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USGS Regional Assessment of the Floridan Aquifer System:

Updating the hydrogeologic framework and underlying hydrologic databases that are being used for future modeling efforts

Prepared for the South Florida Hydrologic Society

Lester J. Williams and Joe D. Hughes

4/18/2011

U.S. Department of the Interior
U.S. Geological Survey

Presentation Outline

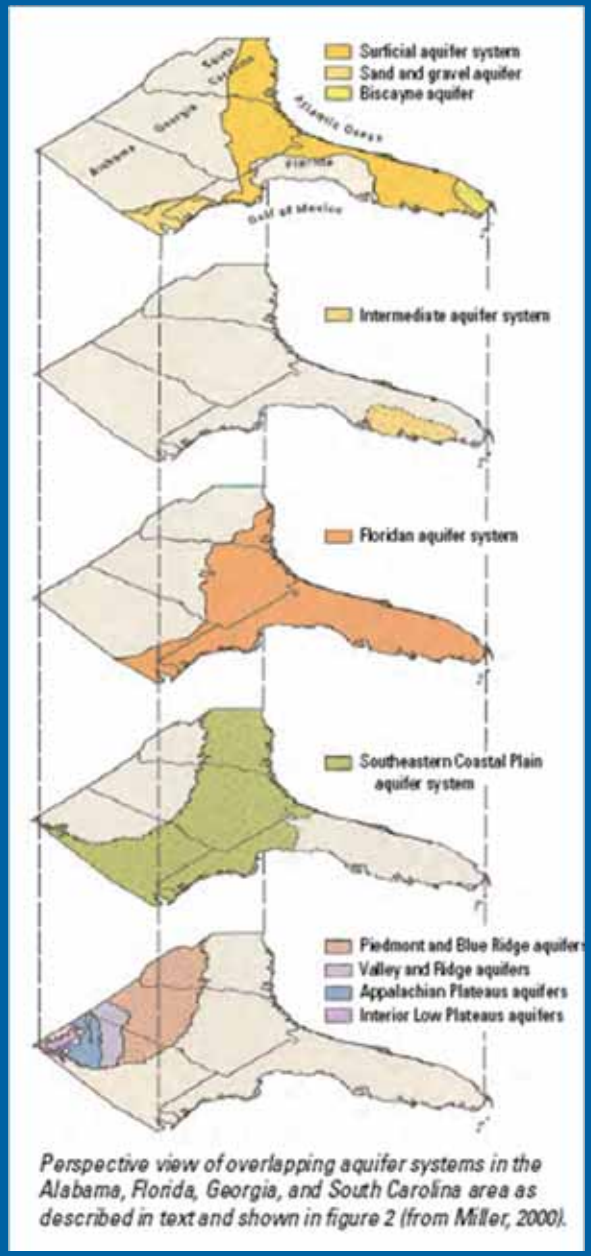
- Give you overview of project background (issues) and objectives
- Databases and Framework
  - Hydrogeologic Framework
  - Database Development
  - Long-term hydrologic records
  - Springs and SW Inventory
  - Potentiometric Map
  - Water-Use Data Compilation
  - Model Development
- SWI Development (Joe)

Finchs Cave, Marion Co. FL
(Photo: A.M. Cressler)

USGS

Project Background

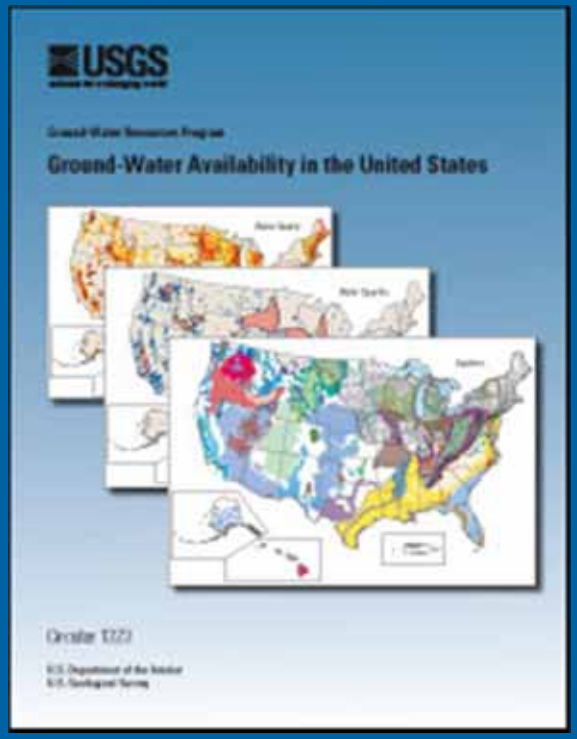
- One of several current ongoing studies being conducted by the USGS Groundwater Resource Program (GWRP)
- Began in Fall of 2009
- Project team members located across Southeastern U.S.
- Several previous meetings have been held between USGS and local districts and states to keep folks apprised of developments and important results



Perspective view of overlapping aquifer systems in the Alabama, Florida, Georgia, and South Carolina area as described in text and shown in figure 2 (from Miller, 2000).

USGS Regional Assessments

- **A key role of national and regional assessments is to provide consistent and integrated information across political boundaries that is useful to those who use and manage the resource.**



U.S. Geological Survey Circular 1323 (Published July 2008)

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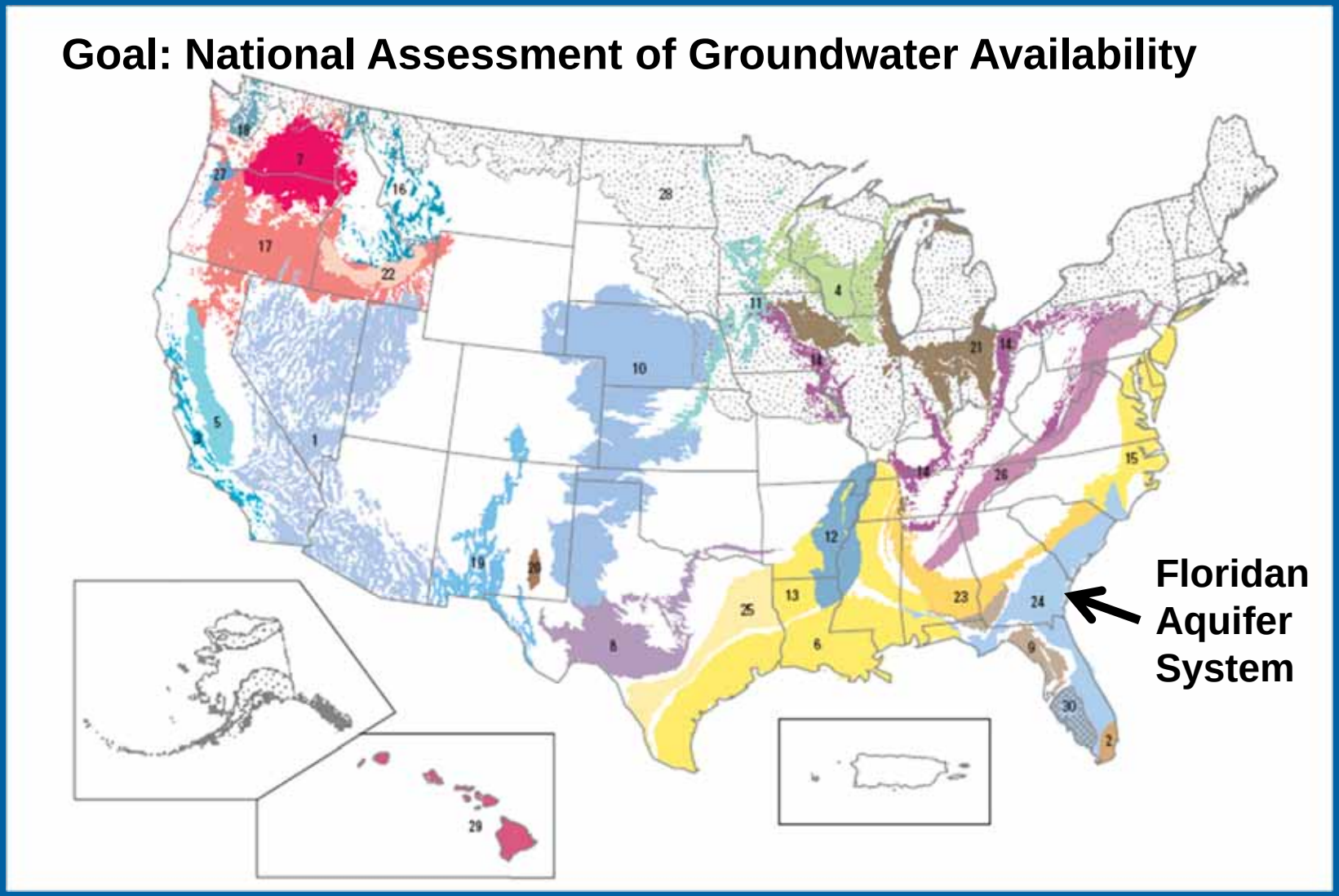
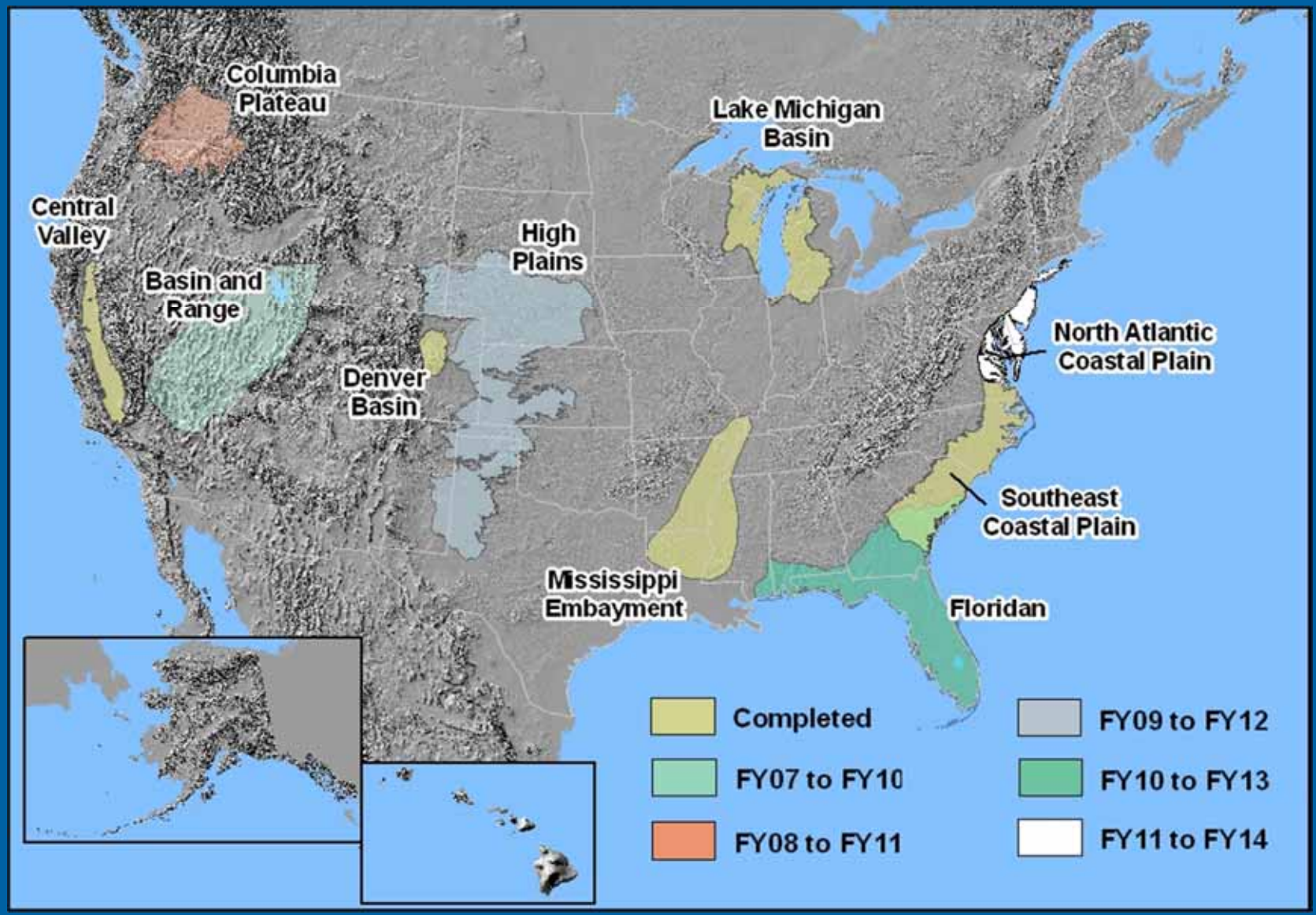
USGS Water Resource Program



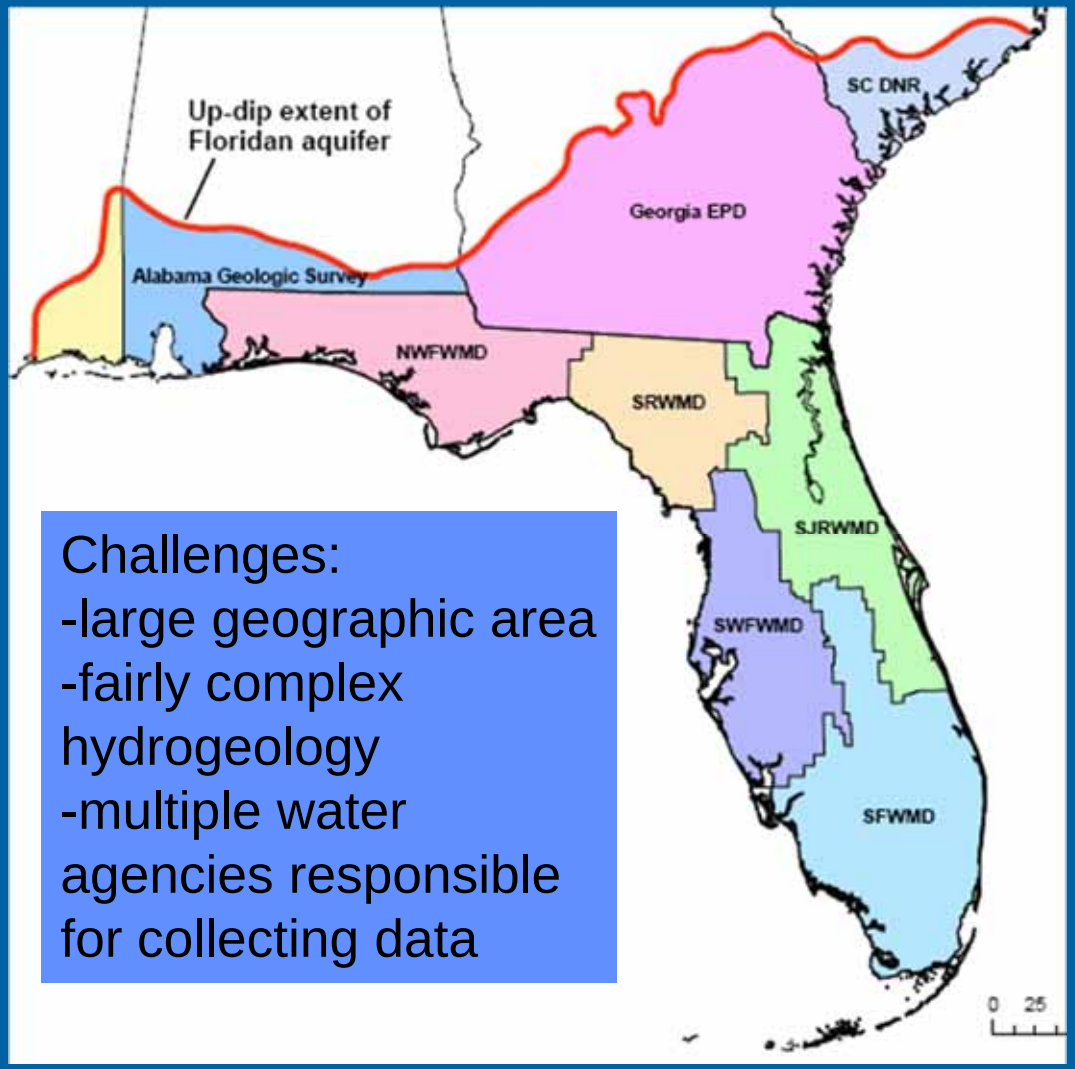
30 principal aquifers account for 94% of total groundwater withdrawals

Current or Completed Studies



Floridan Aquifer System

- Underlies an area of about 100,000 square miles
- Groundwater withdrawals averaged 3,640 Mgal/day in 2000



Challenges:
-large geographic area
-fairly complex hydrogeology
-multiple water agencies responsible for collecting data

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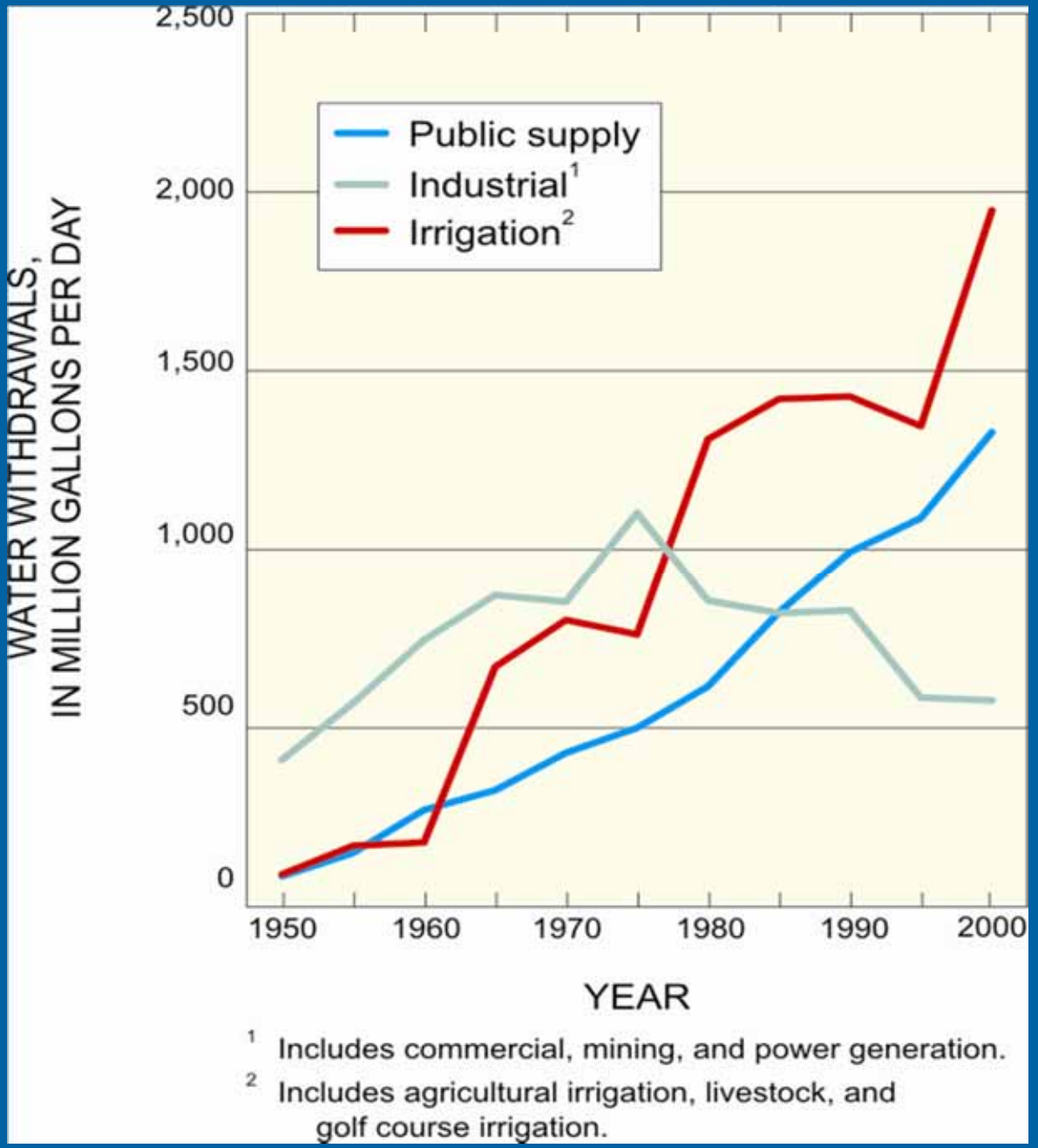
Issues

- One of the major issues for the region is an increased need for freshwater supplies



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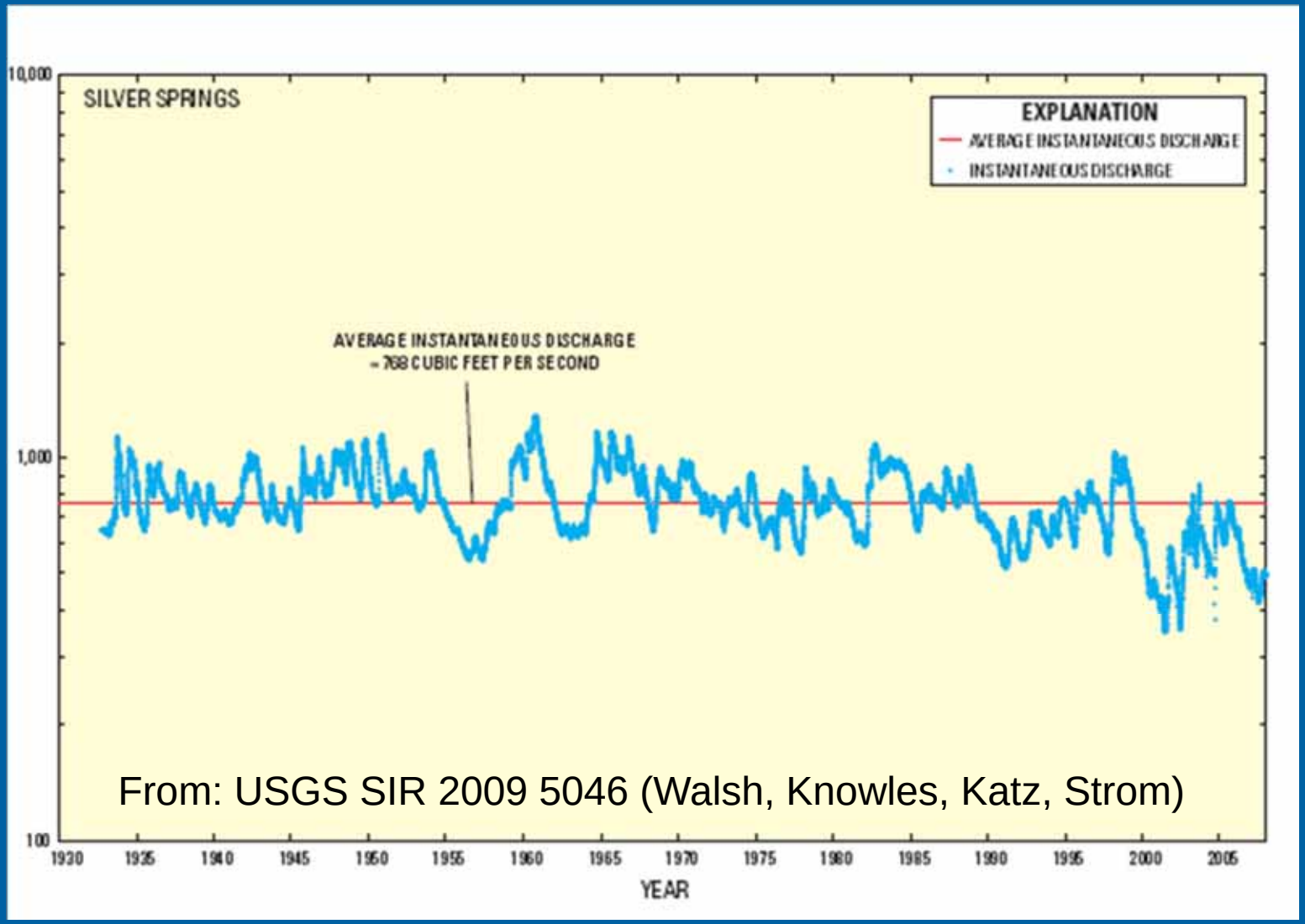
Issue: Flows and Levels



From: USGS SIR 2009 5046 (Walsh, Knowles, Katz, Strom)

Long-Term Trends in Springs

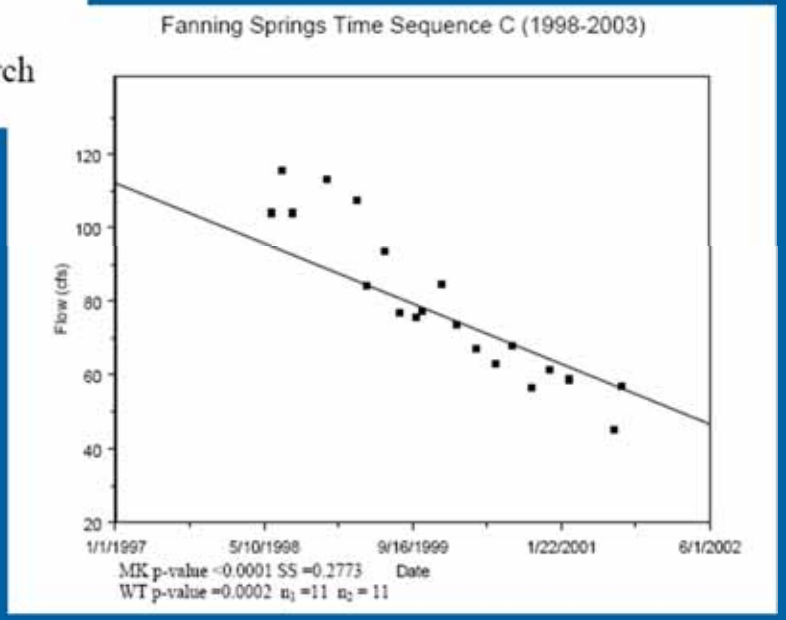
Bulletin No. 69

REGIONAL AND STATEWIDE TRENDS IN FLORIDA'S SPRING AND WELL GROUNDWATER QUALITY (1991-2003)

By

Rick Copeland, Neal A. Doran, Aaron J. White, and Sam B. Upchurch

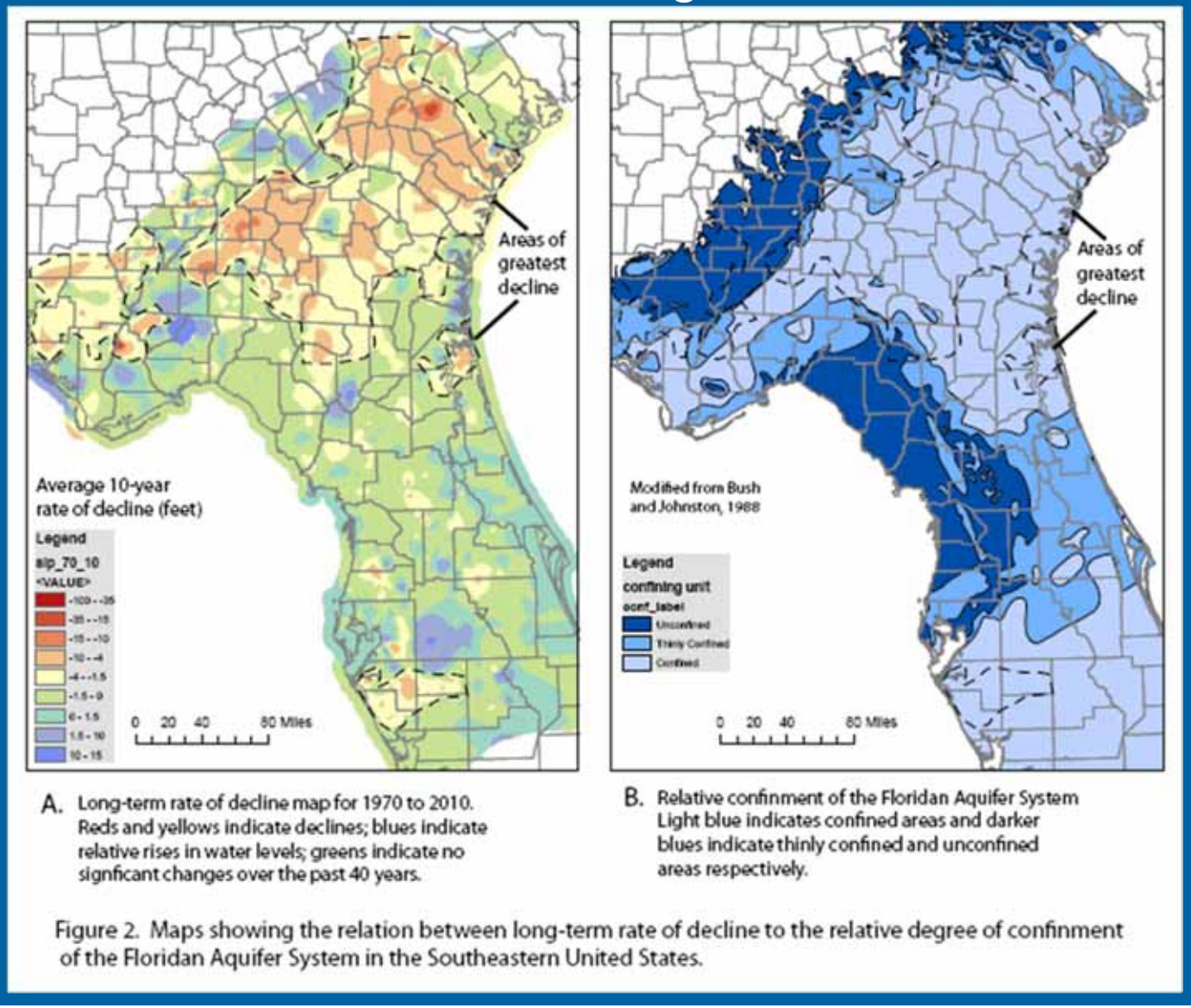
Fanning Springs
Levy County, FL



USGS

Relation to Relative Degree of Confinement

- **Long-term (40-yr) average rate of decline is 3 times greater in the confined areas vs. unconfined areas**



A. Long-term rate of decline map for 1970 to 2010. Reds and yellows indicate declines; blues indicate relative rises in water levels; greens indicate no signficant changes over the past 40 years.

B. Relative confinment of the Floridan Aquifer System Light blue indicates confined areas and darker blues indicate thinly confined and unconfined areas respectively.

Figure 2. Maps showing the relation between long-term rate of decline to the relative degree of confinment of the Floridan Aquifer System in the Southeastern United States.

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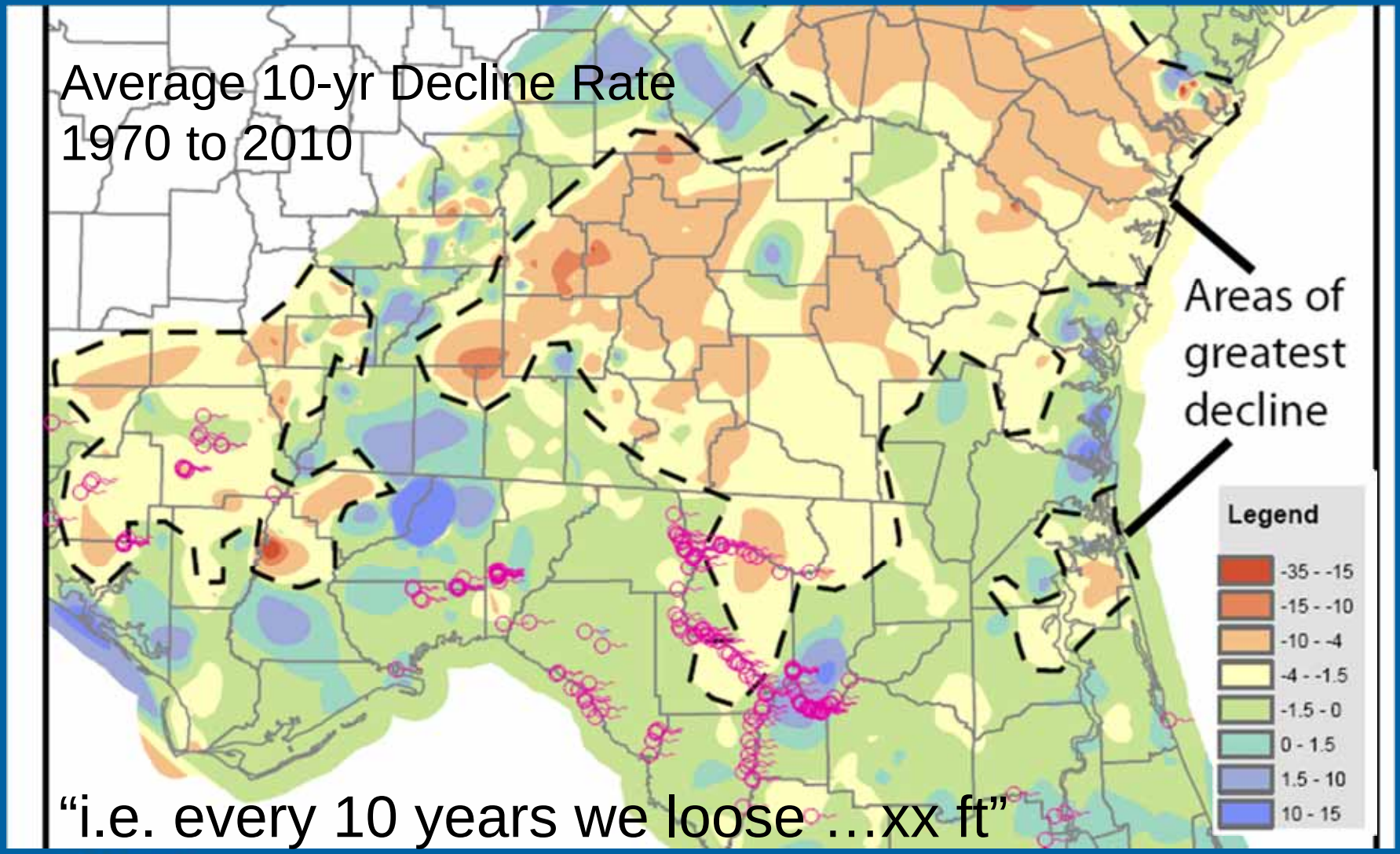
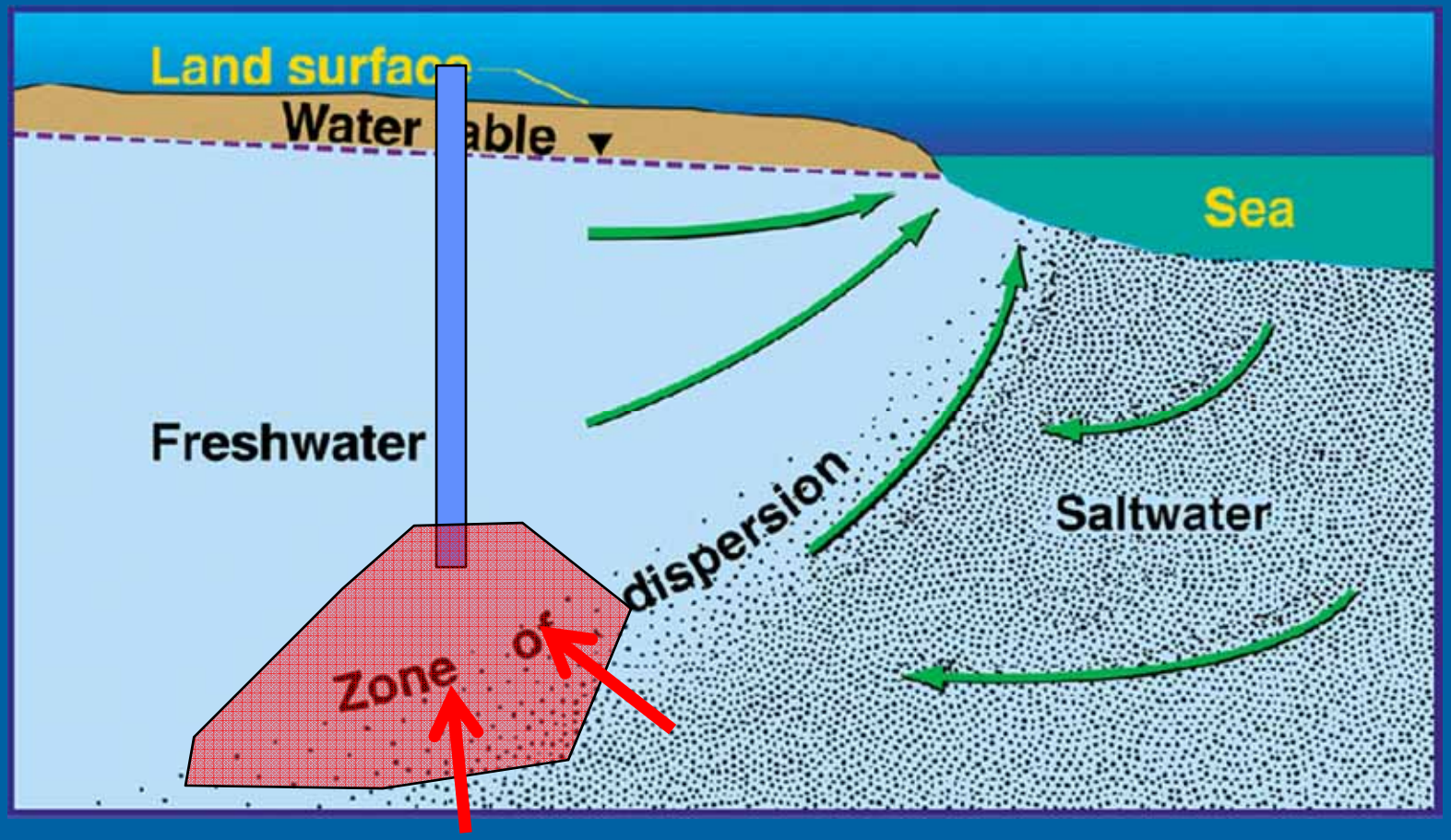
Declining Areas in Relation to Magnitude 1 and 2 Springs



