

ENGINEERING CONSULTING SERVICES

"One firm. One mission."



Sinkholes, Swamps, and Stormwater – Geotechnical Hazard Management in Florida

Presented by: David Wilshaw, MS, PG

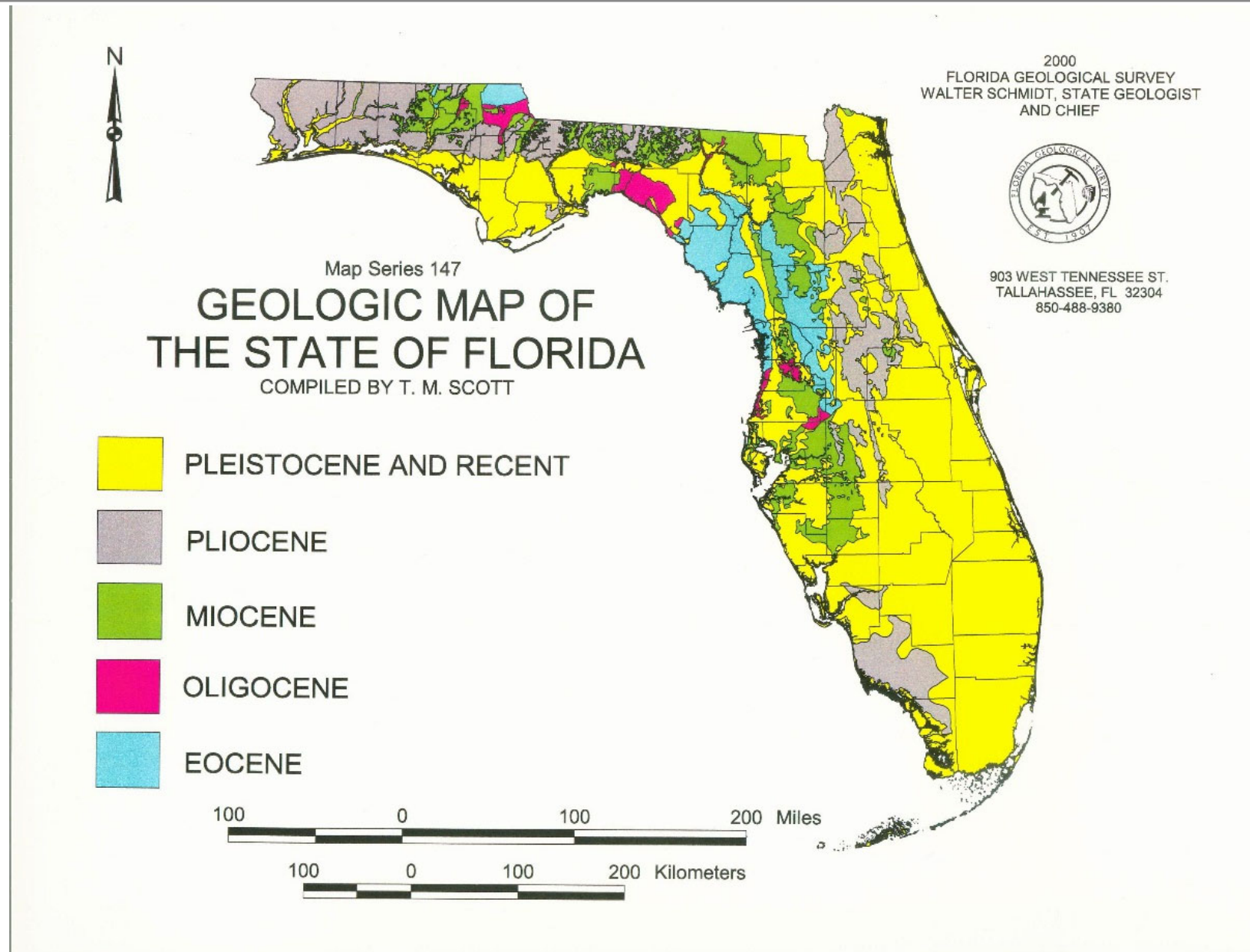
DISCUSSION GOALS

Today's discussion:

- How the deep geology has created Florida's landscape and how the more recent soil deposits are linked to the deeper geological conditions.
- Why our surface water and shallow groundwater conditions are so closely linked to our geology and landscape.
- How your friendly neighborhood geotechnical specialist can help!



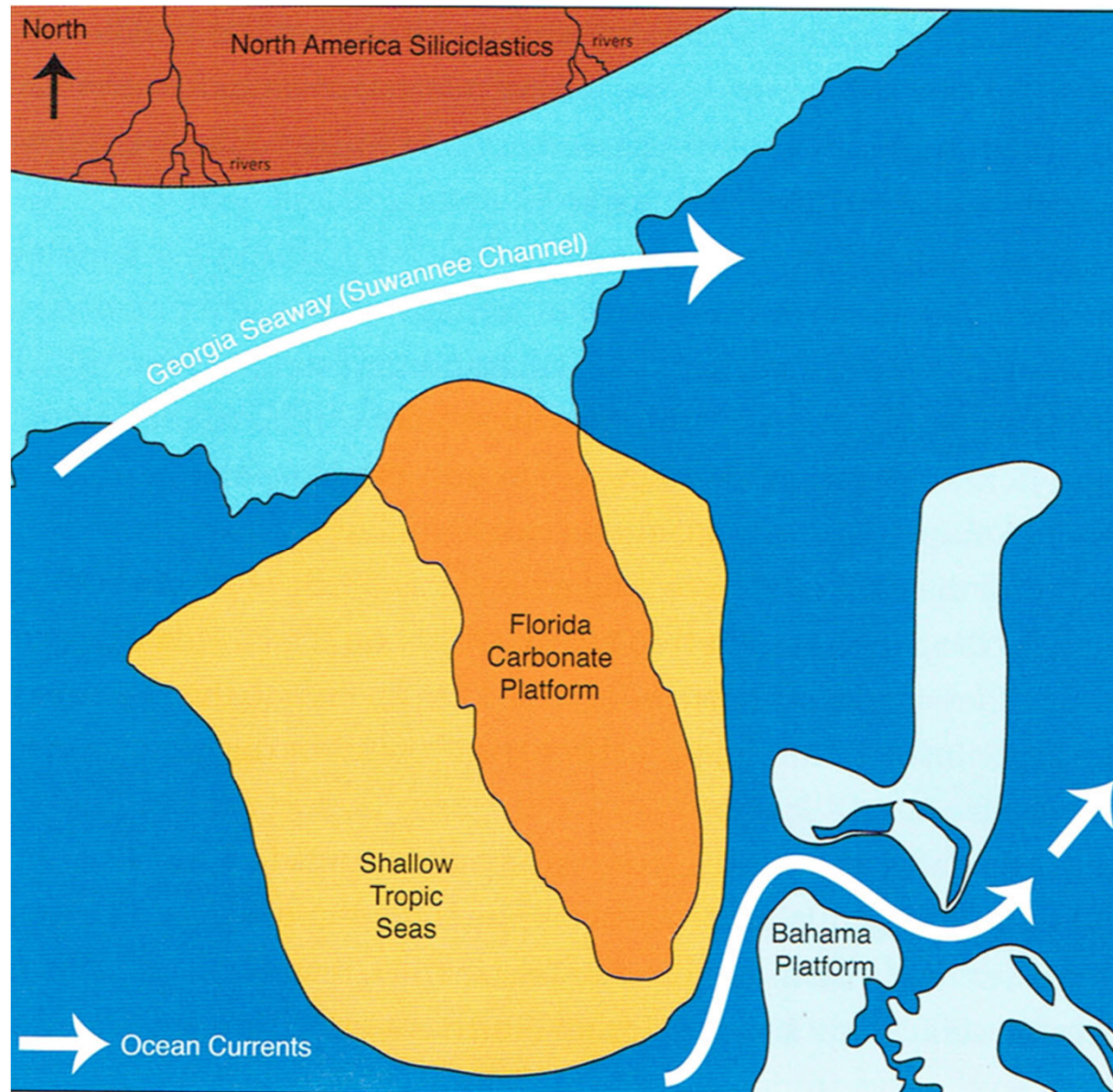
What's so special about Florida's Geology?:



What's so special about Florida's Landscape?:



Where did all that Limestone come from?:



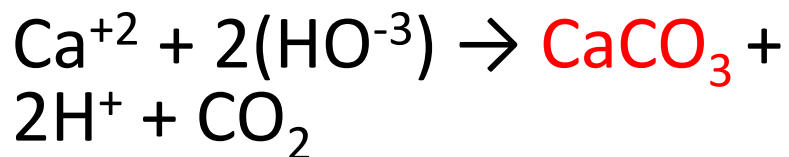
Clean water, shallow seas (<100-feet deep)
Limestone thickness up to 3 miles due to continuous subsidence of a thin area of crust

Hines, 2013



THE TROUBLE WITH LIMESTONE...

- Marine waters contain dissolved calcium (Ca^{+2}) and bicarbonate (HCO^{-3})
- Source of calcium carbonate is both plant and animal
- Some algae secrete large amounts of calcium carbonate
- Calcification is:



- Carbonic acid forms from CO_2 in the atmosphere and soil, thus:
- $\text{CO}_2 + \text{H}_2\text{O} \leftrightarrow \text{H}_2\text{CO}_3 \leftrightarrow \text{H}^+ + \text{HCO}_3$
- H^+ defines the acidity (pH) – average pH of Florida rain is 4.77
- Dissolution:
- $\text{CaCO}_3 + \text{H}_2\text{CO}_3 \rightarrow \text{Ca}^{+2} + 2\text{HCO}_3^{-1}$

SO OVER TIME (1-INCH EVERY 1,000 YEARS)...



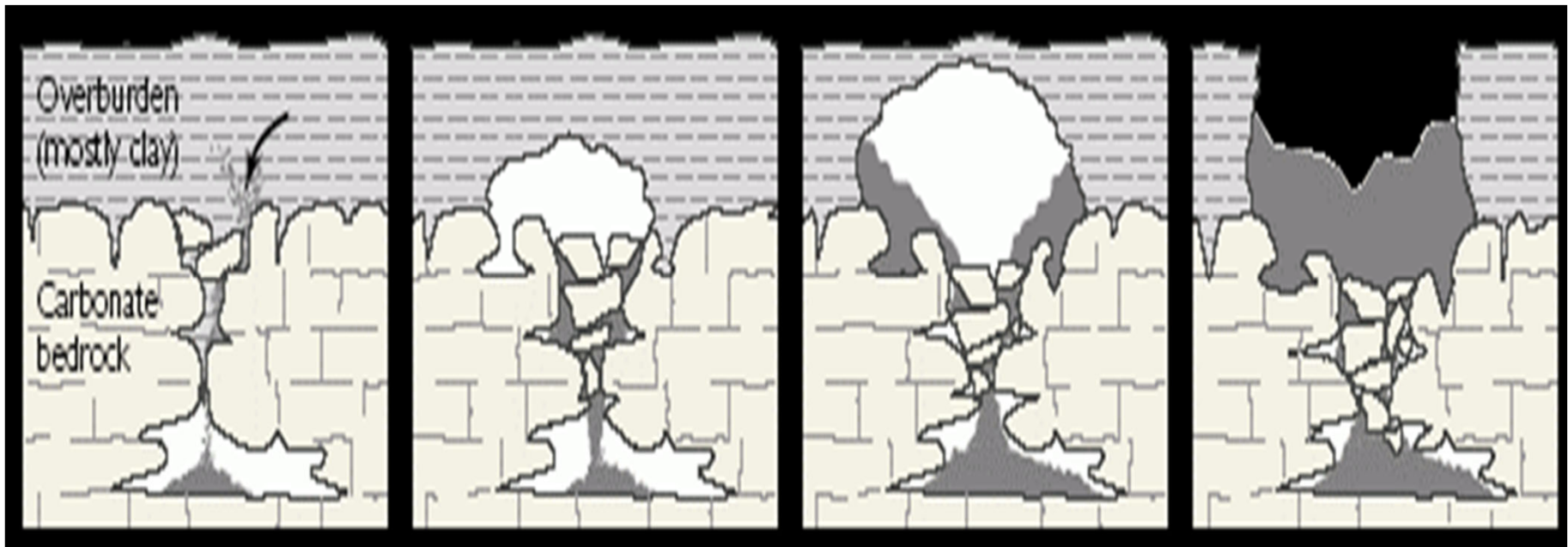
COVER COLLAPSE SINKHOLES:



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EMERGENCY RESPONSE – FILL THE HOLE!



NOT ALL SINKHOLES ARE GEOLOGICAL



JOINTS AND STRUCTURE ENTRIES MOST VULNERABLE



SHALLOW LIMESTONE + SMALL VOIDS = SMALL SINKHOLES:

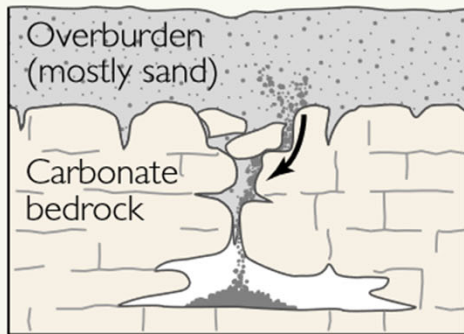


DEEPER LIMESTONE + LARGE VOIDS = HUGE SINKHOLES:

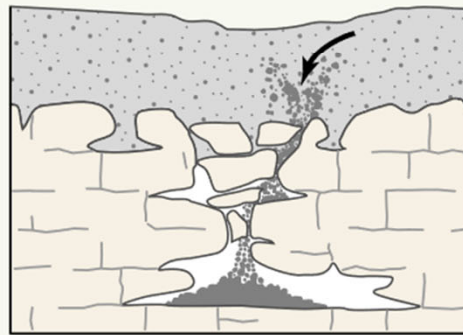


COVER SUBSIDENCE SINKHOLES:

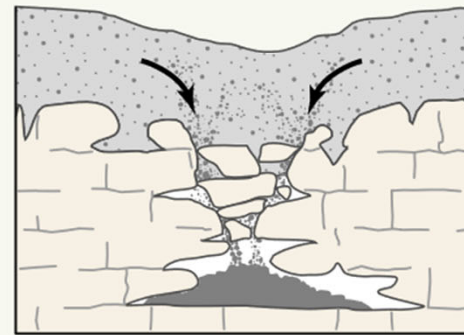
Granular sediments spall into secondary openings in the underlying carbonate rocks.



