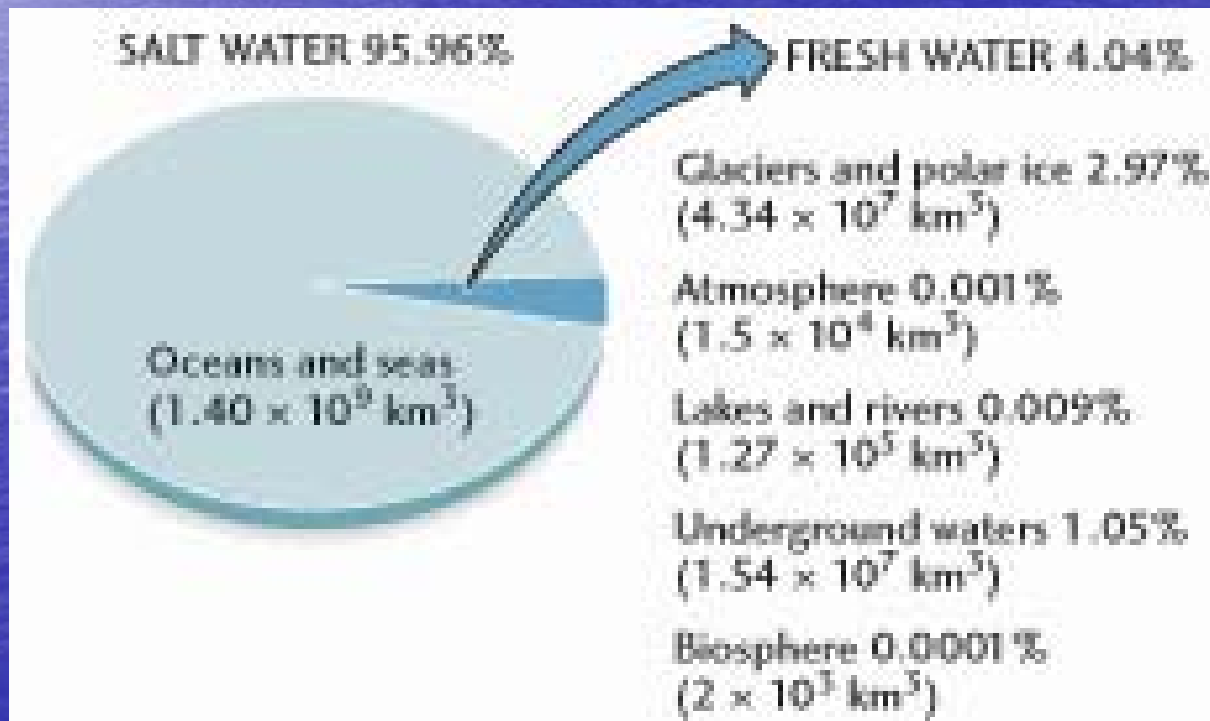


Applied Geomorphology

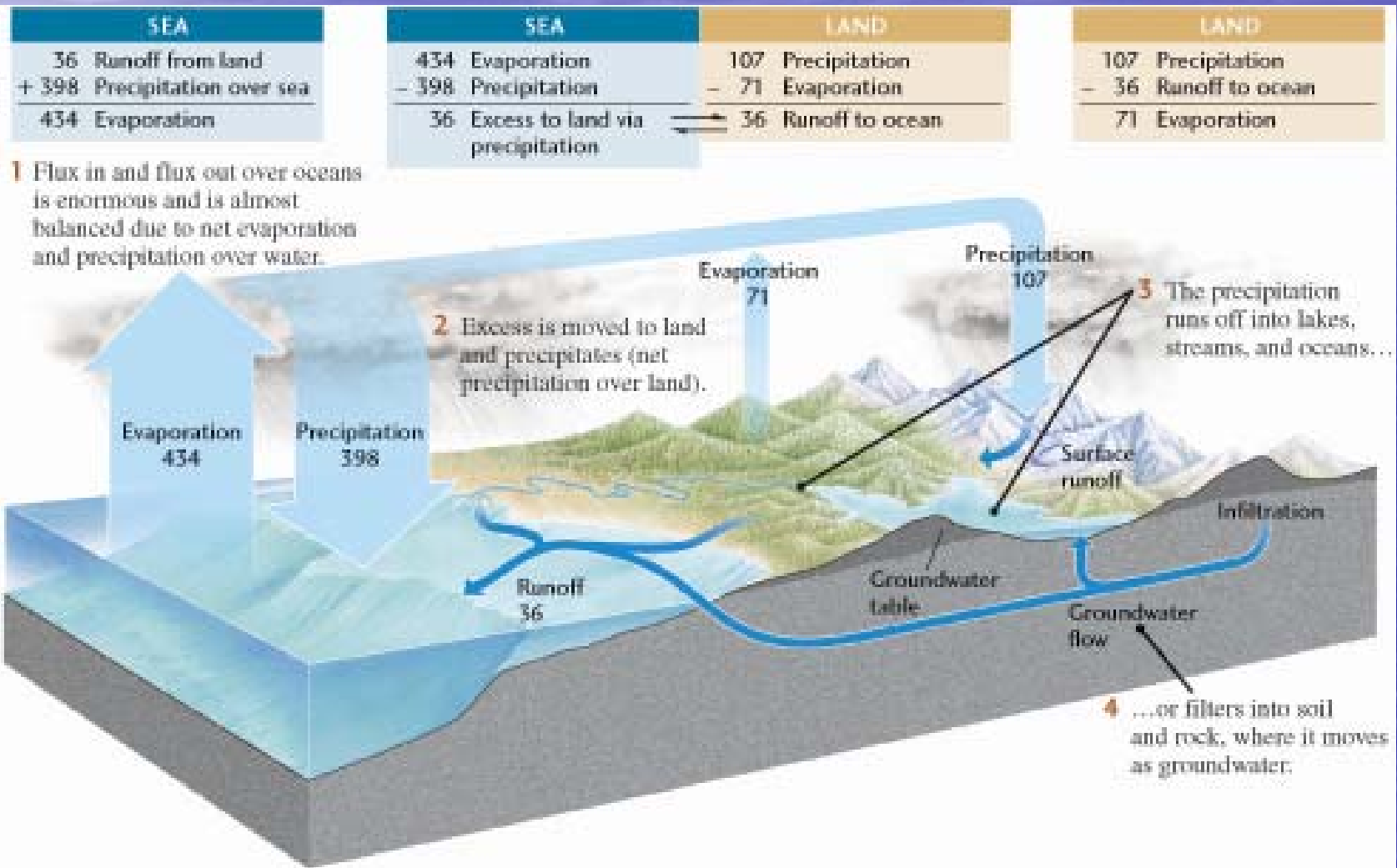
Lecture 9: Groundwater

Water on Planet Earth

- Most of the Fresh Water is in Glacial Ice

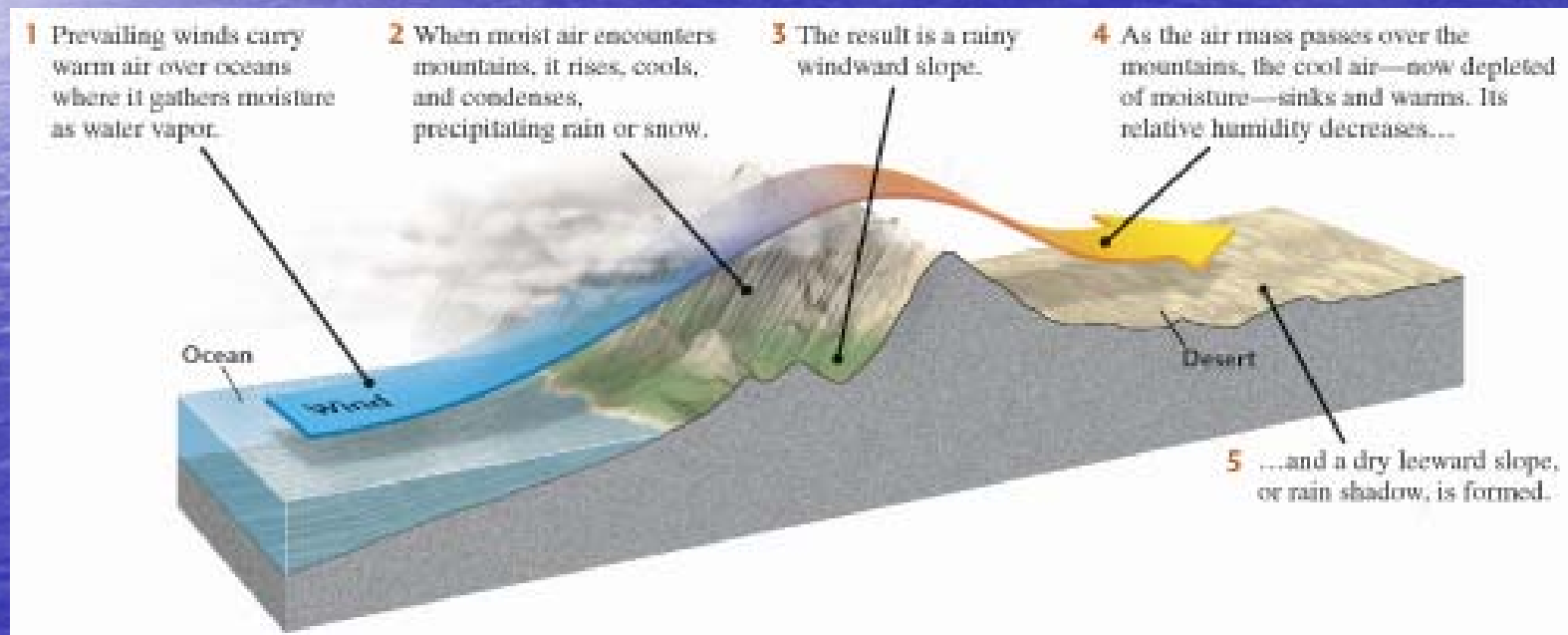


Hydrologic Cycle



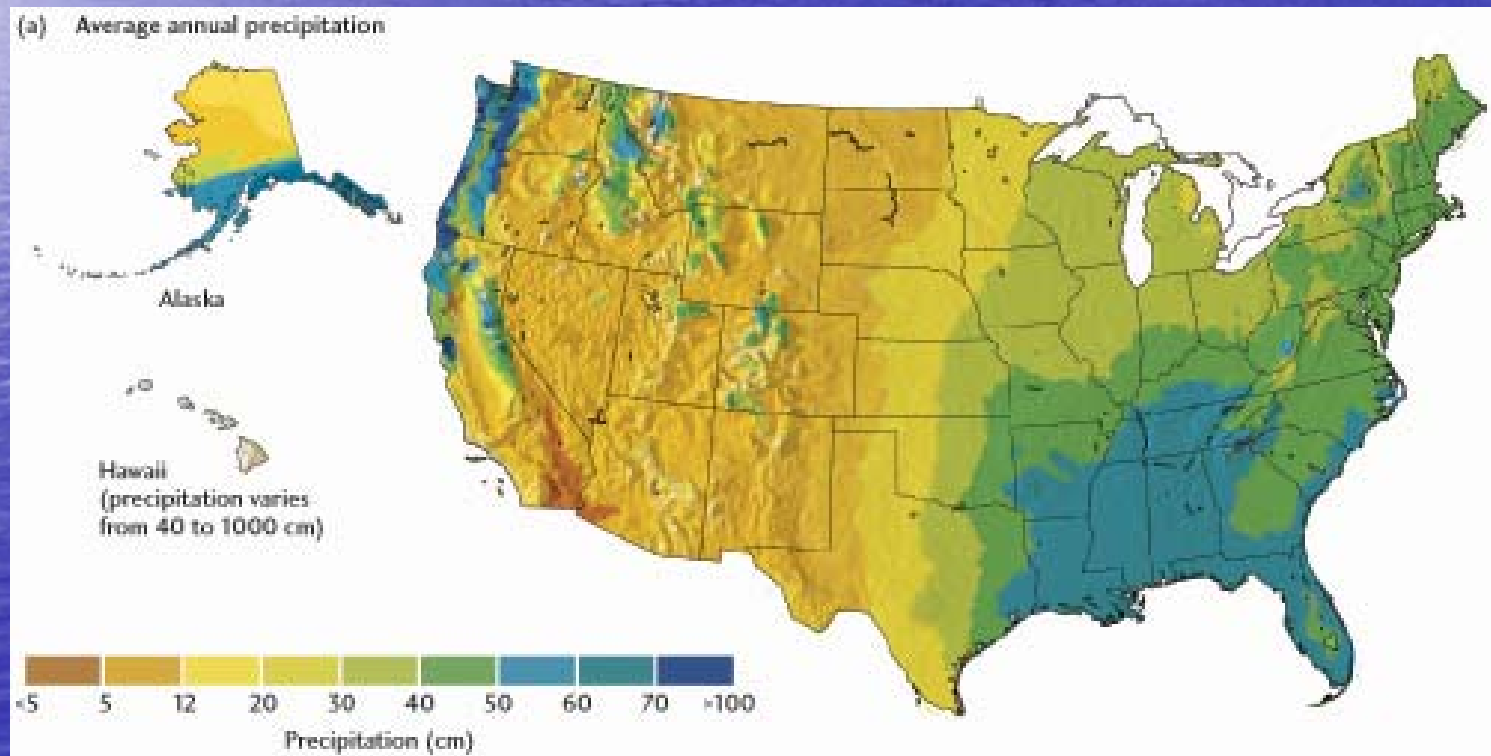
Orographic Lifting

- Rain Shadow Desert results



