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Groundwater Availability Study of the Floridan Aquifer System

Andrew M. O'Reilly
U.S. Geological Survey
Florida Water Science Center
Orlando, Florida

Eve L. Kuniansky
Water Mission Area
U.S. Geological Survey
Norcross, Georgia

NGWA Groundwater Expo
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USGS GROUNDWATER RESOURCES PROGRAM

Mission

To provide objective scientific information and develop interdisciplinary understanding necessary to assess and quantify the availability and sustainability of the Nation's groundwater resources.

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Strategy to Assess the Nation's Groundwater Availability

Reilly, T.E., Dennehy, K.F., Alley, W.M., and Cunningham, W.L., 2008, Ground-Water Availability in the United States: U.S. Geological Survey Circular 1323, 70 p., also available online at http://pubs.usgs.gov/circ/1323/

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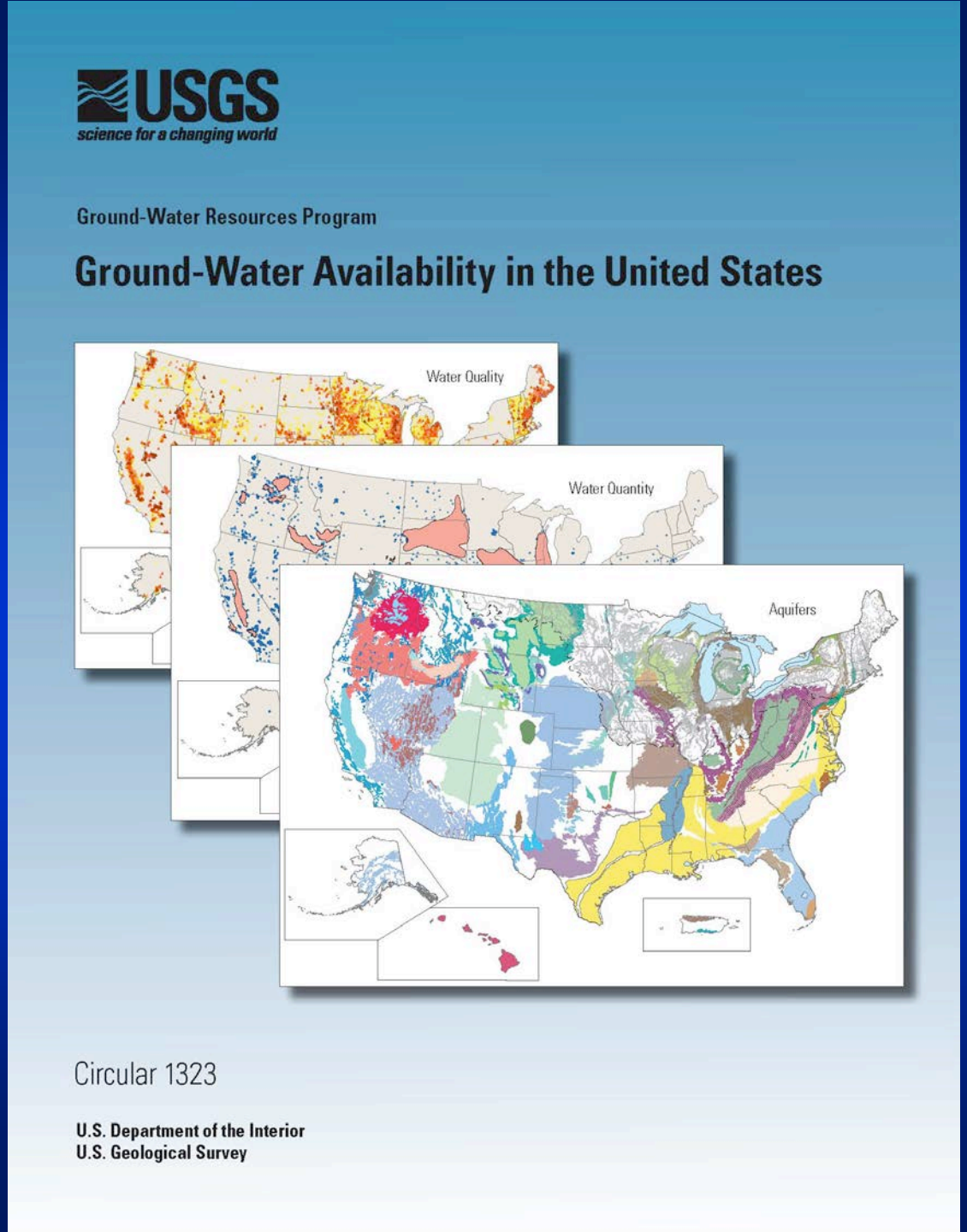

Regional GW Availability Studies

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 or due to climate change or weather variability.

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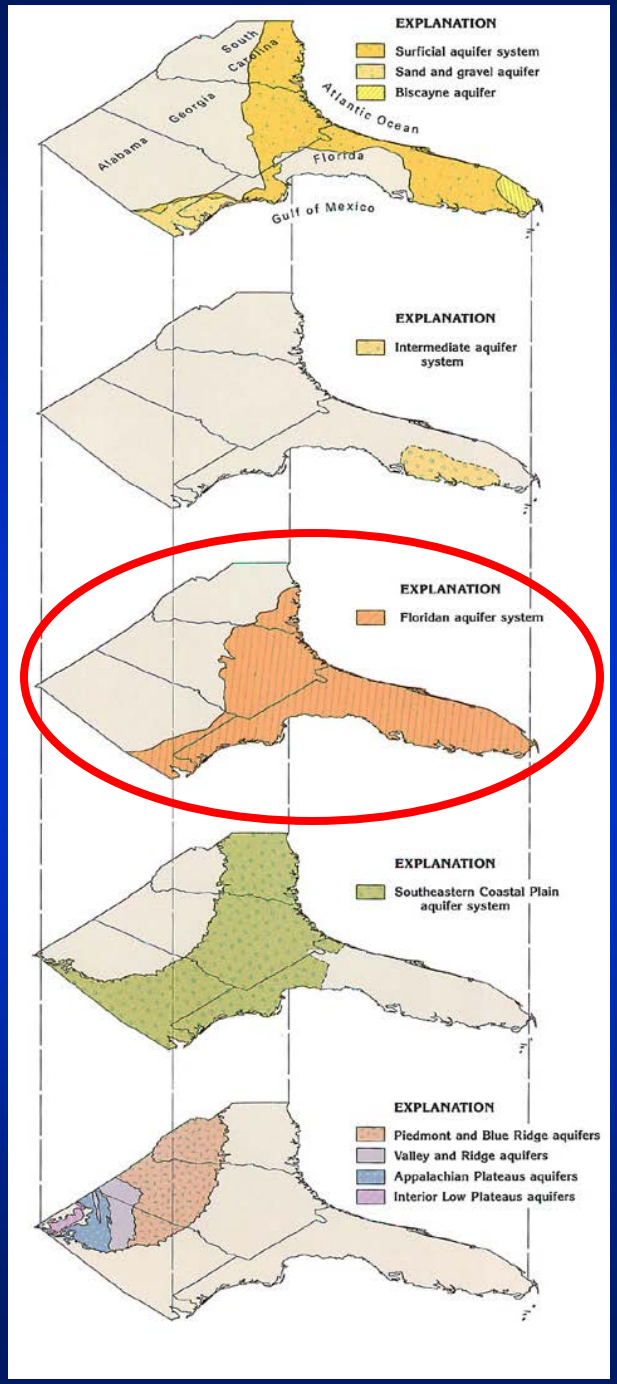
Floridan Aquifer System Extent