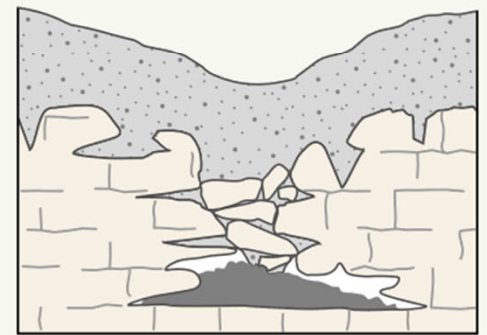
A column of overlying sediments settles into the vacated spaces (a process termed "piping").



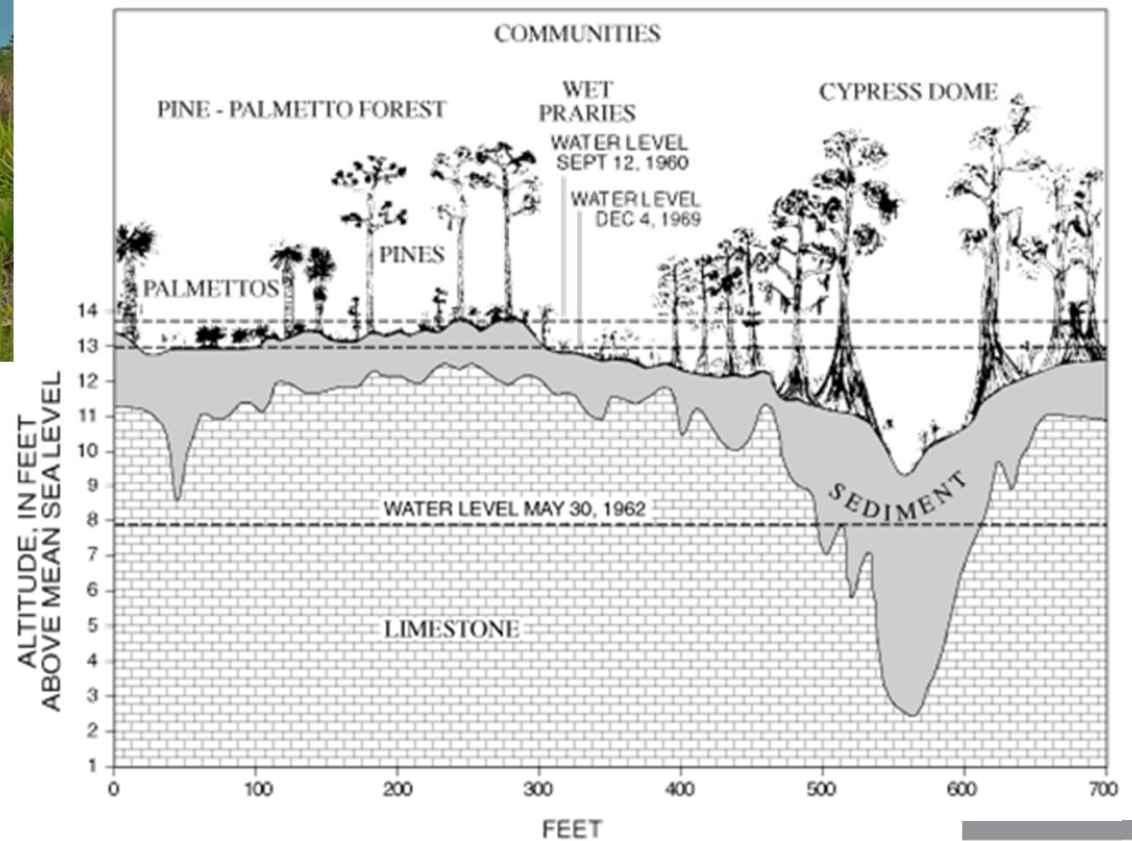
Dissolution and infilling continue, forming a noticeable depression in the land surface.



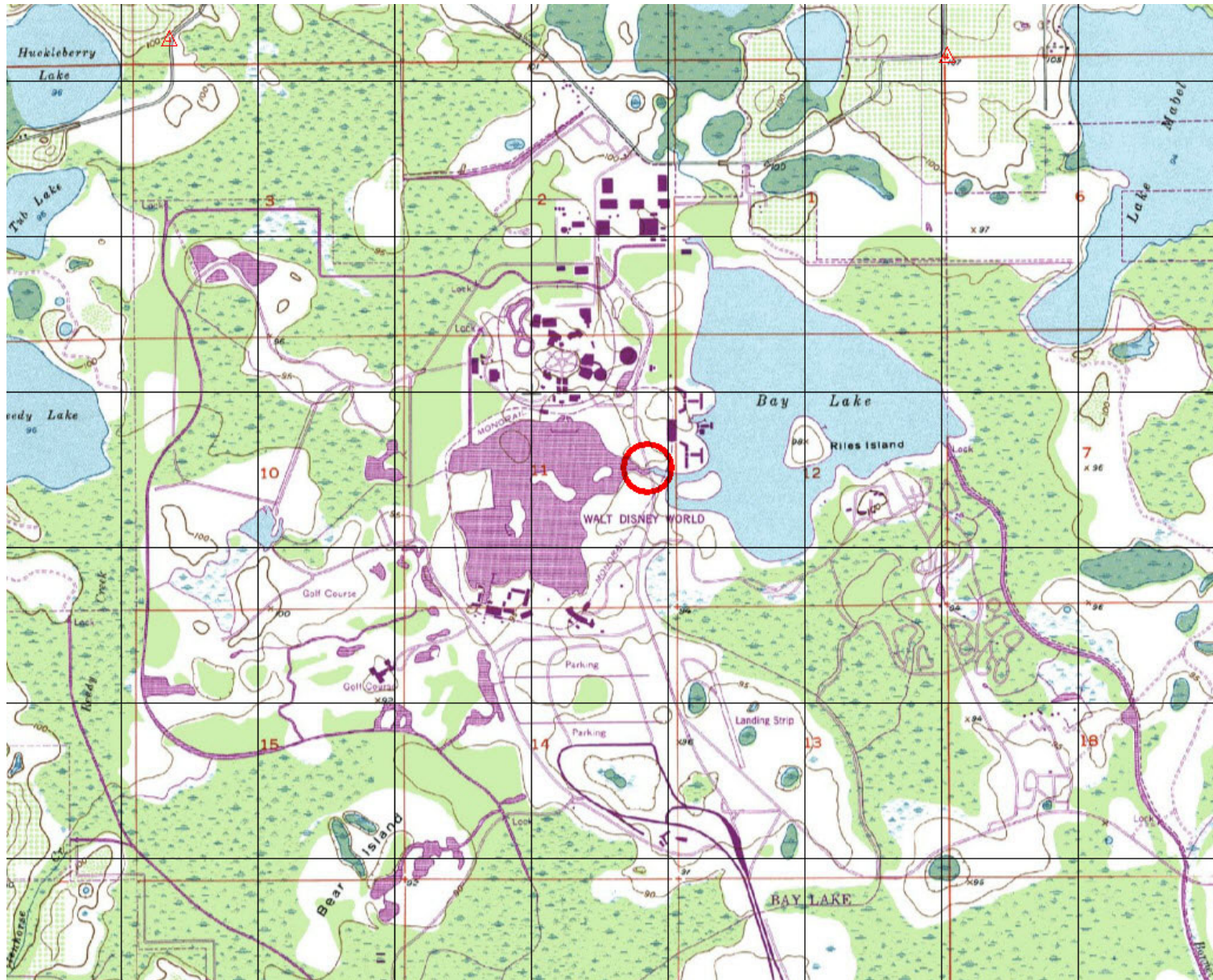
The slow downward erosion eventually forms small surface depressions 1 inch to several feet in depth and diameter.