Average Annual Precipitation

- Used to measure climate
- More accurate to use precipitation/evaporation



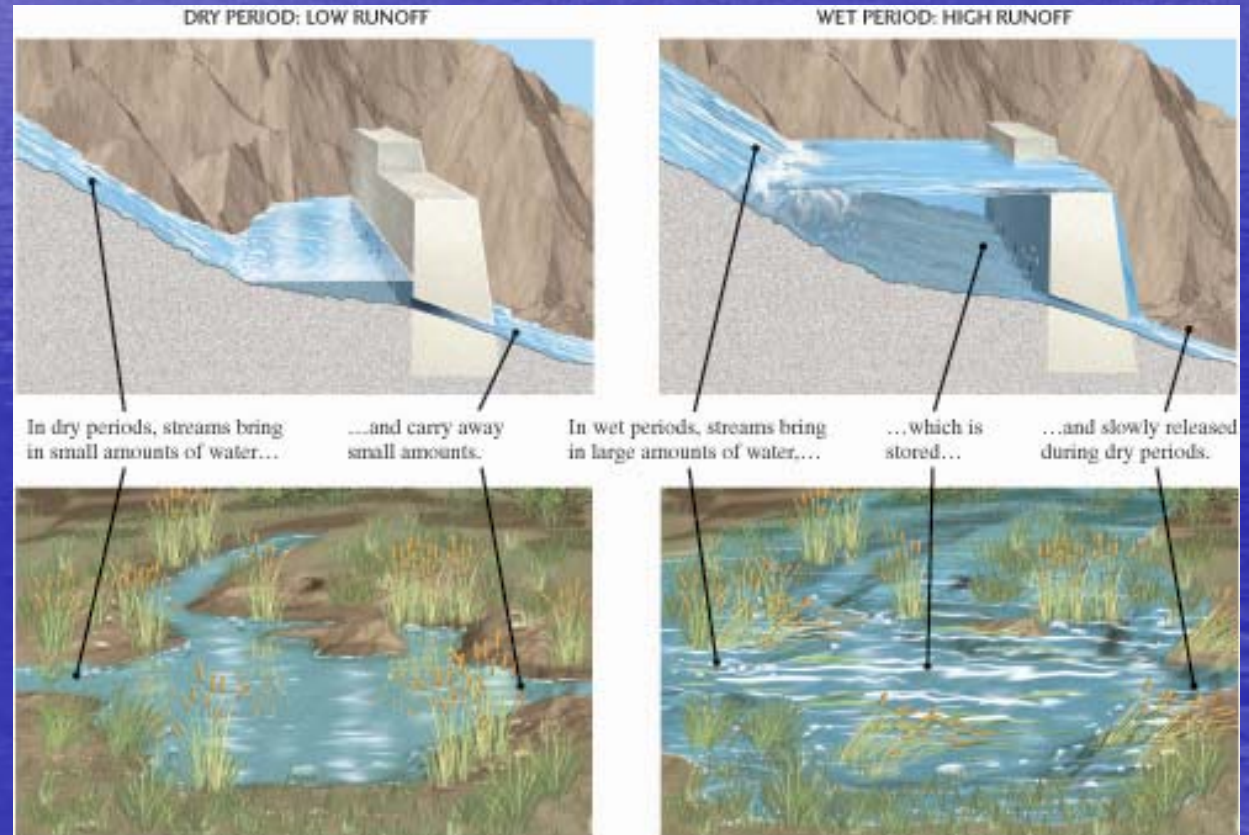
Runoff

- Precipitation that is collected by streams and rivers
- Runoff is transported to the oceans in a matter of several days (Short residence time)

River	Water Flow (m ³ /s)
Amazon, South America	175,000