Issue: Salt Water Intrusion



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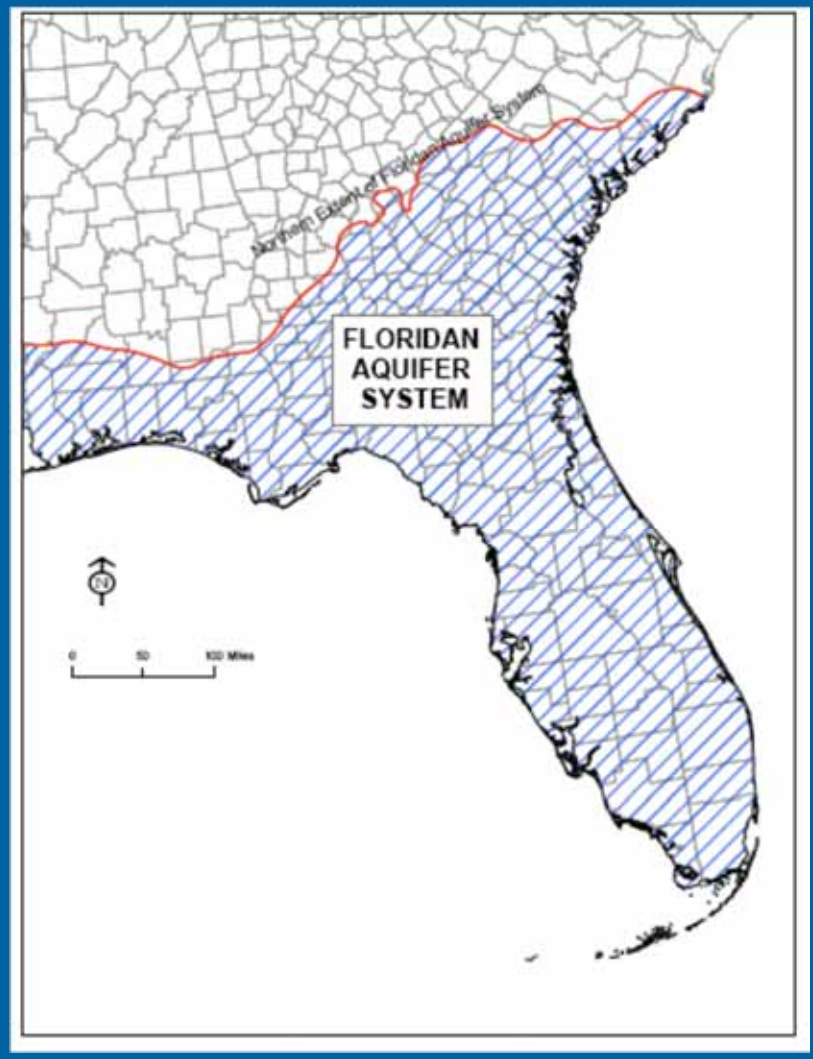
Project Objectives:

- Quantify current ground-water resources
- Evaluate how these resources have changed over time
- Provide tools to forecast system responses to stresses from future human and environmental uses



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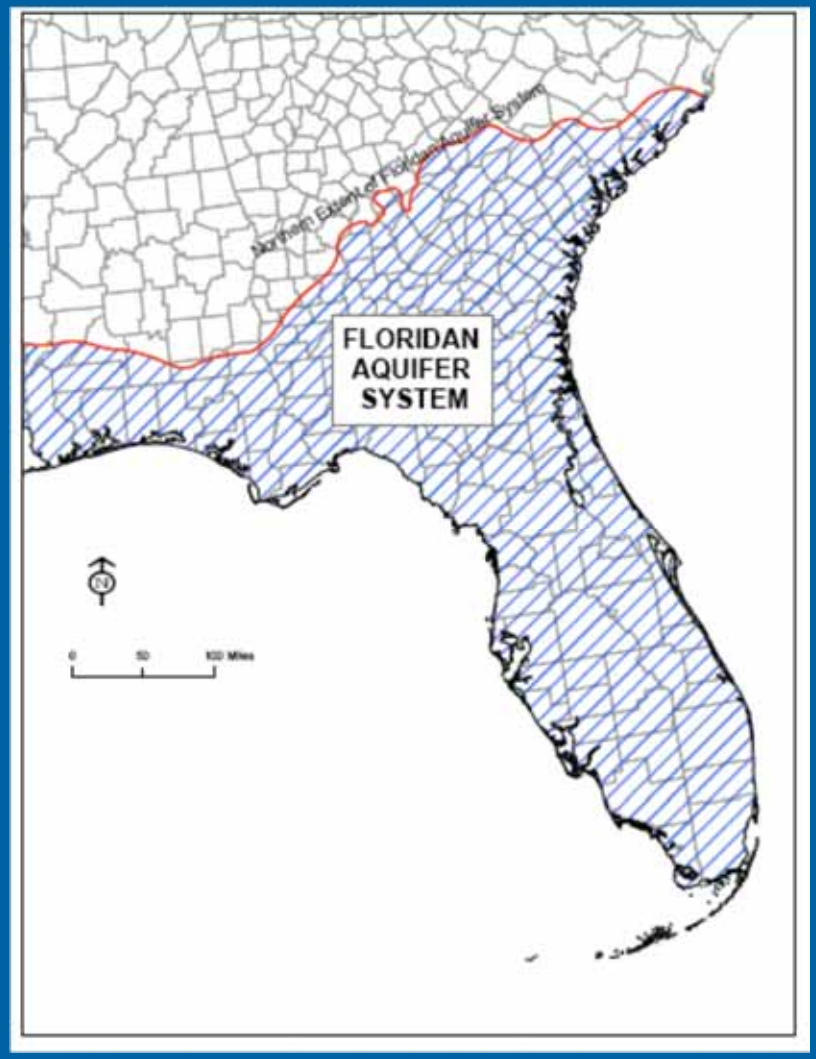
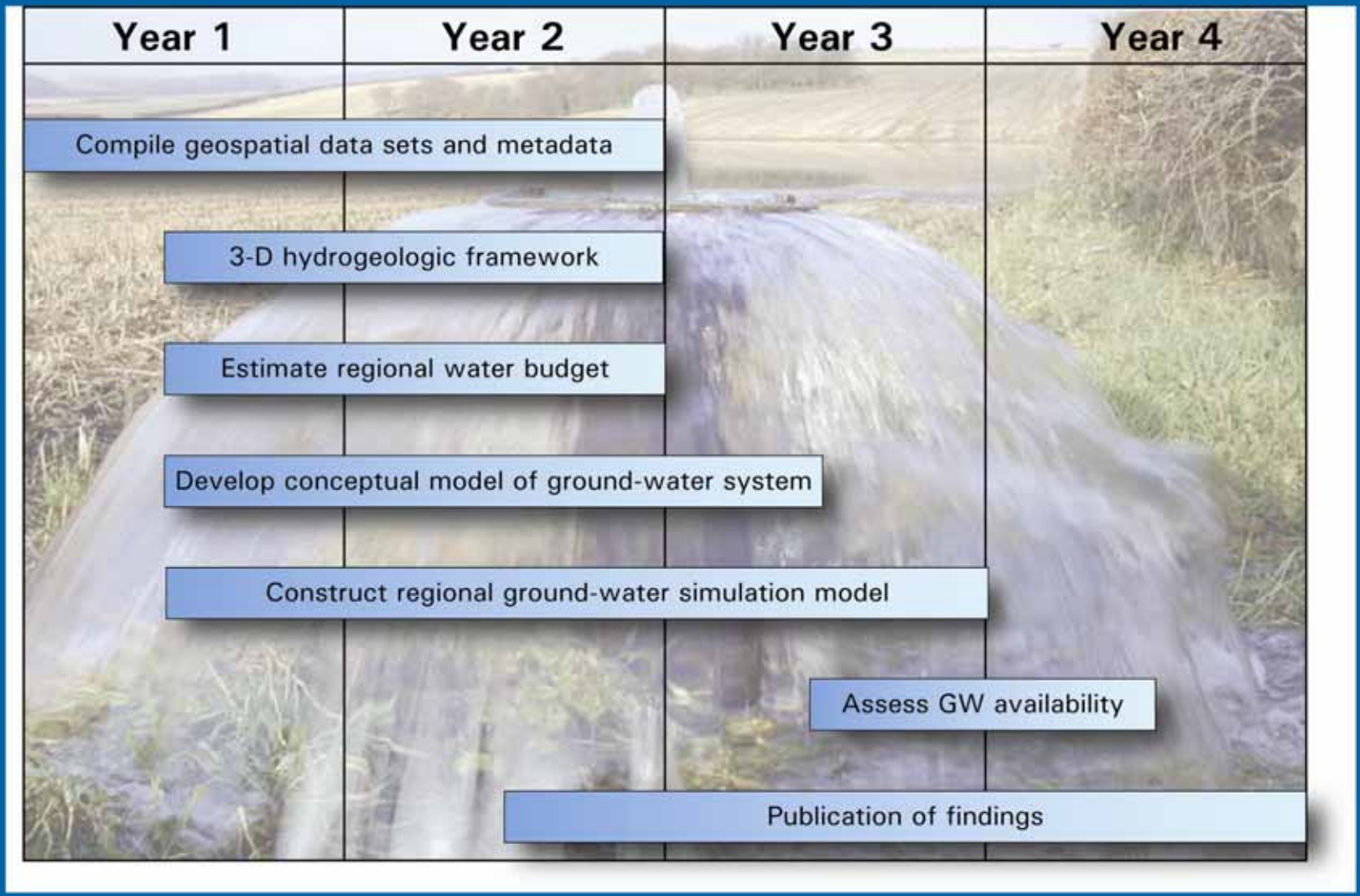


Schedule of Major Work Activities



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Hydrogeologic Framework Revision

- Focus on improving the physical geometry and understanding of the hydraulic properties of the system
- Improve understanding of flow system needed to build numerical model
  - Active surficial
  - Salt-water encroachment

RASA Framework

6 to 8 yrs

New Framework

2 yrs

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The Floridan Aquifer System

- Confined and unconfined areas
- Most areas we have permeable carbonate rocks confined above and below by low-permeability sediments
- Further subdivided into upper and lower aquifers

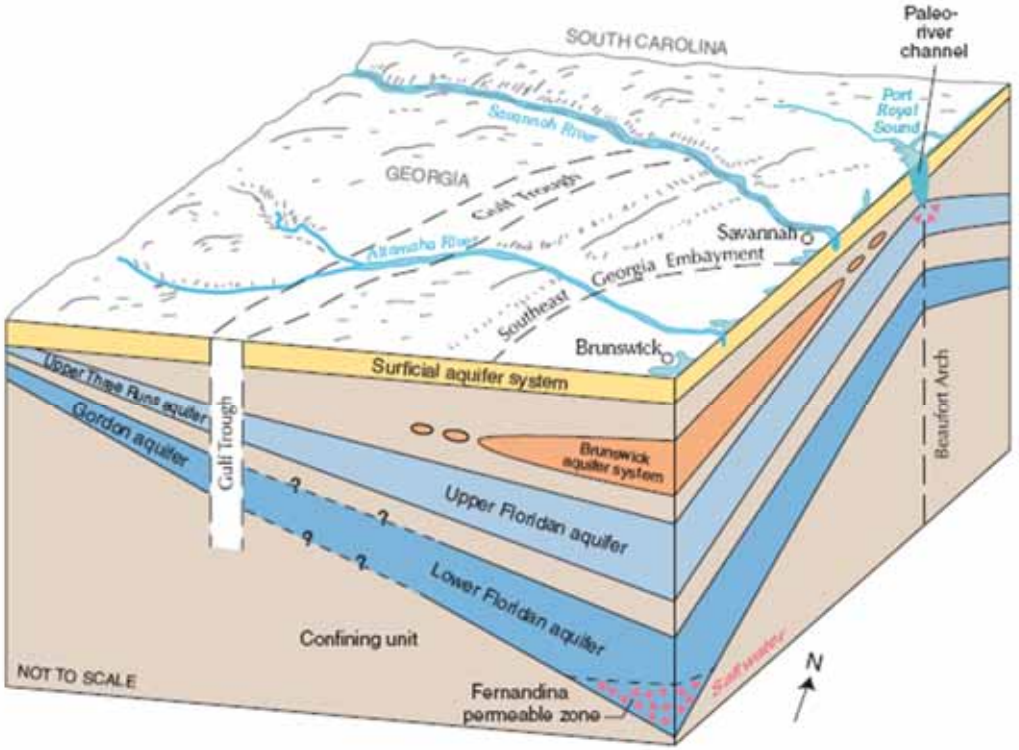

Figure 3. Schematic block diagram showing hydrogeologic units and influence of structural features on their occurrence.

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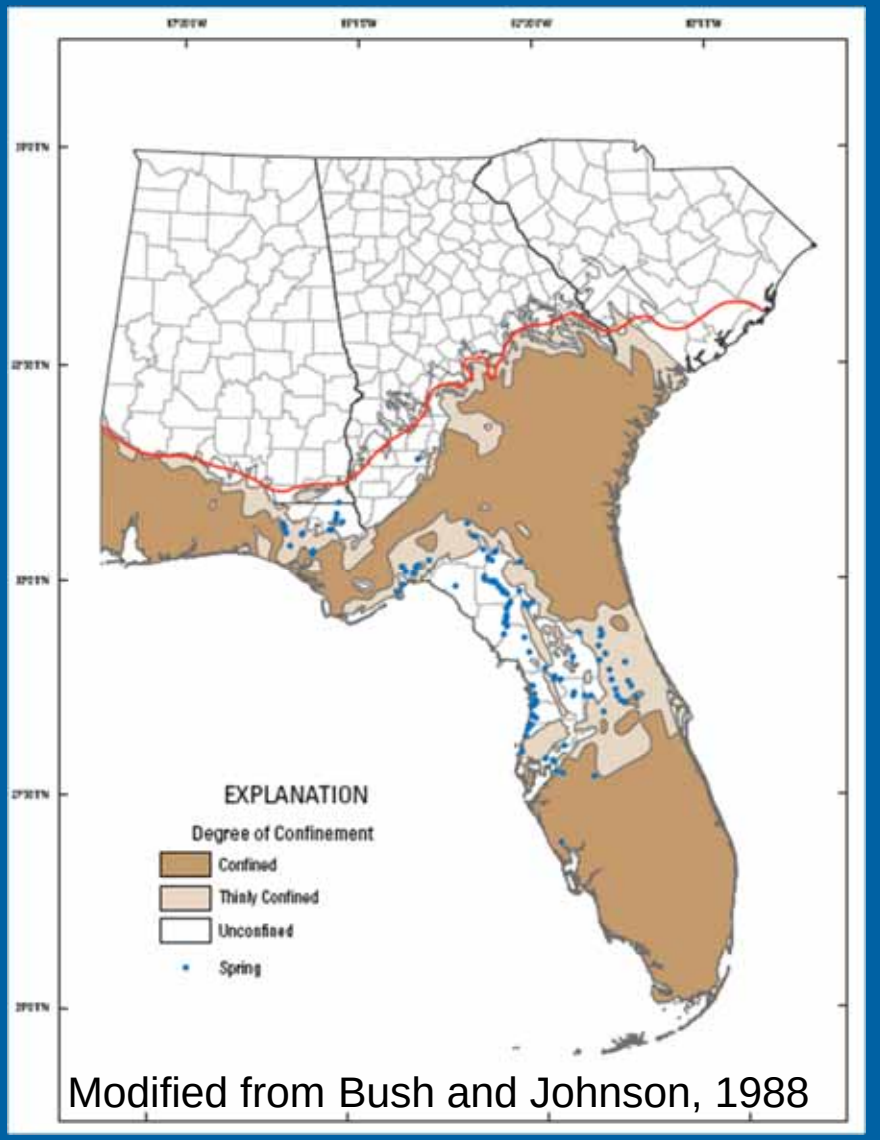
Relative Degree of Confinement

- Large amounts of recharge in the unconfined or thinly confined areas of the system



Modified from Bush and Johnson, 1988

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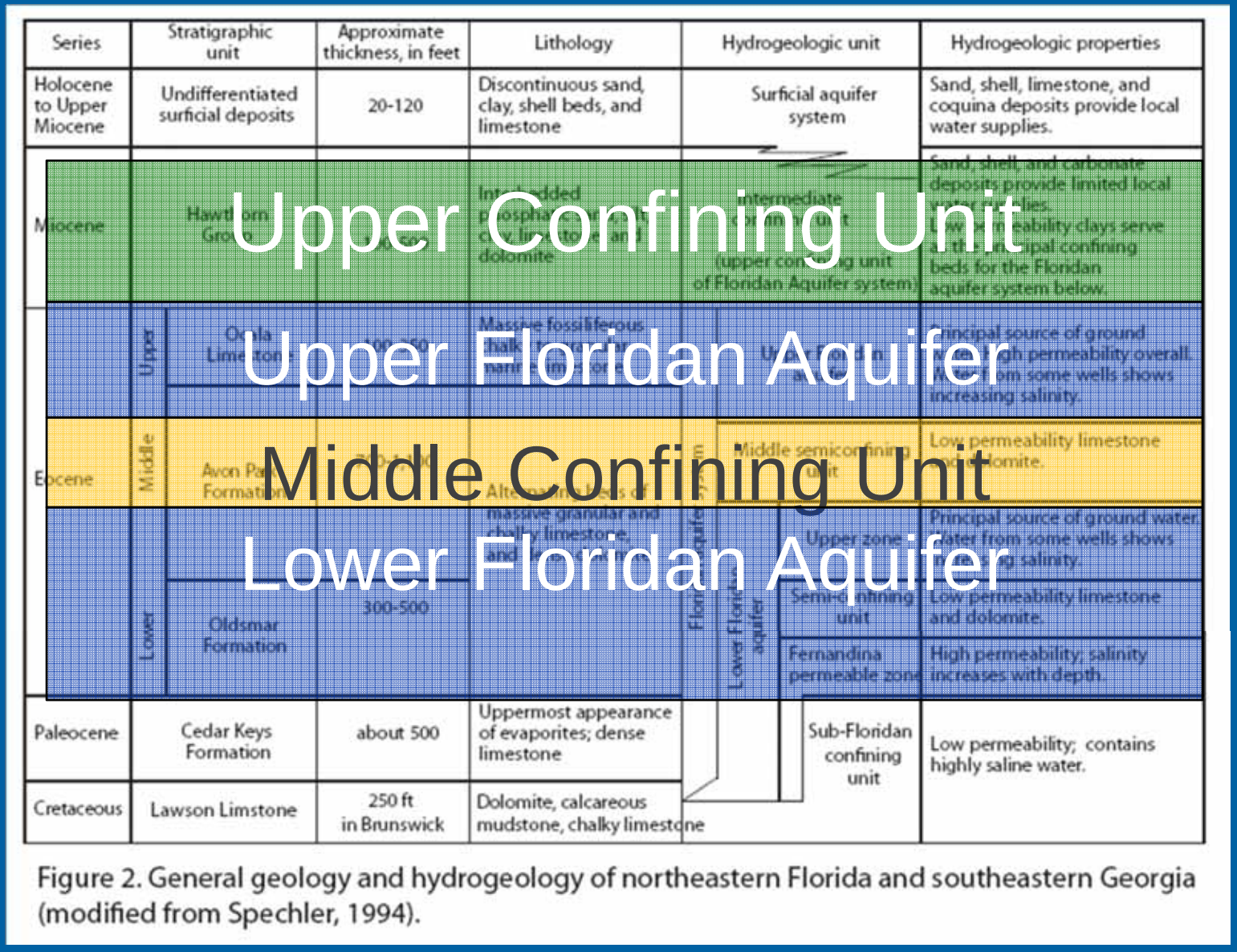
Aquifers and Confining Units



Series	Stratigraphic unit	Approximate thickness, in feet	Lithology	Hydrogeologic unit	Hydrogeologic properties
Holocene to Upper Miocene	Undifferentiated surficial deposits	20-120	Discontinuous sand, clay, shell beds, and limestone	Surficial aquifer system	Sand, shell, limestone, and coquina deposits provide local water supplies.
Miocene	Hawthorn Group		Interbedded phosphatic sand, clay, limestone, and dolomite	Intermediate confining unit (upper confining unit of Floridan Aquifer system)	Sand, shell, and carbonate deposits provide limited local water supplies. Low permeability clays serve as the principal confining beds for the Floridan aquifer system below.
Eocene	Upper: Ocala Limestone	300-350	Massive fossiliferous chalk to hard limestone	Upper Floridan aquifer	Principal source of ground water. High permeability overall. Water from some wells shows increasing salinity.
	Middle: Avon Park Formation	400-500	Alternating zones of massive granular and chalky limestone, and dolomite	Middle semiconfining unit	Low permeability limestone and dolomite.
	Lower: Oldsmar Formation	300-500		Lower Floridan aquifer: Upper zone	Principal source of ground water. Water from some wells shows increasing salinity.
				Semiconfining unit	Low permeability limestone and dolomite.
				Fernandina permeable zone	High permeability; salinity increases with depth.
Paleocene	Cedar Keys Formation	about 500	Uppermost appearance of evaporites; dense limestone	Sub-Floridan confining unit	Low permeability; contains highly saline water.
Cretaceous	Lawson Limstone	250 ft in Brunswick	Dolomite, calcareous mudstone, chalky limestone		

Figure 2. General geology and hydrogeology of northeastern Florida and southeastern Georgia (modified from Spechler, 1994).

Floridan Framework (our focus)

Stratigraphy

- Cretaceous System
- Tertiary System
  - Paleocene Series
  - Eocene Series
  - Oligocene Series
  - Miocene Series
- Post Miocene

Will not be revised

Aquifers and Confining Units

- Surficial Aquifer
- Upper Confining Unit**
- Floridan Aquifer System
  - Extent*
  - Top of System*
  - Upper Floridan*
  - Middle Confining Unit**
  - Lower Floridan*
- Lower Confinement

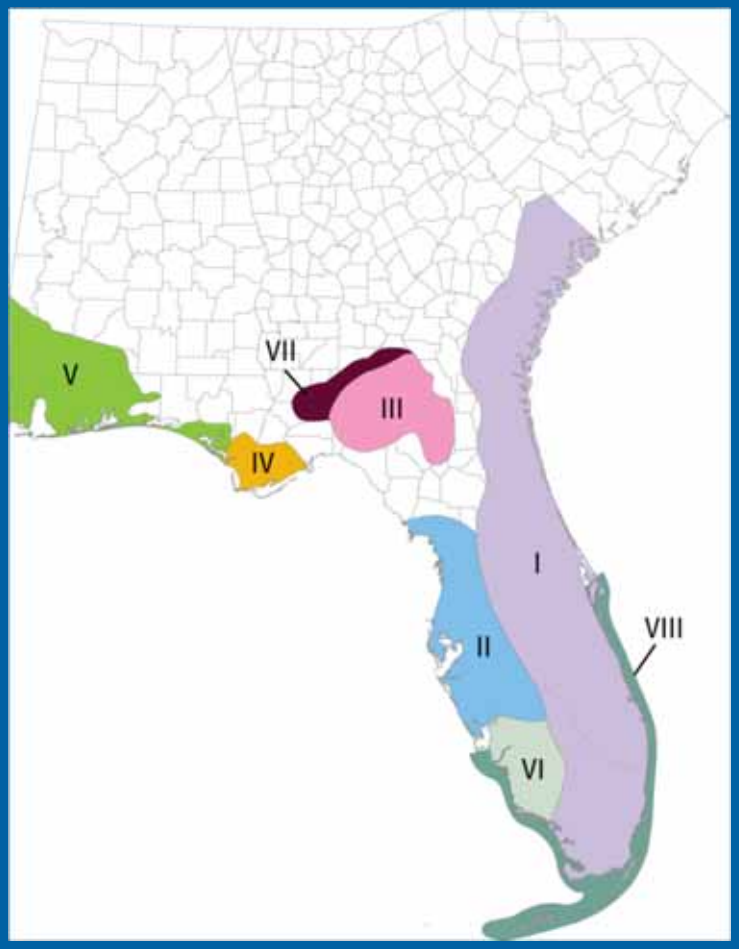
*Minor revision **Major revision

USGS

Revised Hydrogeologic Framework

Major Update

- Middle confining units
  - Extent of each one
  - Configuration of top
  - Thickness of units
- High T Zones
  - APPZ, FPZ, BZ
- Location of freshwater/saltwater Interface



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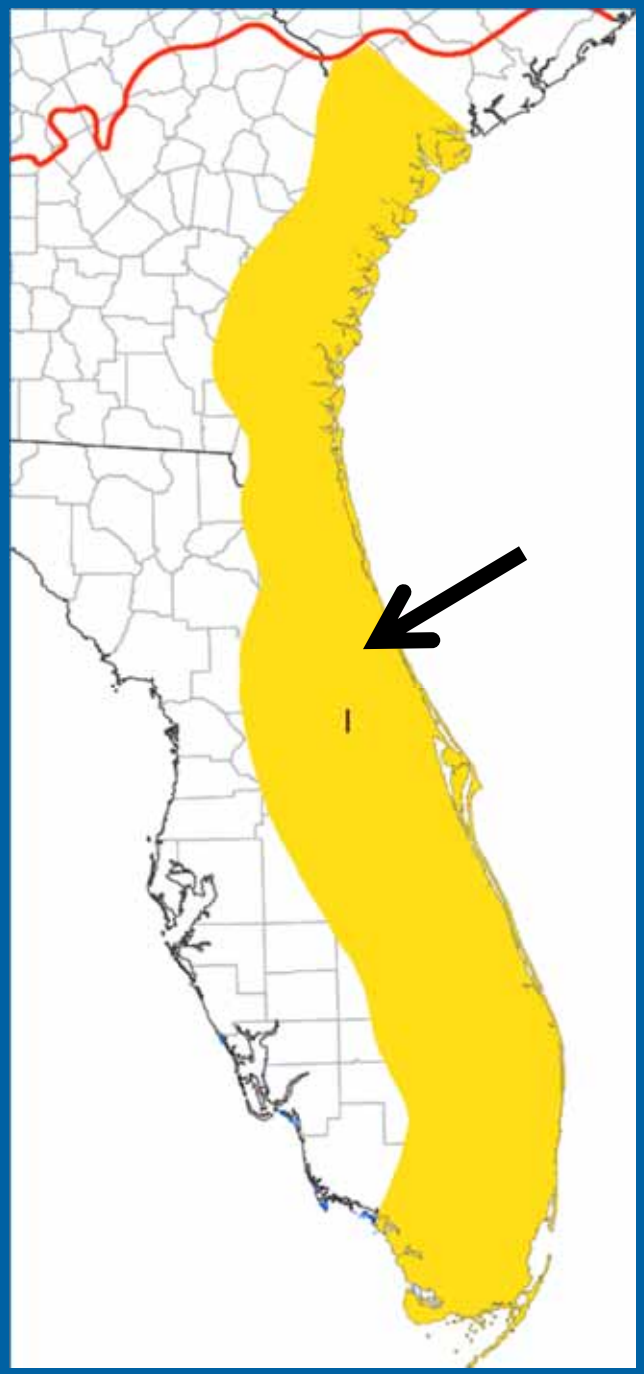
Middle Confining Unit I

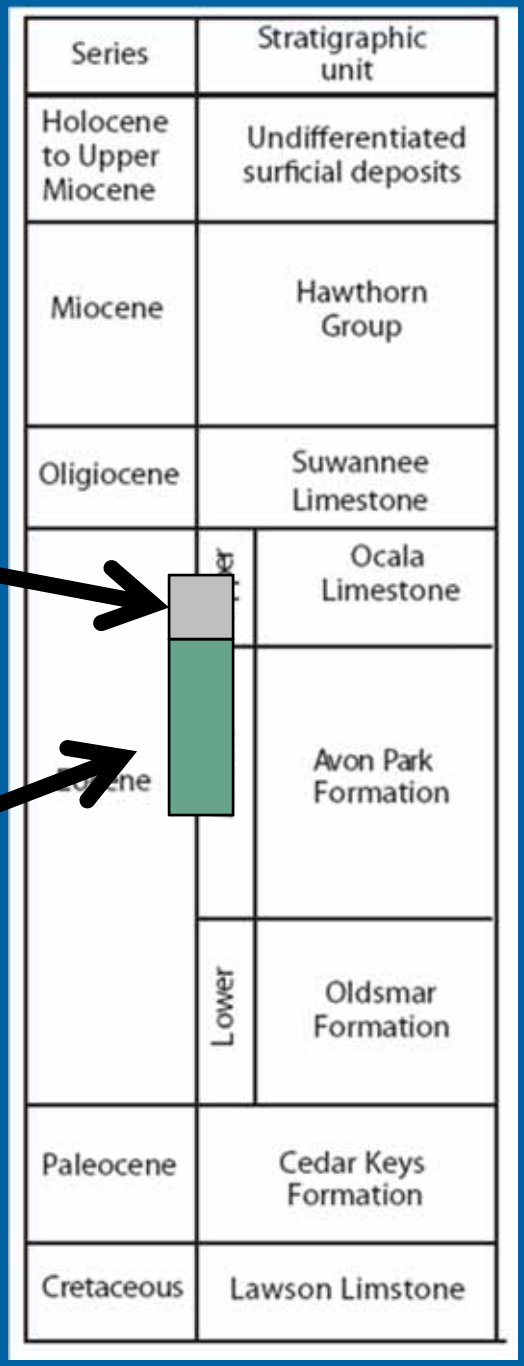
- Low-permeability zone mostly within rocks of middle Eocene age extending from South Carolina to Florida Keys
- Separates the Upper and Lower Floridan aquifers
- Overlaps gypsiferous dolomite of MCU II



USGS

MCU I: Geologic Units and Lithology

- Mostly located in the middle and upper parts the middle Eocene
- Locally lower part of the Late Eocene
- Soft micritic limestone and fine-grained dolomitic limestone, both of low porosity
- Original porosity not greatly affected by pore filling minerals



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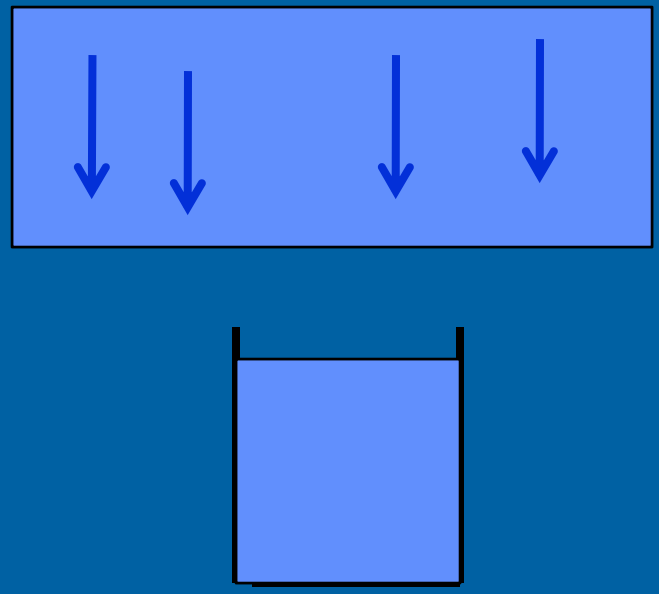
MCU I: Confining Properties

- Leakiest of all MCUs
- Lithology similar to rocks above and below
- Minor head differences and water-quality changes suggests acts as a confining bed

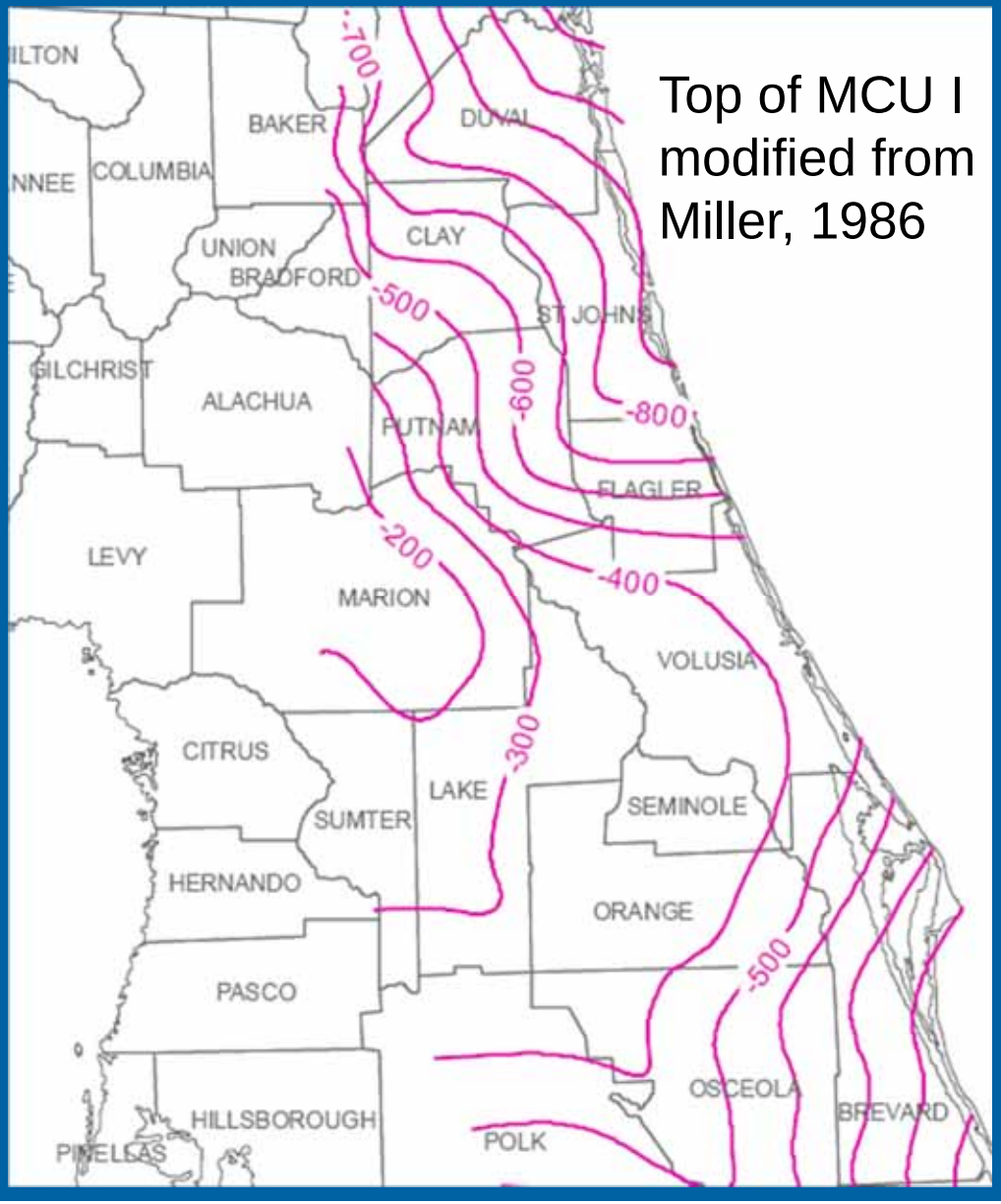


Leak-o-meter

USGS

MCU I: Configuration and Thickness

- Generally dips along stratigraphic horizons
- Thickest in southeastern Georgia embayment and east-central Florida