COVER SUBSIDENCE – MORE SUBTLE LANDSCAPE IMPACT



KARST DOMINATED LANDSCAPE – CLOSED BASINS



USGS



SOIL DEPOSITS IN CLOSED BASINS

- Closed basins, no flushing out of organic detritus
- Plants grow, die, decay, repeat
- Tens of thousands of years-worth of organic material
- Muck!



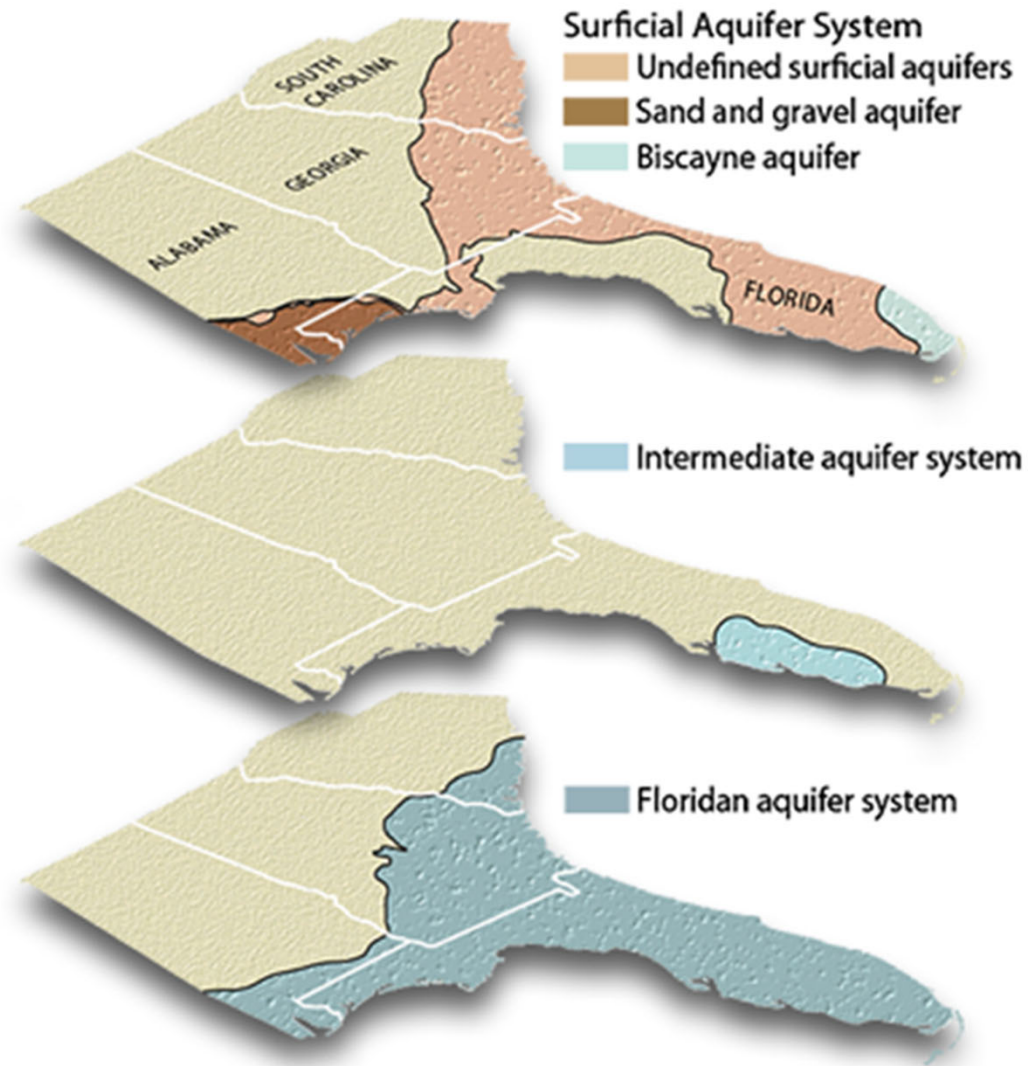
MUCK AS AN ENGINEERING MATERIAL

- Low strength
- High moisture content
- Compressible structure
- Decays in aerobic conditions due to microbial action
- Rule of thumb anything over 5% organic material by weight unsuitable for use as an engineered soil (5% by weight can equal 15% by volume)
- 5 to 10% organics can be OK as landscape fill

