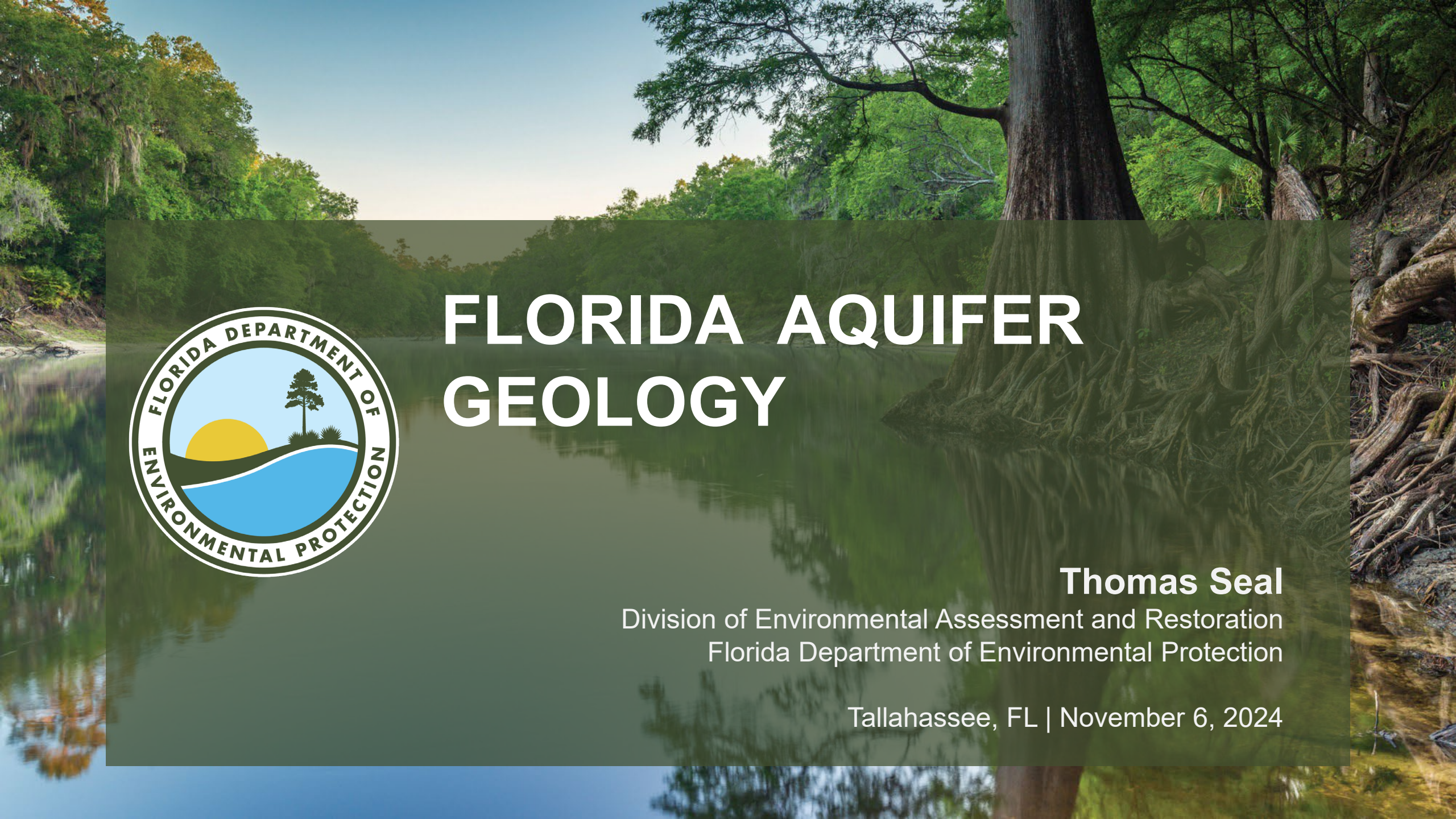

FLORIDA AQUIFER GEOLOGY

Thomas Seal
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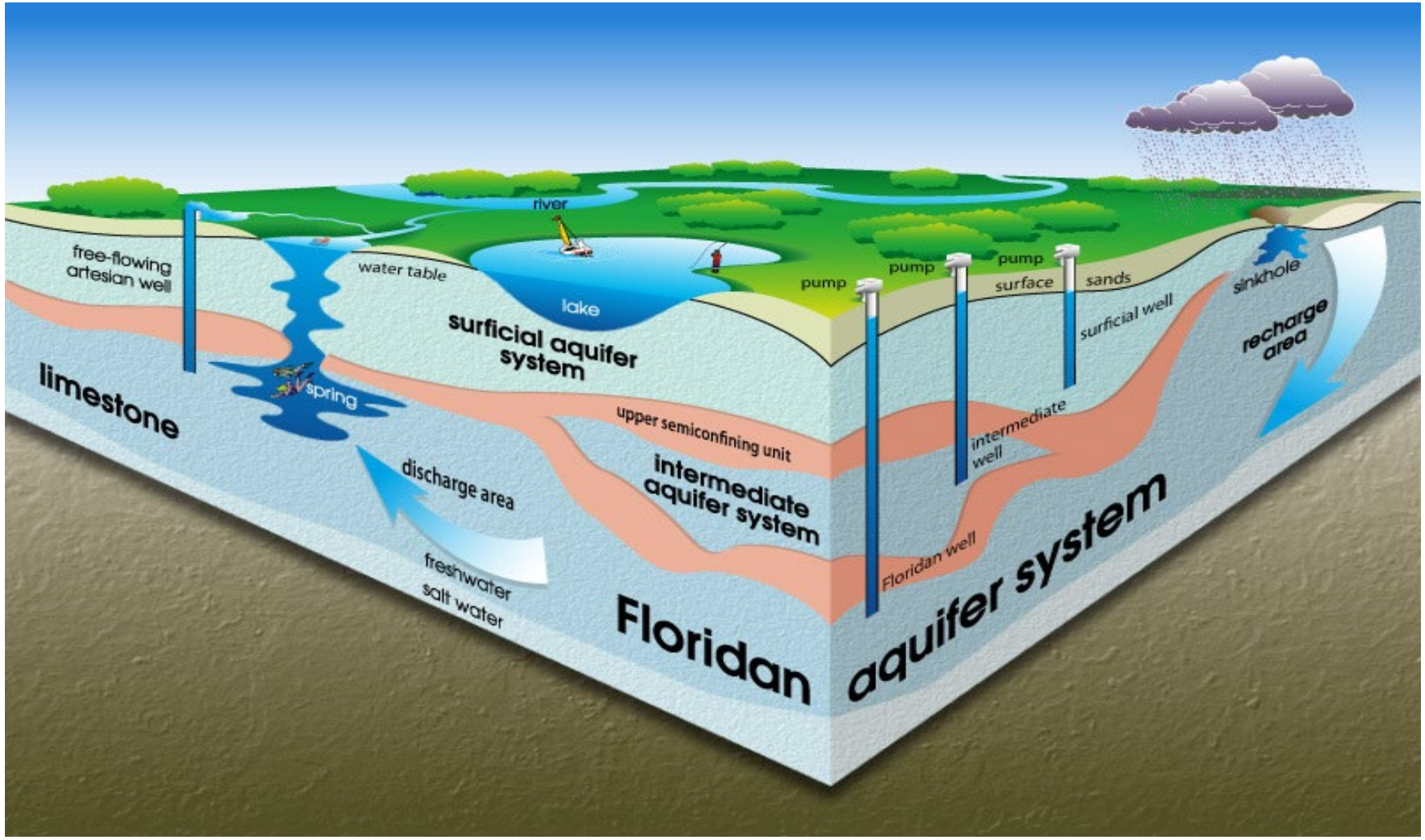
Florida Department of Environmental Protection