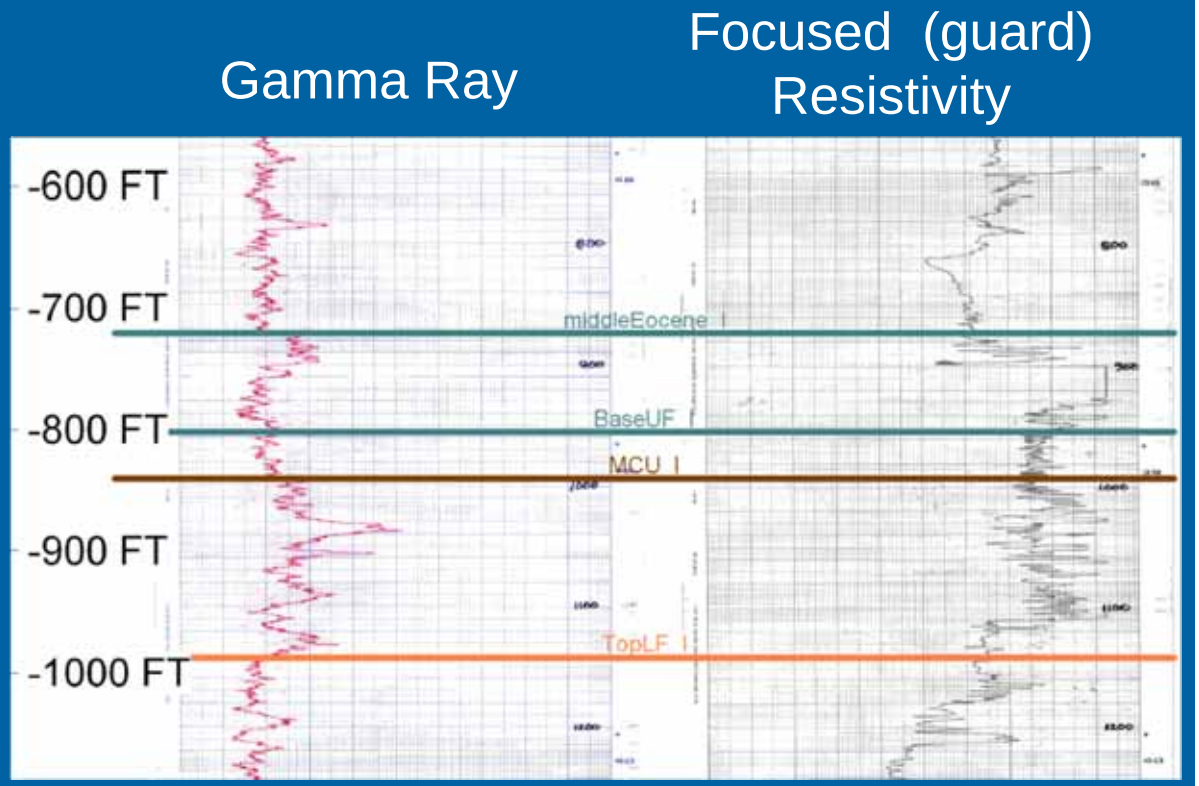


Top of MCU I modified from Miller, 1986

USGS

MCU I: Geophysical Log Characteristics

- High resistivity
- Low porosity
- Multiple beds may comprise this unit

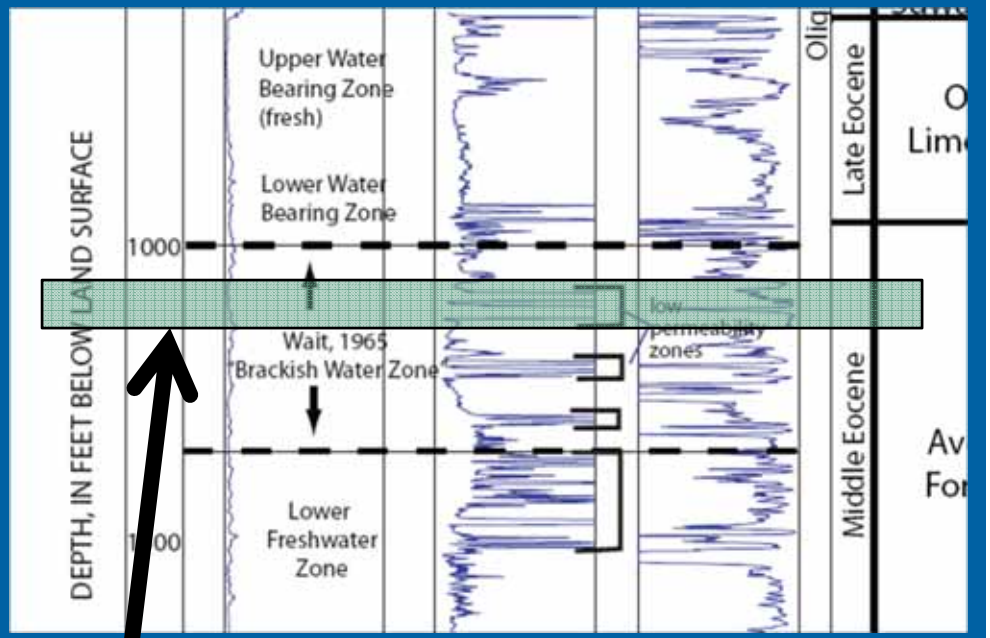


Waycross, GA

USGS

MCU I Mapping Criteria

- Lithology
- Geophysical log response (low porosity beds)
- Position in stratigraphic section
- Top of unit is usually picked on the shallowest low-porosity bed in middle Eocene rocks

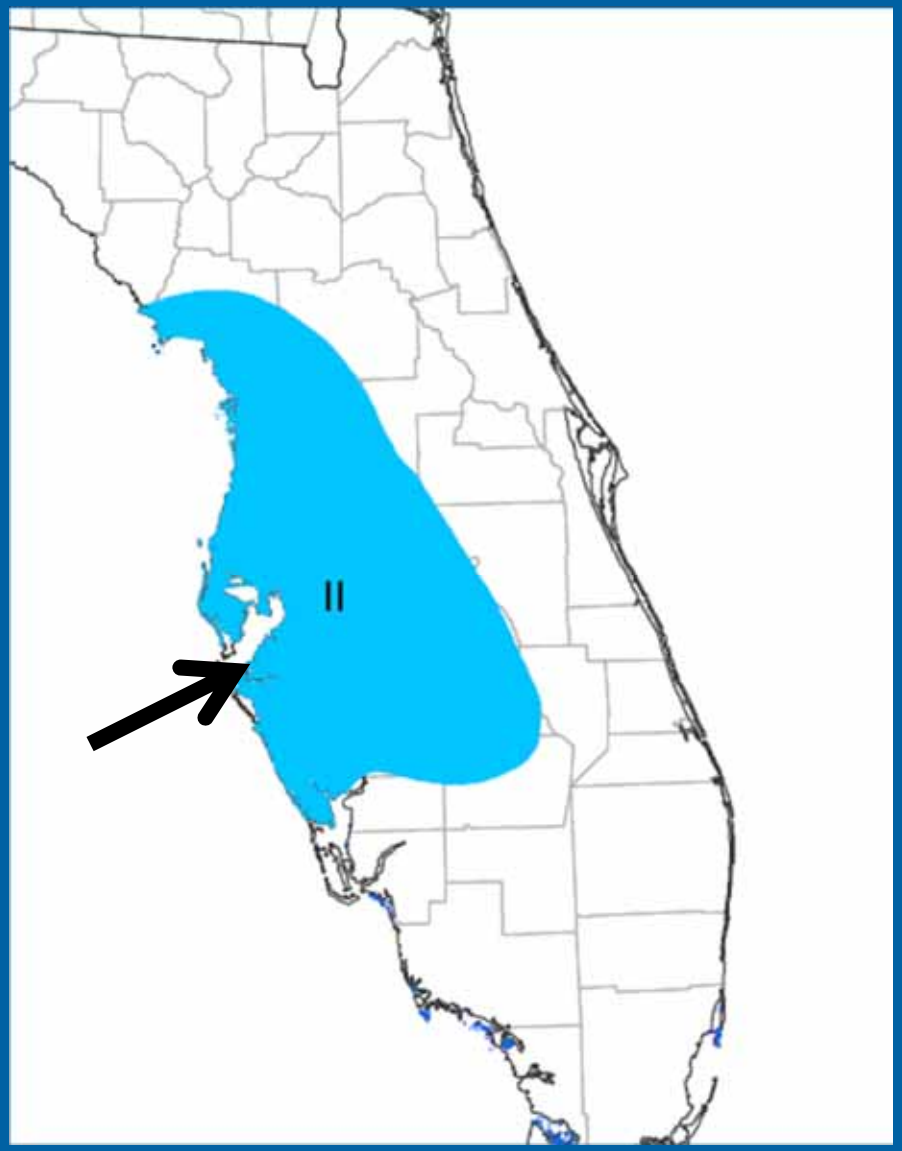


MCUI (Miller, 1986)

USGS

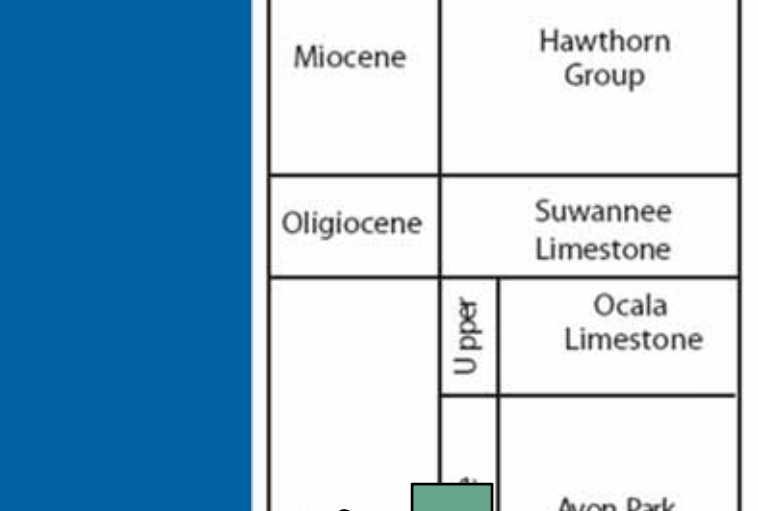
Middle Confining Unit II

- Low-permeability gypsiferous dolomite and dolomitic limestone
- Overlapped by MCU I in part of central Florida
- Extensive middle Eocene sabkha or tidal flat



MCU II: Geologic Units and Lithology

- Located in the middle part of the middle Eocene
- Dolomite and dolomitic limestone
- Intergranular gypsum makes it a very low-permeability unit



Series	Stratigraphic unit	
Holocene to Upper Miocene	Undifferentiated surficial deposits	
Miocene	Hawthorn Group	
Oligiocene	Suwannee Limestone	
Eoc	Upper	Ocala Limestone
		Avon Park Formation
	Lower	Oldsmar Formation
Paleocene	Cedar Keys Formation	
Cretaceous	Lawson Limstone	

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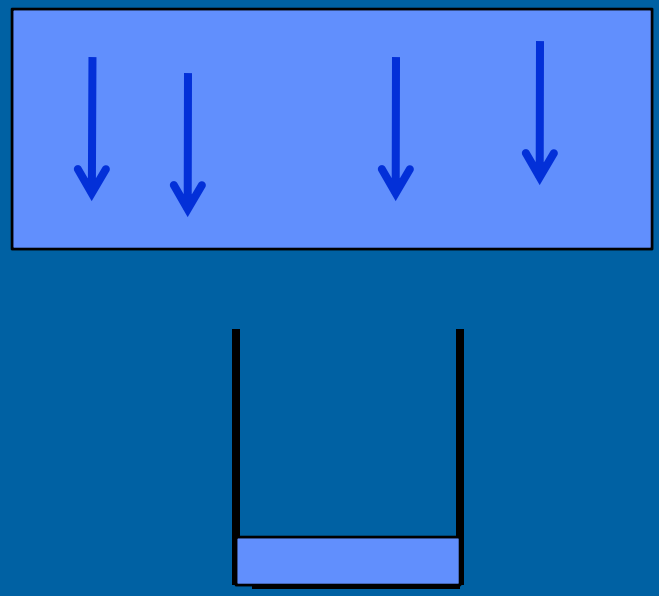
MCU II: Confining Properties

- Non-leaky confining bed
- Mineralized water contained in the unit suggests poor connection with freshwater in the overlying Upper Floridan aquifer

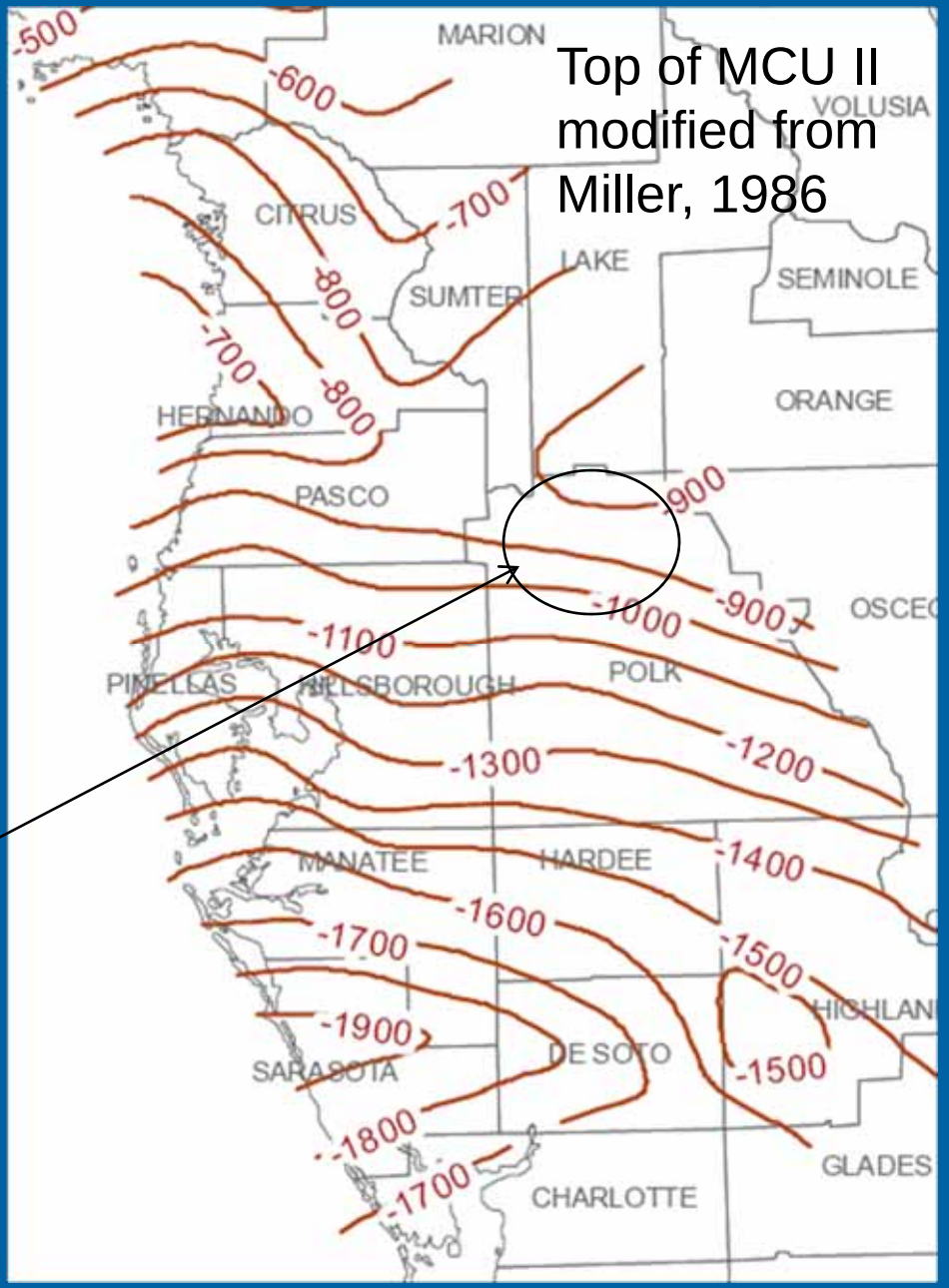


Leak-o-meter

USGS

Configuration and Thickness

- Generally dips along stratigraphic horizons
- Thickest in the northeast and thins to east
- (anomalous thickness in northern Polk)



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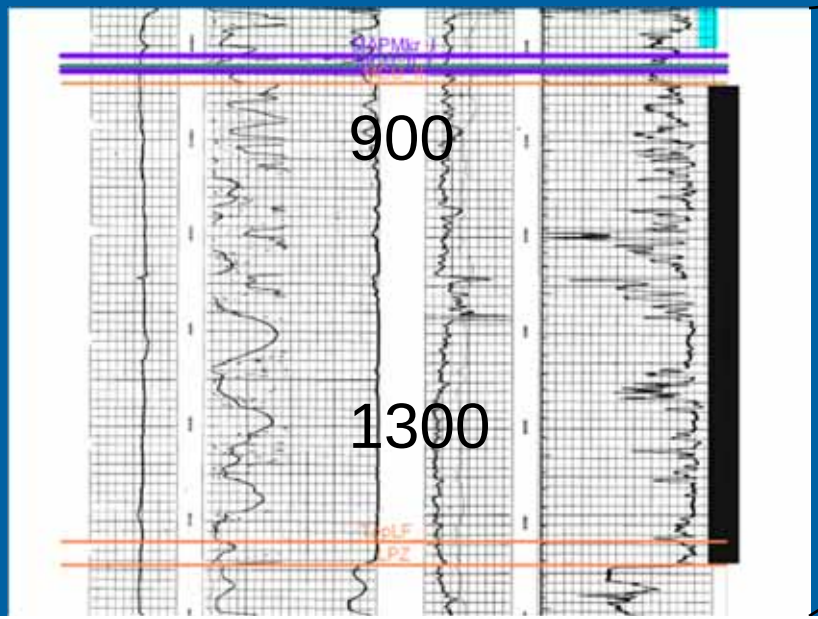
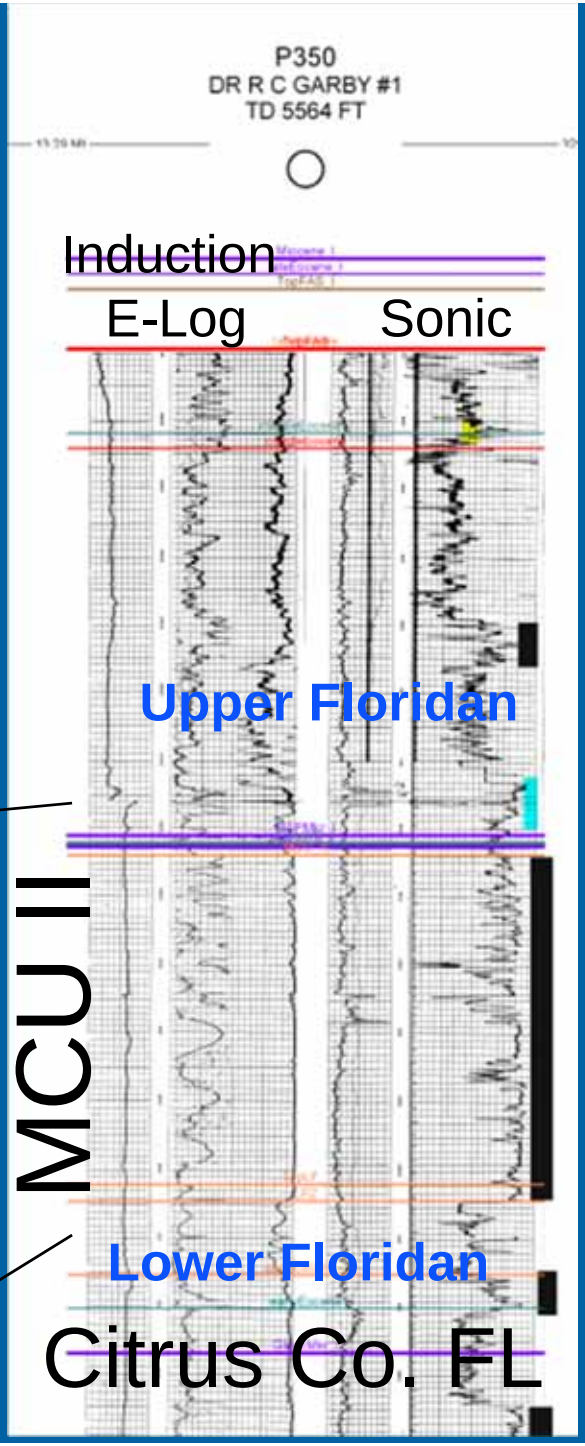
MCU II: Geophysical Log Characteristics

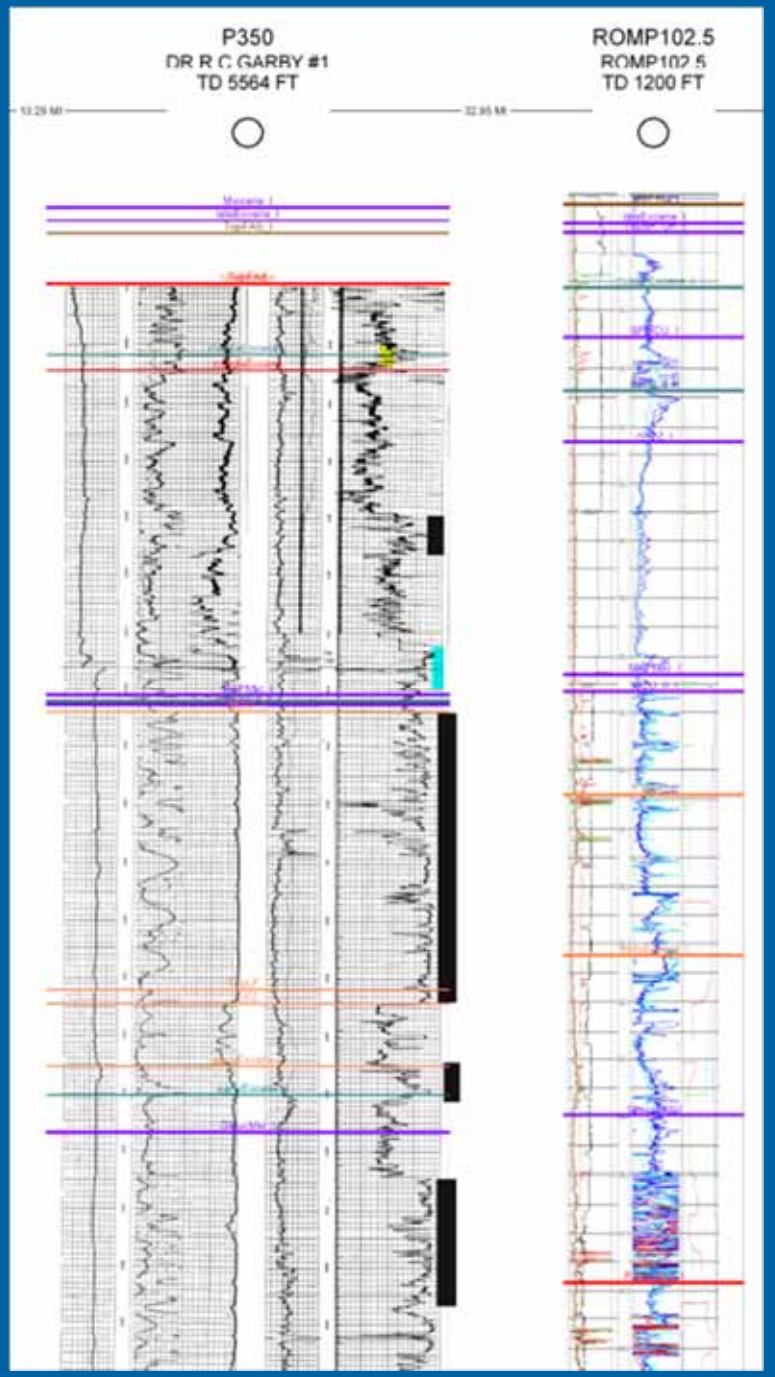
- Identified on elogs by its “spiky” high and low resistivity zones
- Has very Low porosity (<10%)





Correlation

- Oil and gas test well (Citrus Co.) on left
- ROMP core hole (Sumter Co.) on right
- These wells are 33 miles apart



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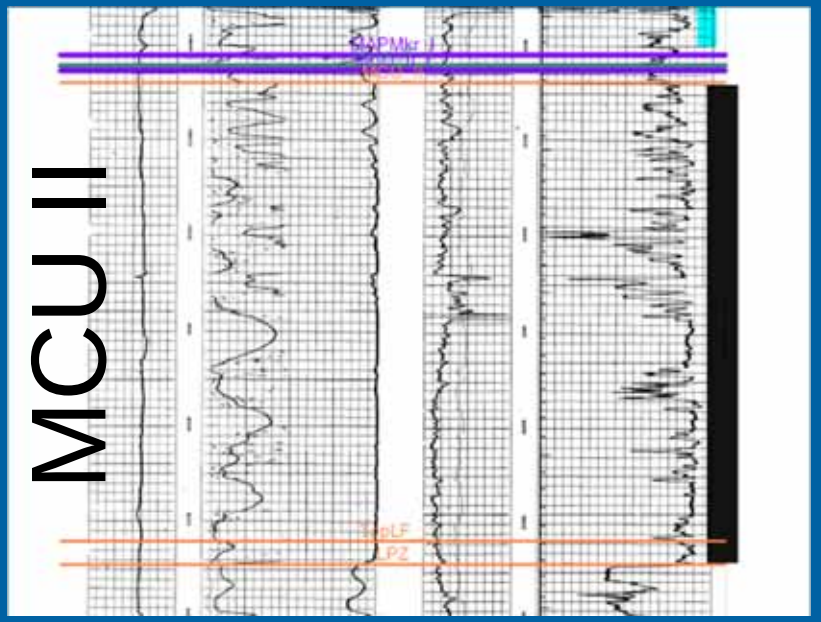
MCU II Mapping Criteria

- Lithology (evaporites)
- Geophysical log response (resistivity and porosity logs)
- Position in stratigraphic section
- Top of unit is usually picked at first occurrence of persistent evaporites



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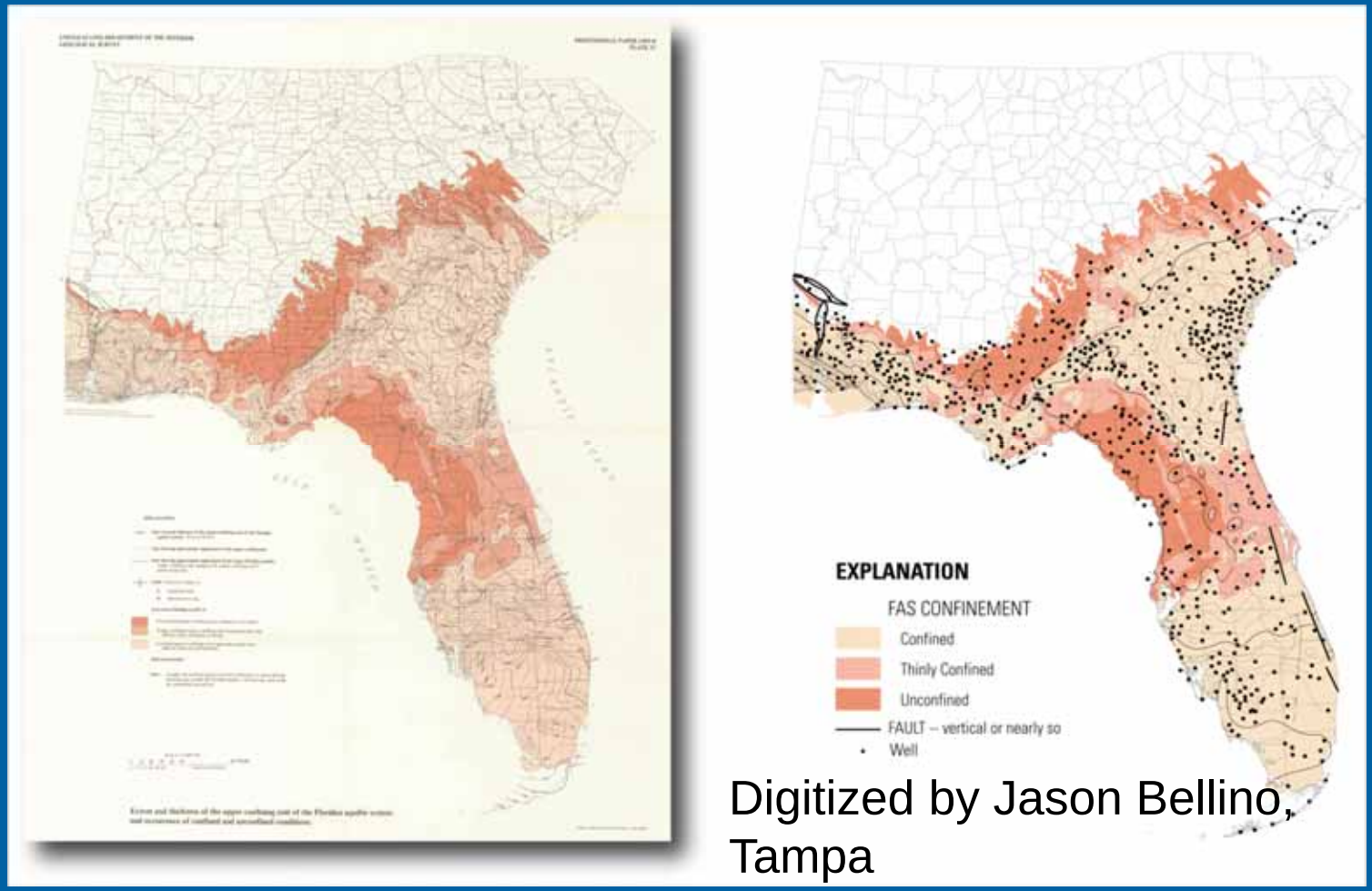
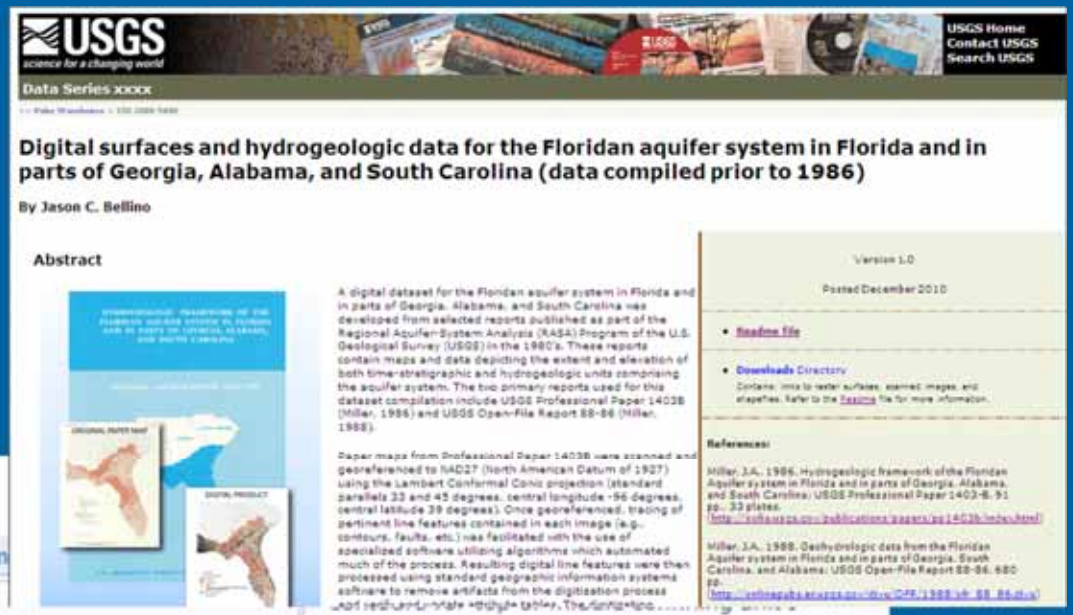
Digital Framework

- **RASA datasets have been digitized!**



Digitized by Jason Bellino, Tampa

Digital Data Series Report of RASA datasets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Data Series xxxx

Digital surfaces and hydrogeologic data for the Floridan aquifer system in Florida and in parts of Georgia, Alabama, and South Carolina (data compiled prior to 1986)

By Jason C. Bellino

Abstract

A digital dataset for the Floridan aquifer system in Florida and in parts of Georgia, Alabama, and South Carolina was developed from selected reports published as part of the Regional Aquifer-System Analysis (RASA) Program of the U.S. Geological Survey (USGS) in the 1980's. These reports contain maps and data depicting the extent and elevation of both time-stratigraphic and hydrogeologic units comprising the aquifer system. The two primary reports used for this dataset compilation include USGS Professional Paper 1403B (Miller, 1986) and USGS Open-File Report 88-86 (Miller, 1988).

Paper maps from Professional Paper 1403B were scanned and georeferenced to NAD27 (North American Datum of 1927) using the Lambert Conformal Conic projection (standard parallels 33 and 45 degrees, central longitude -96 degrees, central latitude 39 degrees). Once georeferenced, tracing of pertinent line features contained in each image (e.g., contours, faults, etc.) was facilitated with the use of specialized software utilizing algorithms which automated much of the process. Resulting digital line features were then processed using standard geographic information systems software to remove artifacts from the digitization process and restructure-relate tables. The digital data

Version 1.0

Posted December 2010

- Readme file
- Downloads Directory
  Contains .mxd to raster surfaces, scanned images, and shapefiles. Refer to the Readme file for more information.

References:

Miller, J.A., 1986, Hydrogeologic framework of the Floridan Aquifer system in Florida and in parts of Georgia, Alabama, and South Carolina: USGS Professional Paper 1403-B, 91 pp., 33 plates.
(http://pubs.usgs.gov/publications/papers/pp1403b/index.html)

Miller, J.A., 1988, Geohydrologic data from the Floridan Aquifer system in Florida and in parts of Georgia, South Carolina, and Alabama: USGS Open-File Report 88-86, 680 pp.
(http://pubs.usgs.gov/of/1988/of88-086/)

Fig/Plate No.	File Nam	
Figure 11	fig11_mcu_i_cntr.shp	
Figure 11	fig11_mcu_i_poly.shp	extent of middle confining unit I
Figure 13	fig13_mcu_ii_cntr.shp	contours for top of middle confining unit II
Figure 13	fig13_mcu_ii_poly.shp	extent of middle confining unit II
Figure 15	fig15_mcu_iii_poly.shp	extent of middle confining unit III
Figure 17	fig17_mcu_iv_poly.shp	extent of middle confining unit IV
Figure 18	fig18_mcu_v_poly.shp	extent of middle confining unit V
Figure 19	fig19_mcu_vi_cntr.shp	contours for top of middle confining unit VI
Figure 19	fig19_mcu_vi_poly.shp	extent of middle confining unit VI
Figure 22	fig22_mcu_vii_poly.shp	extent of middle confining unit VII
Figure 23	fig23_boulderzone_cntr.shp	contours for top of boulder zone
Figure 23	fig23_boulderzone_poly.shp	extent of boulder zone
Figure 24	fig24_mcu_viii_cntr.shp	contours for top of middle confining unit VIII
Figure 24	fig24_mcu_viii_poly.shp	extent of middle confining unit VIII
Figure 26	fig26_fernandina_cntr.shp	contours for top of Fernandina permeable zone
Figure 26	fig26_fernandina_poly.shp	extent of Fernandina permeable zone
Plate 1	plt01_cross_sections.shp	location of cross section lines

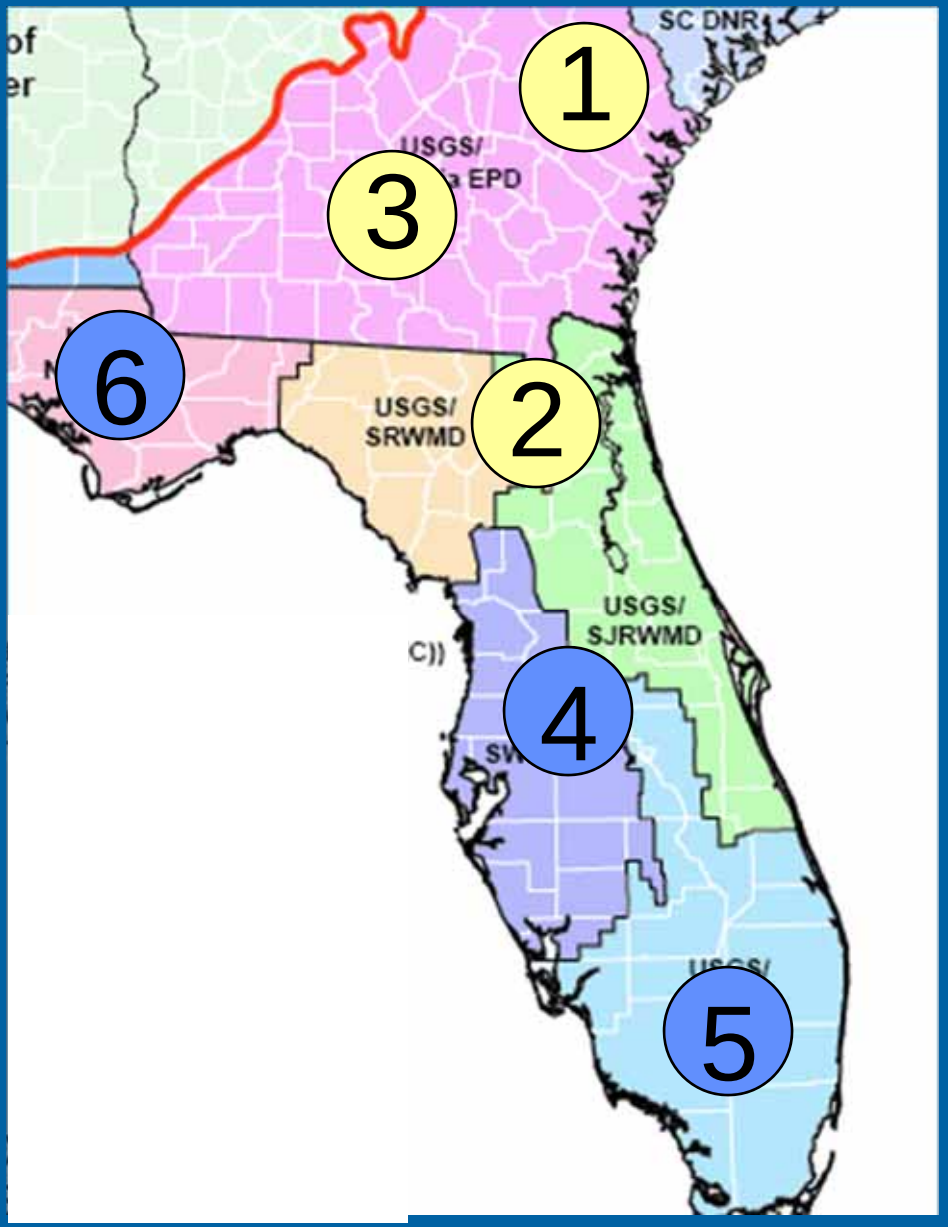
It's Here!