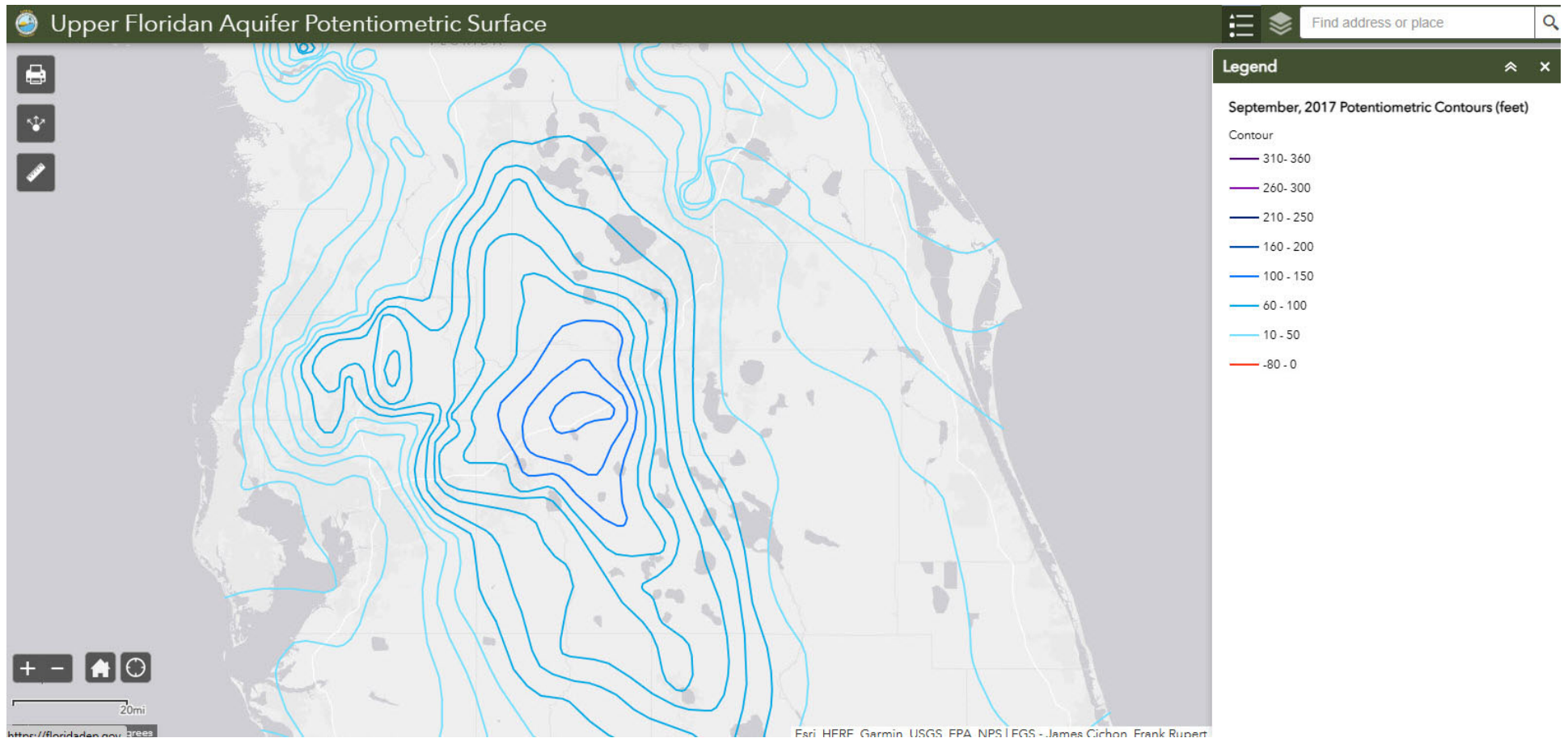


FLORIDA'S GROUNDWATER

Sequence of Aquifers



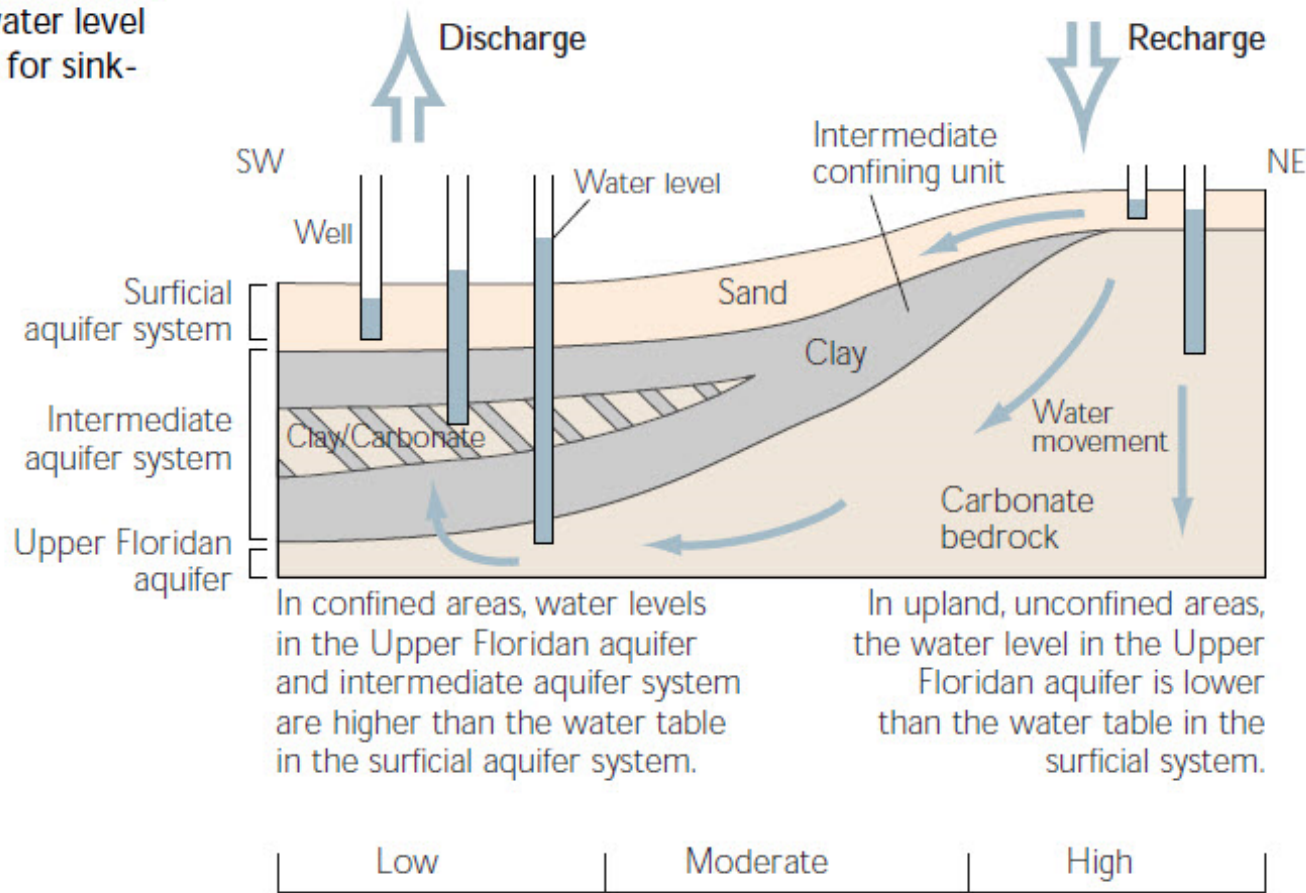
UPPER FLORIDAN AQUIFER IS SUB-ARTESIAN



Areas of **Recharge** in the higher elevations and **Discharge** in the lower elevations

GROUNDWATER GRADIENT GOVERNS SINKHOLES

The presence of a confining unit affects the water level and the potential for sinkholes.



Sinkhole potential

In discharge areas, upward ground-water flow helps provide bouyant support for overburden materials, and sinkholes rarely occur.

In recharge areas, where water movement is downward, sinkholes are more likely to occur.



IMPACTS UPON SITE DEVELOPMENT

- Groundwater control much harder in discharge areas than in recharge areas
- Recharge areas can have challenges due to water from the surficial aquifer concentrating into closed basins
- Breaching confining layers can lead to groundwater problems, springs, artesian groundwater at surface

Builders' creativity gets them in trouble

The Associated Press

OVIEDO — Highway builders learned the value of basketballs — but their construction innovation has gotten them into trouble.

Contractors on the Eastern Beltway in Central Florida said they used “spherical bladders” to plug natural water fountains on the construction project, but it turned out the bladders were deflated basketballs bought at K Mart.

Crews needed to plug about 10 artesian wells drilled under Lake Jesup while testing the foundation for a four-lane bridge.

So they deflated the balls, stuffed them down the holes and reinflated them to temporarily cork geysers gushing with enough pressure to shoot water 18 feet in the air. They followed up with a permanent concrete plug.

But the contractors are in trouble with regulators and environmentalists.

The basketballs were used on holes that were not wide enough to take wooden plugs.

