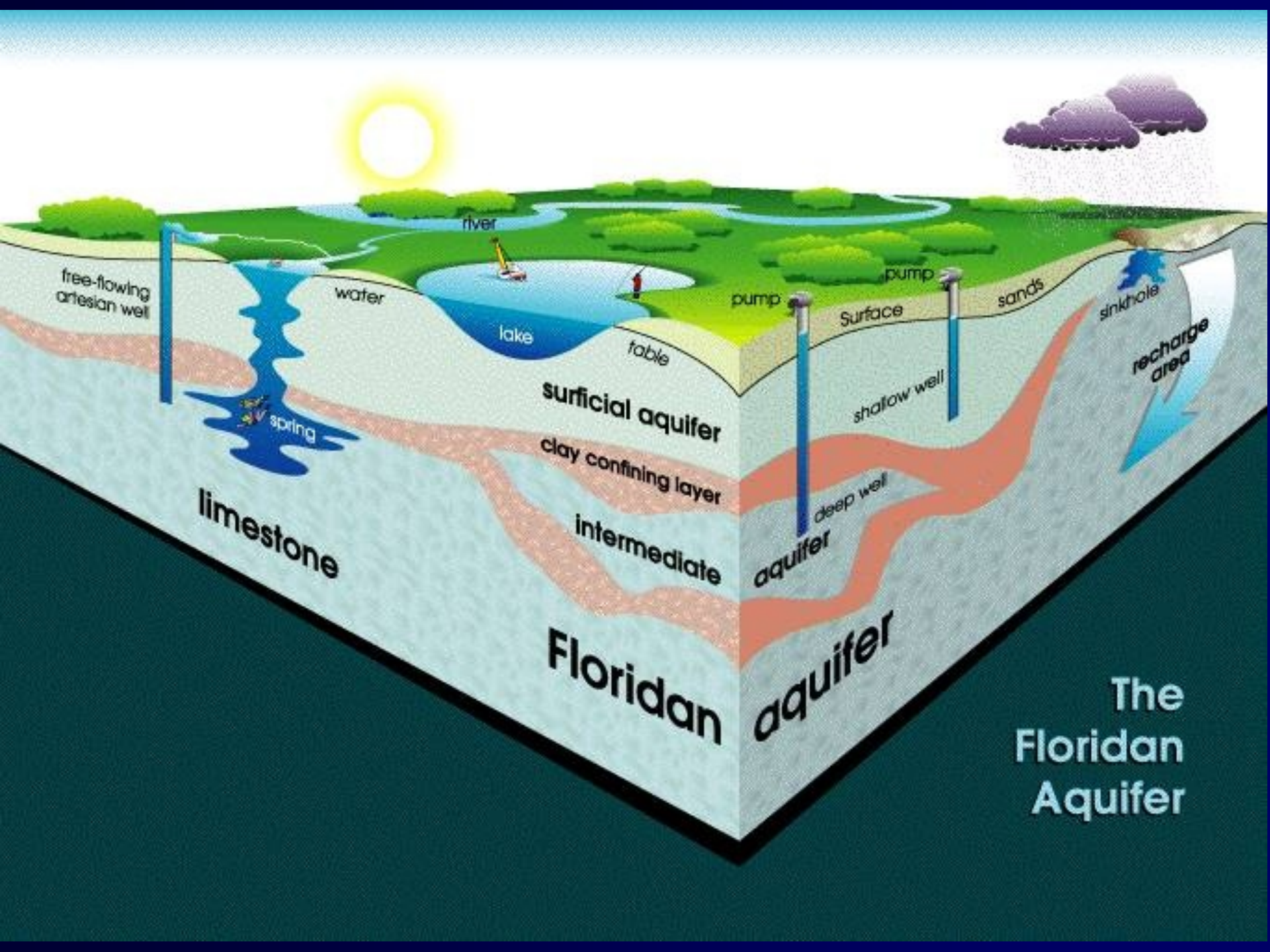
Florida Aquifer Geology

September 2016
Sampler Training Workshop

Thomas Seal, ES III
Watershed Monitoring Section (WMS)
Water Quality Assessment Program
DEAR Tallahassee


river
free-flowing
artesian well
water
lake
table
pump
pump
Surface
sands
sinkhole
recharge
area
spring
surficial aquifer
clay confining layer
shallow well
deep well
intermediate
aquifer
limestone
Floridan aquifer
The
Floridan
Aquifer

Aquifer Basics – Essential Definitions

An aquifer is a rock or sediment layer that contains and transmits ground water.

An aquitard is a rock or sediment layer that slows down or prevents ground water flow.

Porosity is the amount of pore (void) space between the grains of a rock or sediment sample. Porosity values range from 0% up to 35%.

Permeability is the ability of a sample to transmit ground water through interconnected pores. Permeability can be measured in the laboratory with a soil or even a rock (drill core) sample.

