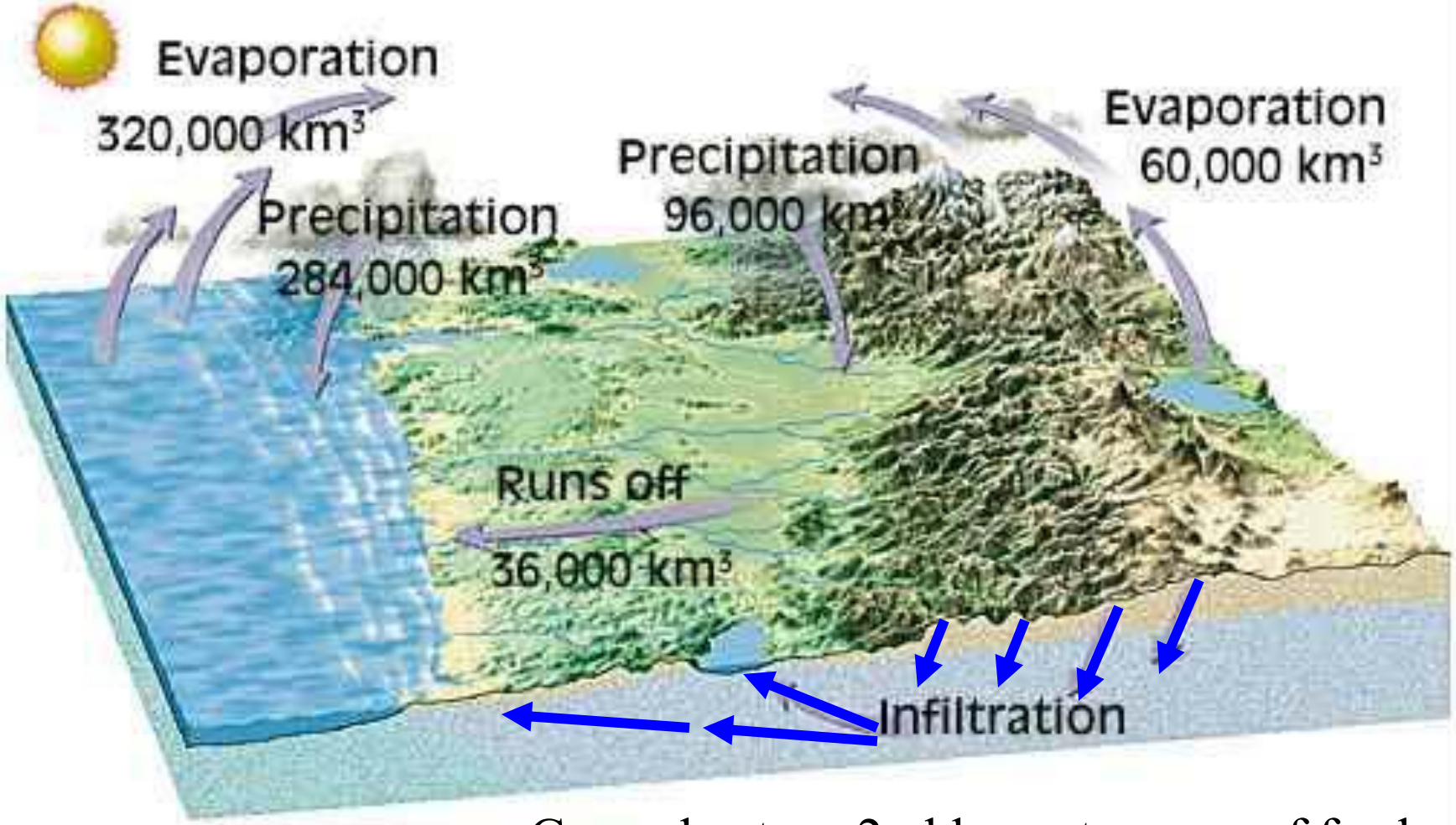
GROUNDWATER

The Flow of Water Through the Subsurface

RUNOFF vs. INFILTRATION

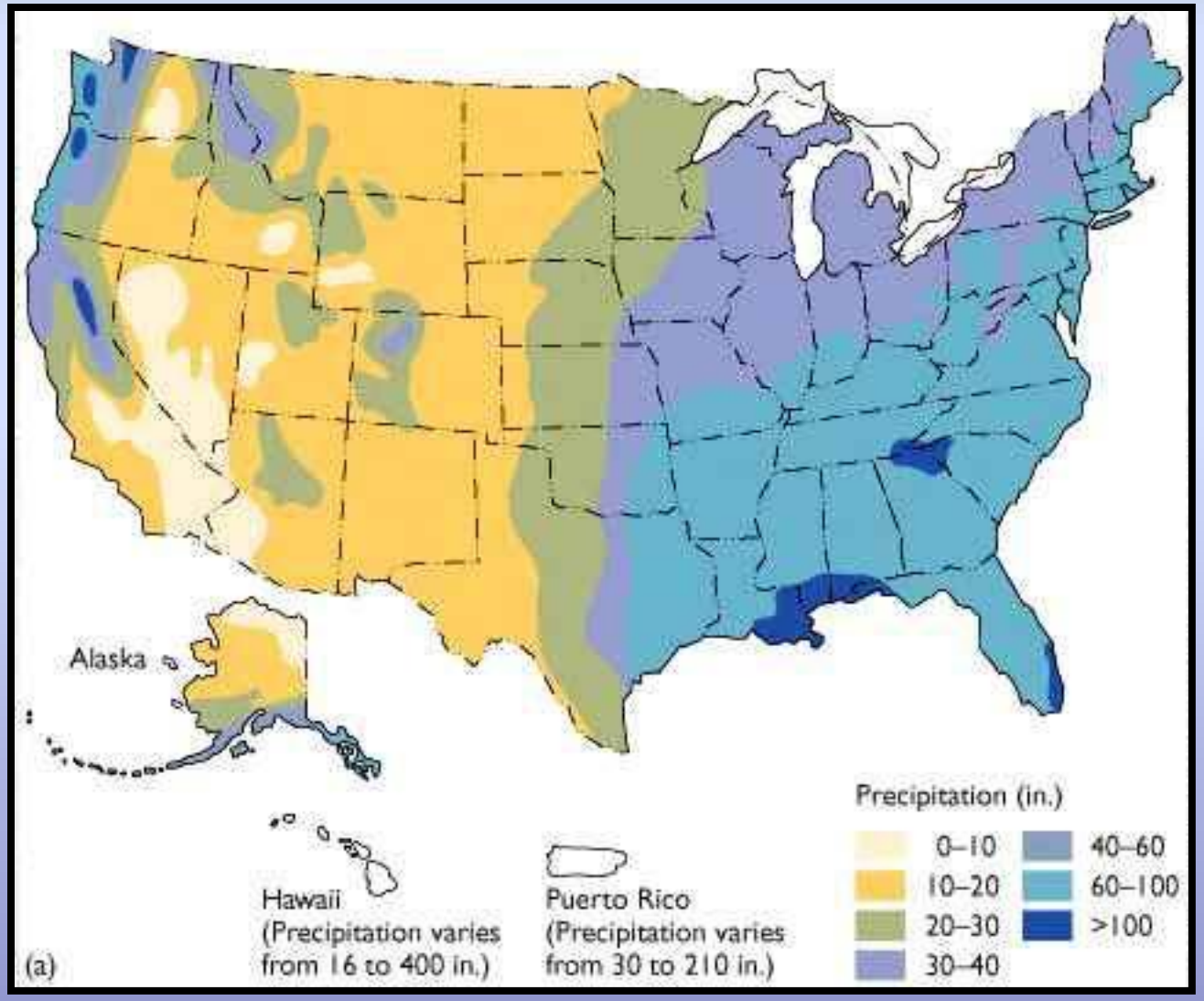


Groundwater - 2nd largest source of fresh water on this planet.

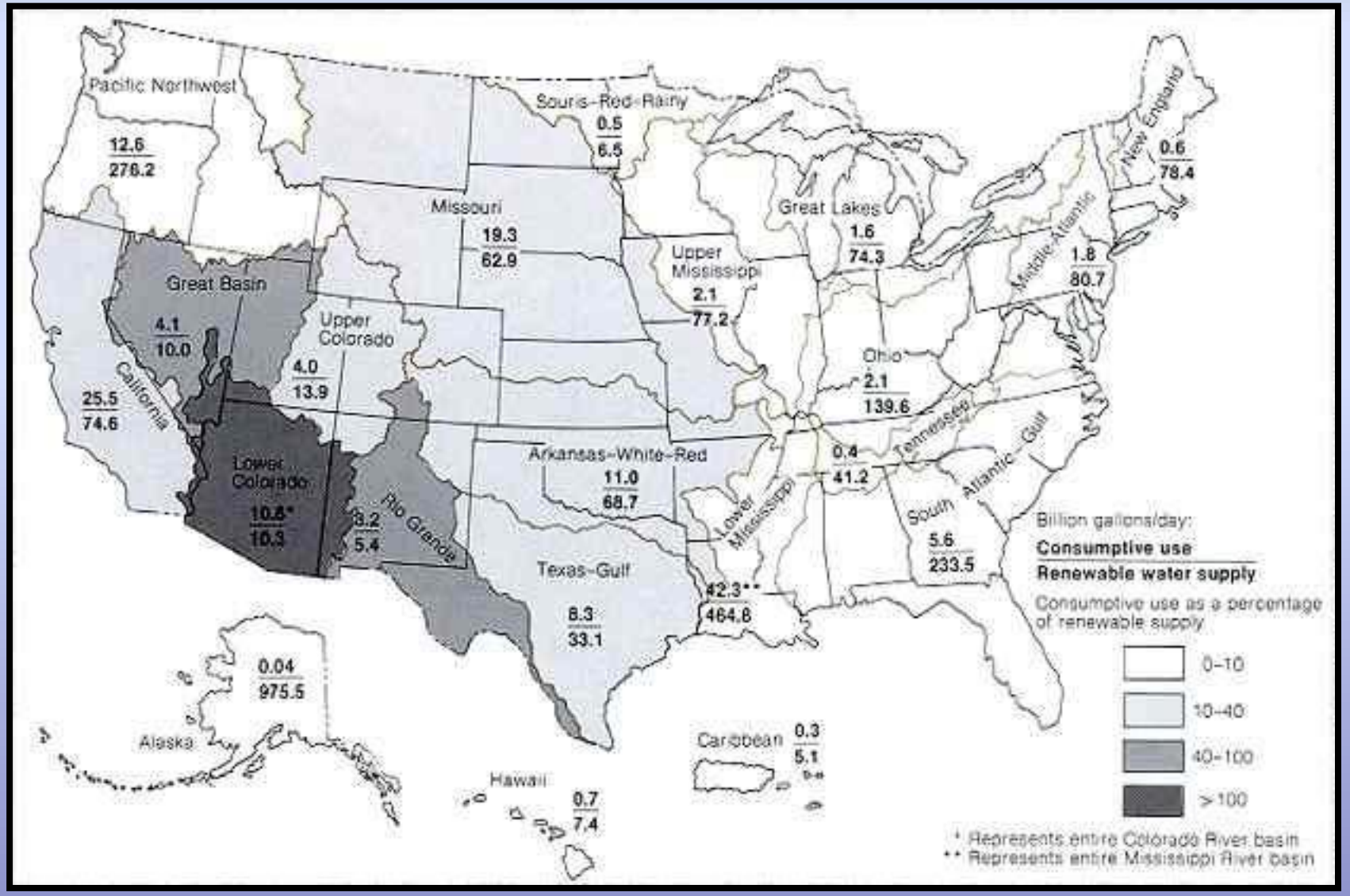
Where's the Water?