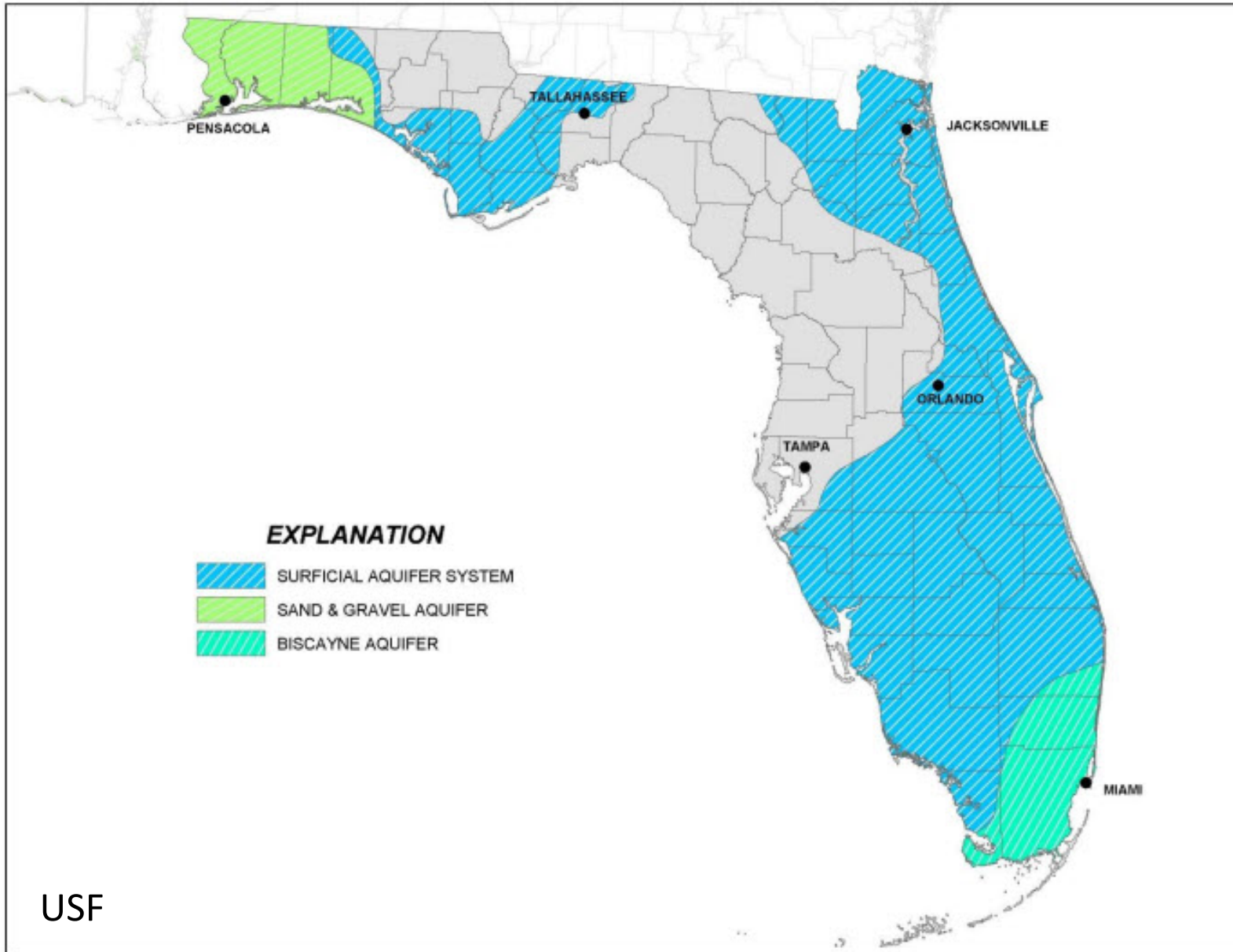
Gov. Lawton Chiles has asked the Transportation Department's chief internal auditor March 19 to investigate the Seminole County Expressway Authority, which launched the project before the state took it over last year.

“We don't wink an eye at environmental concerns,” said Florida's Turnpike Director Jim Ely. “I want the community to feel this is their project.”

Complaints also have led DER to take another look at whether the state should fill marshes near the lake's north shore with dirt.

Construction began five months ago on the beltway, which will extend from south Seminole County to Sanford when completed in December 1993.

SURFICIAL AQUIFER SYSTEM



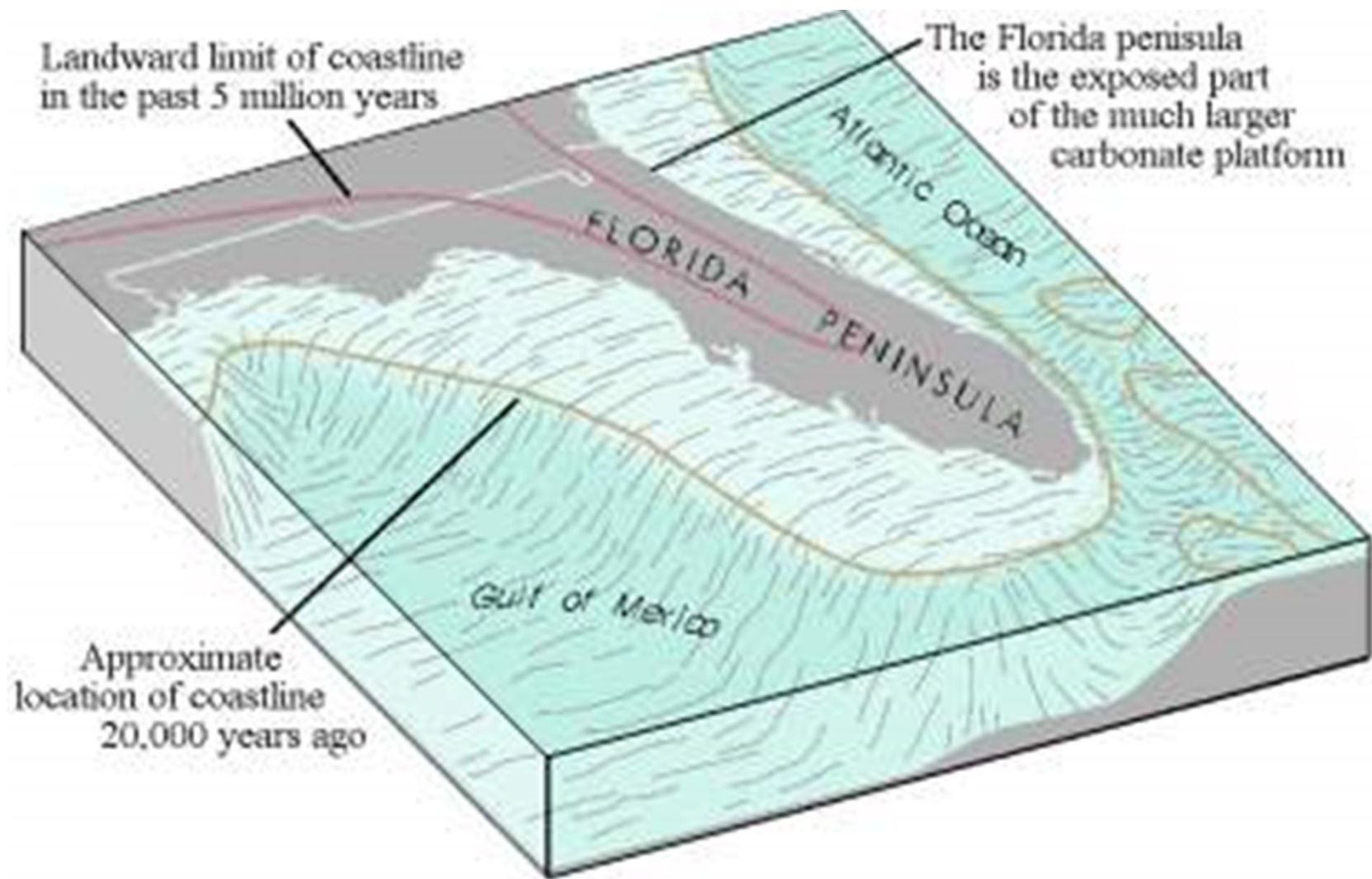
SANDS DEPOSITED 4 TO 8 MILLION YEARS AGO



NPS



SEA LEVEL CHANGE LAST 5 MILLION YEARS



DEPTH TO SEASONAL HIGH GROUNDWATER

- Decisions on wet or dry ponds traditionally governed by depth to SHGWT
- Surface water / groundwater nexus now considered more holistically – potential for infiltration or percolation of pollutants from stormwater to groundwater to a jurisdictional surface water



SHALLOW GROUNDWATER & PAVEMENTS



Minimum separation between shallow groundwater and base course ~18-inches for limerock ~12-inches for crushed concrete or soil cement. Or more..