- ~100,000 mi^2
- ~ 4 BGD in 2000 for ~10,000,000 people
- 2 major aquifer units identified by Miller
  - Upper Floridan
  - Lower Floridan

USGS (USGS Circular 1278)

Floridan Aquifer System
Position Relative to other Southeastern Principal Aquifers

- Below surficial and intermediate aquifer systems
- Above Southeastern Coastal Plain aquifer system
- Ranges in thickness from 0 ft at updip extent to greater than 3,000 ft in south Florida



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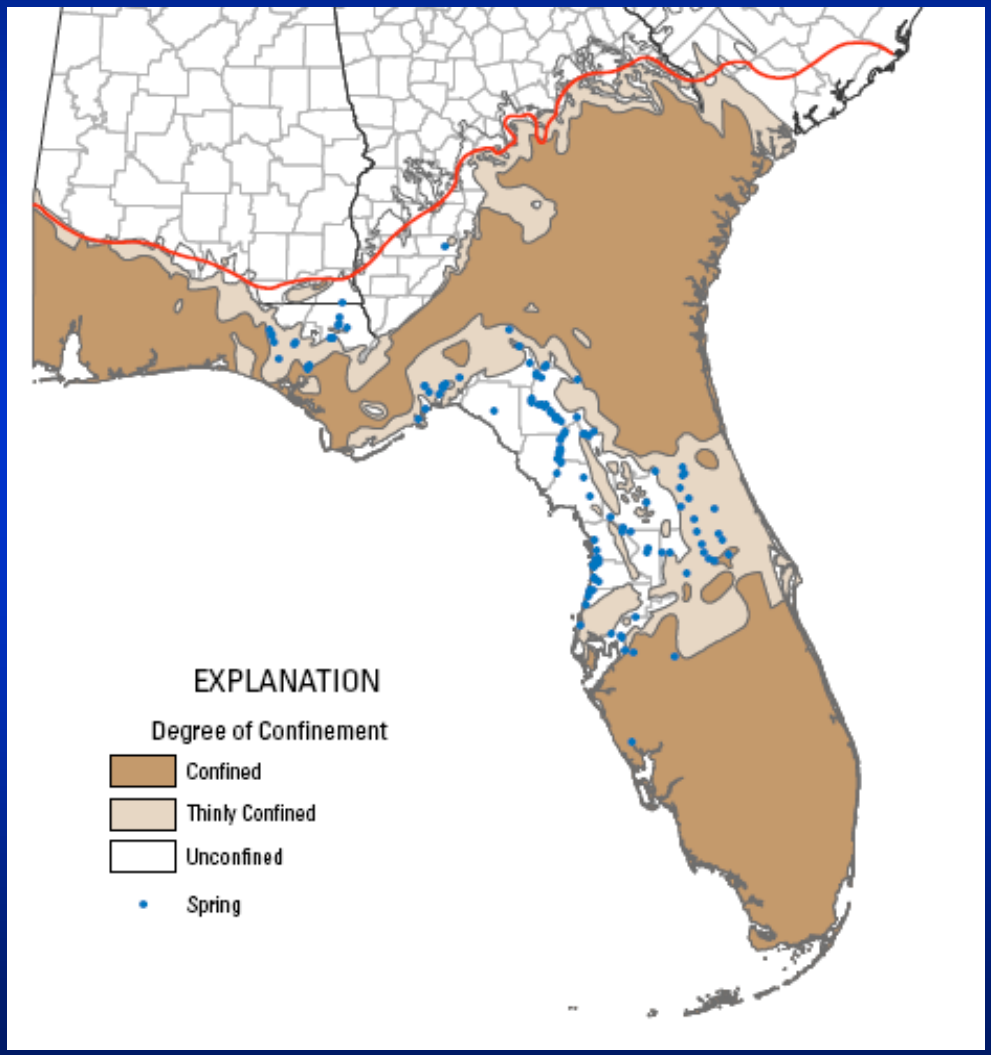
(USGS Hydrologic Investigation Atlas 730-G)

Aquifer System Confinement and Major Springs

- Aquifer is confined beneath thick sequence of sand, silt, and clay over much of its extent
- Confinement limits the amount of direct recharge into the system
  - < 1 in/yr in confined area
  - 10–25 in/yr in unconfined and thinly confined areas (< 100 ft thick)
- Pre-development spring flow was ~2.7 in/yr (12.3 BGD)



(USGS Professional Papers 1403-A and 1403-B)

Groundwater Availability Issues for Floridan Aquifer System

System vulnerabilities:

- Groundwater/surface-water linkage
- Geologic structure and saline water encroachment

External Pressures:

- Development & landscape change
- Climate change & sea-level rise

Finch's Cave, Marion County, FL
(Photo Alan M. Cressler, USGS)

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Dougherty Plain

- Floridan outcrops and is directly connected to streams
- Groundwater withdrawals for irrigation decrease stream flow and water levels

Center pivot irrigation, Terrell County, GA (Photo Alan M. Cressler, USGS)

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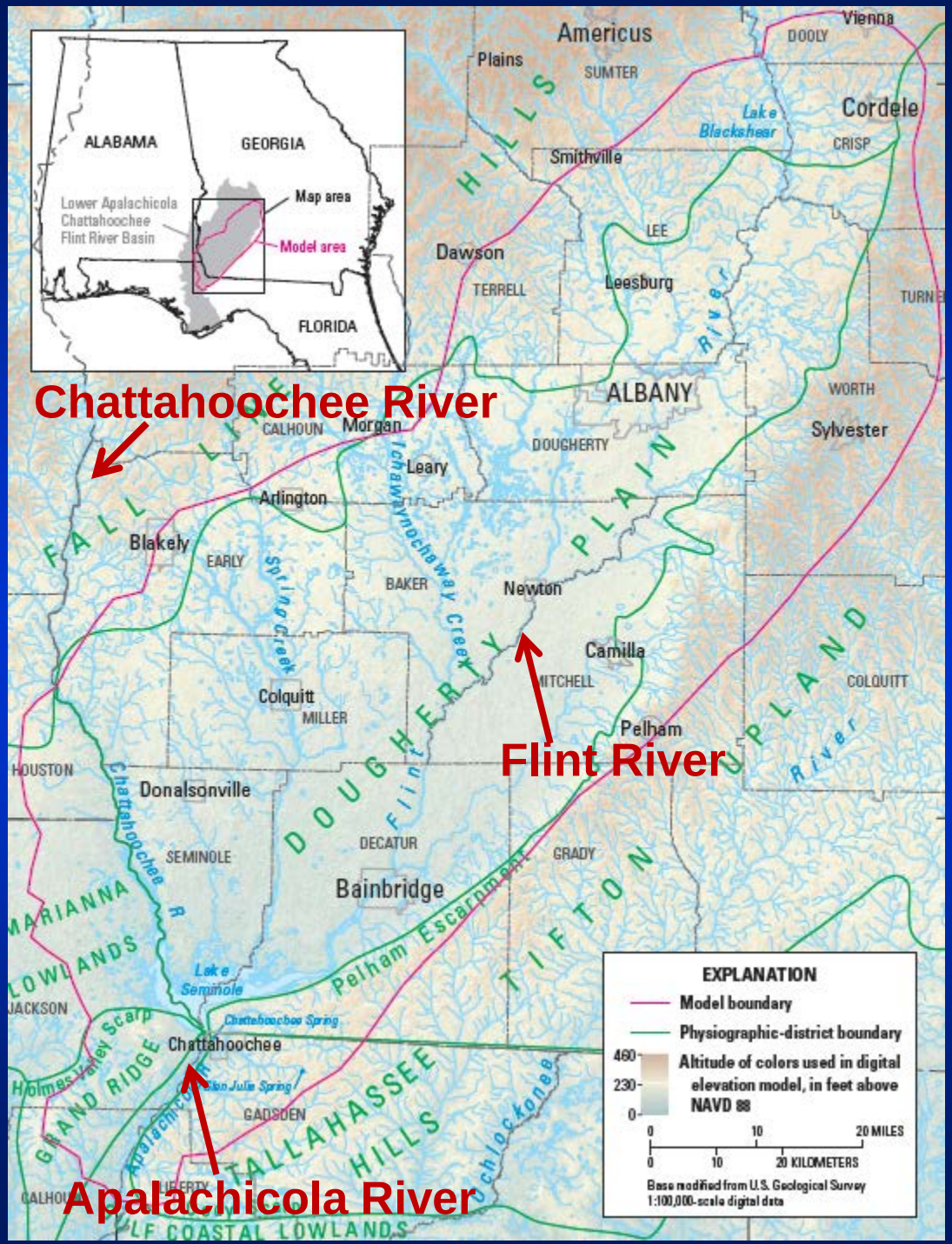