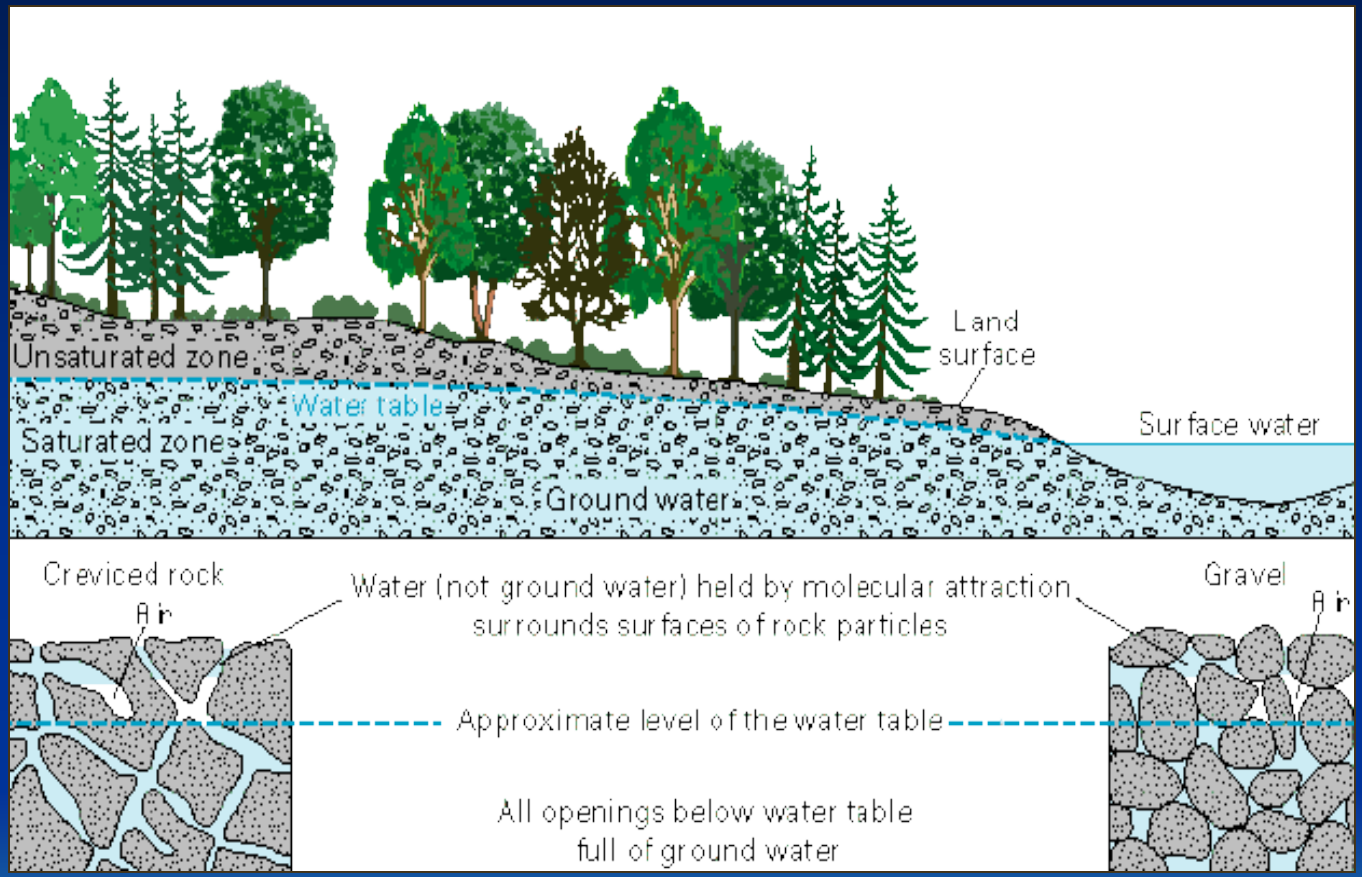
Aquifer Basics - Confined vs Unconfined

Ground water samples collected for the Status Network or the Ground Water Trend Network are from both unconfined and confined aquifers.

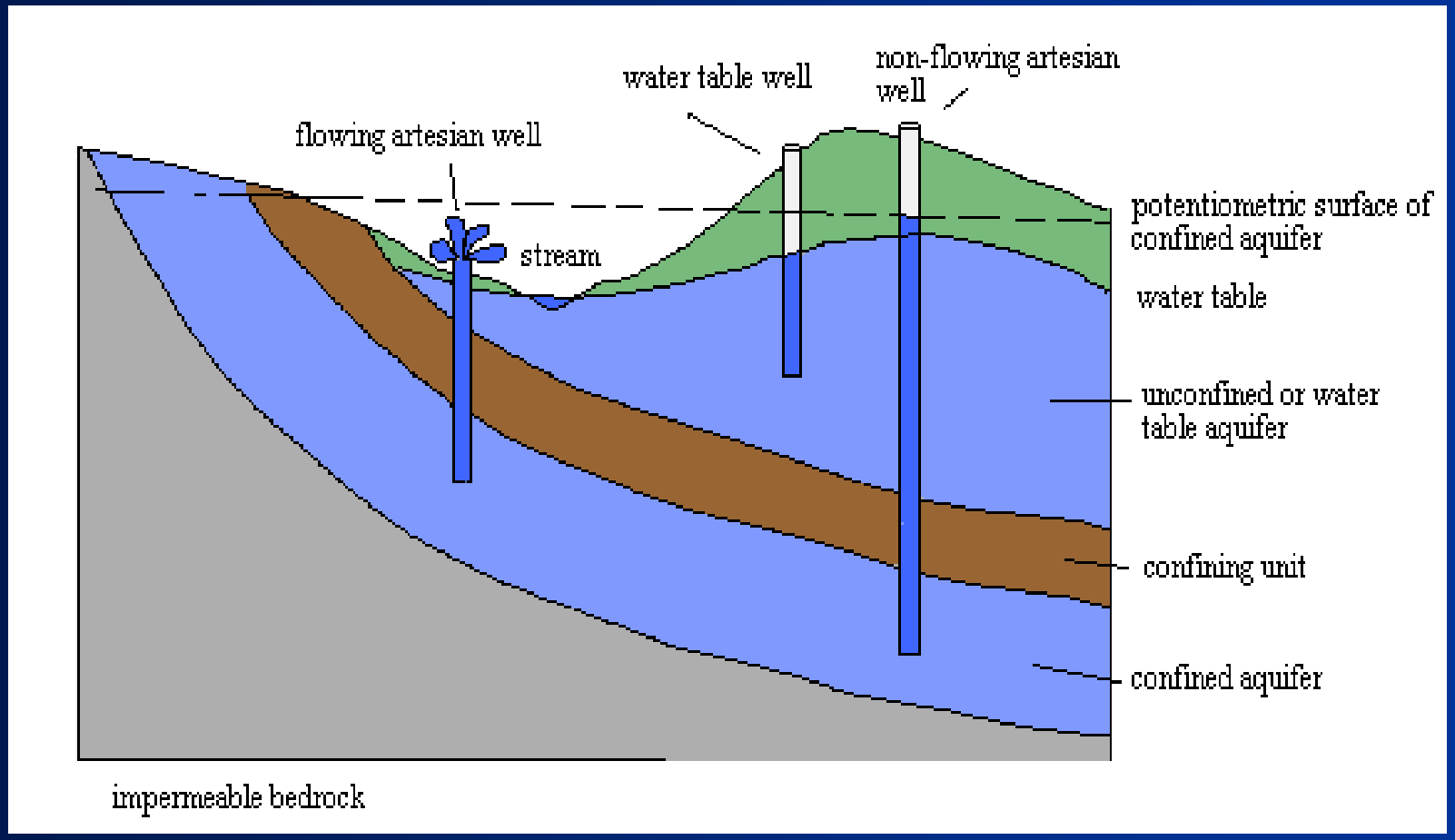
A confined aquifer is confined beneath an aquitard, whereas an unconfined aquifer has no overlying aquitard layer. Confined aquifers can build up (artesian) pressure.