Tallahassee, FL | November 6, 2024

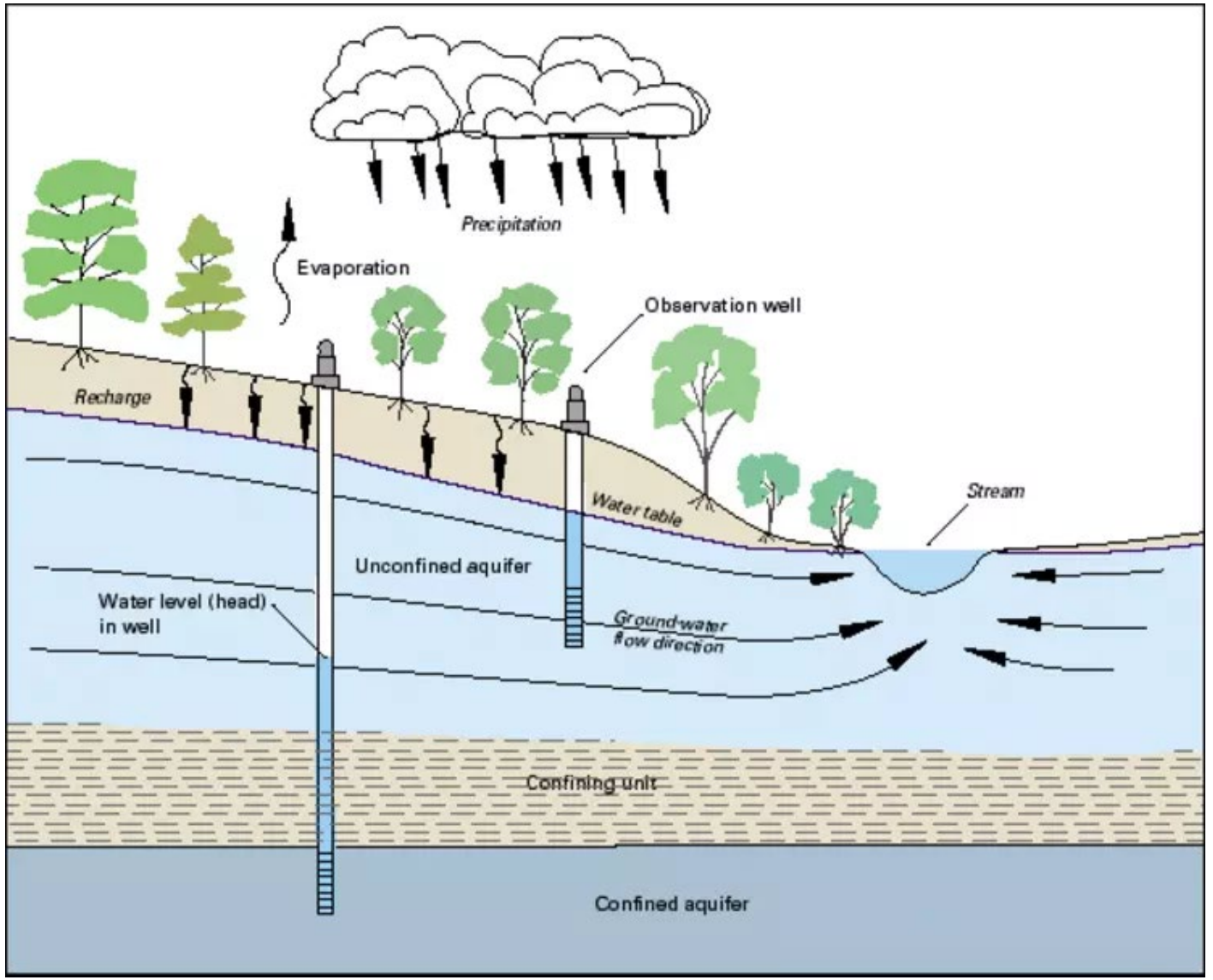
FLORIDA AQUIFER GEOLOGY



AQUIFER BASICS
ESSENTIAL DEFINITIONS

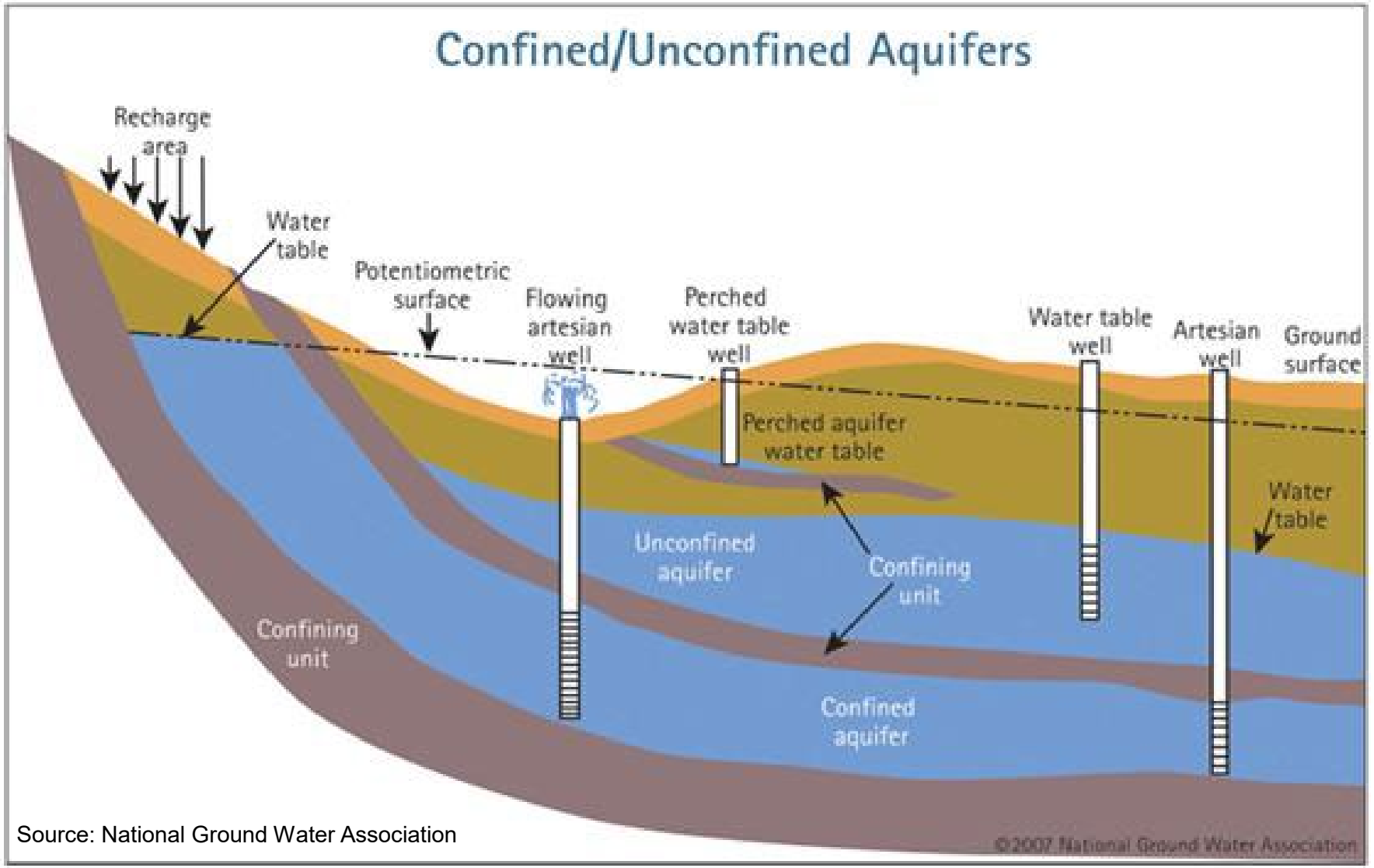
- An aquifer is a rock or sediment layer that contains and transmits groundwater.
- An aquitard is a rock or sediment layer that slows down or prevents groundwater flow.
- A confined aquifer is confined beneath an aquitard, whereas an unconfined aquifer has no overlying aquitard layer. Confined aquifers build up (artesian) pressure due to the force of gravity.
- Groundwater samples collected for the Status Network and the Groundwater Trend Network are from both unconfined and confined aquifers.

