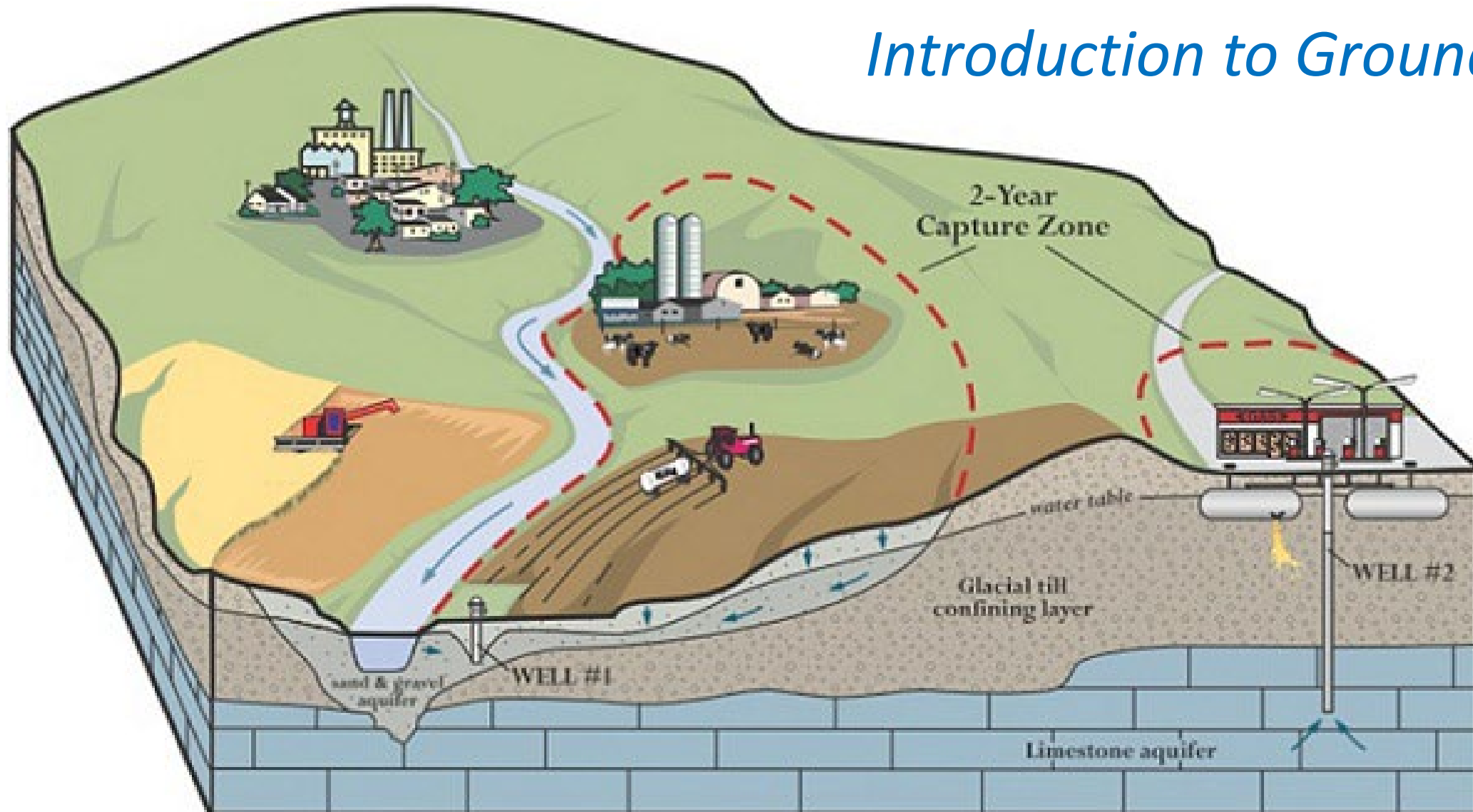


# Iowa's Emerging Water Issues

## *Introduction to Groundwater*



# Adam Smith

*'Water is a curious thing: although vital to life, it costs almost nothing, where as gold and diamonds, which are useless for survival, cost a fortune.'*



1720 to 1790

Economics professor Glasgow University,  
Scotland

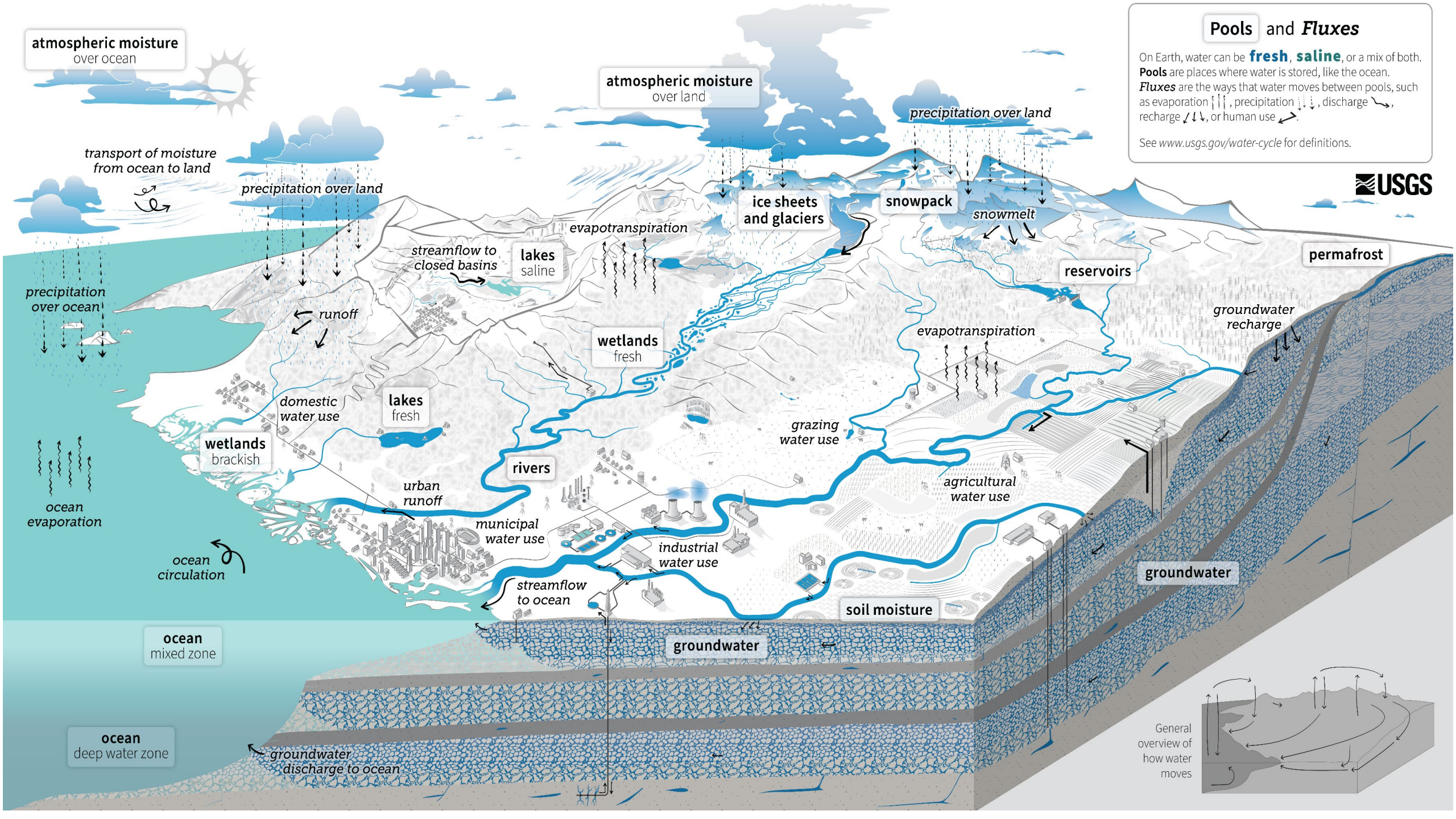
atmospheric moisture  
over ocean

atmospheric moisture  
over land

### Pools and Fluxes

On Earth, water can be **fresh, saline**, or a mix of both. **Pools** are places where water is stored, like the ocean. **Fluxes** are the ways that water moves between pools, such as evaporation ↓↓, precipitation ↓↓↓, discharge ↘, recharge ↙↙, or human use ↘.

See [www.usgs.gov/water-cycle](http://www.usgs.gov/water-cycle) for definitions.