Parts of the Hydrosphere	Volume of Freshwater (km^3)	Share of Total Volume of Freshwater (percent)
Ice sheets and glaciers	24,000,000	84.945
Groundwater	4,000,000	14.158
Lakes and reservoirs	155,000	0.549
Soil moisture	83,000	0.294
Water vapor in the atmosphere	14,000	0.049
River water	1,200	0.004
Total	28,253,200	100.000

Where's the Rainfall?



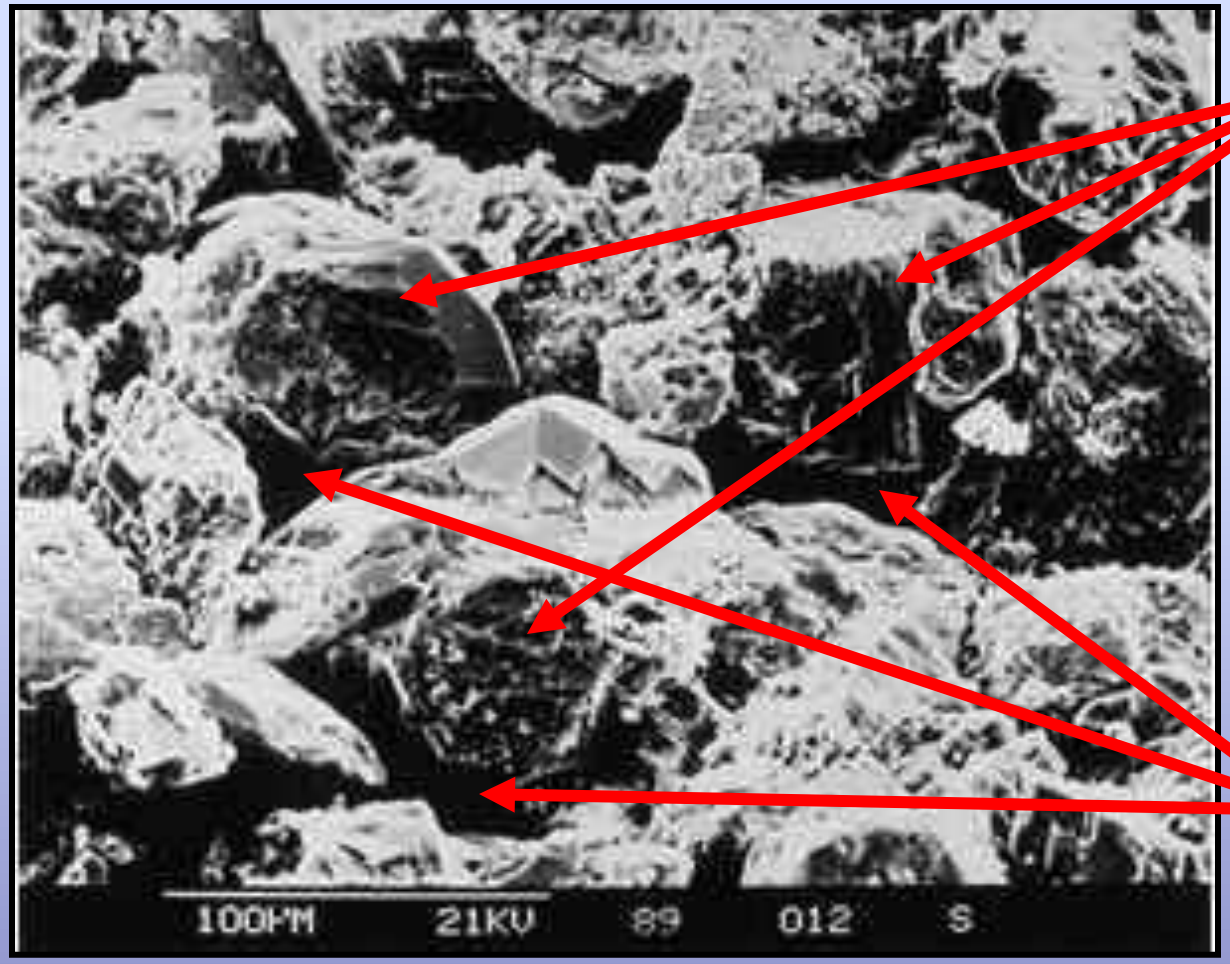
Water Consumption



Rainfall vs. Consumption

- Consumption exceeds renewable water sources in the southwest.
- This is also true in Southern California since about 1900
- Also some places locally in the Midwest
- Necessitates the use of groundwater to meet human needs.

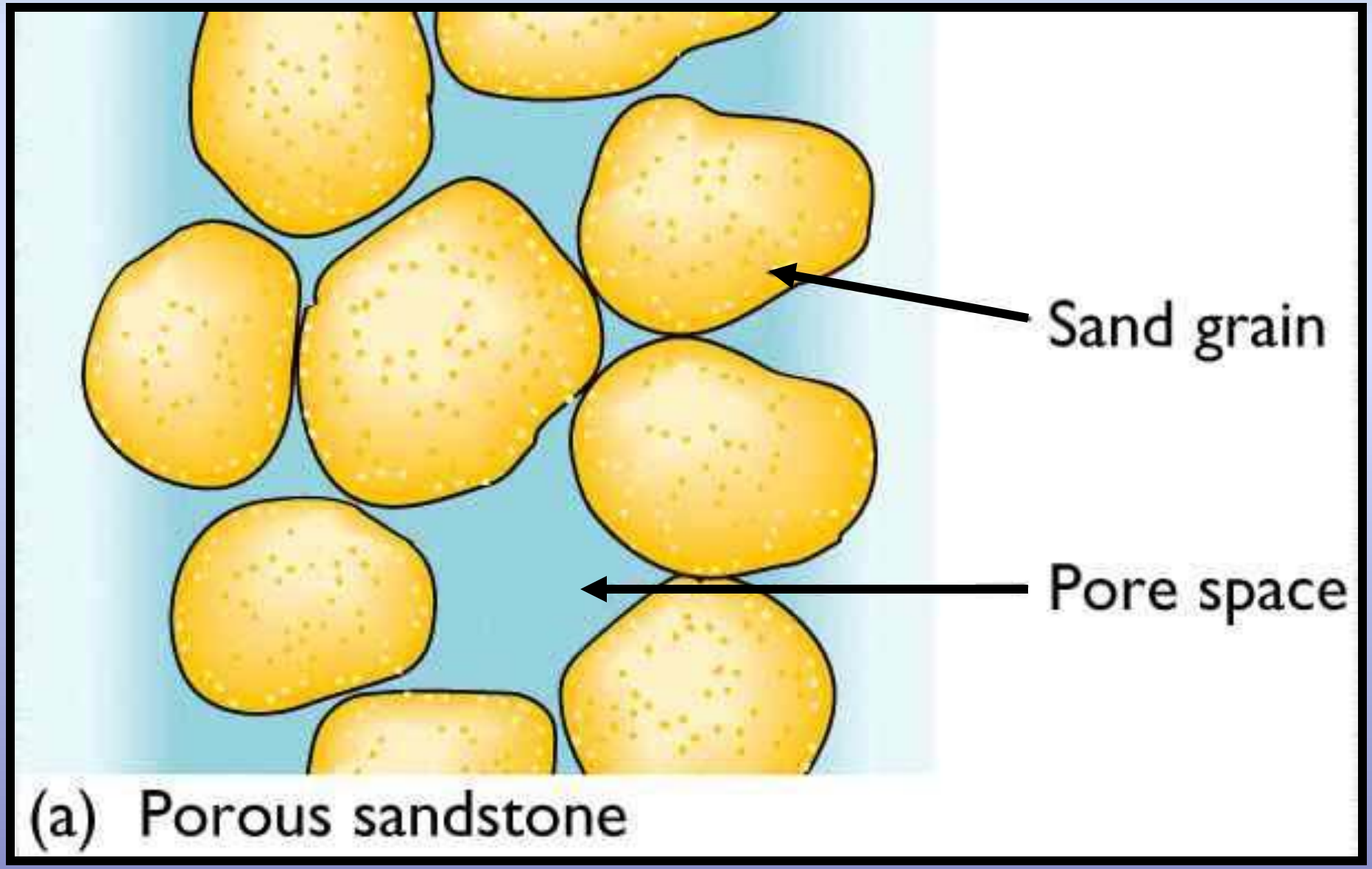
Its All About Porosity...