WHERE DOES THE GEOTECHNICAL ENGINEER FIT IN?

The Geotechnical Engineer:

- Measures and assesses the types and distribution of soils and rocks on a project, identifies poor soils, deleterious fill, sinkhole risk.
- Measures shallow groundwater and predicts seasonal high conditions.
- Characterizes soil behavior and material properties and how to optimize soil performance.



WHAT ARE THE TOOLS WE USE?

- Desk study, research of published data, experience
- Geophysics – allow screening of large areas of land for lower cost
- Shallow testing – hand augers, hand penetrometers, determine shallow groundwater, redoximorphic features in the soil, seasonal groundwater variations
- Deep testing – Standard Penetration Test (SPT) borings, recover both a sample and a number
- Cone Penetration Testing (CPT) – only numbers but great precision, good tool for pile design

DESK TOP STUDY:

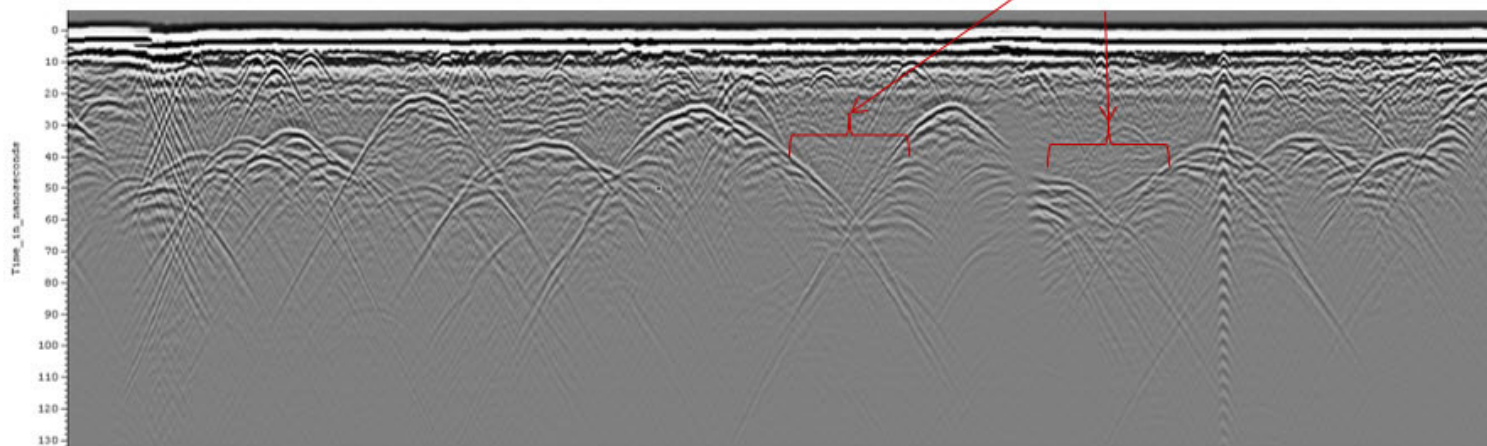
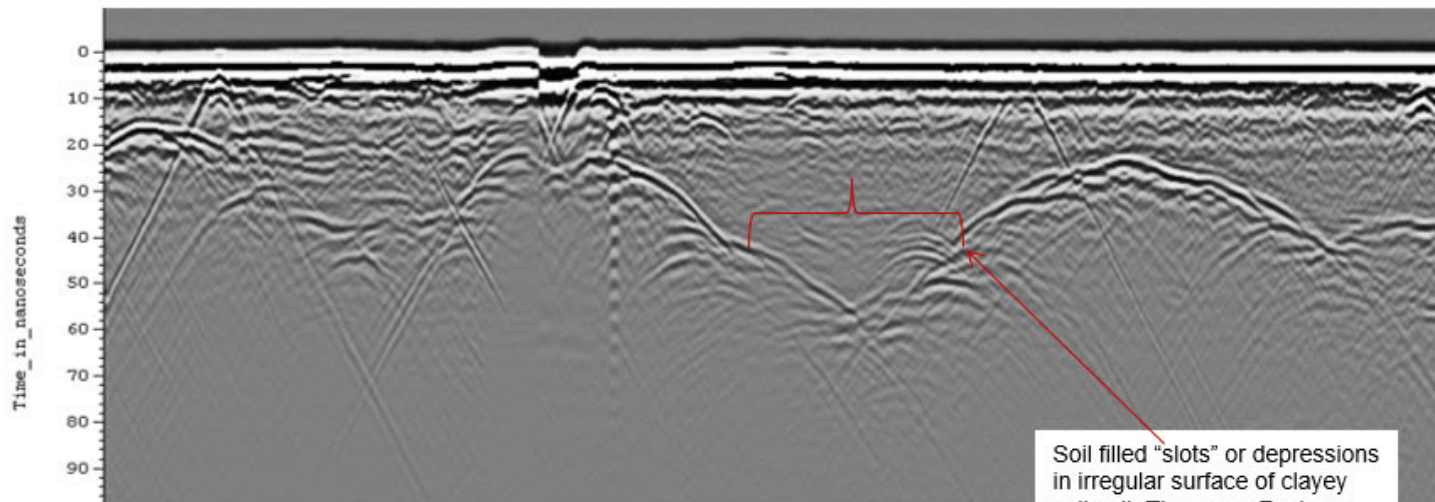