Possible Impacts of Reduced Stream Flow on Apalachicola-Chattahoochee-Flint River

- Loss of
  - Hydroelectric generating capacity
  - Endangered species
  - Commercial fisheries
  - Estuary health
- These losses are
  - Economic
  - Ecological
  - Potentially long term and irreversible

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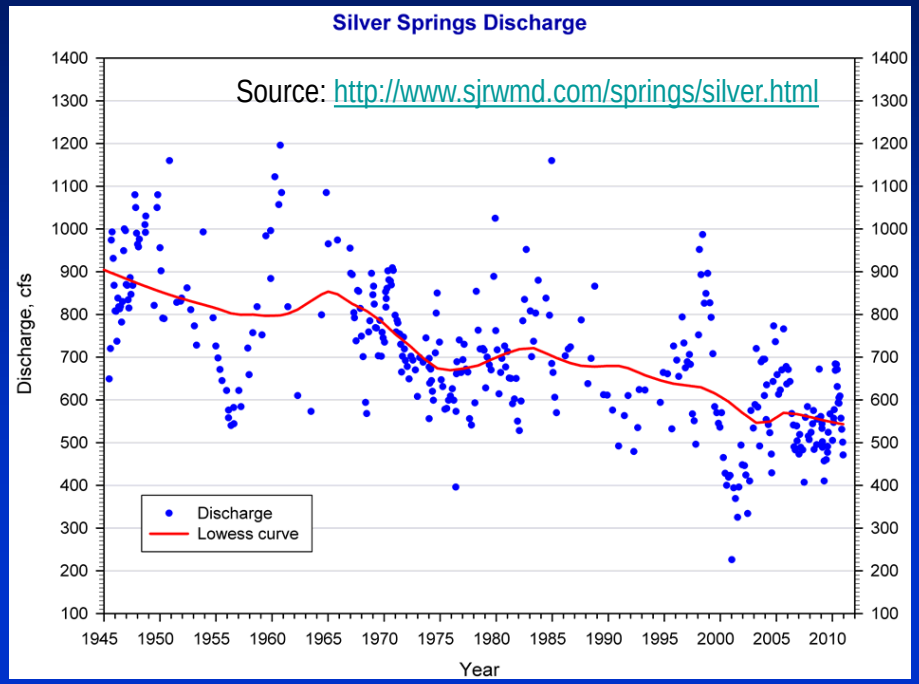
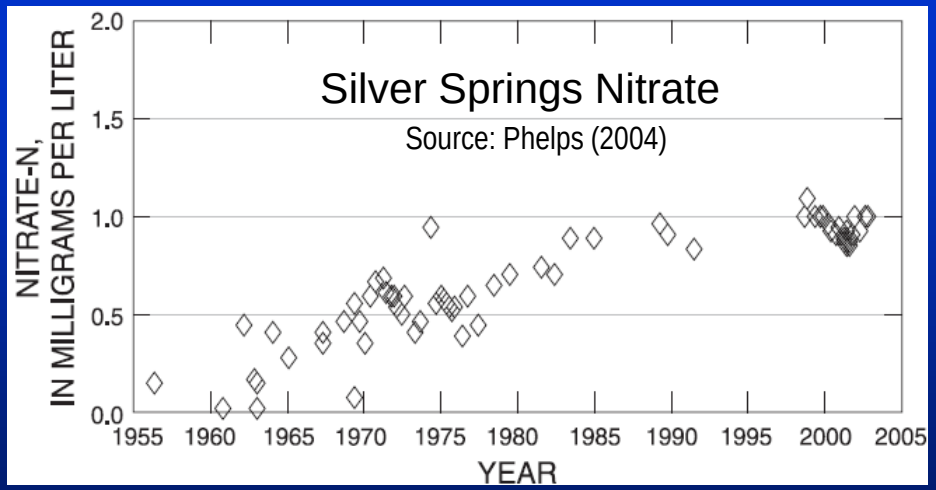
Central, North, and Northwest Florida

- Reduction in spring discharge or even the cessation of some spring discharge
  - Additionally there have been increases in nitrates and other contaminants at some springs
- Sinkhole collapse and lakes draining during droughts
- Increased downward leakage from surficial or intermediate aquifer to Floridan contributing to wetland reductions and lower lake levels





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Lake Jackson, Tallahassee, FL

Drained down Porter's sinkhole in 1999, previously drained in 1950 – minor drop in 2007

Before 1999

After 1999 event

(Photos by Tom Scott, Florida Geological Survey)

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Lowered Lake Levels and Sinkholes

Lake Brooklyn, Clay County, Florida
(Photo Mathew O'Malley, St. Johns River Water Management District)

Winter Park, Florida, May 1981
(Photo Tom Scott, Florida Geological Survey)