A productive aquifer such as the Floridan aquifer in north Florida, or the Biscayne Aquifer in south Florida, has both high porosity and high permeability.

Unconfined Aquifer



Confined Aquifer



Aquifer Basics - Rock types

Hydrogeologists have defined at least (5) types of water-yielding aquifers in North America.

1. Sandstone aquifers – e.g., Oglala Aquifer, Great Plains, central US; Edwards Aquifer, Texas
2. *Carbonate rock (limestone, dolostone) aquifers – e.g., Floridan Aquifer, SE US; Biscayne Aquifer, S.FL
3. *Unconsolidated sand and gravel aquifers – SE Coastal Plain states) AR, LA, MS, AL, GA, TN
4. *Interbedded clastic (sand/silt) + carbonate aquifer common in south FL
5. Volcanic rock (basalt) aquifer – Washington state

*occurs in Florida's subsurface

Aquifer Basics - Rock Types

Carbonate rock (limestone, dolostone) aquifers are the most common and productive in Florida. The Floridan and Biscayne aquifers are best examples.

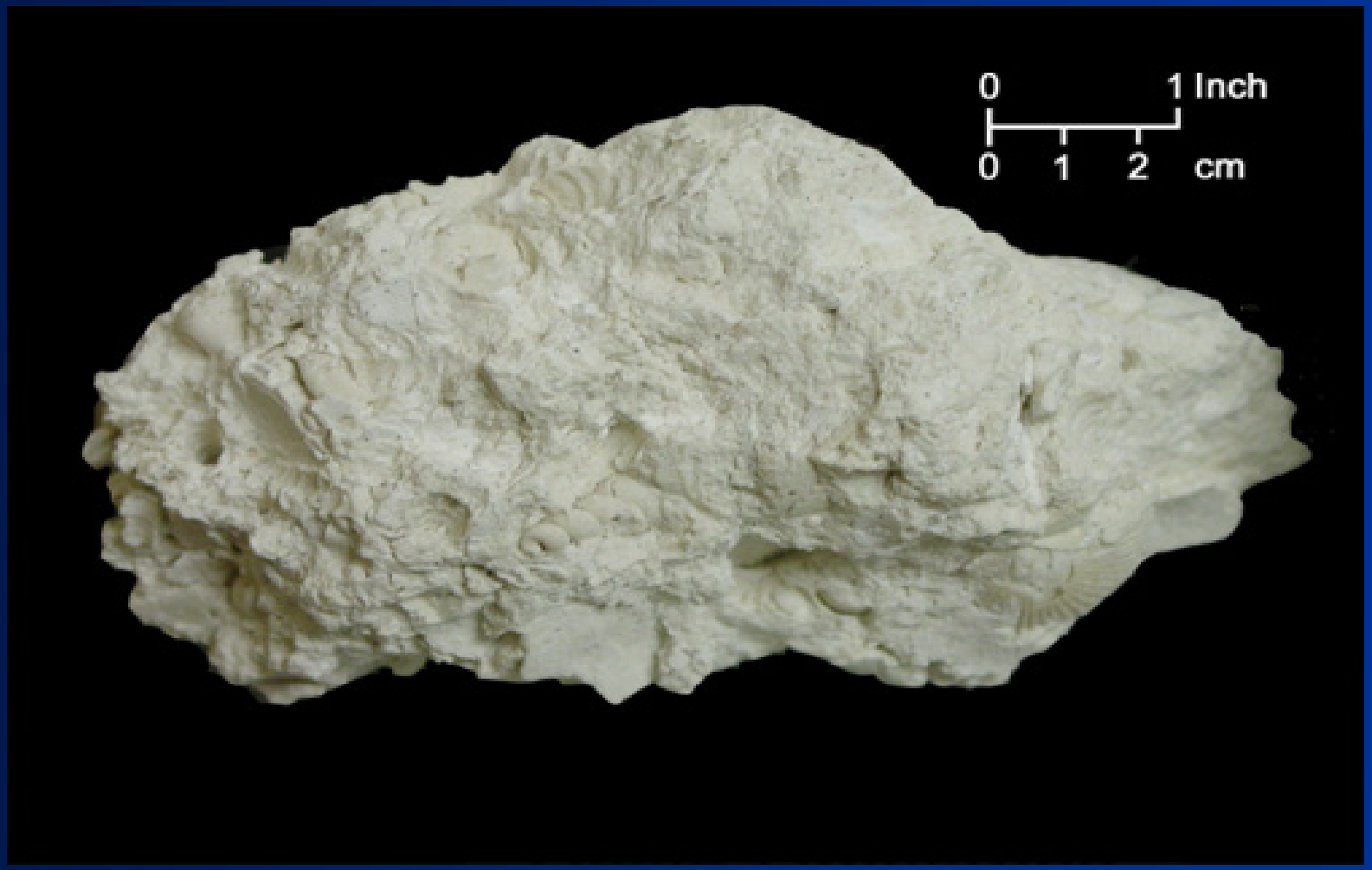
Carbonate rocks are made up almost entirely of calcite ($CaCO_3$) or dolomite ($CaMg(CO_3)_2$). These rocks originated as tropical carbonate sediments.