Includes:
Bush and Johnson, 1988
Miller, 1986

http://pubs.usgs.gov/ds/584/

Revised Framework

- Yellow, basically done
  - Updated MCUs
  - Updated Upper Confining Unit
  - Updated Base of System
- Blue, in progress



USGS

Northern Coastal Region

- During original RASA few wells were used to map permeability variations in the Floridan Aquifer system
- “State Line Fault” between Georgia and South Carolina
- Capacity use area (restrictions on additional groundwater supply)
- Up dip clastic equiv. aquifers

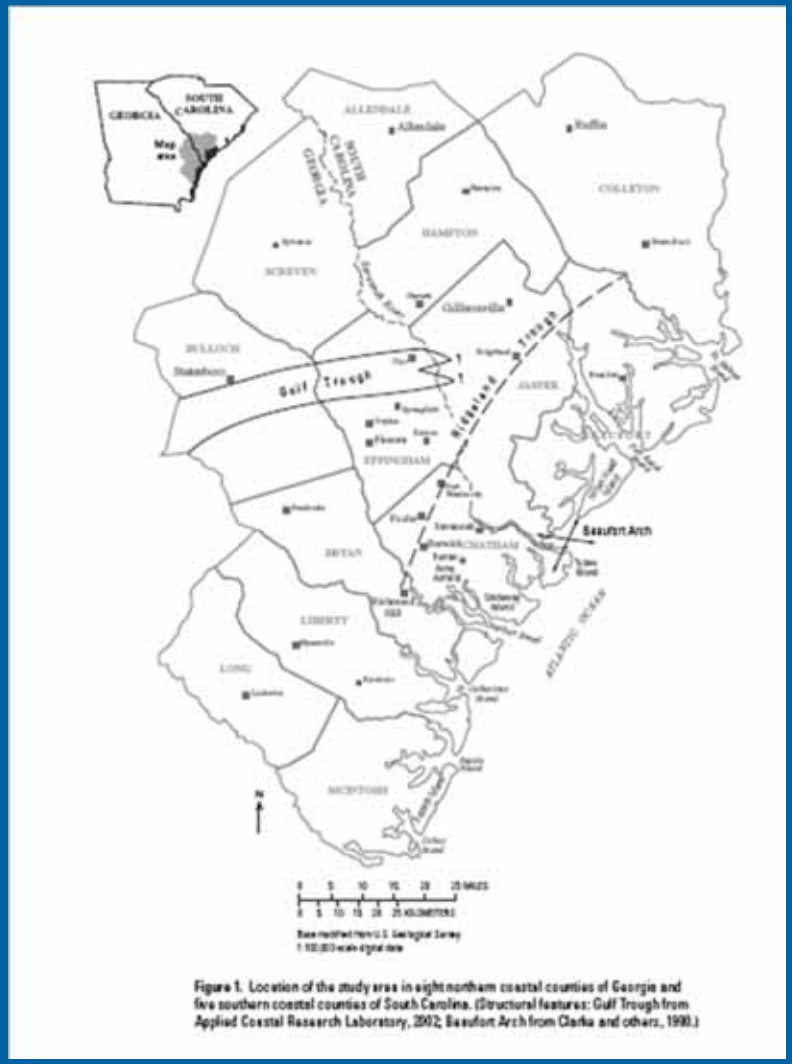
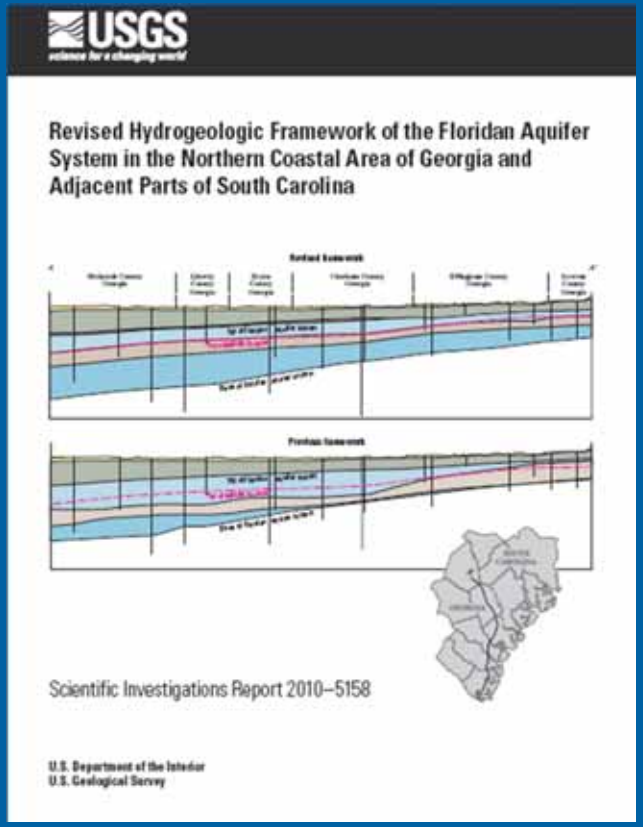


Figure 1. Location of the study area in eight northern coastal counties of Georgia and five southern coastal counties of South Carolina. (Structural features: Gulf Trough from Applied Coastal Research Laboratory, 2002; Beaufort Arch from Clarke and others, 1990.)

USGS

Hydrogeologic Framework Progress

- Completed a revised framework for northern coastal region of Georgia and parts of South Carolina
- Acknowledgments
  - Drennan Park , Joe Gillici, Connie Gawne (SC DNR)
  - Camille Ransom (SC DHEC)
  - Fred Falls (USGS, SC)
  - Harold Gill (USGS, Ret.)



U.S. Geological Survey SIR 2010-5158
(Published May 2010)

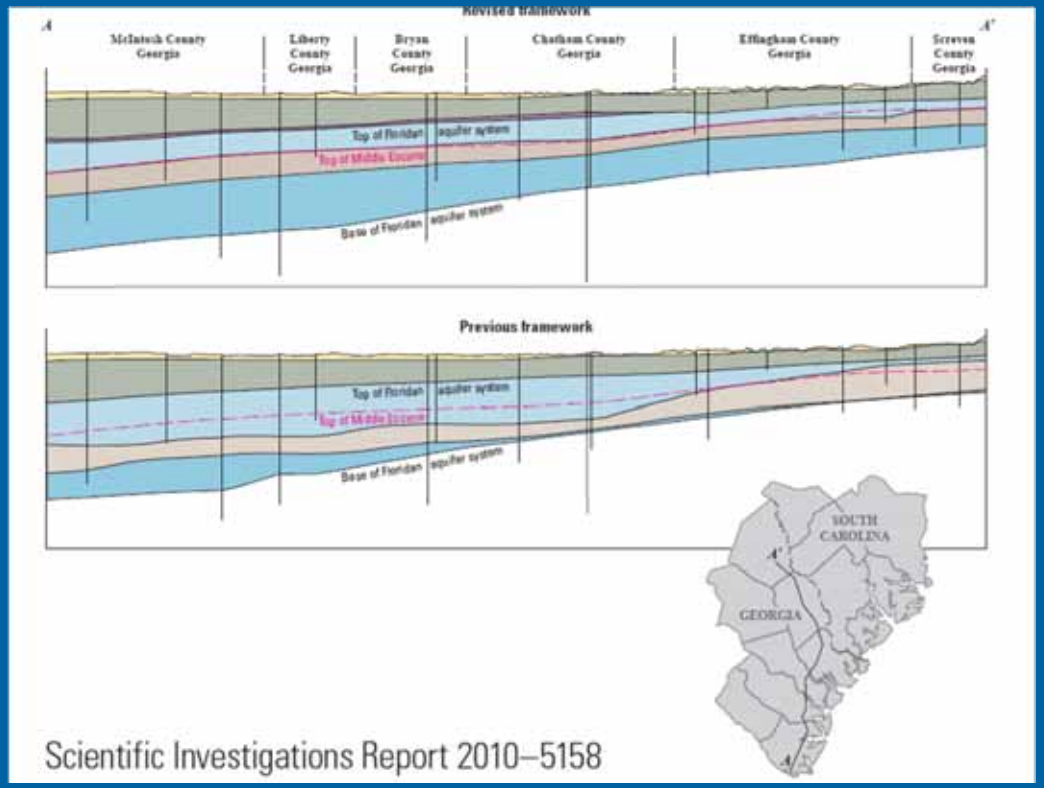
USGS

Northern Coastal Region of Georgia and Parts of South Carolina

- Lot of issues with respect to the placement of the middle confining unit
- Had to heavily rely on flowmeter tests

Revised Framework

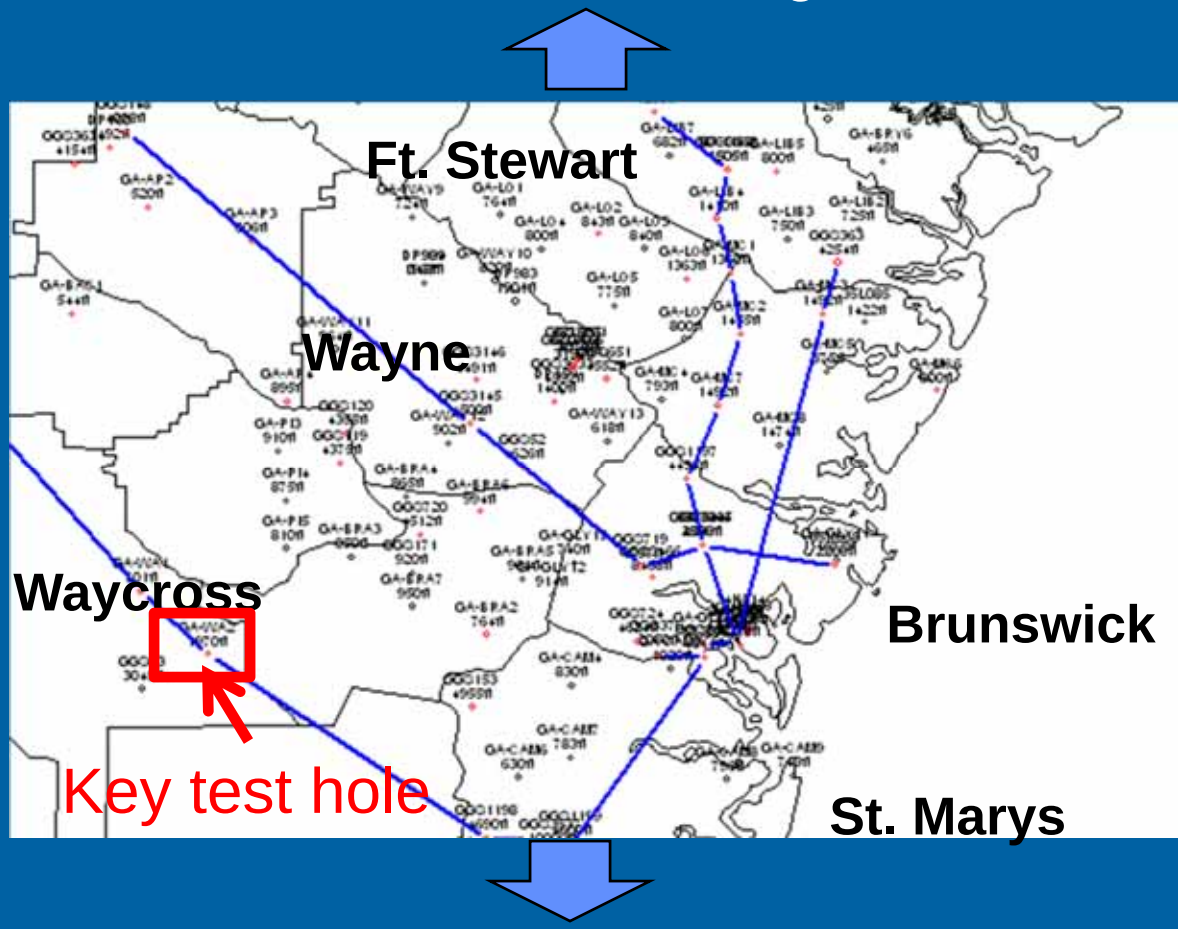
Original Framework



USGS

Hydrogeologic Framework Progress

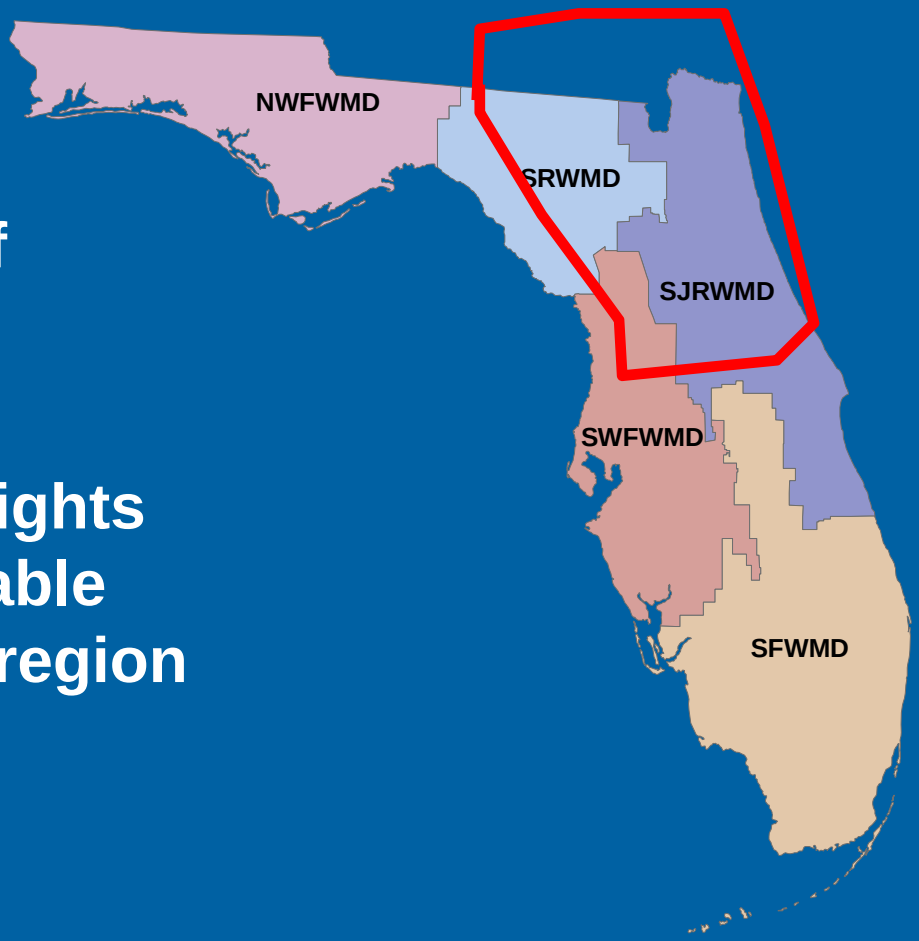
- Extended the new framework into the southeastern Georgia coastal plain
- Identified key geophysical markers in Avon Park/Oldsmar



USGS

Northeast Florida/Southeastern Georgia Revisions (cont.)

- Jeff Davis with SJRWMD provided HUGE amounts of experience and data to us.
- Don Boniel with SJRWMD
- Rick Spechler provided insights into the Fernandina Permeable Zone and hydrogeology of region
- Karst Interest Group Presentation, April 2011

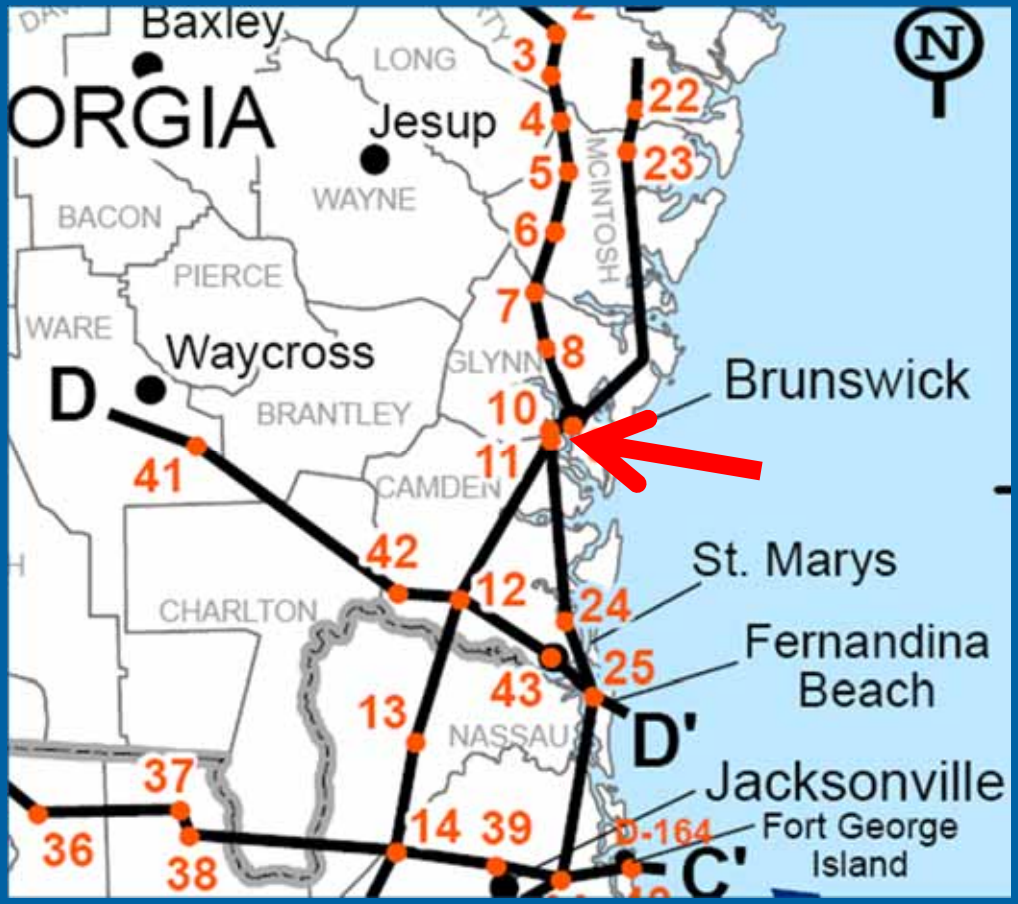


Site Location Map Showing Wells Used in Revising Framework

Figure 1. Study area showing location of wells and cross section lines in northeastern Florida and southeastern Georgia.

USGS

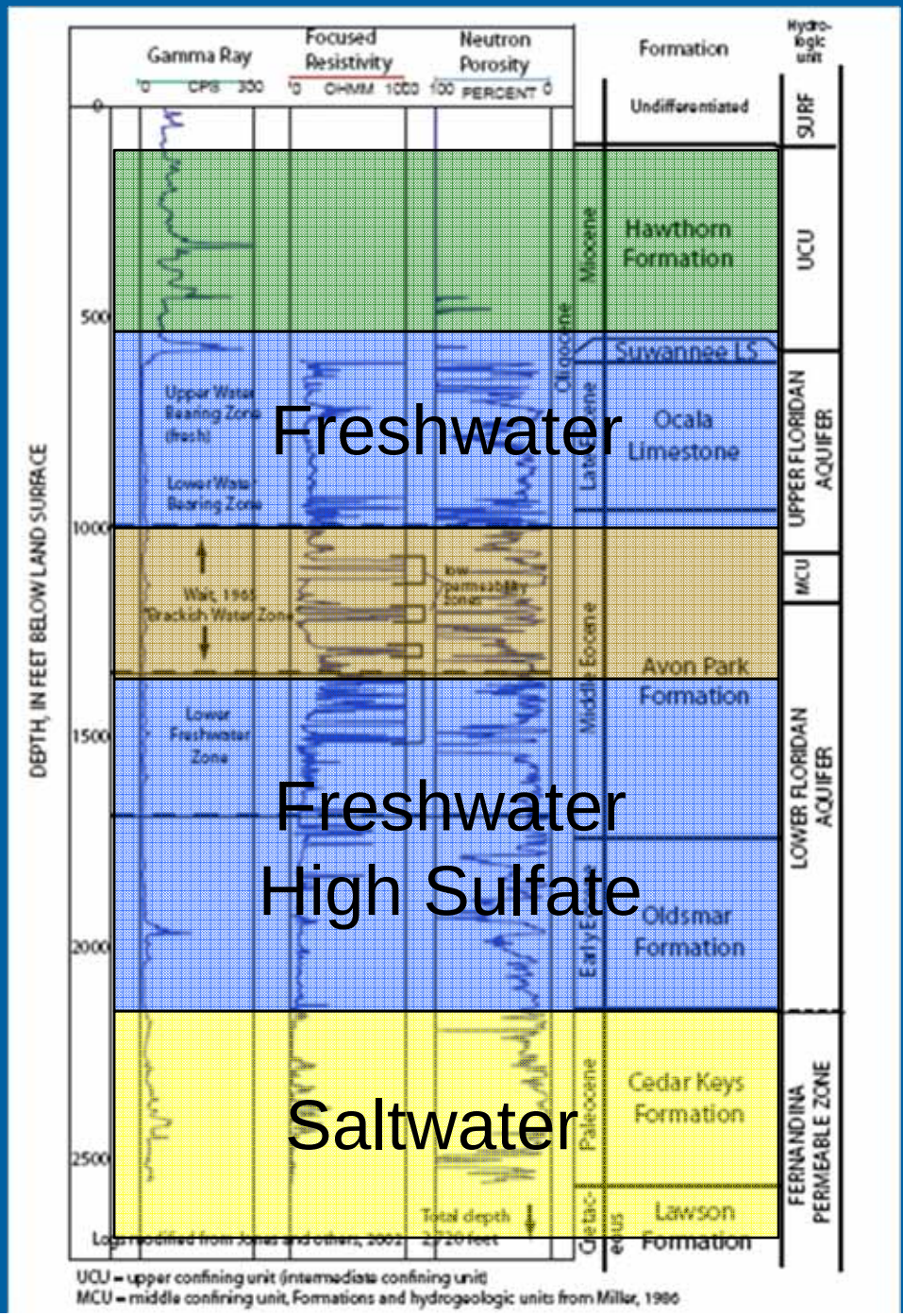
Key Well Site: Test Well 26 Colonels Island



USGS

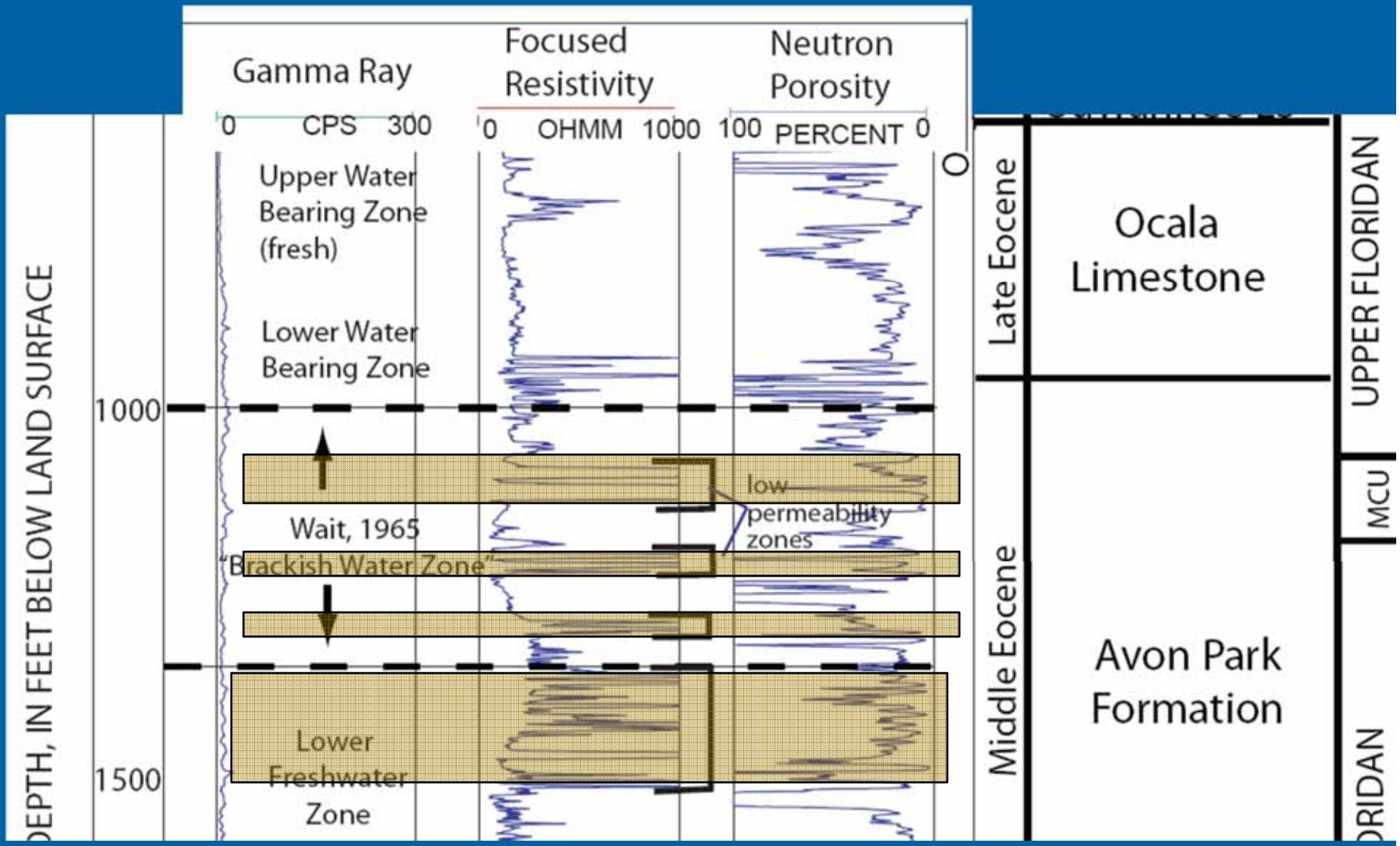
Hydrogeologic Units

- Upper Confining Unit
- Upper Floridian Aquifer
- Lower Floridan Aquifer
- Fernandina Permeable Zone

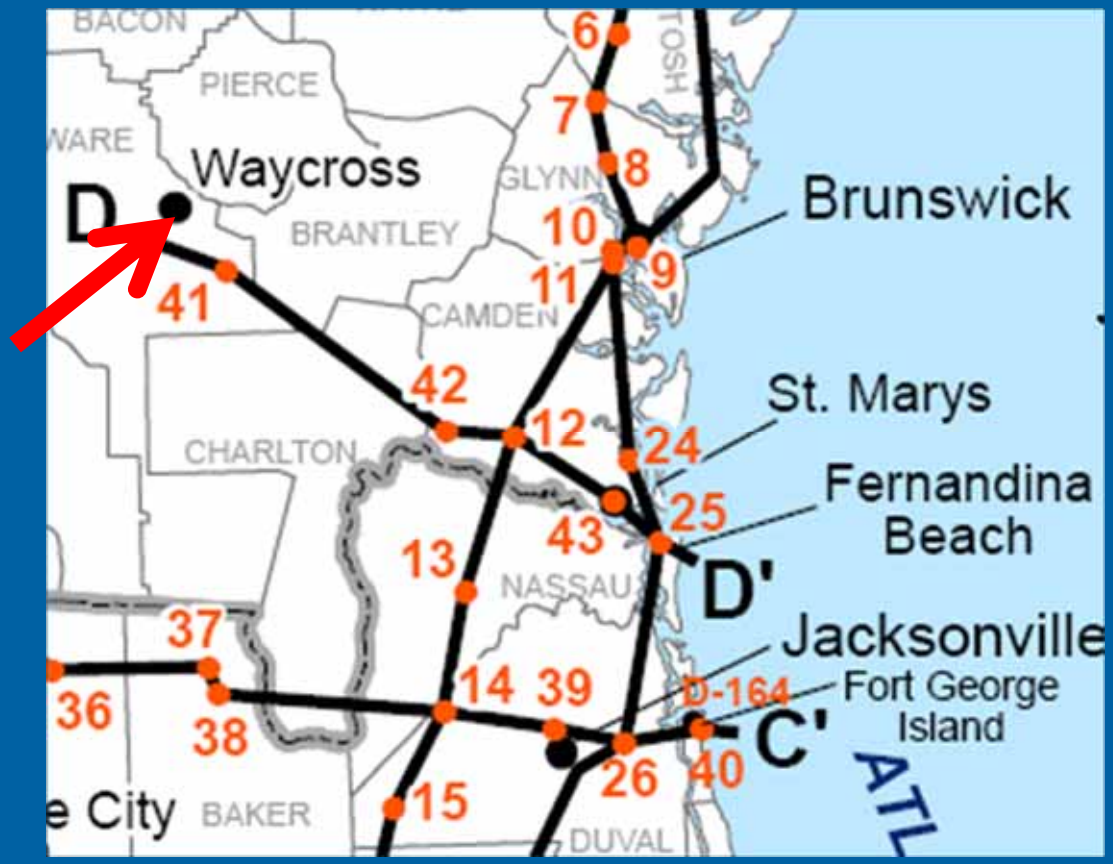


USGS

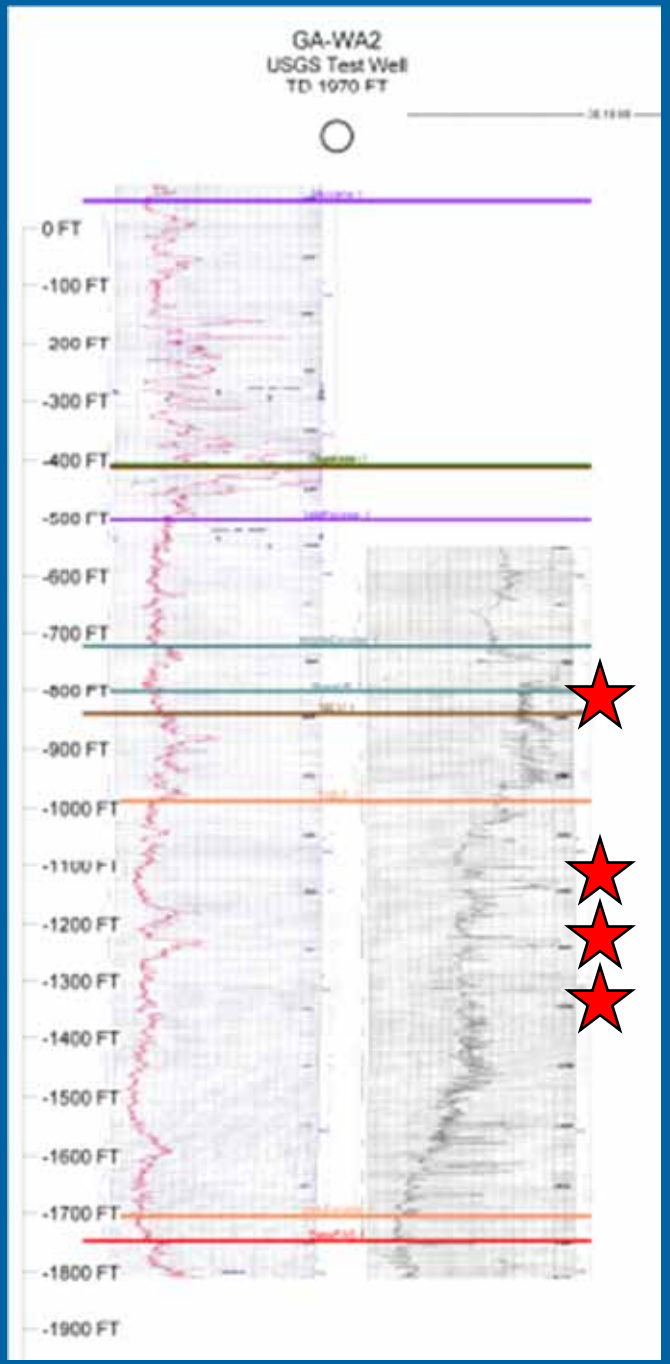
Middle Confining Units in the Floridan Aquifer System



