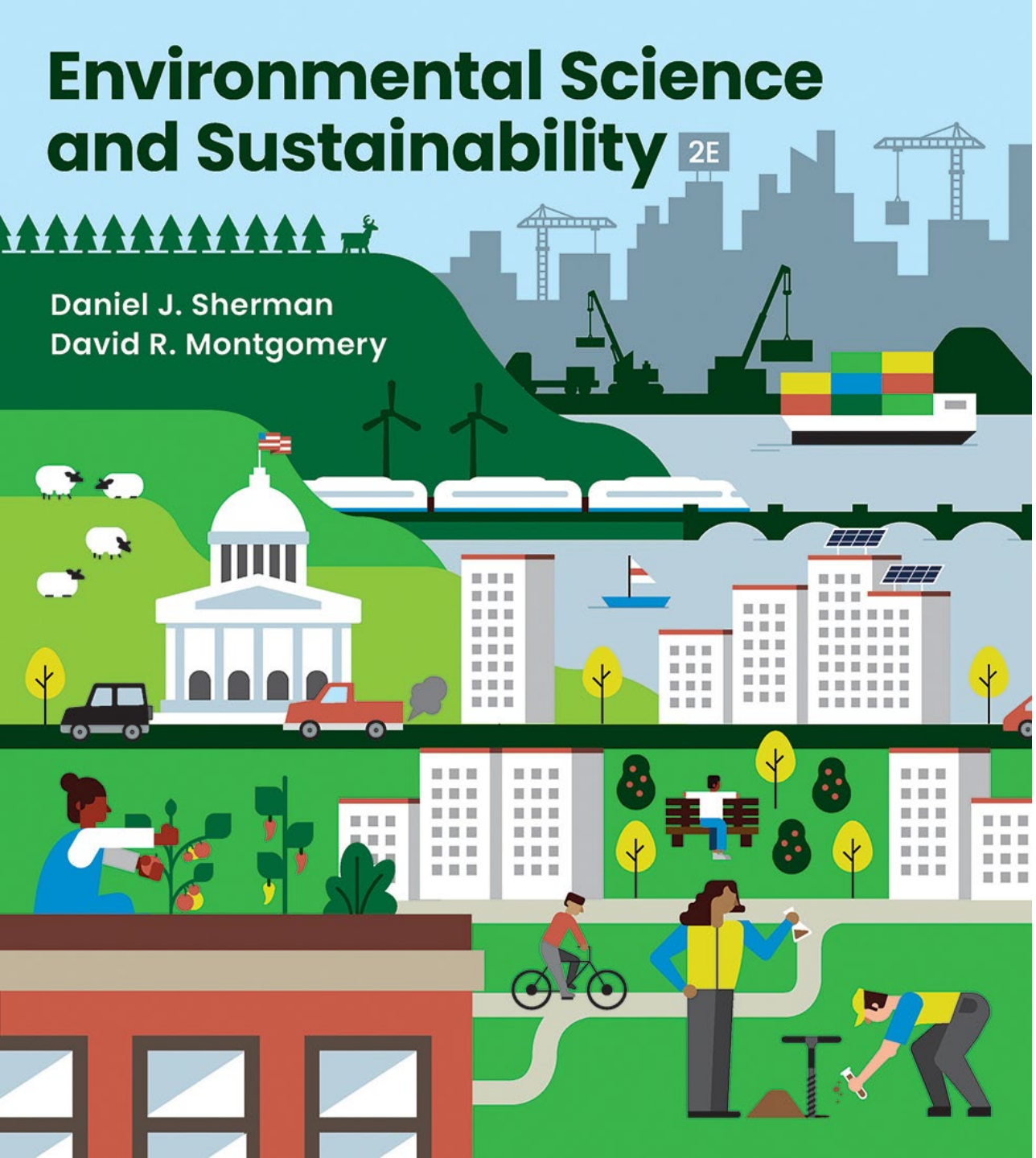


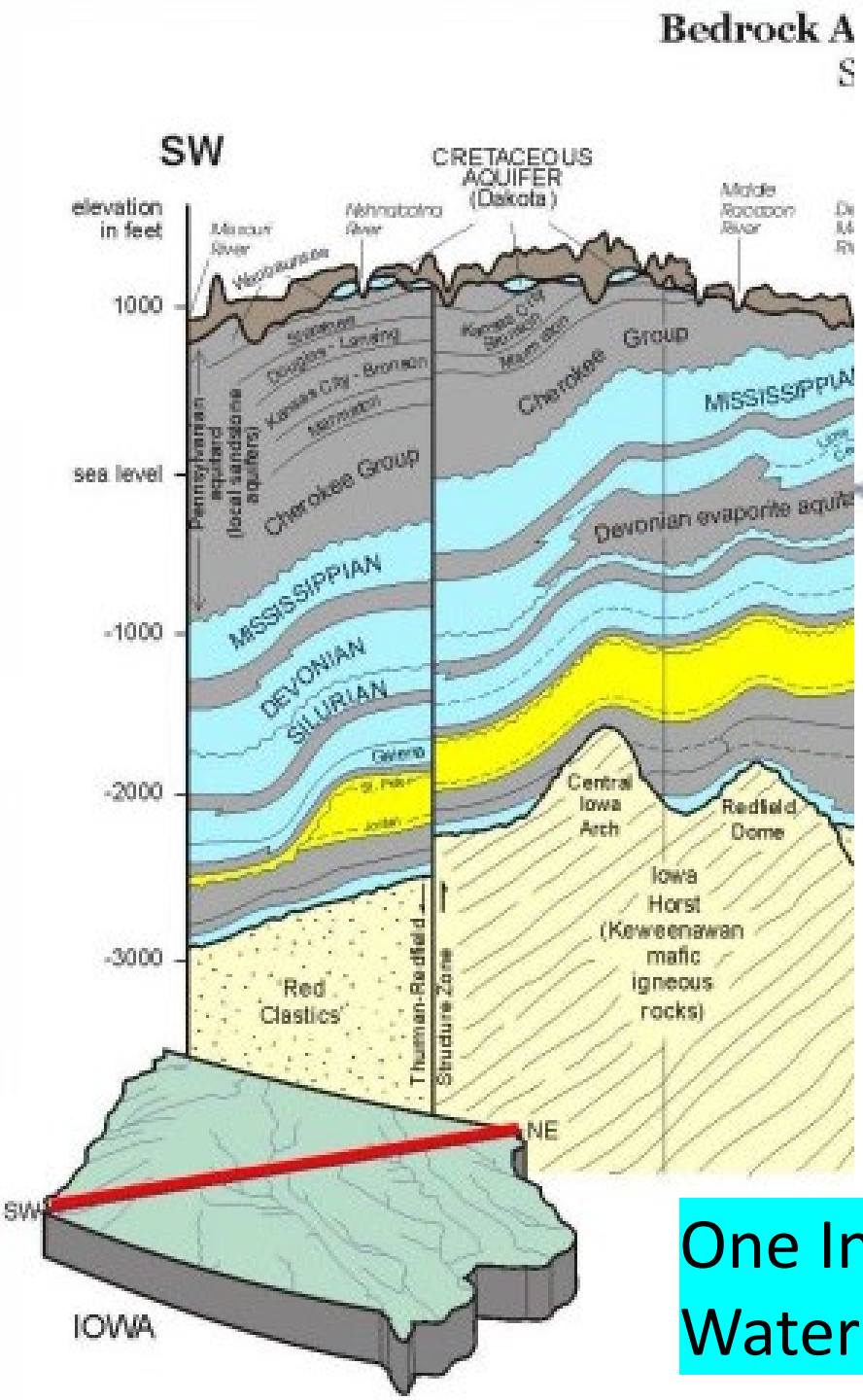
CHAPTER 7 Water