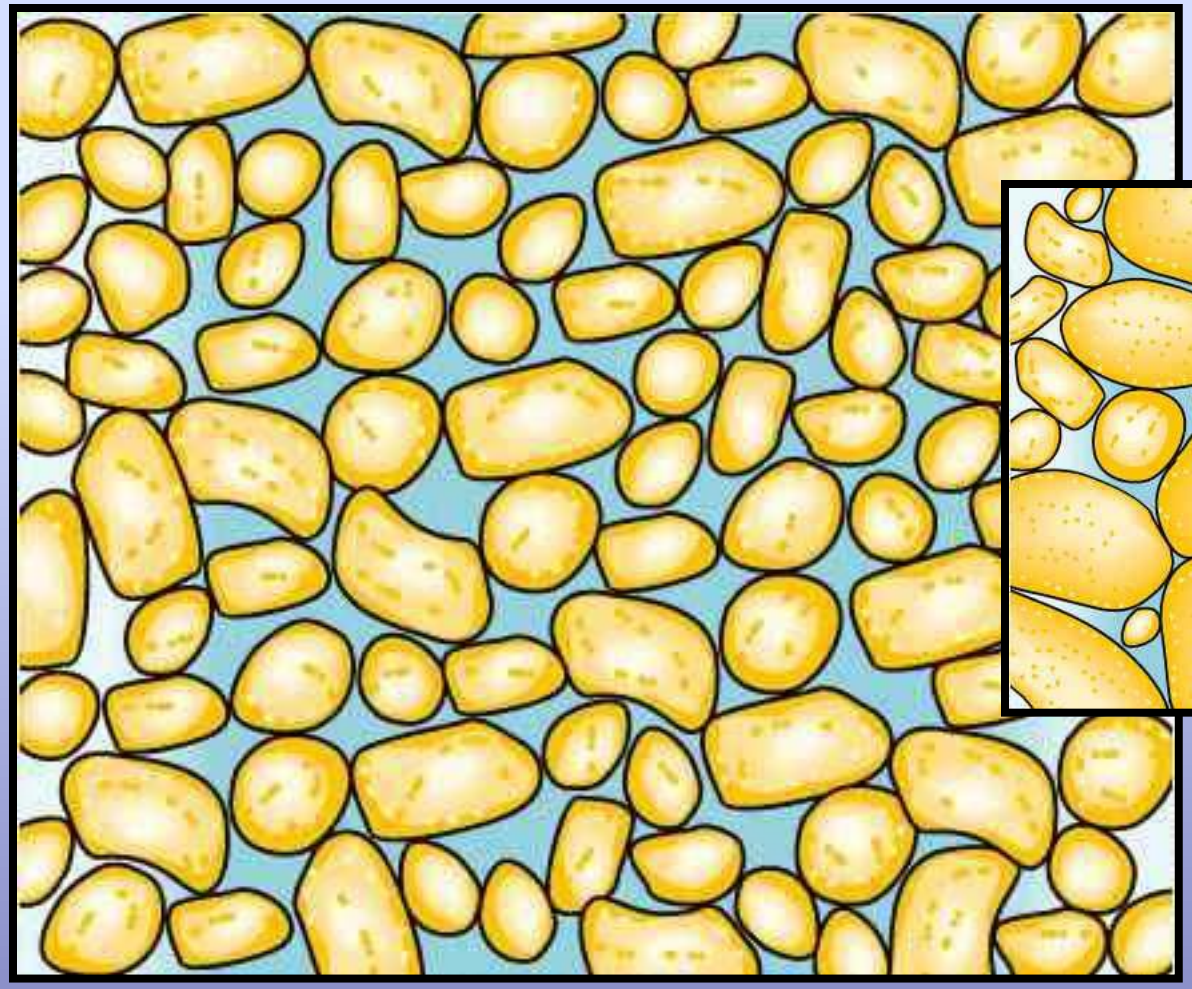
Sand Grains

Porosity

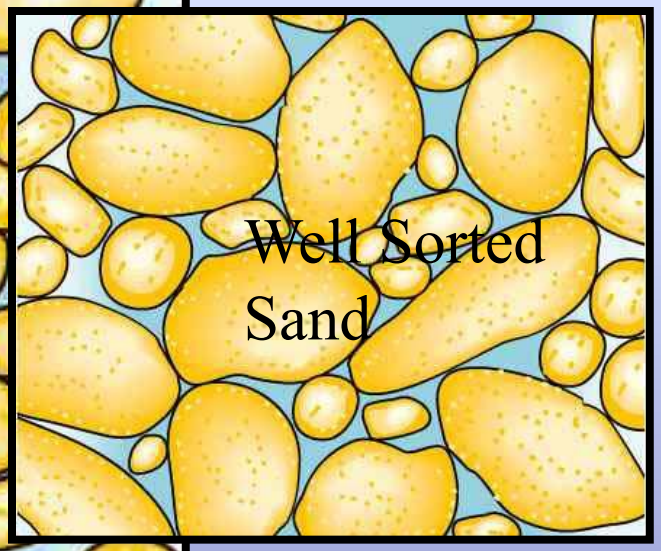
Intragranular Porosity



Sediment Sorting and Porosity

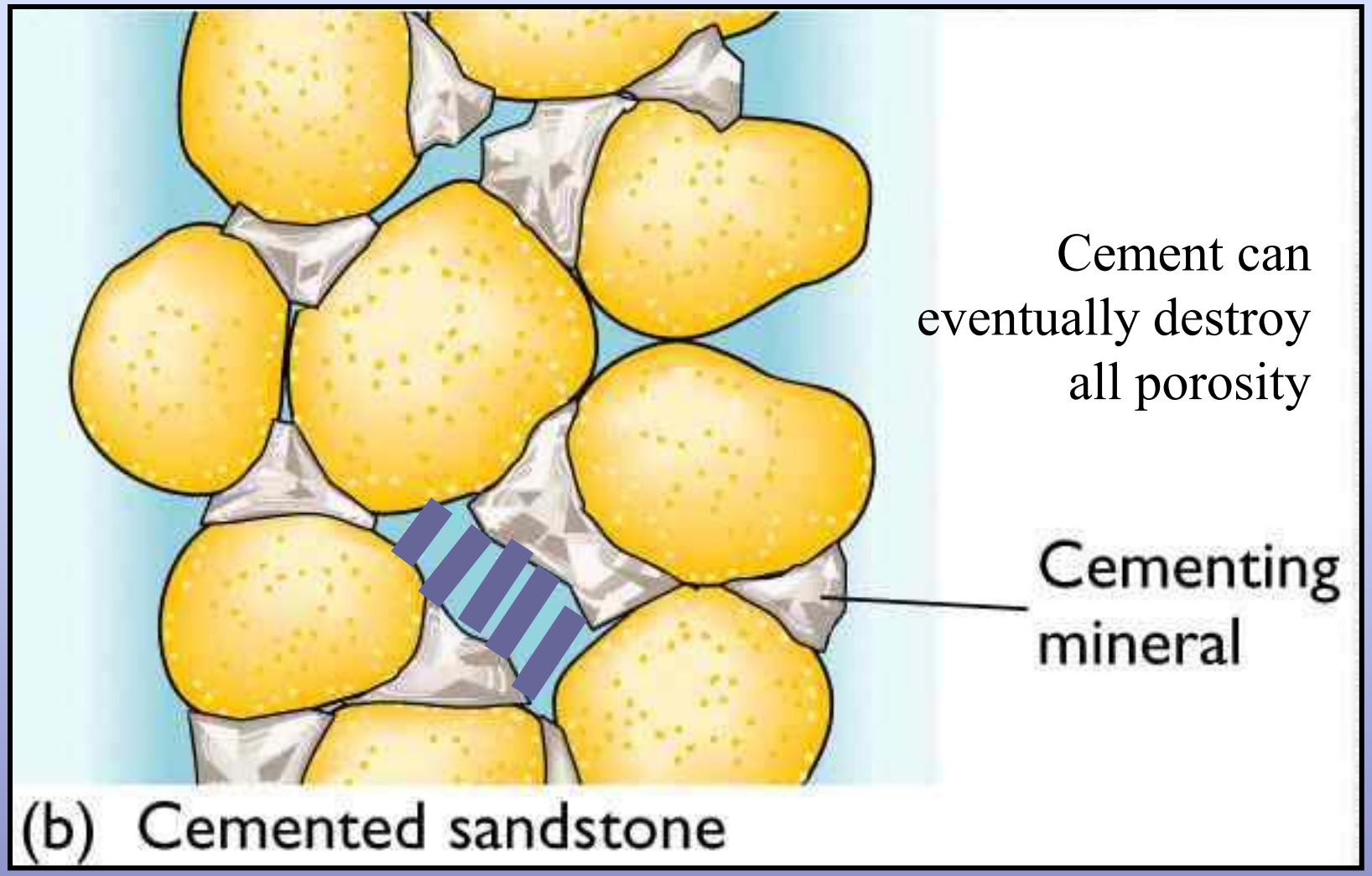


Poorly Sorted Sand

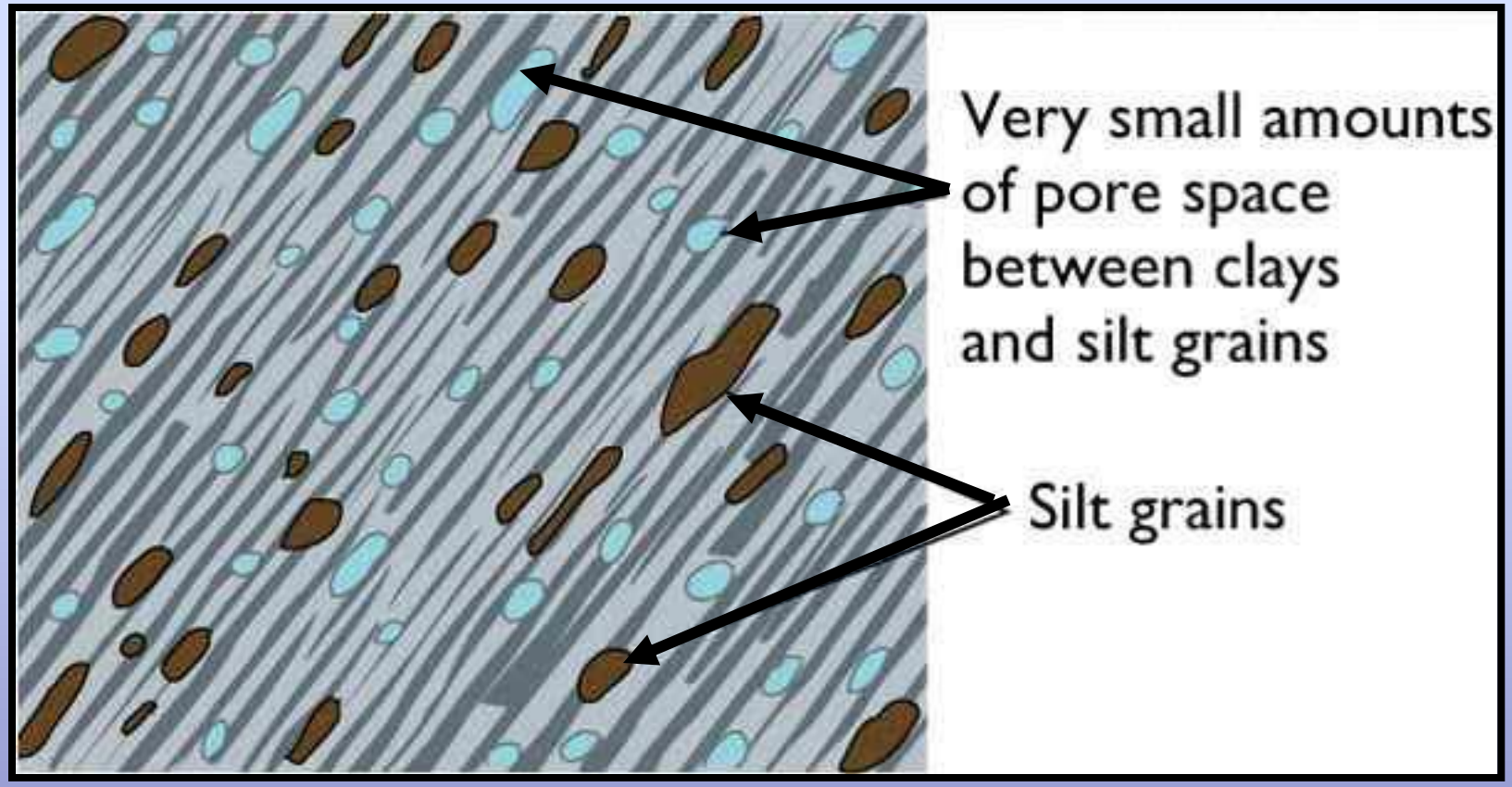


Which has greater porosity?