transport of moisture  
from ocean to land

precipitation over land

precipitation over land

precipitation over ocean

ocean evaporation

ocean circulation

ocean mixed zone

ocean deep water zone

precipitation over land

streamflow to closed basins

lakes saline

evapotranspiration

ice sheets and glaciers

snowpack

snowmelt

reservoirs

permafrost

groundwater recharge

evapotranspiration

wetlands fresh

domestic water use

lakes fresh

wetlands brackish

grazing water use

rivers

agricultural water use

urban runoff

municipal water use

industrial water use

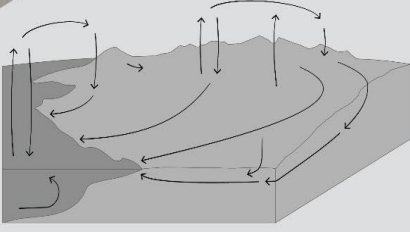
streamflow to ocean

soil moisture

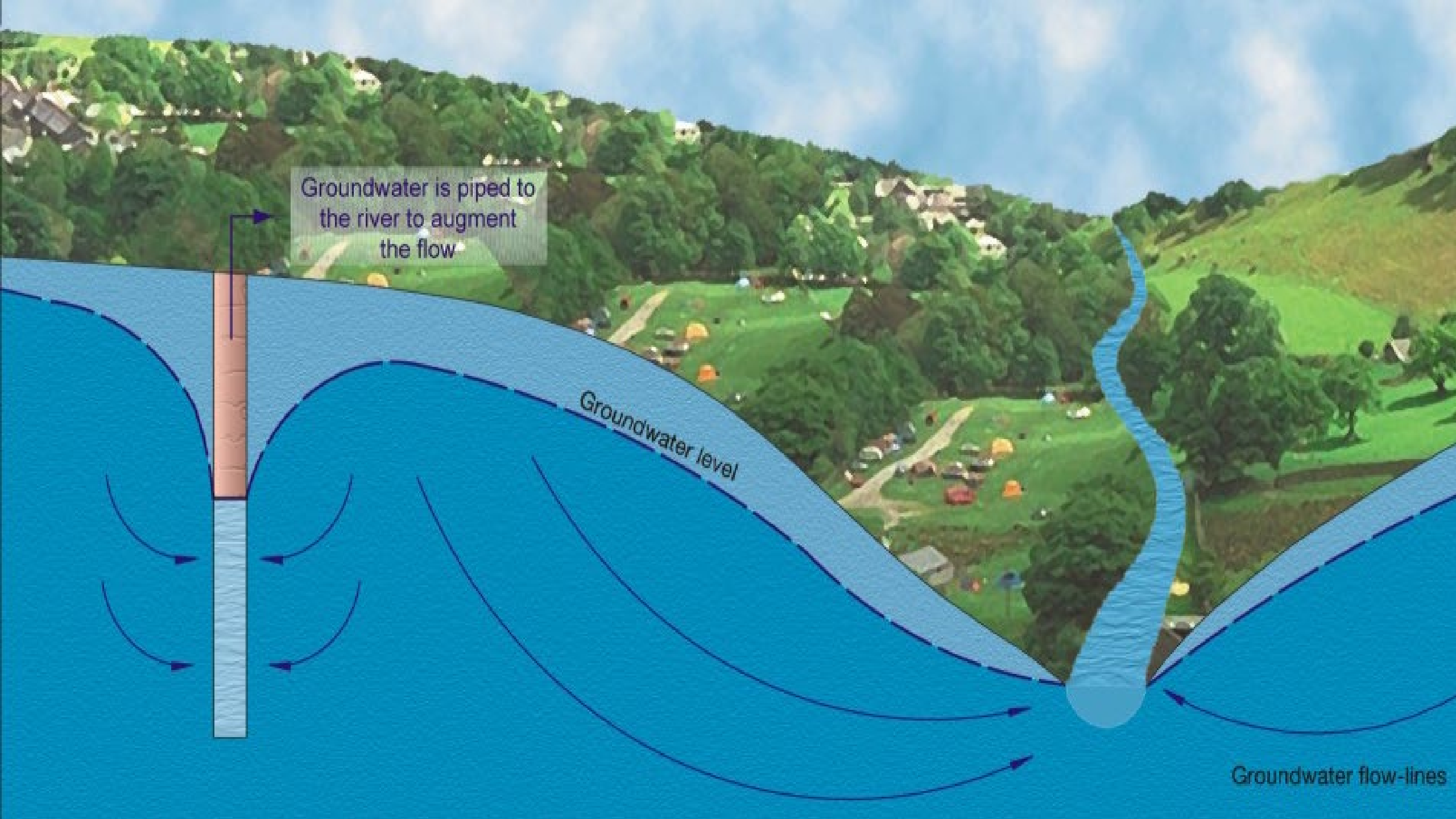
groundwater

groundwater

groundwater discharge to ocean



General overview of how water moves

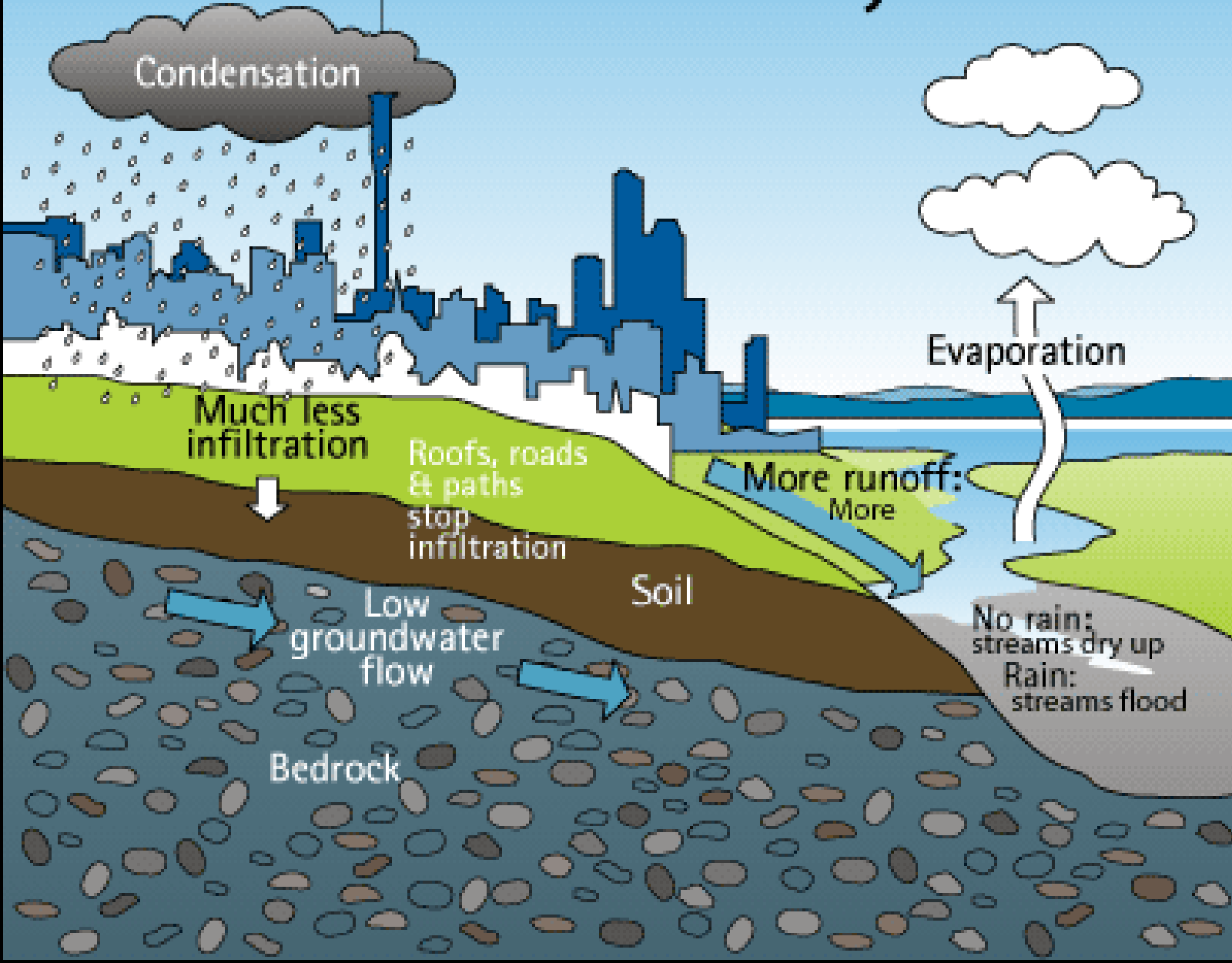


Groundwater is piped to the river to augment the flow

Groundwater level

Groundwater flow-lines

# The urban water cycle



Natural vs Urban settings

Runoff vs Infiltration

Aquifers

Gradients and gravity

▼ The Water Table ▼

# Groundwater

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Infiltration

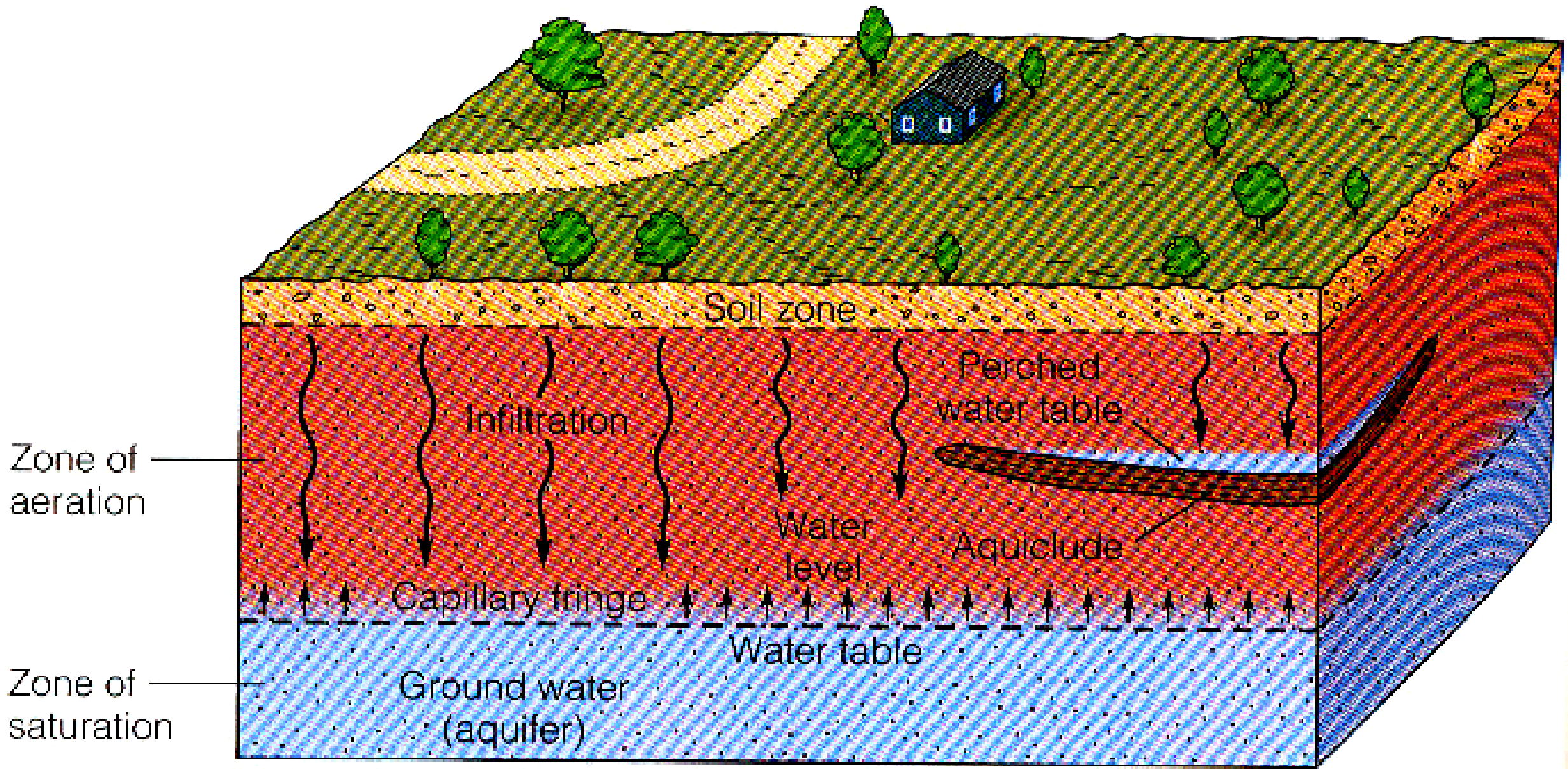
Zone of aeration

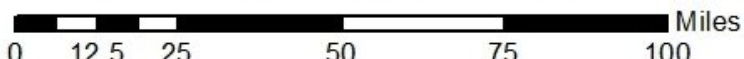
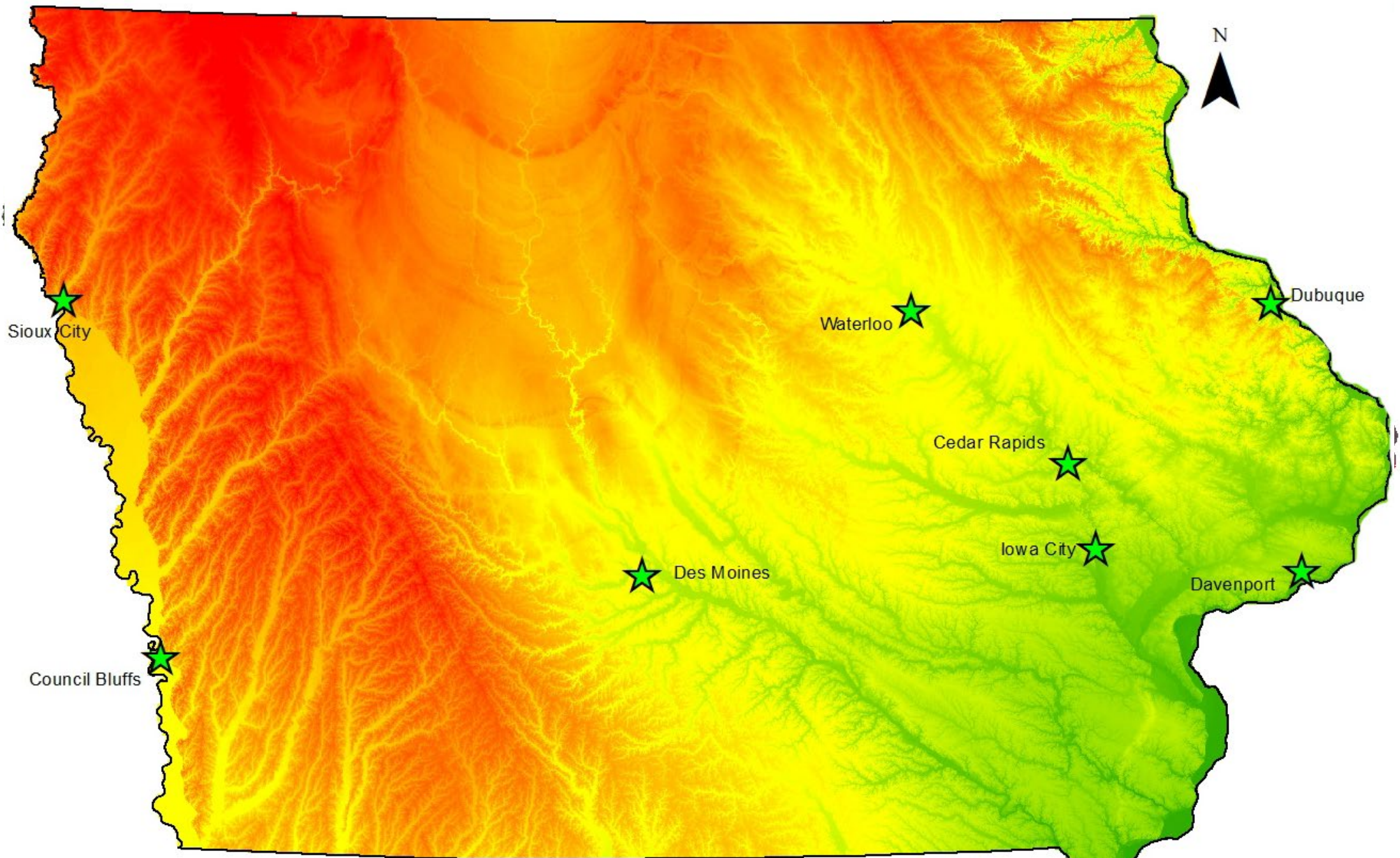


The Water Table



Zone of saturation





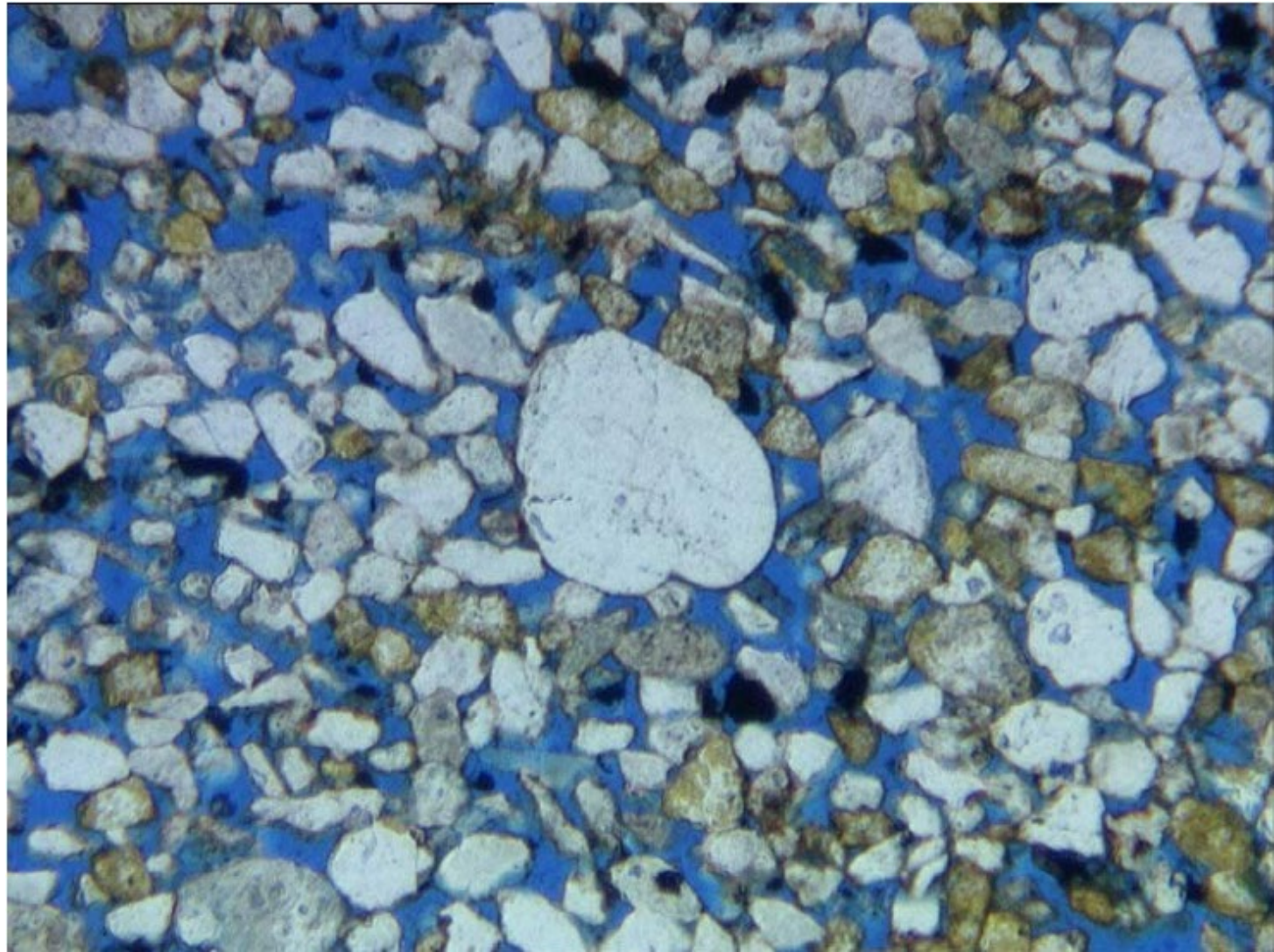
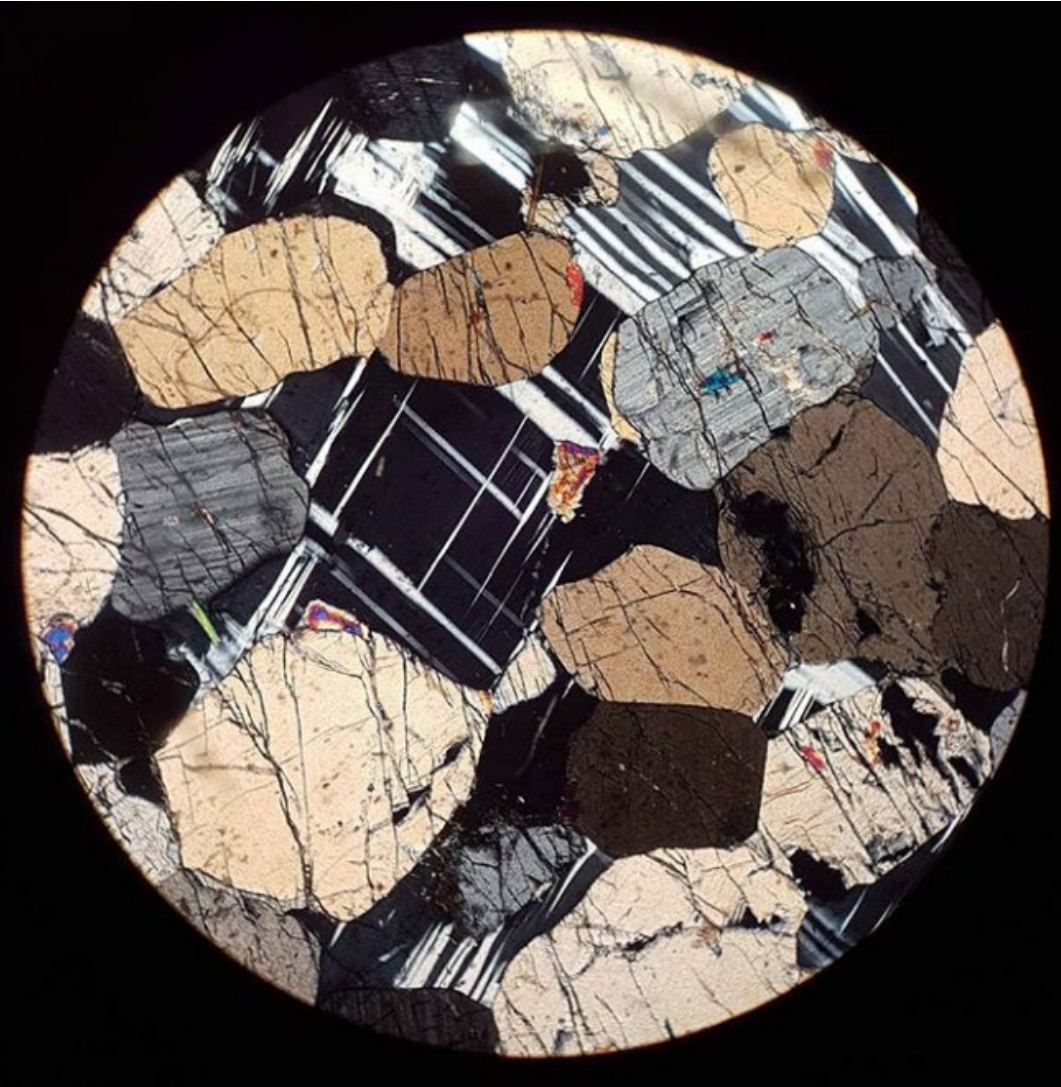
High : 2750



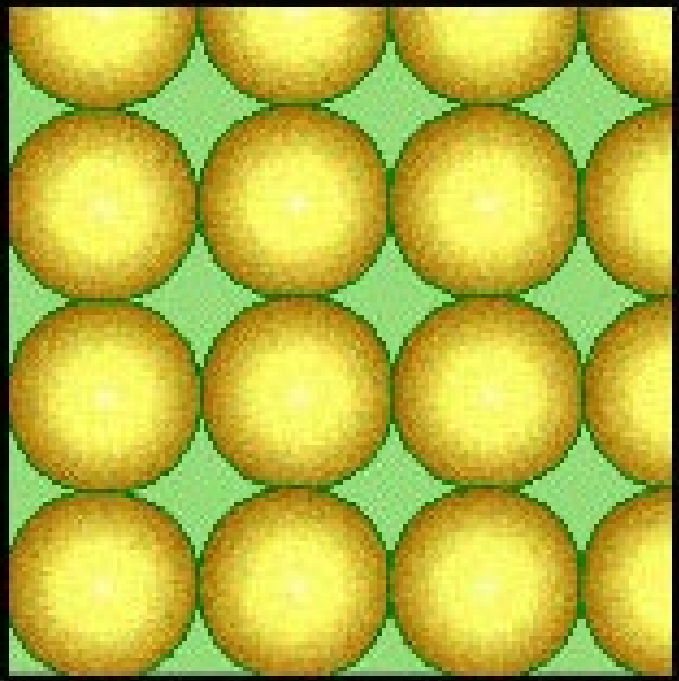
Crystalline rocks

vs

Sedimentary clastic

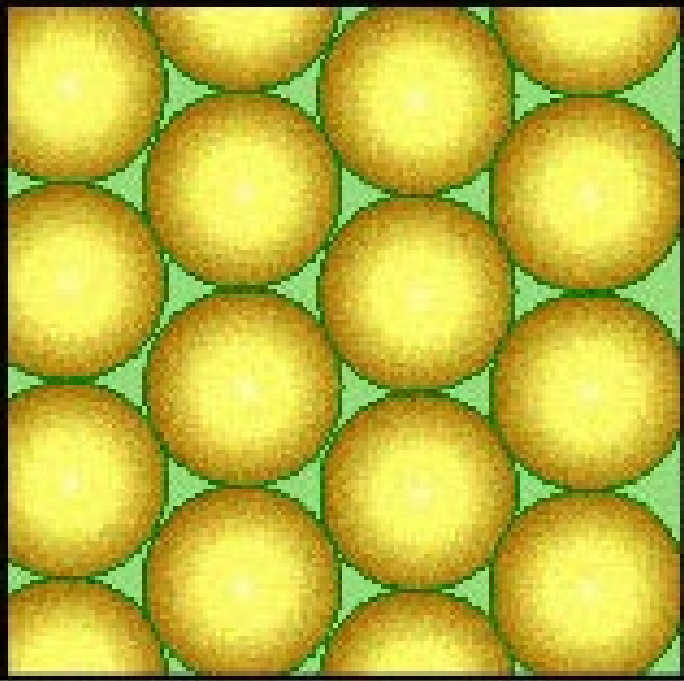


# Porosity Vs. Permeability



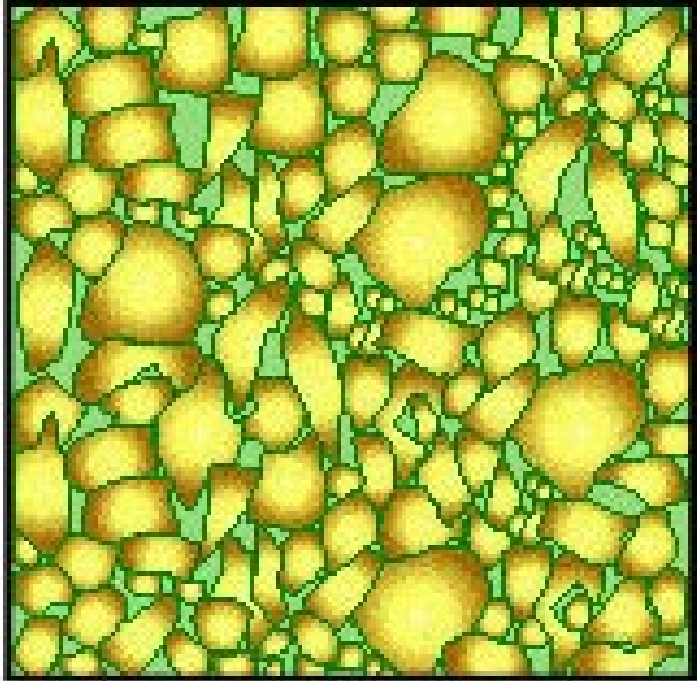
Uniform Spheres  
with Cubic Packing

Porosity = 47.6%  
(for any Sphere Radius)