Ware Co. GA: Waycross Test Hole



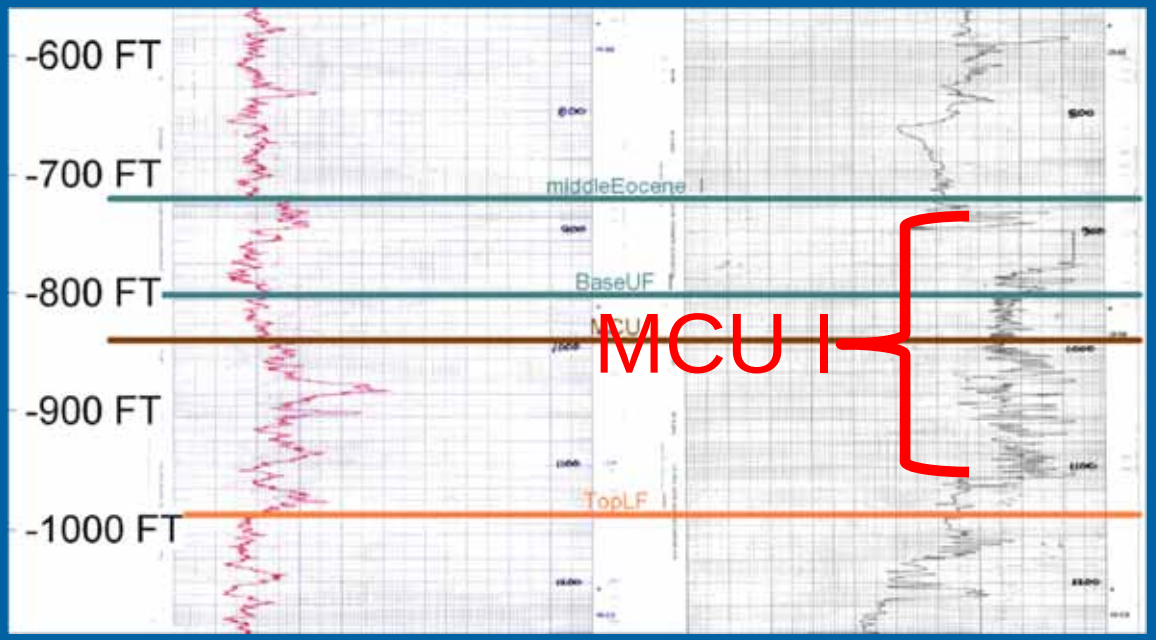
USGS



WaycrossTest well

Gamma Ray

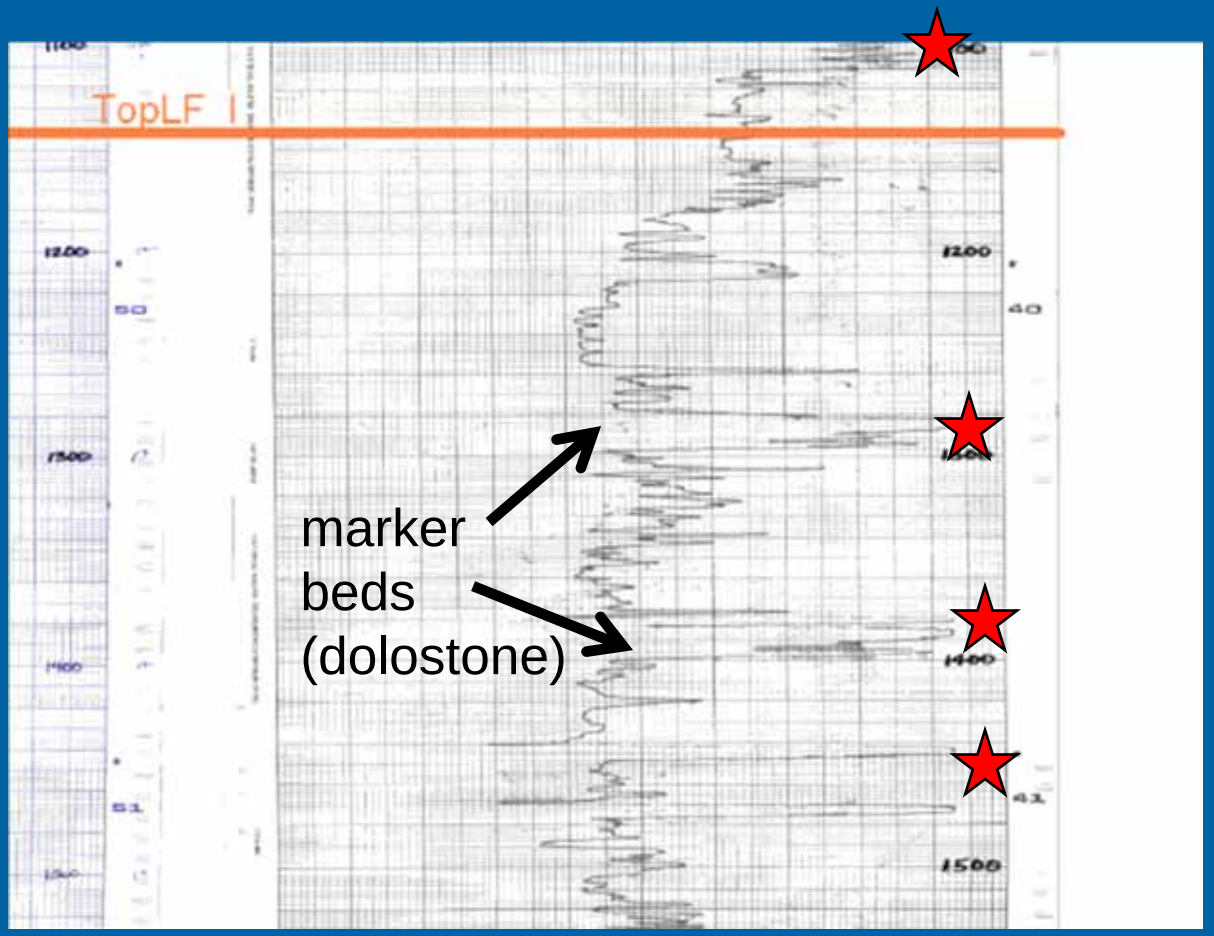
Focused (guard) Resistivity



Logs from files of the USGS

★ Denotes a geophysical marker bed

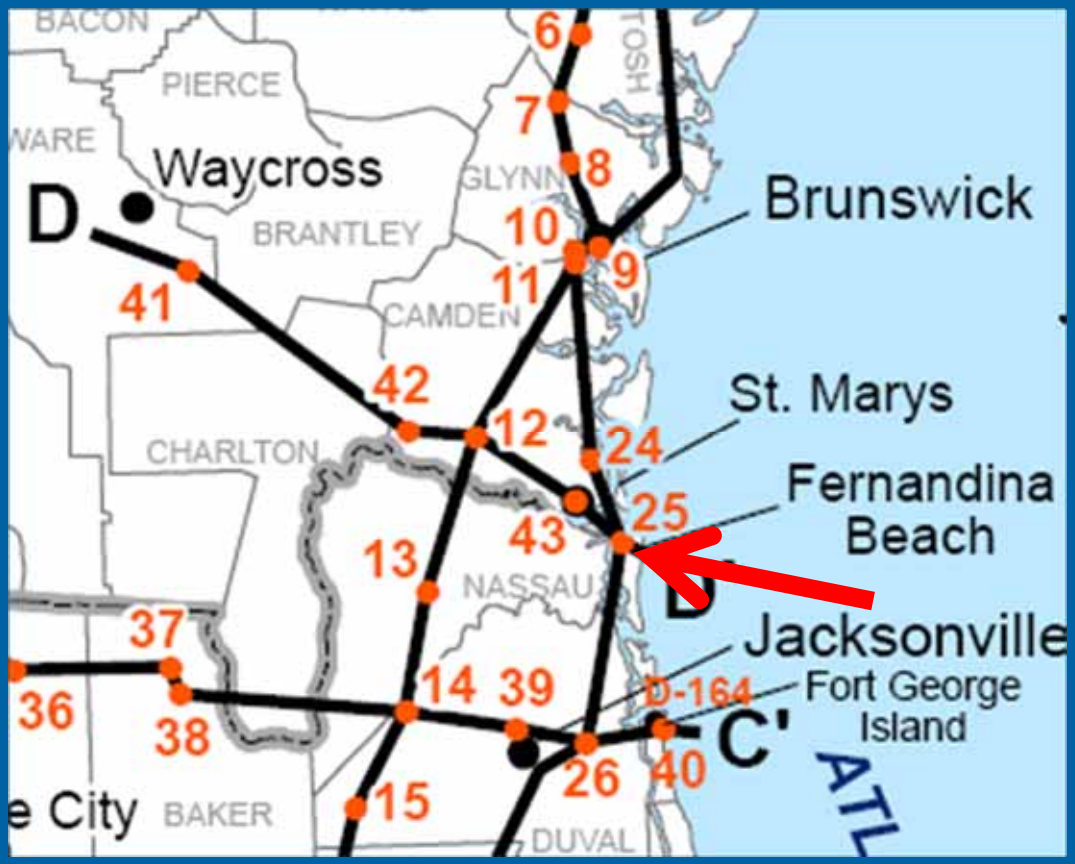
Lower marker beds below MCU I



Logs from files of the USGS

USGS

Nassau Co. FL: Fernandina Beach



USGS

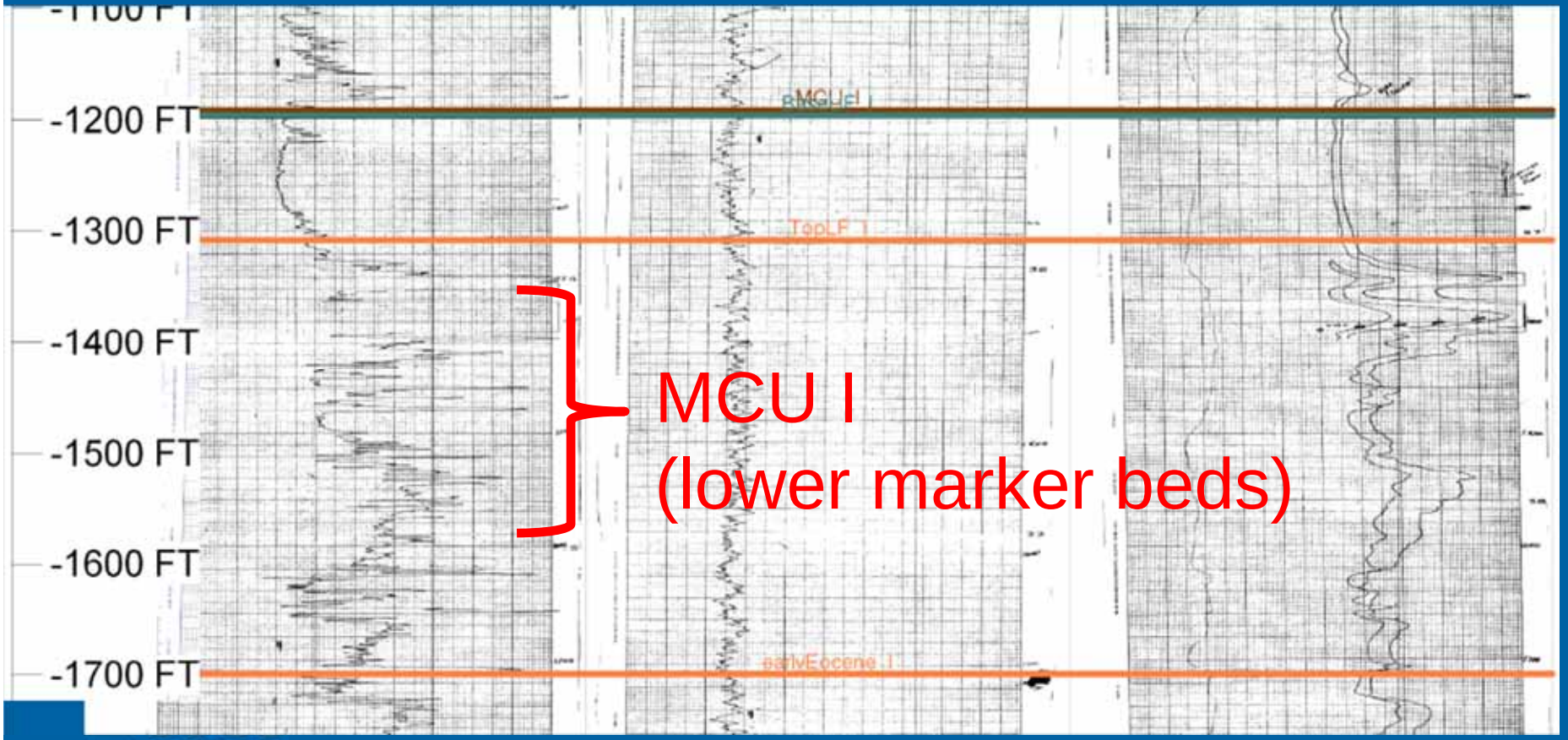
Nassau County FL

FL-NA7
#1 ITT Rayonier
TD 2090 FT

Focused (guard) Resistivity

Gamma Ray

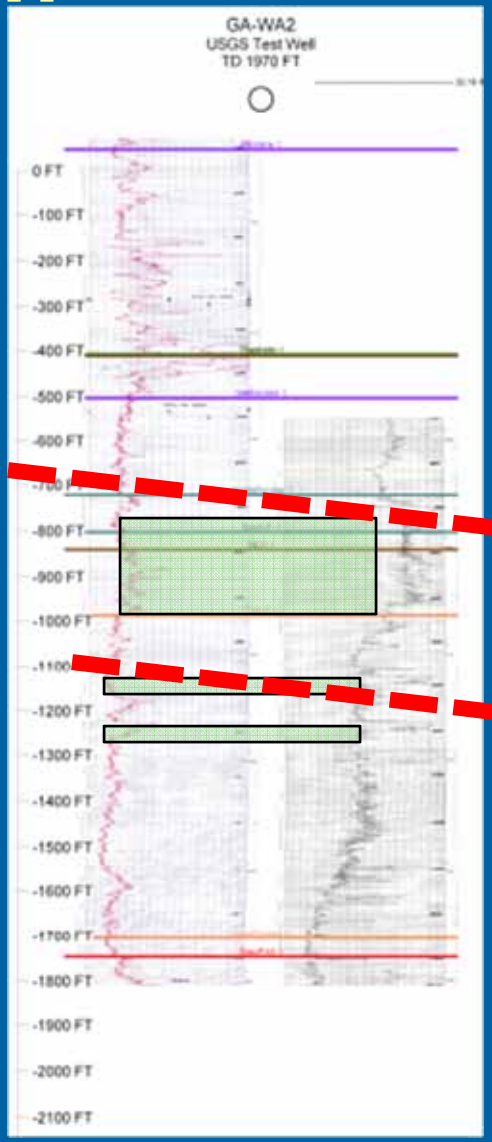
Long and Short Normal



Logs from files of the USGS

Correlation

D — 56 miles — D’



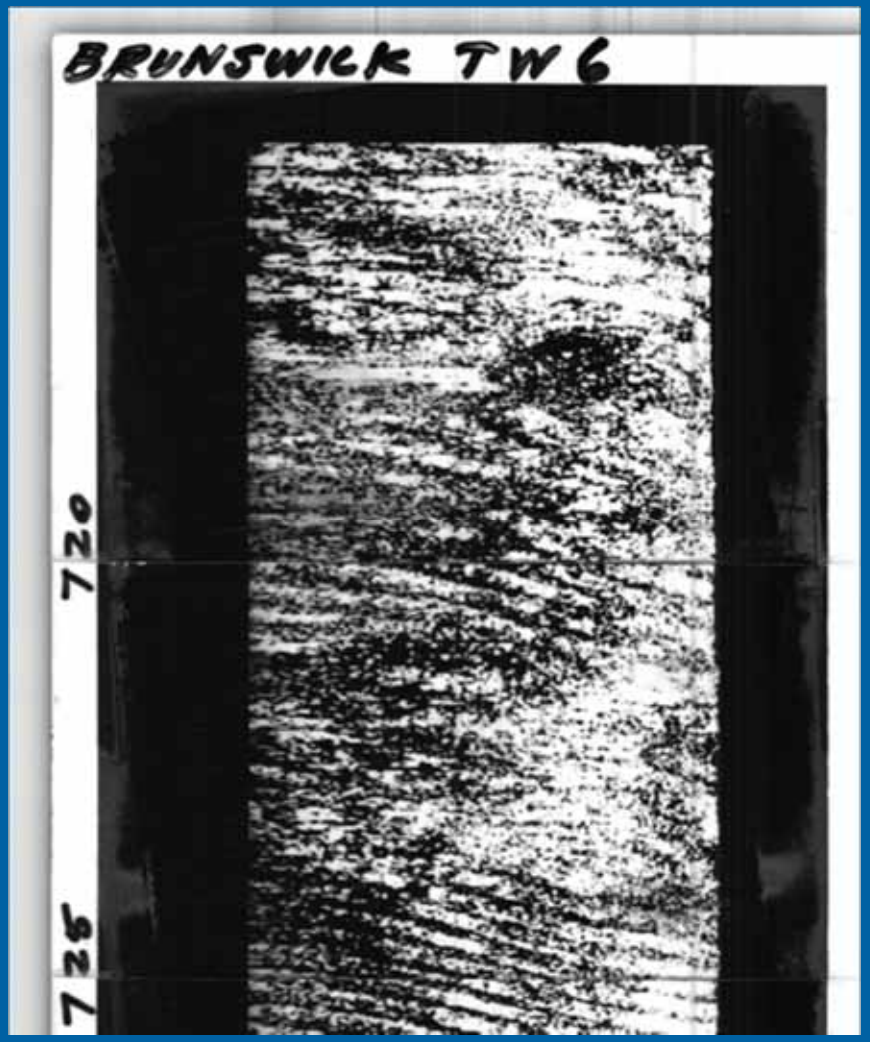
Waycross, GA

Fernandina Beach, FL

USGS

Acoustic Televiewer Images

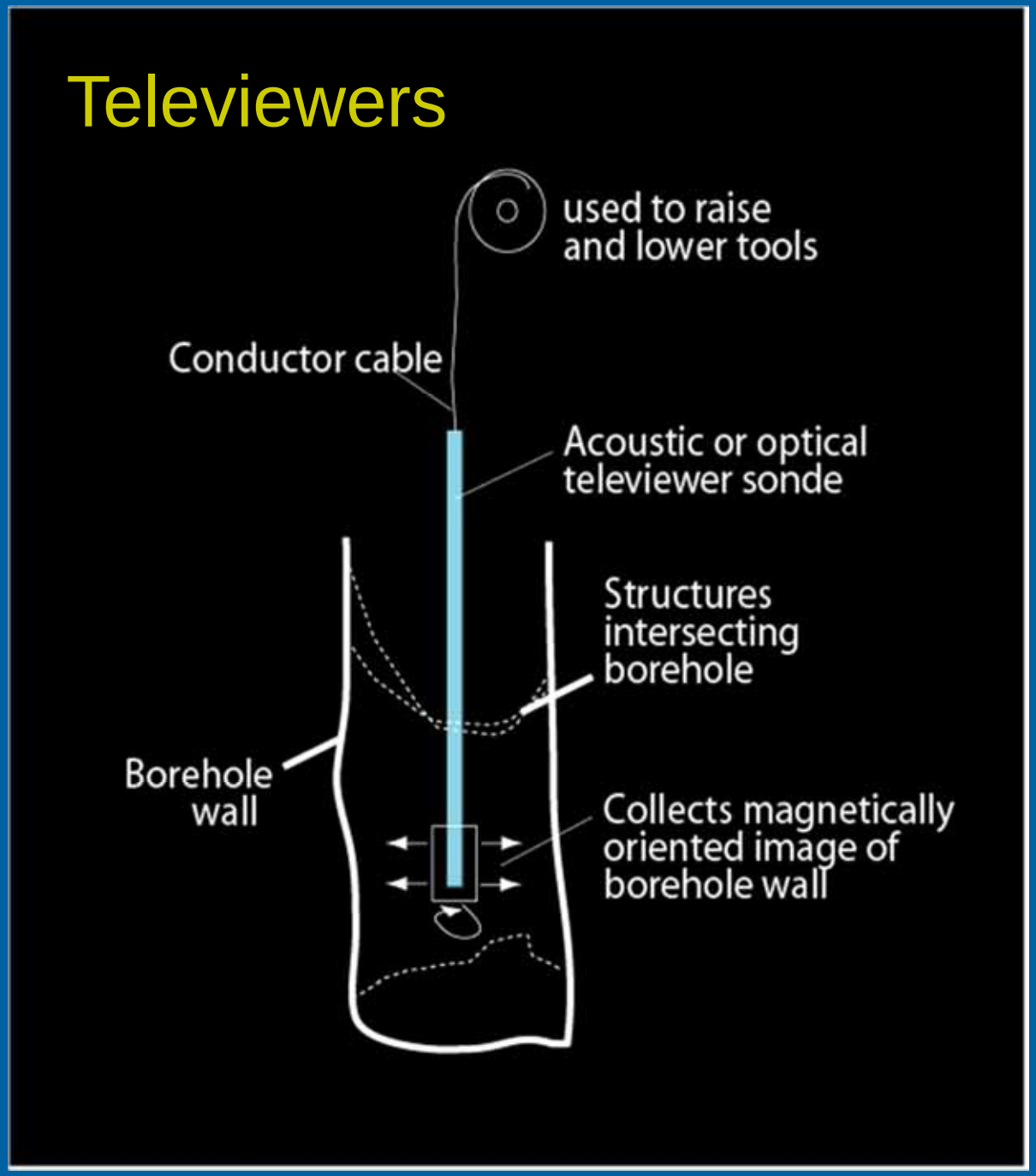
- Collected by USGS in the late 1970's to mid 1990's
- These were scanned in from original Polaroid images
- Show a 360 degree oriented image of the inside of the open portion of the borehole



Stitched together Polaroids of ATV image from test well in Brunswick, GA

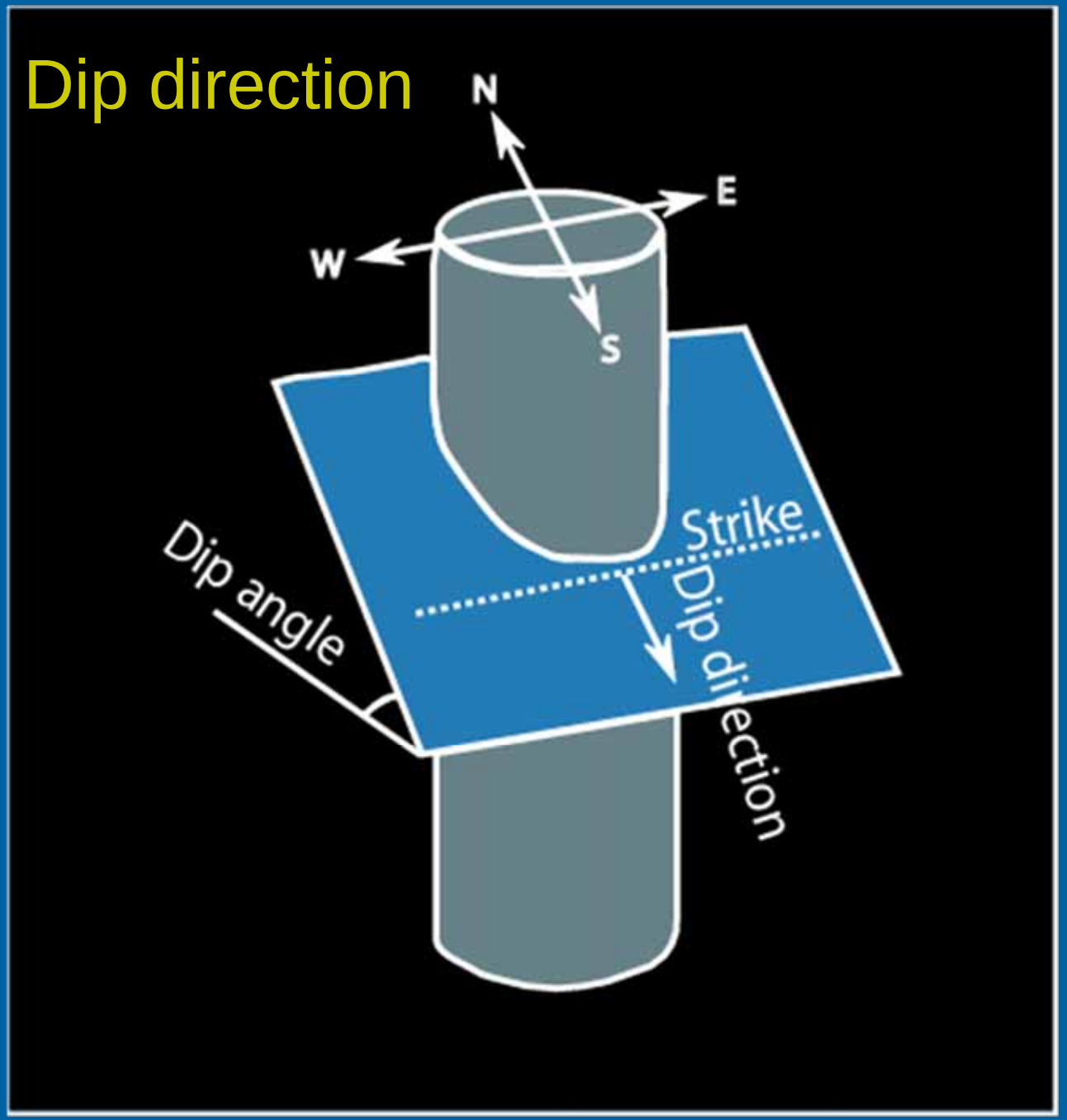
USGS

Televiewers



USGS

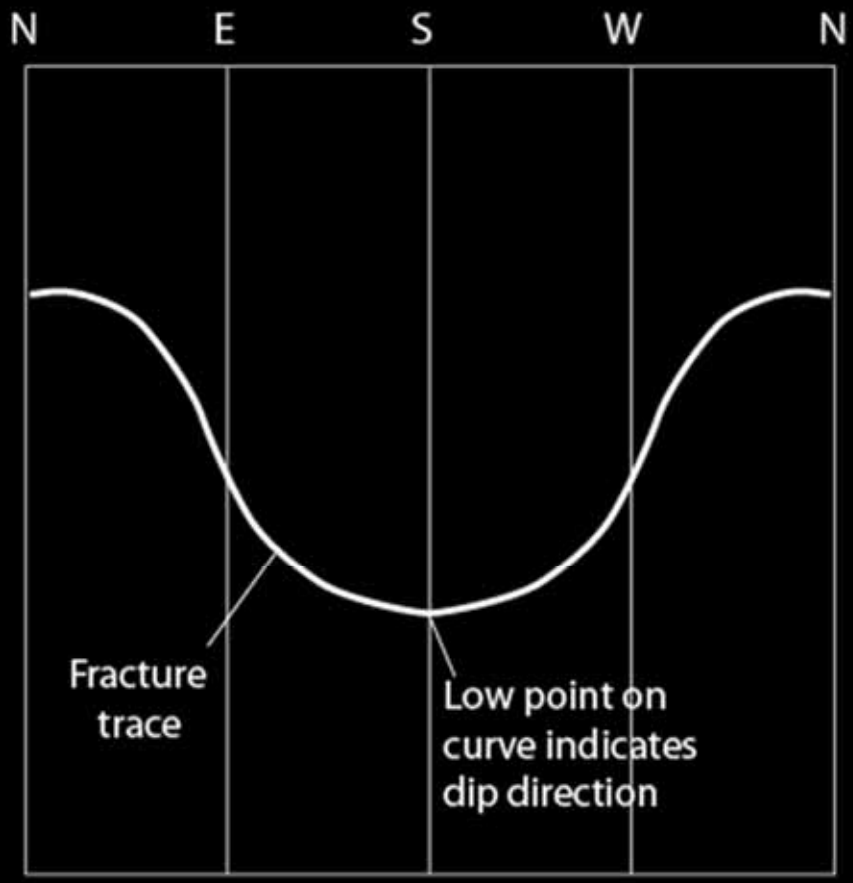
Dip direction



USGS

Projected image on 2-D plane

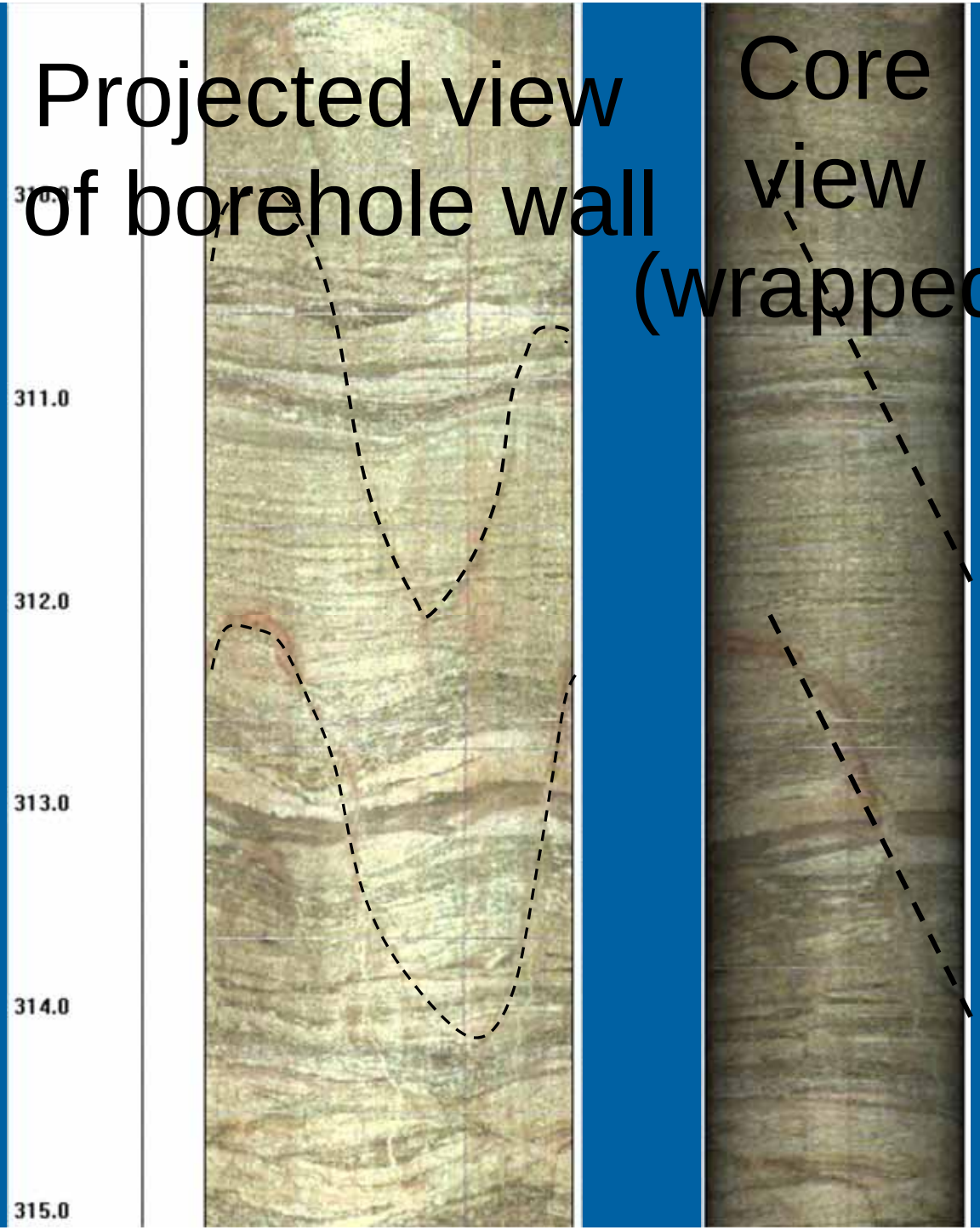
$$\text{dip} = \tan^{-1} \frac{\text{amplitude}}{\text{diameter}}$$

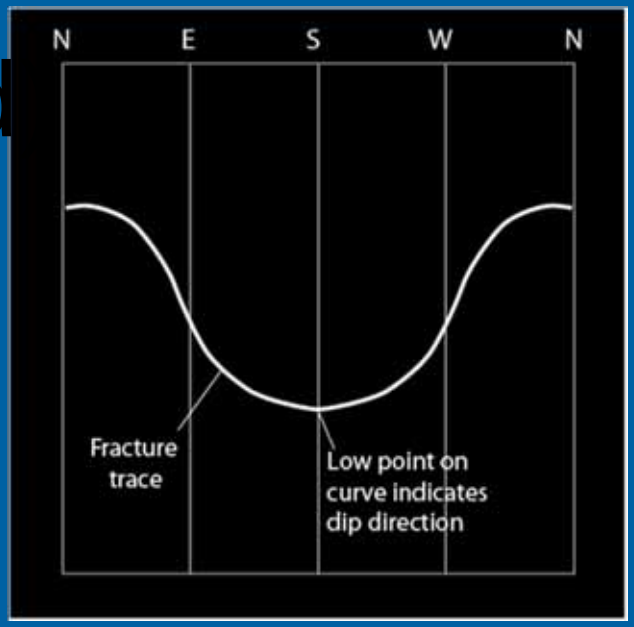


USGS

Projected view of borehole wall

Core view (wrapped)

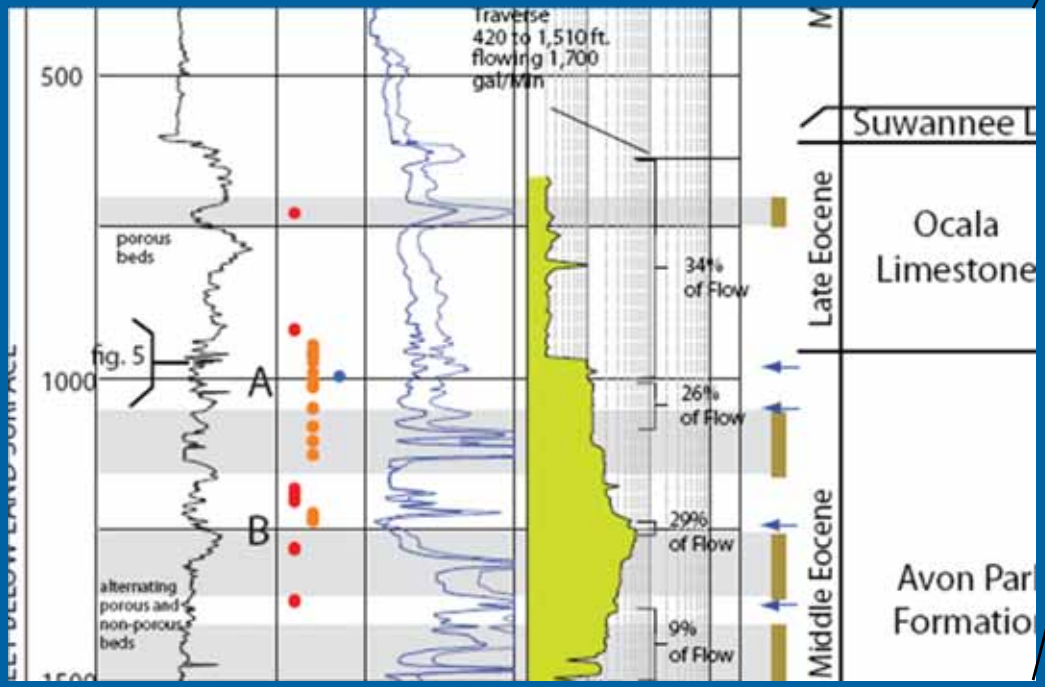


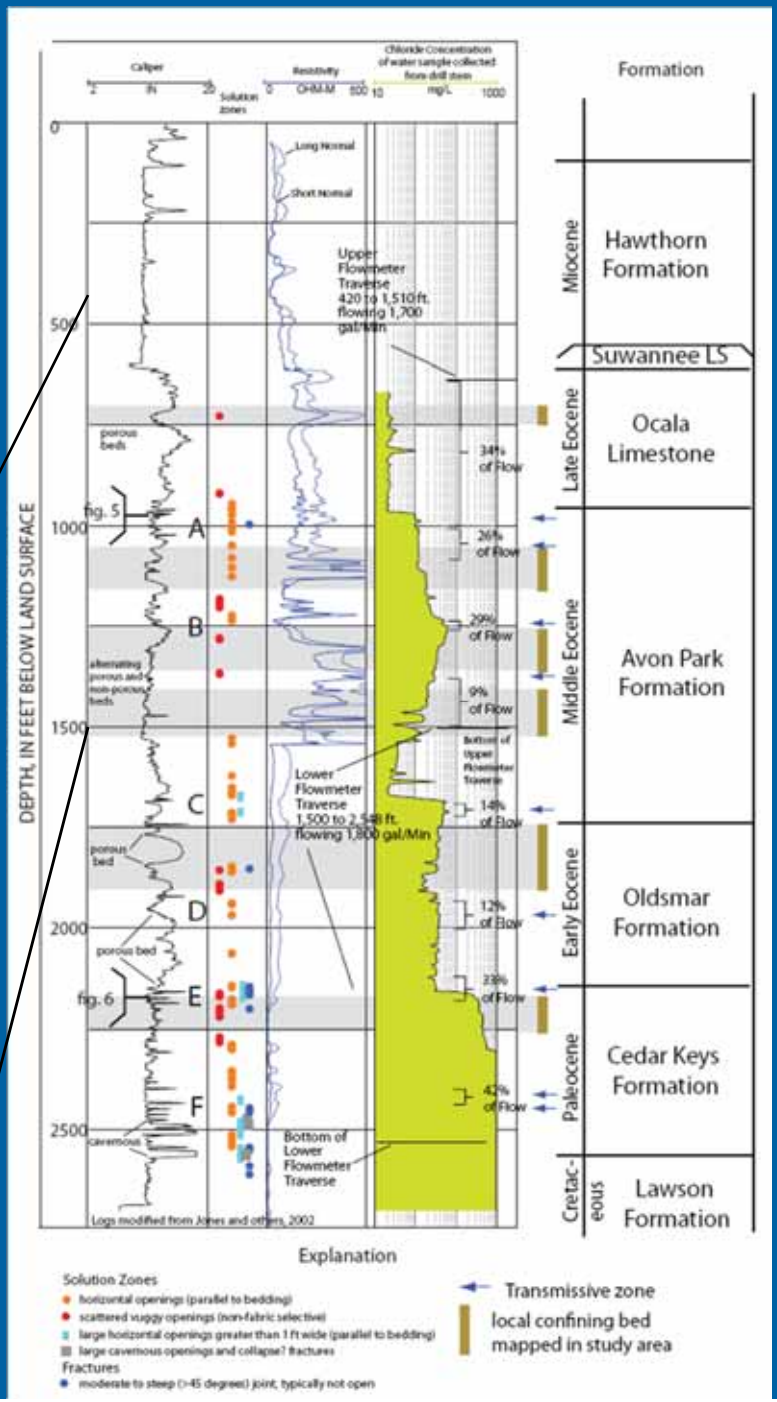


ATV Images: Brunswick

USGS

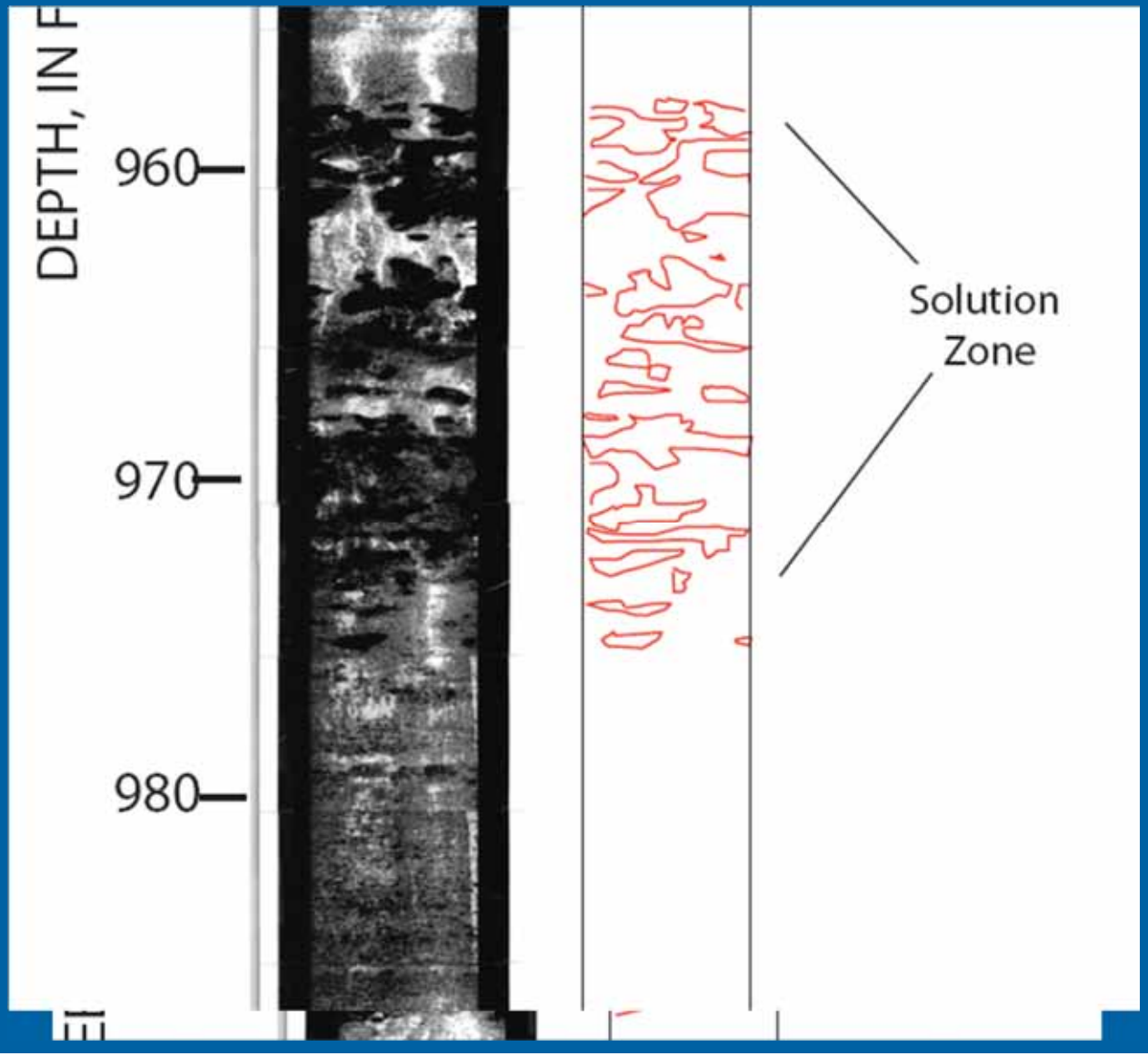
TW-26 Colonels Island, Brunswick GA





USGS

Solution Zones in the Avon Park Formation



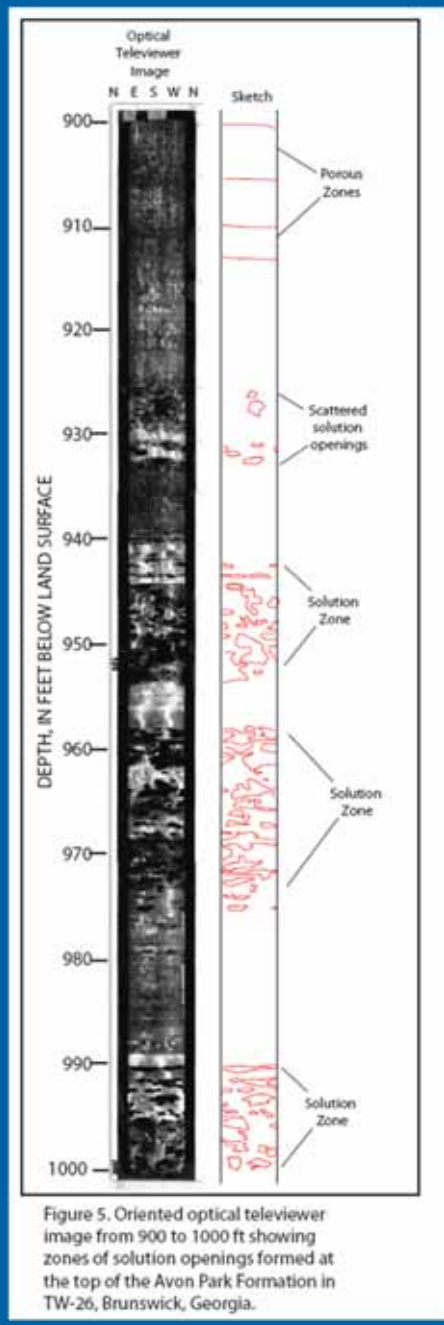


Figure 5. Oriented optical televiewer image from 900 to 1000 ft showing zones of solution openings formed at the top of the Avon Park Formation in TW-26, Brunswick, Georgia.