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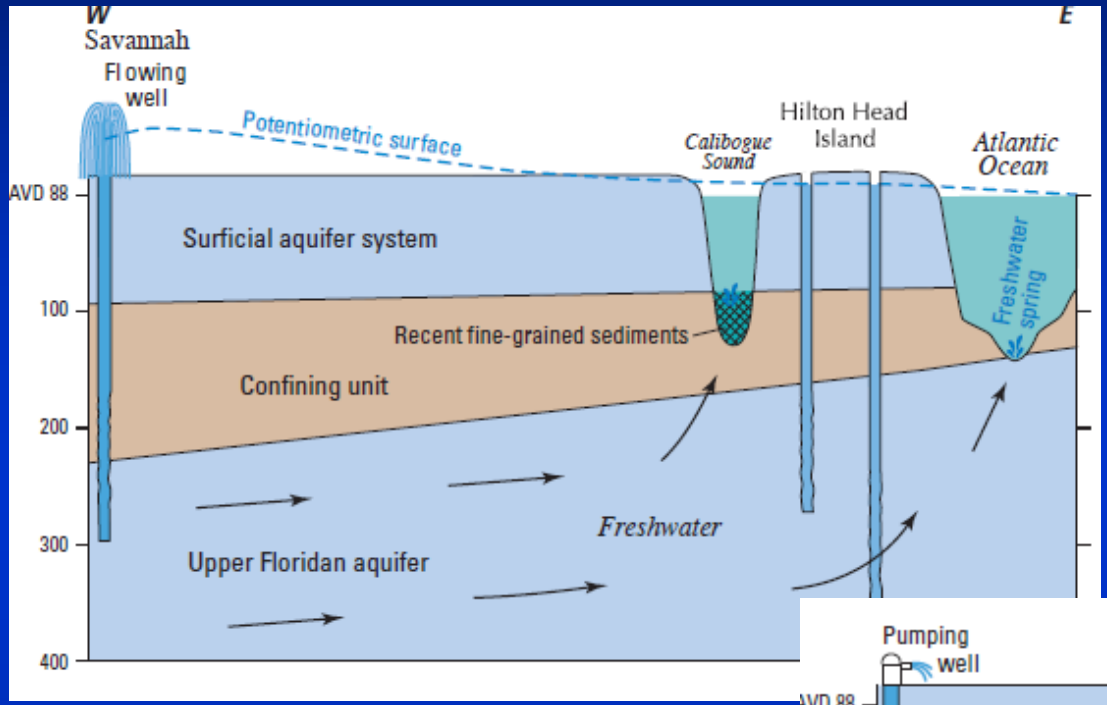
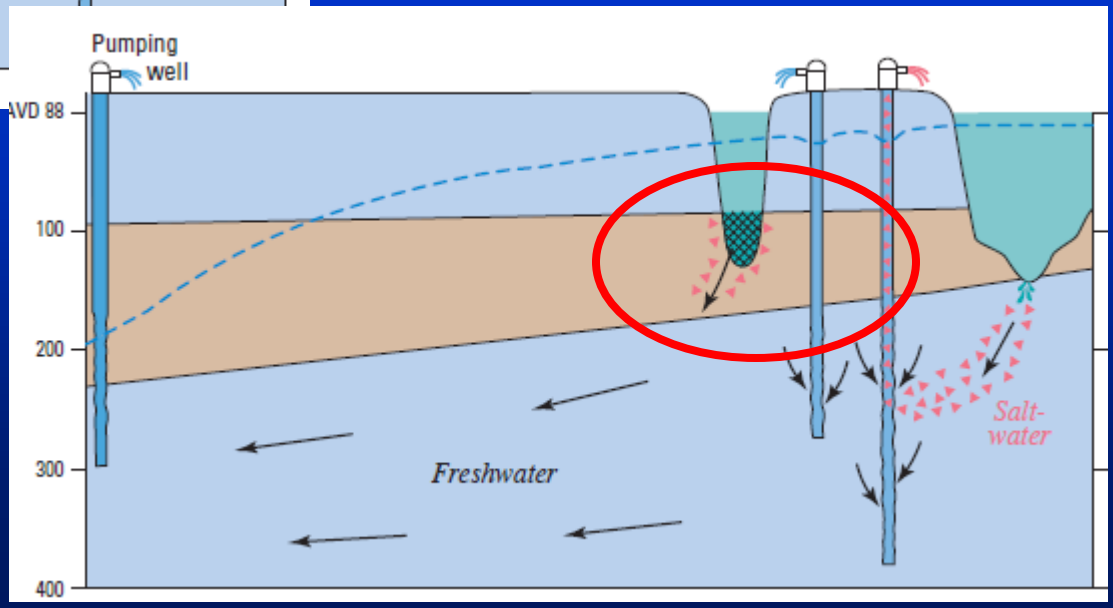
(USGS Circular1278)

Seawater Encroachment and Paleochannels



Savannah/Hilton Head area:

- Upward gradient from Floridan reversed by withdrawals
- Induces downward migration of seawater at existing and in-filled paleochannels



(Krause and Clarke, 2001; Provost and others, 2006)

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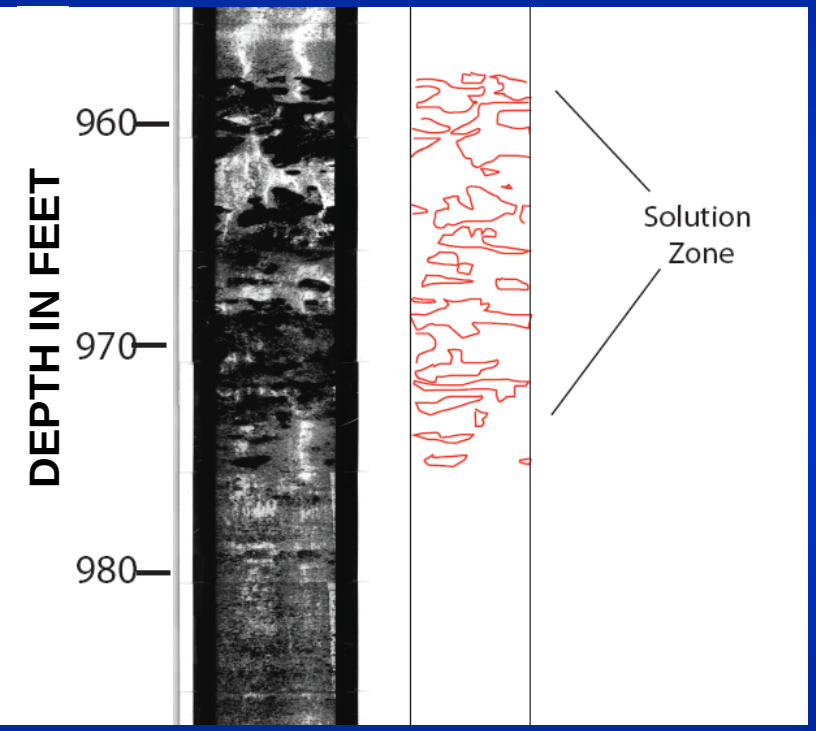
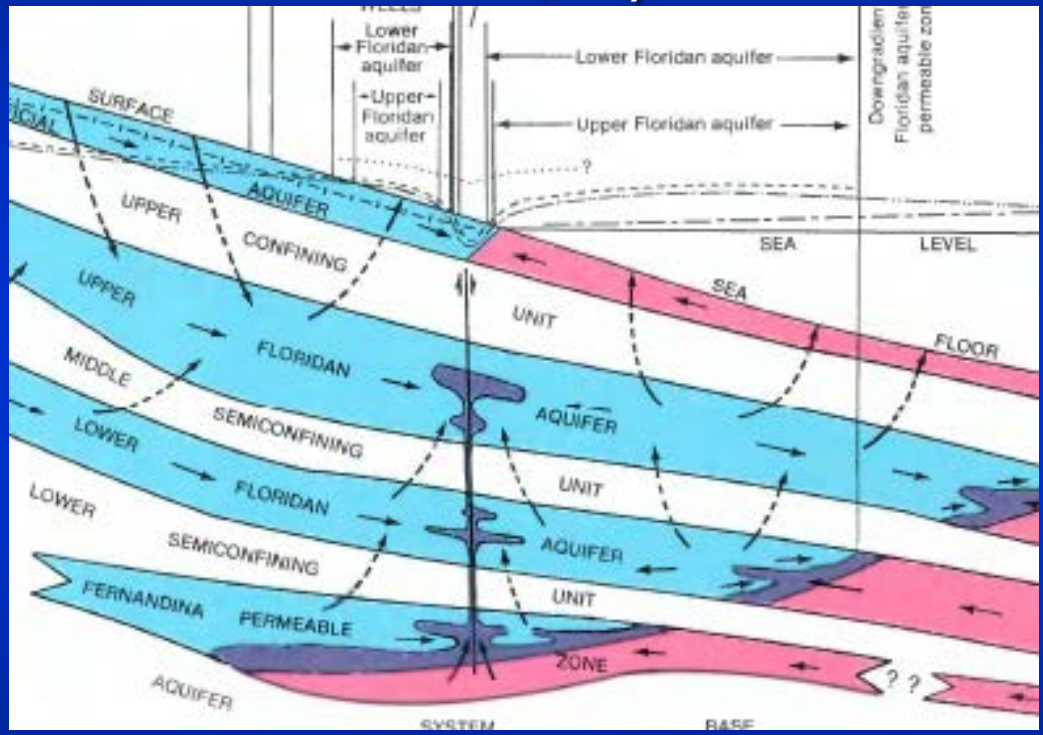
Saline water movement through vertical fractures and horizontal permeable units