Over geologic time, acidic ground water creates many openings in carbonate rock layers. This process has gradually formed the productive (high porosity) aquifers of modern Florida.

Calcite – $CaCO_3$ – the mineral that makes up Florida limestone

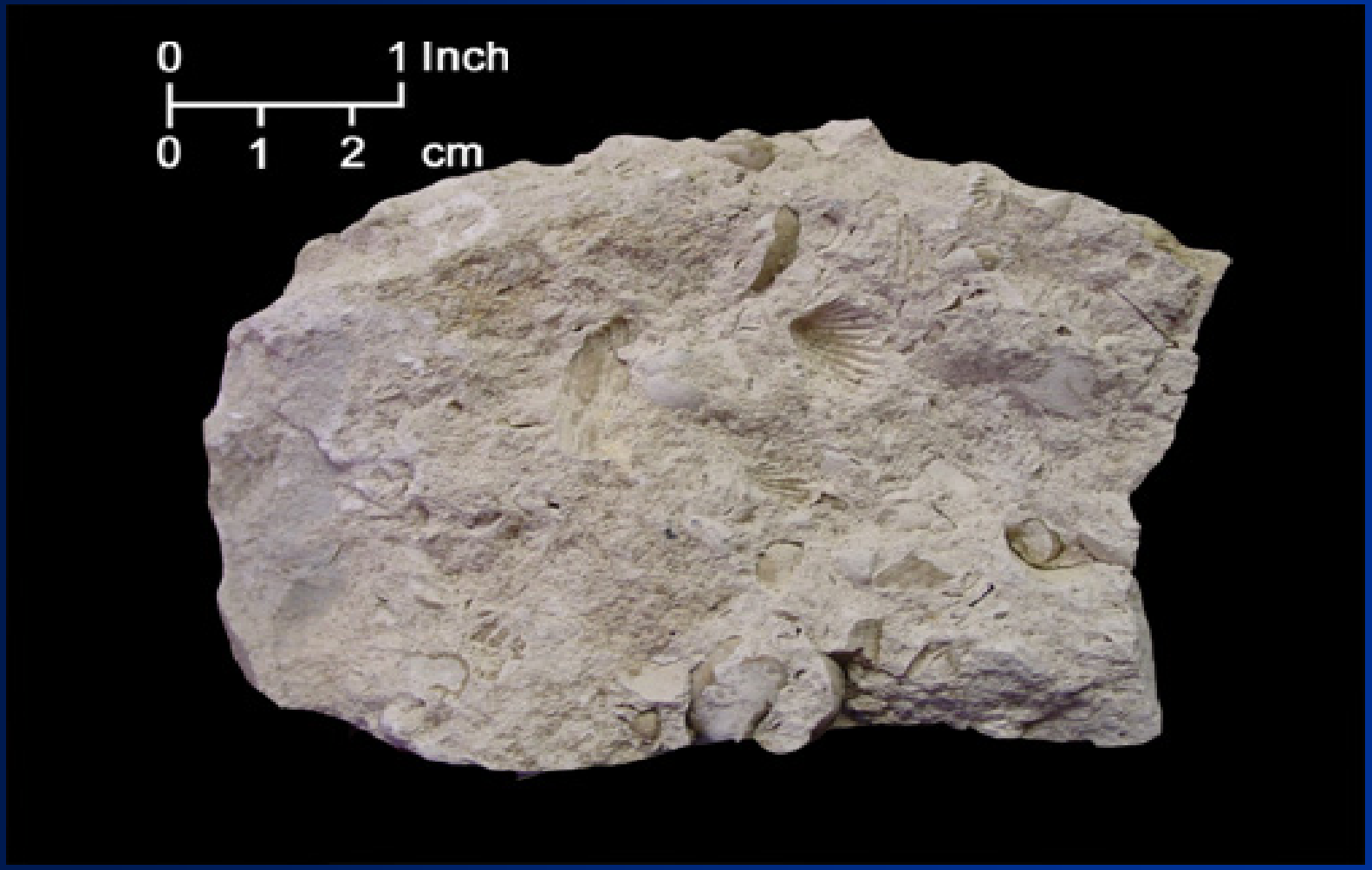
Locality: Citrus County, FL

Ocala Limestone – dominant carbonate rock in the Upper Florida Aquifer



Locality: Alachua County, FL

Avon Park Dolostone – dominant carbonate rock in Lower Florida Aquifer



Locality: Citrus County, FL

Coquina – common shallow aquifer rock in eastern and southern Florida

Locality: St. Johns County. FL

Locations of Florida's Major Aquifers

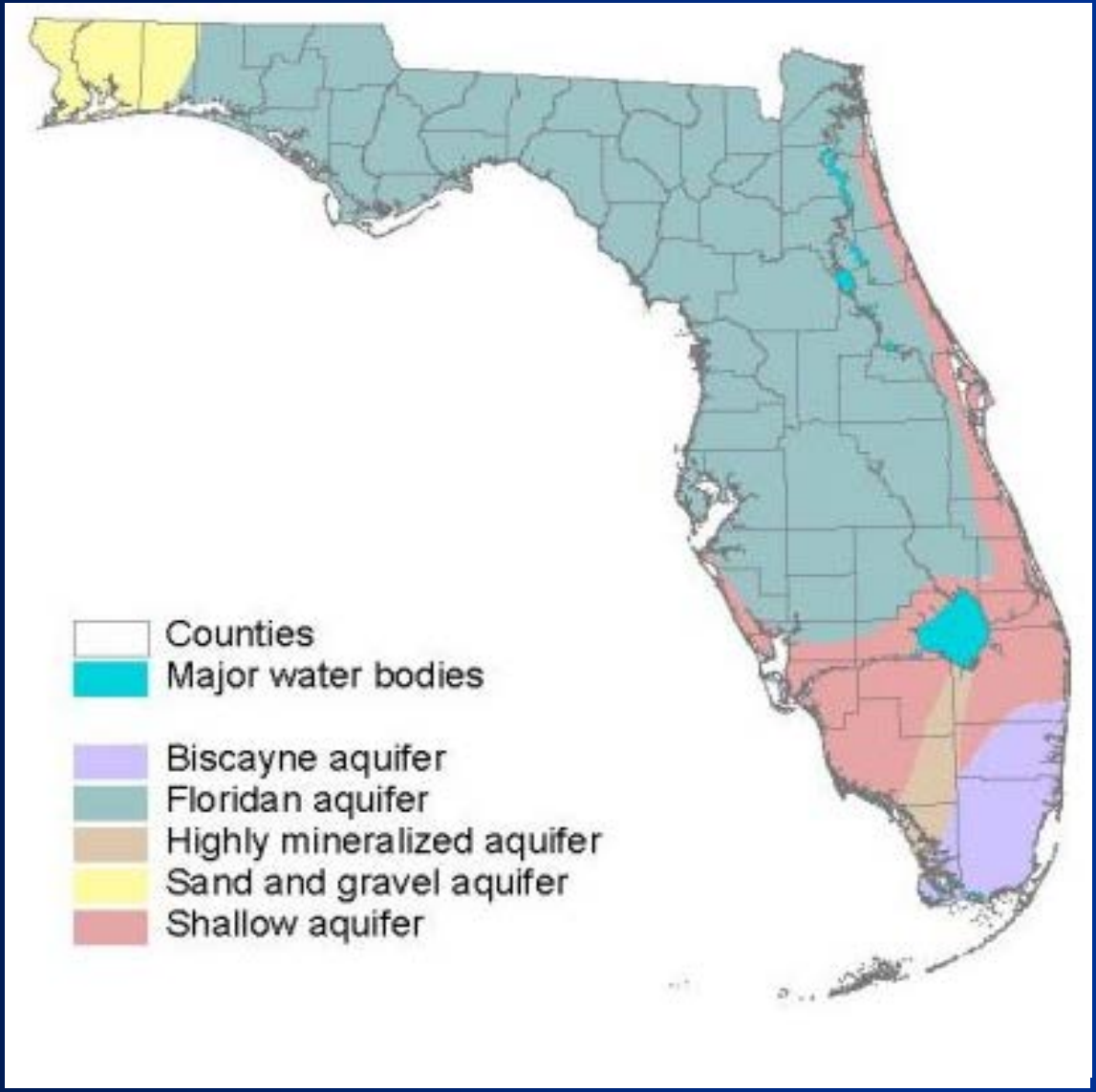
1. Sand and Gravel Aquifer - western panhandle

2. Floridan Aquifer - north/central Florida (carbonate)

3. Biscayne Aquifer - southeast Florida (carbonate)

4. Throughout the state, numerous unconfined aquifers are used for drinking water or agricultural activity. Sometimes these aquifers are referred to as surficial aquifers.