UNCONFINED AQUIFER



Source: Carleton College, Minnesota Science Education Resource Center.

CONFINED AQUIFER



Source: National Ground Water Association

AQUIFER BASIC TERMS

- 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 groundwater through interconnected pores. Permeability can be measured in a rock (drill core) sample in the laboratory.
- A productive aquifer such as the Floridan aquifer in north and central Florida, or the Biscayne aquifer in south Florida, has both high porosity and high permeability.

AQUIFER BASICS

ROCK TYPES

Hydrogeologists have defined at least five types of water-yielding aquifers in North America. An "*" indicates the aquifer type occurs in Florida.

1. Sandstone aquifers – Ogallala Aquifer, central US; Wilcox Aquifer, western TN.
2. Carbonate rock* (limestone, dolostone) aquifers – Floridan aquifer, southeastern USA; Biscayne Aquifer, southern FL.
3. Unconsolidated sand and gravel aquifers* – southeastern Coastal Plain states such as AR, LA, MS, AL, and FL.
4. Interbedded clastic (sand/silt) + carbonate aquifer* – common in south FL.
5. Volcanic rock (basalt) aquifer – Washington state.

AQUIFER BASICS

ROCK GEOCHEMISTRY

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

Carbonate rocks are made up of **calcite** ($CaCO_3$) or **dolomite** ($CaMg(CO_3)_2$). Over time, acidic groundwater creates openings in carbonate rock, thus forming Florida's productive (high porosity) aquifers.

$$CO_2 + H_2O \Rightarrow H_2CO_3 \Rightarrow H^+ + HCO3^-$$

$$H_2O + H^+ \Rightarrow$$

$$2H_3O^+ (aq) + CaCO_3 (s) \Rightarrow Ca^{2+} (aq) + 3H_2O + CO_2 (g)$$

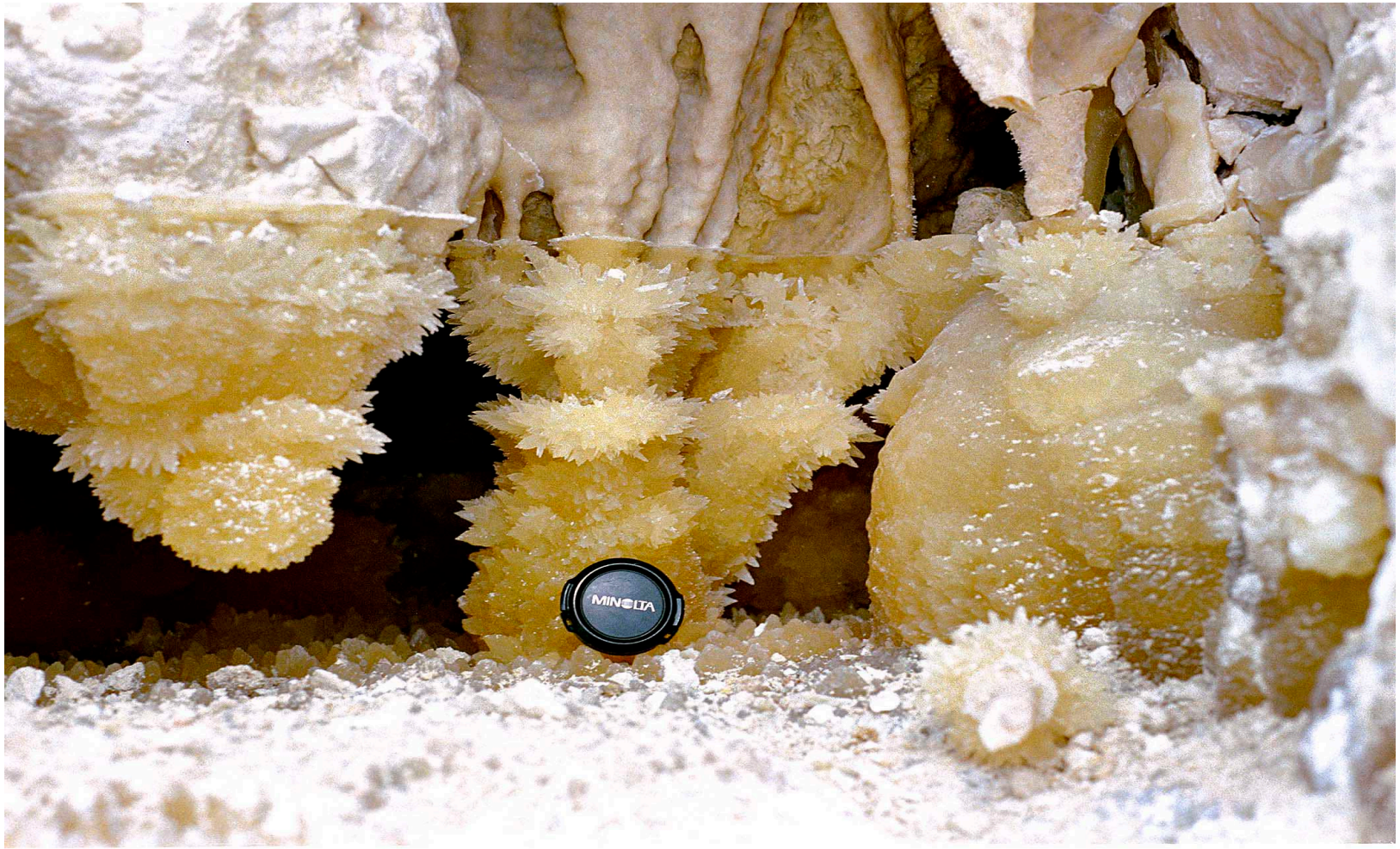
CO_2 = carbon dioxide
H_2CO_3 = carbonic acid
H_2O = water
HCO_3^- = Bicarbonate ion
H_3O^+ = hydronium ion
Ca^{2+} = calcium ion
Mg = magnesium
$CaCO_3$ = calcite mineral formula
Ca = calcium
$CaMgCO_3$ = dolomite mineral formula
aq = aqueous s = solid g = gas

CALCITE

THE MINERAL THAT FORMS LIMESTONE

CALCITE

THE MINERAL THAT FORMS LIMESTONE



Locality: Lecanto, Citrus County, Florida.