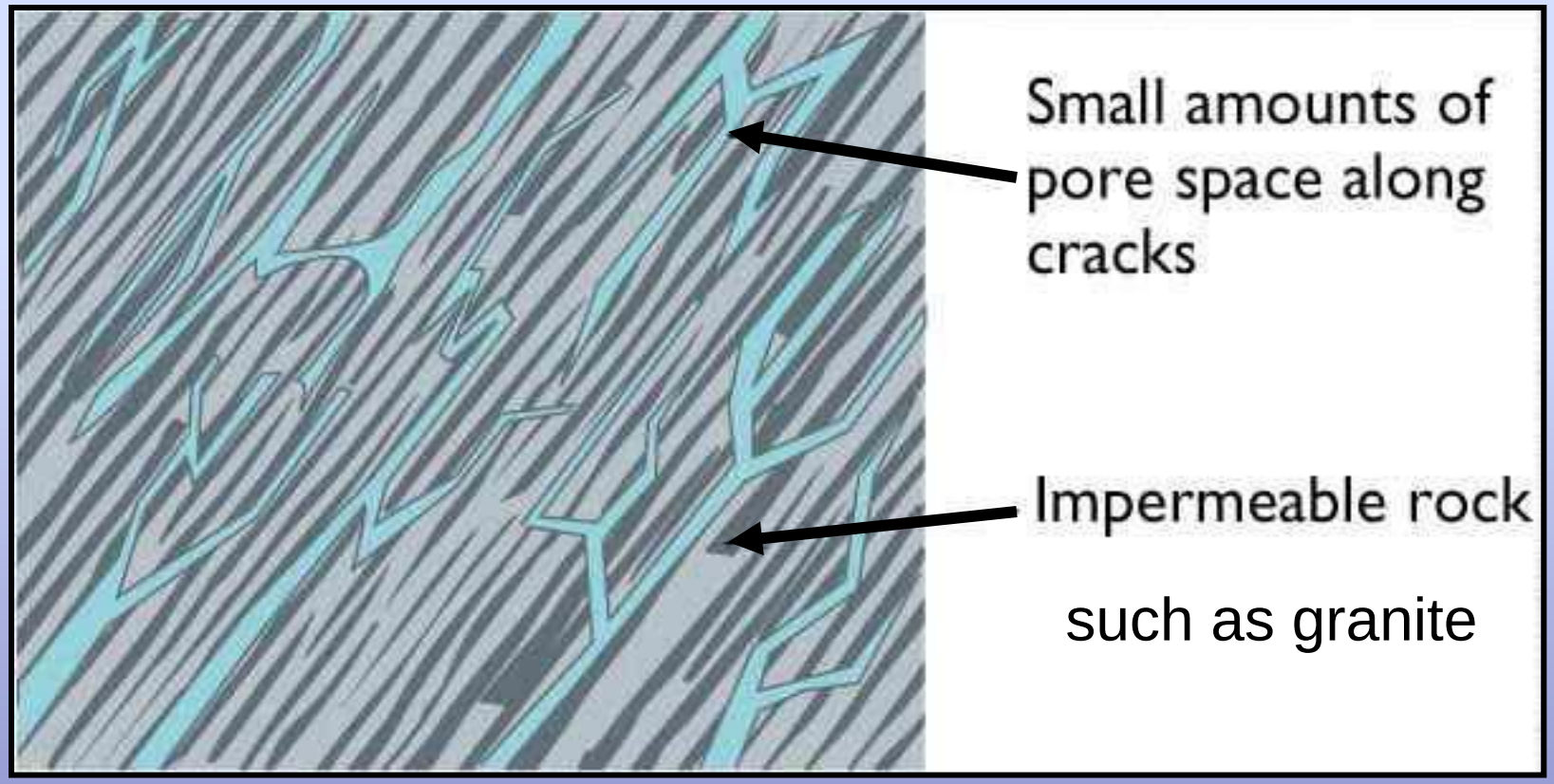
Intragranular Cement and Porosity



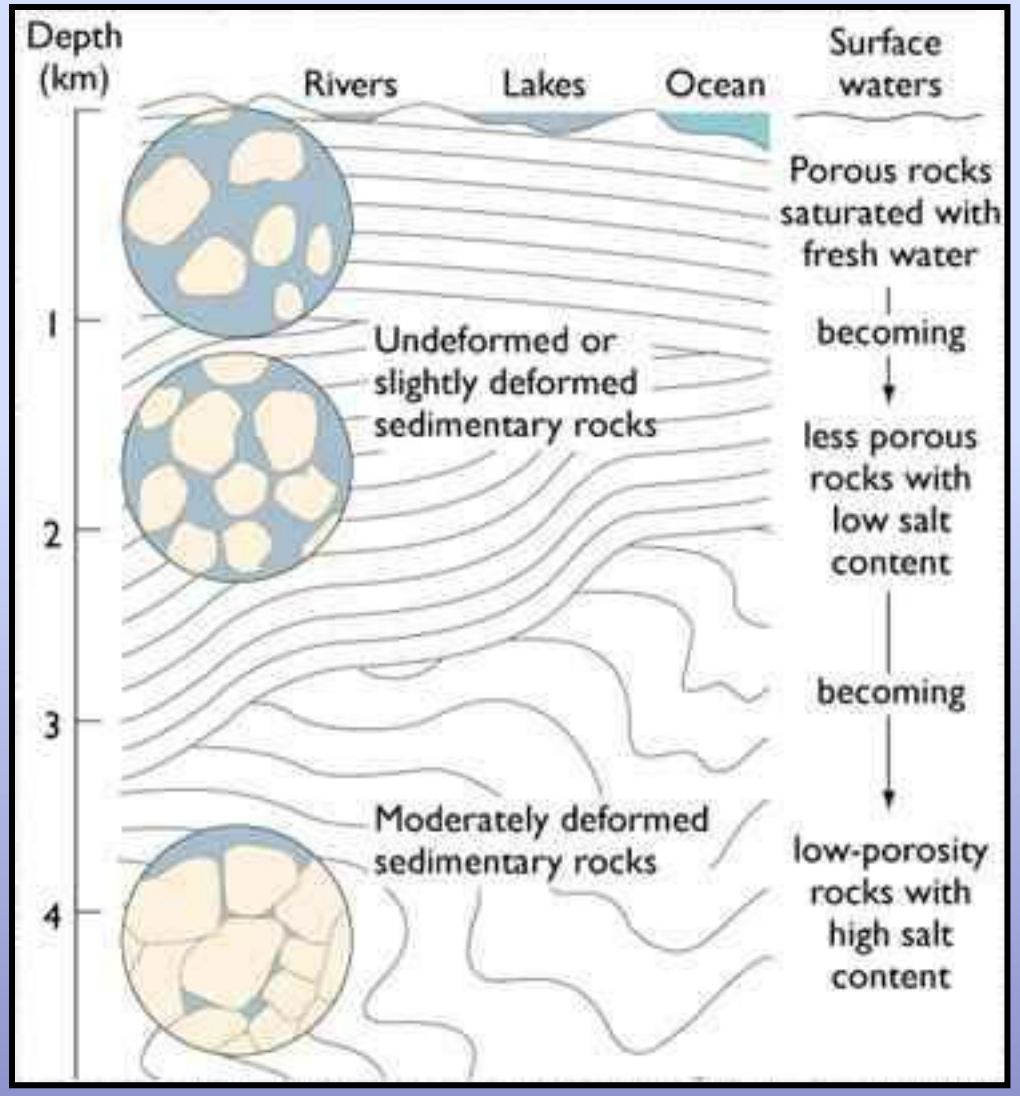
Porosity in Shale



Fracture Porosity



Porosity and Burial



- Loose, unconsolidated sediment
- Consolidated sediment partly cemented
- Well compacted and cemented sediments

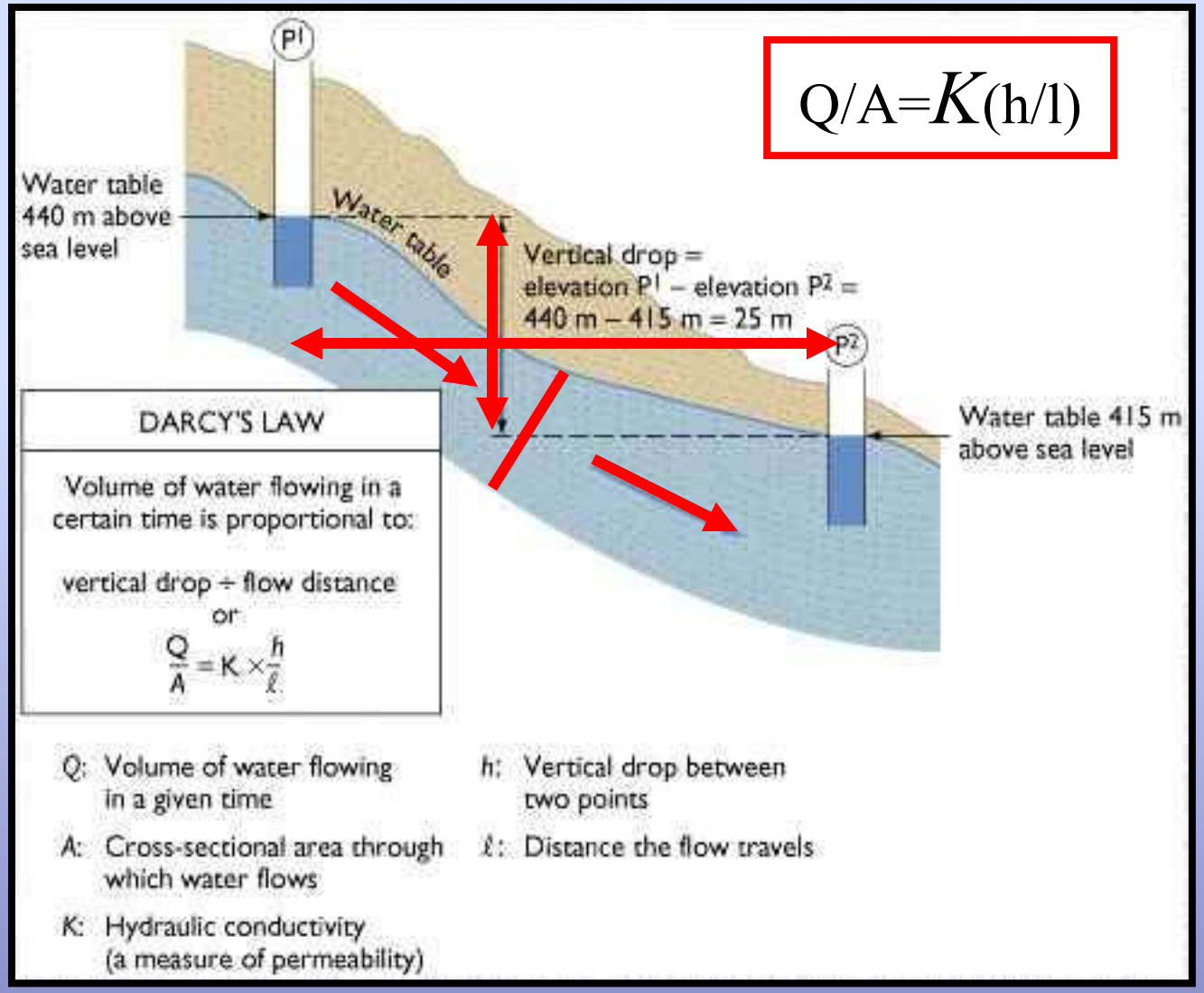
Porosity is important but...