Uniform Spheres with  
Rhombohedral Packing

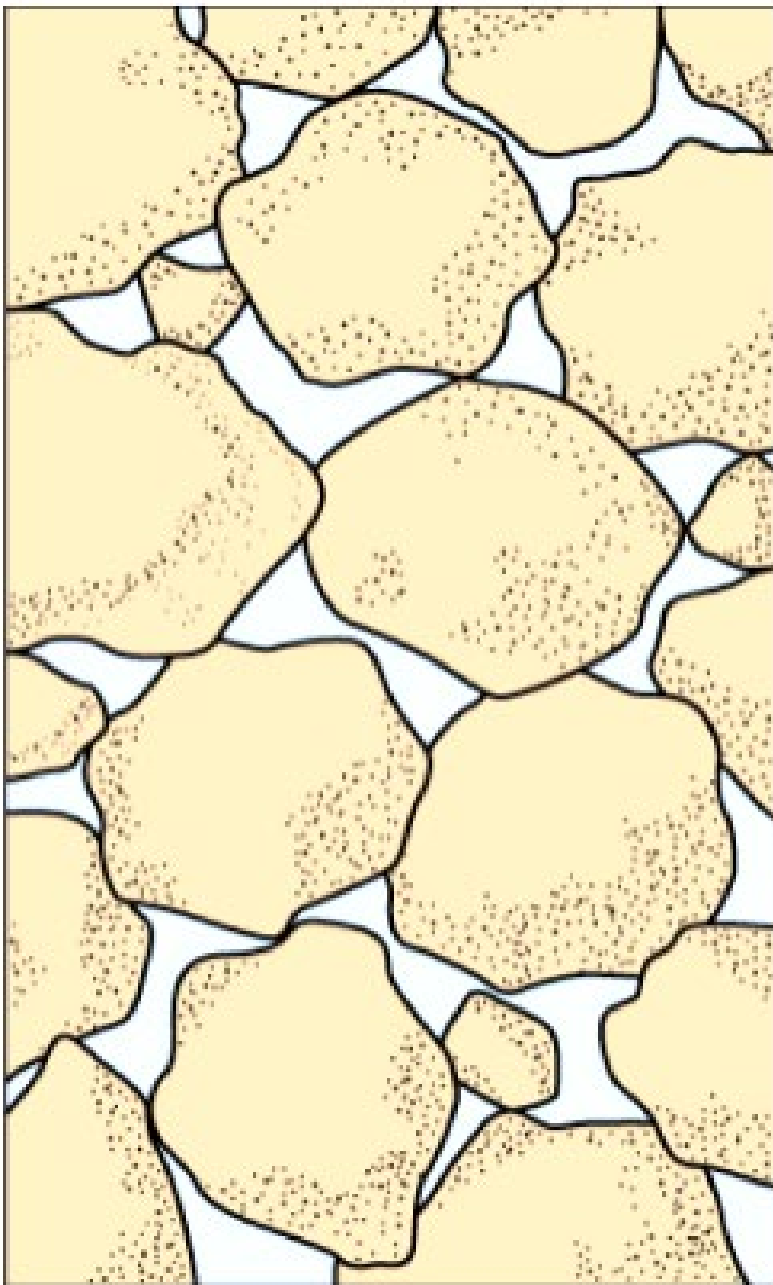
Porosity = 25.96%  
(for any Sphere Radius)



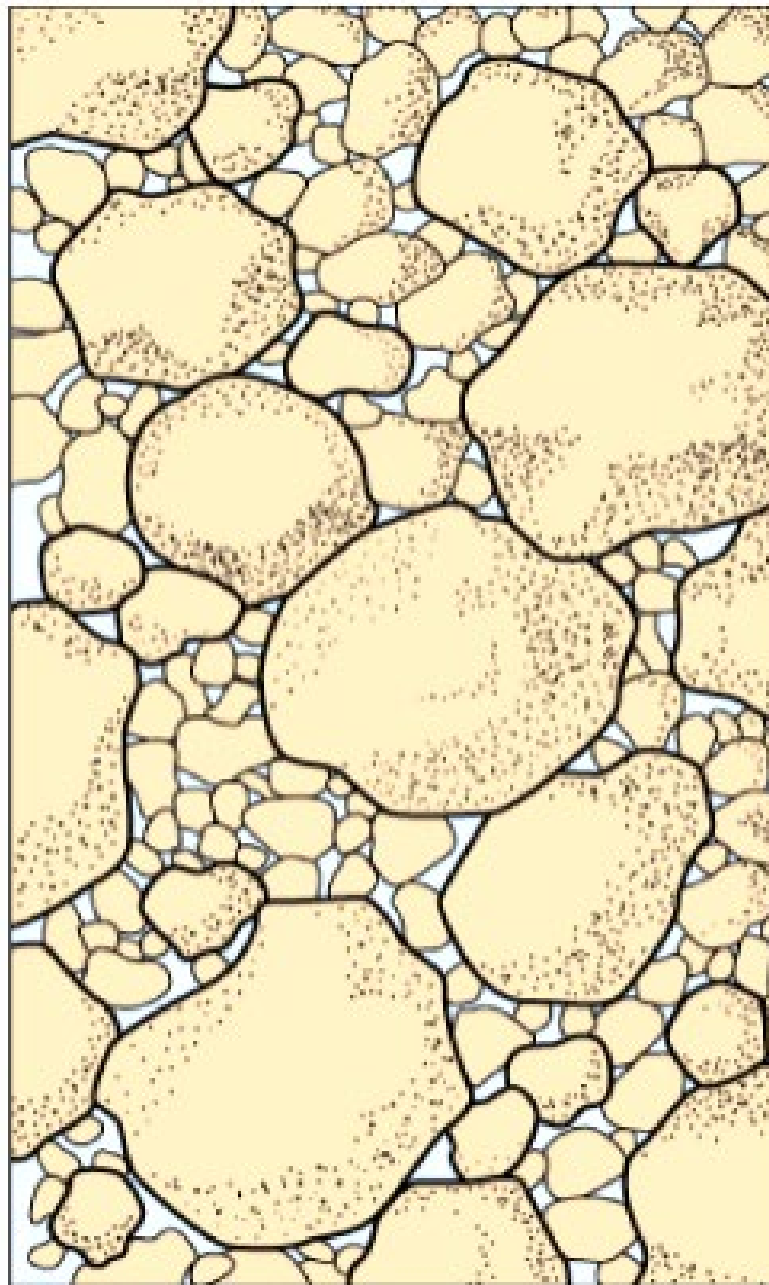
Non-Uniform Particles  
with Non-Uniform Packing  
of Typical Sandstone  
Reservoir Rock

Porosity  $\approx$  5-25%

A.



B.

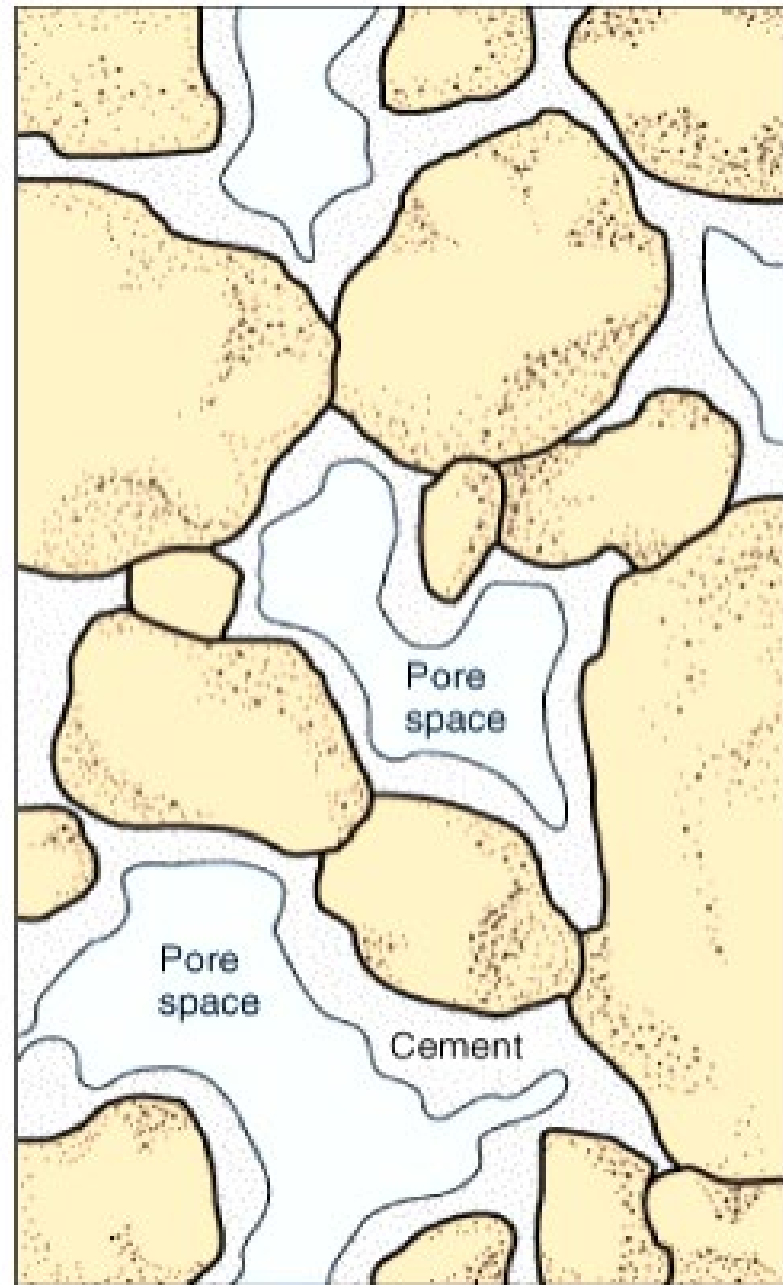


0

0.5mm



C.

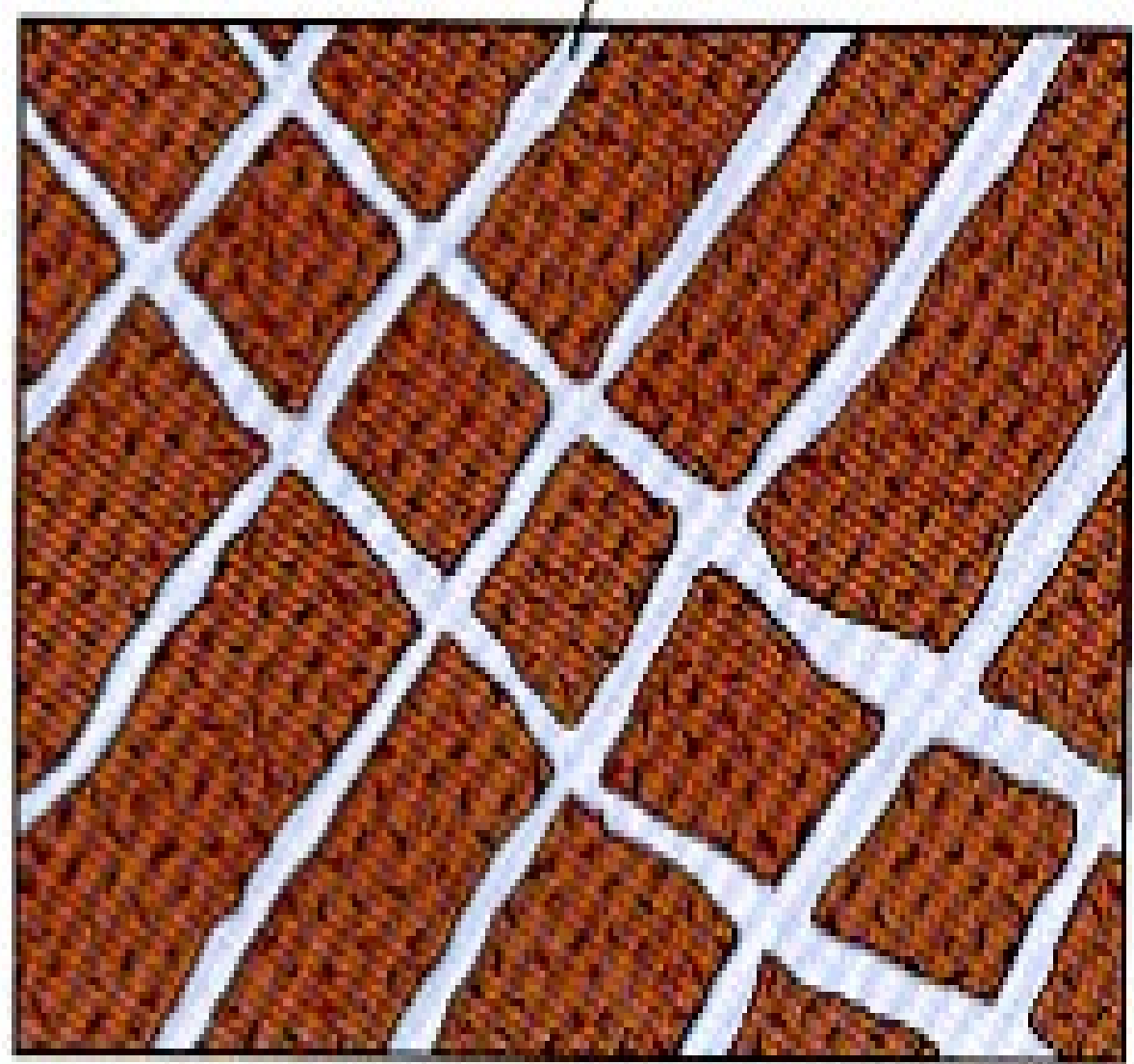
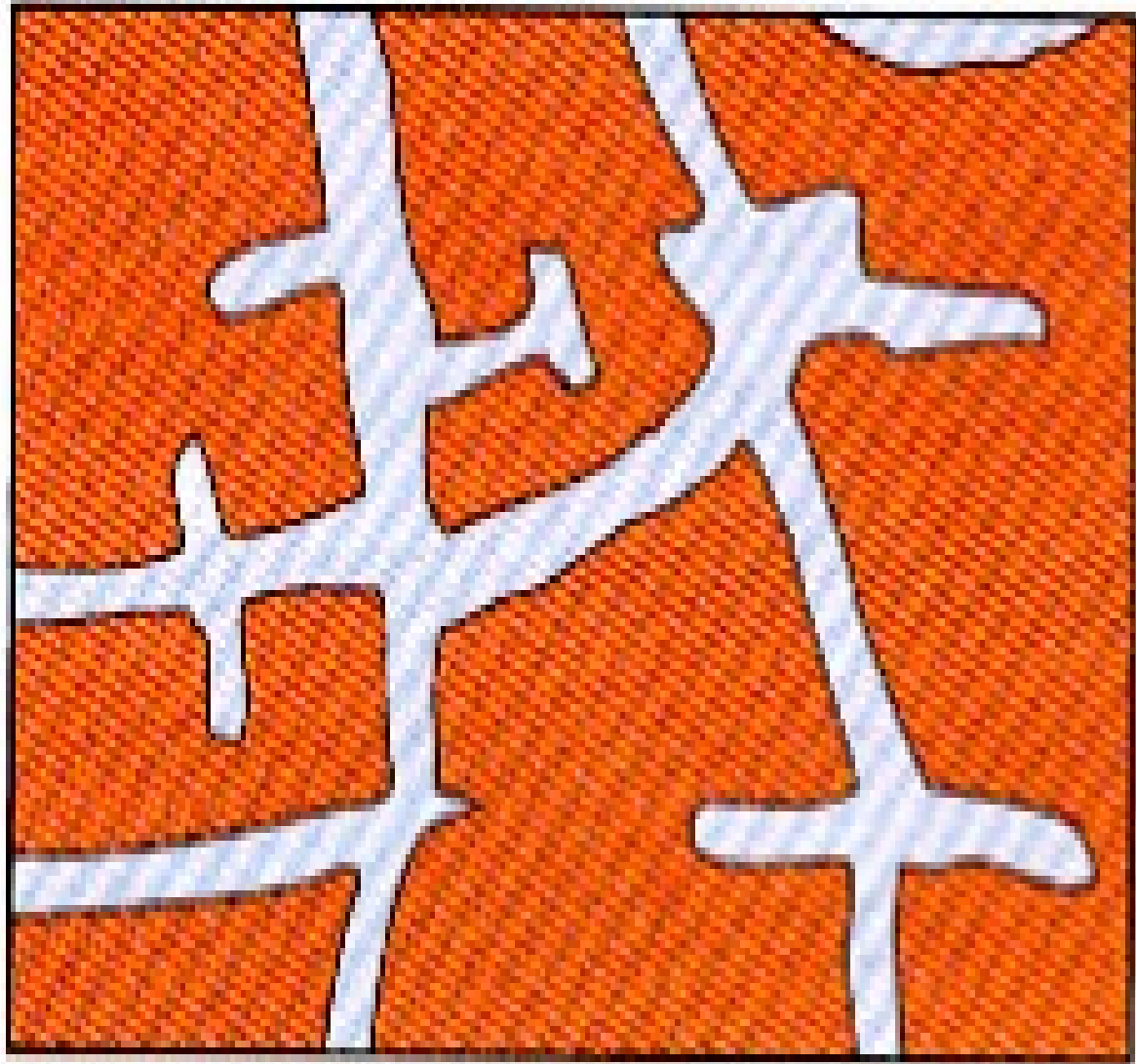