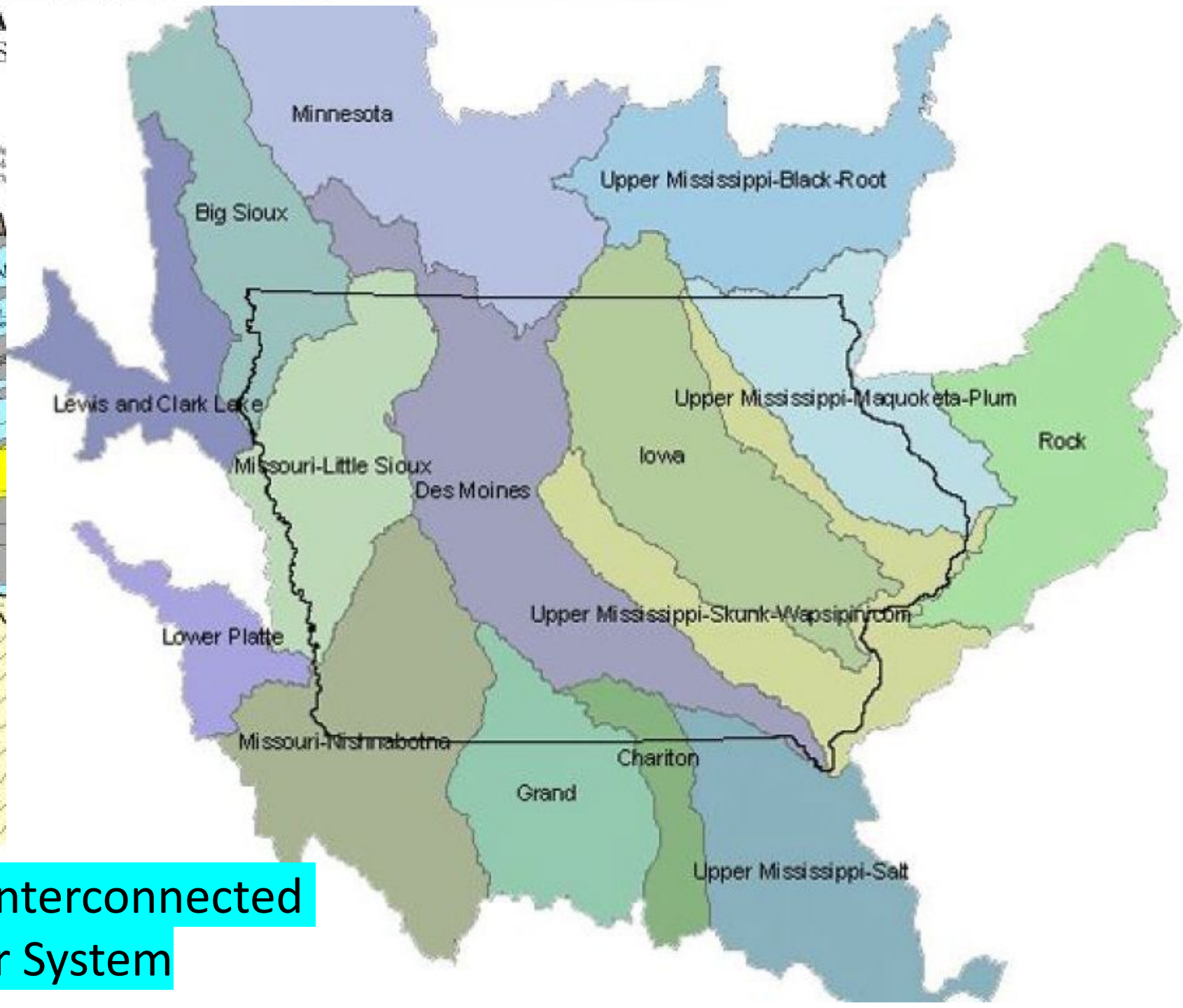
Water: How Do We Use It and Affect Its Quality?