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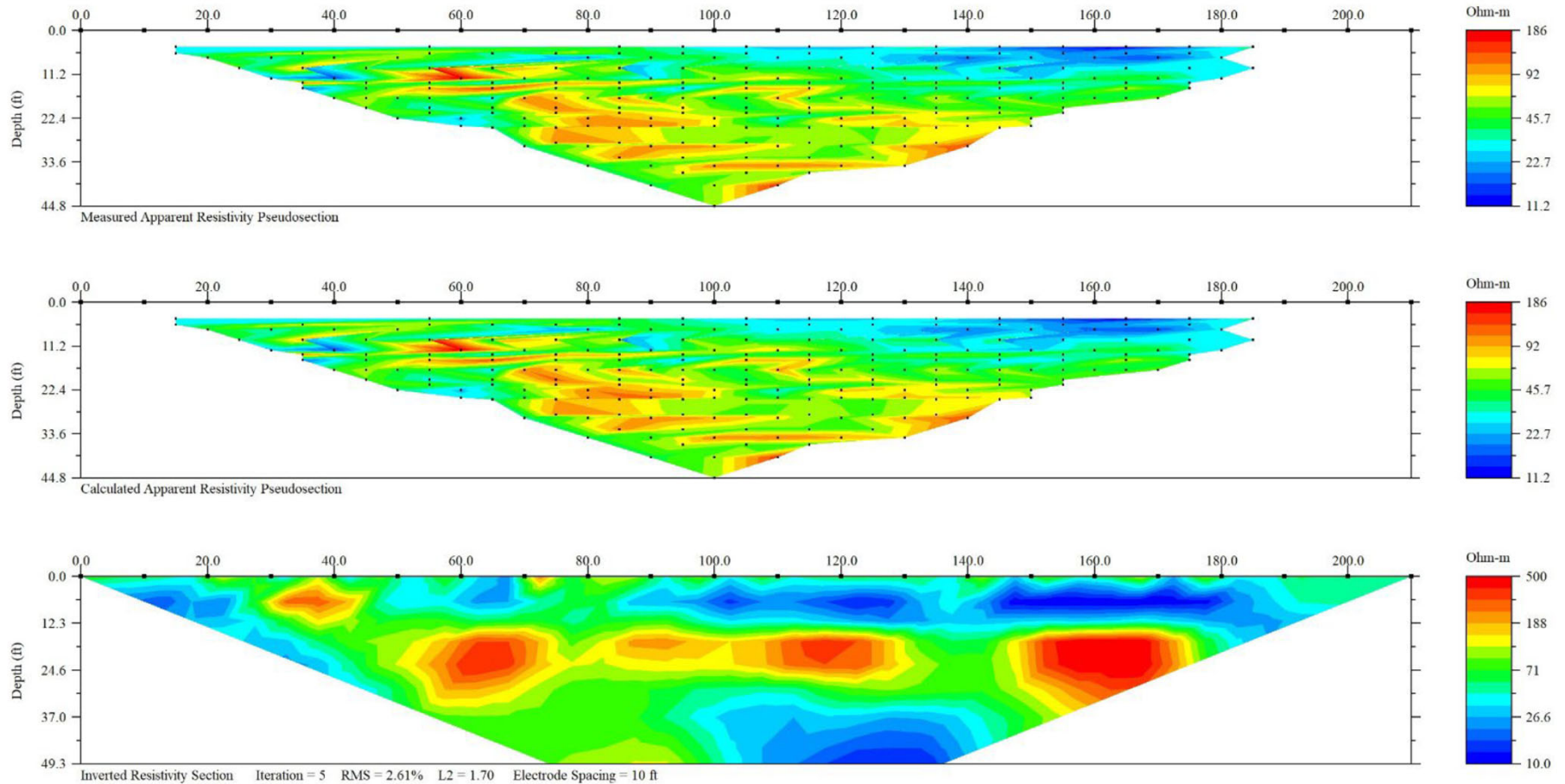
GEOPHYSICS – GROUND PENETRATING RADAR (GPR)

Undulating to broad overlapping convex reflective patterns



GEOPHYSICS – ELECTRICAL RESISTIVITY IMAGING (ERI)

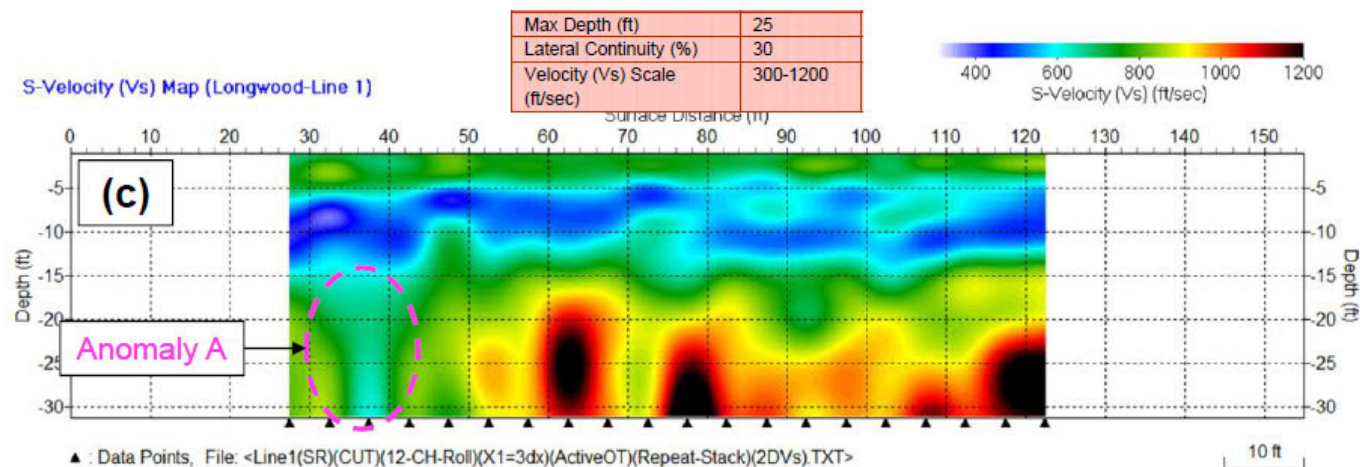
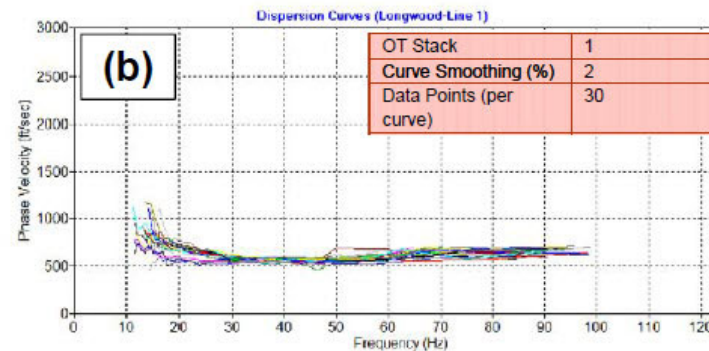
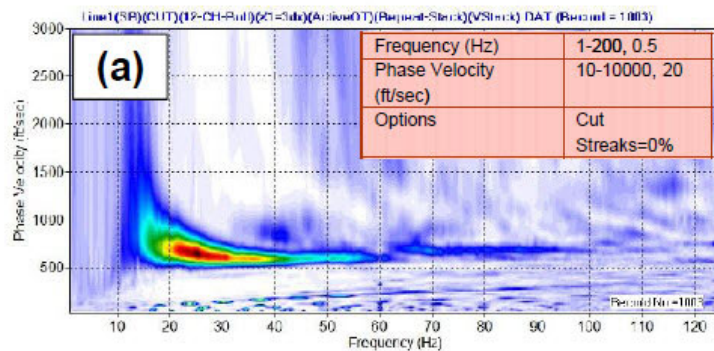
ERI Transect 3



GEOPHYSICS – SHALLOW SEISMIC (MASW)

Results - Line 1

(a) Average Dispersion Image, (b) Extracted Dispersion Curves, (c) Shear-Velocity (V_s) Cross Section



STANDARD PENETRATION TEST (SPT) BORINGS

- Borehole advanced by mud rotary techniques
- Periodic sampling and testing using split spoon sampler driven 18-inches into the ground using a 140 pound hammer dropped 30 inches
- Can be used to install instrumentation, monitoring wells, etc.



SPT DRILLING:



SPT DRILLING:



LABORATORY TESTING

- Soil classification – commonly wash #200 (% passing a #200 sieve) to determine relative clay/silt content and suitability of soil for re-use as fill
- Organic content by weight
- Atterberg Limits – clay soils, to determine plasticity, potential for shrinkage/swelling, pile design
- Constant Head / Falling Head Permeability – percolation rate for dry ponds to determine pond recovery time
- Corrosion test – pH and sulfate, sometimes chloride



QUESTIONS / DISCUSSION

