Freshwater & Groundwater

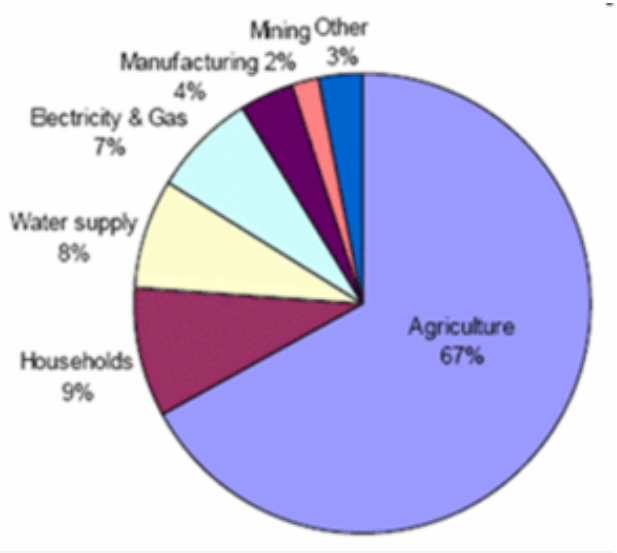
Who needs water?

- Body processes:
  - Water allows organisms to obtain chemicals from their surroundings
  - They can break down food, grow and reproduce
  - Substances can move within their bodies

- Shelter:
  - Water provides habitats.
  - Habitats are the place where an organism lives and obtains all the things it needs to survive

Uses of Freshwater

- World wide, fresh water is important for . . .
  - Agriculture (uses the most fresh water)
  - Industry/factories
  - Drinking (known as potable water)
  - Transportation

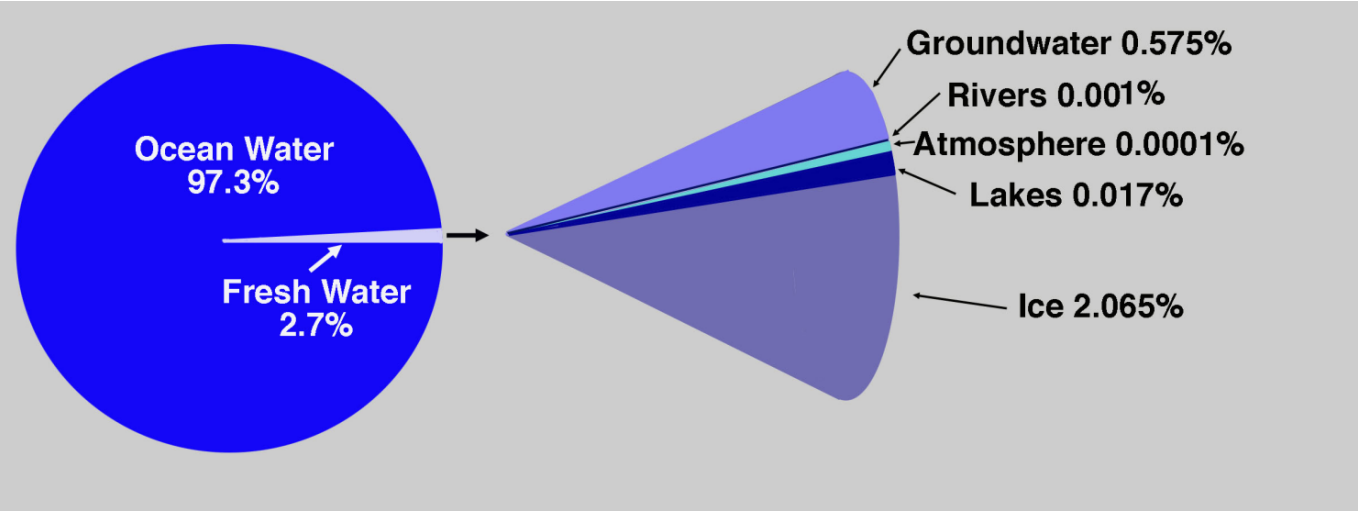


Water use in the world 2005

What is the distribution of water on Earth?

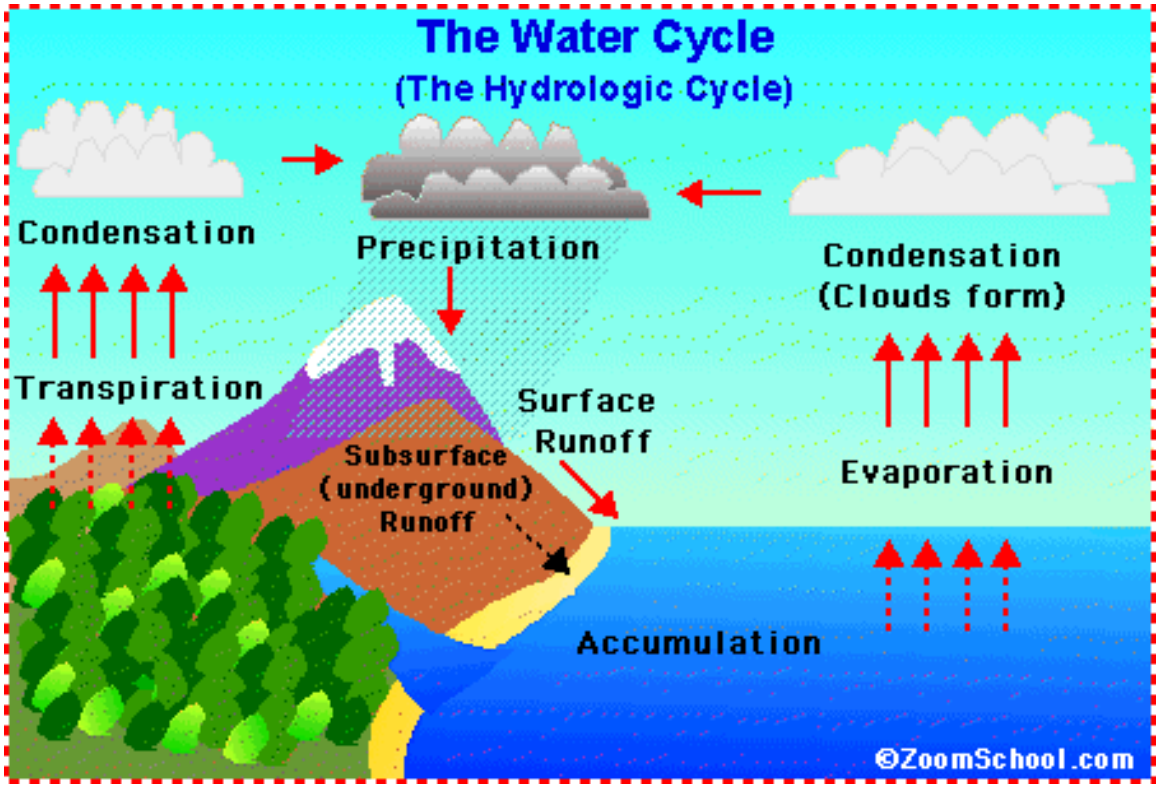
- Most of Earth's water is salt water—97.3%
- Only 2.7% is fresh water.

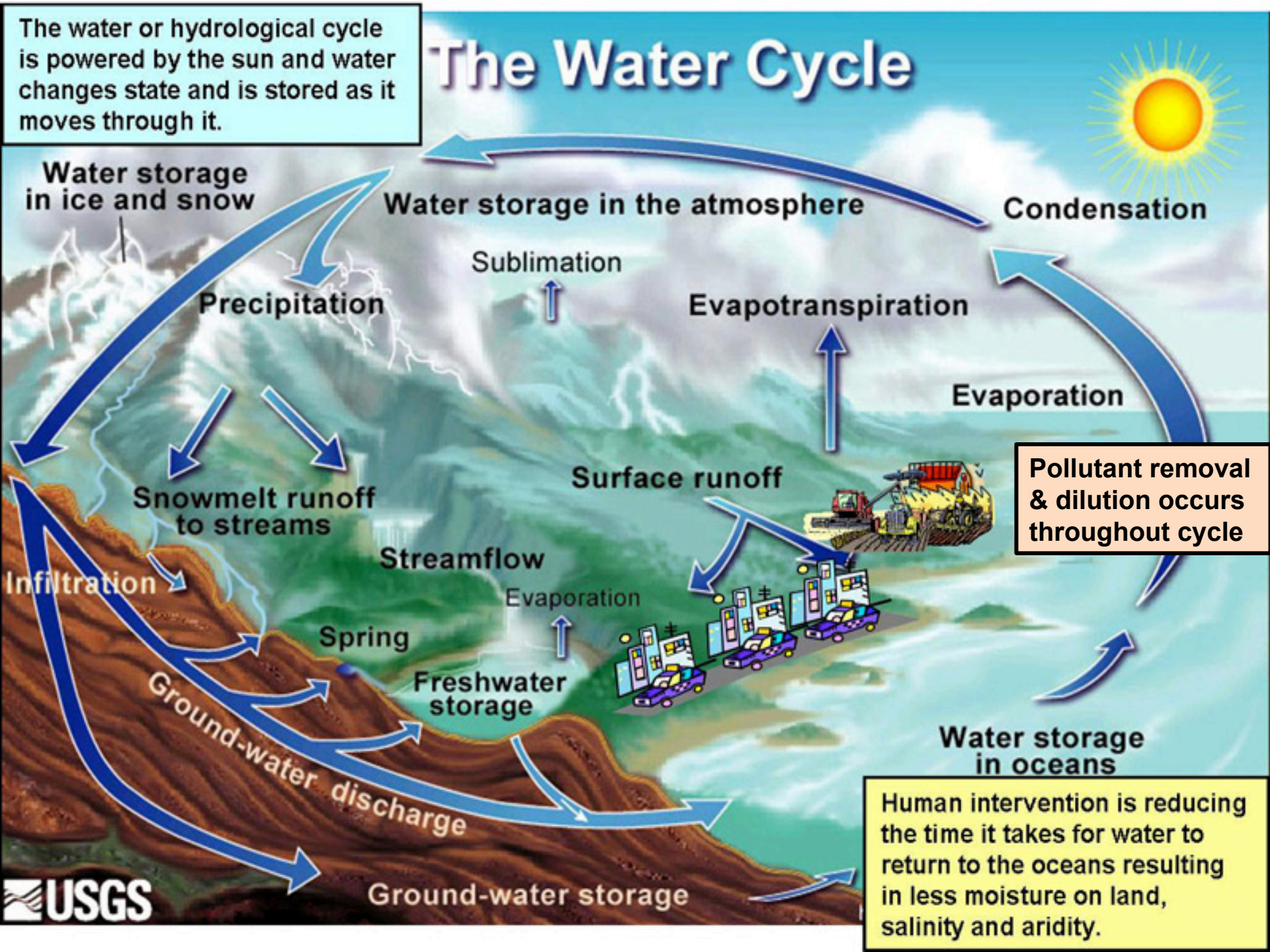
- Most fresh water on Earth is found as ice—76%
- Shallow groundwater 12%
- Deep groundwater 11%
- Lakes and rivers 0.34%
- Water vapor 0.037%



How does water move on Earth?