La Plata, South America	79,300
Congo, Africa	39,600
Yangtze, Asia	21,800
Brahmaputra, Asia	19,800
Ganges, Asia	18,700
Mississippi, North America	17,500

Wetlands

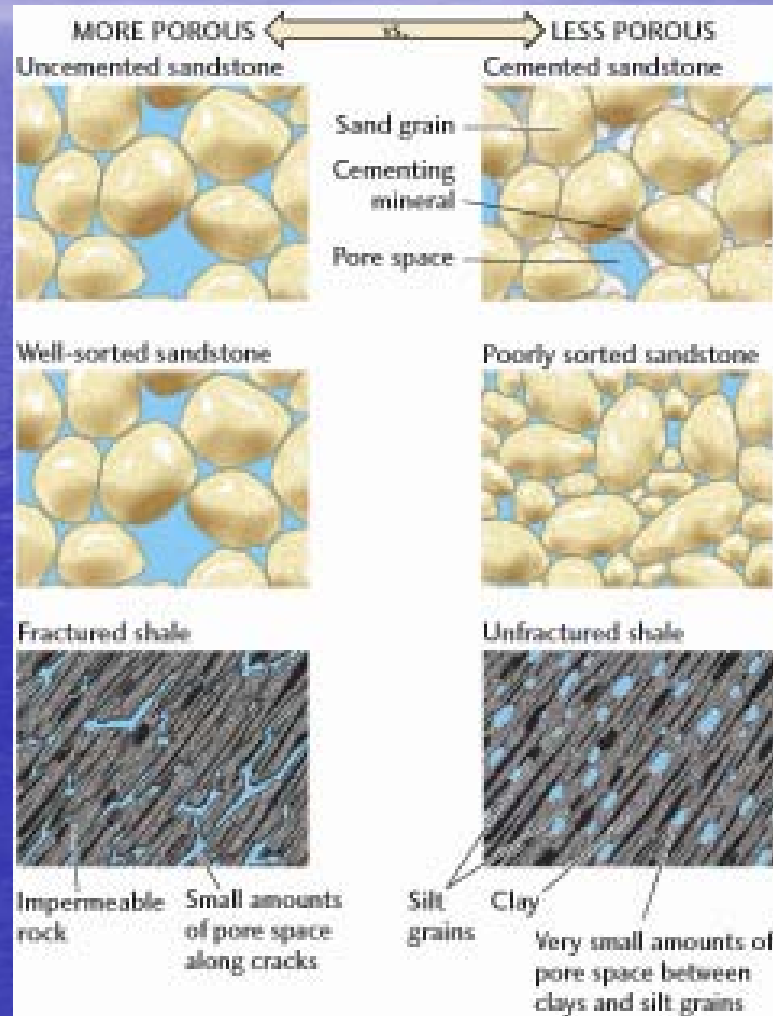
- Wetlands tend to store fresh water
- Wetlands also act as barriers to storm surge
- Wetlands are also one of the most productive biological environments