(Brunswick, GA and Fernandina Beach, FL)





- Mineralized water trapped by local confining units can migrate into adjacent freshwater aquifers
- Horizontal systems may intersect vertical systems

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(Williams and Spechler, 2011)

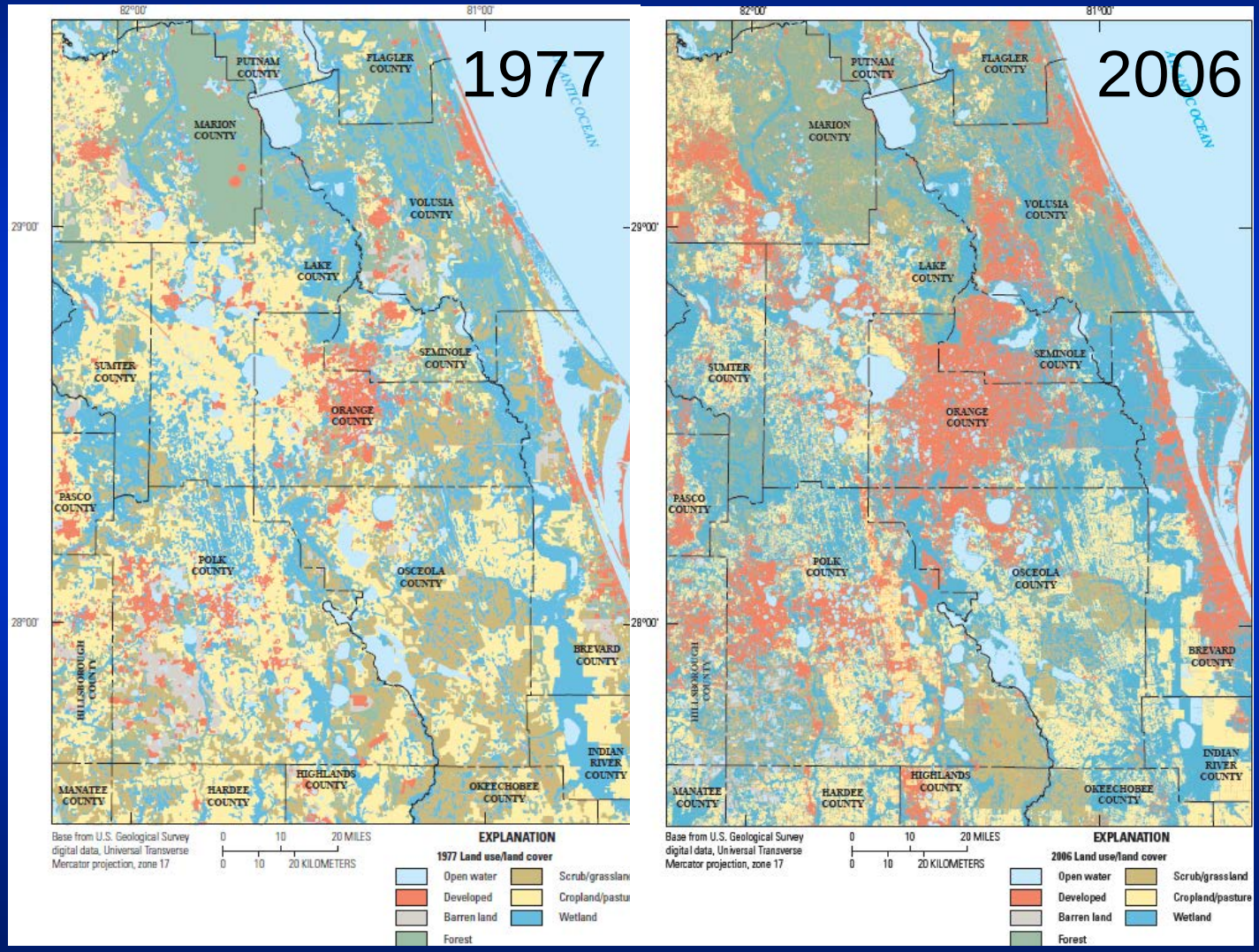
Development and Landscape Change

- Growing urban areas
- Substantial development pressures

<u>Central Florida:</u>

↑160% developed area
↓40% cropland/pasture
(1977 – 2006)

↑140% population
(1980 – 2010)



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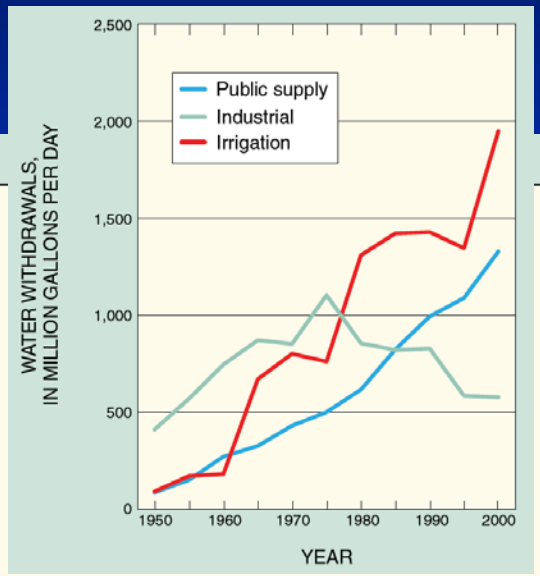
Groundwater Withdrawal Trends, 1950-2000