Pore  
space

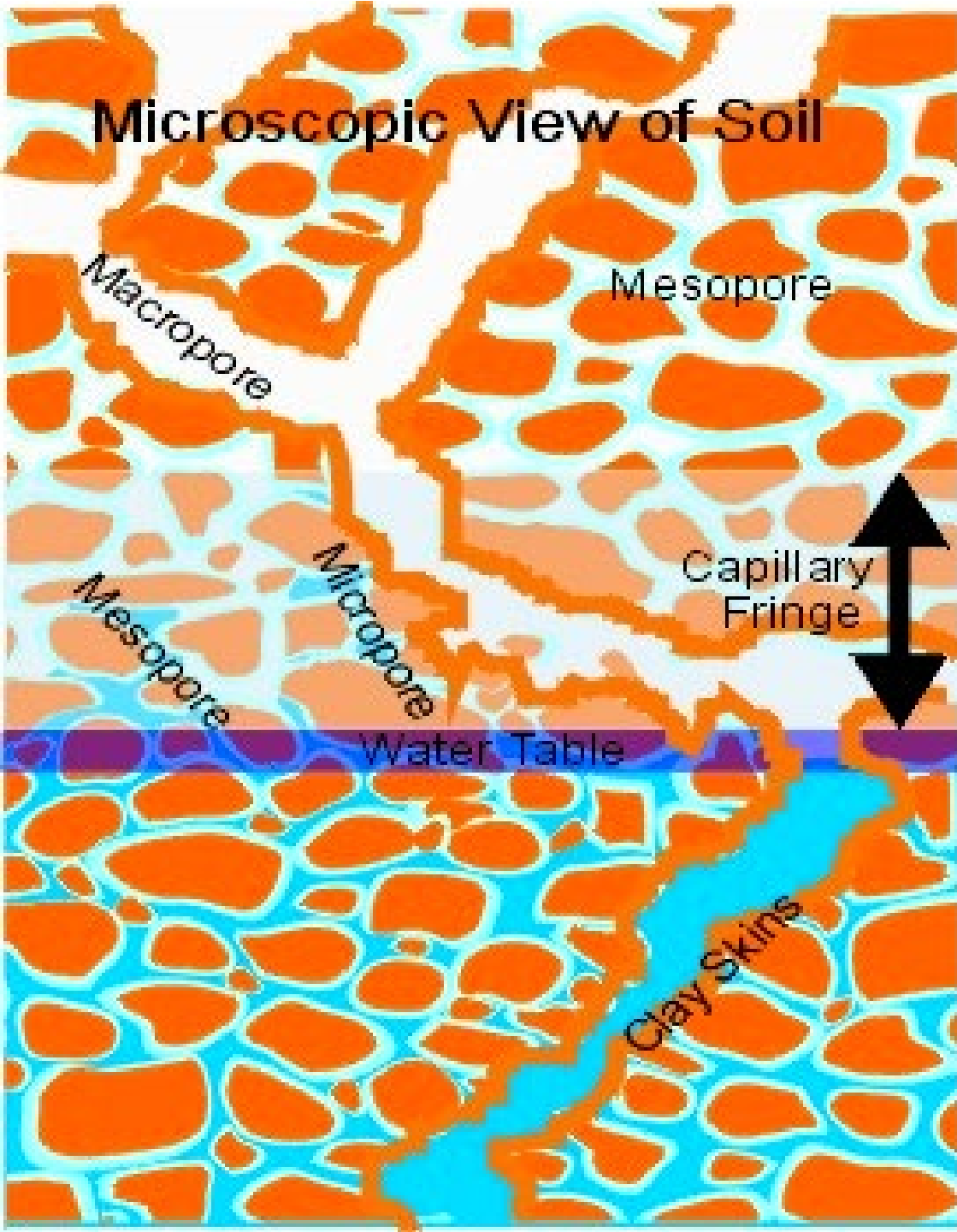
Pore  
space

Cement

# Fractures



# Capillary rise

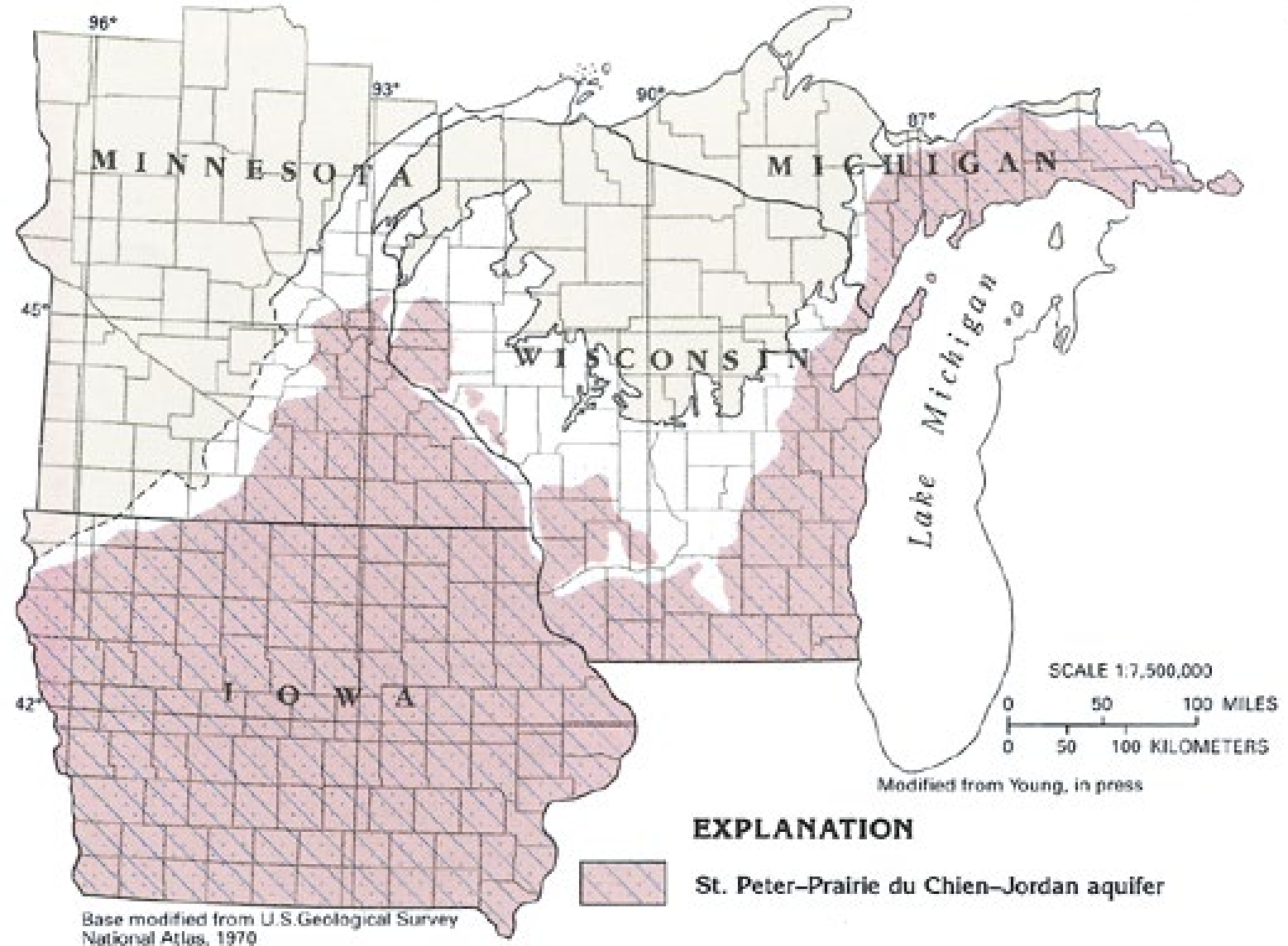


Why?

- Adhesion, water first adheres (fixes itself) to a surface
- Cohesion, Water molecules are attracted, creating a cohesive strength

# Aquifer

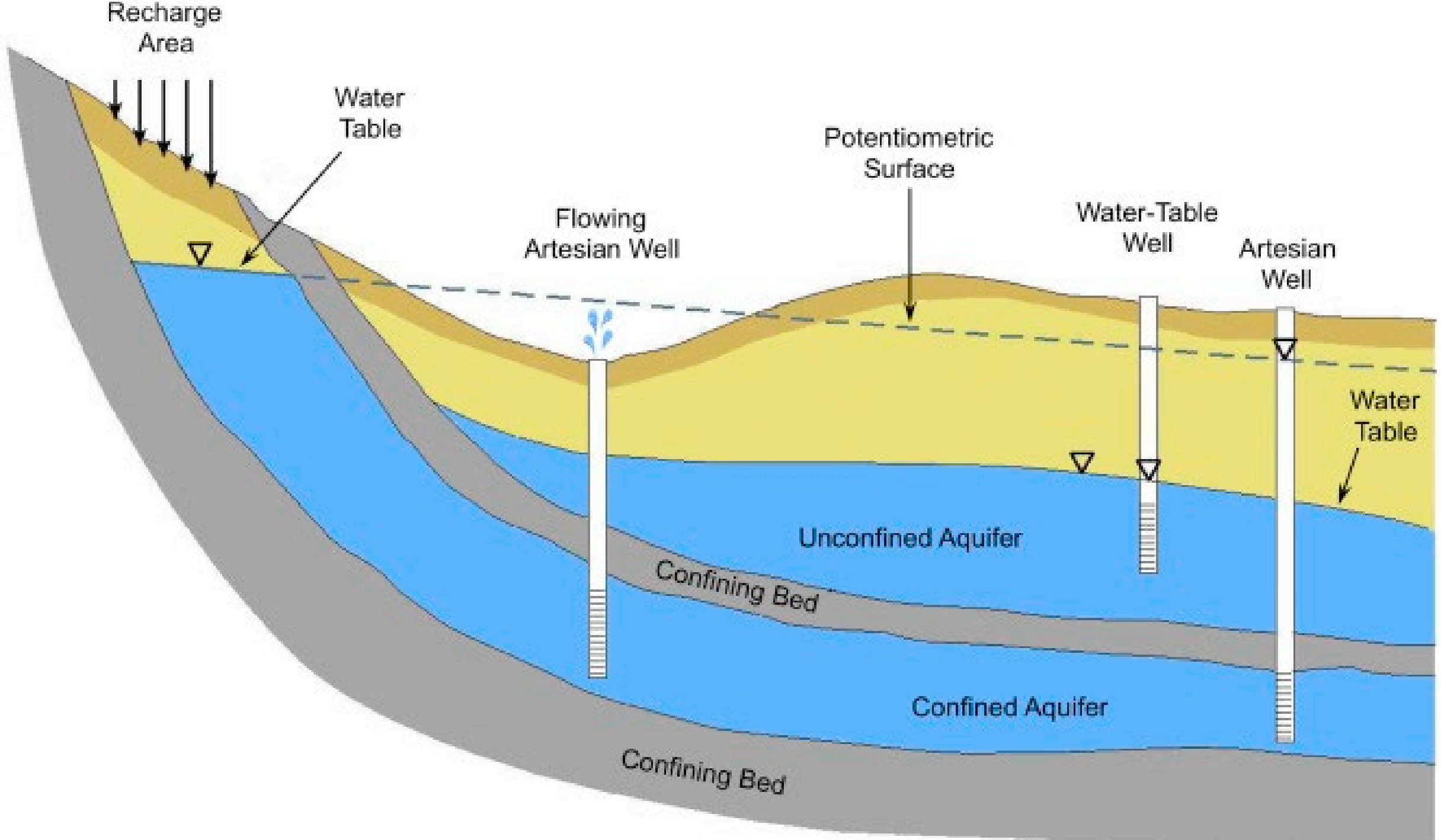
A water saturated geologic formation whose porosity and permeability are sufficient to produce water in the form of natural springs and human made wells.



# Aquifer types

## 1. Unconfined

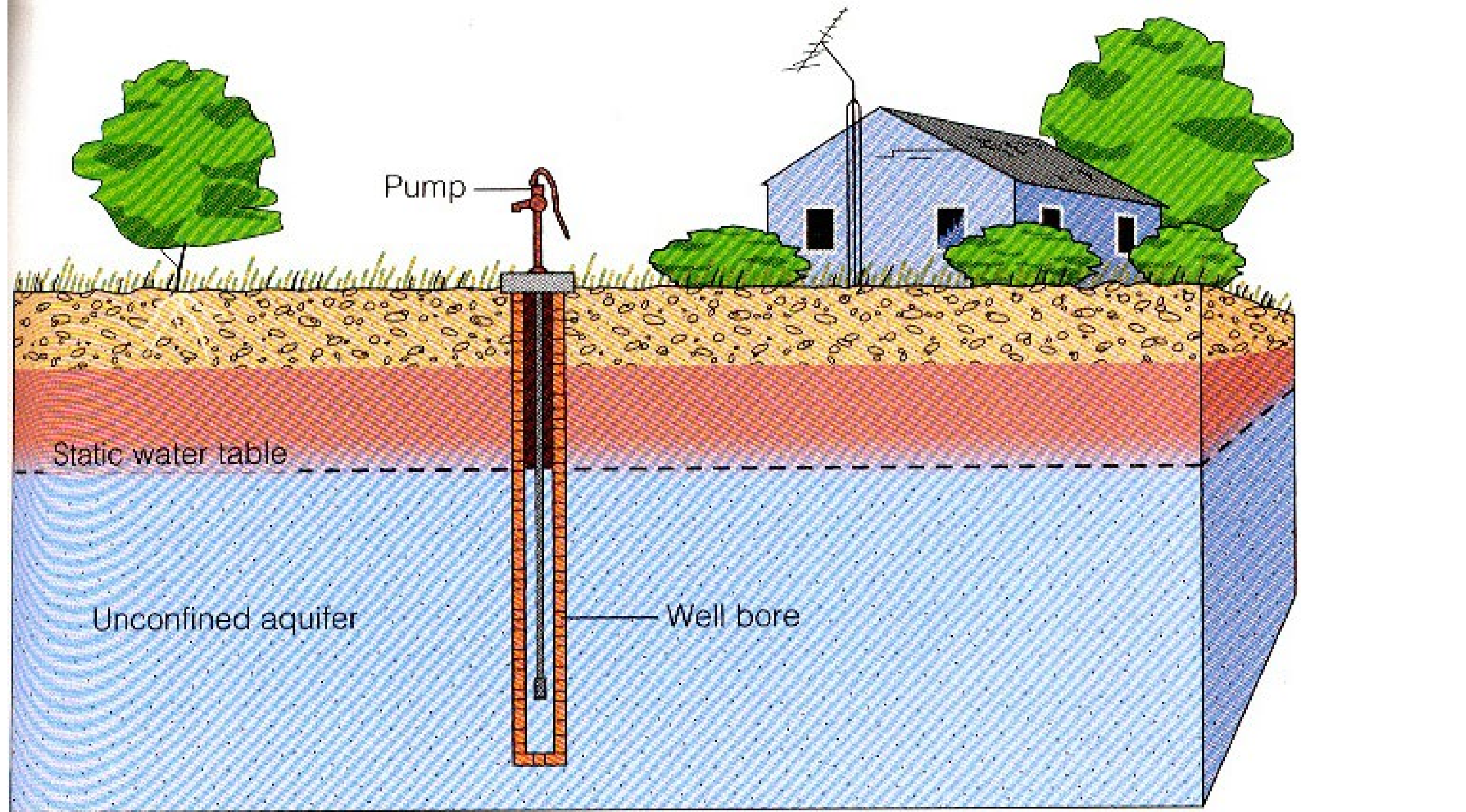
- Are contained within geologic formations that are exposed to atmospheric pressure changes and are capable of providing water by pumping.