…it isn’t the whole story!

Permeability

- Permeability = How well connected are the open spaces (porosity)
- Hydraulic Conductivity (k)
- Both porosity and permeability control the rate of groundwater flow along with…
- (Hint: What's the driving force?)
- GRAVITY!

Darcy's Law



$$Q/A = K(h/l)$$

Q = Volume of water flowing

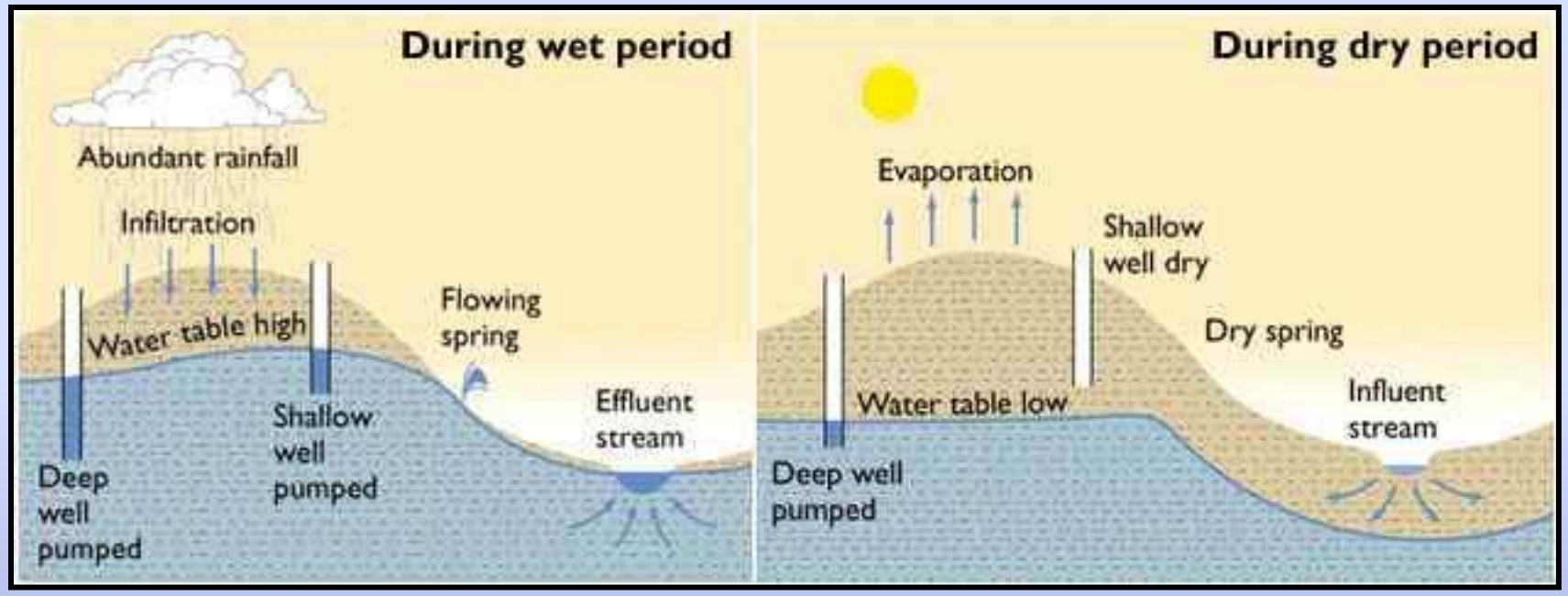
A = Cross-sectional Area

K = hydraulic conductivity

h = height difference

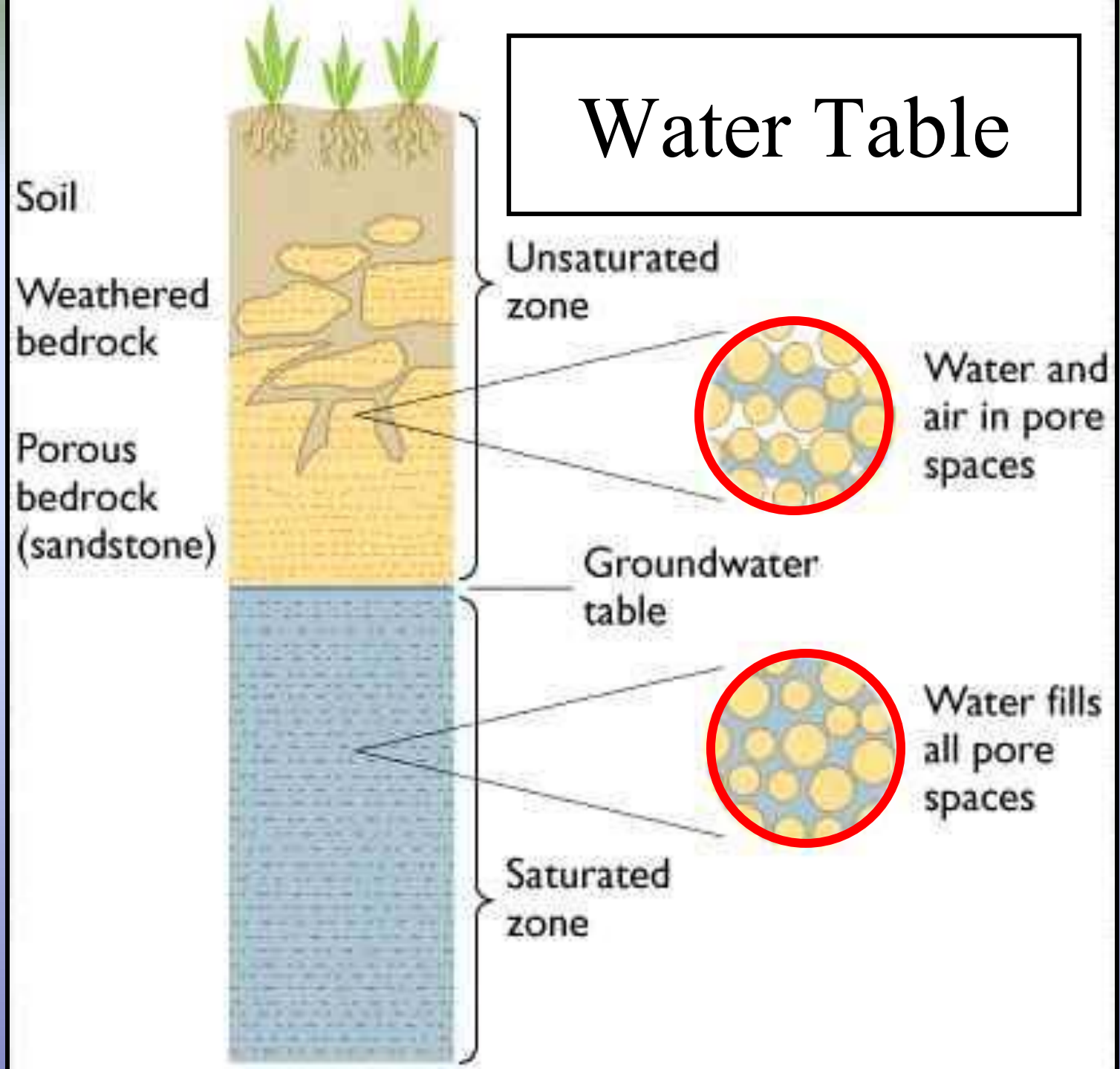
l = Distance traveled

The Water Table

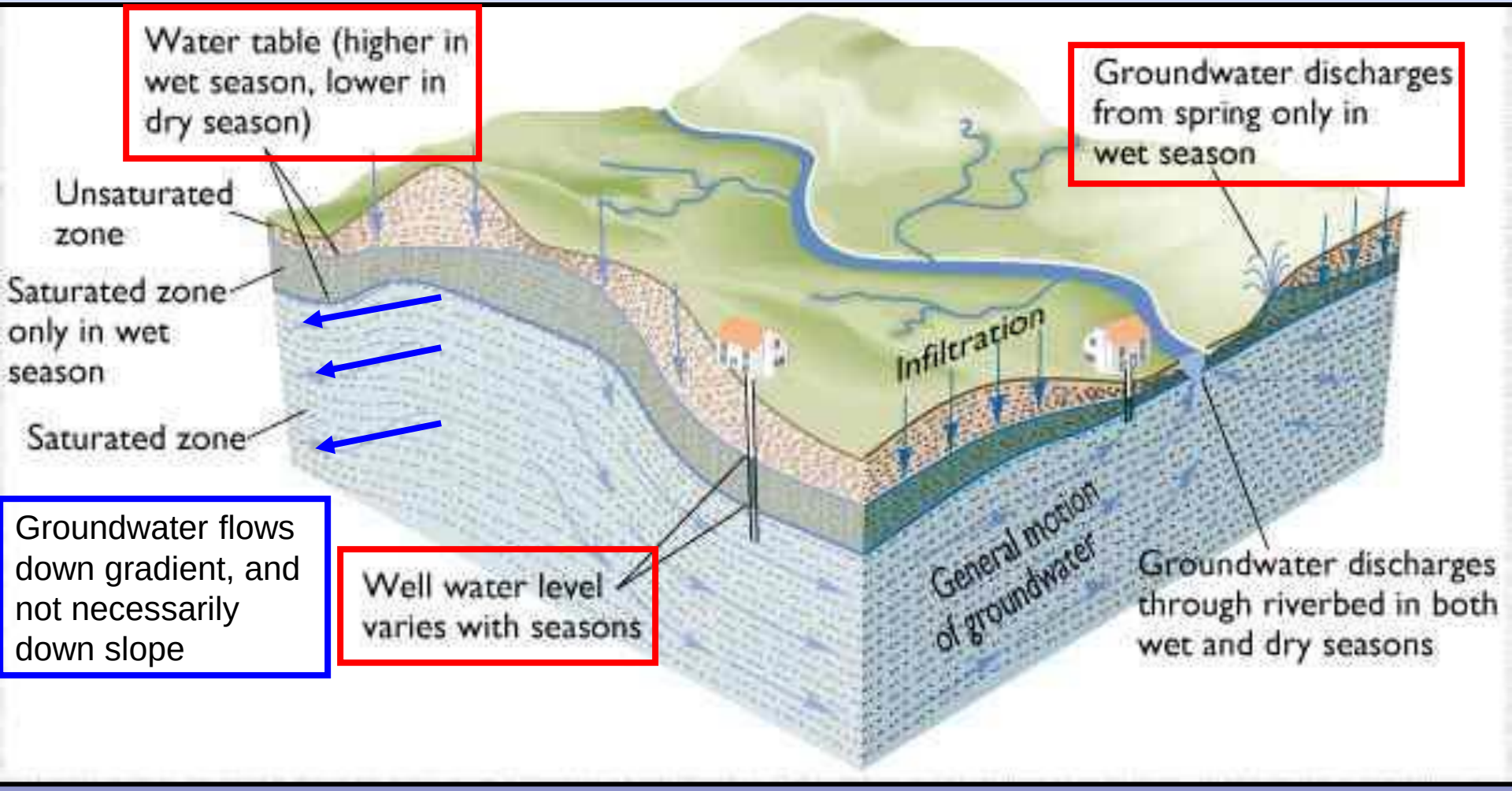


- Downward infiltration from surface
- Percolation from influent streams
- Pore space completely filled = saturation