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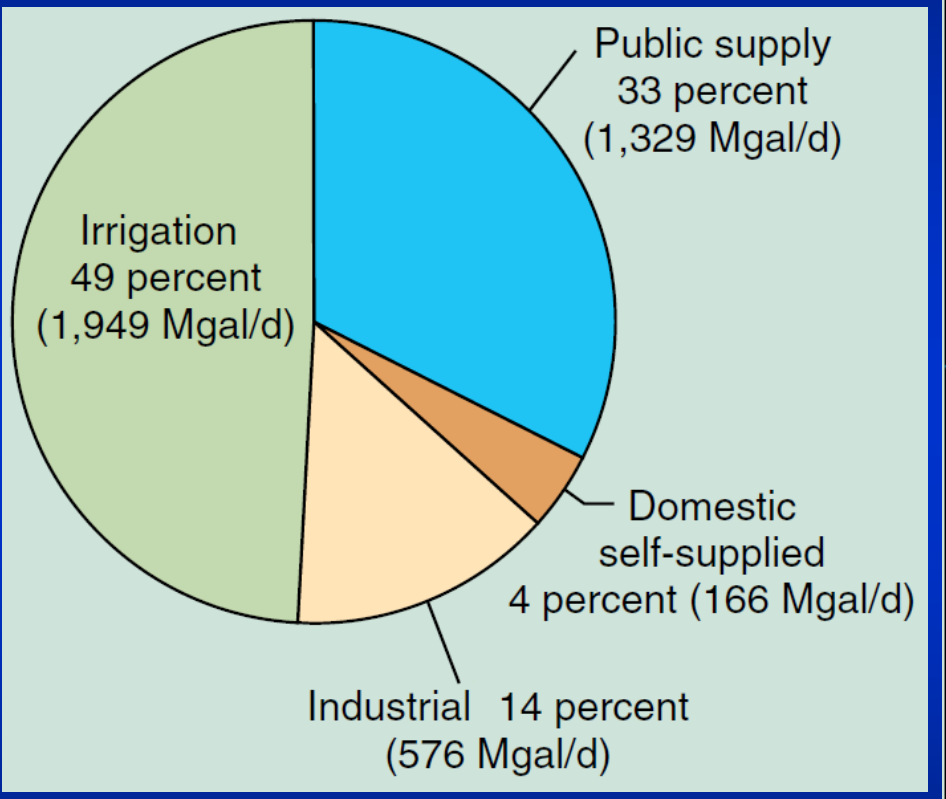
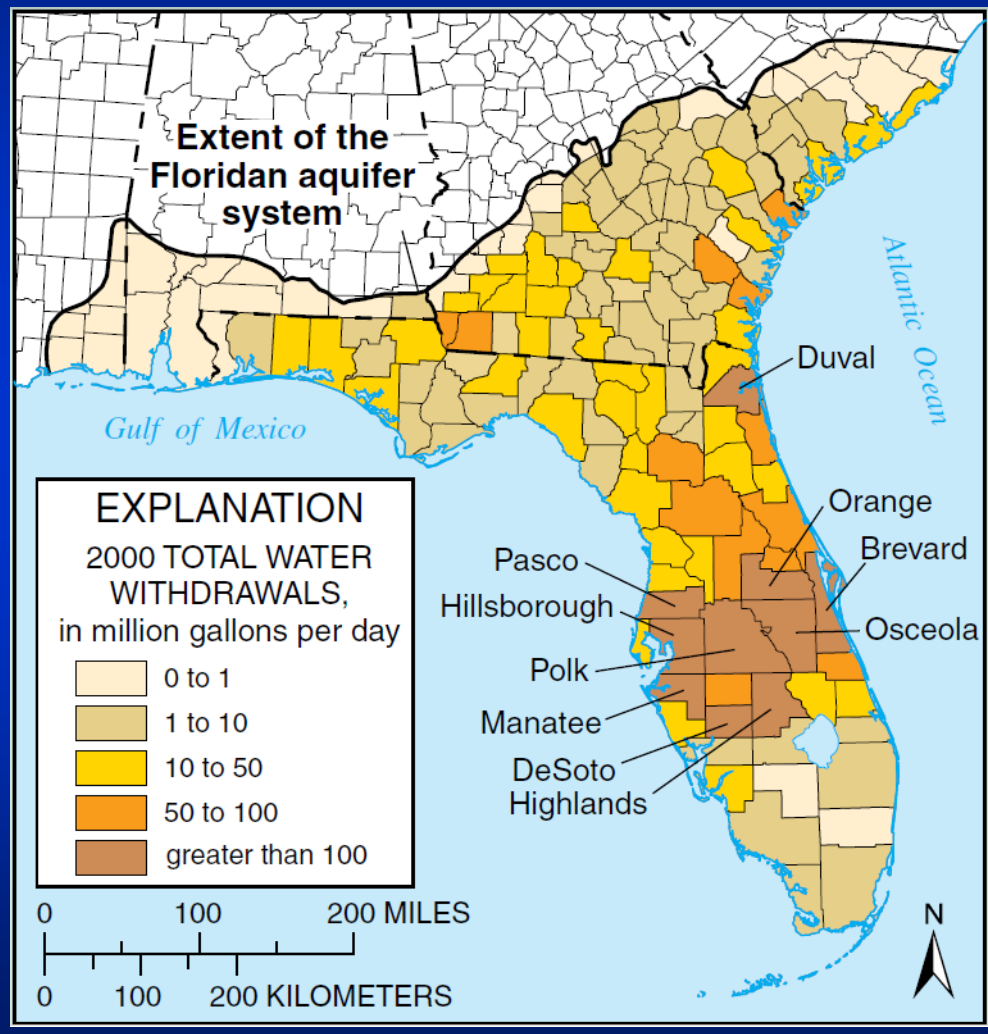
Total water withdrawals from the Floridan Aquifer System

(USGS Circular1278)

Groundwater Withdrawals
Year 2000 Summary





- 90% of groundwater withdrawals are from Upper Floridan aquifer

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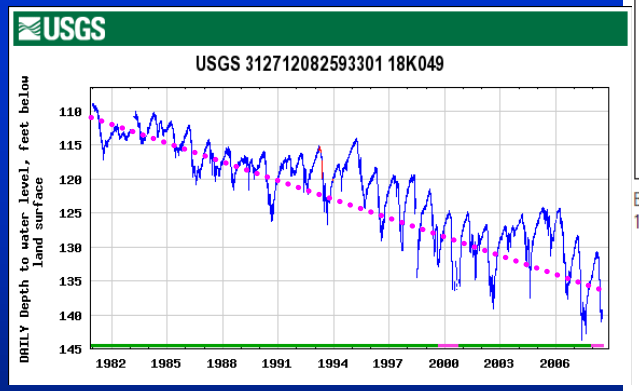
(USGS Circular 1278)

Rate of Decline Relative to Degree of Confinement

- Average rate of decline is 3 times greater in the confined areas vs. unconfined areas



(Williams et al. (2011)
GA Water Resources Conf.)