Aquifers of Florida



Aquifer Basics - Rock Types

Unconsolidated aquifers consist of layers of sand and gravel. The Sand and Gravel aquifer of the western panhandle, which starts west of the Apalachicola River in the Florida panhandle represents this type of aquifer. To produce enough ground water for urbanized areas (e.g., Pensacola) in this region, many shallow supply wells have to be drilled.

Aquifer Basics – Rock Types

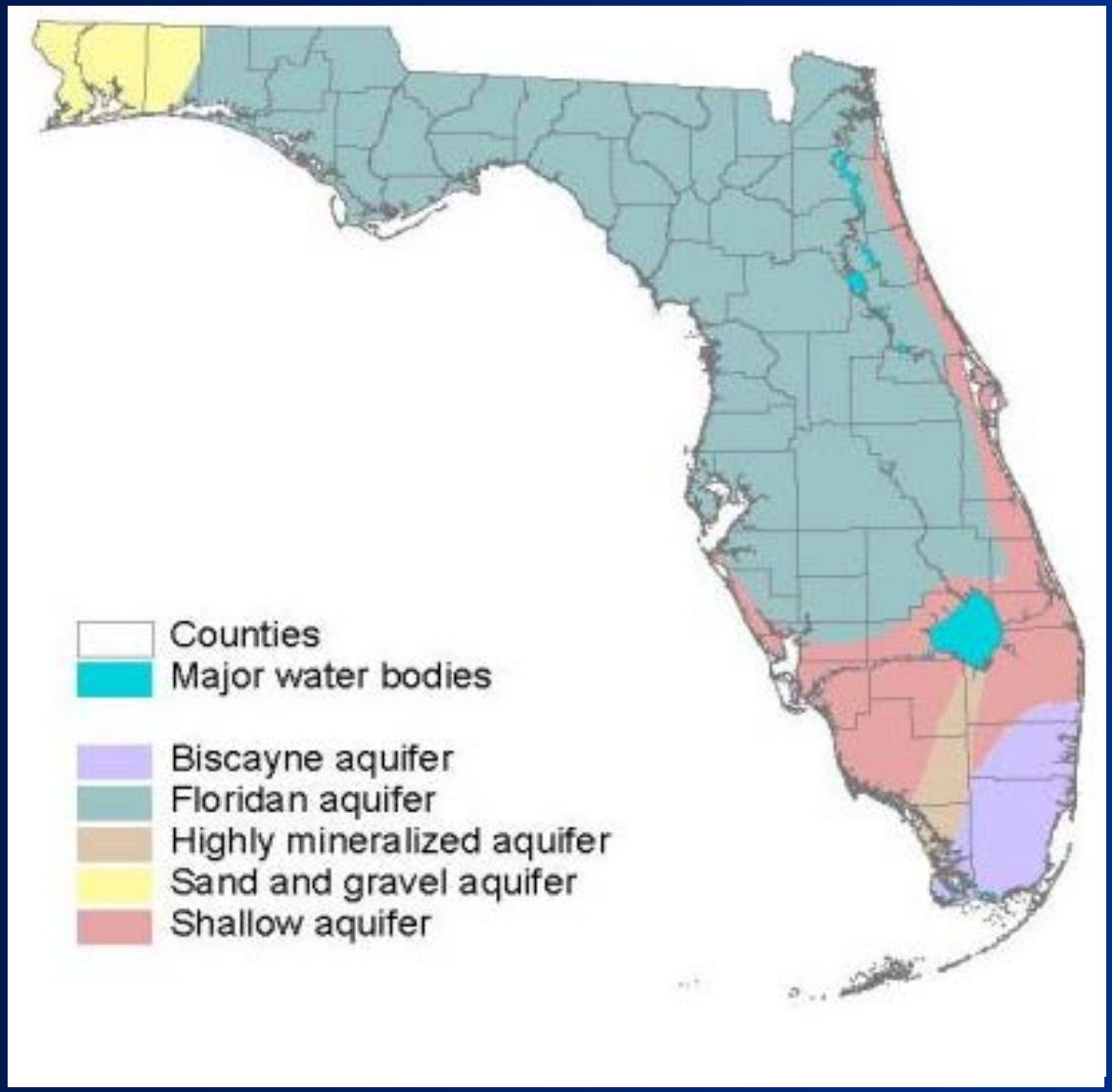
The Floridan aquifer is a carbonate rock aquifer found throughout north Florida, and south through most of the peninsula. It consists mainly of limestone and dolostone layers that range from 50 to 20 million years old. Some layers are hundreds of feet thick. Minor amounts of evaporite minerals (e.g., gypsum) are also present. In south Florida, the Floridan is too saline to use for potable or agricultural water sources.