CALCITE

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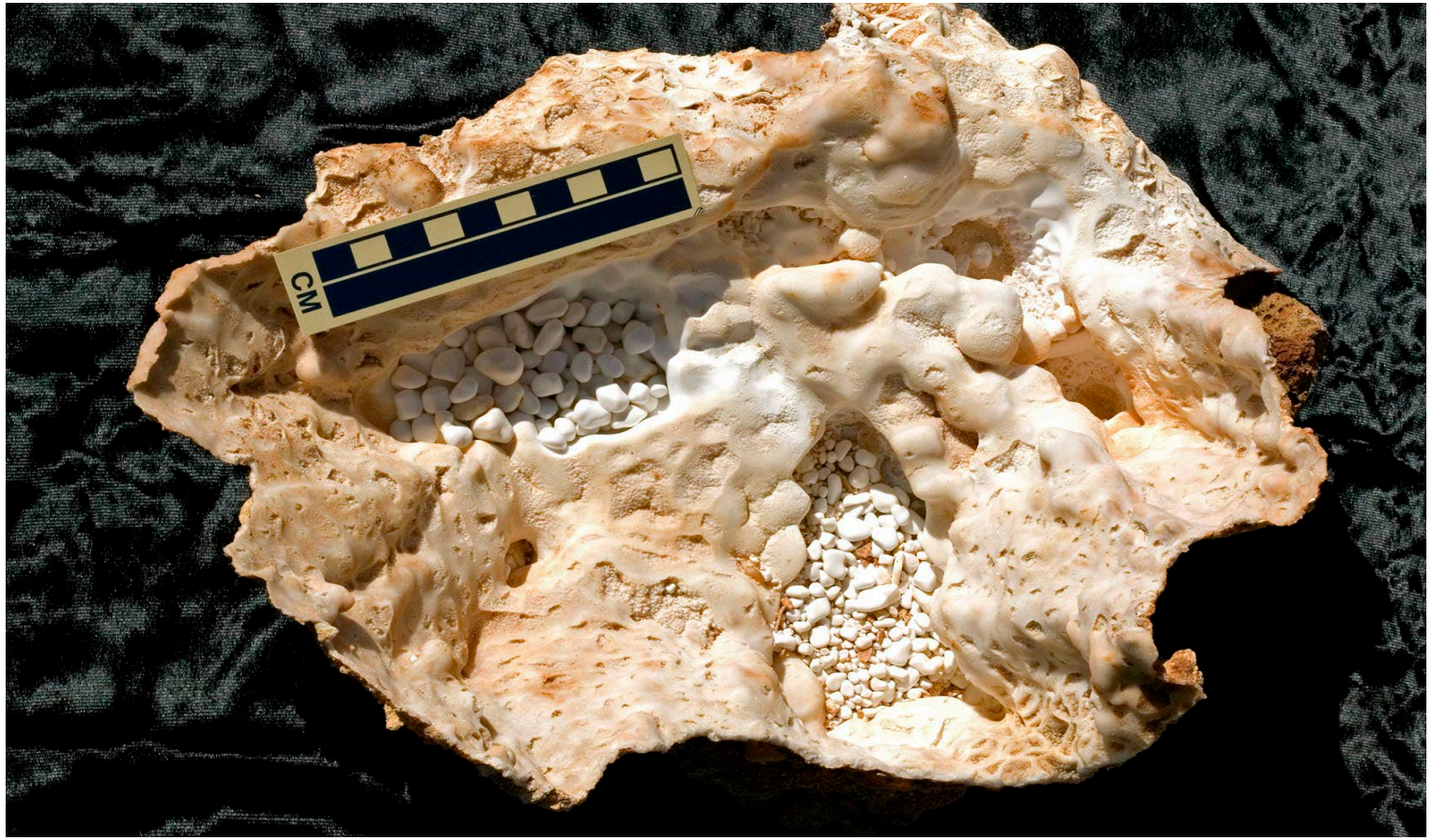
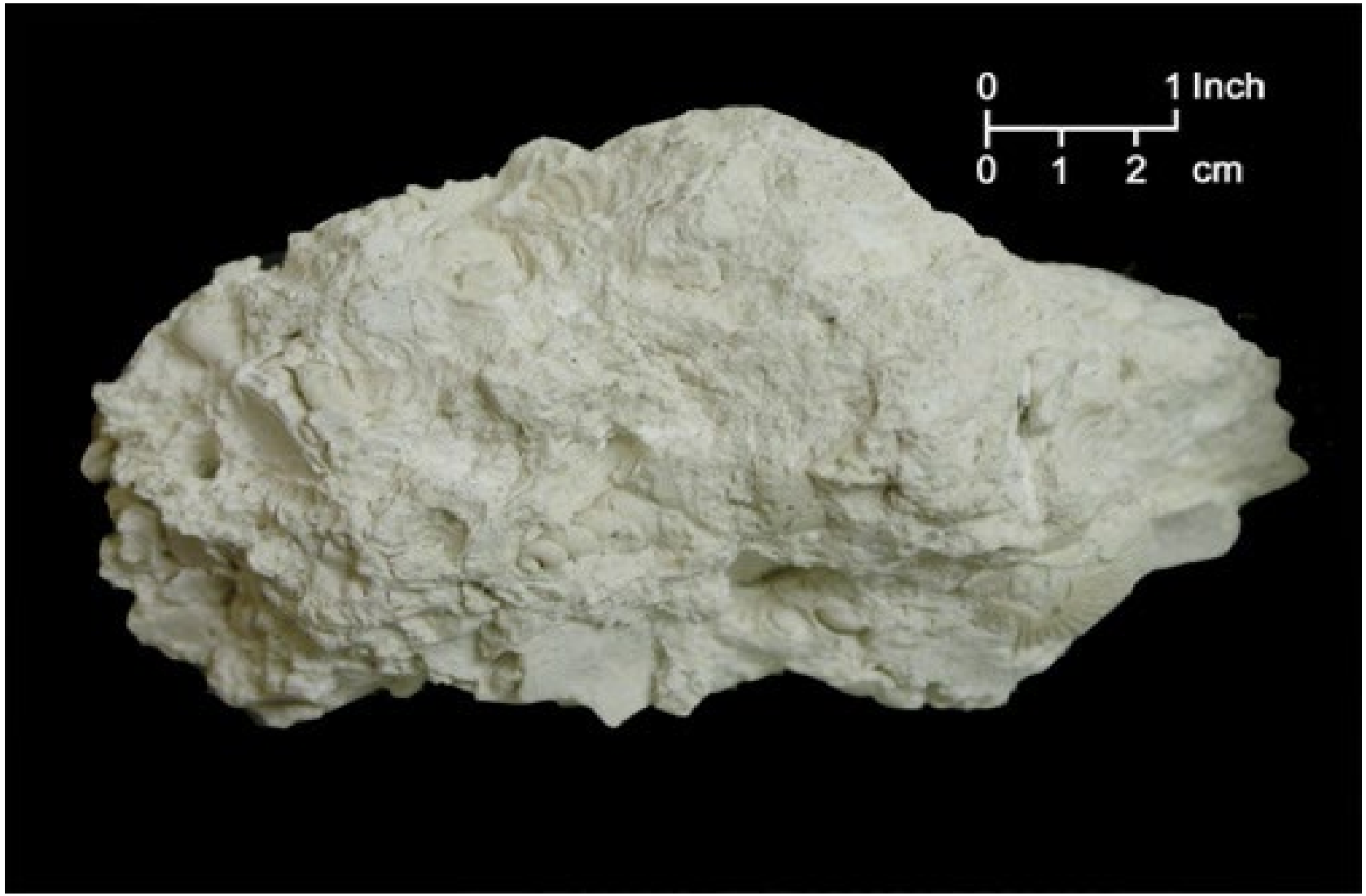