- Water moves on Earth through the continuous process of the water cycle.




The water or hydrological cycle is powered by the sun and water changes state and is stored as it moves through it.
The Water Cycle
Water storage in ice and snow
Water storage in the atmosphere
Condensation
Sublimation
Precipitation
Evapotranspiration
Evaporation
Surface runoff
Snowmelt runoff to streams
Streamflow
Infiltration
Evaporation
Spring
Freshwater storage
Ground-water discharge
Ground-water storage
Water storage in oceans
Pollutant removal & dilution occurs throughout cycle
Human intervention is reducing the time it takes for water to return to the oceans resulting in less moisture on land, salinity and aridity.
USGS

Water Cycle

The water cycle is powered by energy from the sun.

1. Water evaporates from oceans and lakes.
   - Evaporation: changing from liquid to gas.

2. As water vapor rises in the atmosphere, it condenses into water droplets, forming clouds.
   - Condensation: changing from a gas to a liquid.
   - Wind and weather systems move this atmospheric moisture all over Earth.

(cont'd)

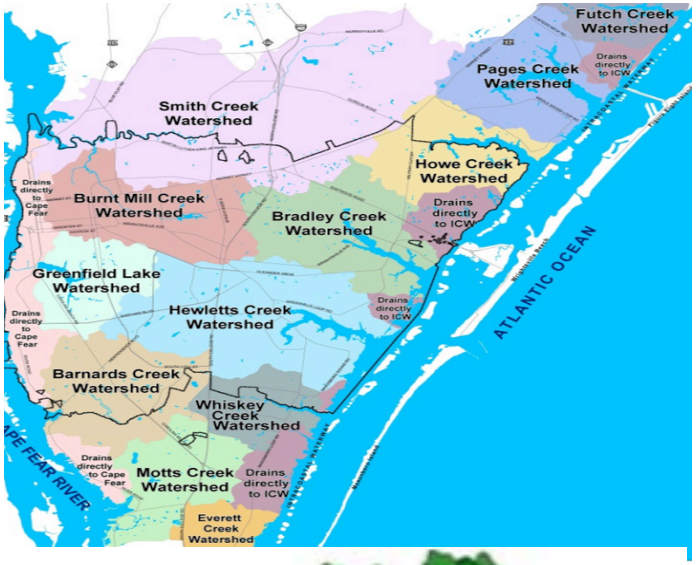
3. Water returns to the surface as precipitation (rain, snow, sleet, hail).

   Then, it has 3 options:

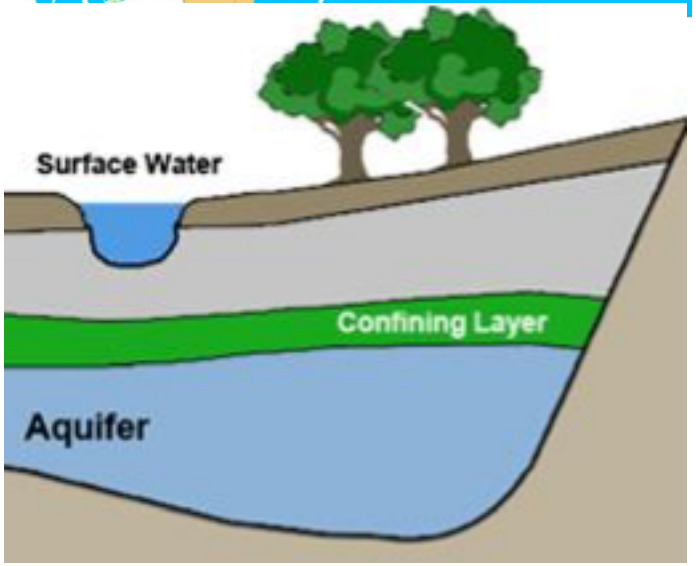
   1) Most soaks into the ground (infiltration) to become groundwater, which eventually returns to the surface through springs.
   2) Some evaporates back into the atmosphere.
   3) Some becomes runoff: water that flows downslope along Earth's surface as streams and rivers and eventually flows into lakes, oceans, etc.

Runoff vs. Infiltration

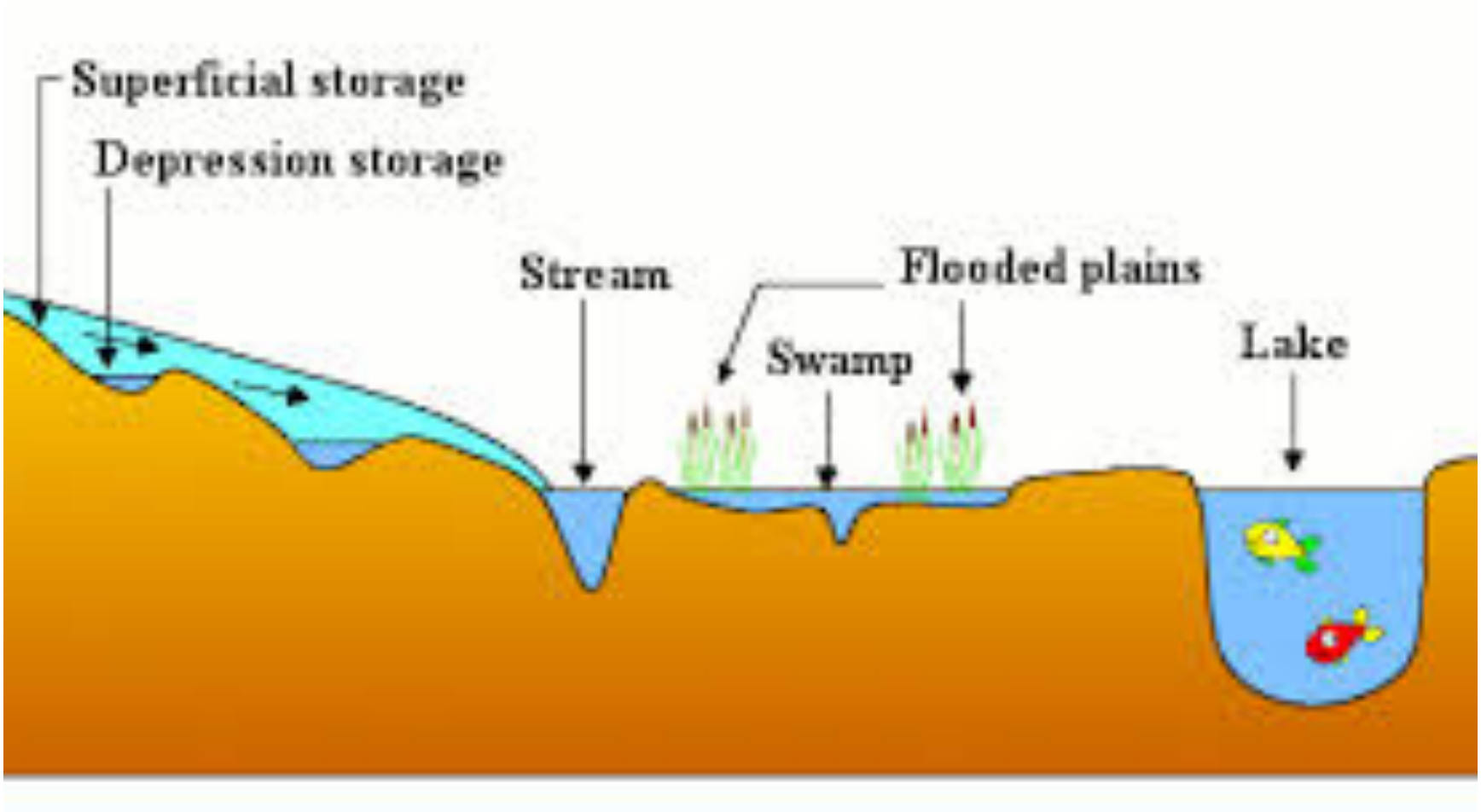
- **River basins**: area of land & small water bodies draining into 1 river; contains numerous watersheds