Keywords

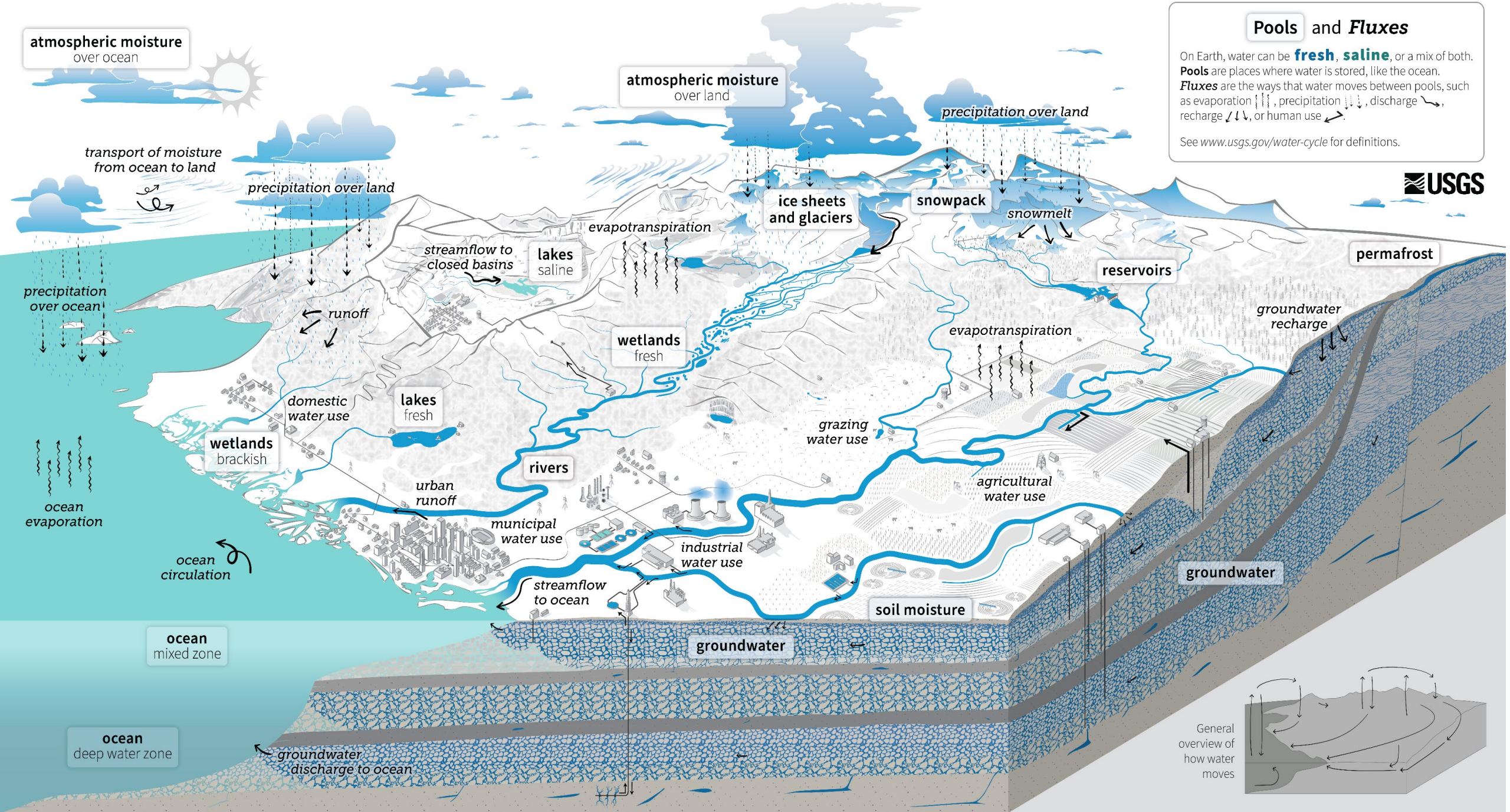
albedo, aquifer, evapotranspiration, lentic & lotic ecosystems, porosity, permeability, leachate, point source, non-point source, recharge, residence time, subsidence, water mining, wetland