Locality: Cave Pearls, Lecanto, Citrus County, Florida.

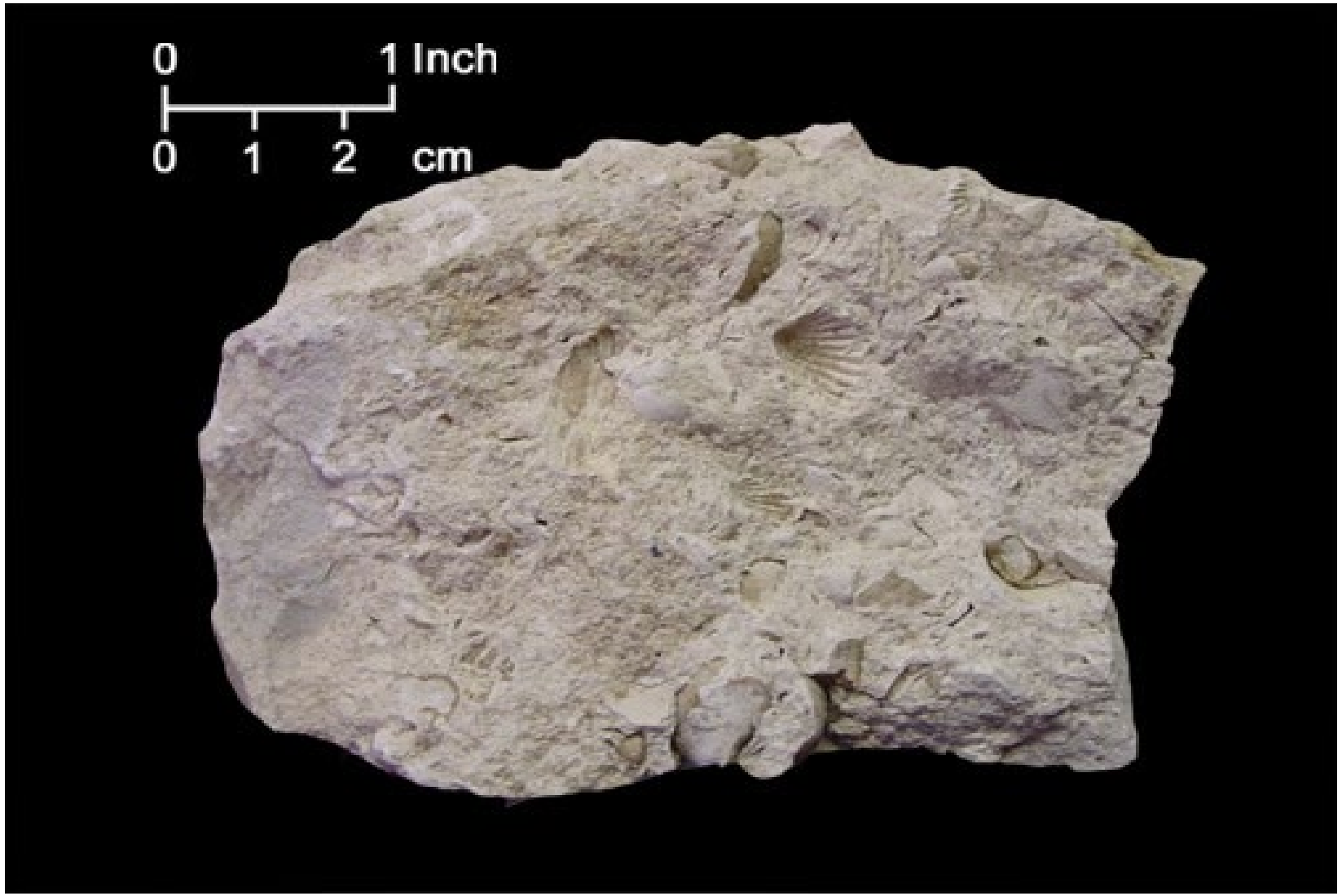
OCALA LIMESTONE

CARBONATE ROCK IN THE UPPER FLORIDAN AQUIFER



AVON PARK DOLOSTONE

CARBONATE ROCK IN LOWER FLORIDAN AQUIFER



COQUINA

COMMON AQUIFER ROCK IN EASTERN AND SOUTHERN FL

COQUINA WALLS

FORT CASTILLO DE SAN MARCOS

St. Augustine, Florida, USA.

Initial construction 1672-1695.