- **Aquifers**: underground area of high permeability where water is stored



Surface Water



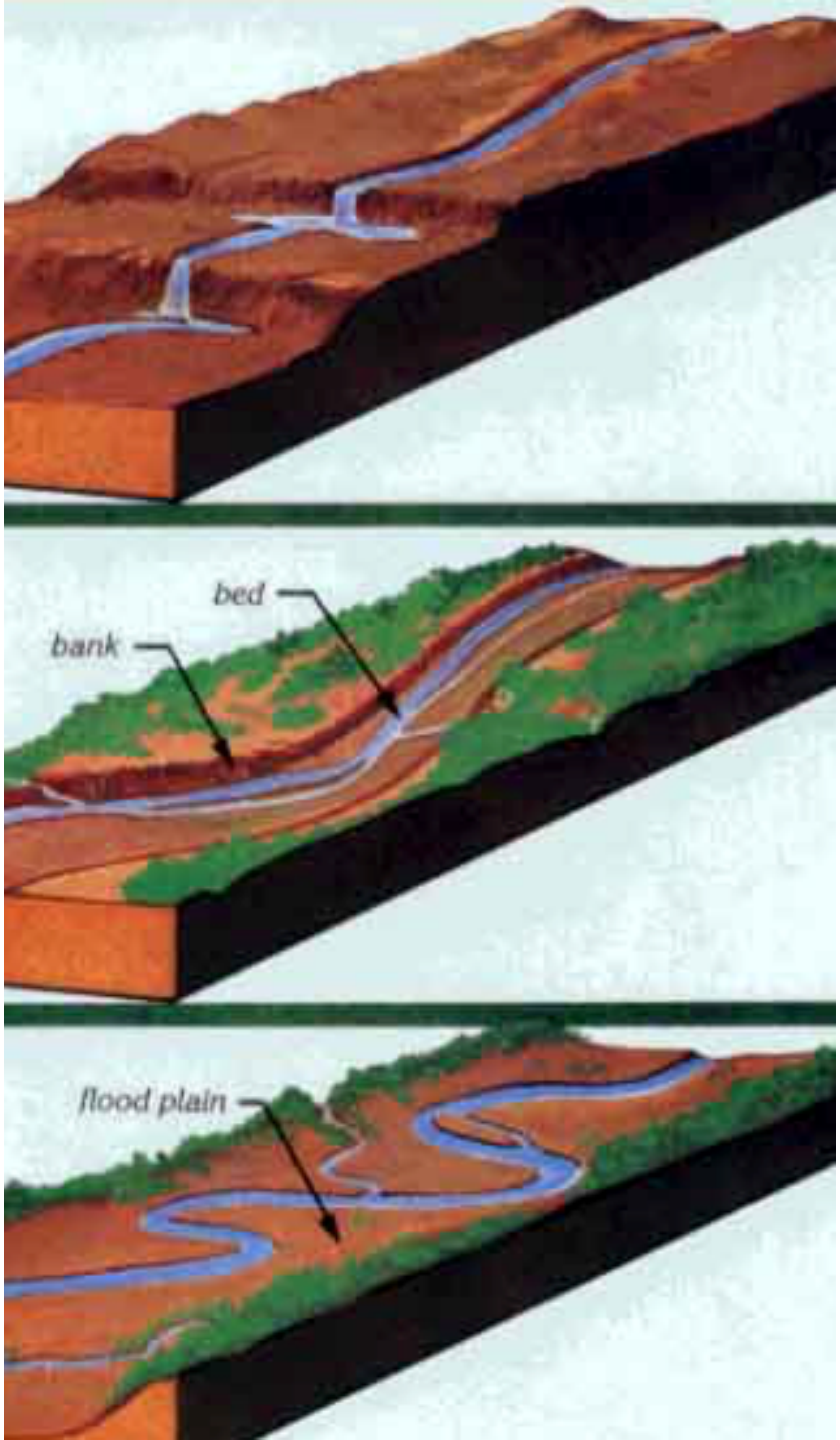
Watershed

- Watershed: all of the land area whose water drains into a stream system (drainage basin)

- Divide: a high land area that separates one watershed from another.

River Channels

- **Straight & Steep**
  - Youngest—little edge erosion
  - V-shaped valley
- **Gently Sloped & Meandering (aka lots of curves/bends)**
  - Older—time for erosion to make the curves
- **Flat with Oxbow lakes**
  - Oldest—time for erosion to make bends and then cut them off)
  - U-shaped valley



Shape & Gradient of Channel

- During active erosion (downcutting), streams are V-shaped.
- Eventually the sides will erode so that they are more gently-sloping, U-shaped valleys.
- A stream's slope (gradient) decreases as it nears its base level and the channel gets wider.

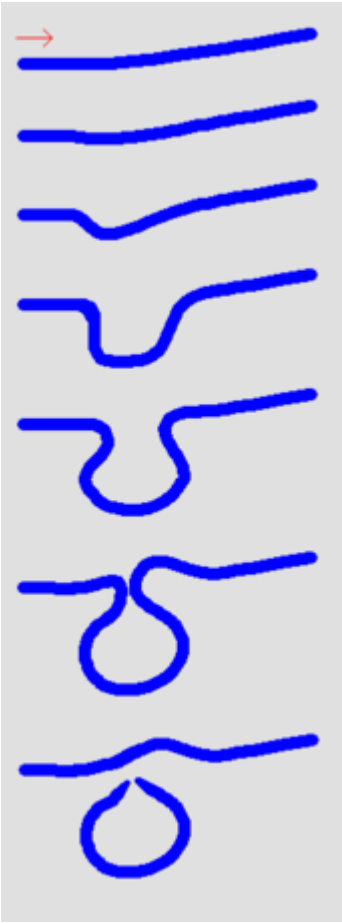
V-shaped & U-shaped Valleys

Velocity (Speed) of Water

- **In straight parts of stream:**
  - Water in the center is moving the fastest.
  - Water along the sides and bottom moves more slowly → more friction

- **In a meandering stream:**
  - Water along outside of a meander curve is the fastest & continues to erode which makes the meander larger.
    - Steep canyons can form.
  - Water on the inside of the meander moves more slowly, depositing some of its sediment.
  - Oxbow Lakes can form when a meander gets cut off.
  - Meander Animation

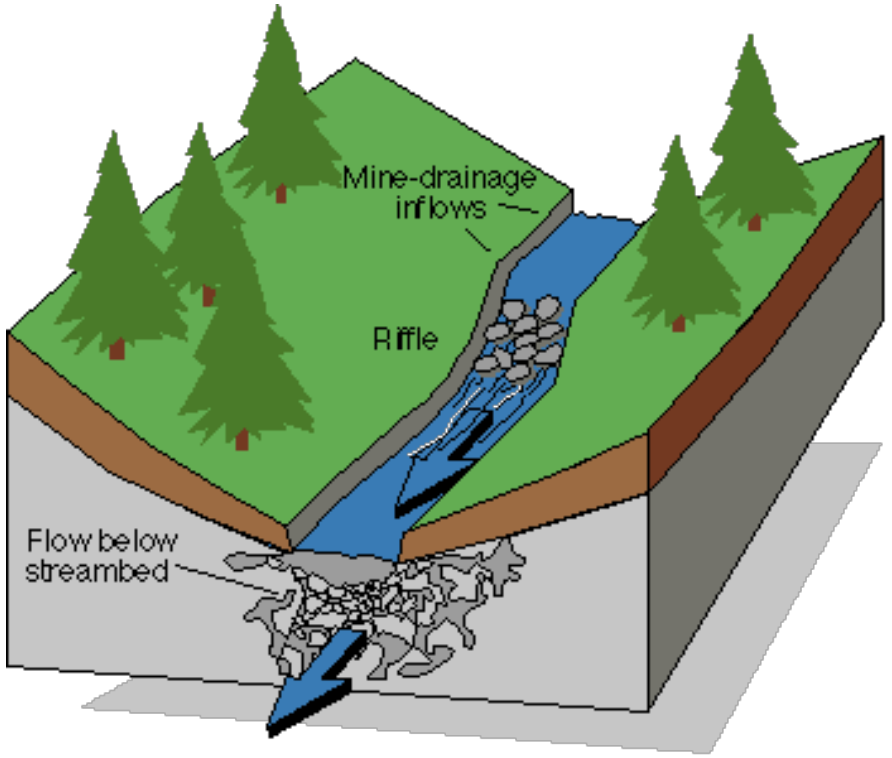
Meander



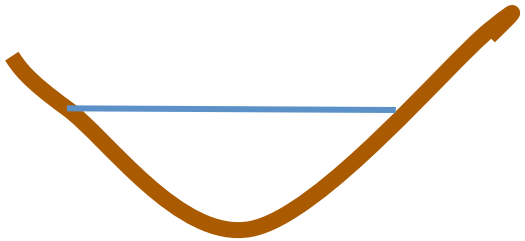
Oxbow Lake

Carrying Capacity & Discharge

- Carrying capacity: the ability of a stream to transport material
  - *Depends on the velocity & amount of water (discharge)*



Discharge

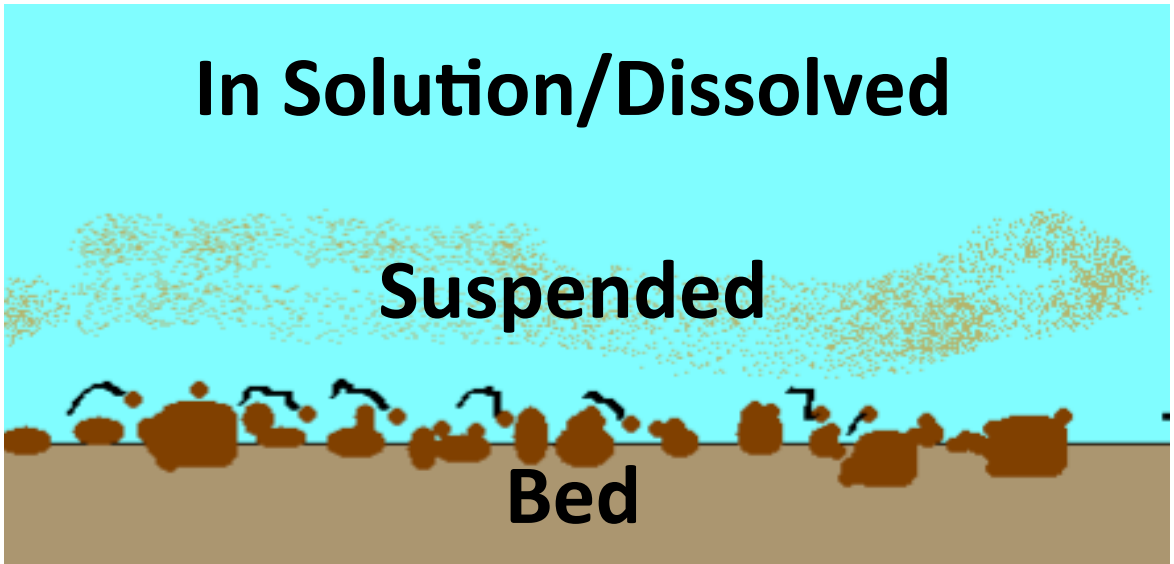


- Discharge: the volume of stream water that flows over a particular location within a given period of time.
  - Discharge Equation:

    Discharge (m^3/s) = width (m) x depth (m) x velocity (m/s)
  - *Mississippi River discharge is 173,600 m^3/s*
  - *Amazon River is ten times this amount.*
  - *The greater the discharge, the greater the carrying capacity.*

Stream Load

- **<u>Stream Load</u>**: all the materials that the water carries.
  - *<u>Living:</u> microscopic life-forms, plants, animals*
  - *<u>Nonliving:</u> sediments, dissolved solids, dissolved atmospheric gases (ex. oxygen)*



3 Ways a Stream Carries its Load

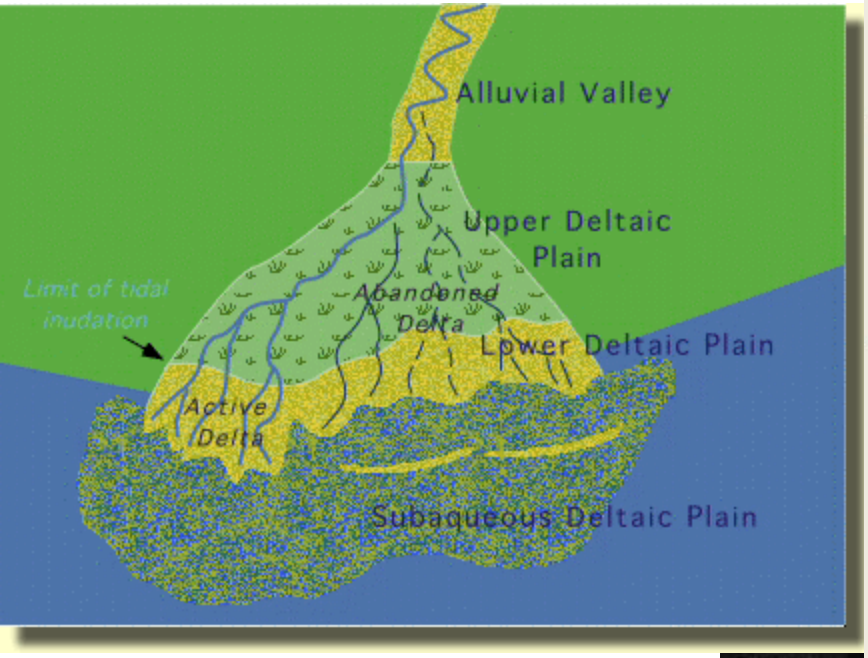
1) **Solution**: materials that dissolve into the stream as it runs over rocks containing soluble minerals.
   - Ex. salts, calcium carbonate from limestone & marble.

2) **Suspension**: particles that do not dissolve, but are small enough to be held up by the turbulence of the stream's water.
   - Ex. Silt, sand
   - *Faster moving stream can carry larger particles. Particles settle as stream slows.*

3) **Bed load**: sediments too large or heavy to be in suspension are rolled along the stream bed.
   - Ex. pebbles, rocks

Delta

- Delta: formed when str
  water, slow down sudde
  - Ex. Mississippi River De



Flooding

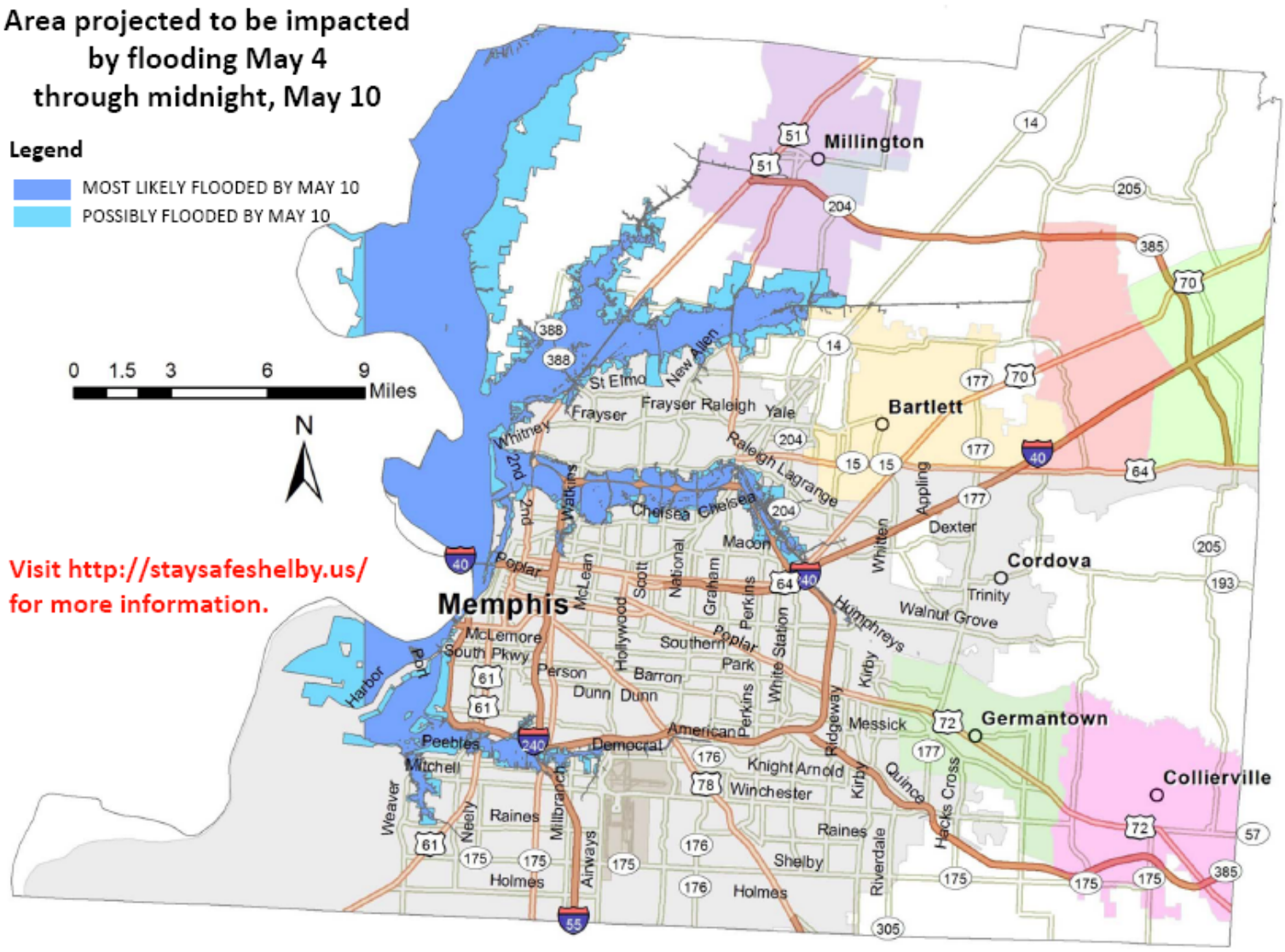
- Flood: when water spills over the sides of a stream's banks into the adjacent land.
  - Causes: Heavy precipitation, melting of snow

- *Rivers tend to "crest" a couple of days after the rain stops. Why does the water continue to rise even after the rain has ended?*

- Floodplain: the broad, flat area that extends out from a stream's bank and is covered by excess water during flooding.

Projected to crest at 48 ft on May 10.

Floodplain



Nile River Flooding

- *Soils are very fertile from the sediments deposited during flooding, but this is very risky farming!*

Lakes & Eutrophication

- Lake: a depression that collects and holds water.
  - *From runoff, streams, local precipitation, springs*