Groundwater

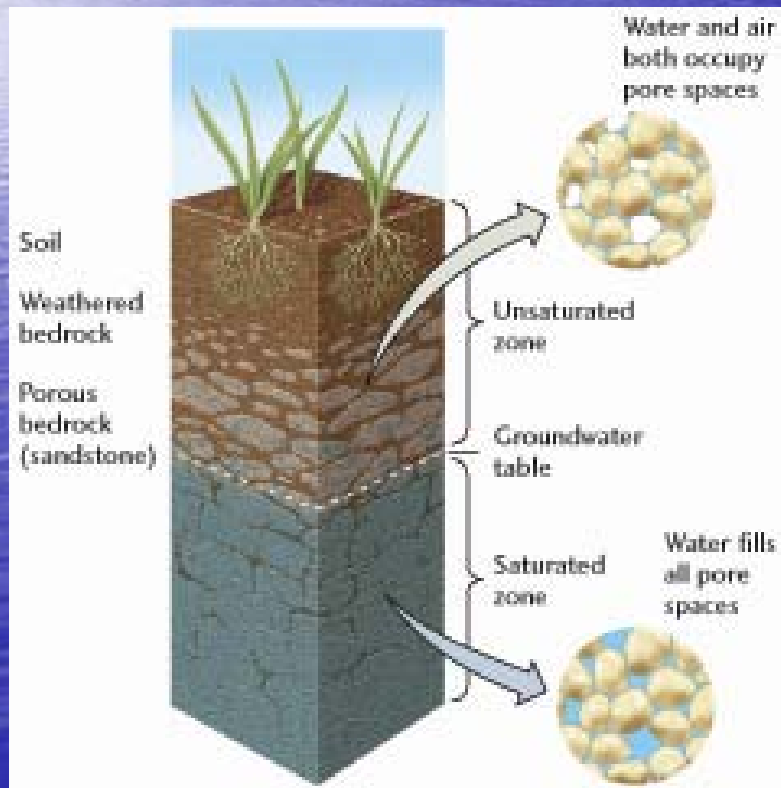
- Groundwater is water that infiltrates below the erosional surface
- Porosity: percent void space in a material
- Permeability: ability of a material to transmit a fluid
- Common permeable geological material includes sandstone, limestone, marble, fault breccia

Examples of Porosity & Permeability



Water Table

- Saturated Zone: all void space is filled with water



Water Table Morphology

- The water table is a subdued replica of the overlying topographic surface
- Where the water table intersects the surface there will be a water discharge (spring, pond, lake or stream)
- The recharge area is where the precipitation enters the groundwater system
- Clay layers may generate a perched water table

Perched Water Table

- Impermeable clay layer generates a localized water table

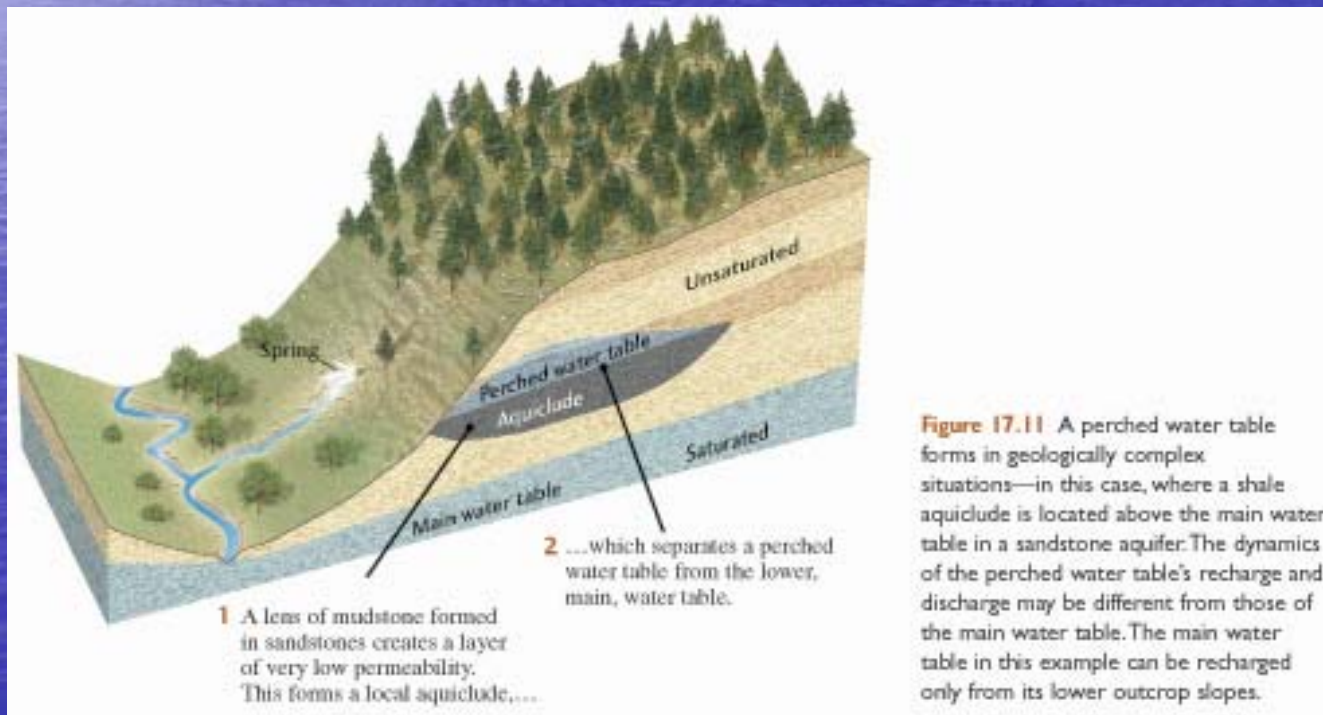
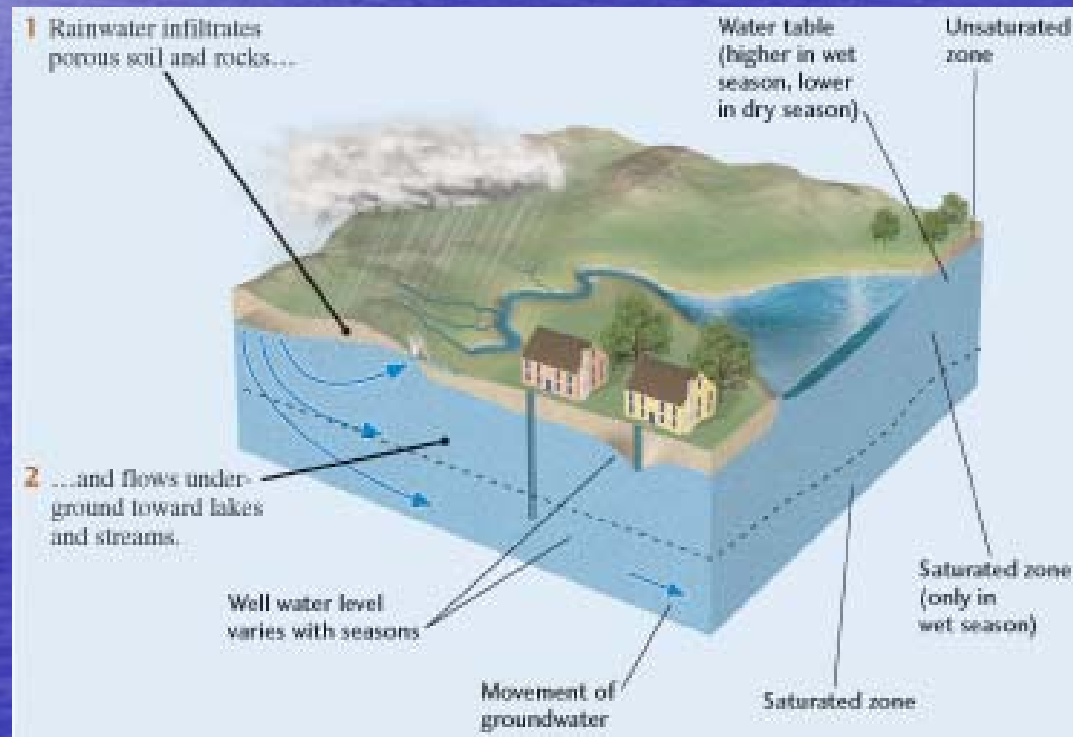