Source: U.S. National Park Service

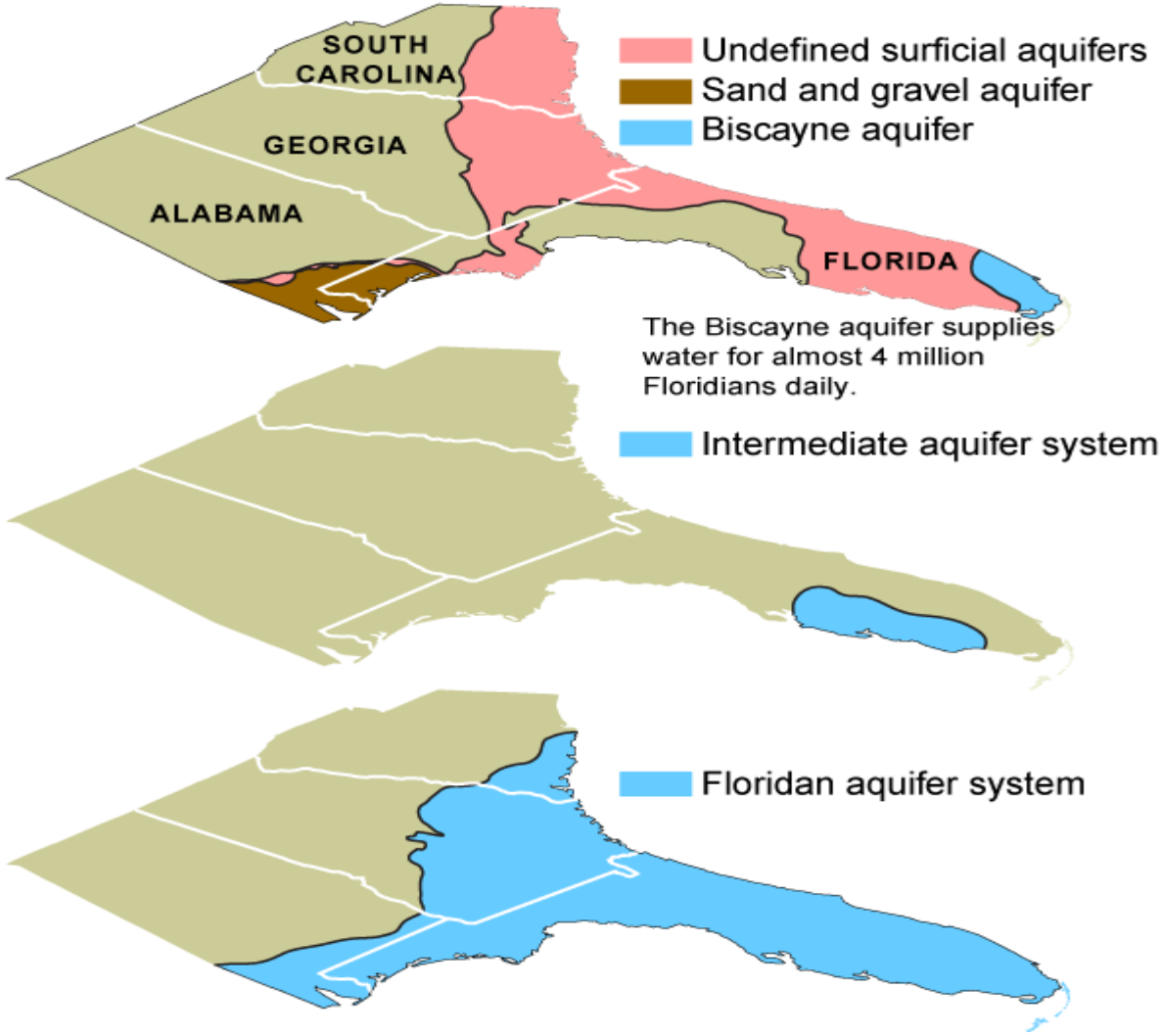
LOCATIONS OF FLORIDA'S MAJOR AQUIFERS

1. Sand and Gravel Aquifer - western panhandle (gravel, silt, clay).

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

3. Biscayne Aquifer - southeast Florida (carbonate).

AQUIFERS OF FLORIDA



Source: United States Geological Survey (USGS)
Professional Paper 1807

FLORIDA AQUIFER BASICS

ROCK TYPES

- The Sand and Gravel aquifer of the western panhandle consists of unconsolidated to poorly consolidated sedimentary layers of silt, sand, and gravel deposited by coastal river systems such as the Escambia River.

- To produce enough groundwater for urbanized areas in this region (e.g., Pensacola), water from multiple shallow supply wells is blended/treated at central locations prior to public distribution.

FLORIDA AQUIFER BASICS

ROCK TYPES

- The Floridan Aquifer System is a carbonate rock aquifer found throughout Florida. In south and extreme western Florida panhandle, the water in the Floridan aquifer is too saline to use for potable or agricultural water sources.

- The aquifer system consists of limestone and dolostone layers hundreds of feet thick that range from 20 to 50 million years old. Minor amounts of evaporite minerals (e.g., gypsum, halite) are present as discrete layers within the carbonate rocks.

FLORIDA AQUIFER BASICS

ROCK TYPES

- The Biscayne aquifer is an unconfined coastal aquifer located southeastern Florida. Overpumping has led to saltwater intrusion in some areas, which is monitored by hydrogeologists from both the South Florida Water Management District (SFWMD) and USGS.

- The main rock type, the Miami Limestone, includes fossils of complete coral heads, echinoids (sea urchins), mollusks (oysters, scallops) and calcareous algae. It is essentially an intact fossilized coral reef that formed about 100,000 years ago during the last interglacial period.

FLORIDA AQUIFER BASICS

ROCK TYPES

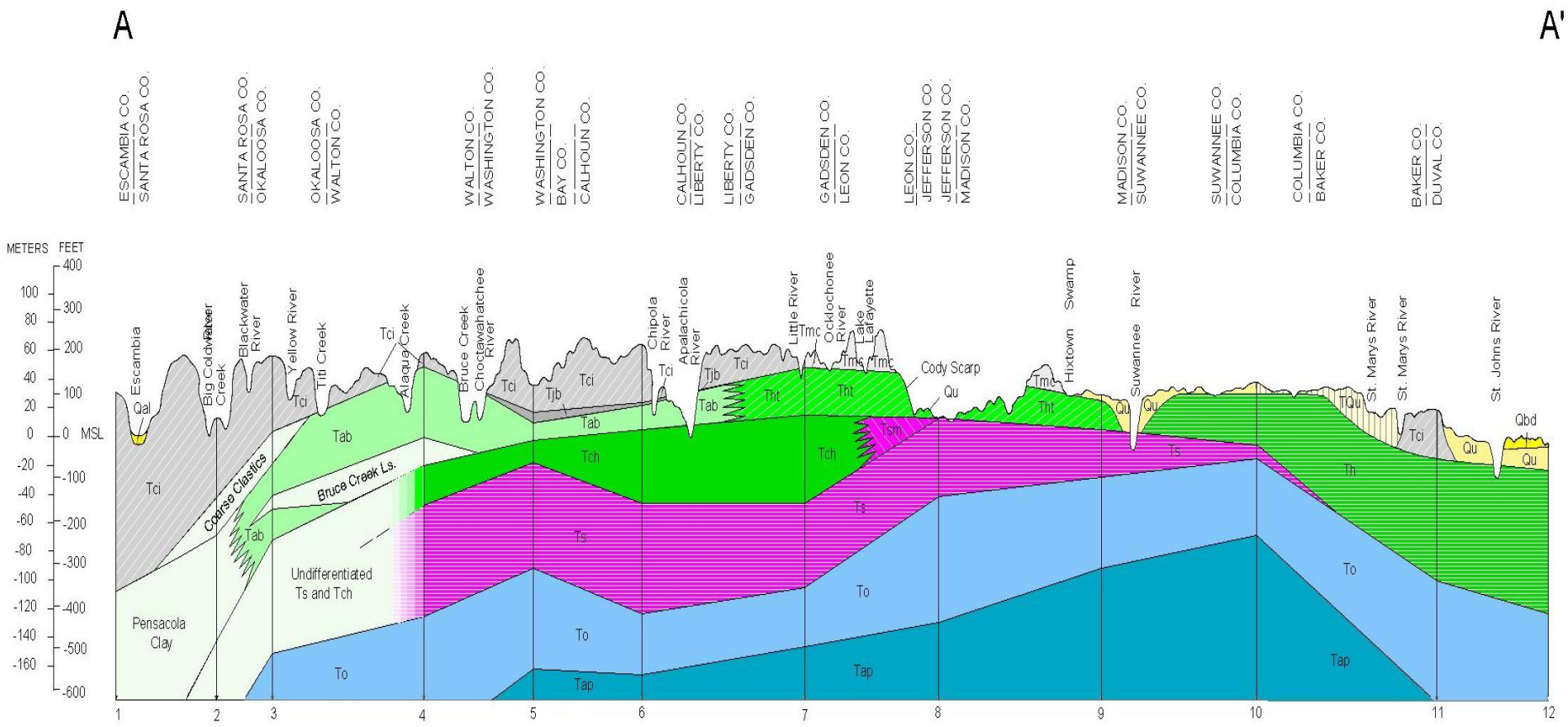
- **Interbedded clastic and carbonate aquifers**, common in southern Florida peninsula, consist of discontinuous limestone and dolostone layers interbedded with sand, silt and clay layers.