- Zone of saturation below water table.

Water Table


Soil
Weathered bedrock
Porous bedrock (sandstone)
Unsaturated zone
Water and air in pore spaces
Groundwater table
Water fills all pore spaces
Saturated zone

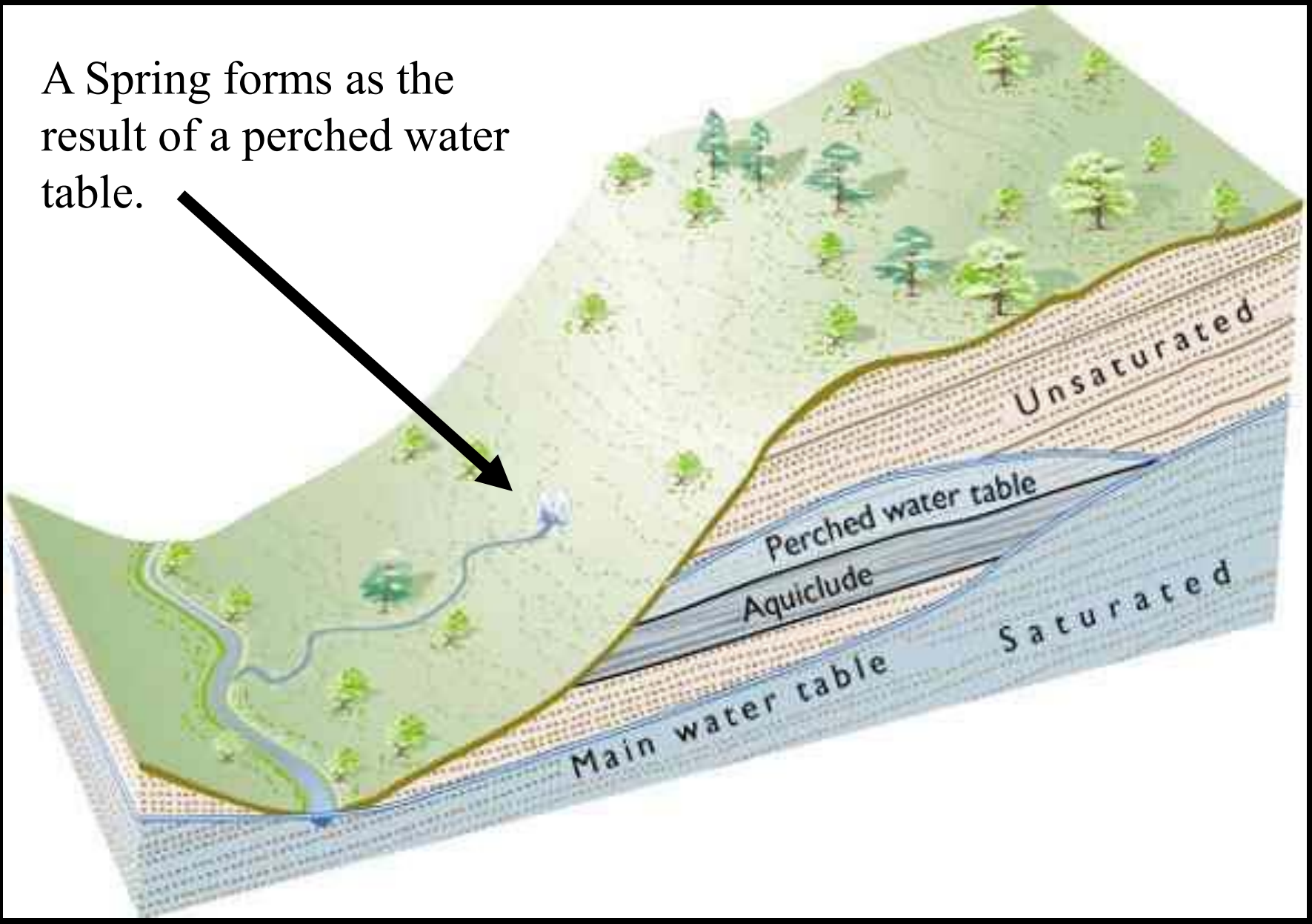
Water Table Characteristics



- Aquafer - has high porosity and permeability therefore allowing the transmission of water
- Aquatard - retards the flow of water through the sub surface
- Aquaclude - prohibits the flow of water through the subsurface

Springs often occur when groundwater is forced to the surface by an aquatard.

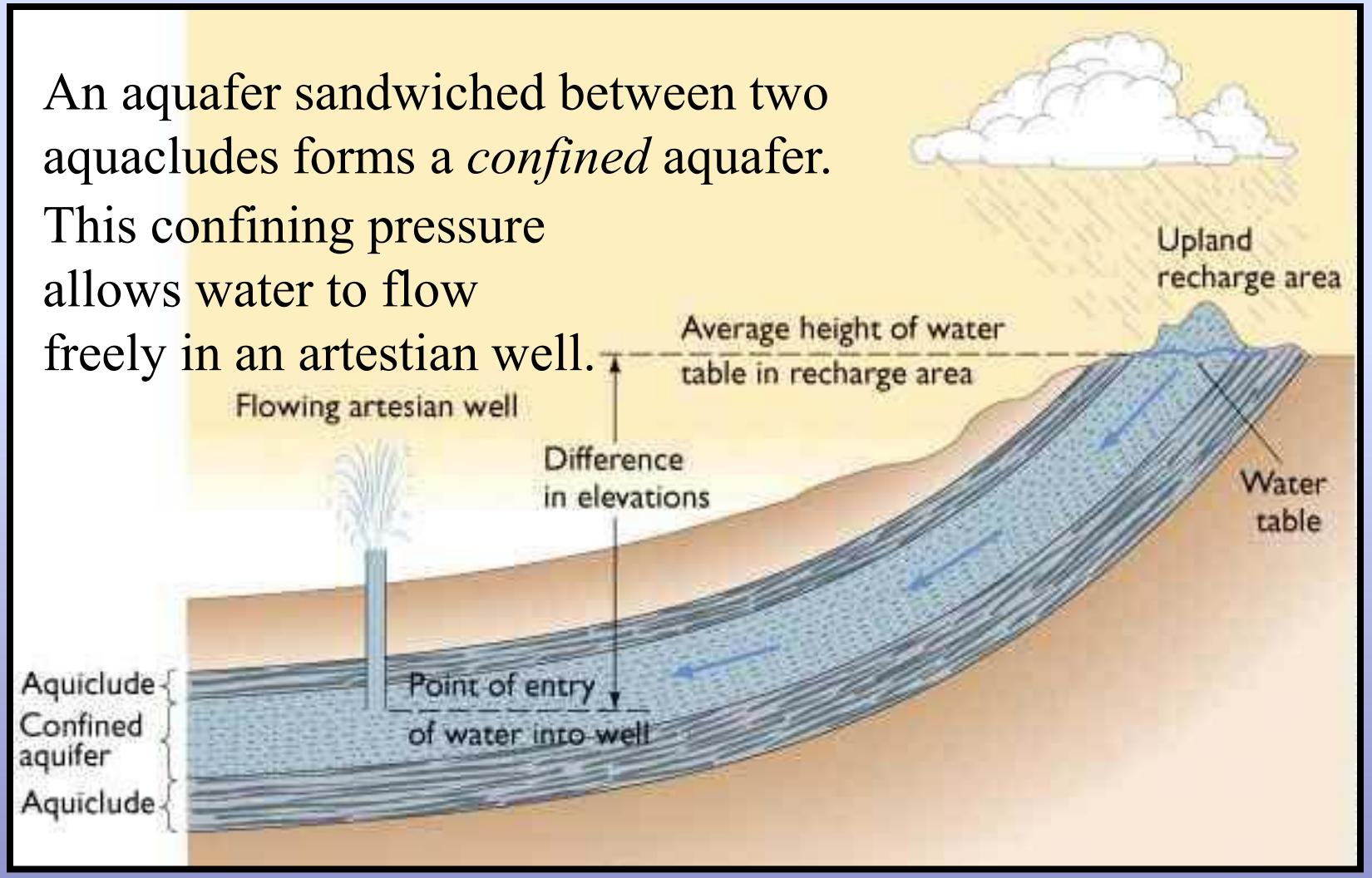
A Spring forms as the result of a perched water table.