Characteristics of solution zones in Avon Park Formation

- Appear to be formed preferentially along dolostone or dolomitic limestone intervals
- Each solution zone consists of many individual pipes and openings
- Zones of solution openings range from few feet to several 10's of feet

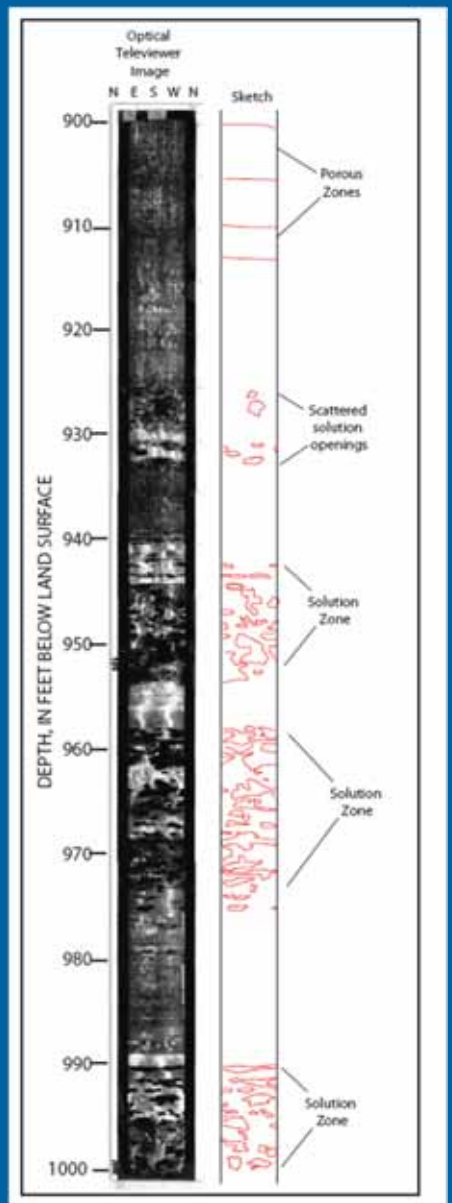
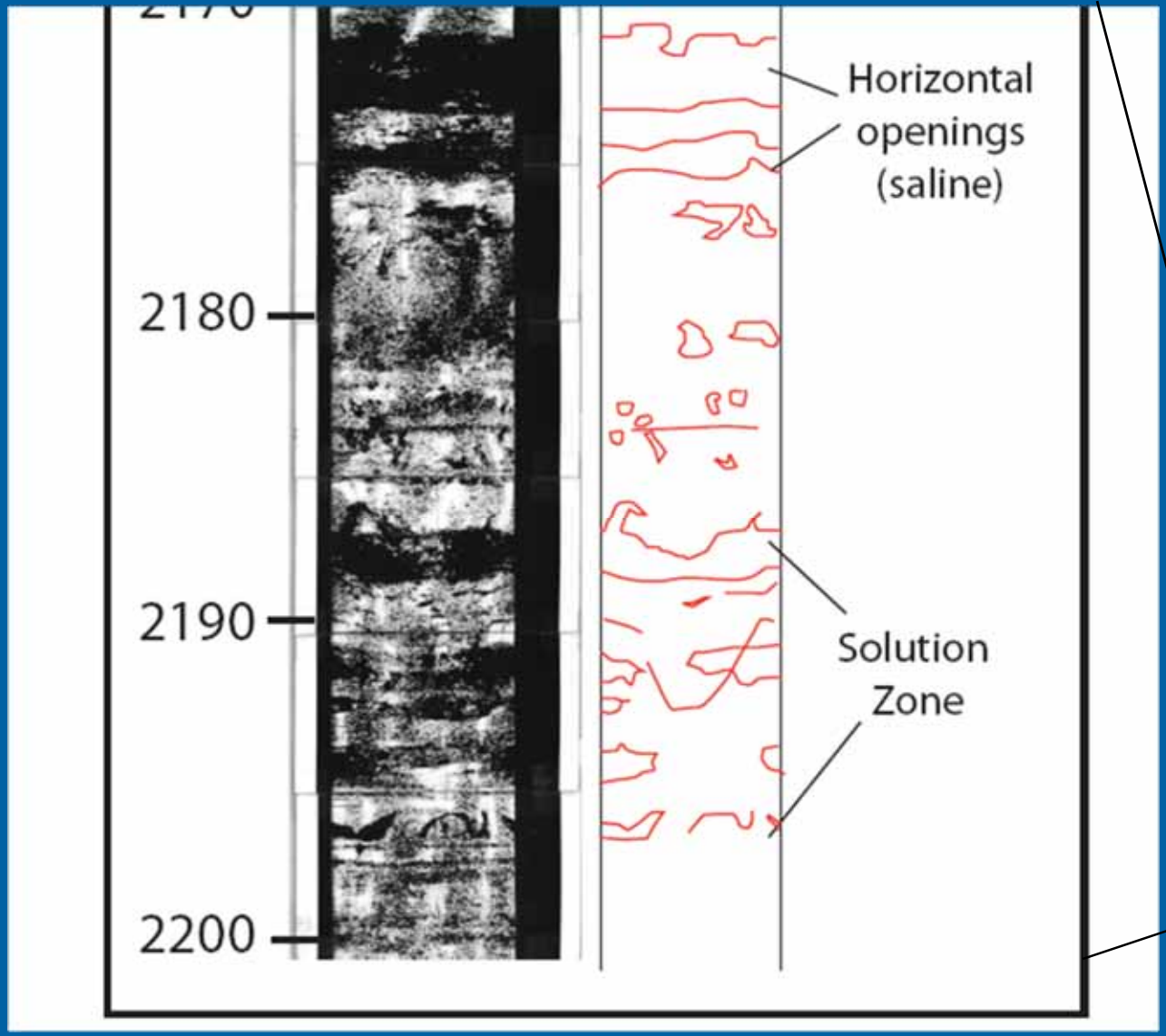


Figure 5. Oriented optical televiewer image from 900 to 1000 ft showing zones of solution openings formed at the top of the Avon Park Formation in TW-26, Brunswick, Georgia.

USGS

Solution Zones in the Oldsmar Formation



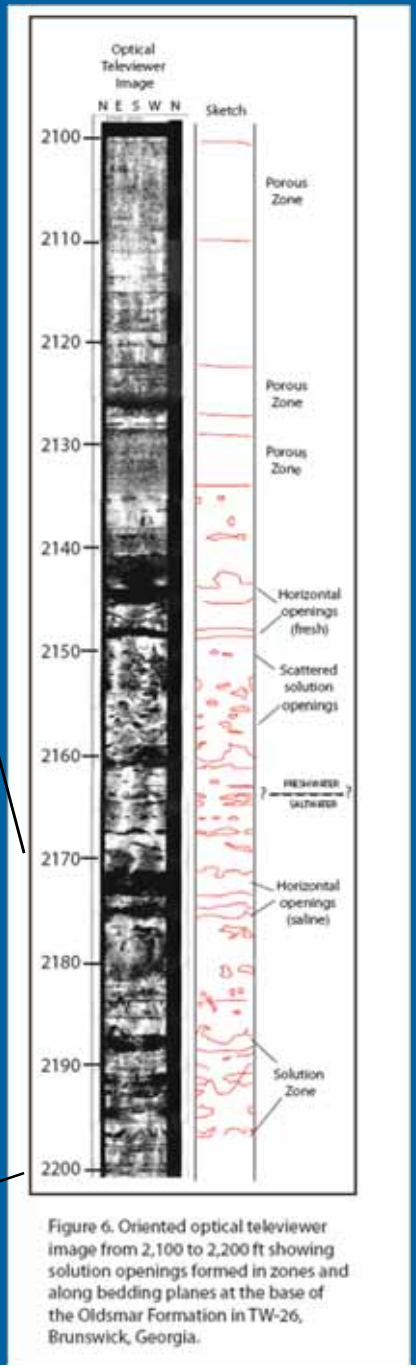
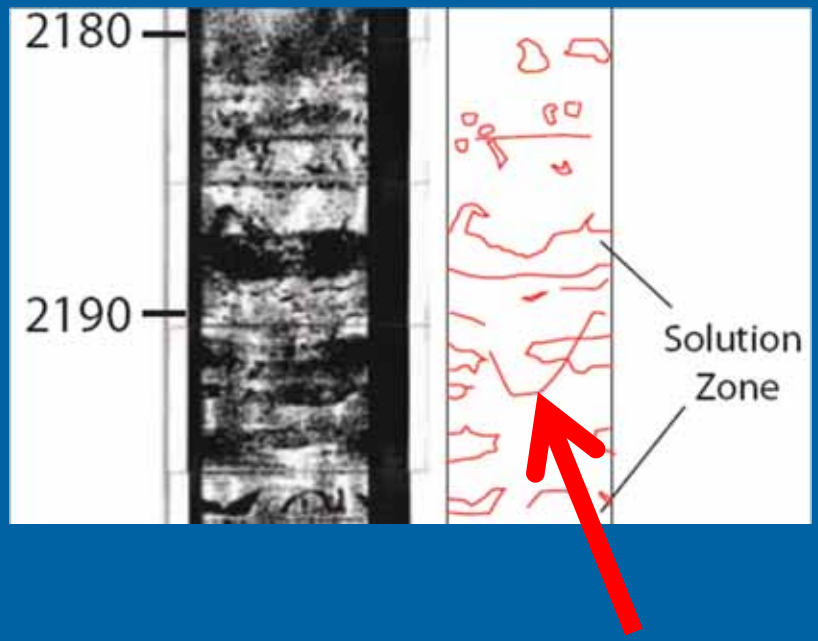


Figure 6. Oriented optical televiewer image from 2,100 to 2,200 ft showing solution openings formed in zones and along bedding planes at the base of the Oldsmar Formation in TW-26, Brunswick, Georgia.

Fractures

- Very few observed in ATV images
- Most are observed in the cavernous zones possibly associated with collapse?
- Relative absence of fracturing in ATV images suggest that vertical fracture systems must be widely spaced or more related to collapse features described by others working in area



Conceptual Model

- As water is pumped from the conduit systems leakage is induced from adjacent confining beds or from intersecting vertical fractures

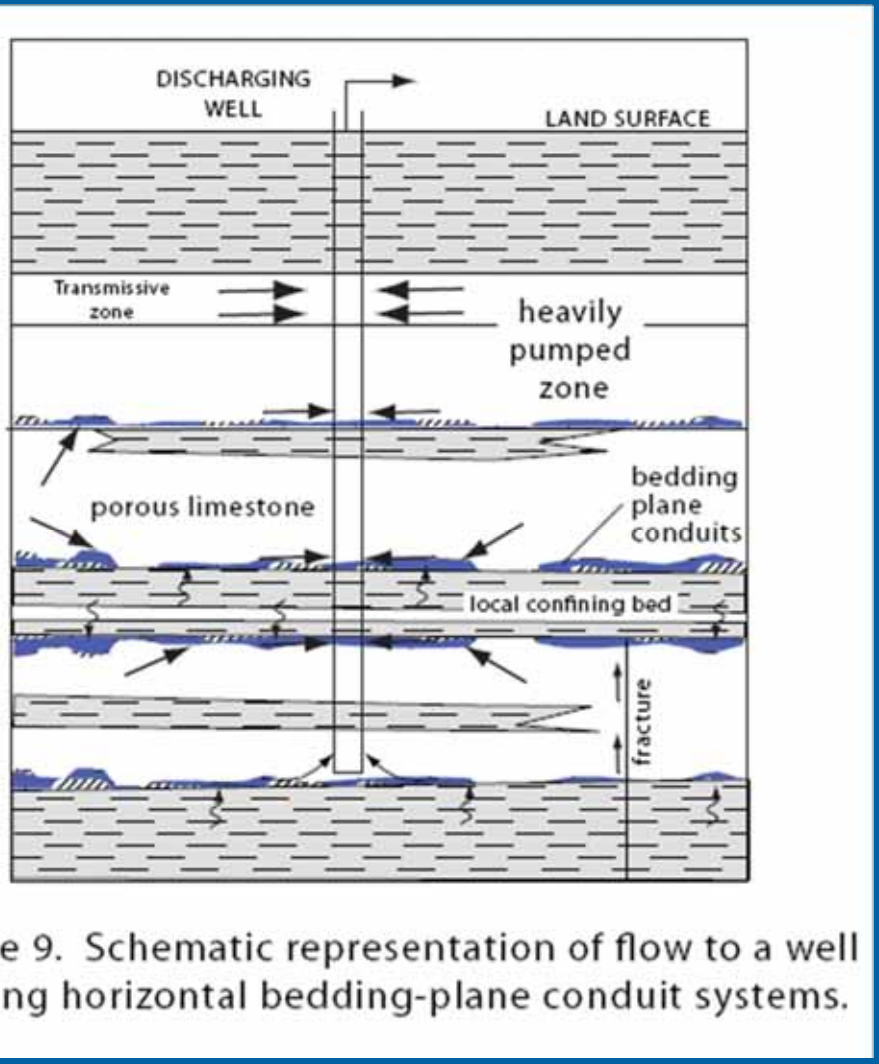


Figure 9. Schematic representation of flow to a well tapping horizontal bedding-plane conduit systems.

USGS

Revised Conceptual Model of Flow

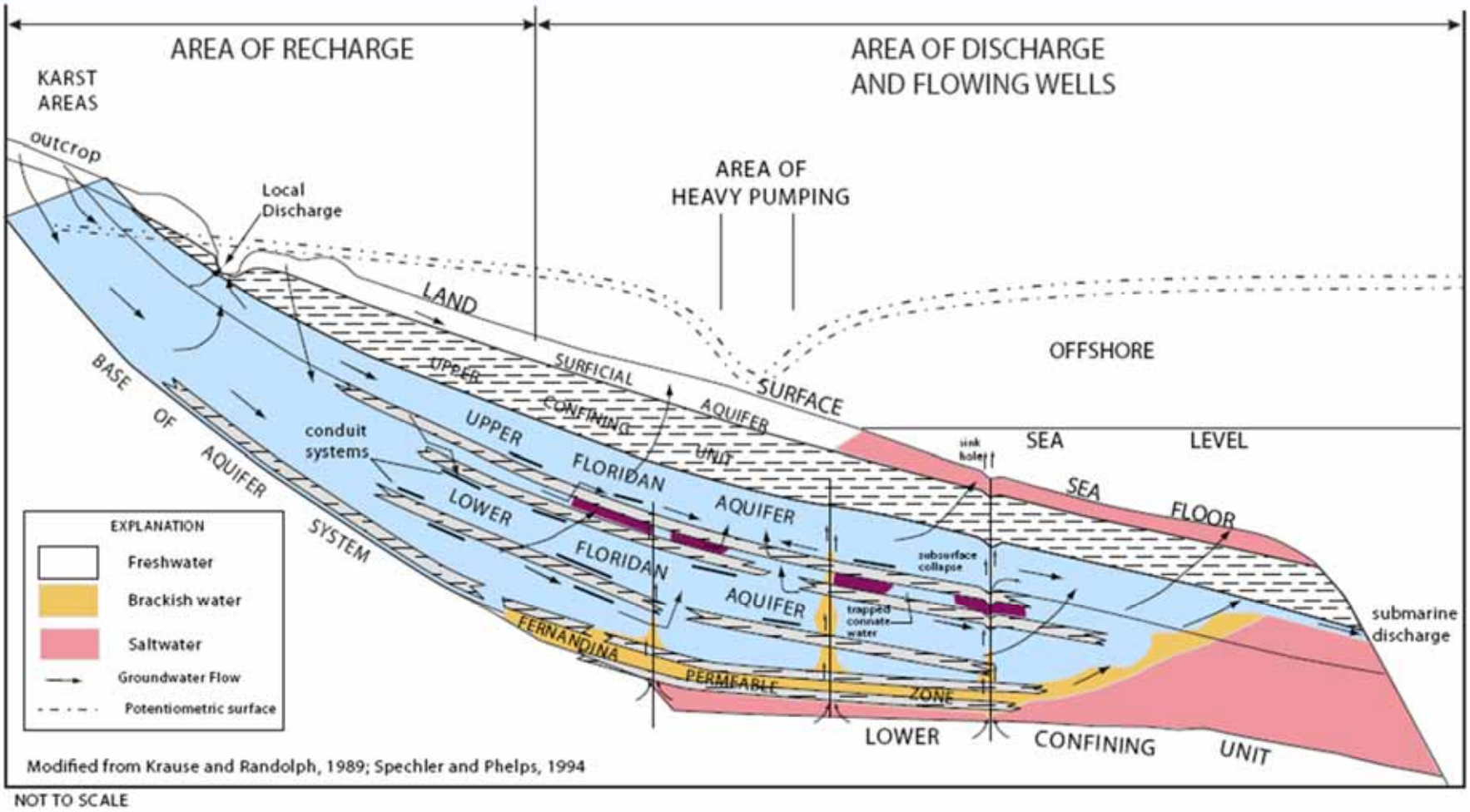
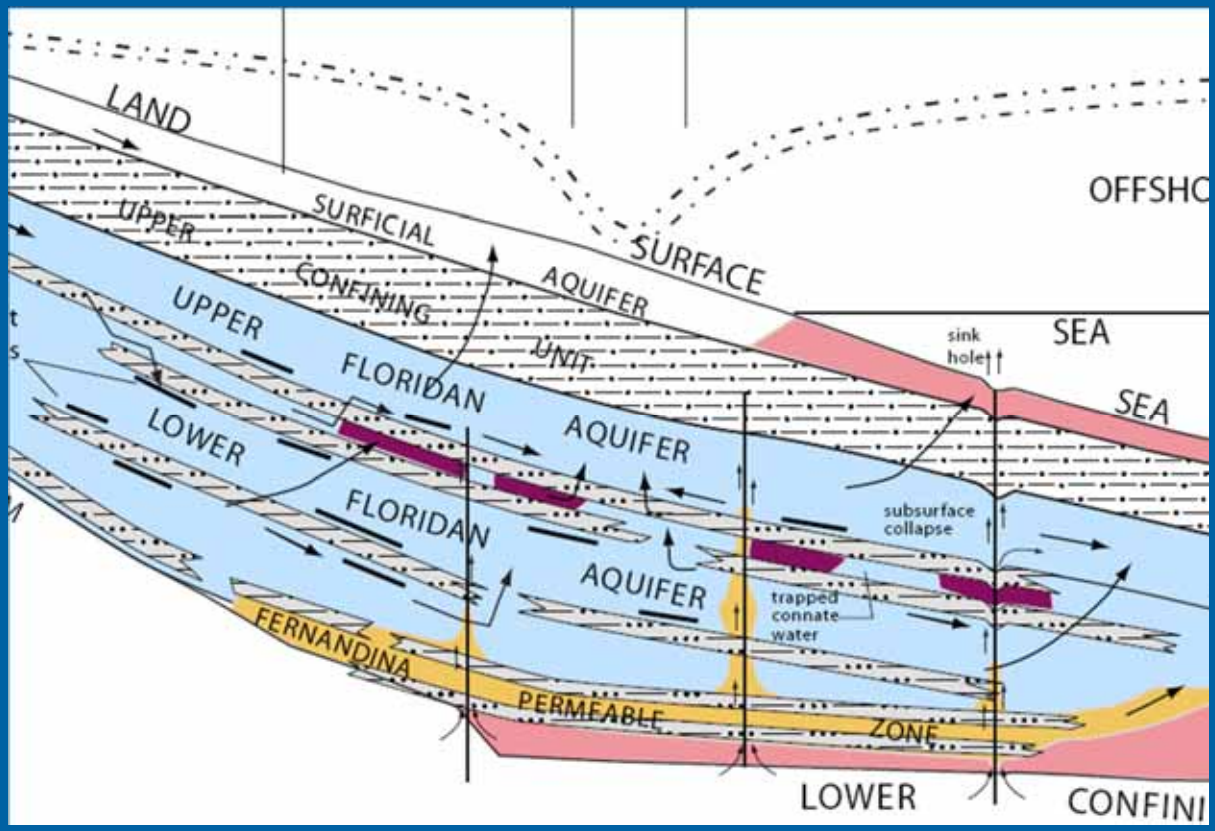


Figure 10. Conceptual model of for the Floridan aquifer system from the outcrop area to the offshore area.

Sources of Salt Water

- Trapped connate water inside confining beds
- Saline aquifers near base of system



USGS

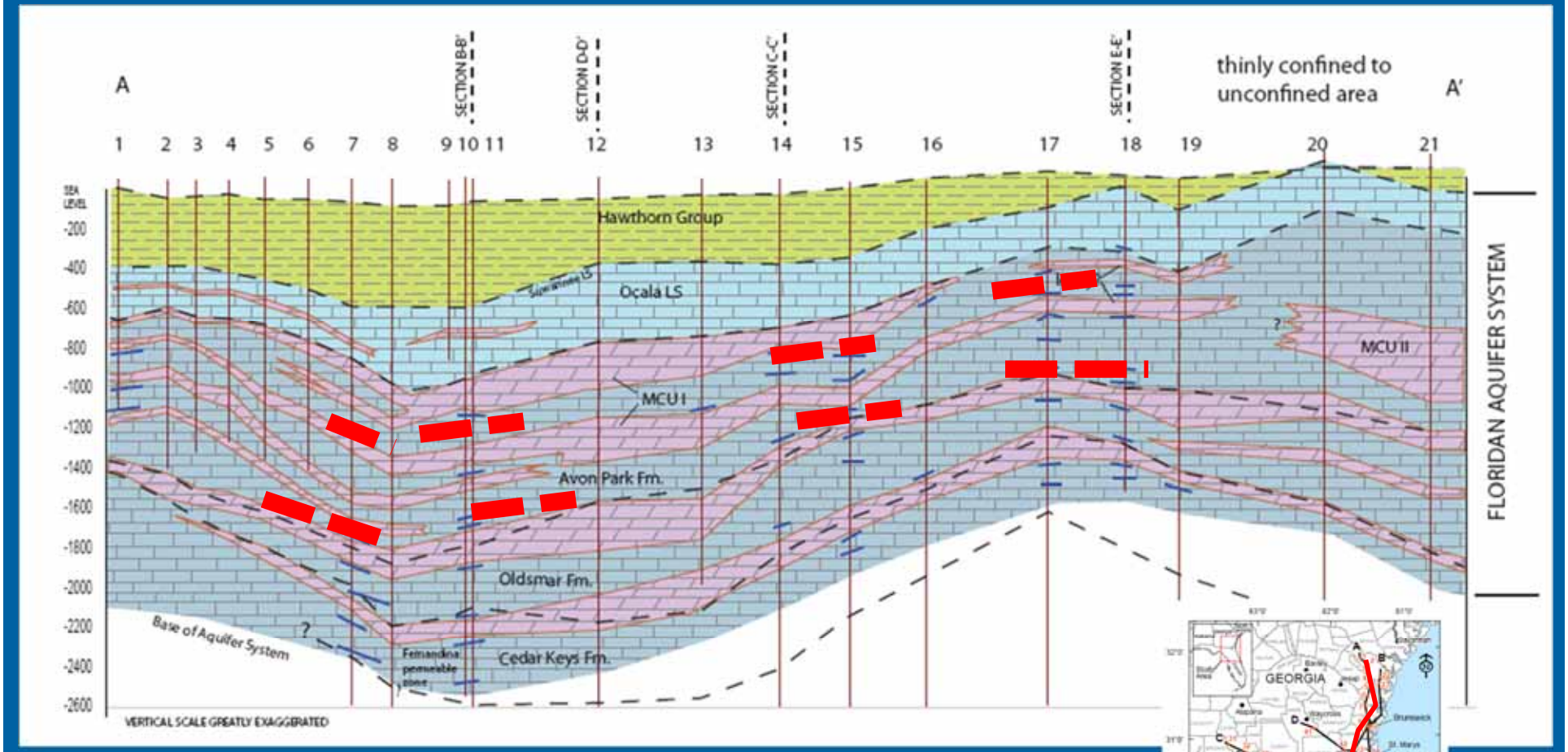
Cross Sections

- Deep water test wells
- Oil test wells
- Some of the older oil test wells were the best for correlating across the full thickness of aquifer

Figure 1. Study area showing location of wells and cross section lines in northeastern Florida and southeastern Georgia.

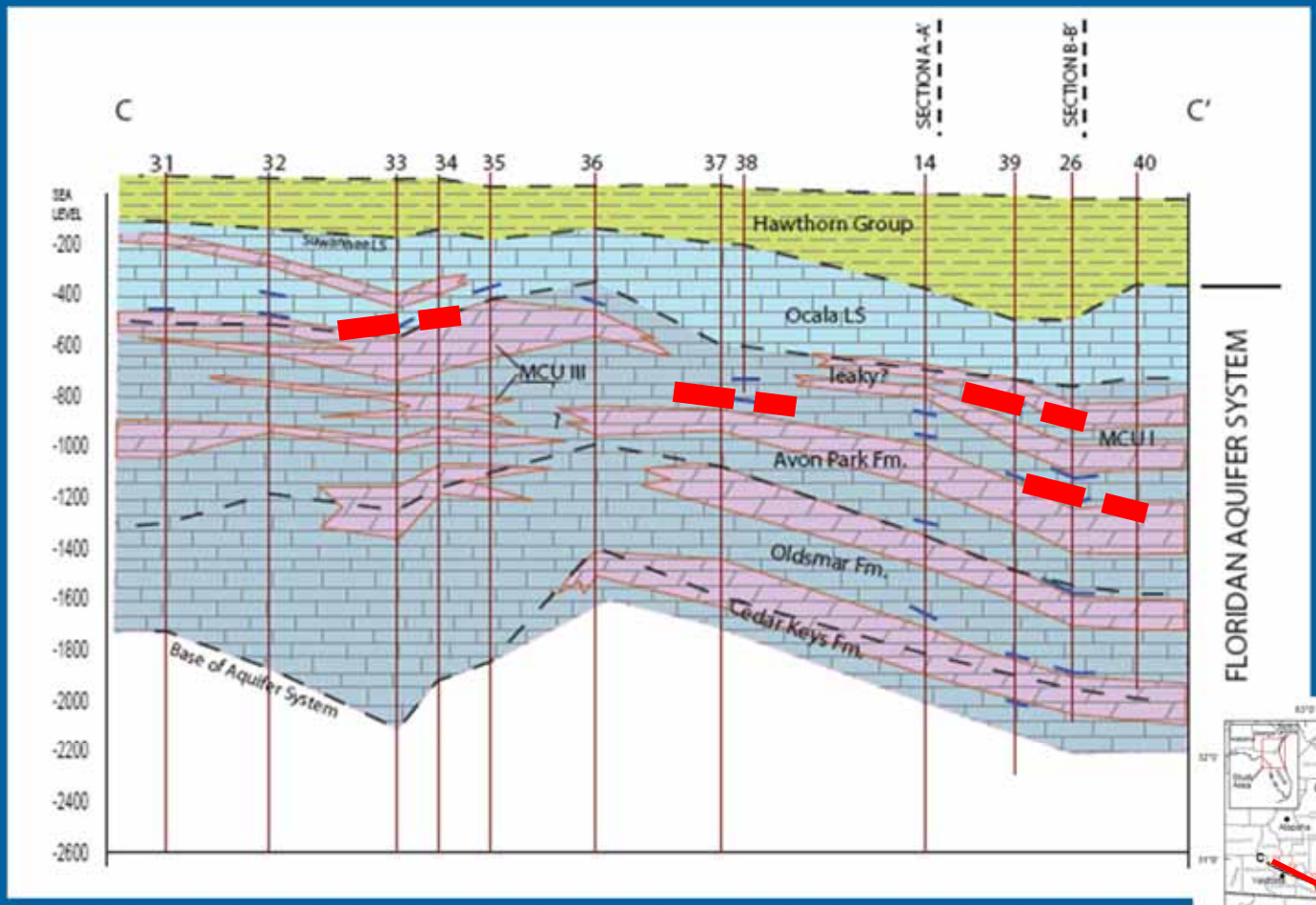
USGS

North-South Section



USGS

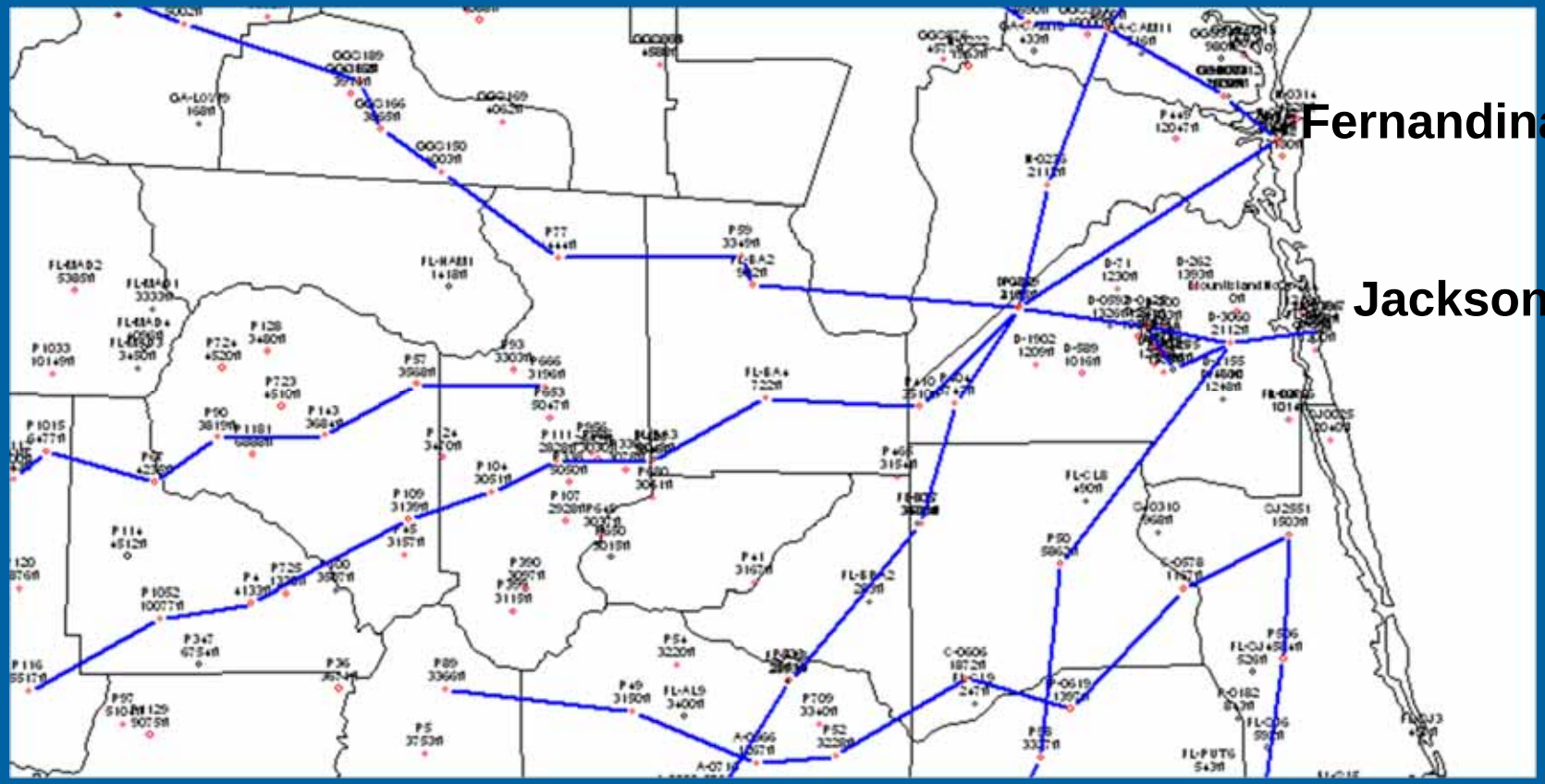
East-West Section



USGS

Hydrogeologic Framework Progress

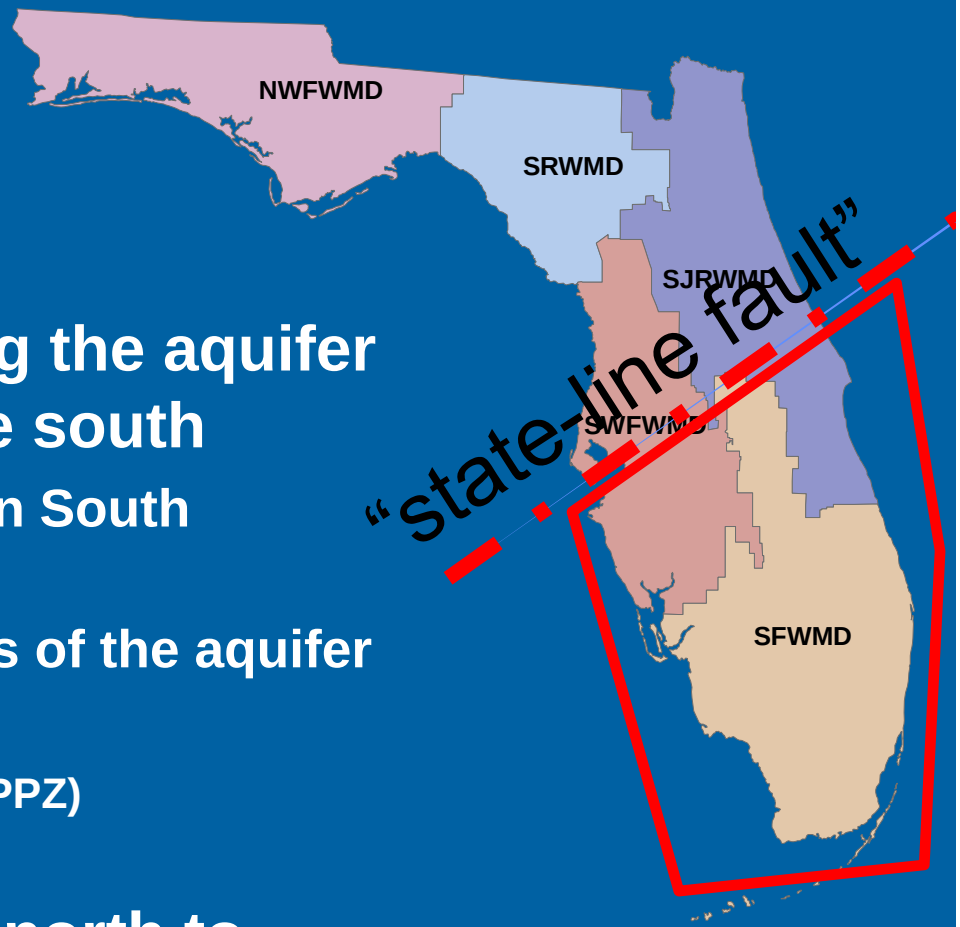
Georgia



USGS

Central and South Florida

Central and South Florida

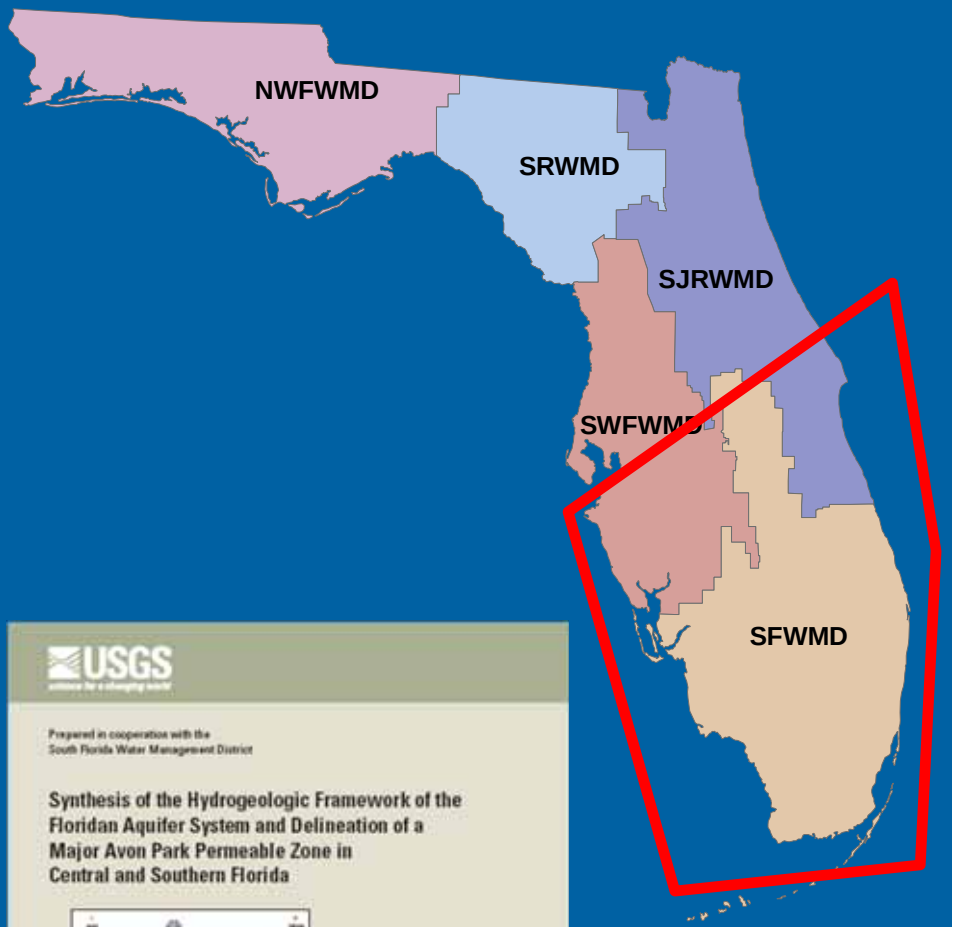


- The formations comprising the aquifer thicken dramatically to the south
  - Thickest part of the FAS is in South Florida Basin
  - Brackish and saline portions of the aquifer
  - Highly permeable zones
    - Avon Park Permeable Zone (APPZ)
    - Boulder Zone (BZ)
- Hydrogeologic units from north to south have some differences in how represented in literature

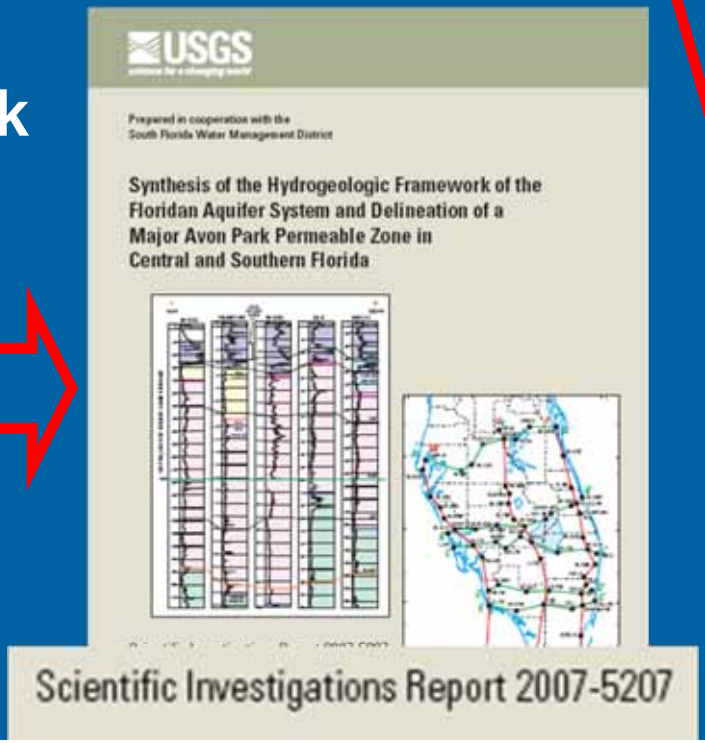
USGS

South Florida

- Ron Reese and Emily Richardson's framework of the APPZ being incorporated
- We have a preliminary meeting to discuss south Florida framework this week.