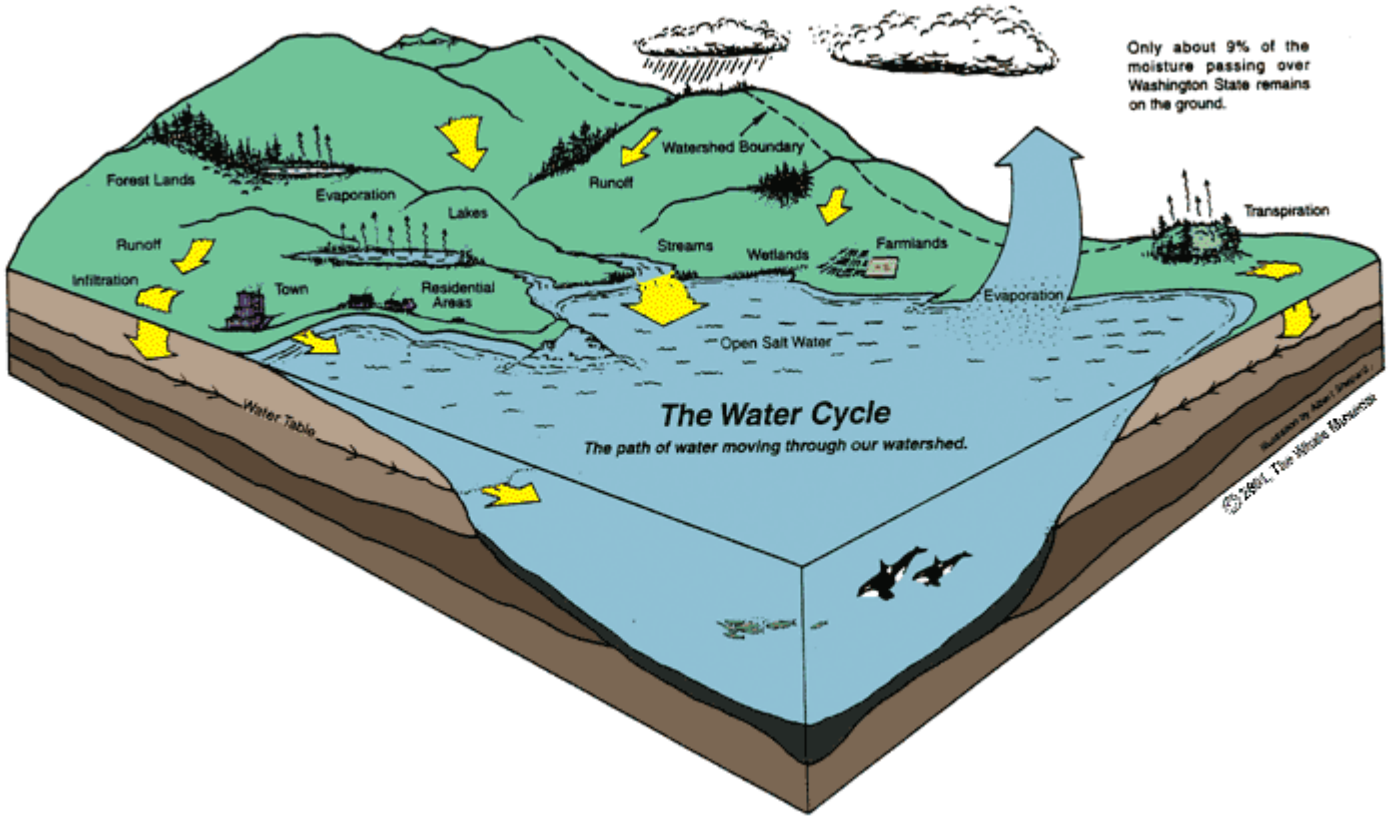
- Eutrophication: when lakes become rich in nutrients from the surrounding watershed, resulting in a change in the kinds of organisms in a lake.
  - *Can be sped up with fertilizers adding lots of nitrogen and phosphorus.*
  - Can lead to sudden excessive algae growth which depletes the water's dissolved oxygen supply. Plants and animals can die as a result.

Wetlands

- Wetland: a land area that is covered with water for a large part of the year.
  - Ex. bogs, marshes, swamps
  - Wetlands improve water quality by acting as a filtering system, trapping pollutants and pathogenic bacteria.

How do pollutants move through a watershed?

- Pollutants move through a watershed along with the water!



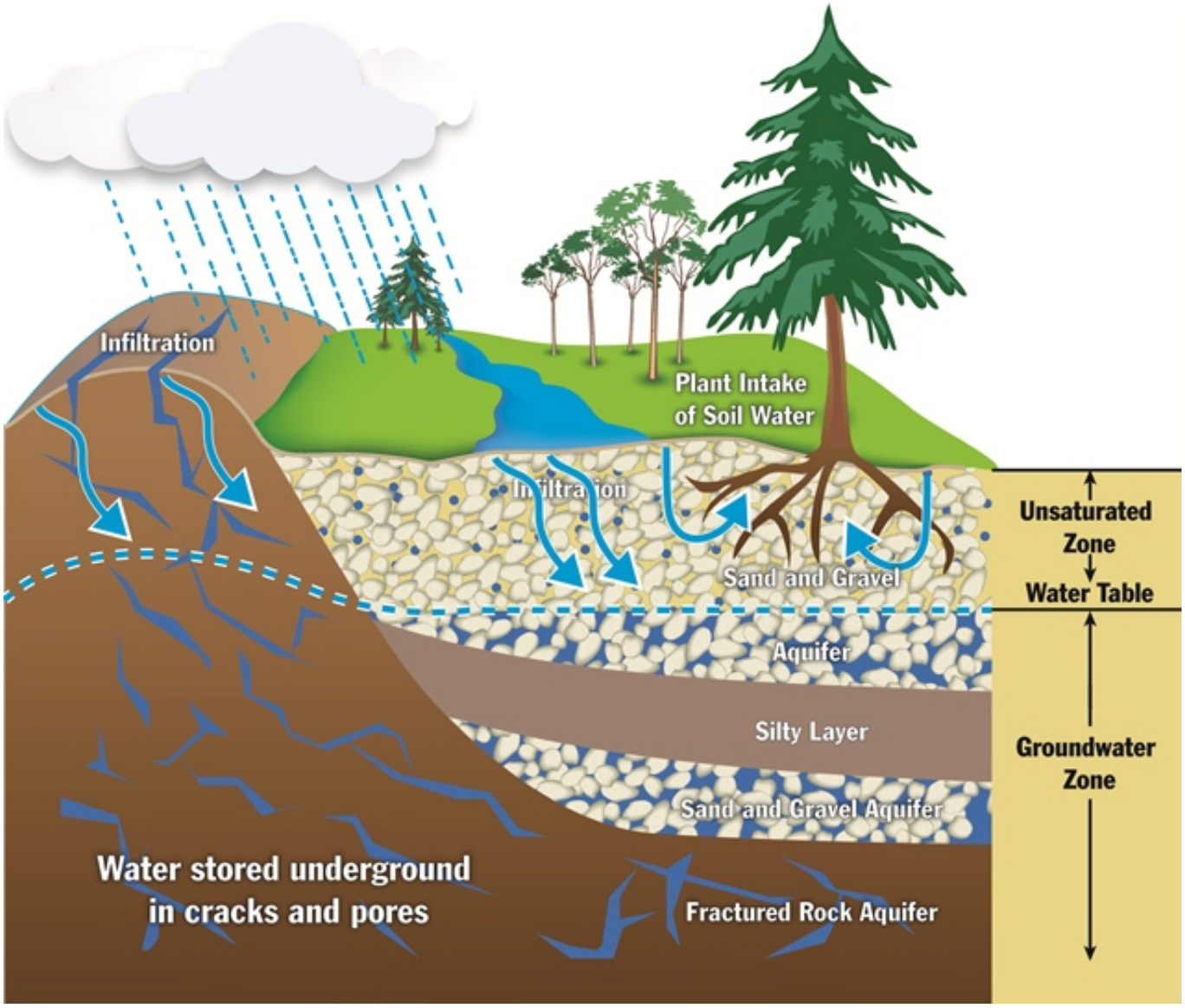
How can we help keep the watershed clean?

- Use fertilizer and pesticide according to package directions—don't use too much!
- Have septic systems inspected every 2-3 years.
- Conserve water. Overwatering your lawn can damage your landscape and places extra stress on our water supply.
- Never dump anything down a storm drain.
- Pick up after your pets. Pet waste left on the ground can spread E. coli, roundworms and Salmonella.

How does pollution affect potable water?

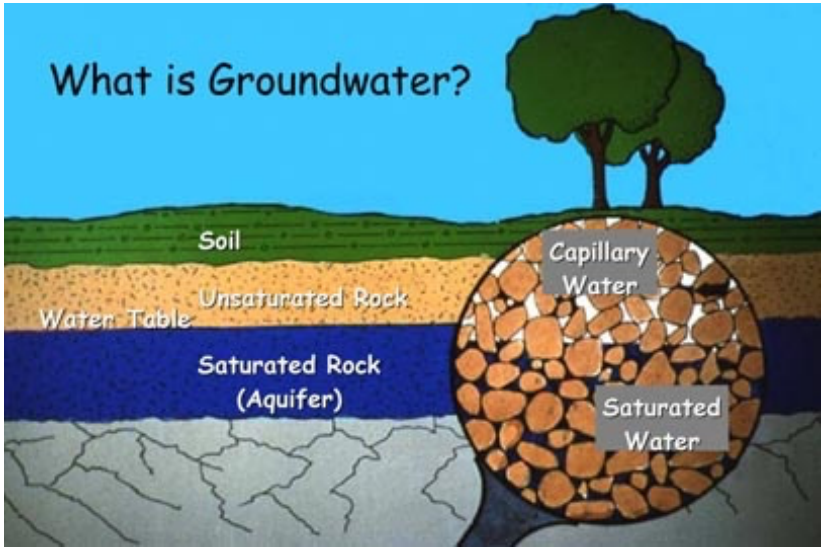
- Pollution of drinking water causes many deaths and much illness among urban residents all over the world.