Figure 17.11 A perched water table forms in geologically complex situations—in this case, where a shale aquiclude is located above the main water table in a sandstone aquifer. The dynamics of the perched water table's recharge and discharge may be different from those of the main water table. The main water table in this example can be recharged only from its lower outcrop slopes.

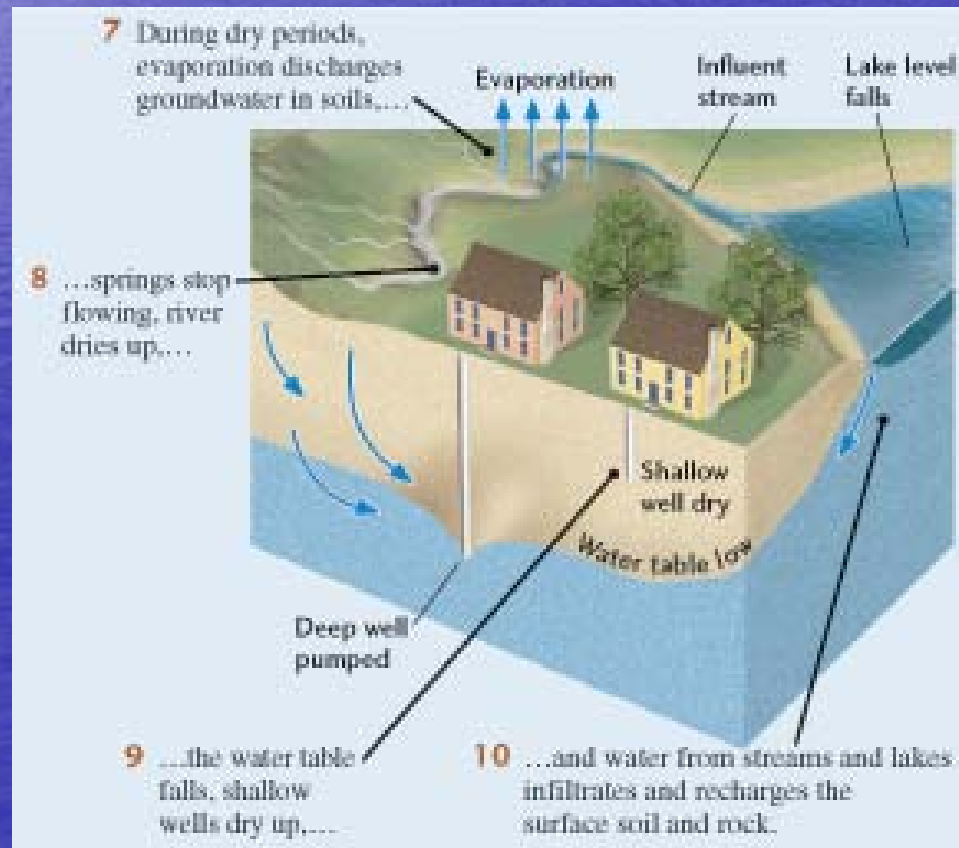
Anthropogenic Effects

- Excessive pumping lowers the elevation of the local water table (Drawdown)