Aquifer Basics - Rock Types

Interbedded clastic + carbonate aquifers consist of limestone and/or dolostone layers interbedded with layers of partially cemented sand, silt and clay. Much of southern Florida has this type of aquifer.

Few of these aquifers are given formal names, although their local presence is well documented by WMD, FGS, and USGS geologists and hydrologists.

Aquifers of Florida

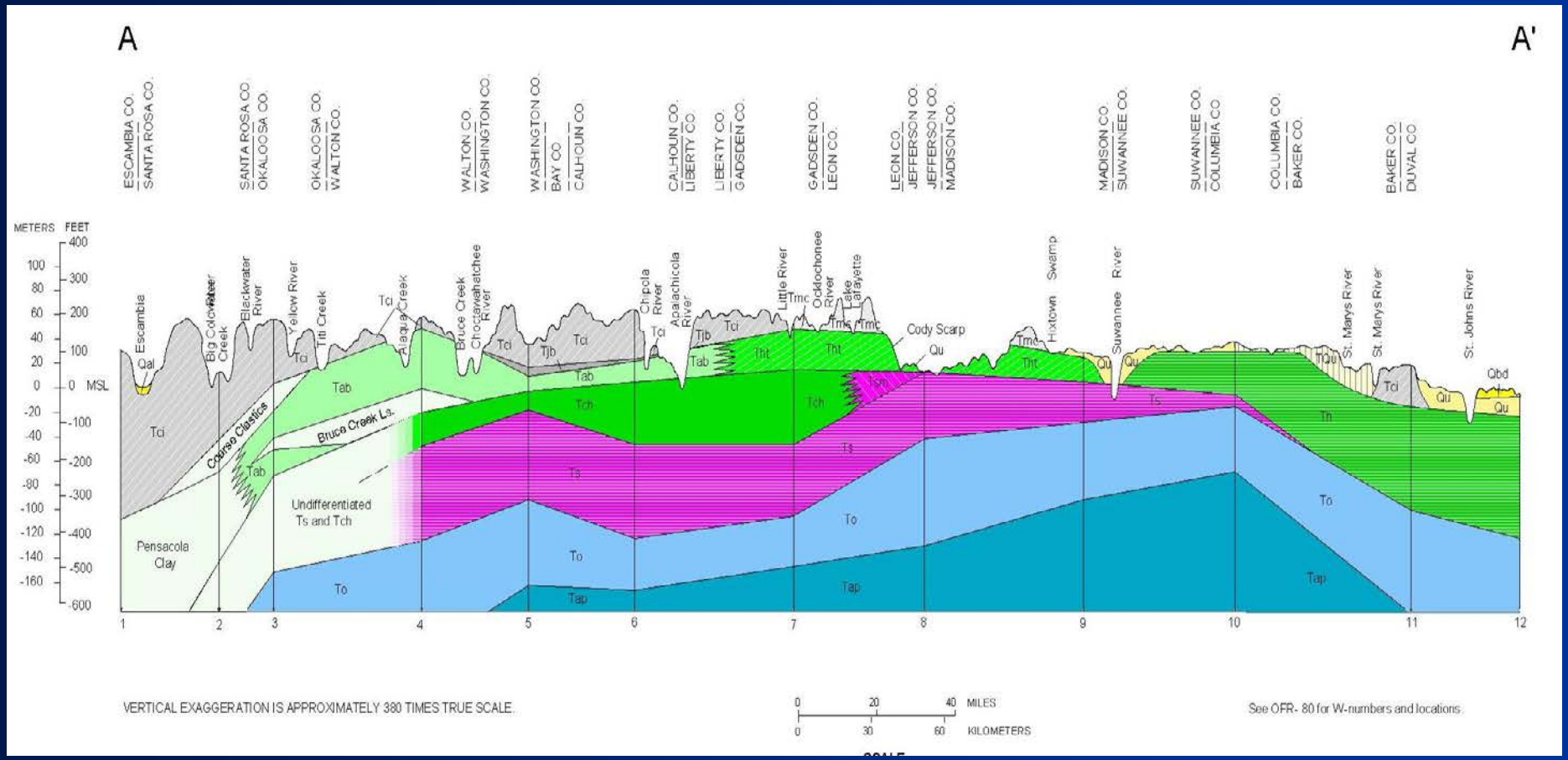


For next two slides, which are geological cross-sections, the A - A' cross-section extends from