SUSTAINABLE DEVELOPMENT GOALS





One Interconnected Water System

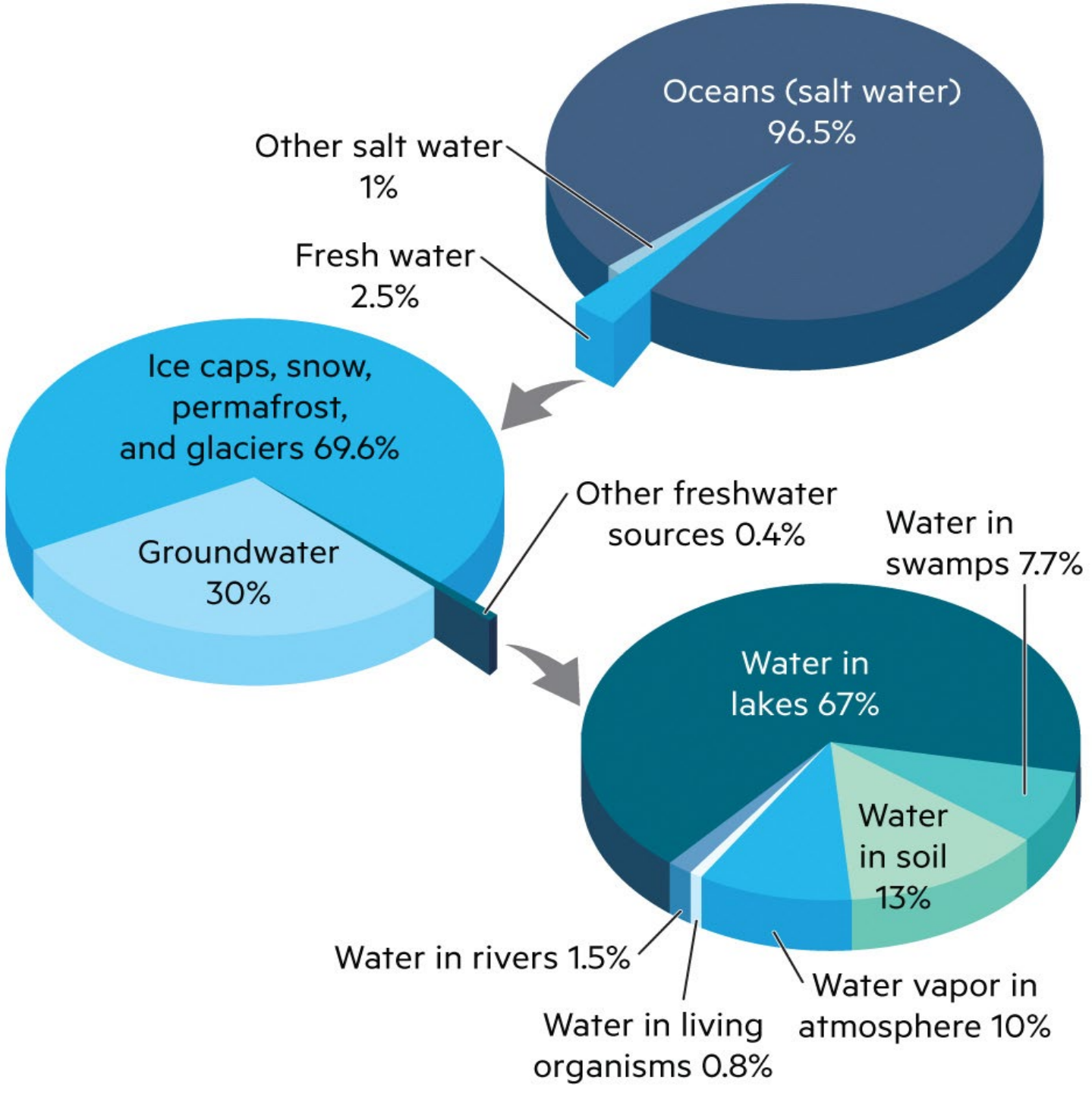

atmospheric moisture
over ocean
atmospheric moisture
over land
transport of moisture
from ocean to land
precipitation over land
precipitation over land
ice sheets
and glaciers
snowpack
snowmelt
permafrost
reservoirs
evapotranspiration
streamflow to
closed basins
lakes
saline
precipitation
over ocean
runoff
wetlands
fresh
groundwater
recharge
evapotranspiration
domestic
water use
lakes
fresh
wetlands
brackish
grazing
water use
rivers
urban
runoff
agricultural
water use
ocean
evaporation
municipal
water use
industrial
water use
ocean
circulation
streamflow
to ocean
groundwater
soil moisture
ocean
mixed zone
groundwater
ocean
deep water zone
groundwater
discharge to ocean
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 for definitions.
USGS
General
overview of
how water
moves