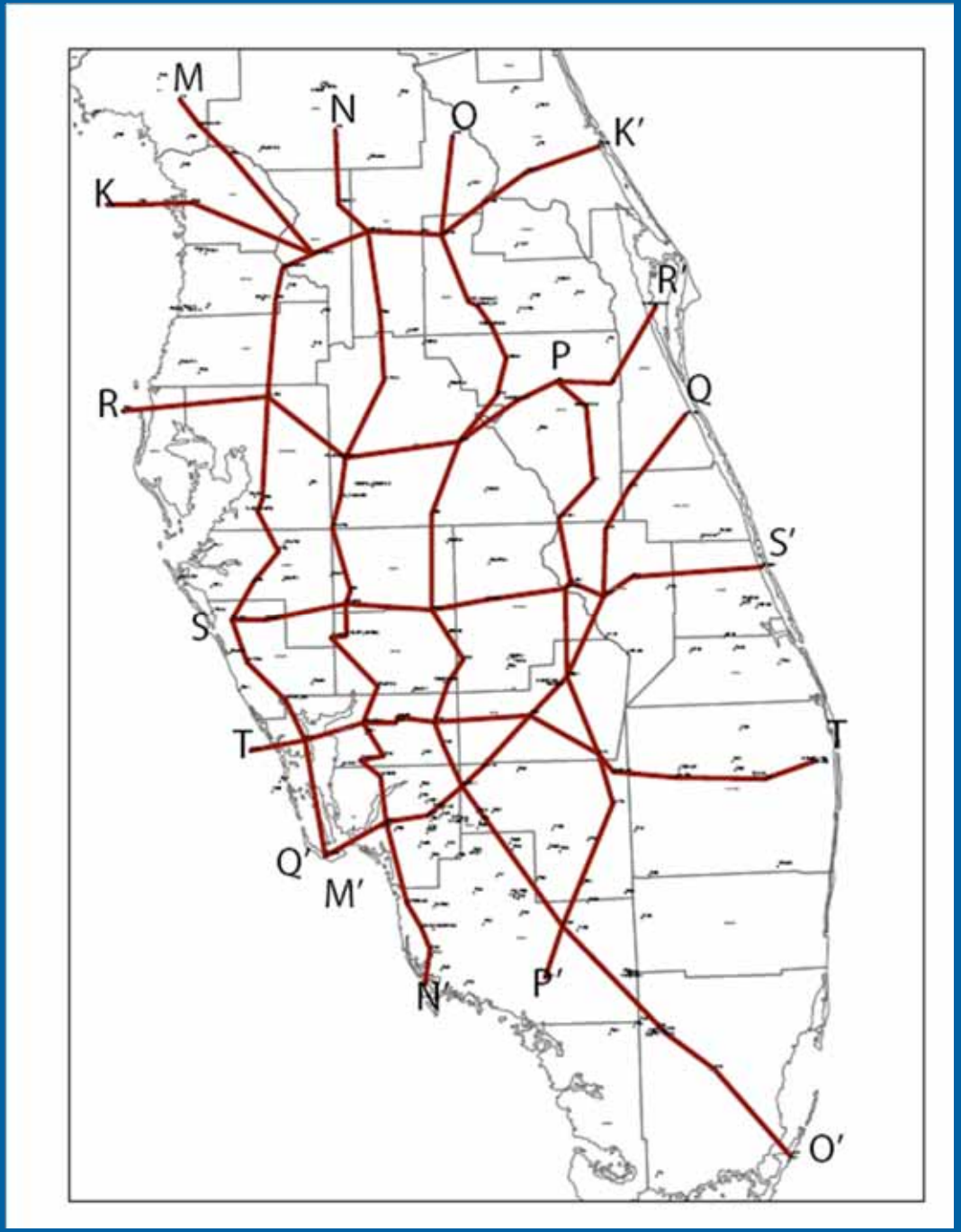
Sub-Regional Framework



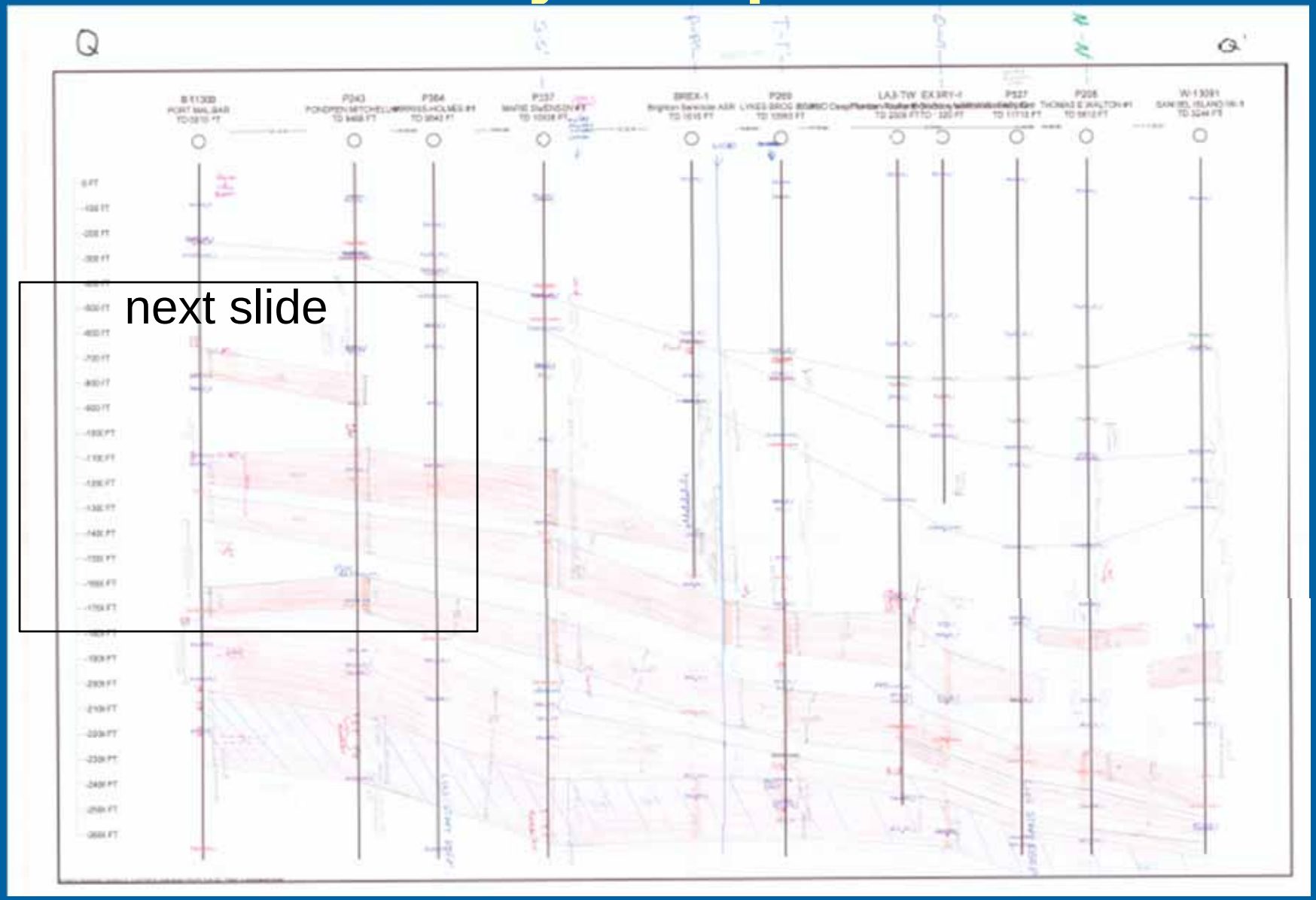
USGS

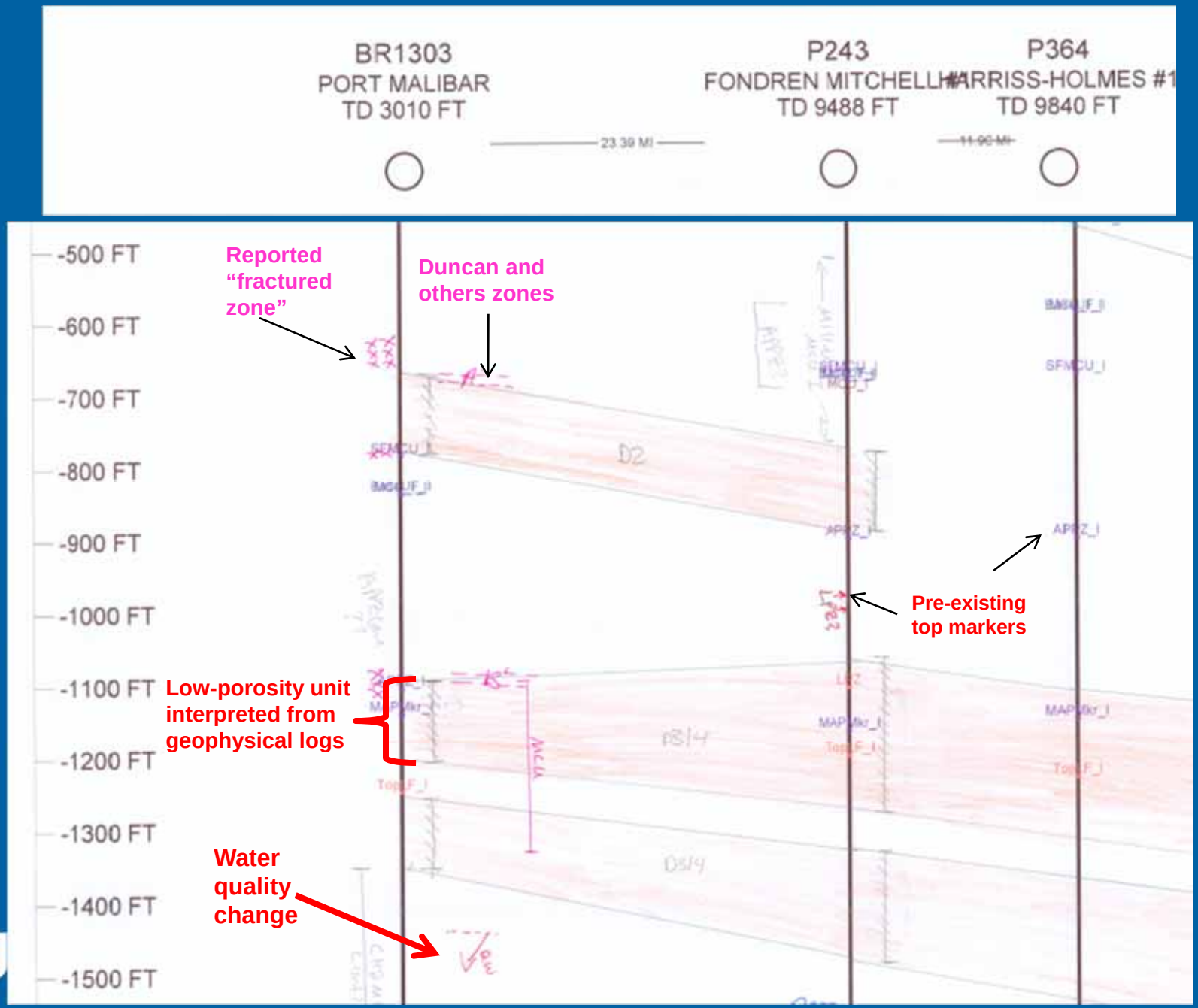
Approach

- Deep injection wells and exploratory well reports
- Geophysical logs
  - Aquifers
  - Confining units
  - Transmissive zones
- Aquifer Tests
- Head Gradients
- Cross Sections!!!



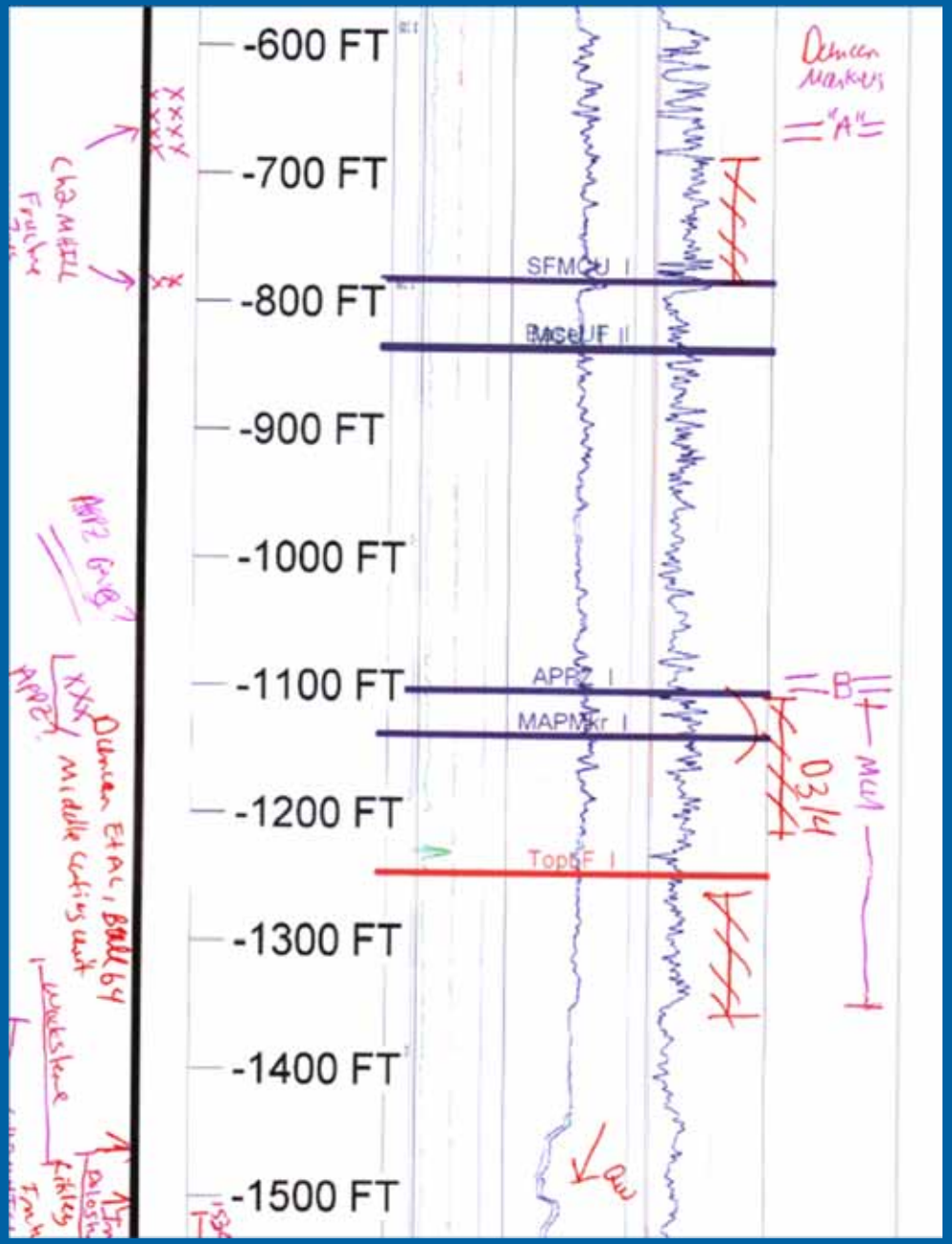
Basis for all my interpretations



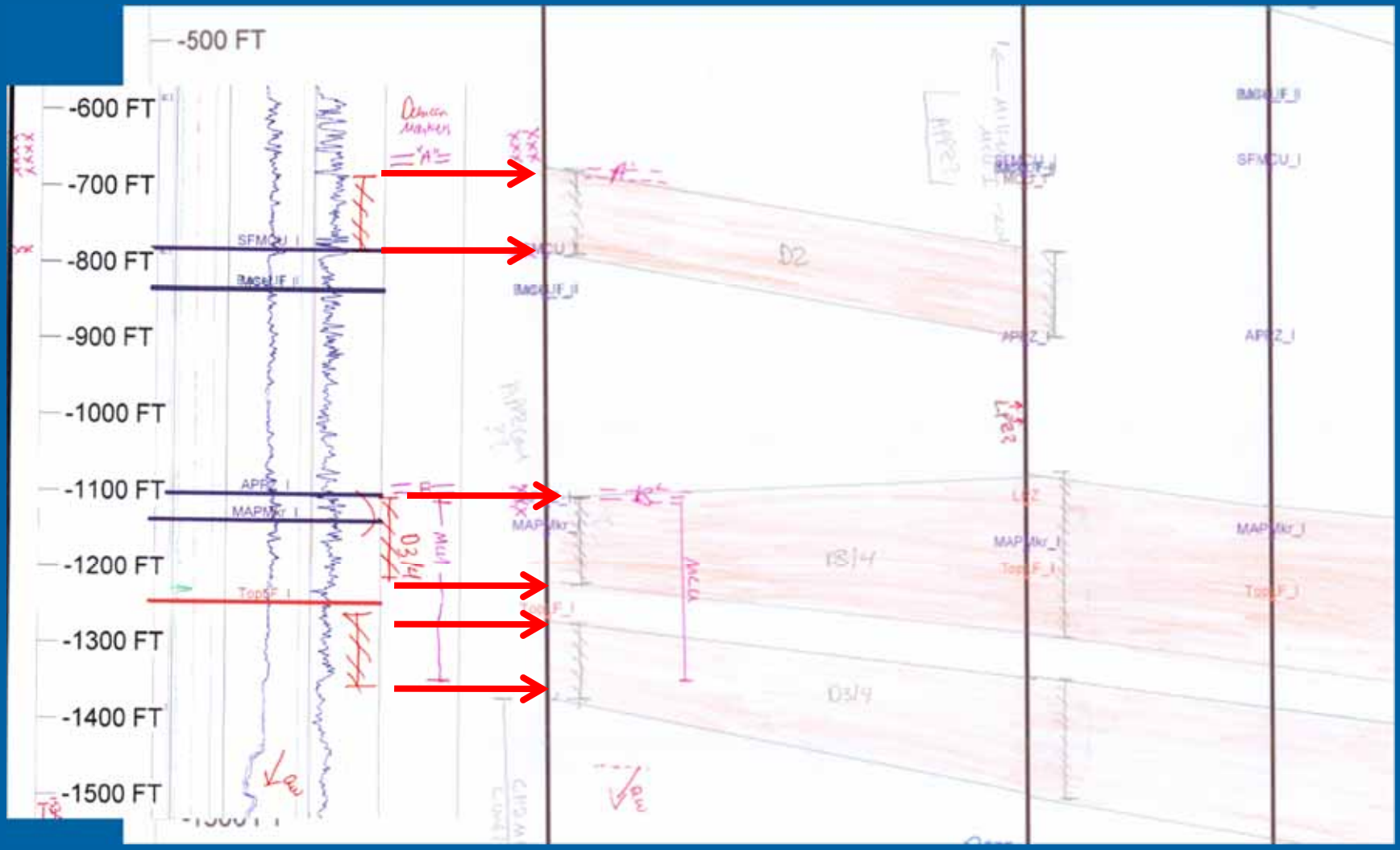

BR1303
PORT MALIBAR
TD 3010 FT
23.39 MI
P243
FONDREN MITCHELL
TD 9488 FT
P364
HARRISS-HOLMES #1
TD 9840 FT
11.90 MI
-500 FT
-600 FT
-700 FT
-800 FT
-900 FT
-1000 FT
-1100 FT
-1200 FT
-1300 FT
-1400 FT
-1500 FT
Reported "fractured zone"
Duncan and others zones
Pre-existing top markers
Low-porosity unit interpreted from geophysical logs
Water quality change

Marked up log

- Interpreted position of the confining units marked on logs
- Other notations included
- Then transferred to hand-drawn cross sections



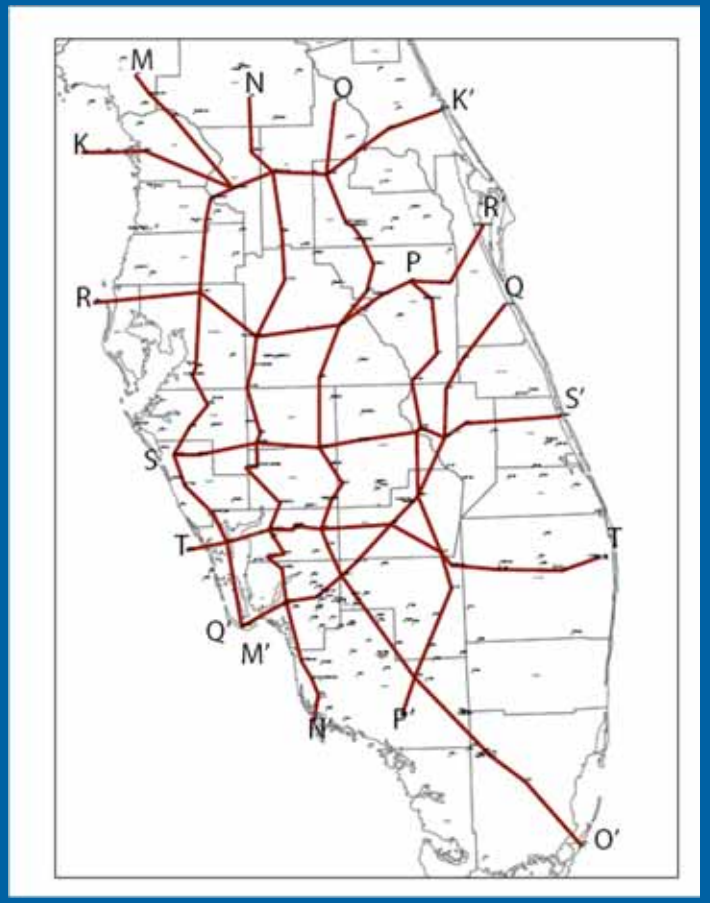
USGS


-500 FT
-600 FT
-700 FT
-800 FT
-900 FT
-1000 FT
-1100 FT
-1200 FT
-1300 FT
-1400 FT
-1500 FT
SFMCU_I
BASE_IF_I
APPZ_I
MAPMkr_I
TopSF_I
D2
D3/4
LPZ2
MAPMkr_I
TopSF_I
SFMCU_I
APPZ_I

USGS

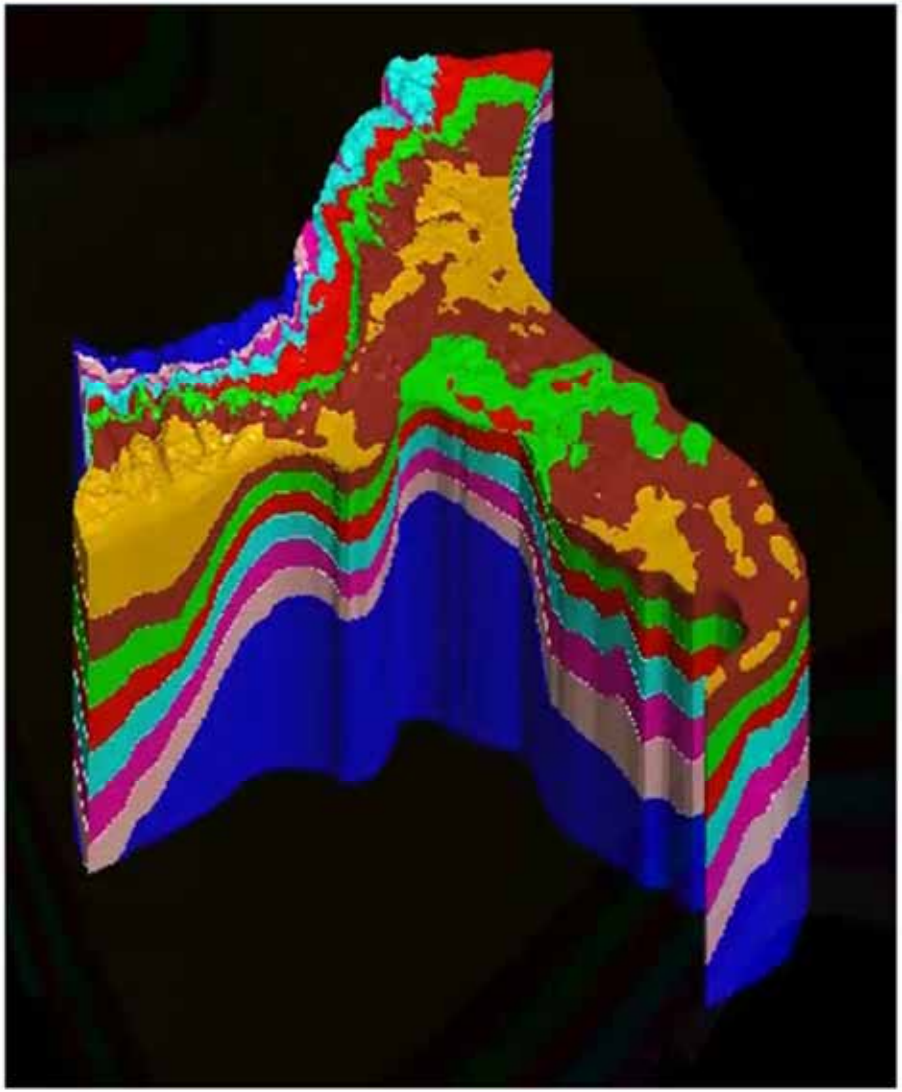
Why Cross Sections?

- Main reason is to enable us to build a 3D framework
- Continuity of confining beds and permeability variations can be better understood
- Very thick system with many different permeable zones and confining beds



USGS

3D Geologic Model



Preliminary Geologic Model of major stratigraphic units in the Floridan Aquifer System based on USGS PP1403B (Miller, 1986)

The model was built by Rick Lane (Aranz Geo Ltd.) and Lester Williams (USGS) using Leapfrog Hydro V.1.3.1. Numerical modeling in the software was used to constrain layering to boreholes and some surface outcrops. Internal extents of some layers that are known to be absent (Oligocene) have not yet been constrained within the model. Also, bathemetry has not been incorporated. Imagery shown is from Google Earth.

Color Key
Surficial - Yellow
Miocene - Brown
Oligocene - Green
Late Eocene - Red
Middle Eocene - Aqua
Early Eocene - Dark Pink
Paleocene - Light Pink
Cretaceous - Blue

Click here to view video

Database Development

- Geared toward long-term hydrologic records
  - Groundwater levels
  - Streamflow
  - Springflow and pool levels
- Hydrologic Properties
  - T, S, etc…
- Hydrogeologic Data (tops)

Types of data

- Water levels
- continuous
- periodic
- Chlorides
- Aquifer performance tests
- Precipitation
- Temperature
- Geophysical
- Other
- surface water
- springs
- water use

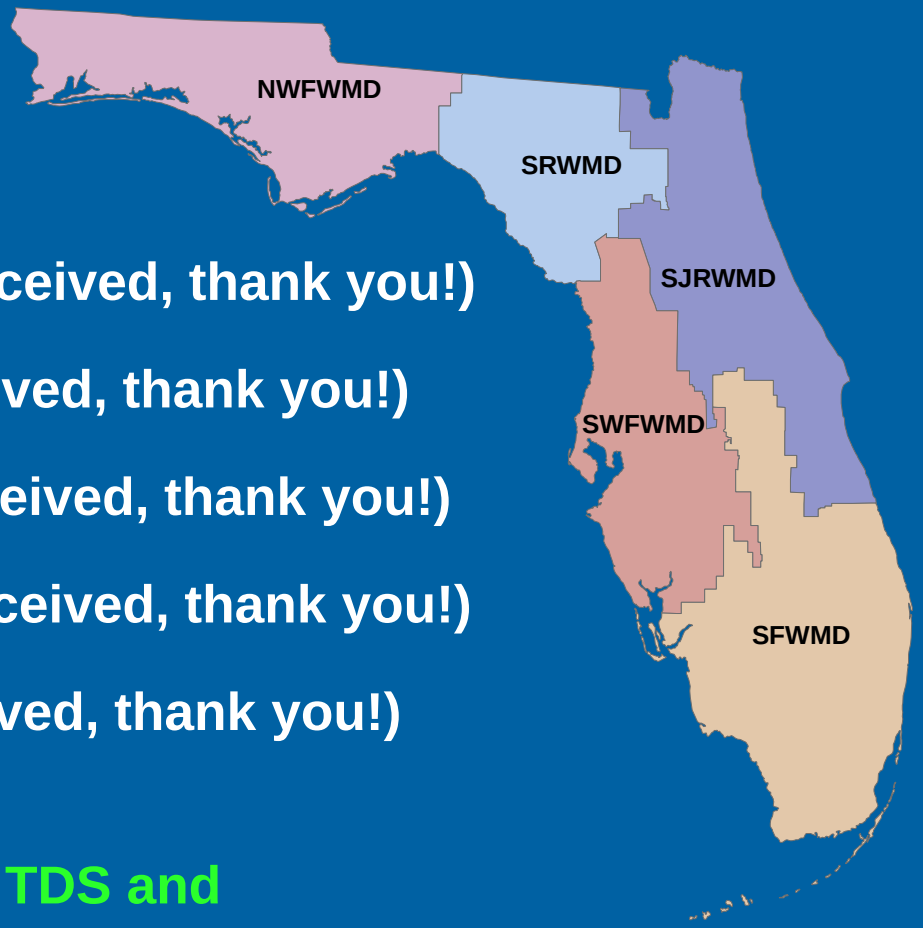
Sources of data

- US Geological Survey
- Florida Geological Survey
- Georgia Geological Survey
- Geological Survey of Alabama
- Florida's Water Management Districts
- Consultants data reports
- Florida Oil & Gas Board
- FDEP
- South Carolina DHEC
- …

Data Requests

Spring Flow Records

Groundwater Levels



- **NWFWMD** (received, thank you!)
- **SRWMD** (received, thank you!)
- **SJRWMD** (received, thank you!)
- **SWFWMD** (received, thank you!)
- **SFWMD** (received, thank you!)