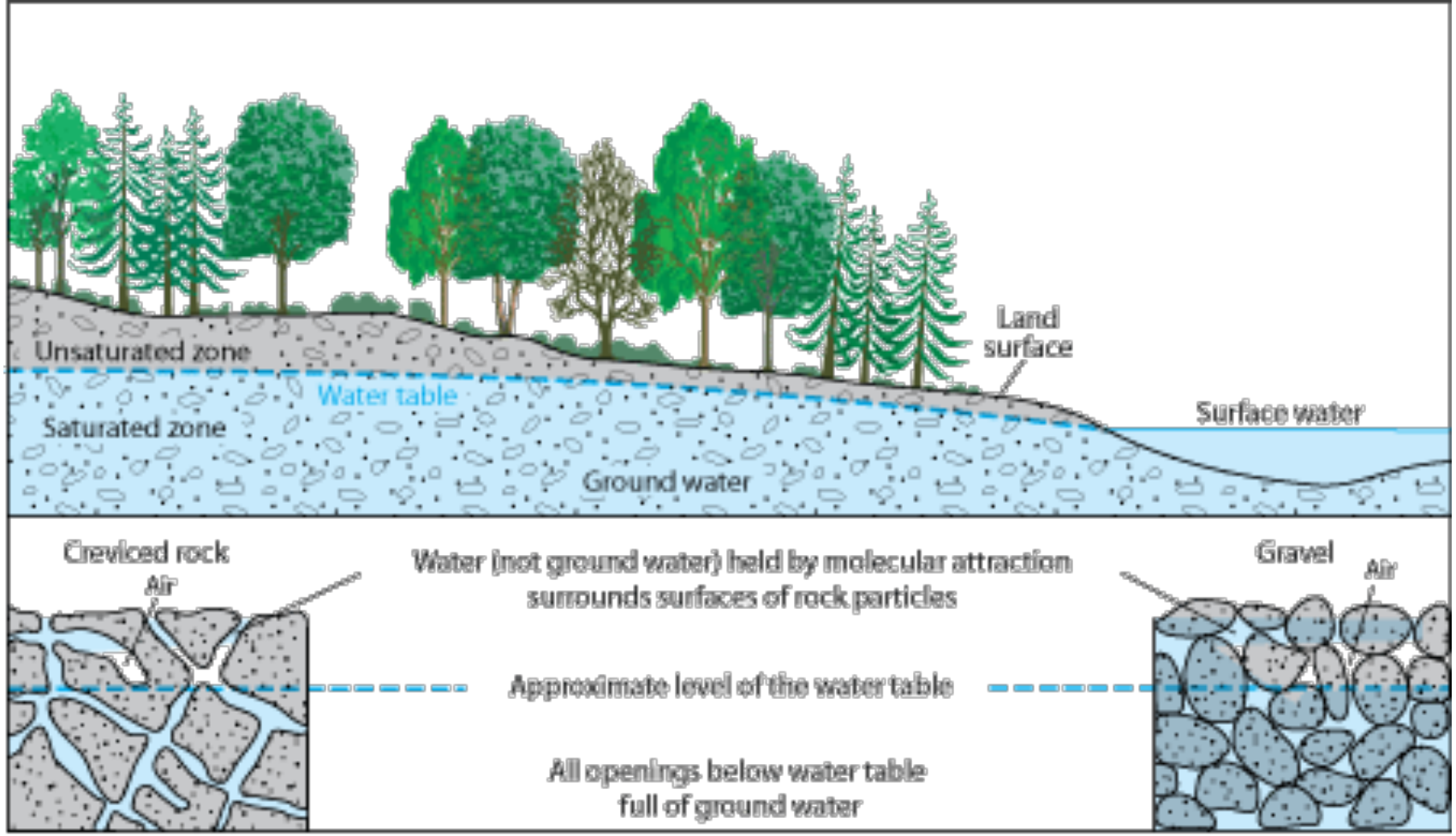
Groundwater



Water Table

- Zone of saturation: the depth below Earth's surface at which groundwater completely fills all the pores.
- Water table: the upper boundary of the zone of saturation.
- Zone of aeration: above water table; ground is moist but pores contain mostly air.





Primary human use: Well water supply

Environmental importance:

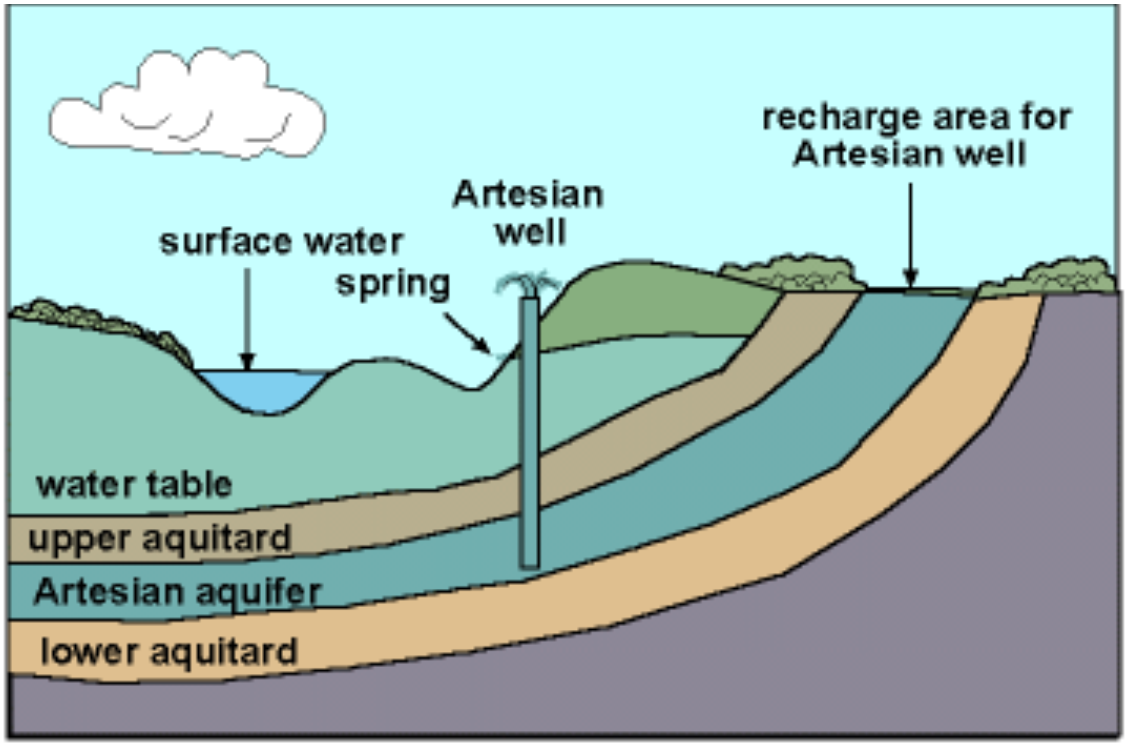
- Maintain water supplies to lakes, rivers, etc. when droughts occur
- Plant & animal dependence (food, habitat, etc.)

Aquifer

- Aquifers: permeable underground layer through which groundwater flows relatively easily

Recharge:

- Infiltration/ Percolation
- High porosity = high/fast infiltration
- Low infiltration = increased surface water = increased flooding

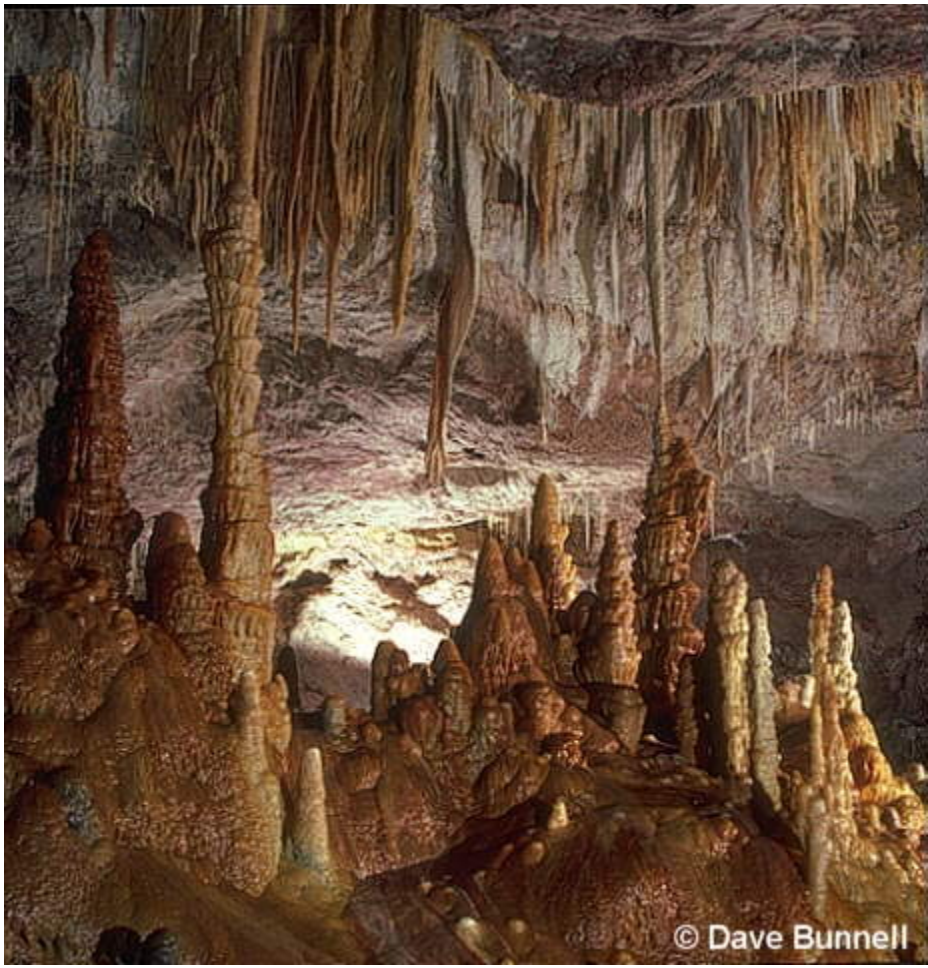


CROSS SECTION OF EARTH SHOWING PARTS OF AN AQUIFER

Caves

Most of the ions in groundwater are due to carbonic acid & calcium carbonate.

- Cave: a natural underground opening with a connection to Earth's surface.
  - Forms when slightly acidic groundwater dissolves limestone (calcium carbonate).
  - Calcium carbonate deposits:
    - Stalactites – from ceiling
    - Stalagmites – from ground



Geysers

- Geysers: explosive hot springs that erupt at regular intervals
  - Ex. "Old Faithful" *in Yellowstone National Park, Wyoming*
    - *Erupts every hour with 40-m high column of boiling water/steam.*

Subsidence and Saltwater Intrusion in North Carolina

What is subsidence?

- Subsidence is the sinking of the Earth's surface in response to *geologic* or man-induced causes.
- Pumping water out of the ground can cause subsidence.