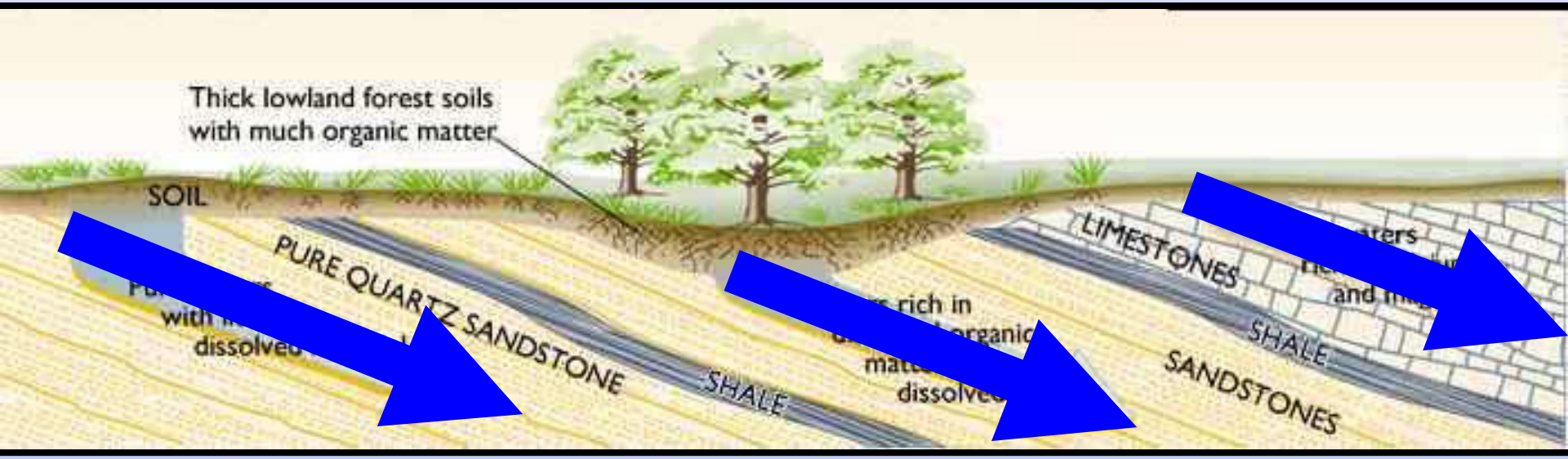
Artesian Groundwater Systems

An aquafer sandwiched between two aquacludes forms a *confined* aquafer.

This confining pressure allows water to flow freely in an artestian well.