1) Pensacola to Jacksonville

2) Lake City to Miami

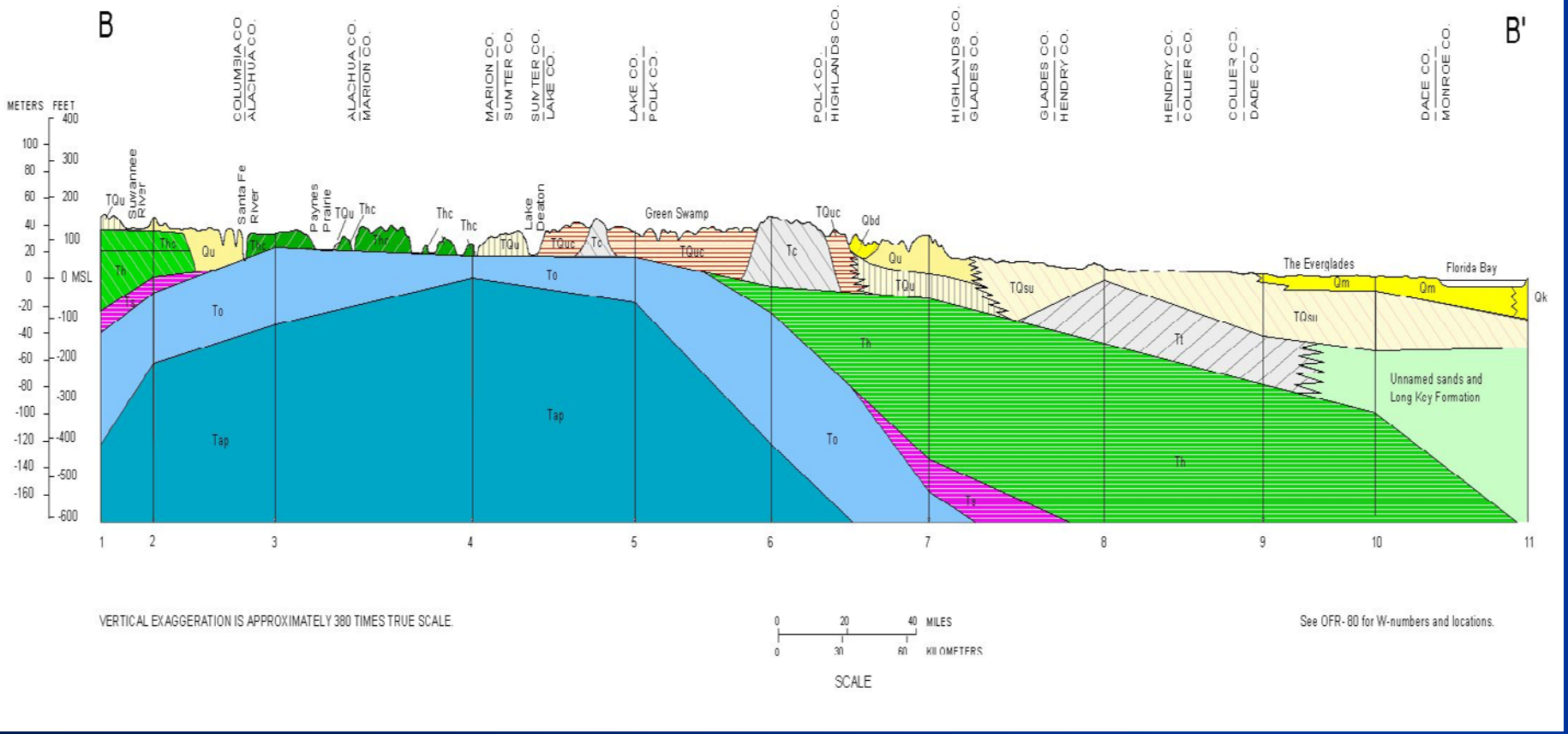
East-West Geologic Cross Section



Pensacola

Jacksonville

North-South Geologic Cross Section



Lake City

Miami

Ground Water Chemistry

Water is described as the universal solvent, because over geologic time, water dissolves minerals (even quartz) given enough time.

Carbonate minerals, such as calcite and dolomite, are especially susceptible to dissolution.

Thus ground water contains, in the dissolved fraction, ions/compounds such as calcium (Ca^{2+}), magnesium (Mg^{2+}), potassium (K^{+}), chloride (Cl^{-}), bicarbonate (CO_3^{2-}), sodium (Na^{+}), sulfate (SO_4^{2-}).

Ground Water Chemistry

Water is not considered drinkable (pōtable) if the quantity of dissolved minerals (total dissolved solids) exceeds 1,000 mg/l (milligrams/liter).

Slightly saline water with a few thousand mg/l dissolved minerals is sometimes used in areas of Florida where less-mineralized water is not available.

Ground Water Chemistry

Definitions of water hardness vary, but water is considered soft if it contains <75 mg/L as $CaCO_3$; moderately hard from 75-150 mg/L, hard between 150-300 mg/L, and very hard if >300 mg/L as $CaCO_3$

Very hard water is not desirable for domestic uses, as it leaves a scale inside pipes, boilers, and tanks. Hard water can be softened, though some hardness filters add sodium to the water.

Typical Floridan Aquifer and Sand and Gravel Aquifer Water Chemistry

These ground water data are in mg/Liter, which is equivalent to parts per million. Note how the host rock affects water chemistry.