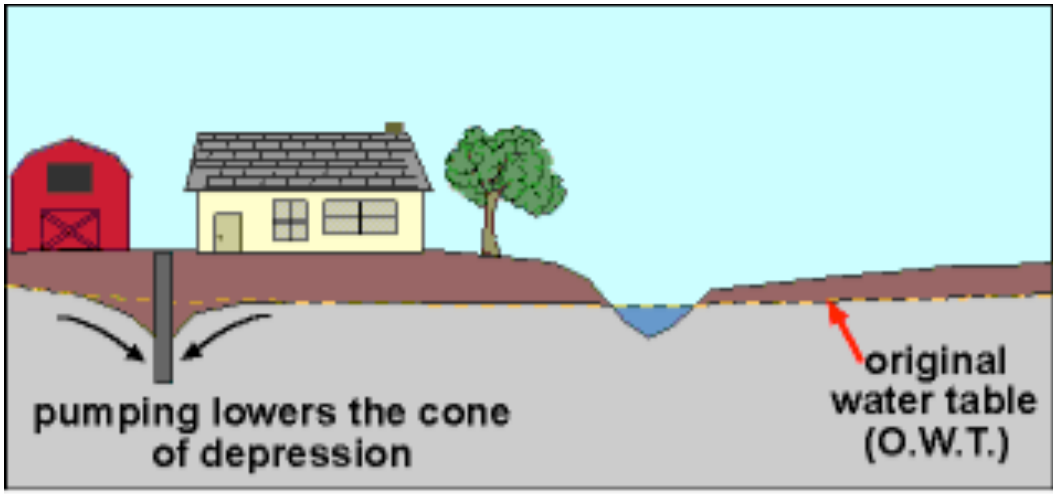
Cones of Depression

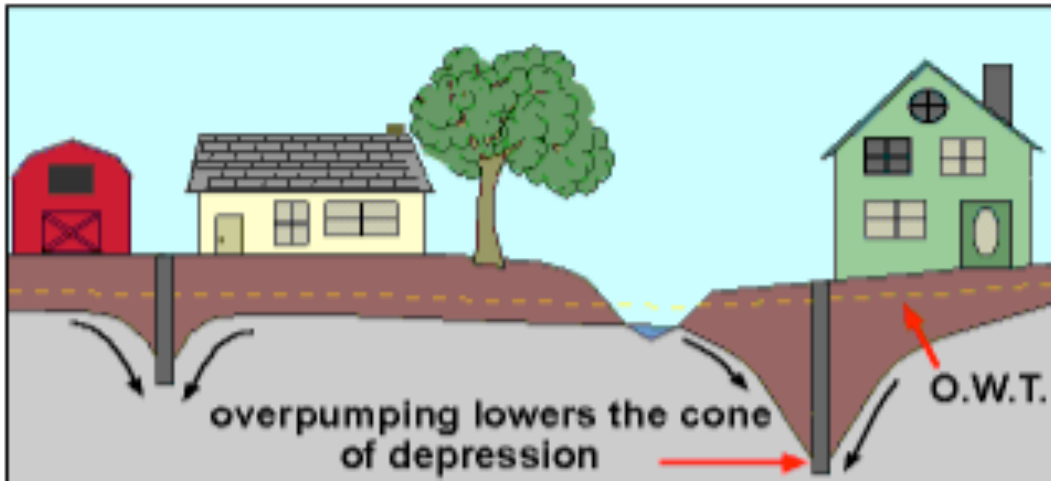
Rate of withdraw > rate of infiltration

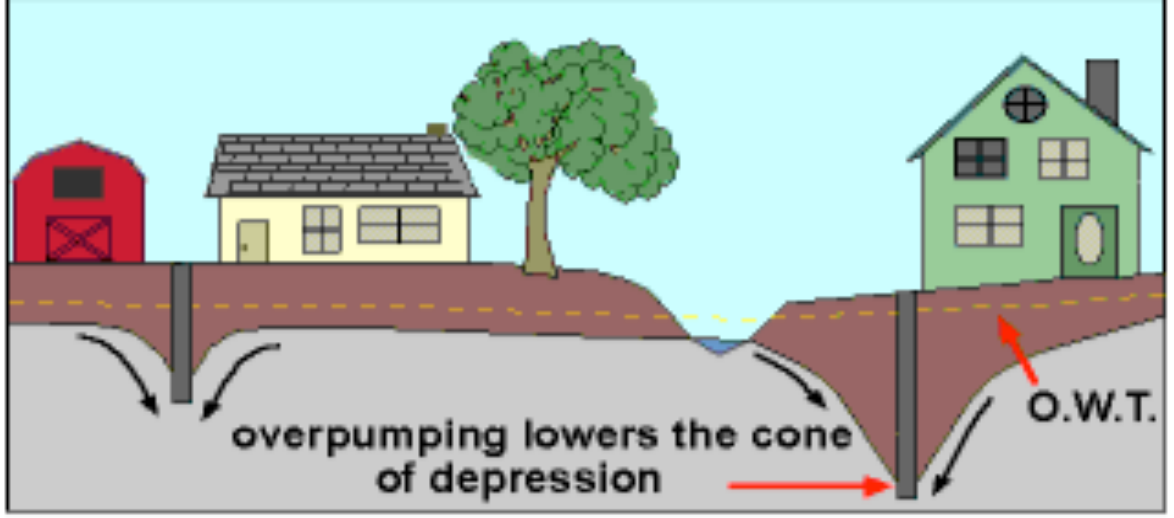
Causing localized dip in water table

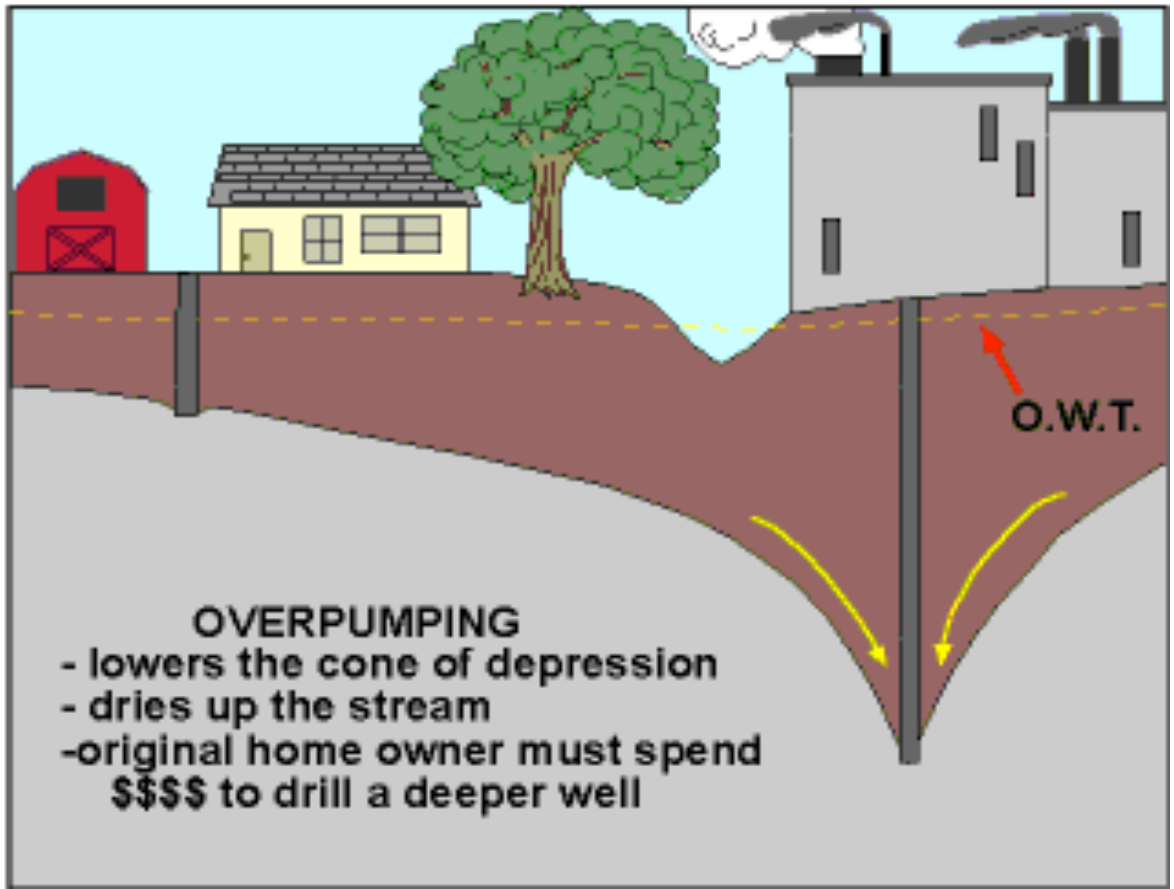
Main cause: over-pumping of well water

Can lead to subsidence






overpumping lowers the cone
of depression
O.W.T.


O.W.T.
OVERPUMPING
- lowers the cone of depression
- dries up the stream
-original home owner must spend
$$$$ to drill a deeper well

What causes subsidence?