After this week, you should be able to…

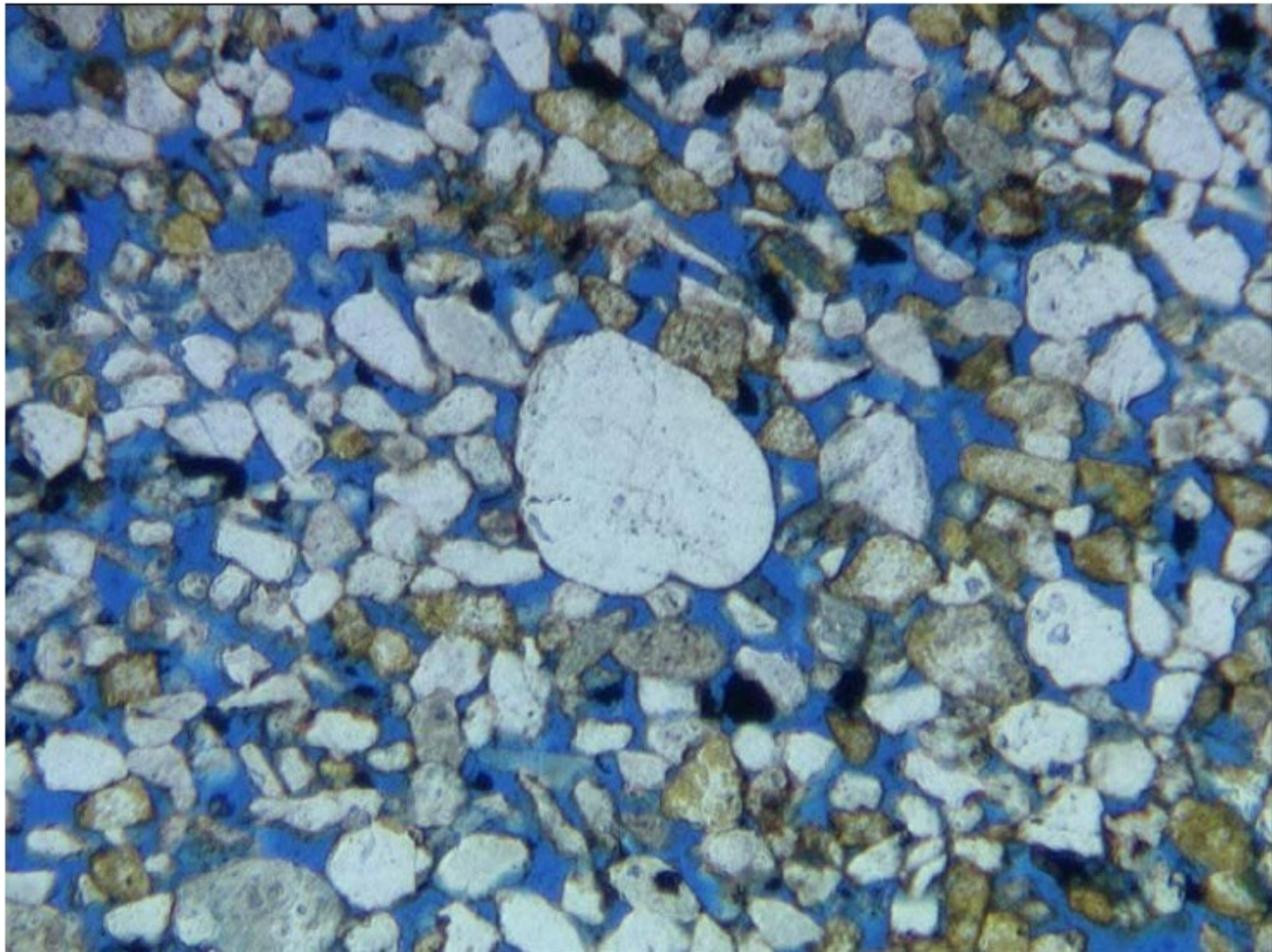
- Describe how rock affects the flow of water
- Know the aquifer types
- Discuss how surface water is connected to groundwater
- Identify major sources of contamination
- Construct a water cycle