Aquifer	Calcium	Magnesium	Iron	Sodium	Bicarbonate
Floridan	52	15	0.2	11	146
Sand/Gravel	4	1	2	5	5

Ground Water Chemistry

The pH test is an acidity test of water, and has a scale from 0 to 14. A pH value of 7 indicates neutral water; greater than 7, the water is basic; less than 7, it is acidic.

Many water wells in the Panhandle have naturally low pH values (below 5.0). Florida Panhandle well water samples, especially if acidic, may contain excessive amounts of iron, which can stain plumbing fixtures. Like hardness, excessive iron can be reduced by treatment.

Typical Floridan Aquifer and Sand and Gravel Aquifer Field Analytes

Aquifer	pH	Conductance	Temp
Floridan	7.4	385	22°C
Sand/Gravel	4.9	50	24°C

All ground water typically has low dissolved oxygen values due to limited contact with the atmosphere. Many springs, when they first exit the aquifer, have low dissolved oxygen values.

Ground Water Chemistry

Ground water is (usually) less susceptible to bacterial contamination than surface water because it flows through rock or sediment that screen out bacteria. Most surface water bacteria do not survive long in ground water. But changes in ground water quality, particularly shallow ground water, can occur as a result of human activities.

Ground Water Quality Problems

The growth of population (20,270,000 in 2015), industry, agriculture, and the corresponding increased water use, stresses the state's ground water resources.

Municipal and industrial wastes, along with fertilizer, herbicides, and pesticides, have infiltrated some aquifers and locally degraded ground water.

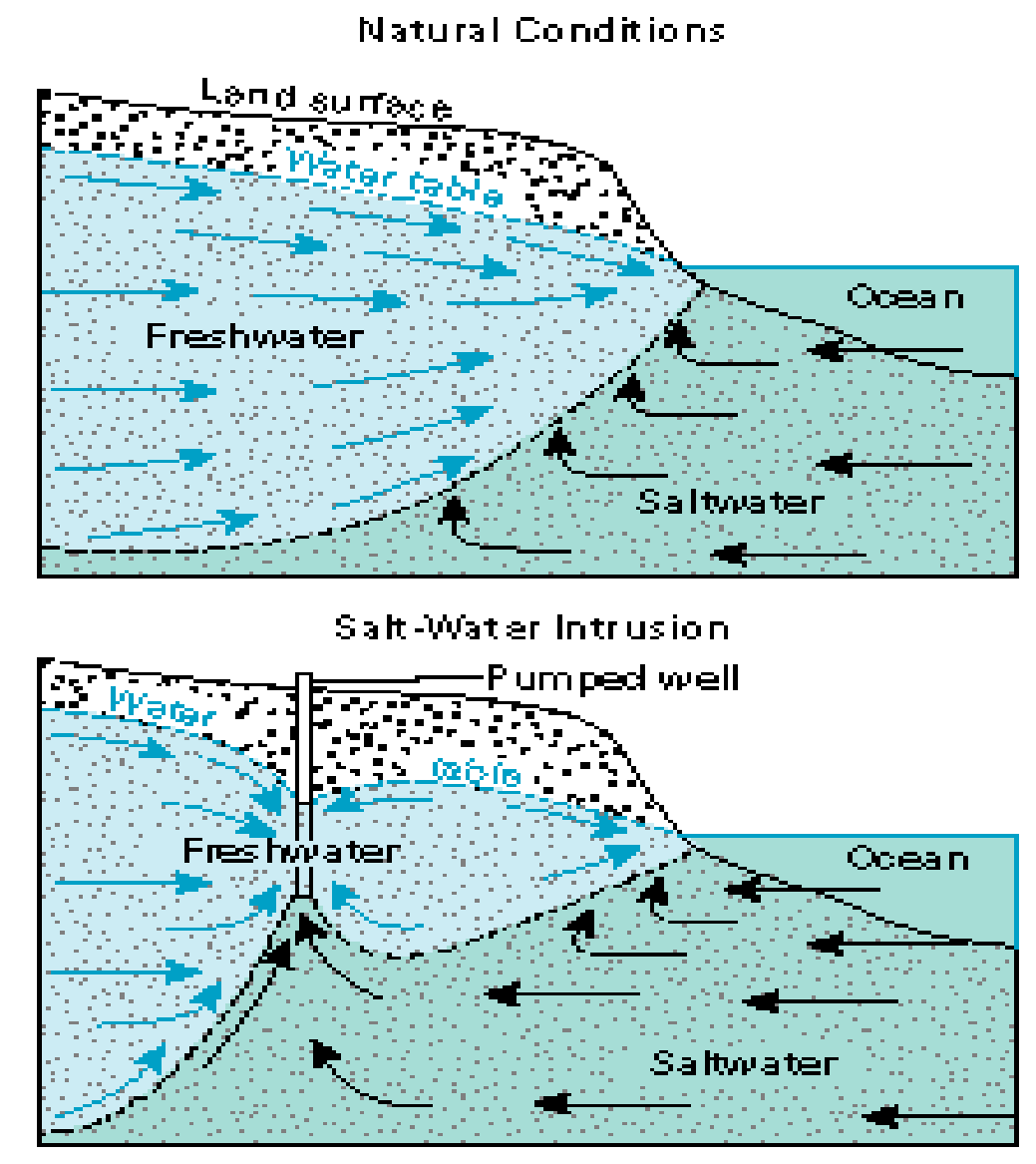
Other problems include underground sewer pipe leakage, faulty septic tanks, landfill leachate, and reduced recharge areas due to development.

Ground Water Quality Problems

In some Florida coastal areas, ground water pumping has caused salt water to intrude into freshwater aquifers. This process is monitored to greater or lesser degrees, by the USGS, the DEP and the five Water Management Districts.

In 2011, the WMS Section staff (specifically Rick Copeland) began the Florida Salinity Network, in an effort to coordinate the data flow from around the state to address this critical problem.

Salt Water Intrusion



Counties with real or potential salt water intrusion problems

Dade

Palm Beach

Broward

Levy

Manatee

Hillsborough

Duval

Walton

The End