920	18.5	430
Civic Theatre	SSG Station 11	7,920	35.5	225
Civic Theatre	SSG Station 19	7,920	42	190
Civic Theatre	SSG Stations 18, 20, 23	7,920	82	95
Civic Theatre	SSG Stations 21 & 28	7,920	118	65
Civic Theatre	SSG Station 14	7,920	286	30
Tuscawilla	32 South Boathouse Vent	26,930	303.5	90
Pontiac Pit Sink	62 Blue Skies Well 1	18,480	103	180
Pontiac Pit Sink	63 Cedar Hills Well	12,670	53.5	235
Pontiac Pit Sink	64 Fort King Forest Well	23,230	155.5	150

DISCUSSION

- PATHWAYS AND TRAVEL TIMES WERE SUCCESSFULLY IDENTIFIED BETWEEN INJECTION SITES AND SILVER RIVER OR INTERMEDIATE SAMPLING LOCATIONS.

- TRAVEL TIMES ARE SIGNIFICANTLY FASTER THAN PREVIOUSLY SUSPECTED.

- NO DYE DETECTED AT SILVER RIVER FROM THE ORANGE LAKE INJECTION SITE. EITHER SAMPLING WAS STOPPED TO EARLY, VELOCITY SLOWED DOWN POSSIBLY BECAUSE OF MATRIX INSTEAD OF CONDUIT FLOW, OR DYE PATHWAY MISSED THE SAMPLING SITES. SAME FOR PONTIAC PIT SITE.

- DYE DID NOT REACH ALL VENTS AT SILVER RIVER SUGGESTING MULTIPLE PATHWAYS.

- NO DYE DETECTED AT RAINBOW SPRINGS.

- ADDITIONAL TEST MAY BE ABLE TO COMPLETE THE PATH.

THANK YOU FOR PARTICIPATING!