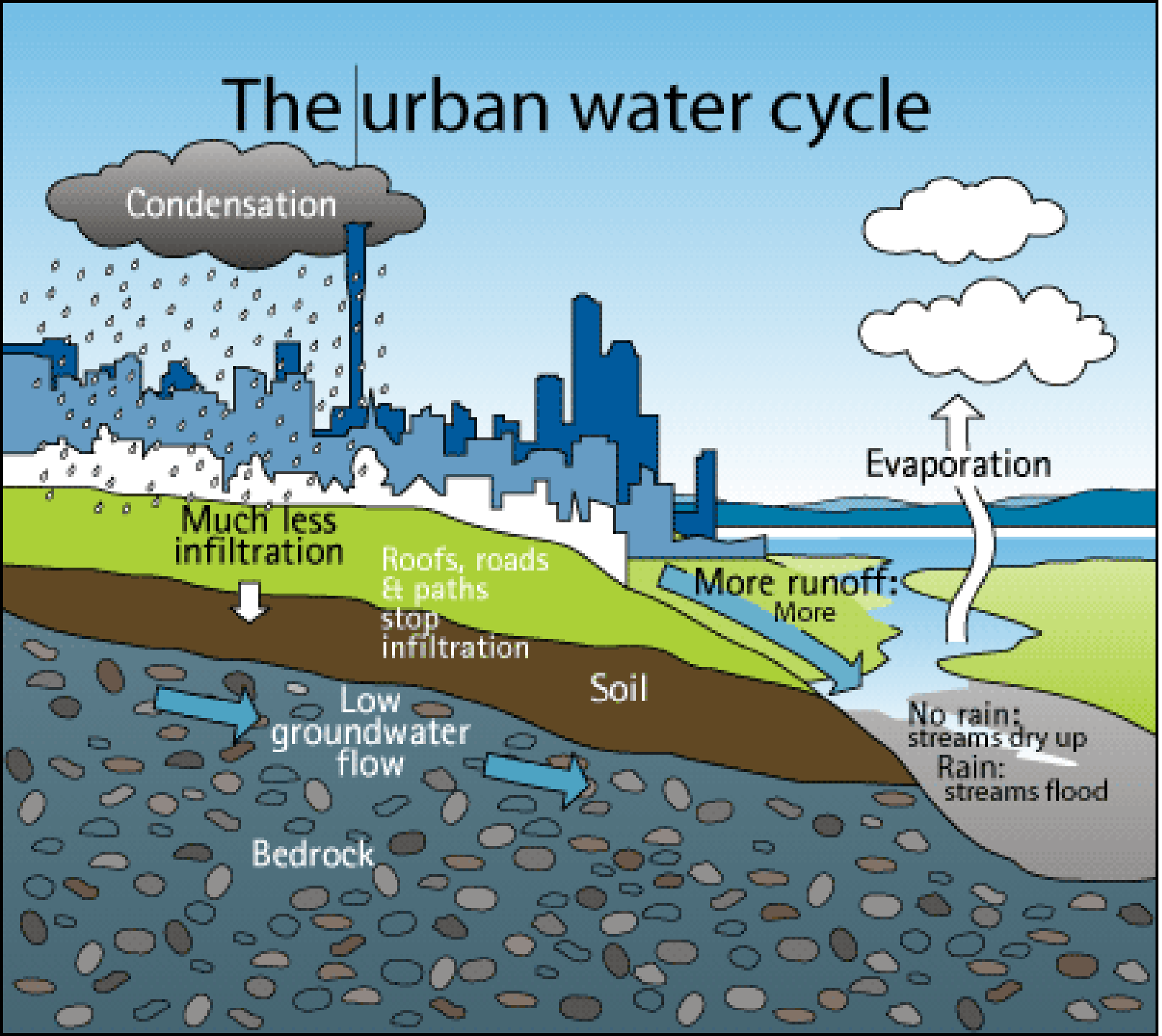
Water

- 4 properties – p. 70-71
- Fresh vs Salt
  - Total Dissolved Solids (TDS)
- Porosity
- Permeability