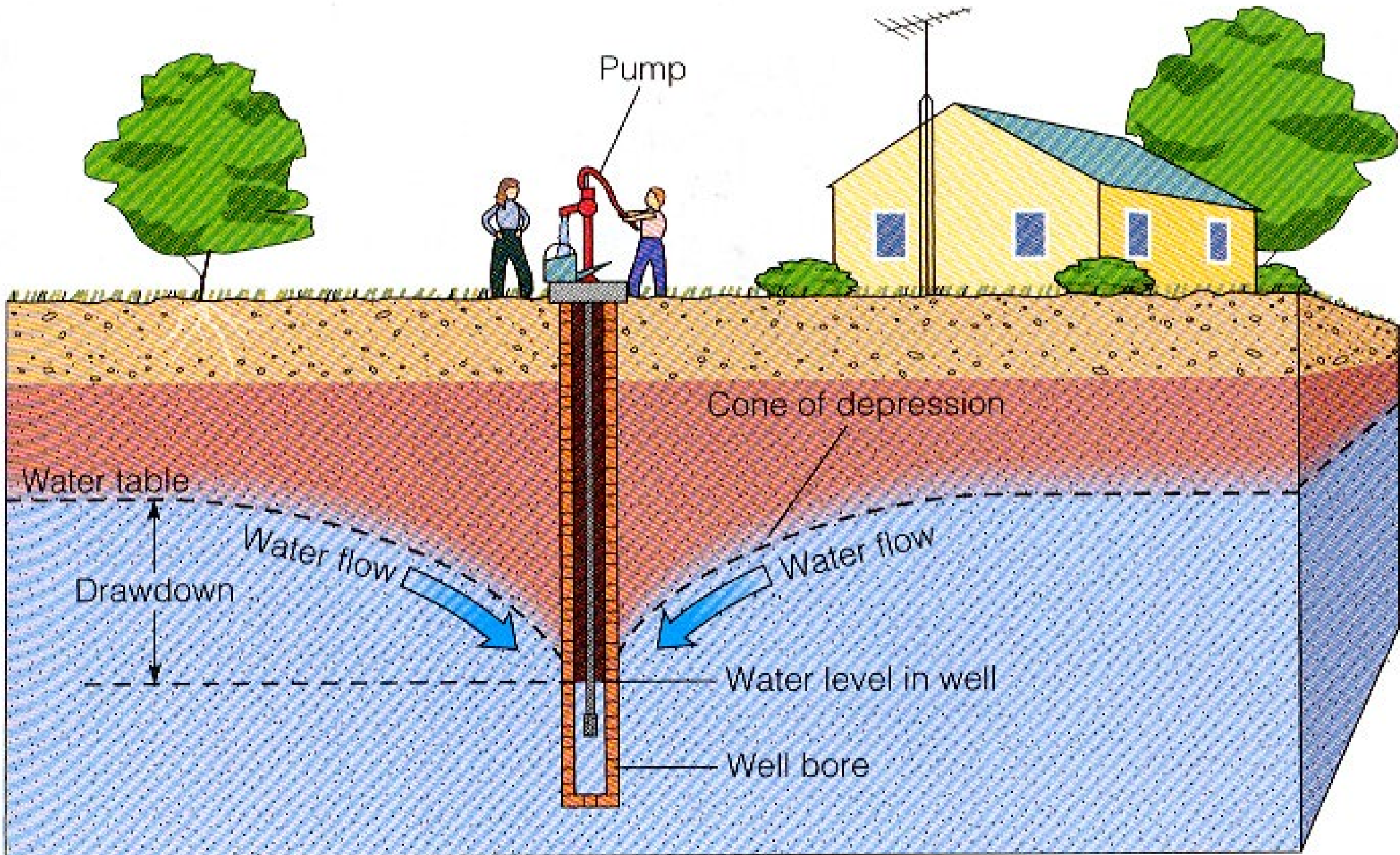






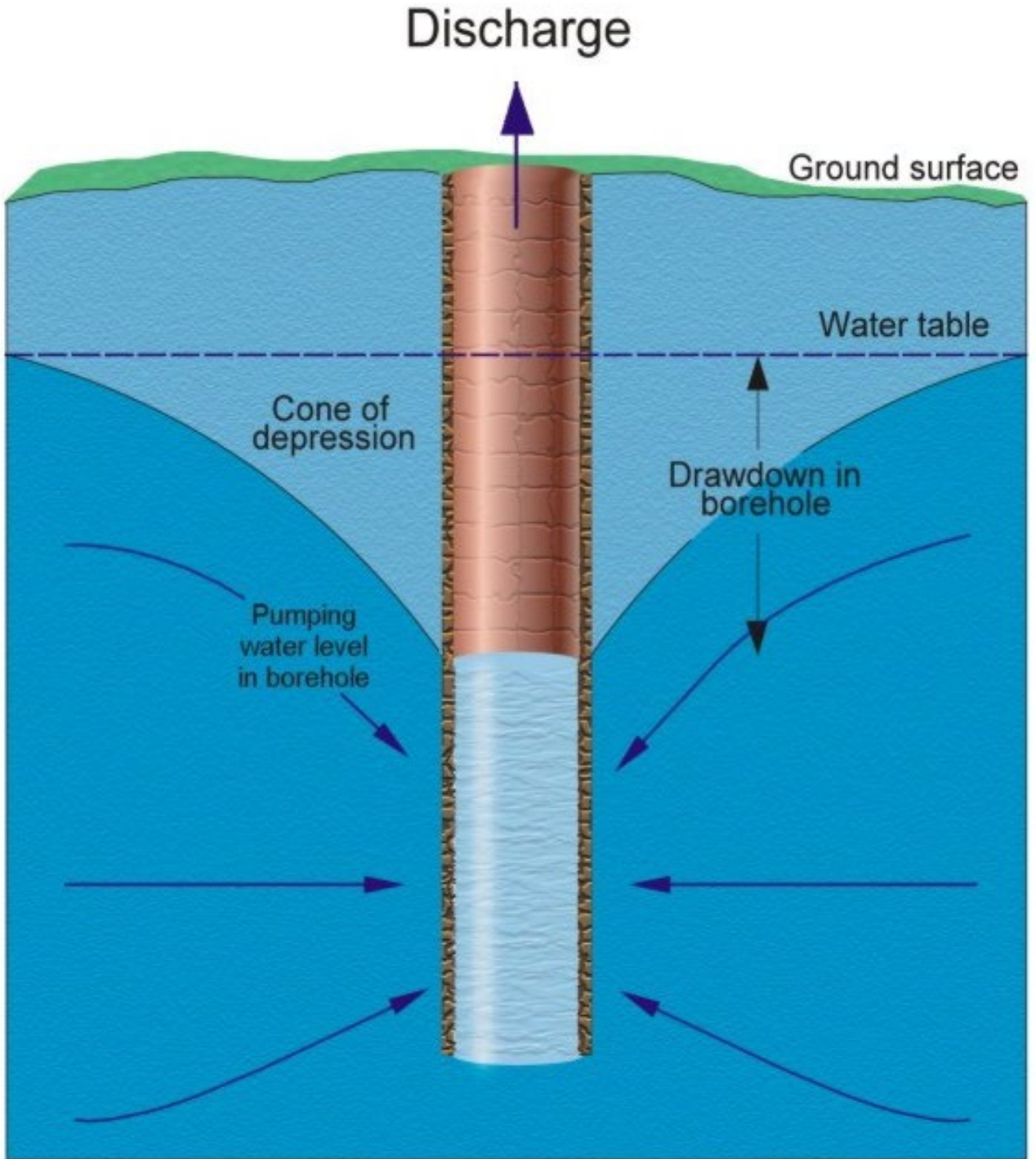
Drilling for the water table



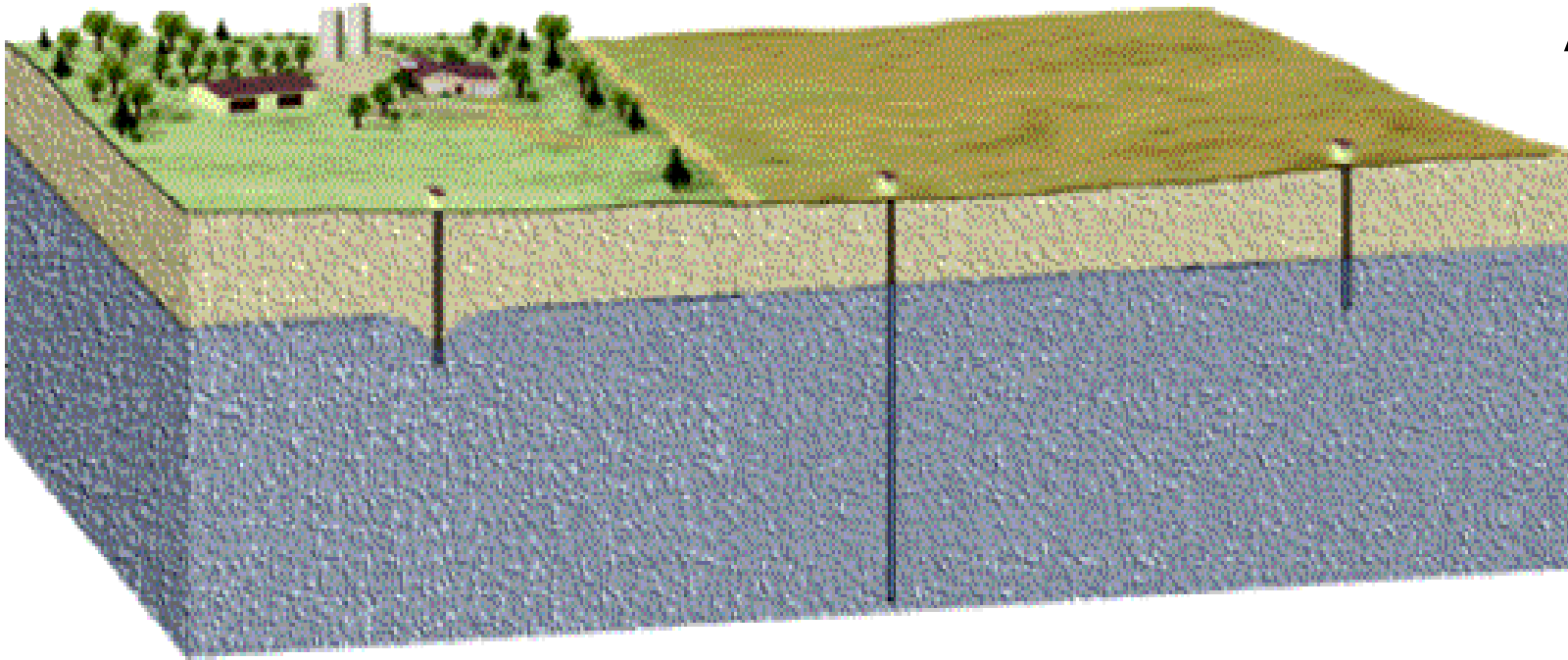


Be careful!

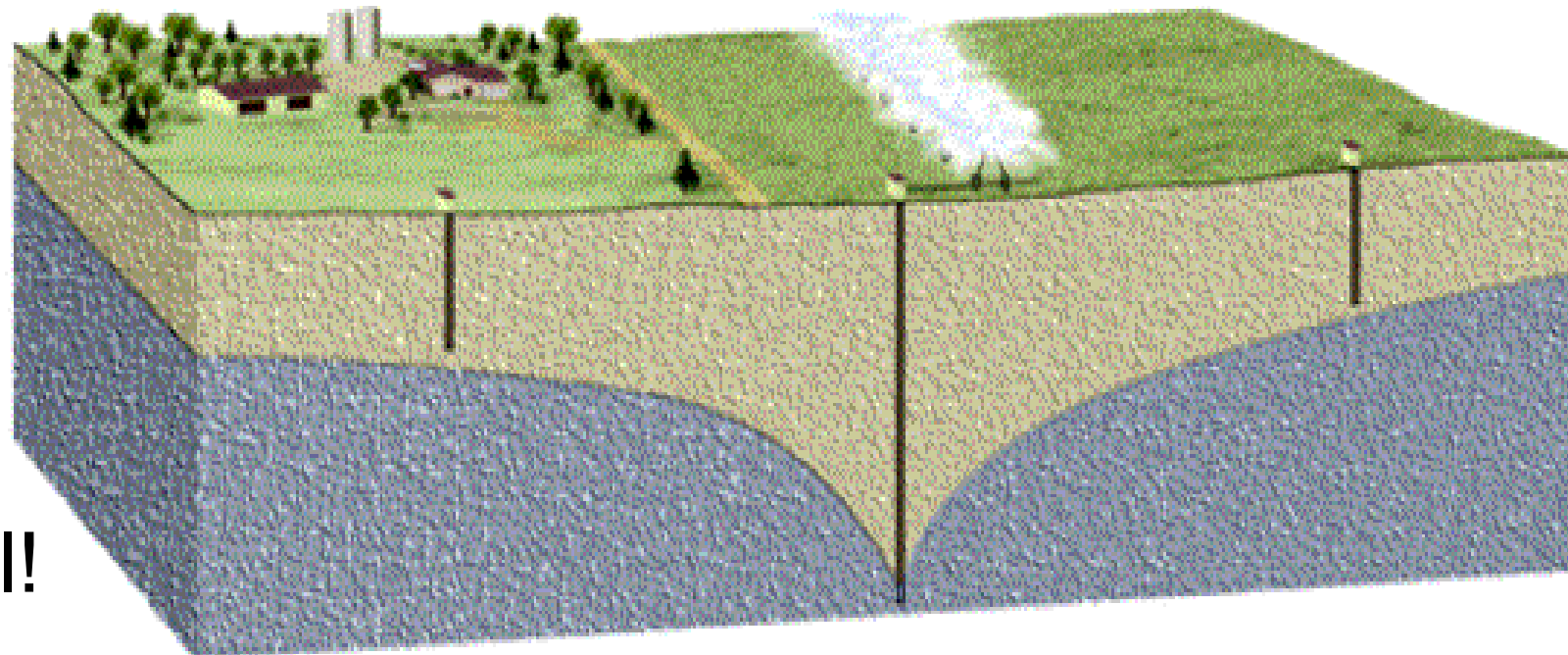
Discharge vs.  
Permeability



All is well.

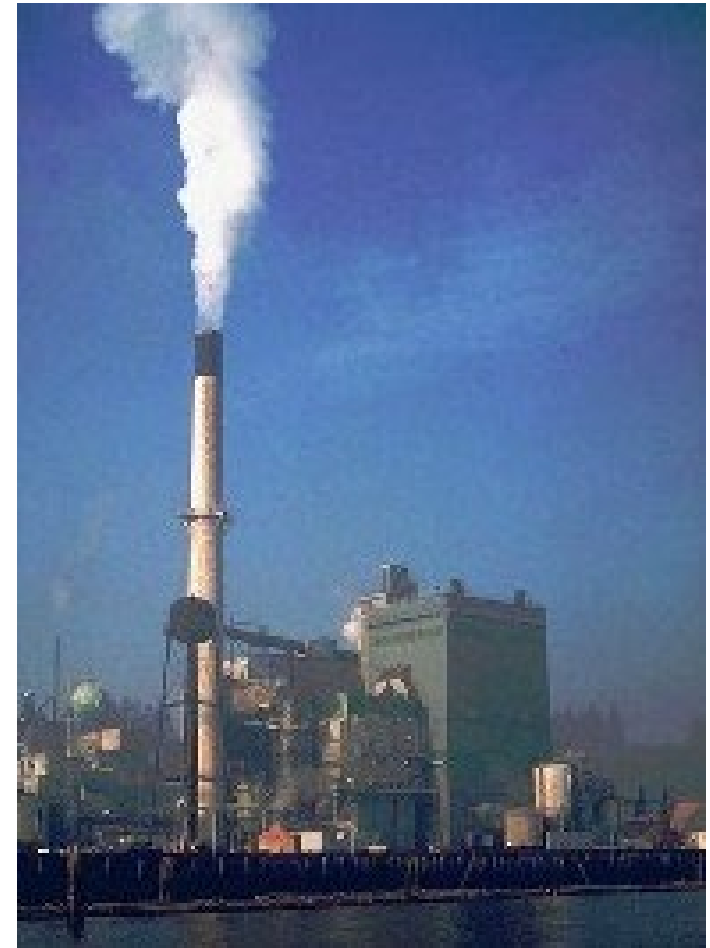


All is not well!

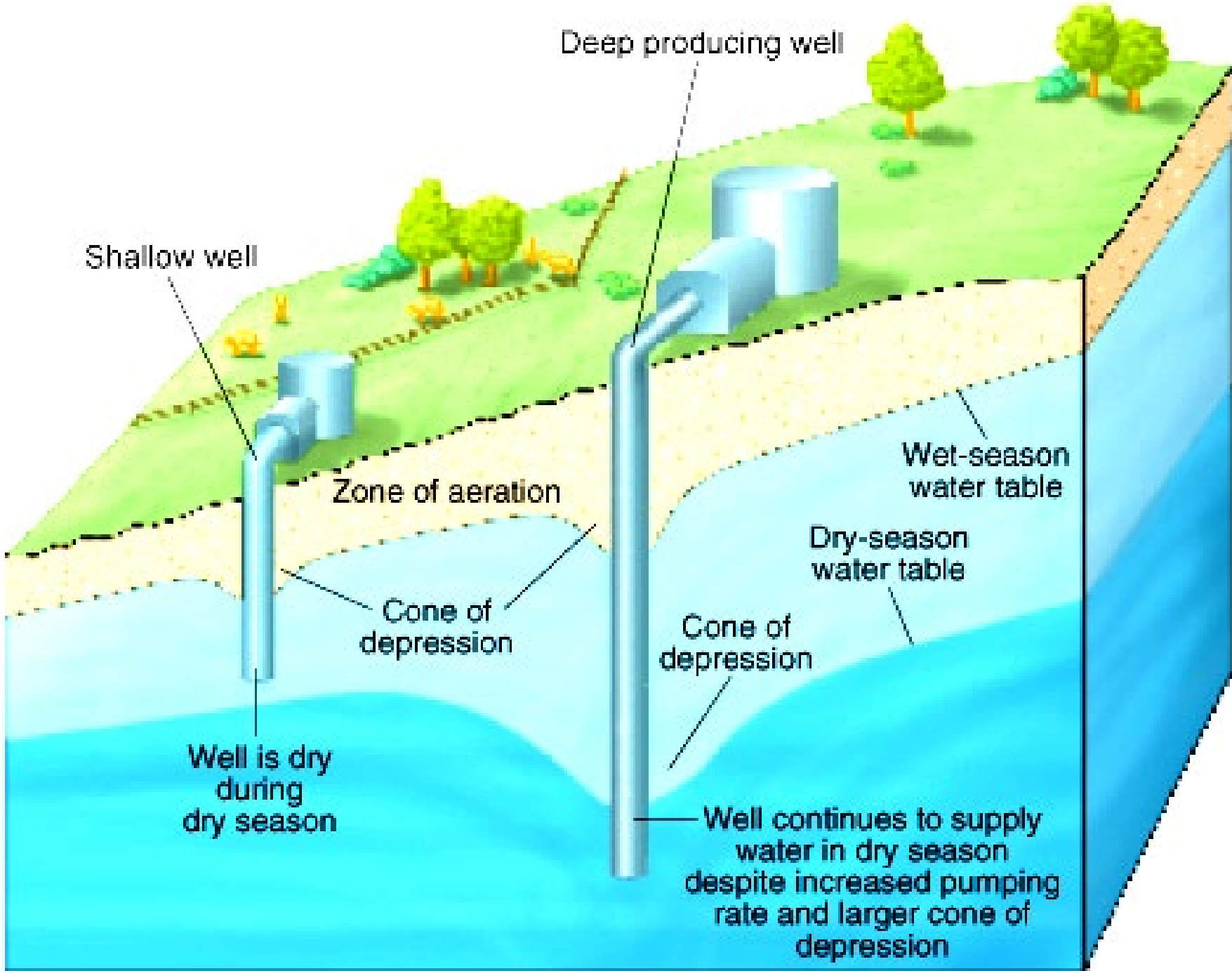


# Be kind to your neighbors, but also watchful!

- Agriculture (irrigation) and industries use a lot of water, so much that it can leave your well high and dry!