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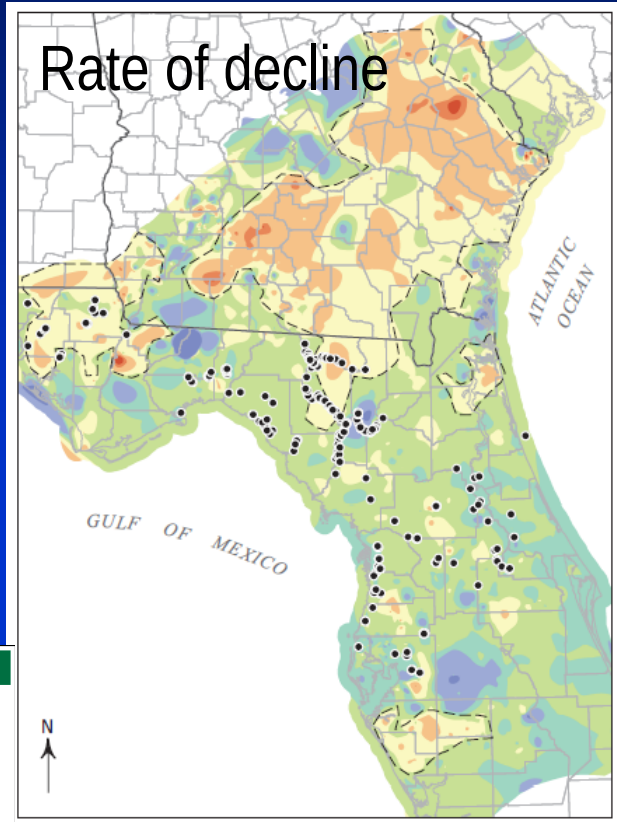
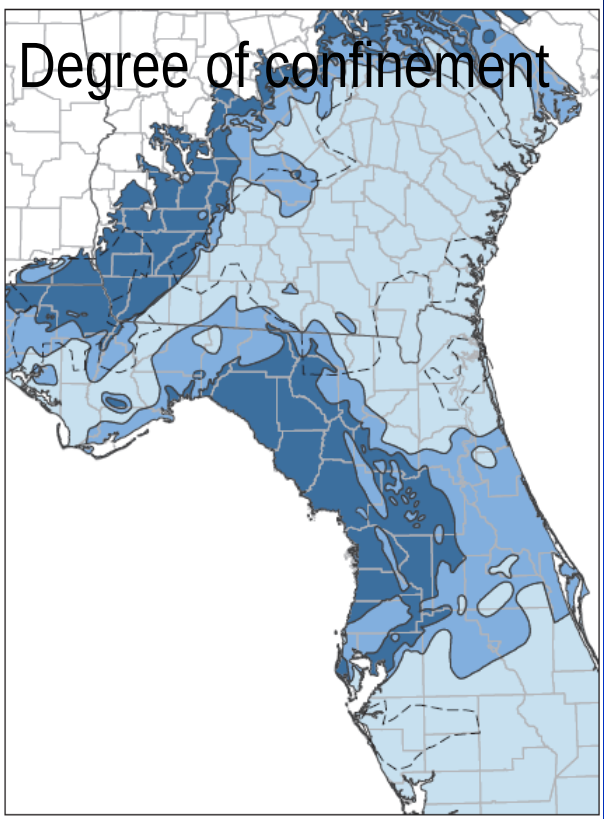




Base modified from U.S. Geological Survey
1:2,000,000-scale digital data

0 40 80 MILES
0 40 80 KILOMETERS

EXPLANATION

Map *A*

Composite 10-year rate of water-level decline, in feet, from 1970 to 2010

–35 to –15	–1.5 to 0
–15 to –10	0 to 1.5
–10 to –4	1.5 to 10
–4 to –1.5	10 to 15

Area of greatest decline

Spring (magnitude 1 or 2)

Map *B*

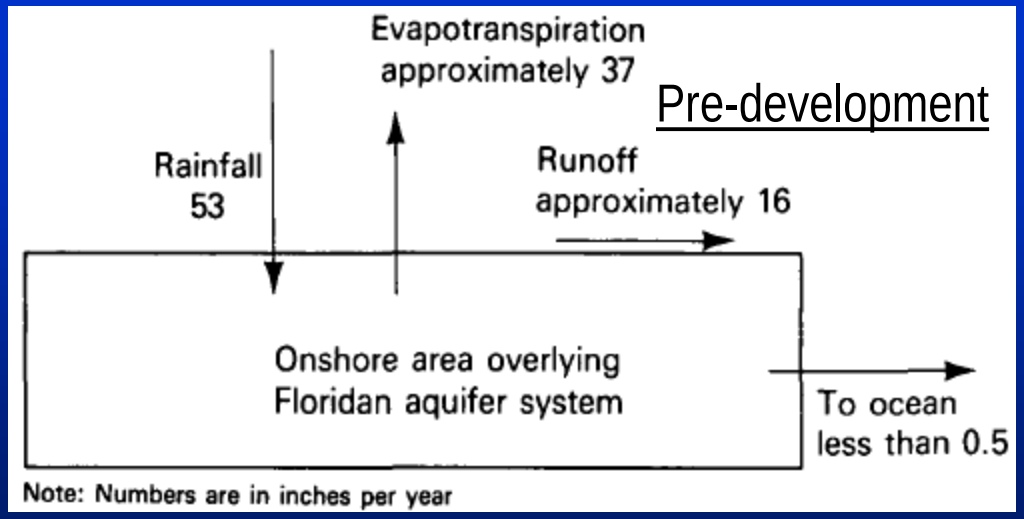
Degree of confinement

Unconfined
Thinly confined
Confined

Area of greatest decline

Climate Change and Sea-Level Rise

- The Floridan aquifer system is currently being stressed by the combination of “normal” meteorological variability and groundwater withdrawals.
- Pumpage is relatively small component of system-wide water budget.
- System is largely meteorologically driven, thus will be sensitive to future weather extremes and climate change.
- Climate change and sea-level rise will likely exacerbate existing impacts.



(USGS Professional Paper 1403-C)

Post-development (2000)

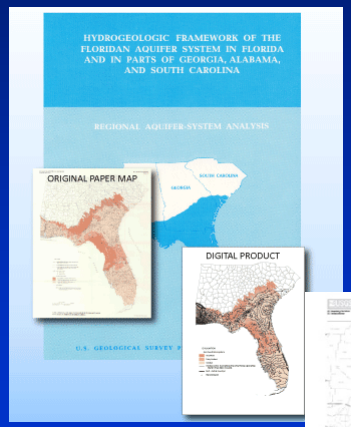
- Pumpage 4 BGD (0.9 in/yr)

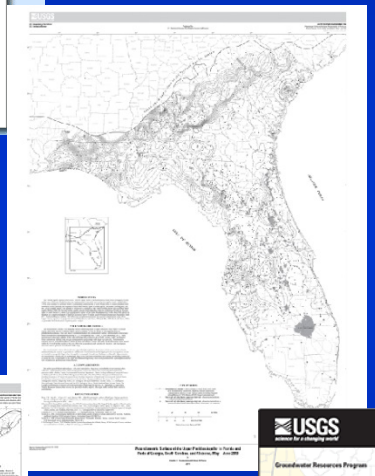
Represents modest component of major pre-devel. outflows:

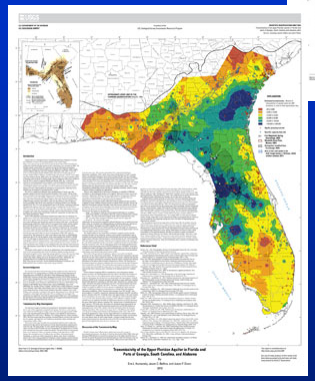
- 2% of ET
- 6% of Runoff

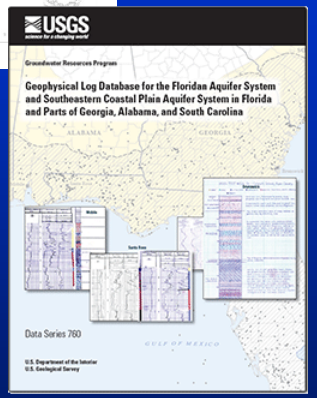
Published Products for Floridan Study

- Digitized surfaces and hydrogeologic data from USGS Regional Aquifer-System Analysis (RASA) study of Floridan aquifer system
- Upper Floridan aquifer potentiometric map
- Upper Floridan aquifer transmissivity map
- Geophysical log database
- Revised hydrogeologic framework to be released in 2014