Effects of Drought on Water Table

- During drought water lowers throughout area

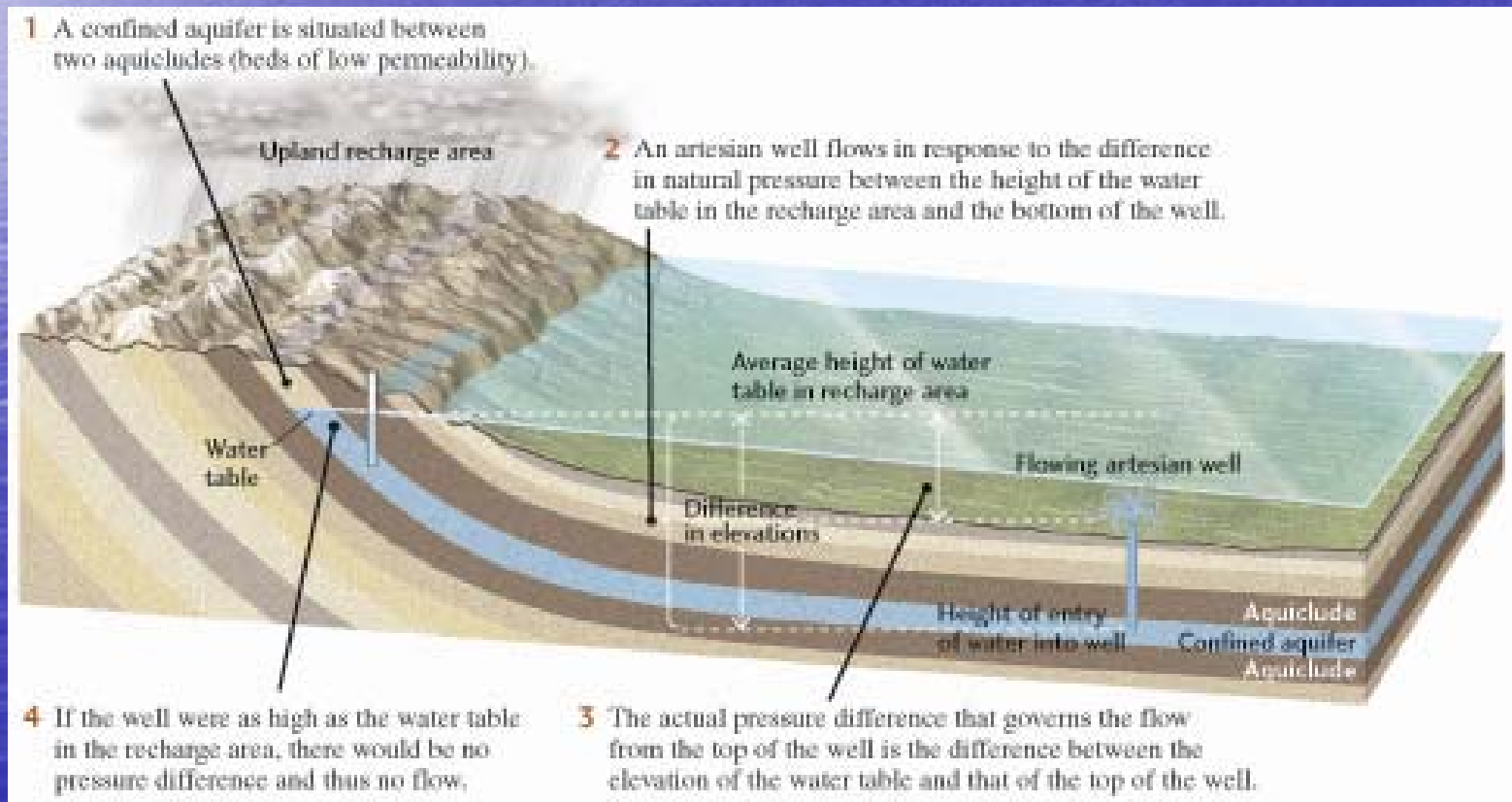


Aquifer

- Aquifer: a geological unit that contains water (porous and permeable)
- Confined Aquifer: bracketed by aquicludes (impermeable)
- Potentiometric Surface: elevation to which the pressurized water in a confined aquifer will rise
- Artesian Well: water rises to an elevation above the aquifer
- Flowing Artesian Well: potentiometric surface is above the ground surface

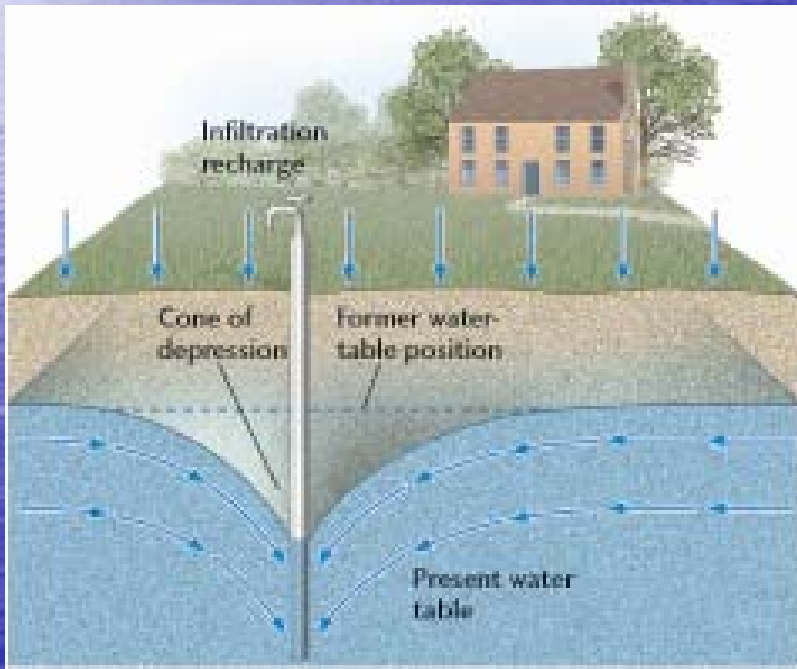
Example of Confined Aquifer

- Confined aquifers may contain pressurized water (hydraulic head)