Crystalline rocks vs Sedimentary clastic





Natural vs Urban settings

Runoff vs Infiltration

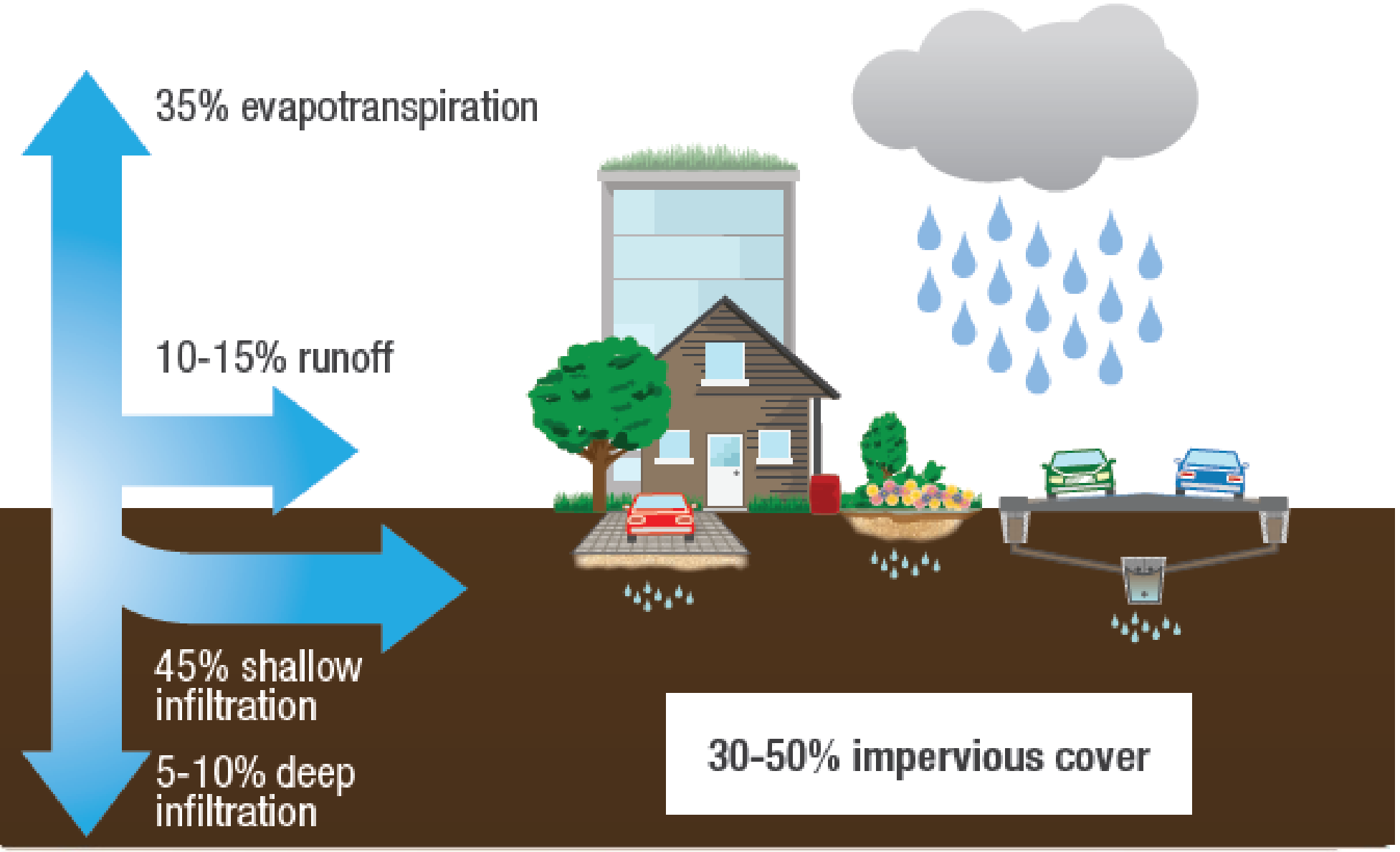
Aquifers

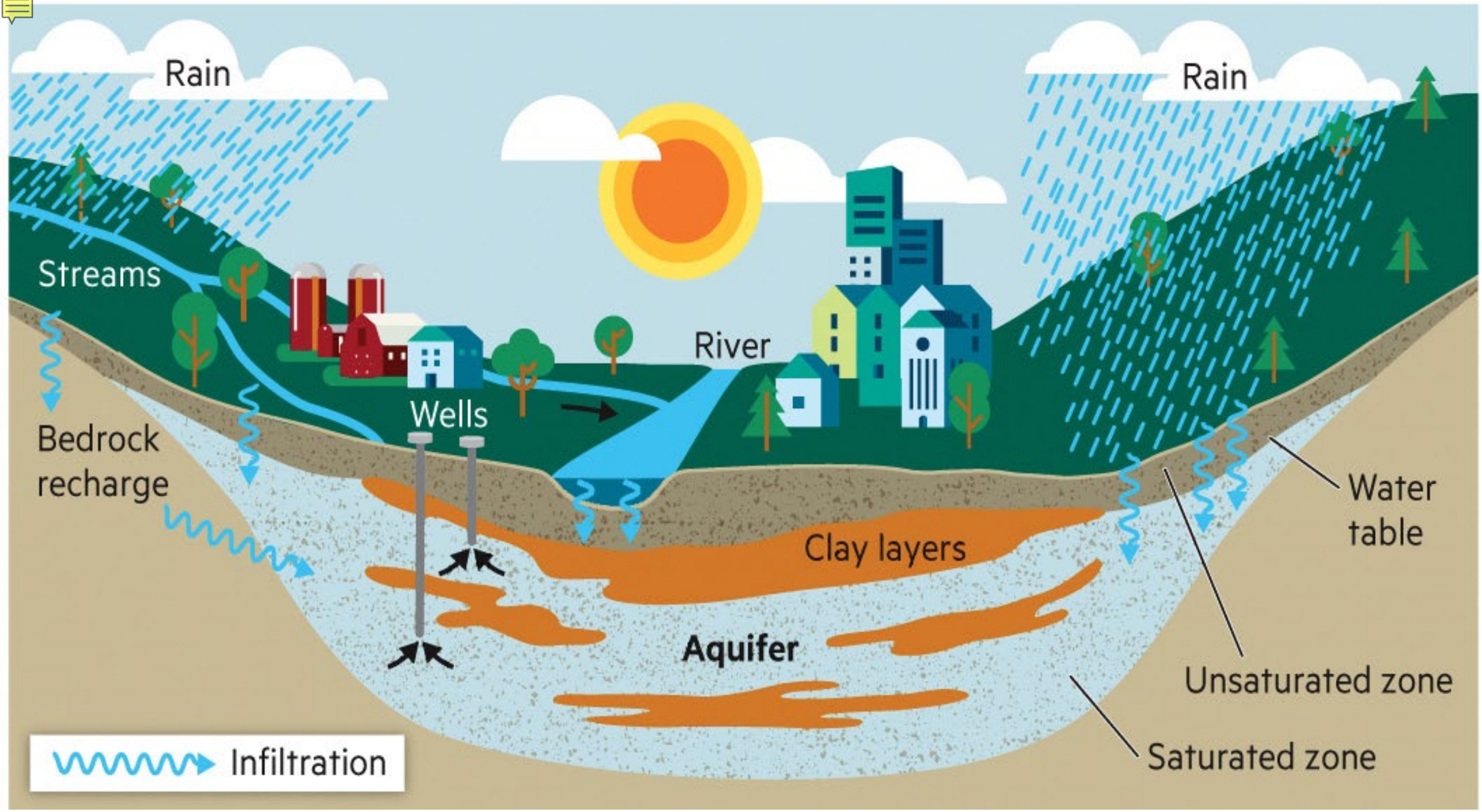