http://fl.water.usgs.gov/FASWAM/

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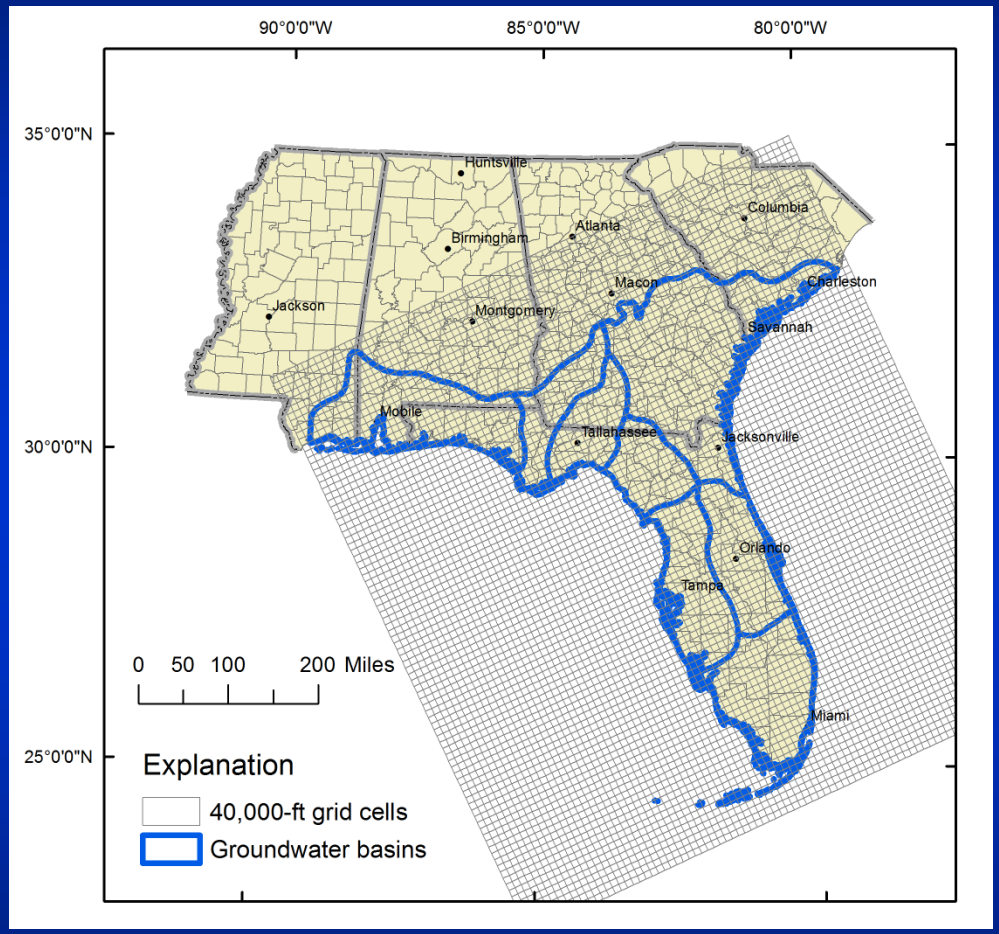
Major Remaining Products

- Independent water budget
  - pre-development
  - current conditions
- Numerical GW model
  - start simple (RASA used 8-mi grid cells)
  - add complexity as warranted (5000-ft cell probably minimum)
- Assessment of climate, sea-level rise, and monitoring networks



FAS FLORIDAN AQUIFER SYSTEM
WATER AVAILABILITY MODEL WAM

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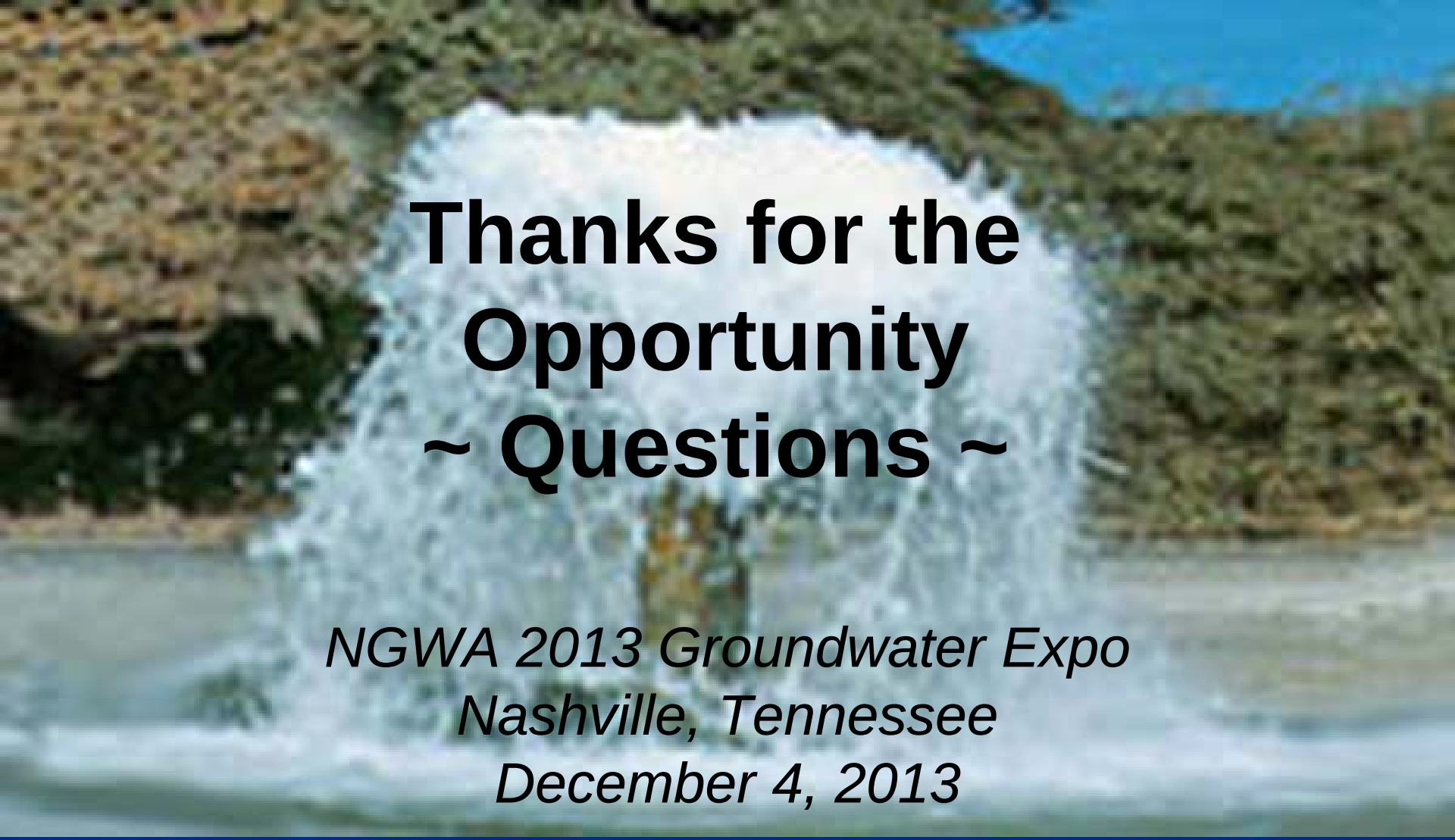

Thanks for the Opportunity ~ Questions ~

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