- Much of southern Florida has this type of aquifer, but few are given formal names, although their local presence is well documented by water management districts (WMD) and USGS hydrologists.

EAST-WEST GEOLOGIC CROSS SECTION

PENSACOLA

JACKSONVILLE

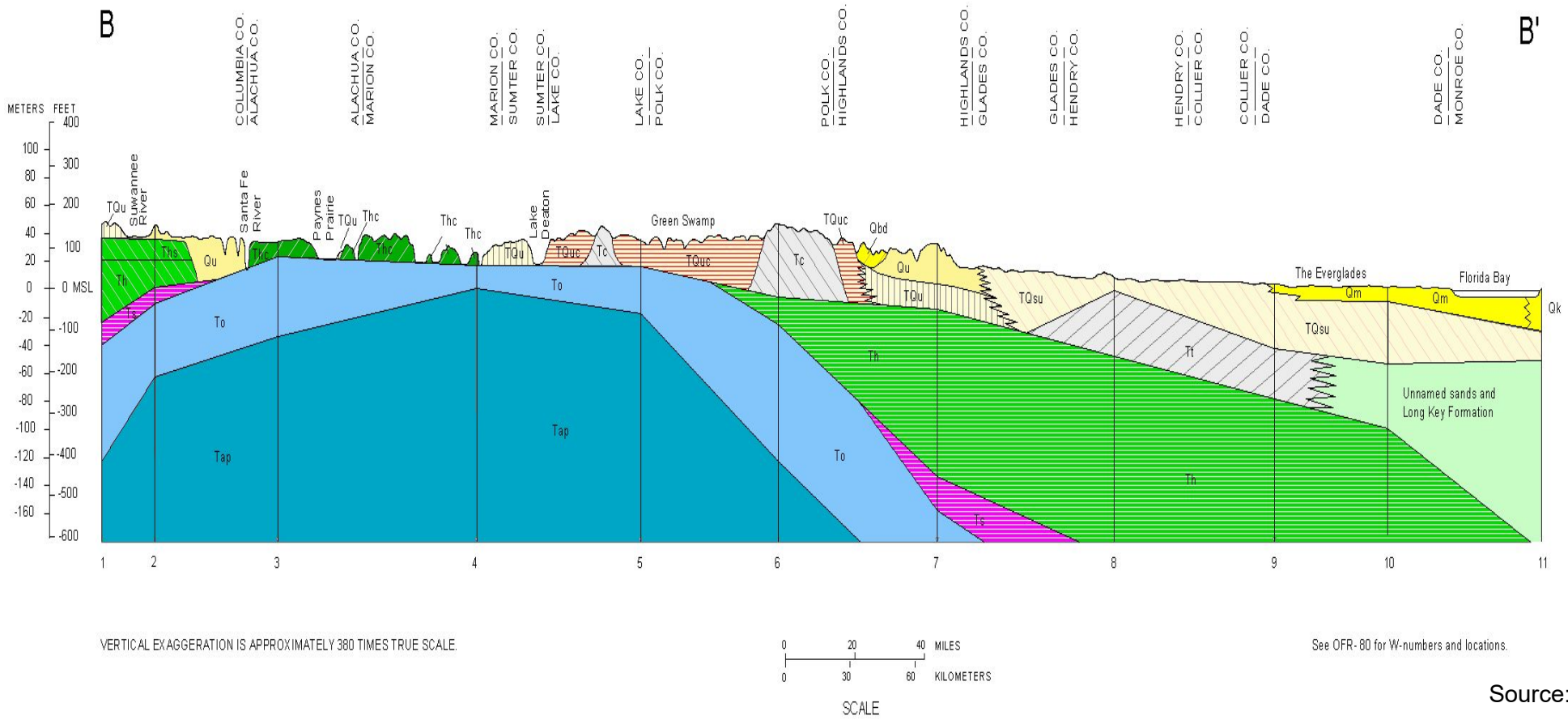


Source: Florida Geological Survey, 2001

NORTH–SOUTH GEOLOGIC CROSS SECTION

LAKE CITY

MIAMI



VERTICAL EXAGGERATION IS APPROXIMATELY 380 TIMES TRUE SCALE.

0 20 40 MILES
0 30 60 KILOMETERS
SCALE

See OFR-80 for W-numbers and locations.

Source: Florida Geological Survey, 2001

GROUNDWATER CHEMISTRY

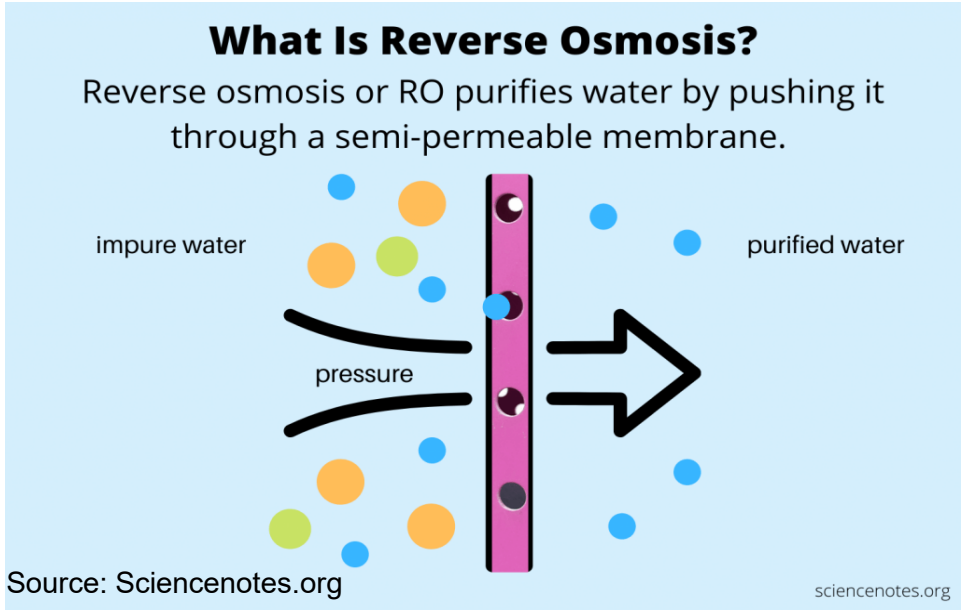
- Water is described as the universal solvent, because water dissolves all minerals with time. Carbonate minerals (calcite and dolomite) are especially susceptible; even quartz (SiO_2) will break down in the presence of groundwater.