Geophysical Logs

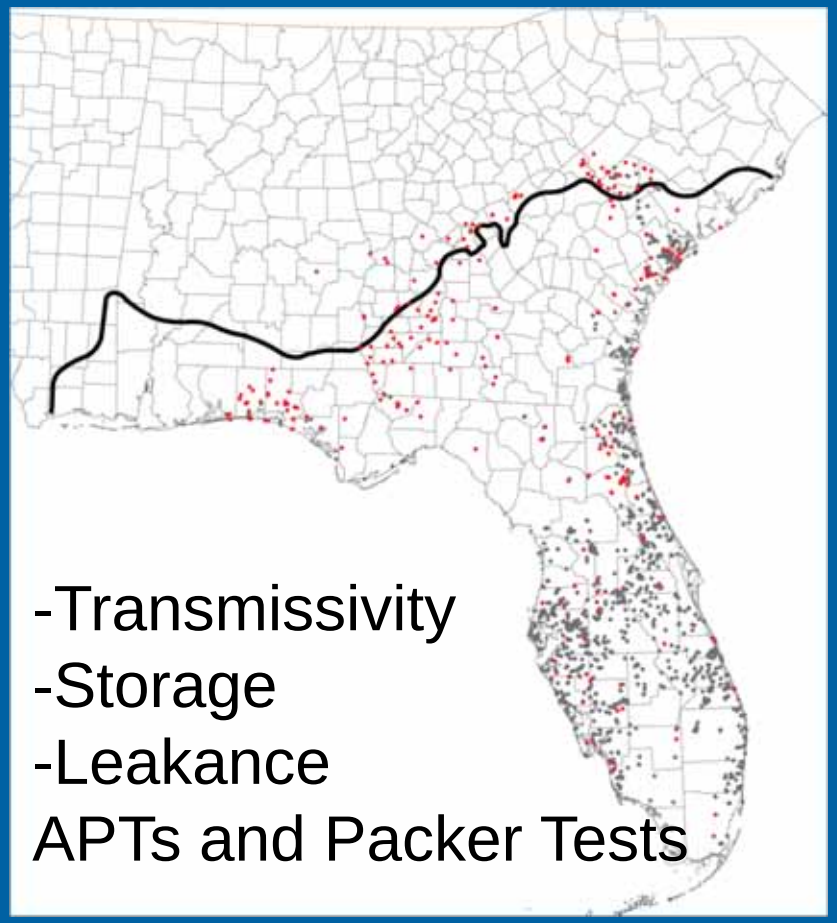
TDS and Chloride Data

Lithology

USGS

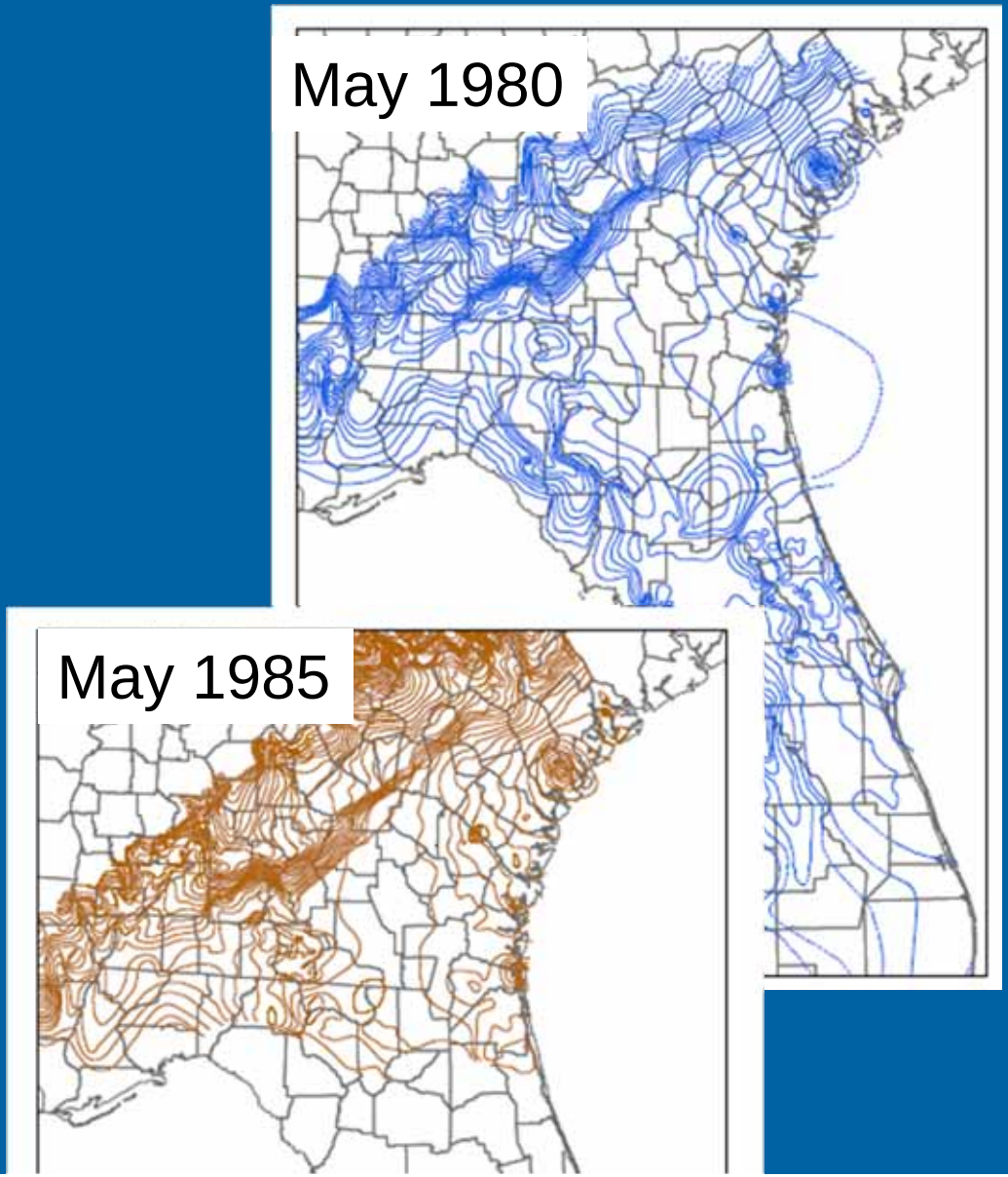
Hydraulic Properties Database

- Databases from
  - Robert Peterson (SWFWMD)
  - Emily Richardson (SFWMD
  - Chris Richards (NWFWMD)
  - Dale Jenkins (SRWMD)
  - David Toth (SJRWMD)
- Cross-referenced all databases
- Added USGS data
- Removed duplicates
- Checked references
- 2,741 test values across study area



Potentiometric Map Database

- Model Input
- Compare regional changes over time
- Comparison to pre-development surfaces
- Groundwater divides

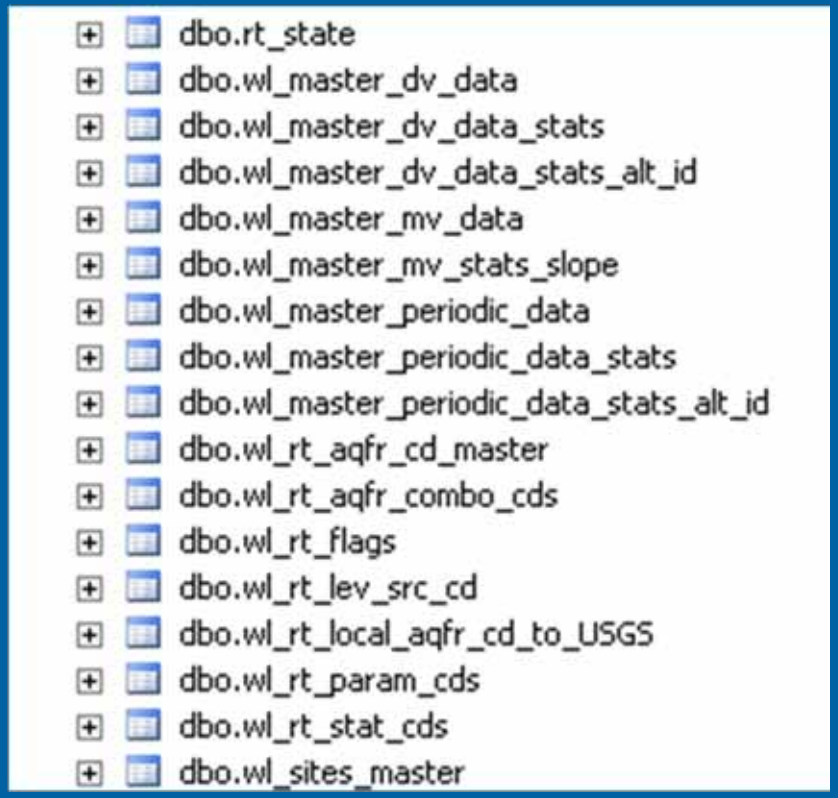


USGS

Groundwater Levels

- Water-level database developed
- Model Input
- 33,500 wells across study area
- 12,387,226 daily values (October 1930 through Early 2010)

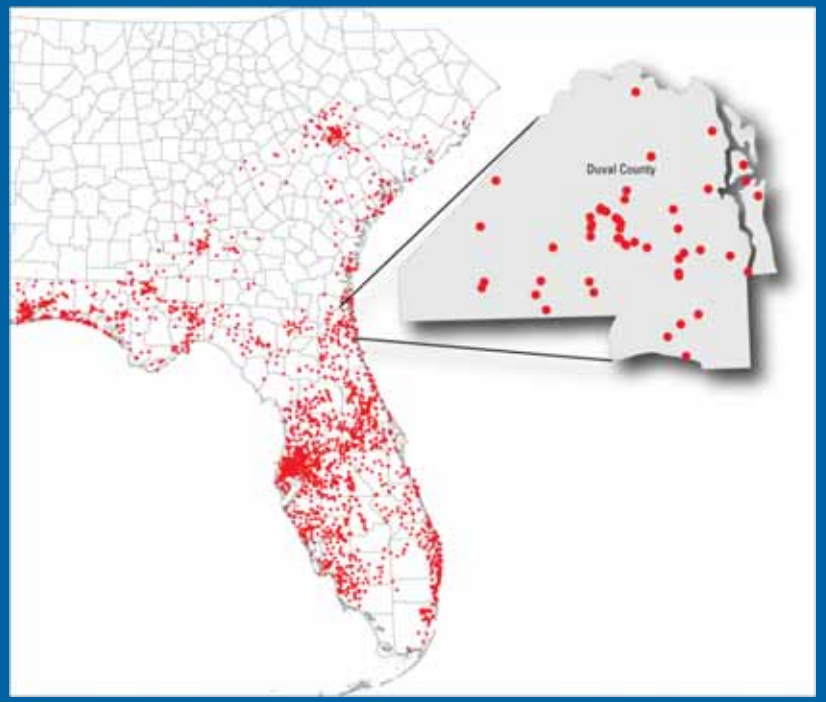
Water-Level Tables for Floridan Project Database



Groundwater-level Analysis

- Long-term trends
- Aquifer system response to hydraulic events
- Vertical gradients
  - Evaluating relative degree of confinement across MCUs
- Observation points for model

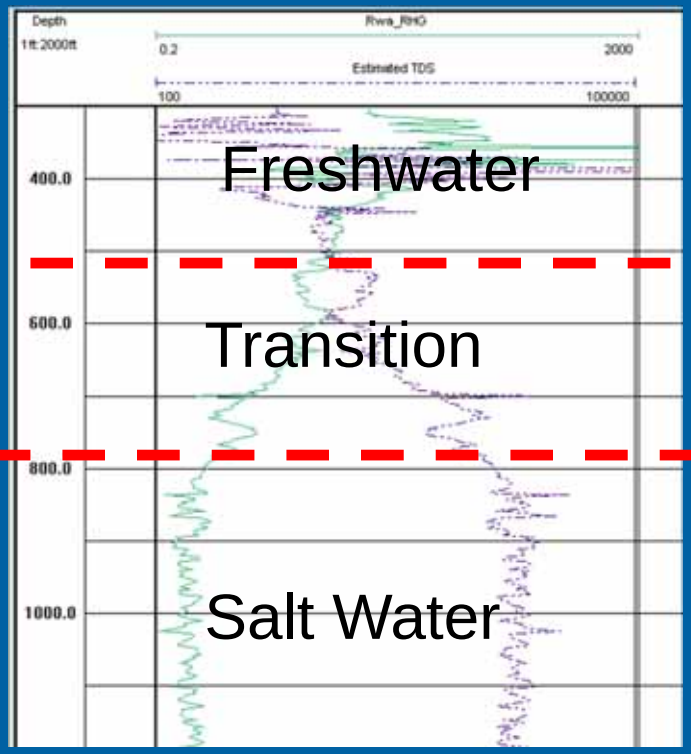
Well Cluster Sites



USGS

Saline Water Aquifer Mapping Project

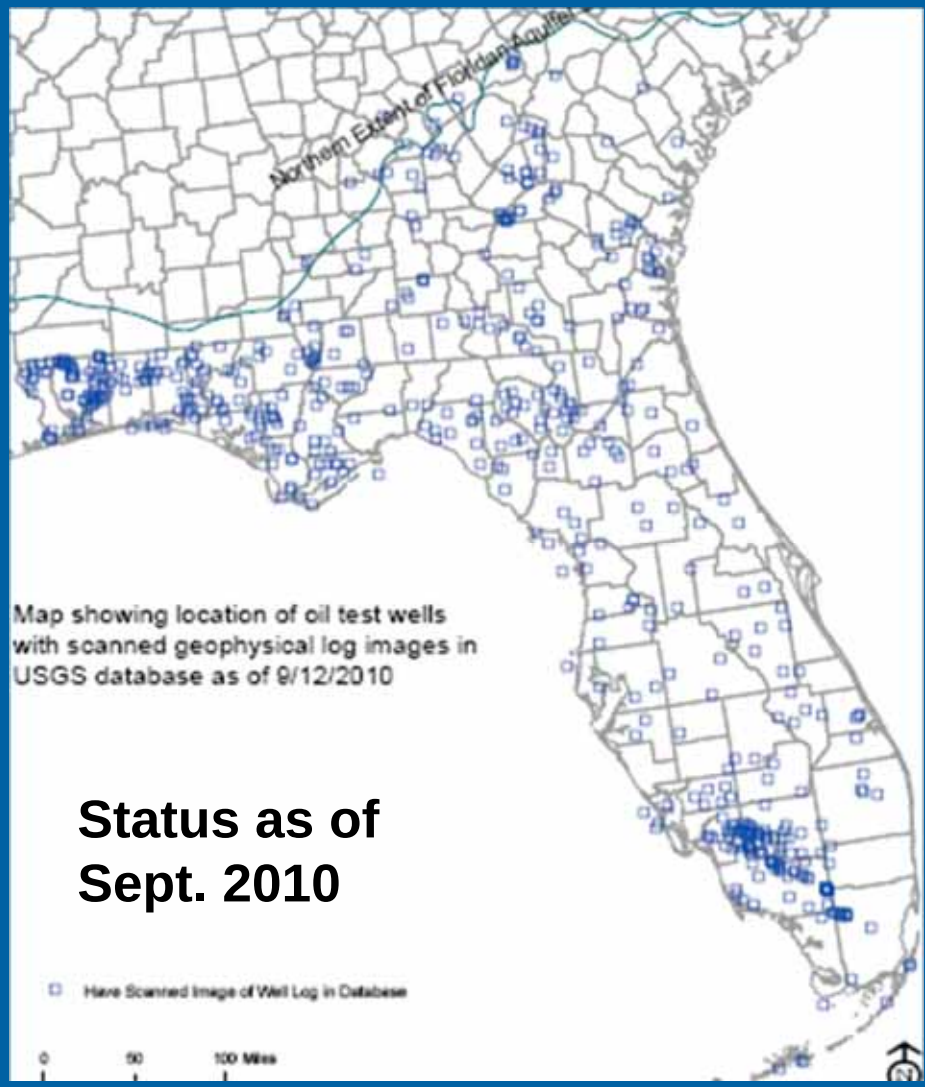
- This is a separate study funded through Office of Groundwater (OGW)
- Began Oct. 2009
- Conducting well-log analysis to determine salinity variations in deep part of Floridan and underlying saline aquifers
- Work is being conducted parallel to the Floridan Aquifer System modeling effort



USGS

Geophysical Log Database Development

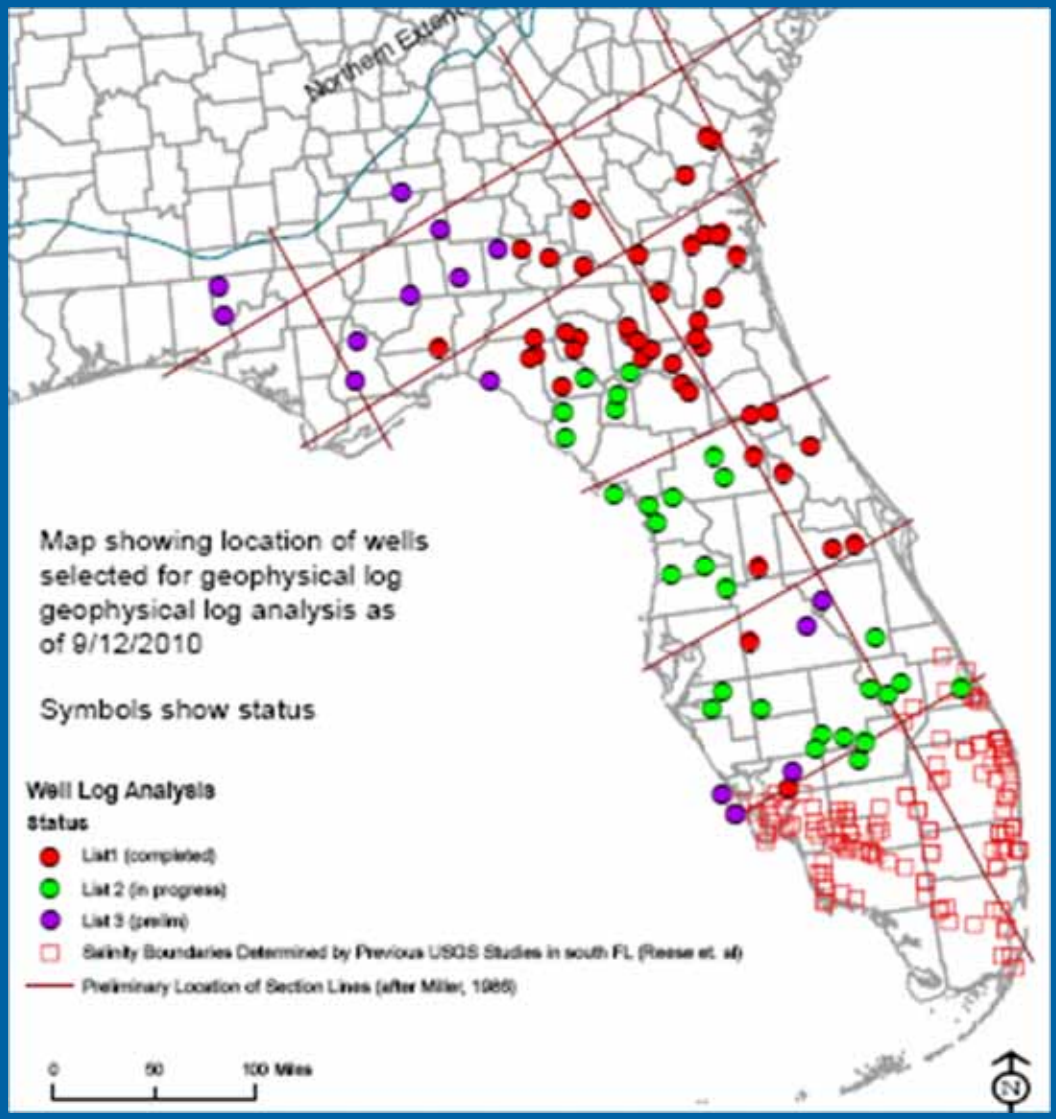
- Compiled well log data from:
  - 479 wells in FL
  - 13 wells offshore
  - 111 wells in GA
- Acknowledgments
  - Dave Taylor (FL Oil and Gas, FDEP)
  - Steve Walker (GA EPD)



USGS

Log Analysis: more model input!

- Red circles: we have completed an initial analysis
- Green circles: these are in progress
- Purple: next
- Red squares: Ron Reese completed sites



USGS

Springs and Surface-Water Inventory

- Using ArcMap and Microsoft Office Access Database

By: Leel Knowles, Jr.
Joanne Dixon

USGS

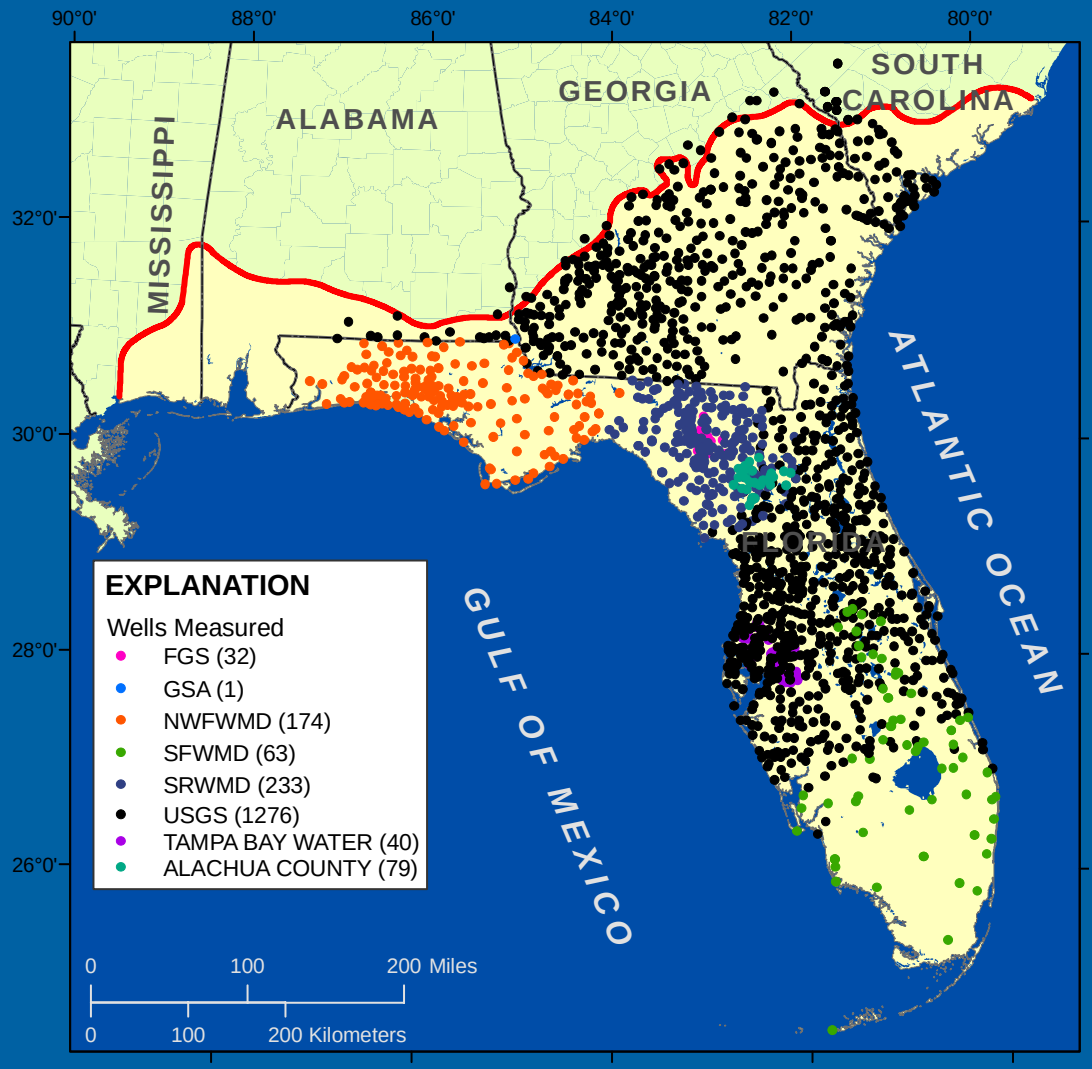
Aquifer-Wide Potentiometric Map

- Important input to model and the hydrogeologic framework
- Funded as a separate sub-project through USGS Groundwater Resources Program (GWRP)
- Headed up by Sandy Kinnaman, USGS Orlando
- Approximately 1,900 water-level measurements from May 11 – June 8, 2010

USGS

Well Locations Used for Potentiometric Mapping Effort

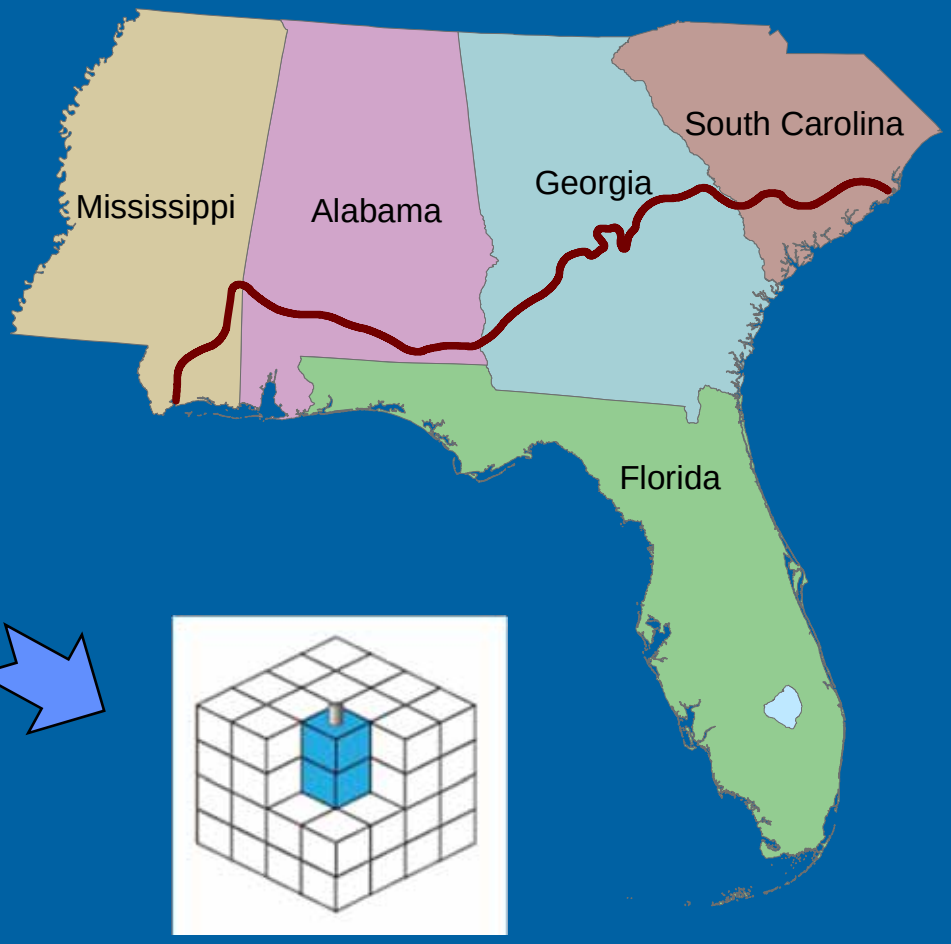
- 1,900 water-level measurements made by 8+ different state and local agencies
- Has not been done since 1985!!!



USGS

Water Use Data Compilation: Domestic, Municipal, Agricultural

- Improved water-use data for model input
- Mid 1970s to 2010
- Monthly values
- Requires disaggregation
- Linkage to well data



USGS

Water Use

Data Requests for Florida

- **NWFWMD** (received, thank you!)
- **SRWMD** (received, thank you!)
- **SJRWMD** (received, thank you!)
- **SWFWMD** (received, thank you!)
- **SFWMD** (received, thank you!)

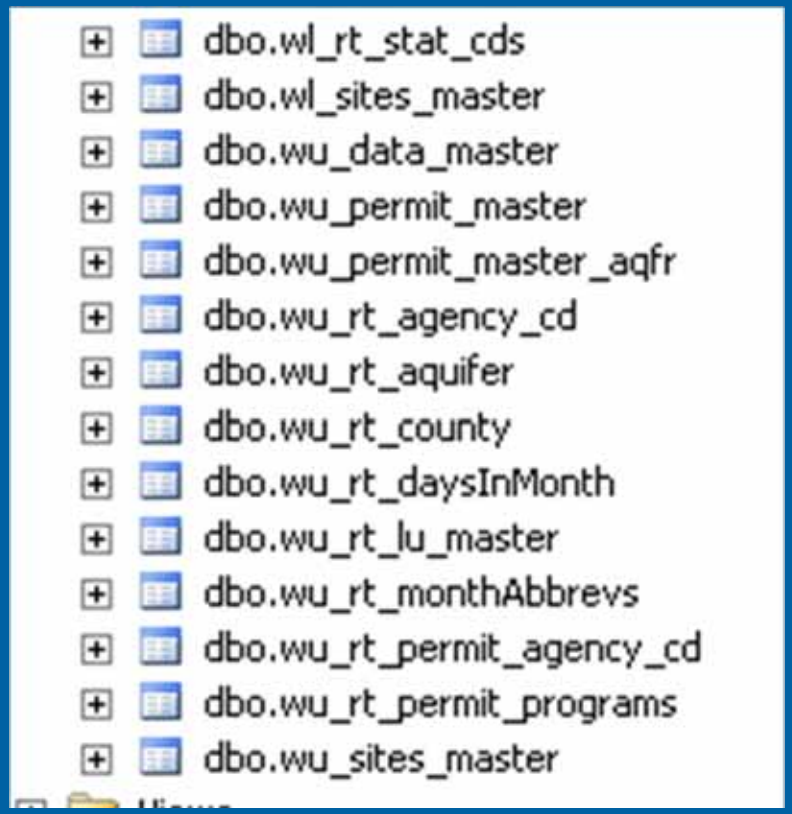
USGS

Water-Use Data Compilation

- Various sources used
  - USGS Aggregated Water-Use Database (AWUDS)
    - Contains aggregated quantities for various uses
    - 1985-2005
  - Site-Specific Water-Use Data
    - Florida DEP
    - Georgia Municipal and Industrial Permitting Program
    - Georgia Water-Use Database (USGS site-specific)
    - South Carolina Capacity Use Area Permitting
    - NWFWMD, SRWMD, SJRWMD, SWFWMD, SFWMD
  - Agricultural Water-Use Estimates
    - NESPAL (Tifton, UGA, Georgia)

Water-Use Data Compilation (cont.)

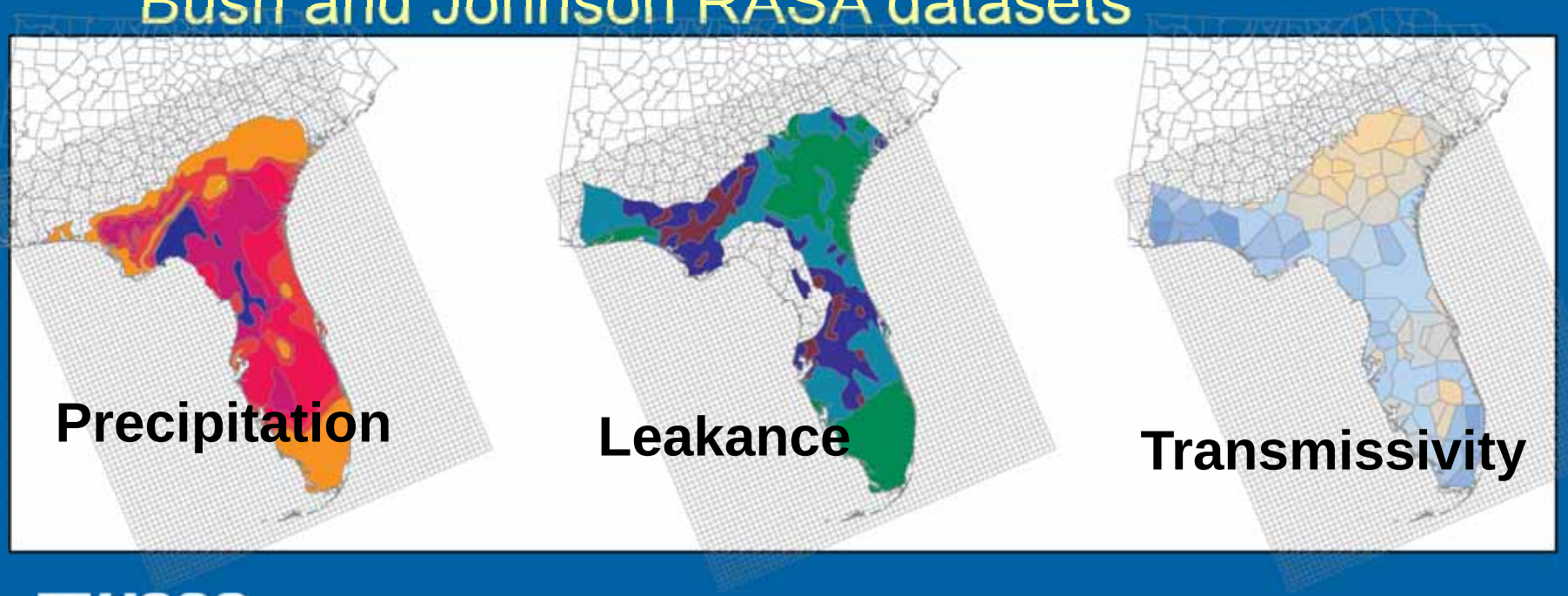
- Master Database
  - Monthly values
    - Site-specific
    - Disaggregated data
    - Estimated values
  - Permit record represents a single utility or water supplier
  - A permit has one or more sources (wells)



Model Development

- Started with RASA Model
- Preliminary Model Development

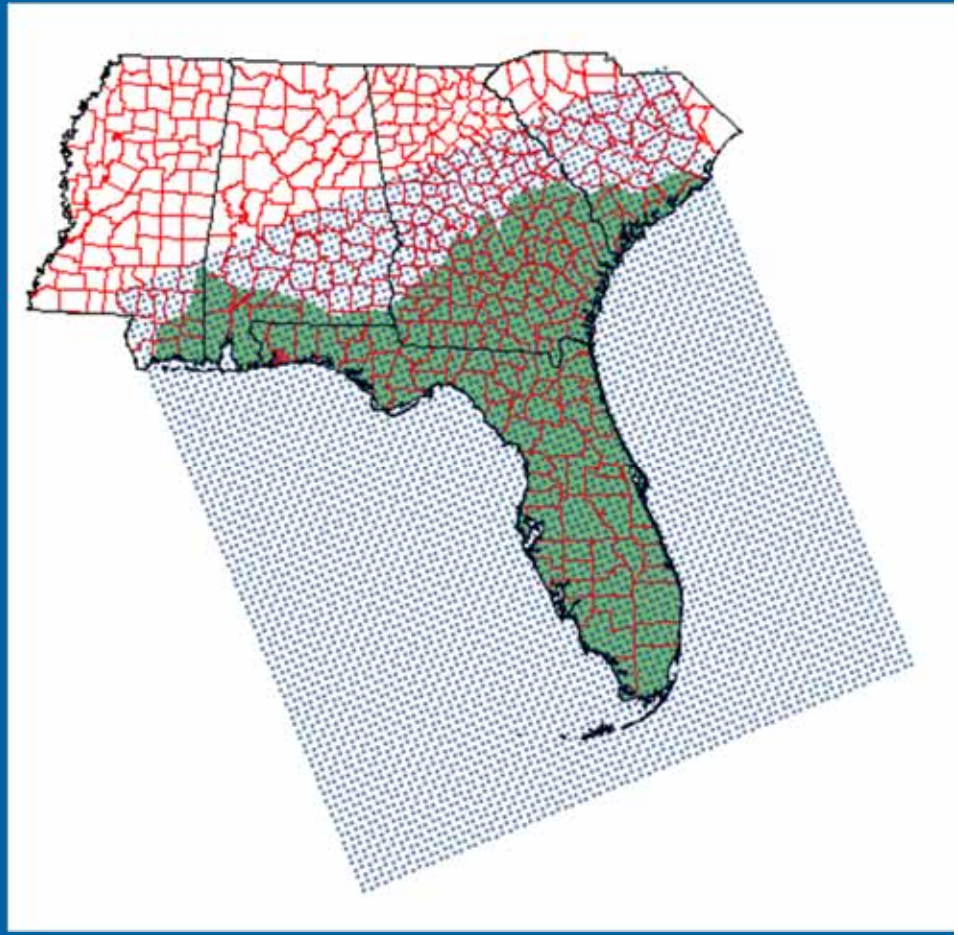
Bush and Johnson RASA datasets



USGS

Numerical Model Applications

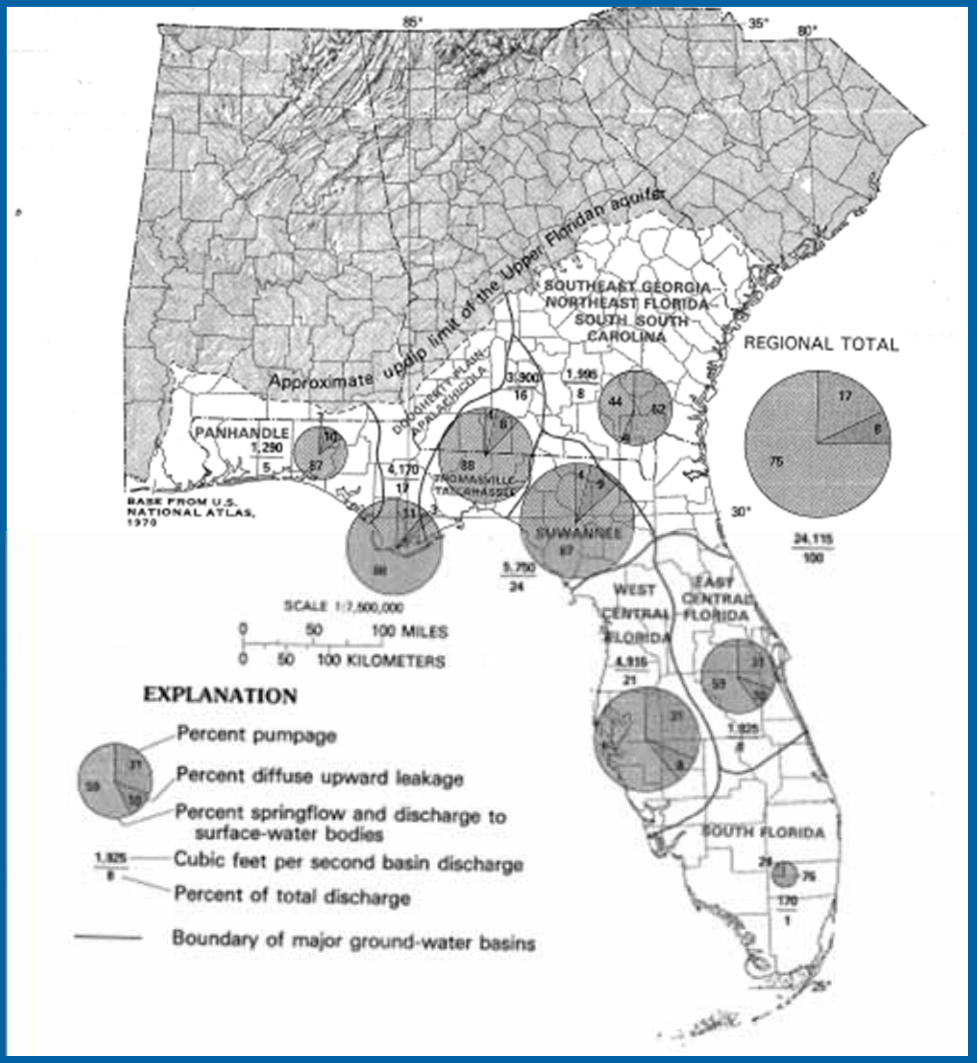
- Water budgets over time
- Climate change
- Tool to guide data collection
- Saltwater Encroachment
- Hydrologic system response to stresses (drought, increased pumping etc.)



USGS

Spatial & Temporal Variability in Water Budgets

- Looking at boundaries of major groundwater basins for model
- 8 water budget areas used in the RASA



1980 Estimated discharge from major groundwater basins, Bush & Johnson, 1988

Salt-Water Interface (SWI) package for Numerical Model

- Funded by Office of Groundwater
  - Being brought into the USGS as “official” MODFLOW-2005 package (updated with additional “bells and whistles”)
  - Joe Hughes (USGS) heading it up
  - Working with Mark Bakker (Delft Technology), Frans Schaars (Artesia),
  - Chris Langevin and Alyssa Dausman (USGS)
- Can be used to evaluate:
  - Sea Level Rise
  - Seawater Encroachment (vertically and horizontally)
  - Used in calibration of Saline Map

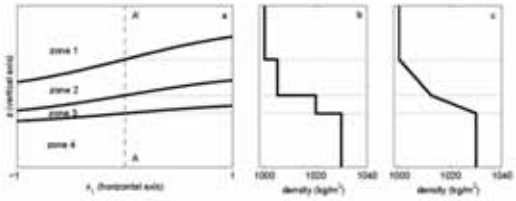


Figure 1: Conceptual models. (a) Vertical cross–section of an aquifer; (b) density distribution along A–A' for stratified flow; (c) density distribution along A–A' for variable density flow

Planned Publications and Tools

- Hydrogeologic Framework (SIR)
- Model + Documentation (SIR)
- Techniques and Methods paper for SWI package
- Data/GIS releases (Data Series-online only, etc.)
- GW Availability of the Floridan aquifer (PP)
- Fact sheet summarizing PP

USGS

Summary

- Framework being constructed to bring more internal consistency between districts
- Should have fairly comprehensive regional datasets that can be utilized locally or sub-regionally
- Develop and share tools to better simulate the groundwater flow system

Burke Co. GA
Photo: A.M. Cressler

USGS