# Seasonal Change

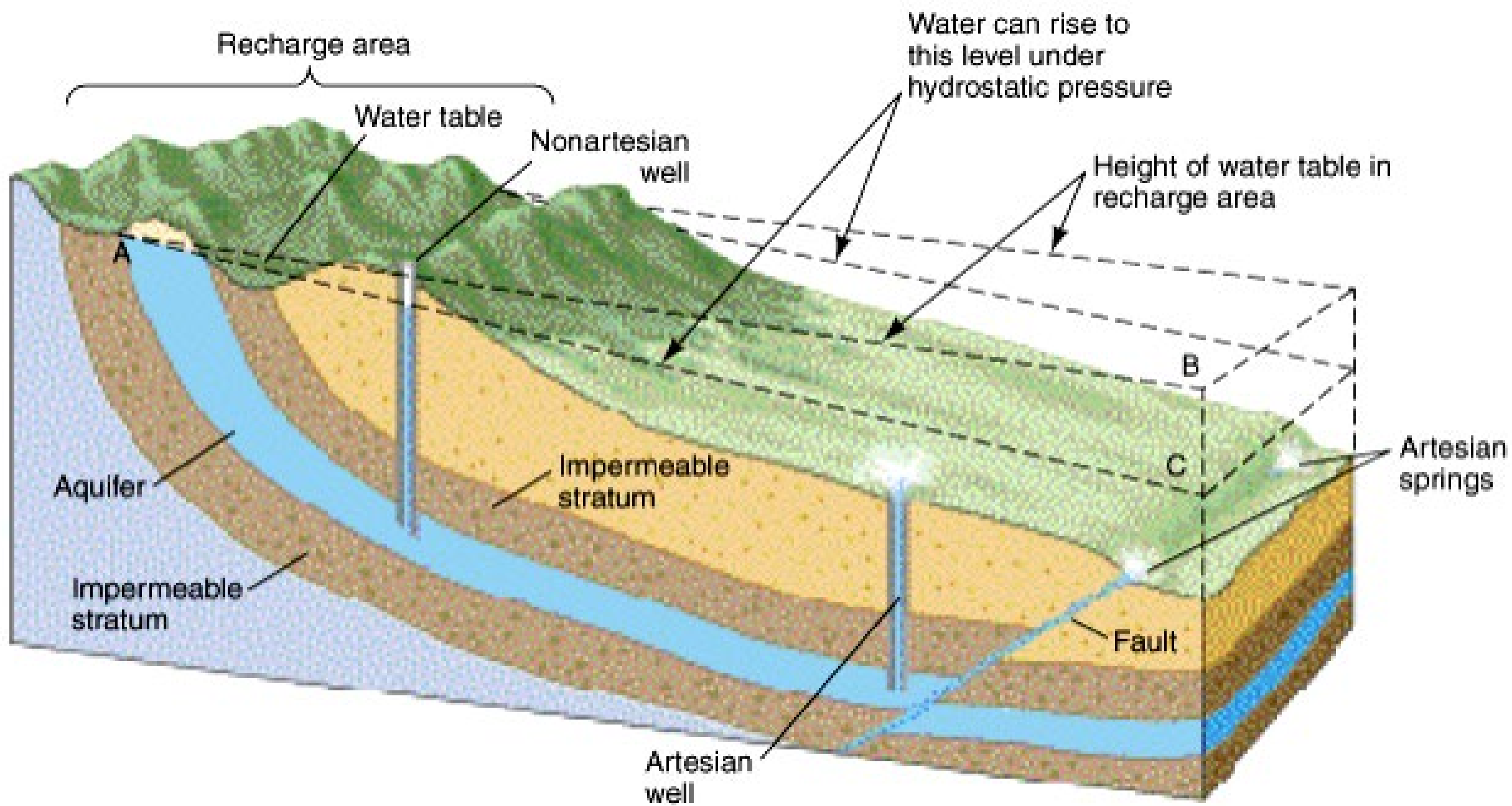


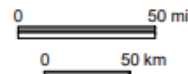
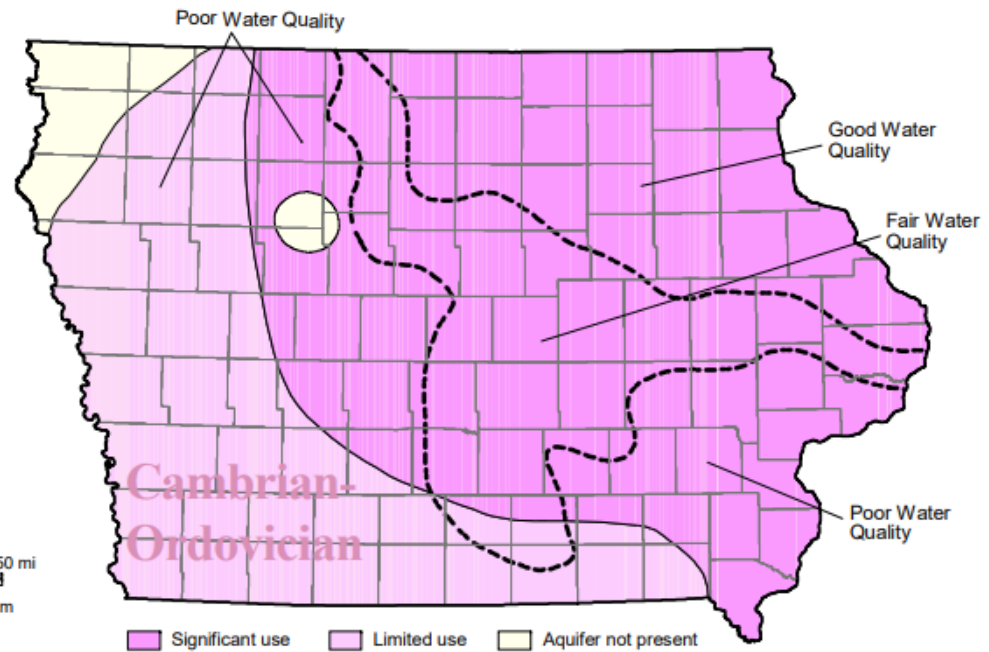
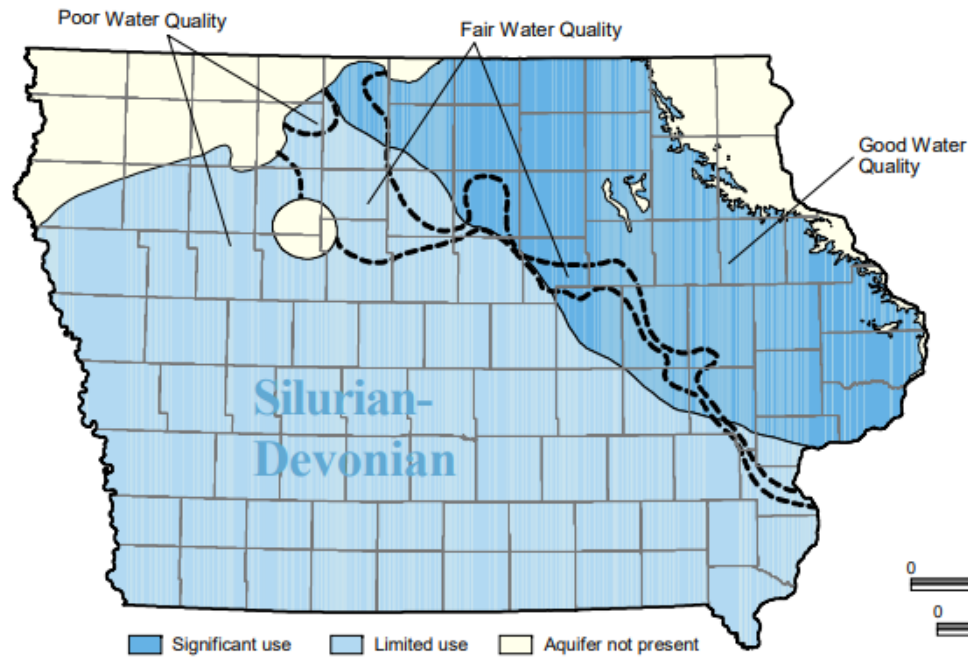
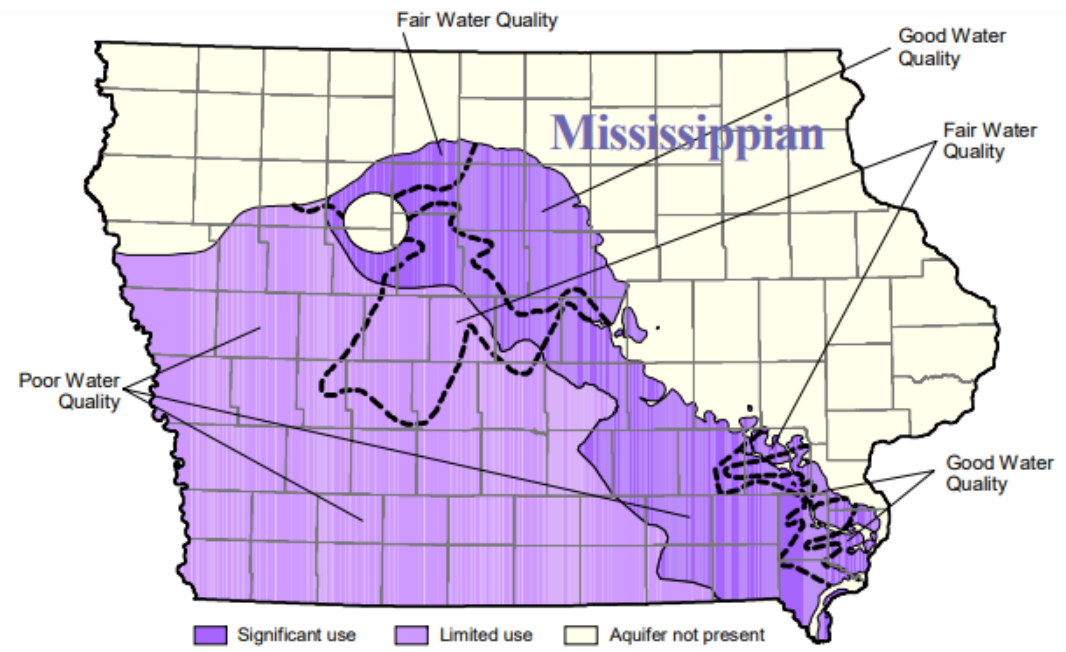
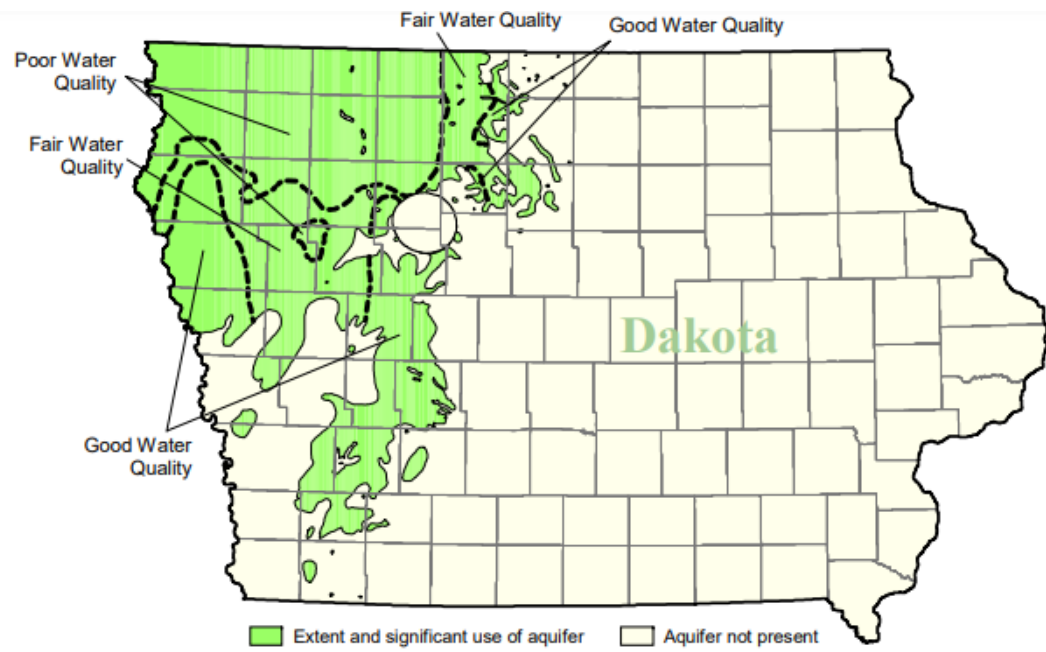
# Aquifer types

## 2. Confined

- Are pressurized systems that occur where water-saturated permeable layers are enclosed between two aquicludes.
- Also called artesian wells



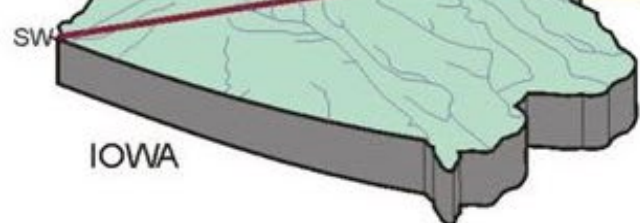
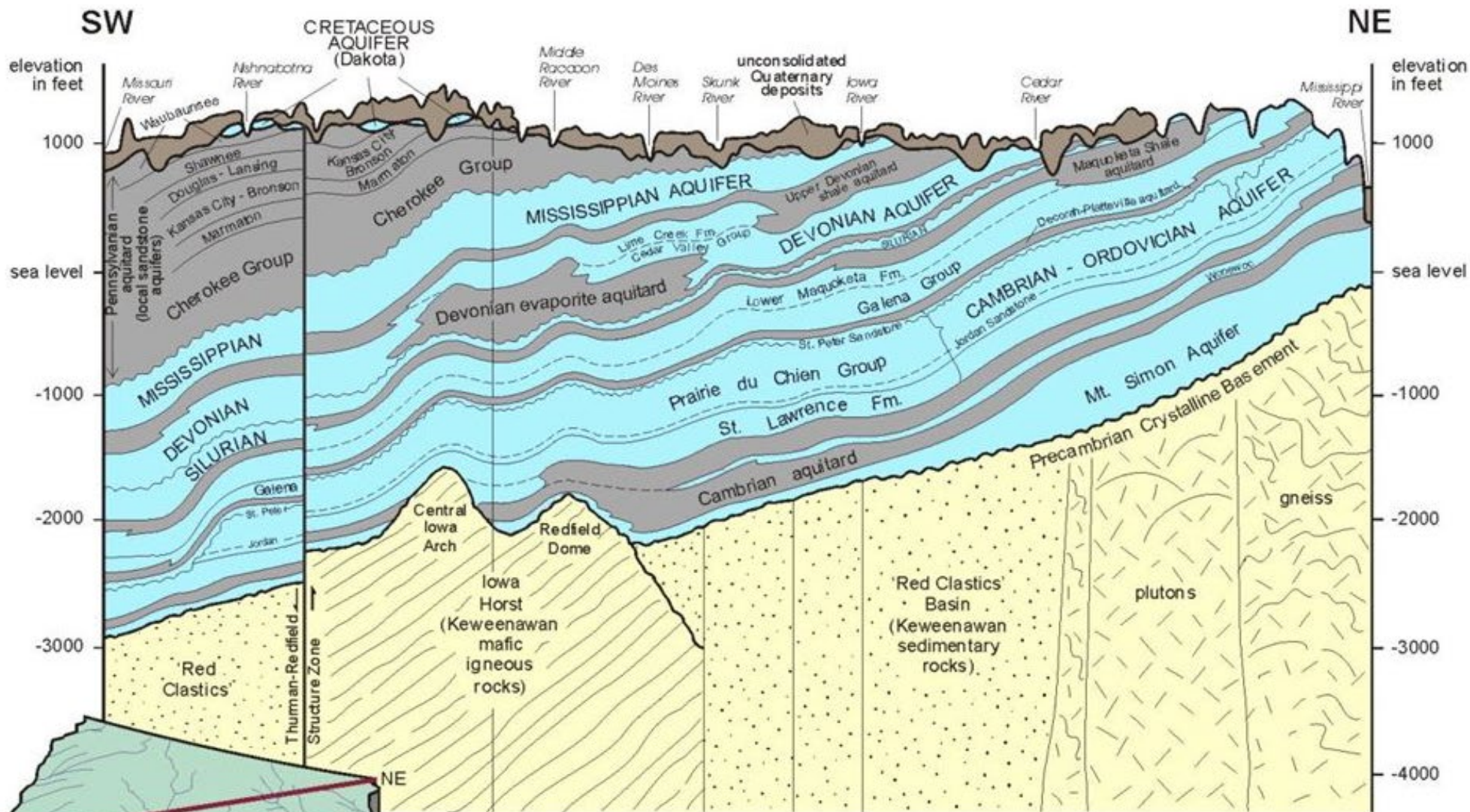


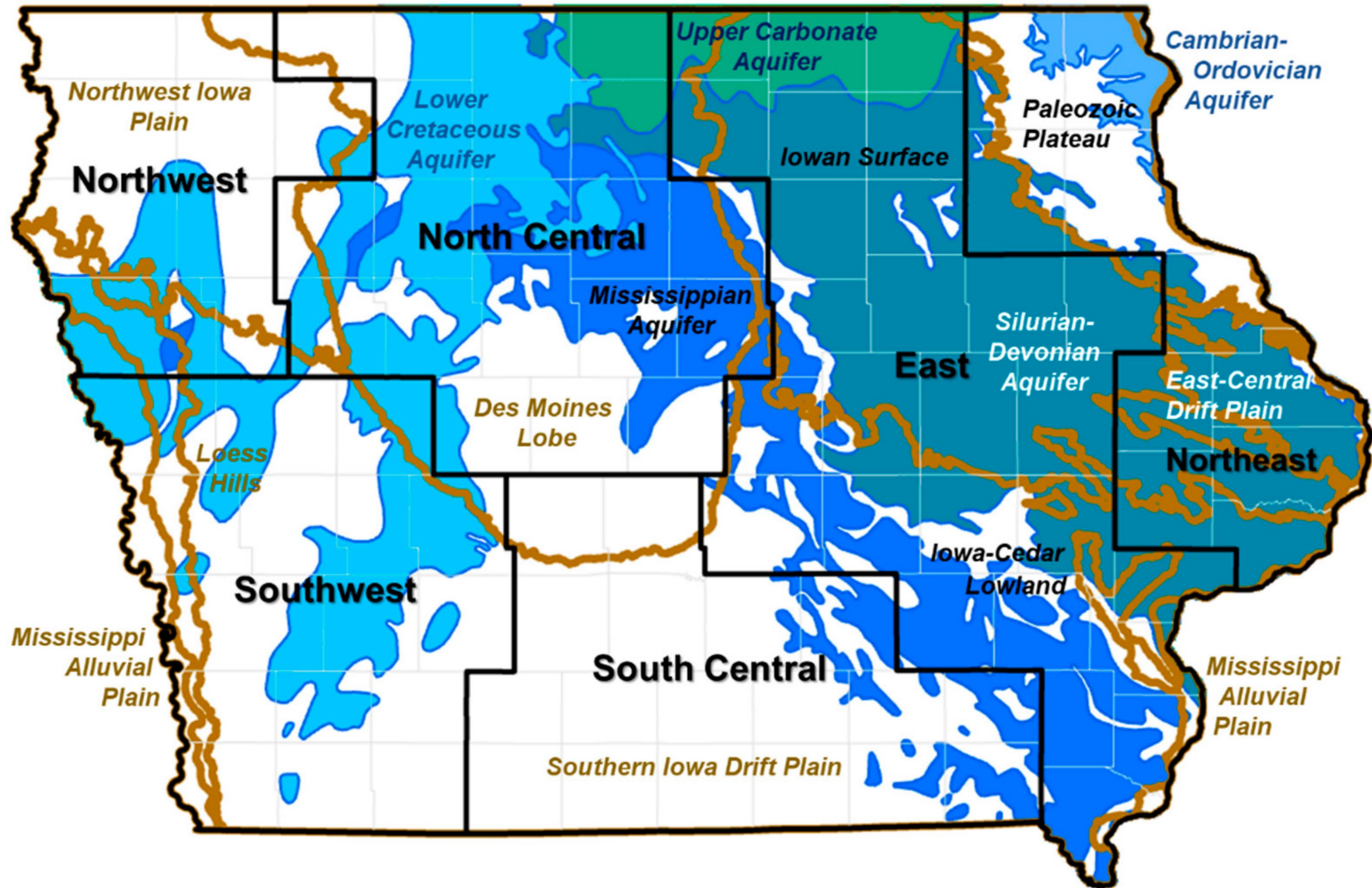


Water Quality Regions based on Total Dissolved Solids: Good = < 500 mg/L; Fair = 500 - 1,000 mg/L; Poor = > 1,000 mg/L

# Bedrock Aquifer Systems across Iowa

## Southwest to Northeast



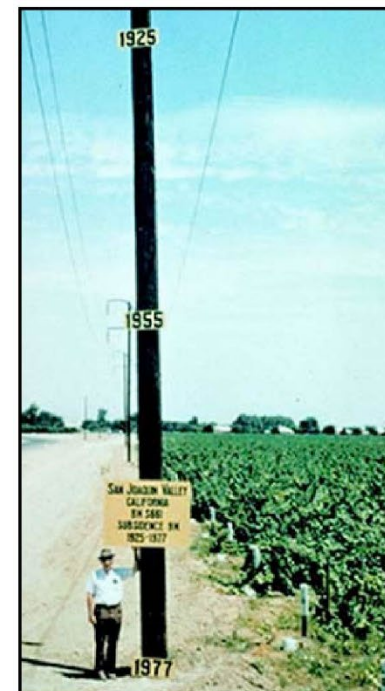


# Groundwater Mining

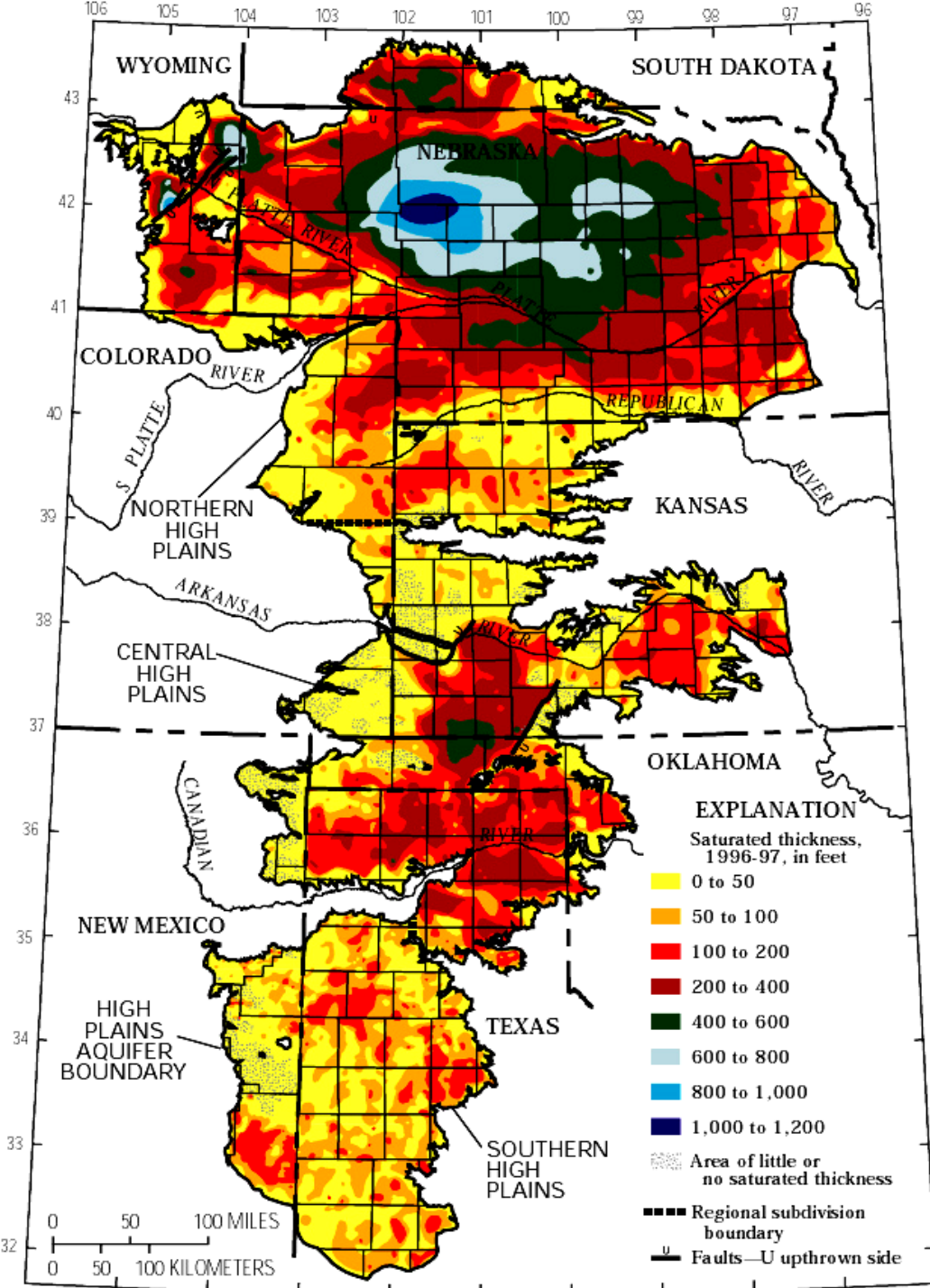
Exists when the amount of water withdrawn from an aquifer exceeds the aquifer's sustained yield = an overdraft.