Groundwater Issues

- Drawdown

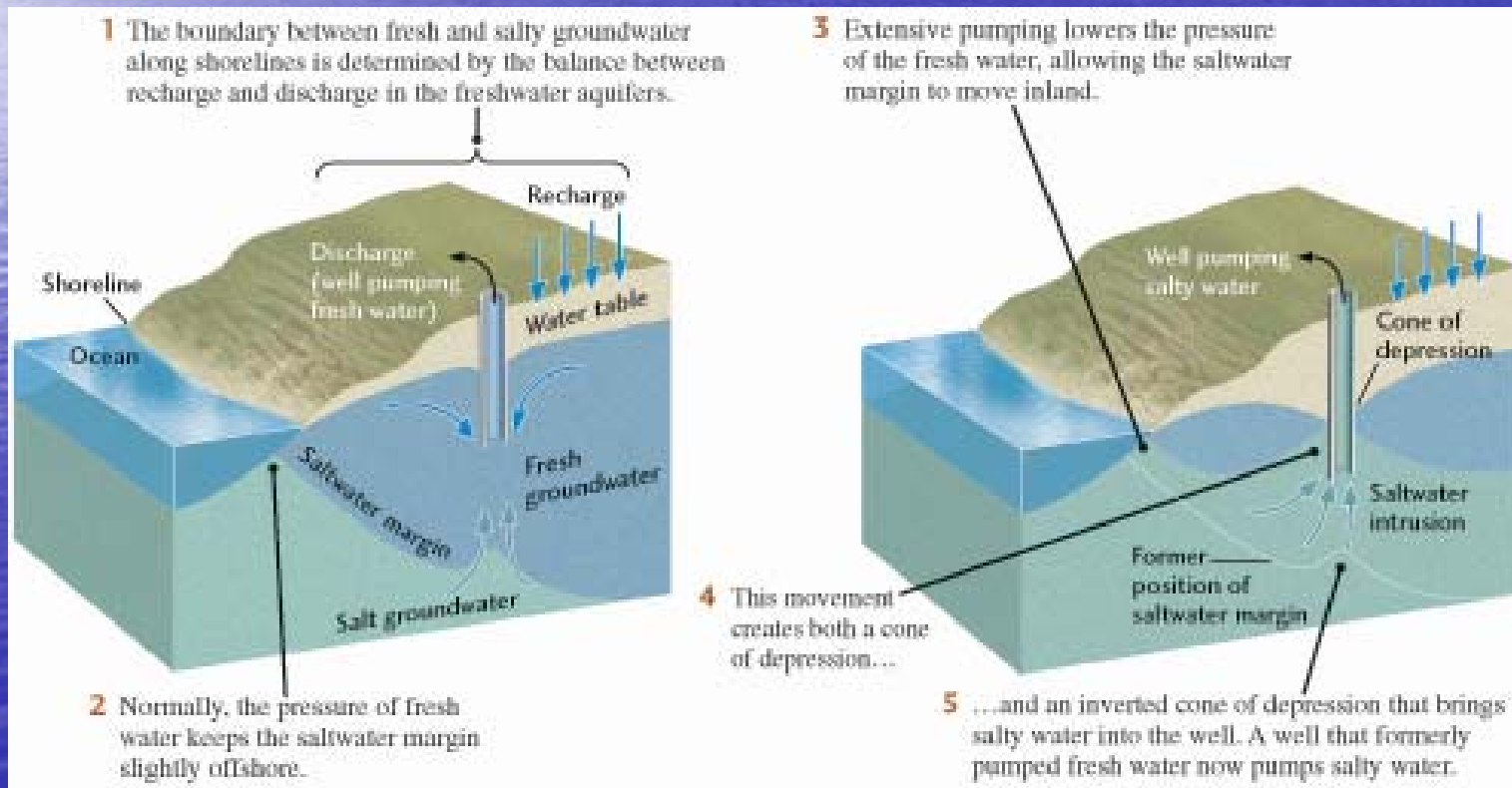


Sinkholes



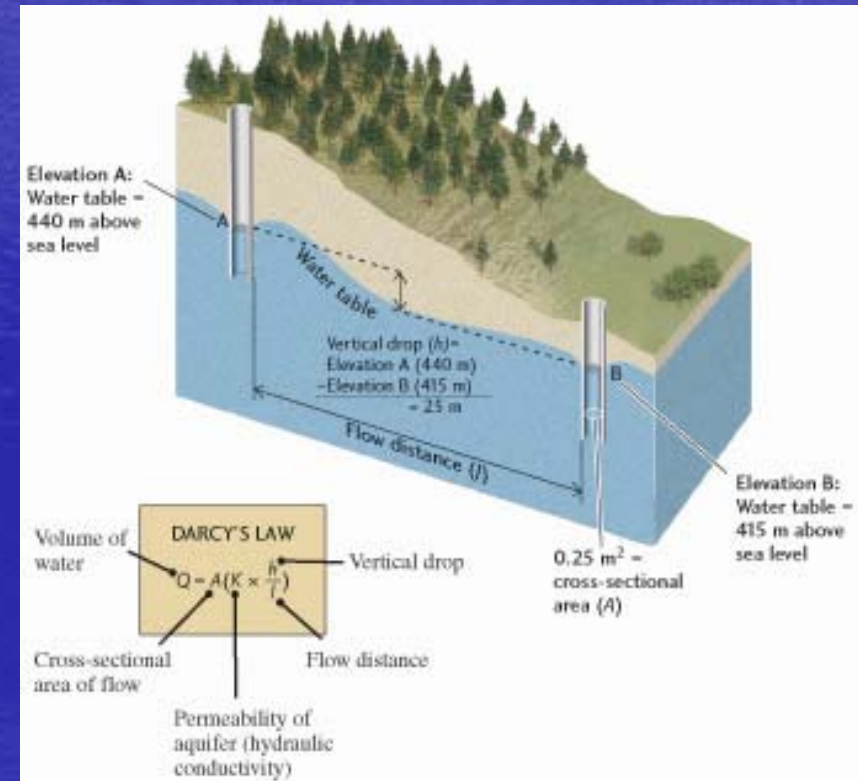
Saltwater Intrusion

- Salt water is more dense than fresh water



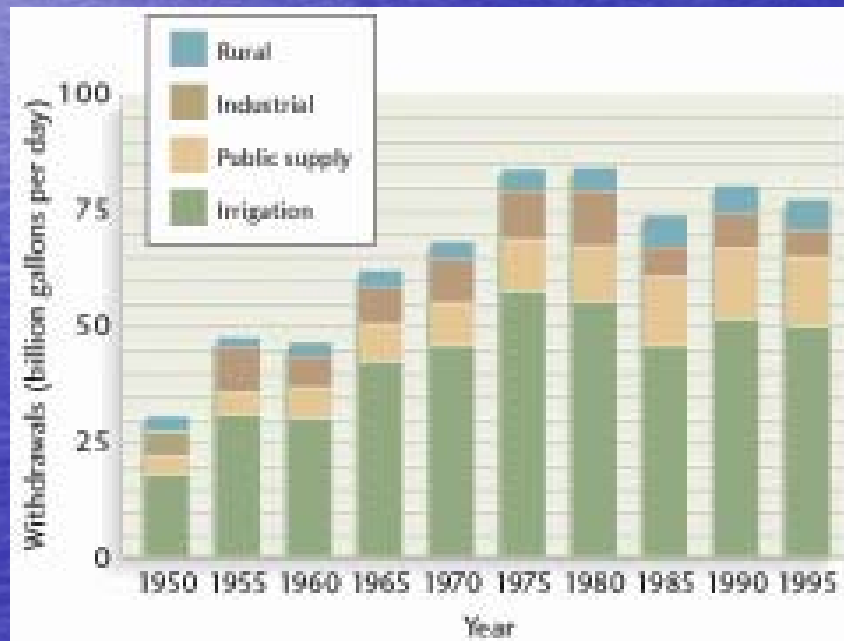
Groundwater Flow

- Darcy's Law: governs the volume of groundwater produced at a well head
- $Q = A(K)(h/l)$
 - Q is volume
 - A is cross sectional area of aquifer
 - K is permeability
 - h is hydraulic head
 - l is map distance



Water Resources

- Potable groundwater is a rapidly diminishing resource



Erosional Work of Groundwater

- Natural groundwater is acidic (pH=6.5)
- Carbonates are susceptible to dissolution