Water Quality Issues - Source Area

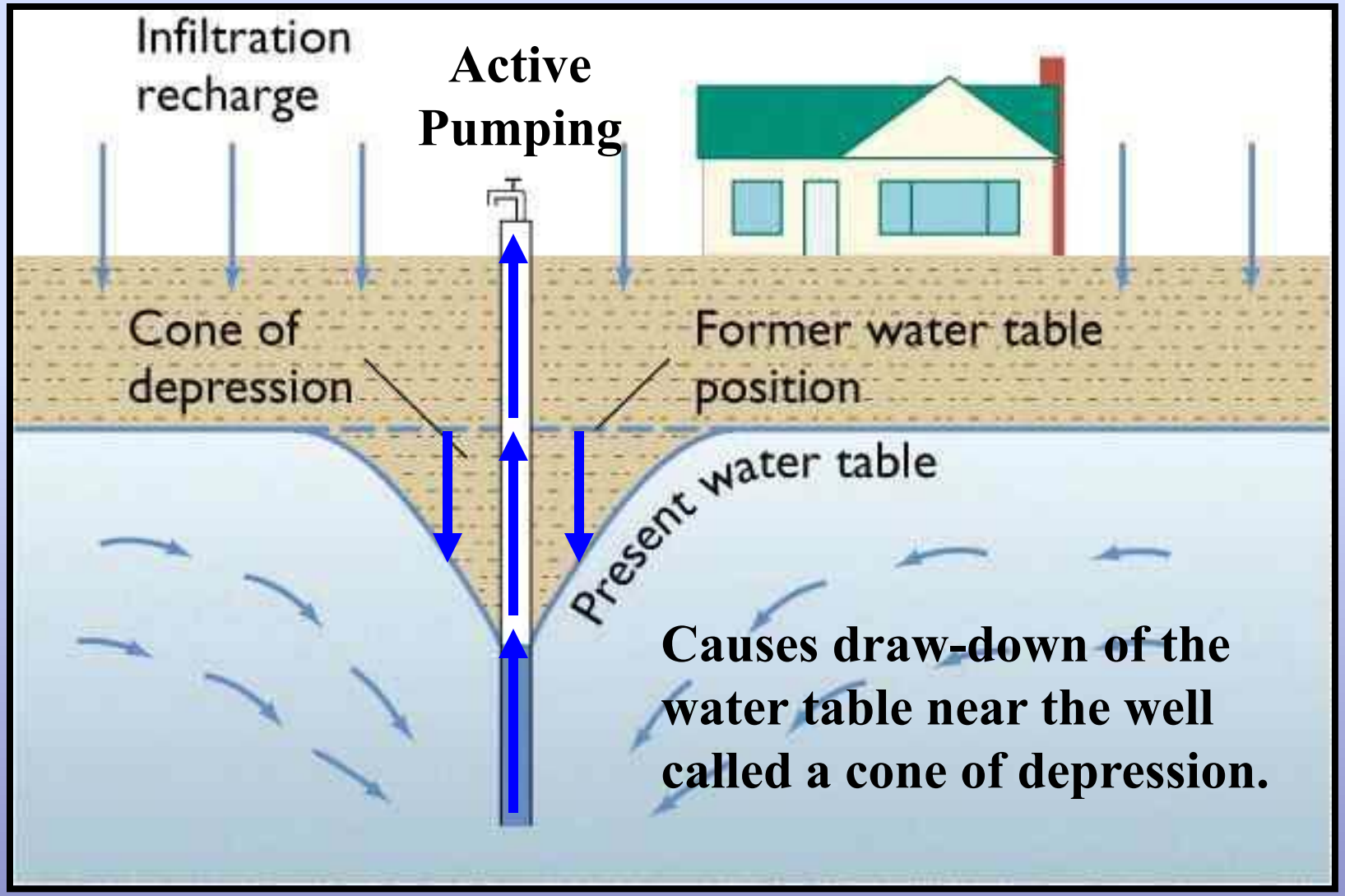


Sandstone - Good pure water

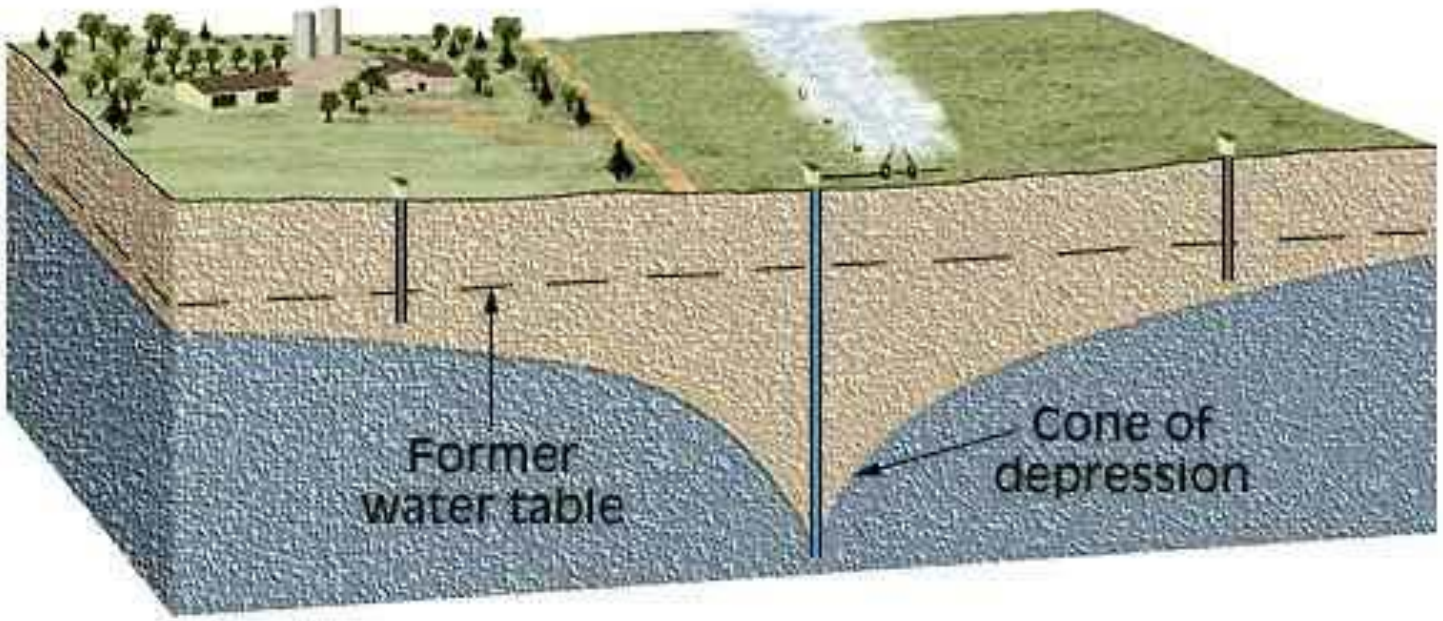
Swampy source - Lots of organics

Limestone - High in calcium carbonate

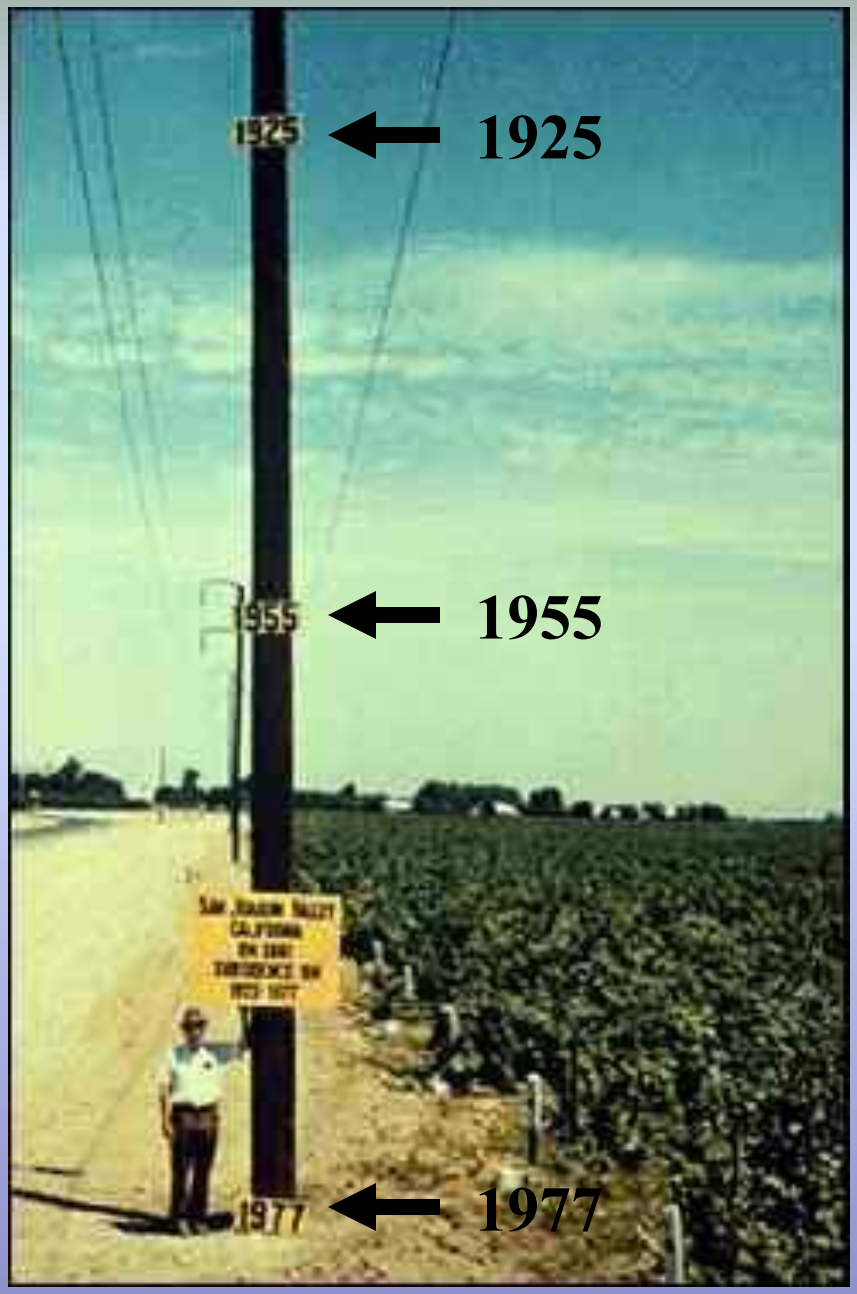
Cone of Depression



Overpumping can produce a large cone of depression causing shallow wells to go dry.

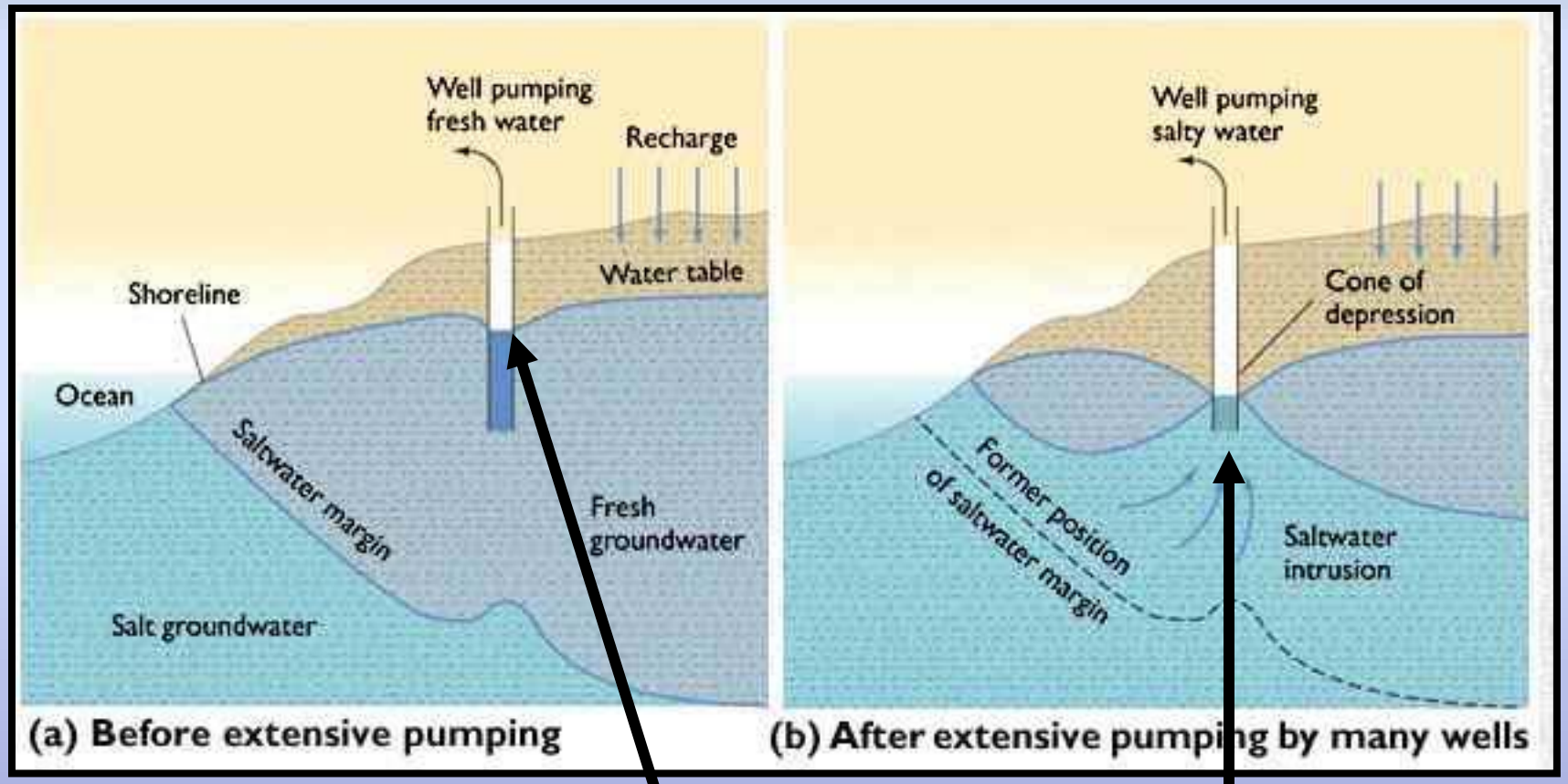


If heavy pumping lowers the water table, the shallow wells may be left dry.



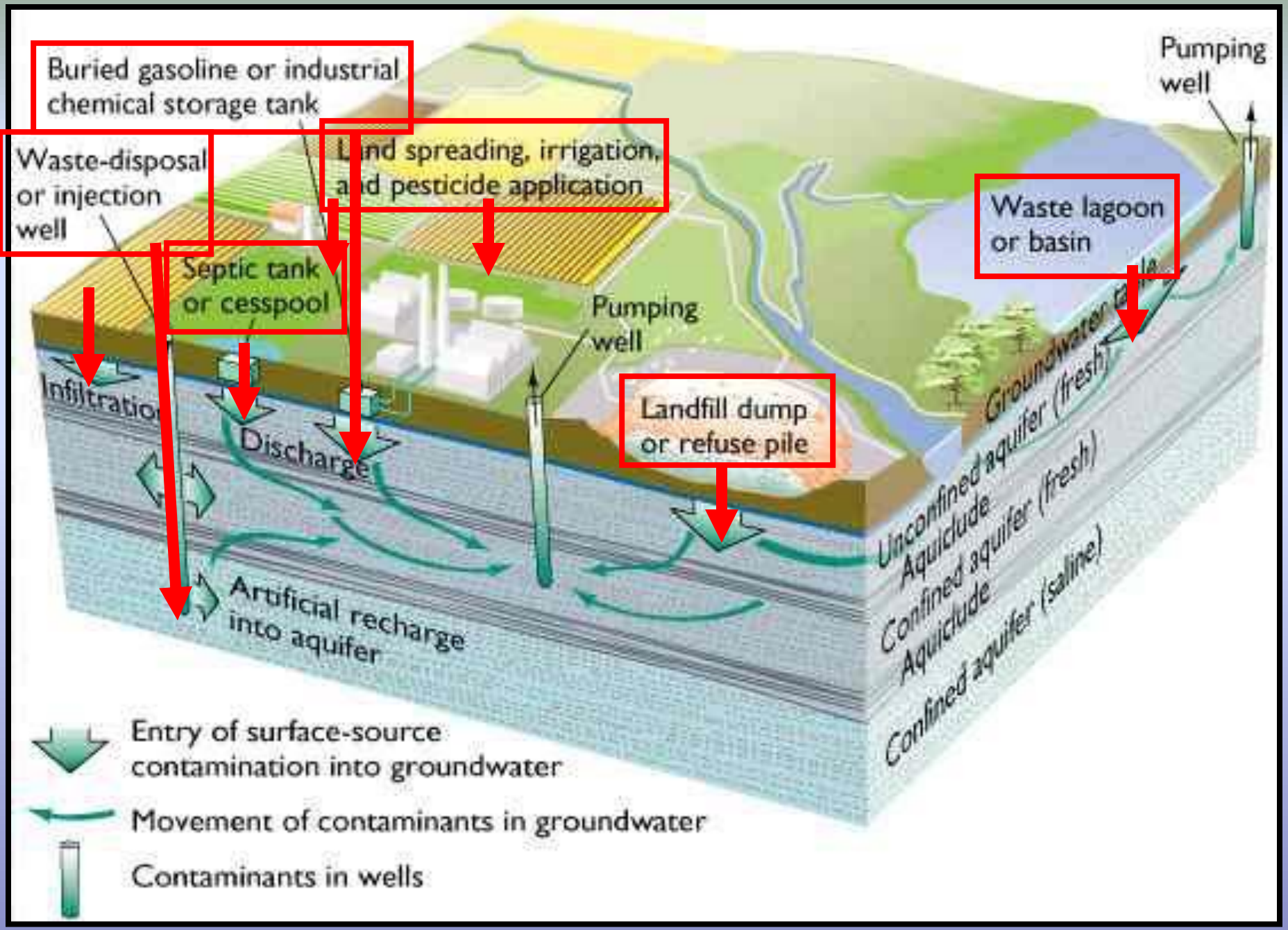
In the San Joaquin Valley of California, over-pumping has not only depleted aquafers but caused the ground to subside drastically.

Salt Water Intrusion



Pumping causes a cone of depression and...

…draws the salt water upwards into the well.


Buried gasoline or industrial chemical storage tank
Waste-disposal or injection well
Land spreading, irrigation, and pesticide application
Septic tank or cesspool
Pumping well
Waste lagoon or basin
Pumping well
Infiltration
Discharge
Landfill dump or refuse pile
Groundwater table
Unconfined aquifer (fresh)
Aquiclude
Confined aquifer (fresh)
Aquiclude
Confined aquifer (saline)
Artificial recharge into aquifer
Entry of surface-source contamination into groundwater
Movement of contaminants in groundwater
Contaminants in wells

Groundwater - Some Main Points

- Part of the hydrologic system
- Subsurface flow of water
- Porosity *and* Permeability
- Fluid flow (Darcy's Law)
- Water table - Zone of saturation
- Aquafers, Aquacludes, Aquatards
- Confined aquifers
- Effects of over pumping
- Effects on water quality.