## California and groundwater mining

San Joaquin Valley, has subsided (sank) approximately 9 meters (29 ft.) from 50 years of heavy irrigation.



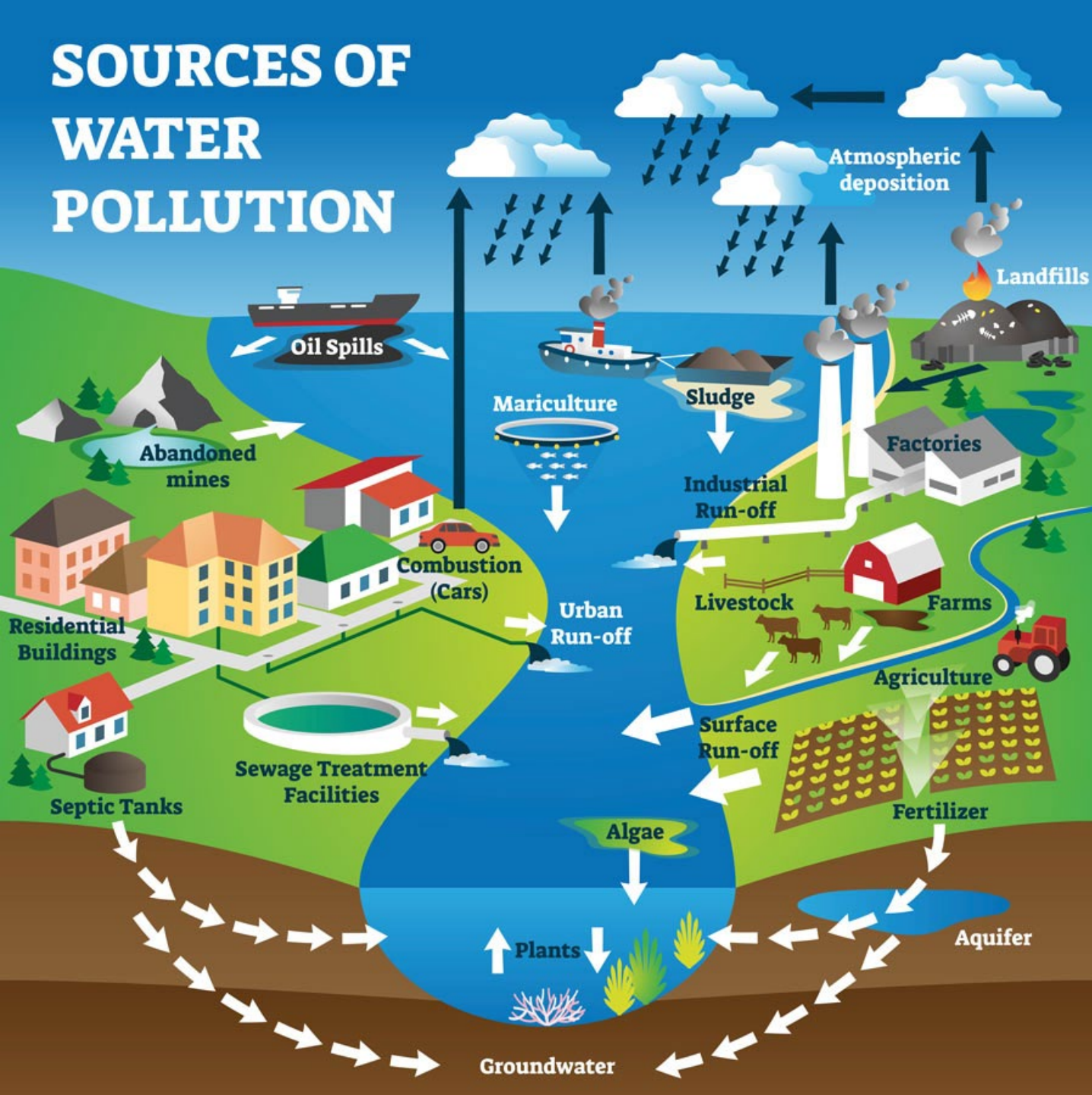
# The Ogallala Sandstone



# Groundwater contamination



# SOURCES OF WATER POLLUTION

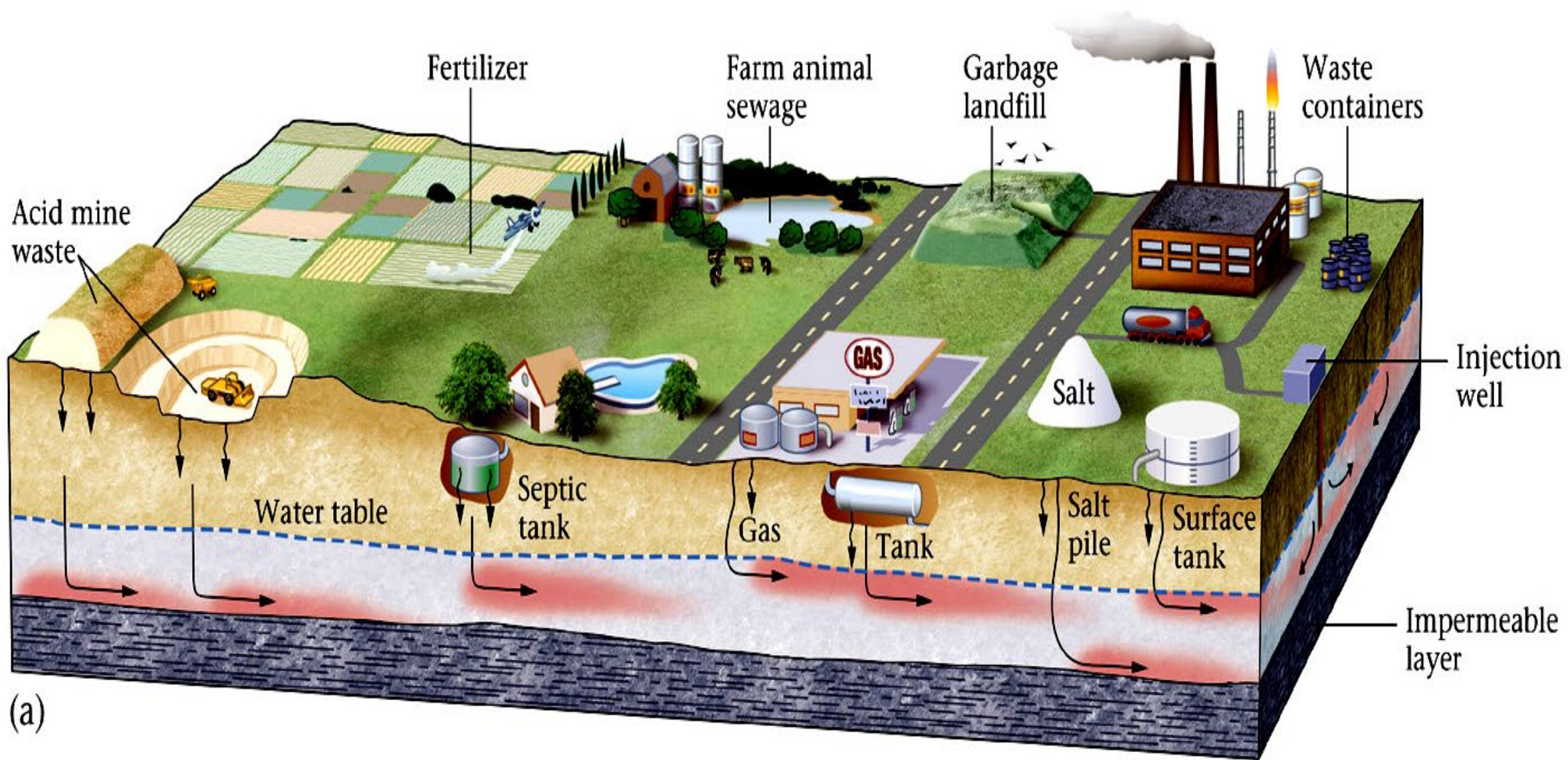


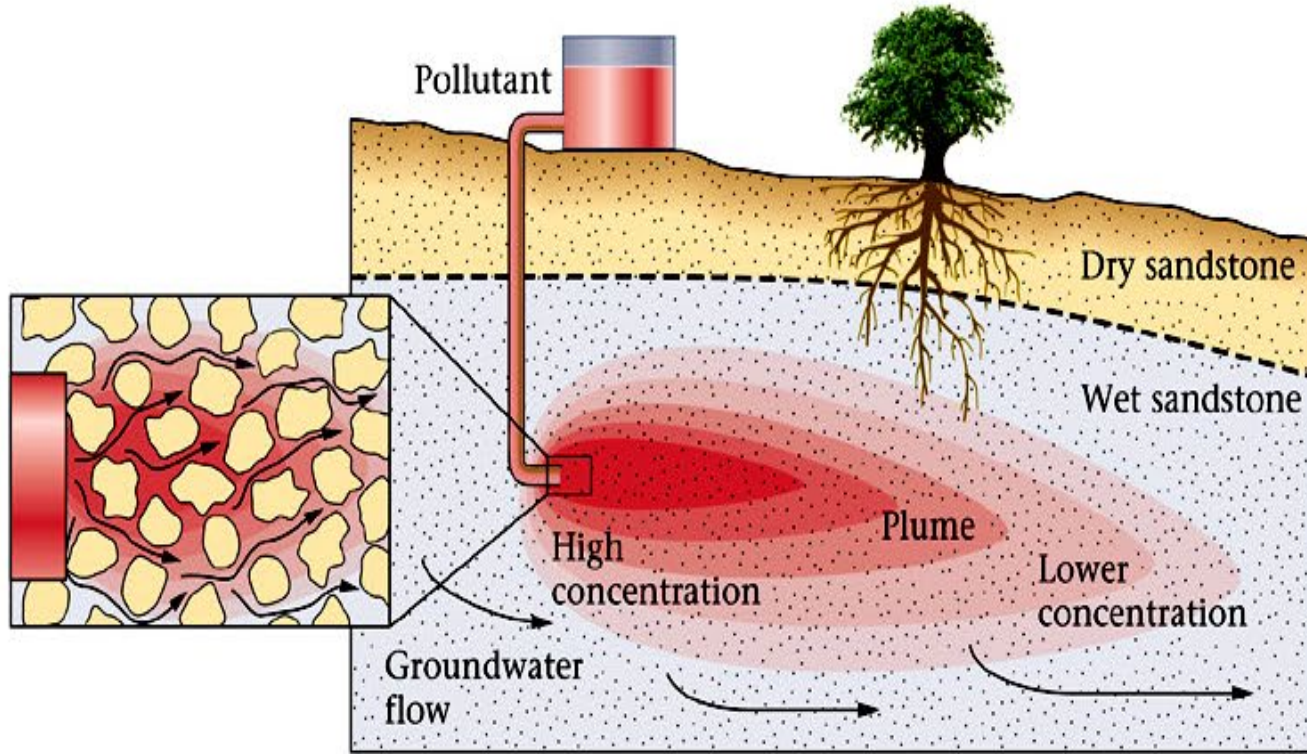
# Residence Time



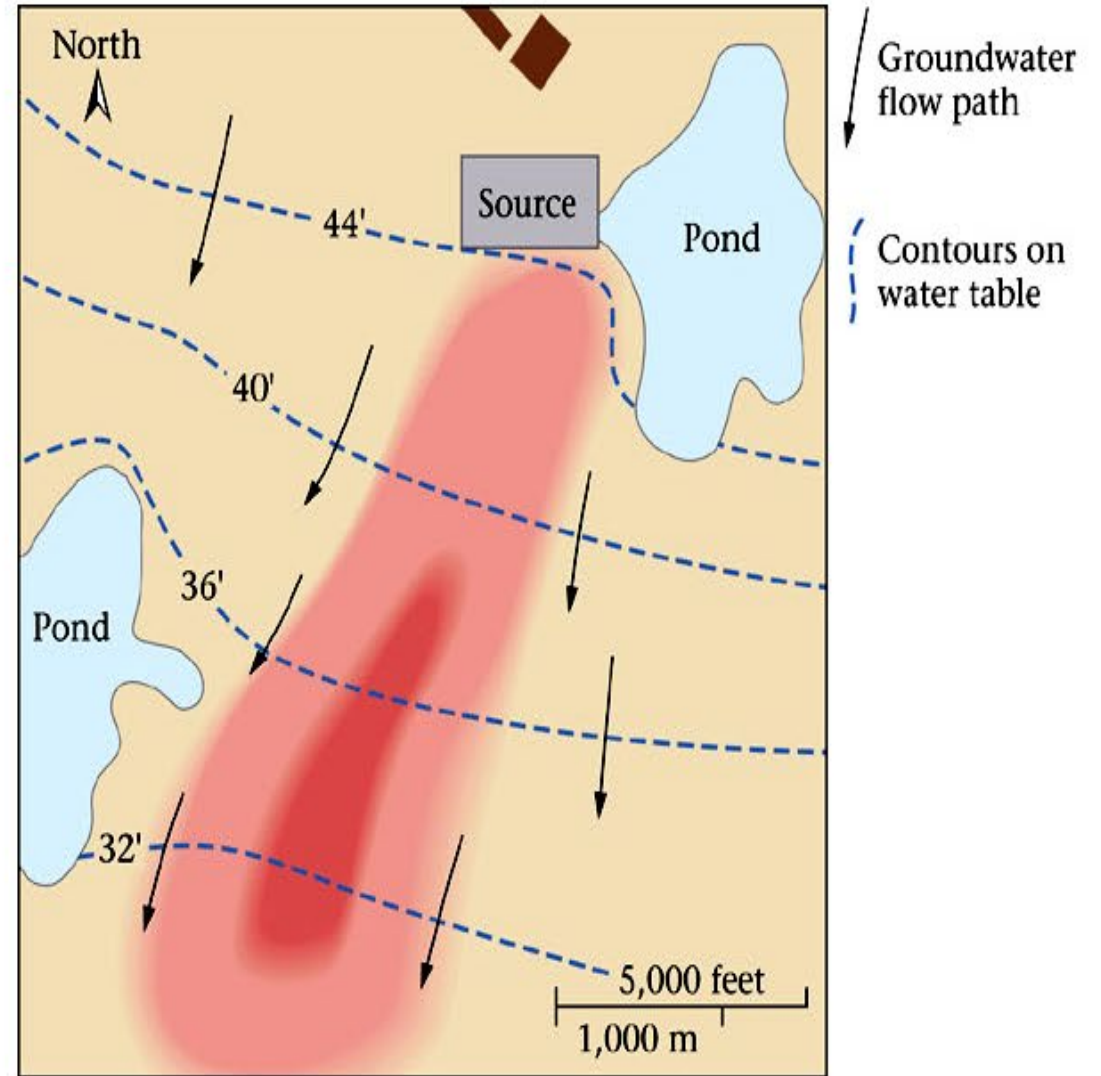
# Common sources of groundwater contamination

1. Agriculture
2. Commerce
3. Industry
4. Our homes
5. Waste management

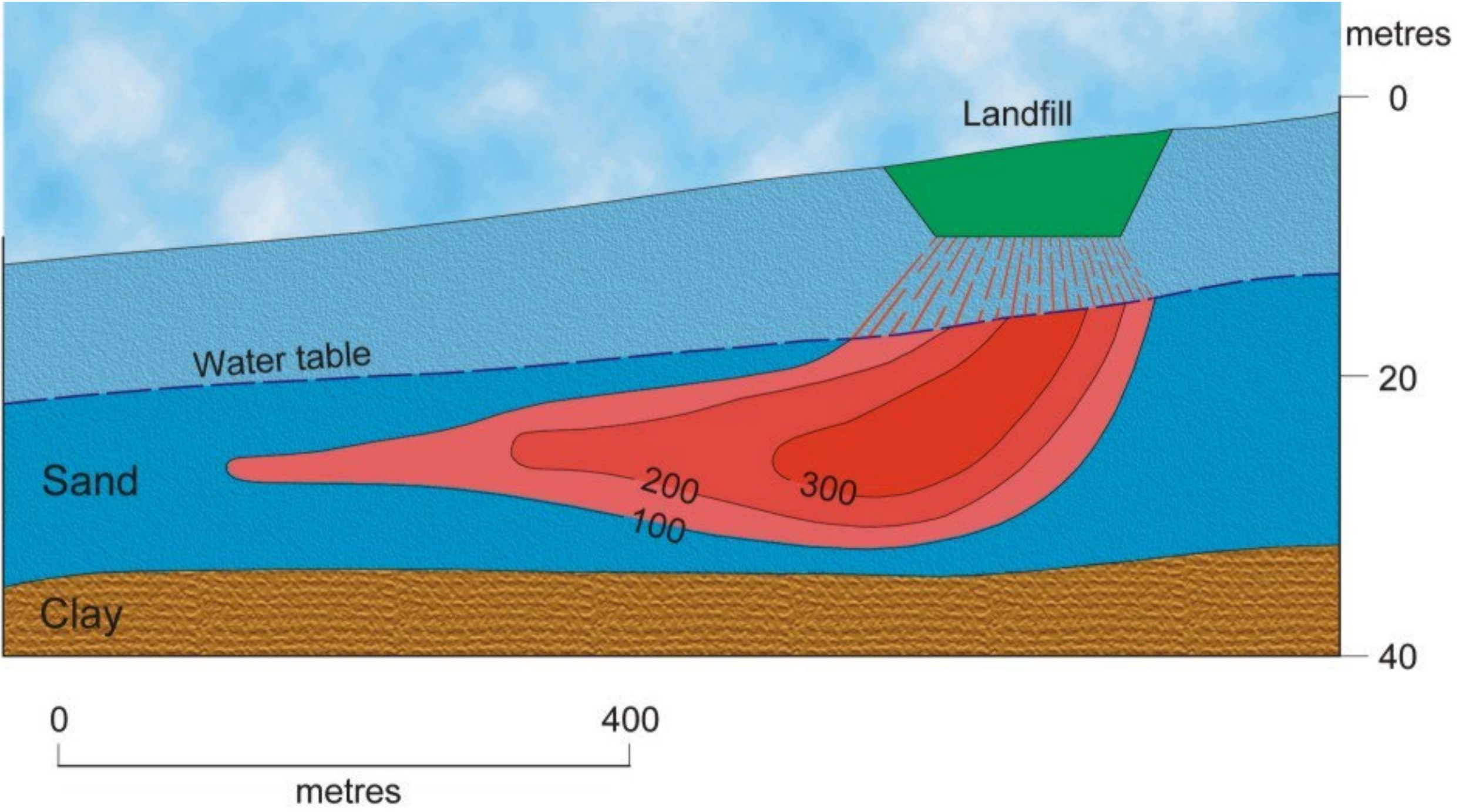




(b)