Sinkhole Formation



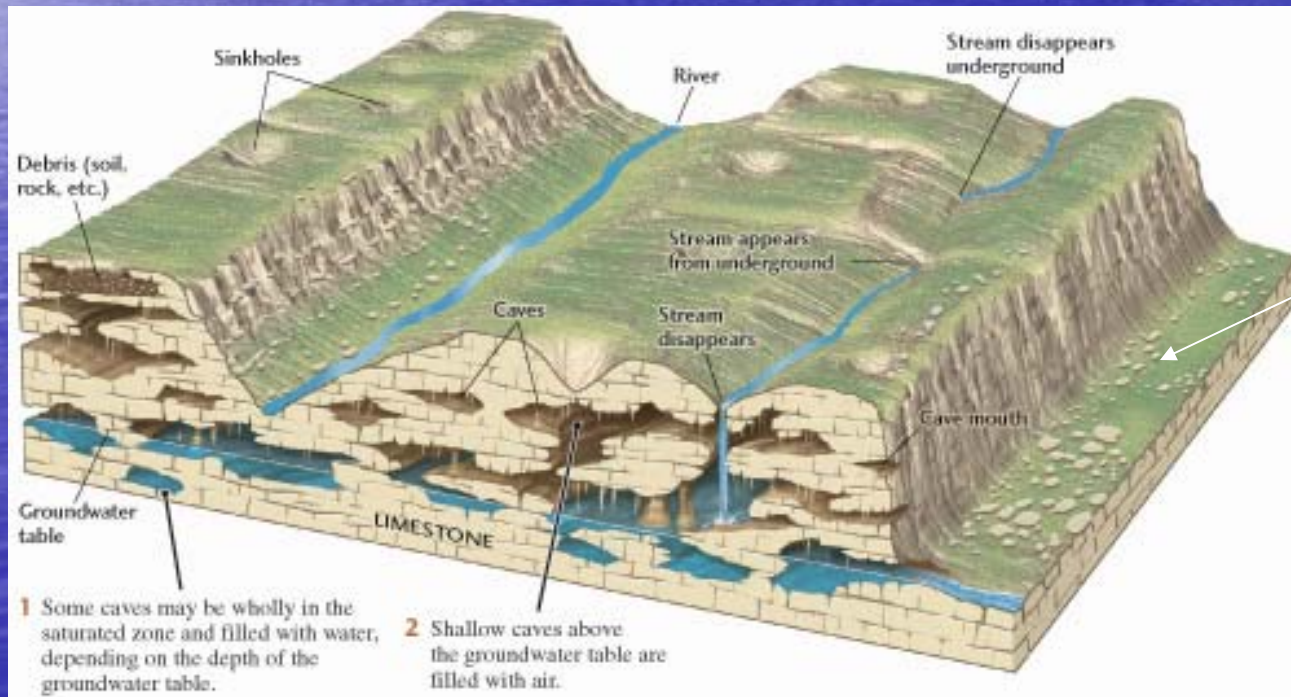
Stalagtite

Stalagmite



Stages of Landform Erosion in Karst Regions

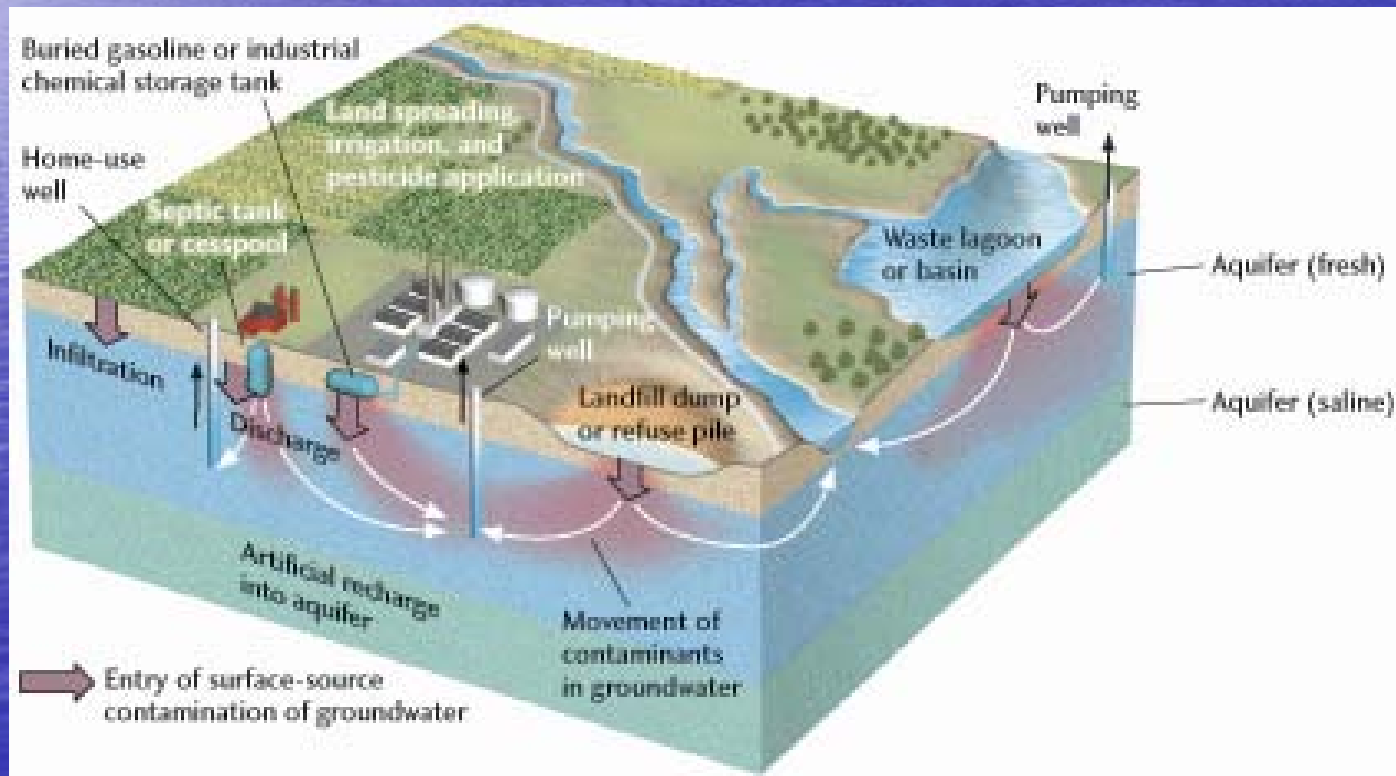
- Landforms dominated by solution of bedrock are termed **Karst** landforms



Solution Valley

Water Quality

- Contamination of groundwater supply



Contamination Issues

- Lead (Pb): sources include atmospheric pollution and older lead pipes
- Radioactive Waste: natural and anthropogenic sources
- Microorganisms: sewage and waste water, flooding and storm surge
- Other chemical contaminants (solvents, gasoline, nitrates, road salt, etc.)

Hydrothermal Systems

- Groundwater heated by magmatic sources