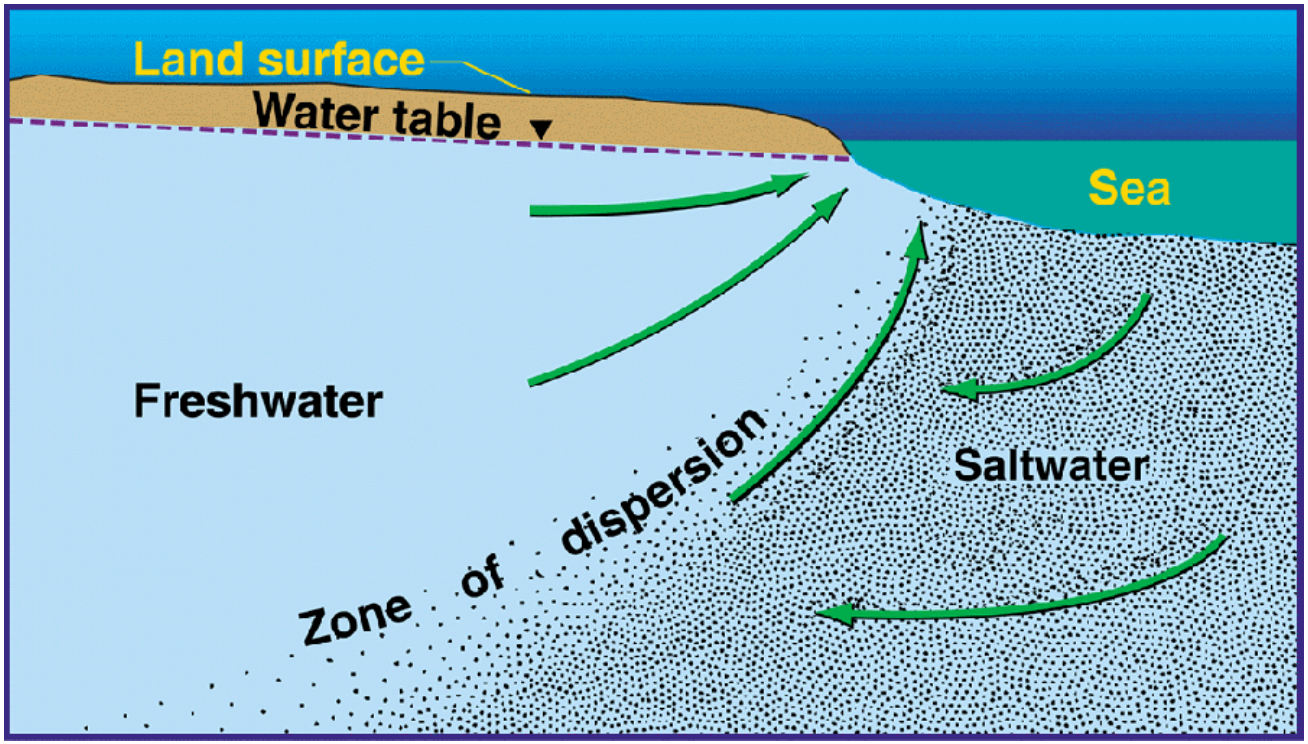
- Pushing out of water and gas from soft soils
- Compression and compaction of soil and rock layers

- http://abcnews.go.com/blogs/headlines/2013/03/golfer-swallowed-by-sinkhole/

- http://gallery.usgs.gov/videos/347

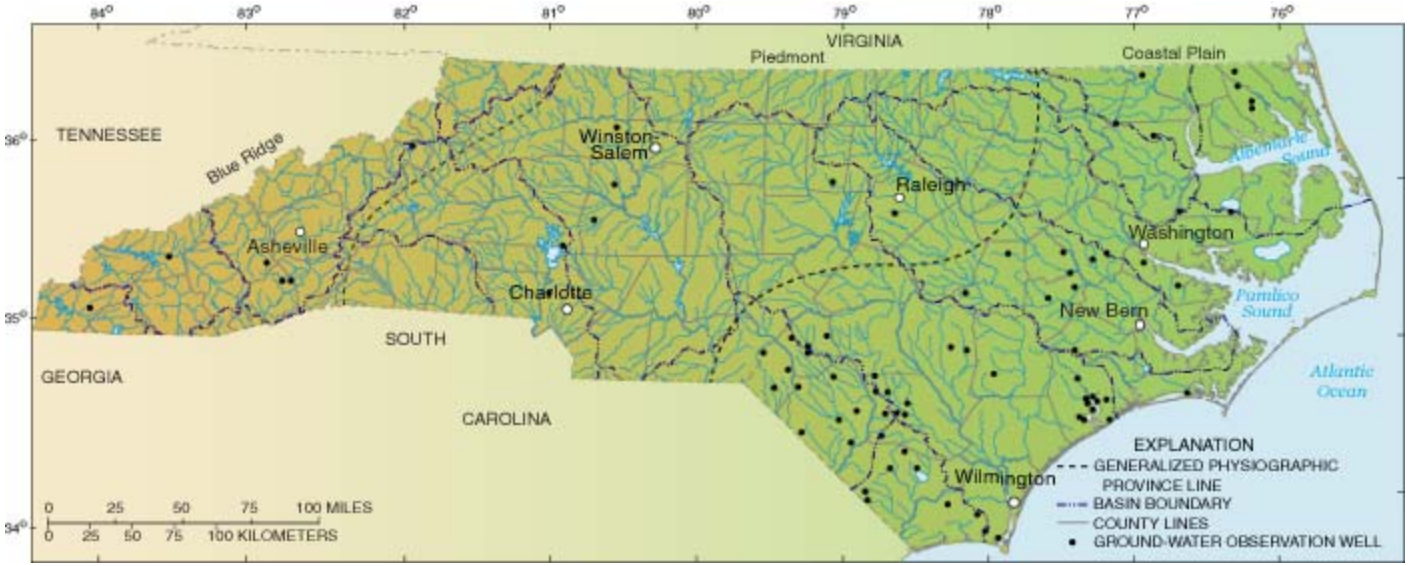
What is saltwater intrusion?

- **Saltwater intrusion** is the movement of saltwater into freshwater aquifers.



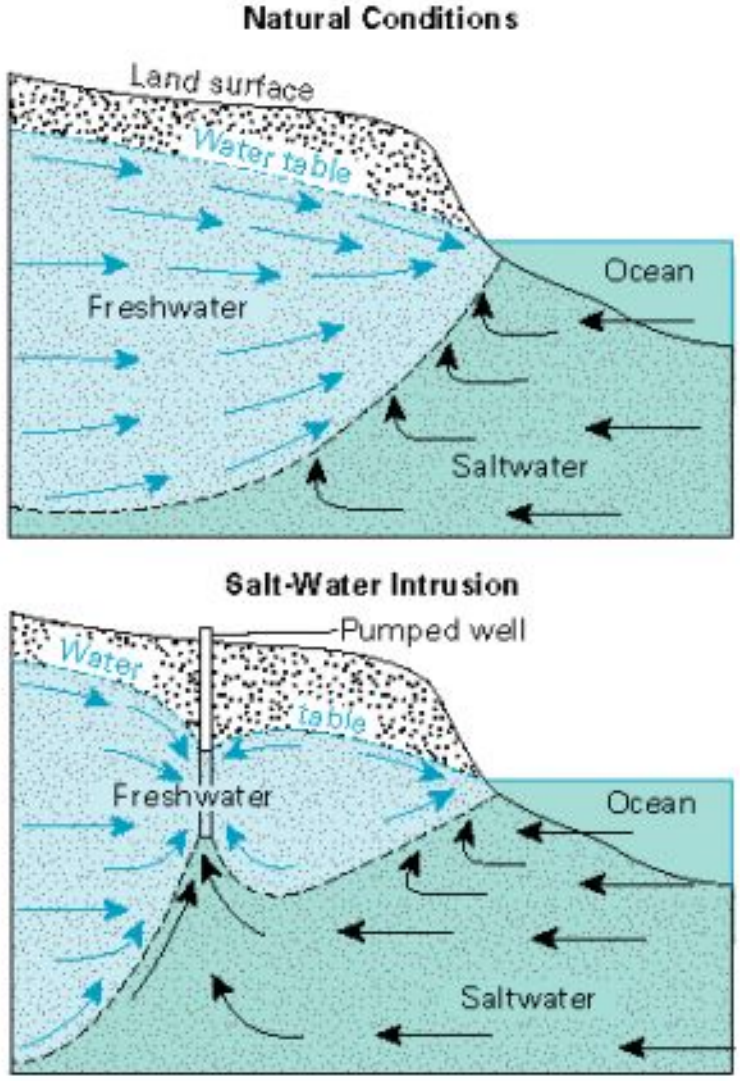
Where and how does it occur?

- Saltwater intrusion occurs naturally to some degree in most coastal aquifers.
- Saltwater has a higher mineral content than freshwater so it is denser and has a higher water pressure.
- Saltwater can push inland beneath the freshwater.



Do human activities make a difference?

- Human activities have increased saltwater intrusion in many coastal areas,
  - groundwater pumping from coastal freshwater wells.
  - Digging navigation channels
  - Wells for agricultural
  - Digging drainage canals



Why is saltwater intrusion and subsidence an issue for North Carolina?

- It can lead to contamination of drinking water sources and destruction of property and habits.

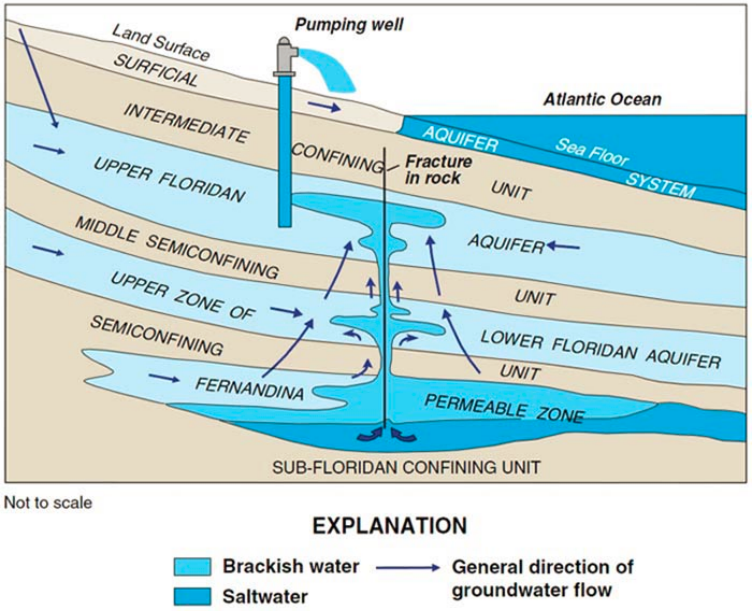


Figure 1. Saltwater inundation into the Floridan aquifer in Southeastern Georgia in response to groundwater pumping.

Does weather make a difference?

- Saltwater intrusion can be worsened by extreme events like hurricane storm surges.