(c)



# Common Pollutants

- Hydrocarbons
- Solvents (benzene, toluene, and xylene)
- Fertilizers
- Pesticides
- Manure











Weed-b-gone

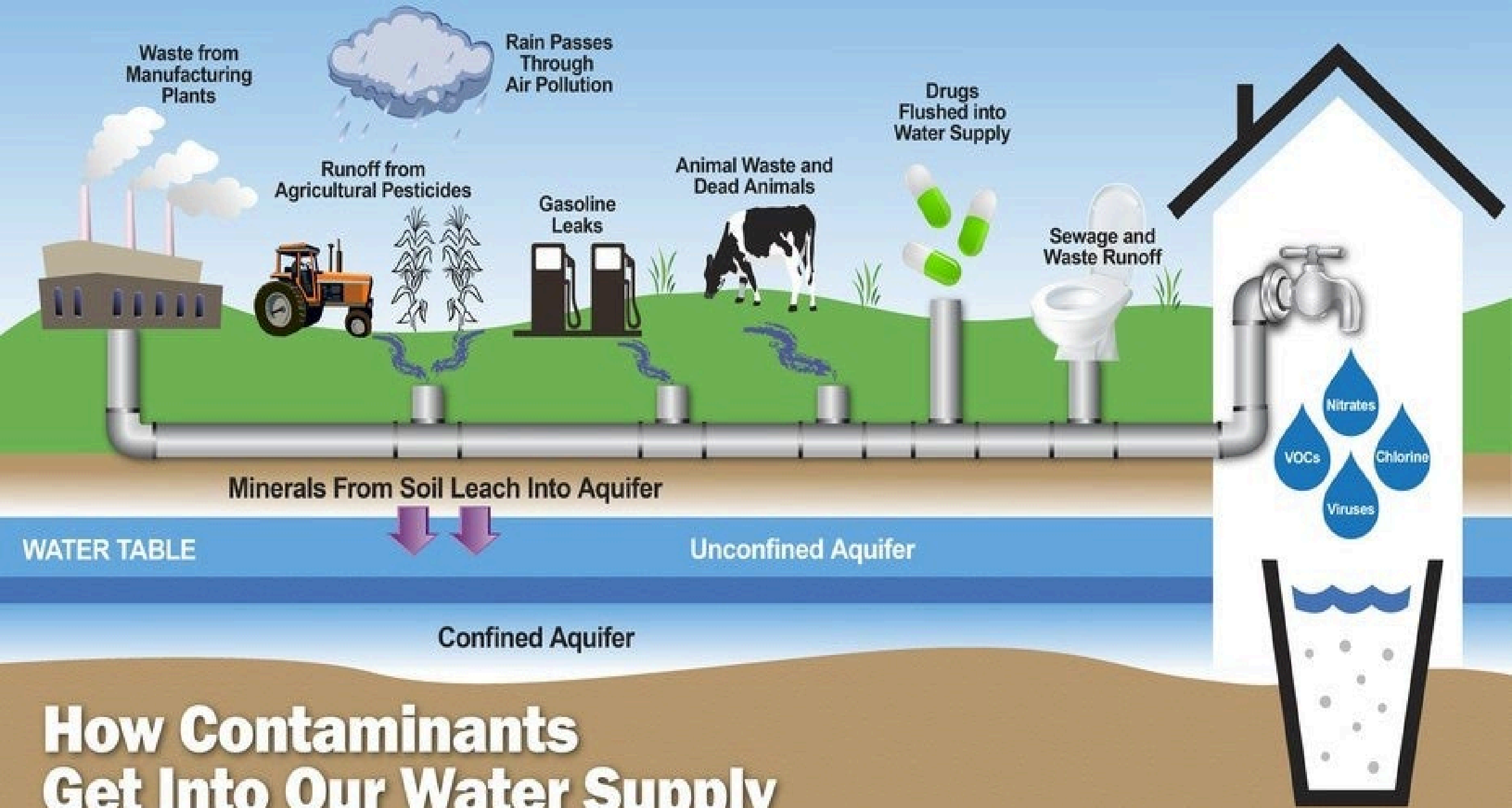
DRAIN  
CLEANER

GASOLINE

Motor Oil  
10W-40

bleach

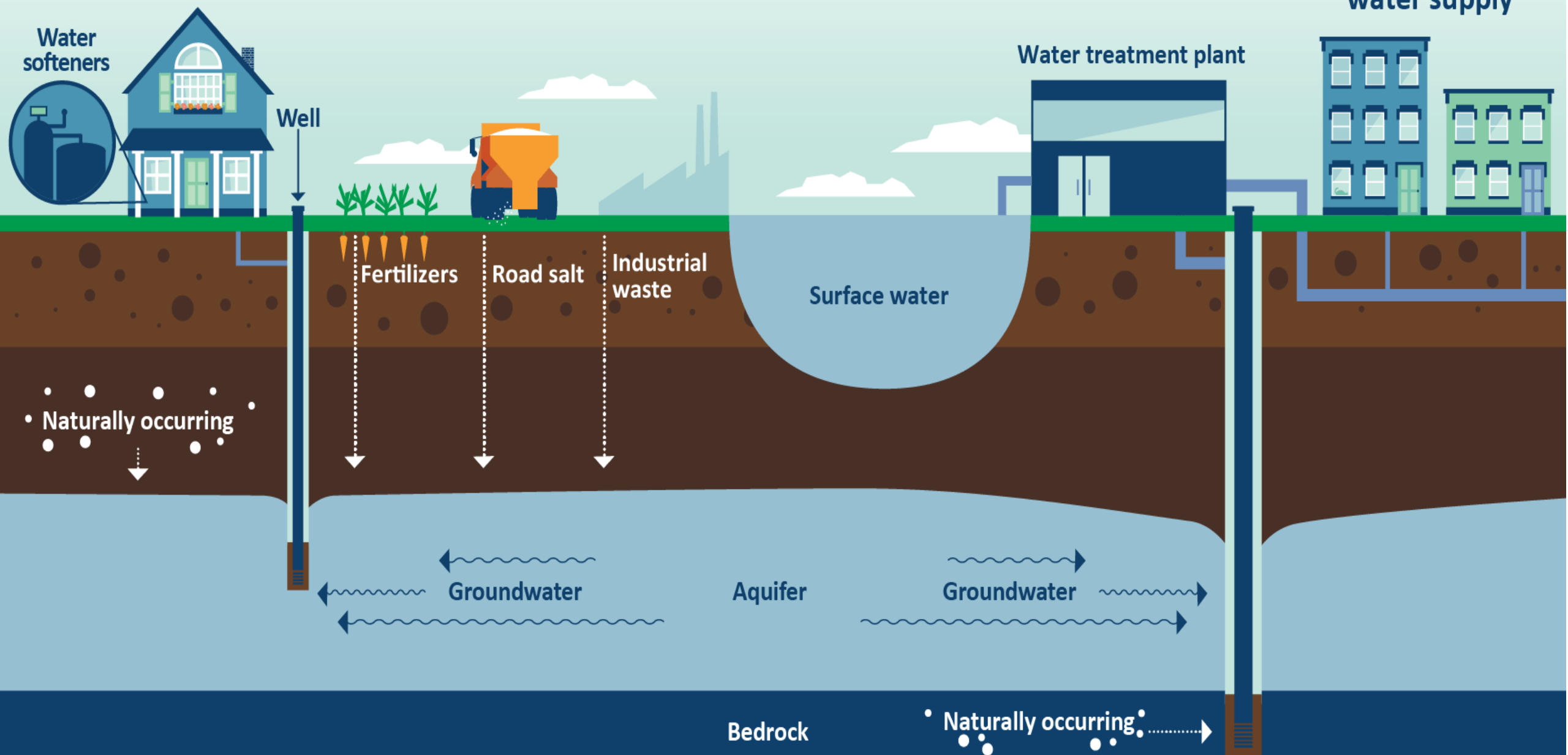
Flammable



# How Contaminants Get Into Our Water Supply

# Private water supply

# Community public water supply



# Remediation (clean-up)

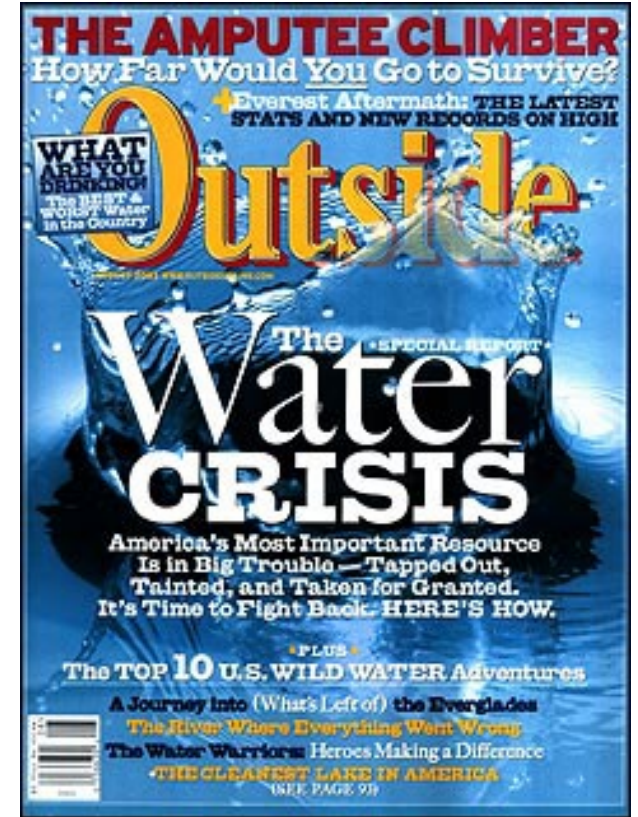
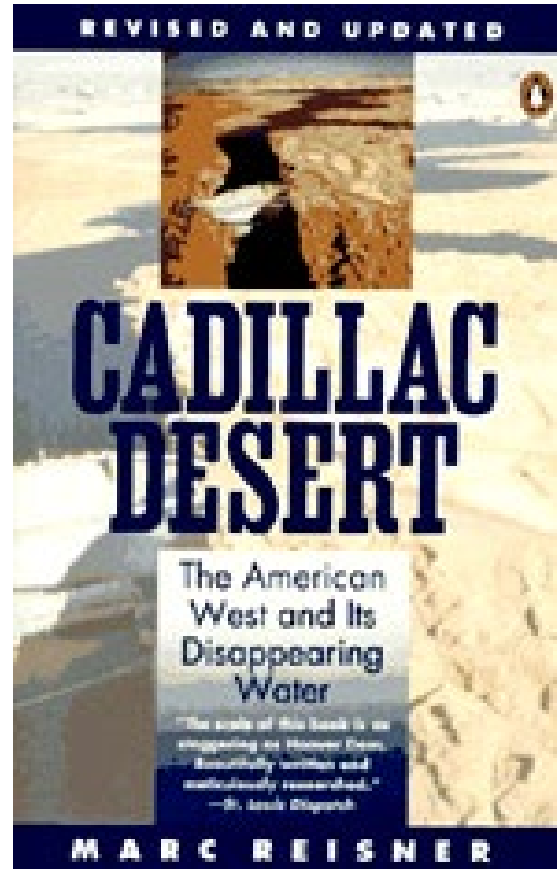
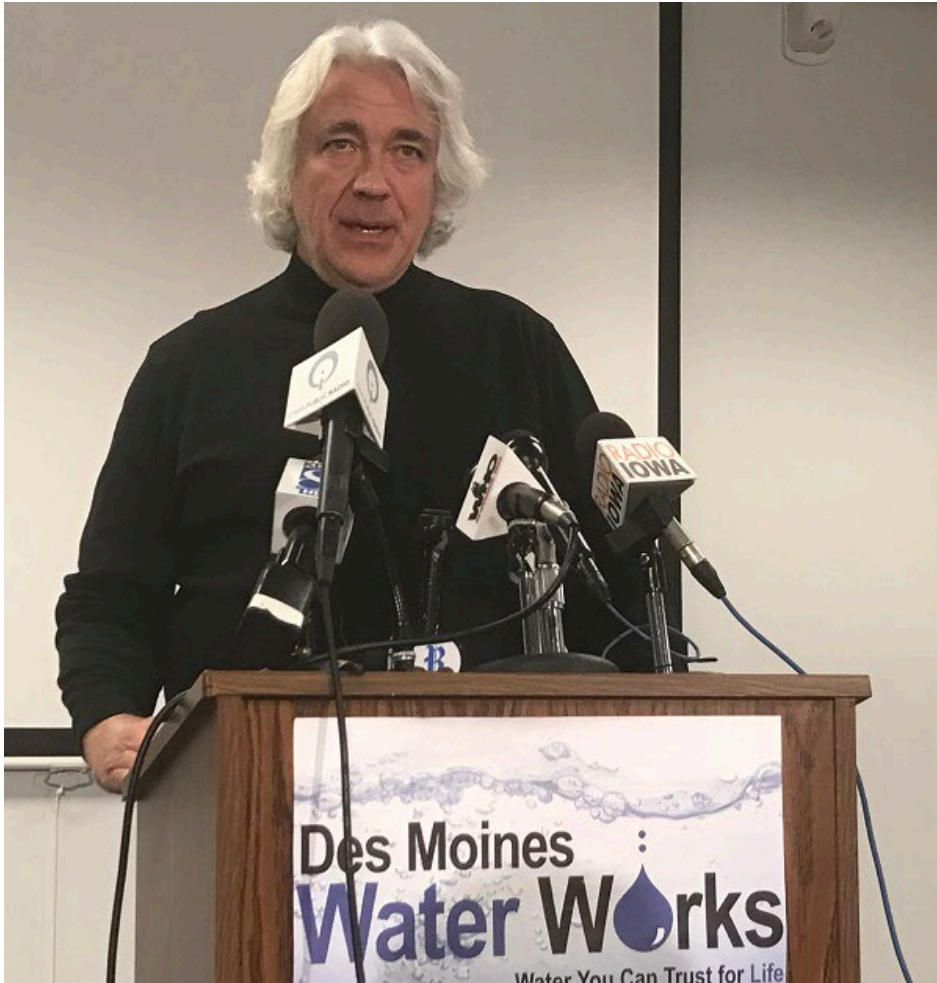
1. Problem identification
2. Remove the contaminate source
3. Isolate the contaminate
4. Determine the possible effects of the contamination
5. Determine the best way to remove the remaining contaminants
  - a. Bioremediation (microbes)
  - b. Pumping (Extraction and Injection wells)
  - c. Filtration



Iowa's groundwater resources by region.

Website <http://www.igwa.org>

Discussion?



Israel/Gaza

New York

# Geologic Work by Underground water

Karst topography

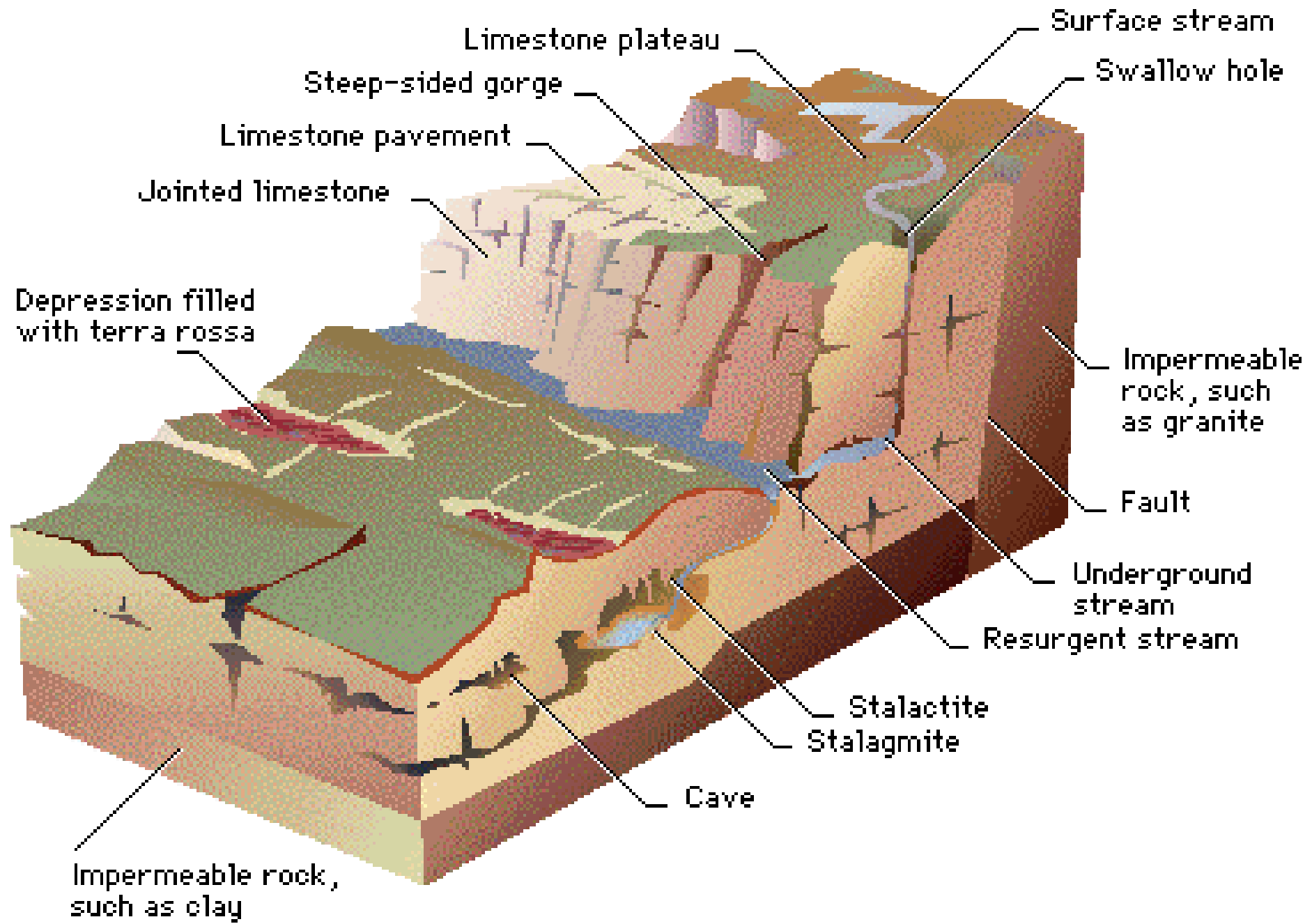


# Factors in developing a Karst system

- A product of chemical weathering, (solution weathering) of carbonate rock by carbonic acid ( $\text{H}_2\text{CO}_3$ )
- Soluble rock (E.g. limestone)
- Areas of moderate rainfall
- Valleys

# Karst features

1. Pitted grooves in surface rocks
2. Dolines (sink holes)
3. Karst Plain
  - Few streams
  - Shallow holes in the ground (good places to hide)
4. Caves
  - Caverns
  - Speleothems (flowstone, dripstone)







Stalactites

Stalagmites



Photograph by J.D. Kiefer



# MARGINAL REGION KARST SINKHOLE HYDROLOGY