- Thus, Florida's groundwater contains in the dissolved fraction calcium (Ca^{2+}), magnesium (Mg^{2+}), potassium (K^{+}), chloride (Cl^{-}), bicarbonate (CO_3^{2-}), sodium (Na^{+}), sulfate (SO_4^{2-}) and silicon ($Si(OH)^4$).

GROUNDWATER CHEMISTRY

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

- Slightly saline water (brackish water) is used in areas of Florida where fresh water is not available.



Source: Sciencenotes.org

COMPARISON OF FLORIDAN AQUIFER AND SAND AND GRAVEL AQUIFER WATER

These groundwater data are in milligrams per liter, which is equivalent to parts per million. Note how the host sedimentary material affects water chemistry.

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

COMPARISON OF FLORIDAN AQUIFER AND SAND AND GRAVEL AQUIFER FIELD ANALYTES

Some Florida Panhandle wells have naturally low pH values (below 5.0), and high amounts of iron, which stains plumbing fixtures. Iron can be reduced by filtration treatment.

Aquifer	pH	Specific Conductance (µmhos/cm)	Temperature (°C)
Floridan	7.4	385	22
Sand/Gravel	4.9	50	24

GROUNDWATER CHEMISTRY

HARDNESS

- Definitions of water hardness vary.
  - Water is considered soft if it contains less than 75 mg/L as $CaCO_3$.
  - Moderately hard water from 75-150 mg/L as $CaCO_3$.
  - Hard water between 150-300 mg/L as $CaCO_3$.
  - Very hard water if greater than 300 mg/L as $CaCO_3$.
  - Magnesium ions also contribute to hardness.
- Very hard water is not desirable for domestic uses, as it leaves scale inside pipes, boilers and tanks.
- Hard water can be softened, though some hardness filters add sodium to the water.

GROUNDWATER QUALITY PROBLEMS

- The growth of population (20,150,000 in 2016; estimated to be greater than 22,250,000 in 2024), plus existing industry and agriculture, stresses the state's surface and groundwater resources.

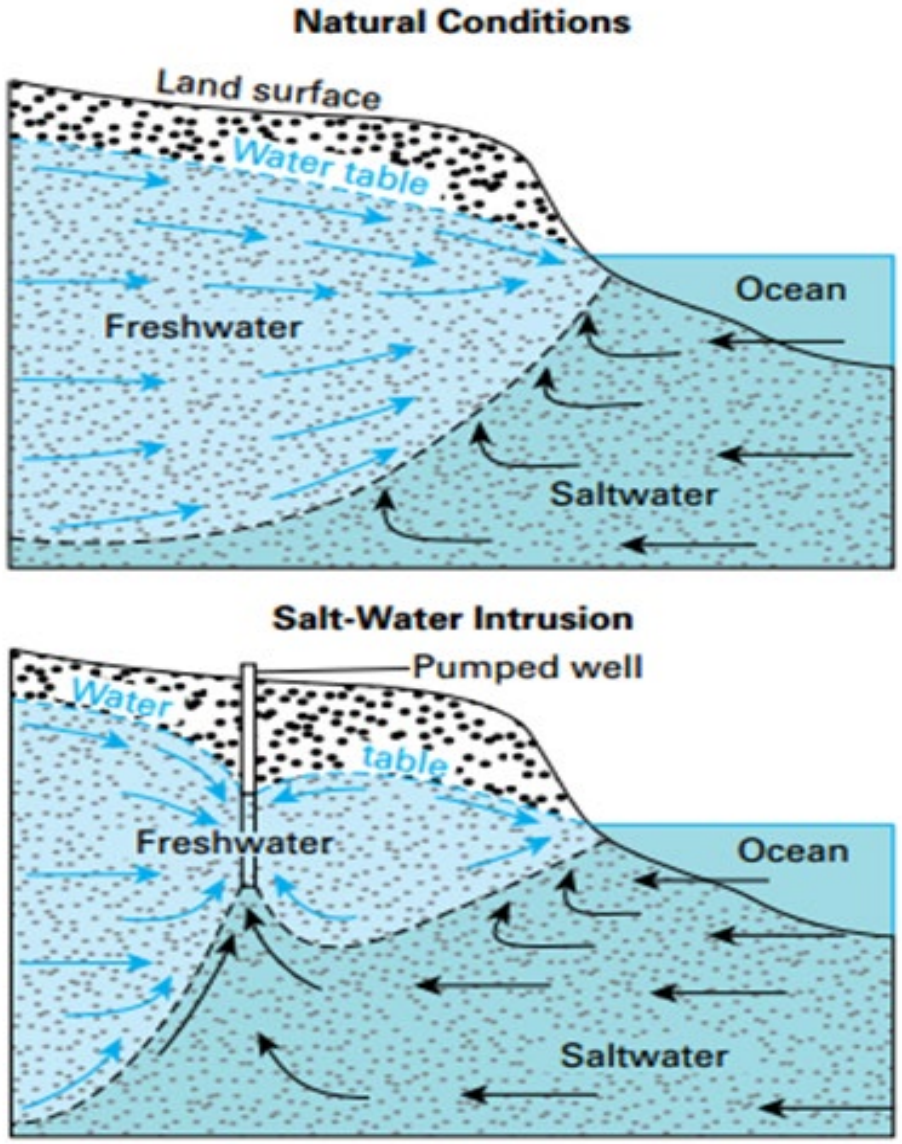
- Municipal and industrial wastes, along with fertilizer and pesticides, have locally infiltrated aquifers, degraded groundwater, and caused surface water quality problems where aquifers supply water to Florida's springs and rivers.

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

GROUNDWATER QUALITY PROBLEMS

- In some Florida coastal areas, groundwater pumping has accelerated the rate that salt water intrudes freshwater aquifers, both laterally and vertically.
  - This process is monitored by the USGS, the five WMDs and now DEP.
  - Sea level rise has been occurring for about 20,000 years in Florida as the last glaciation advance event recedes, allowing more saline water to move into the coastal aquifers.
- Southeastern Florida counties have an even more complex saltwater intrusion problem exacerbated by decades of canal construction which allowed salt water to move inland, as well as groundwater withdrawal by agriculture and residential users.

SALTWATER INTRUSION



Source: University of Florida, Thompson Earth Systems Institute.

Florida counties with real or potential saltwater intrusion:

- Dade
- Broward
- Palm Beach
- Levy
- Manatee
- Hillsborough
- Duval
- Walton

FLORIDA AQUIFER GEOLOGY

Source: USGS, 1995.

THANK YOU

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Florida Department of Environmental Protection

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