Gradients and gravity

Urban Hydrology

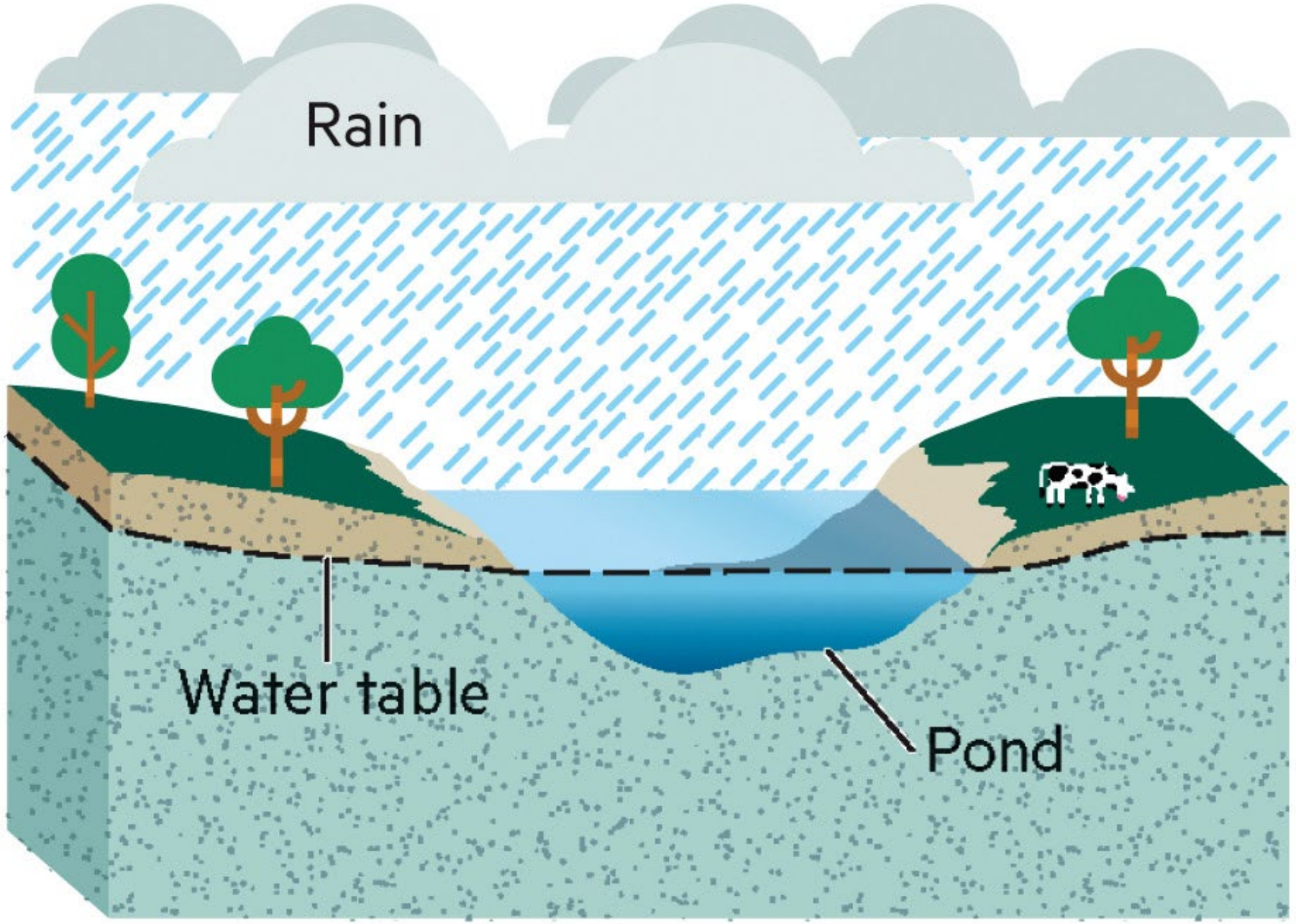
Development with Low Impact Development

https://wiki.sustainabletechnologies.ca/wiki/Urbanization



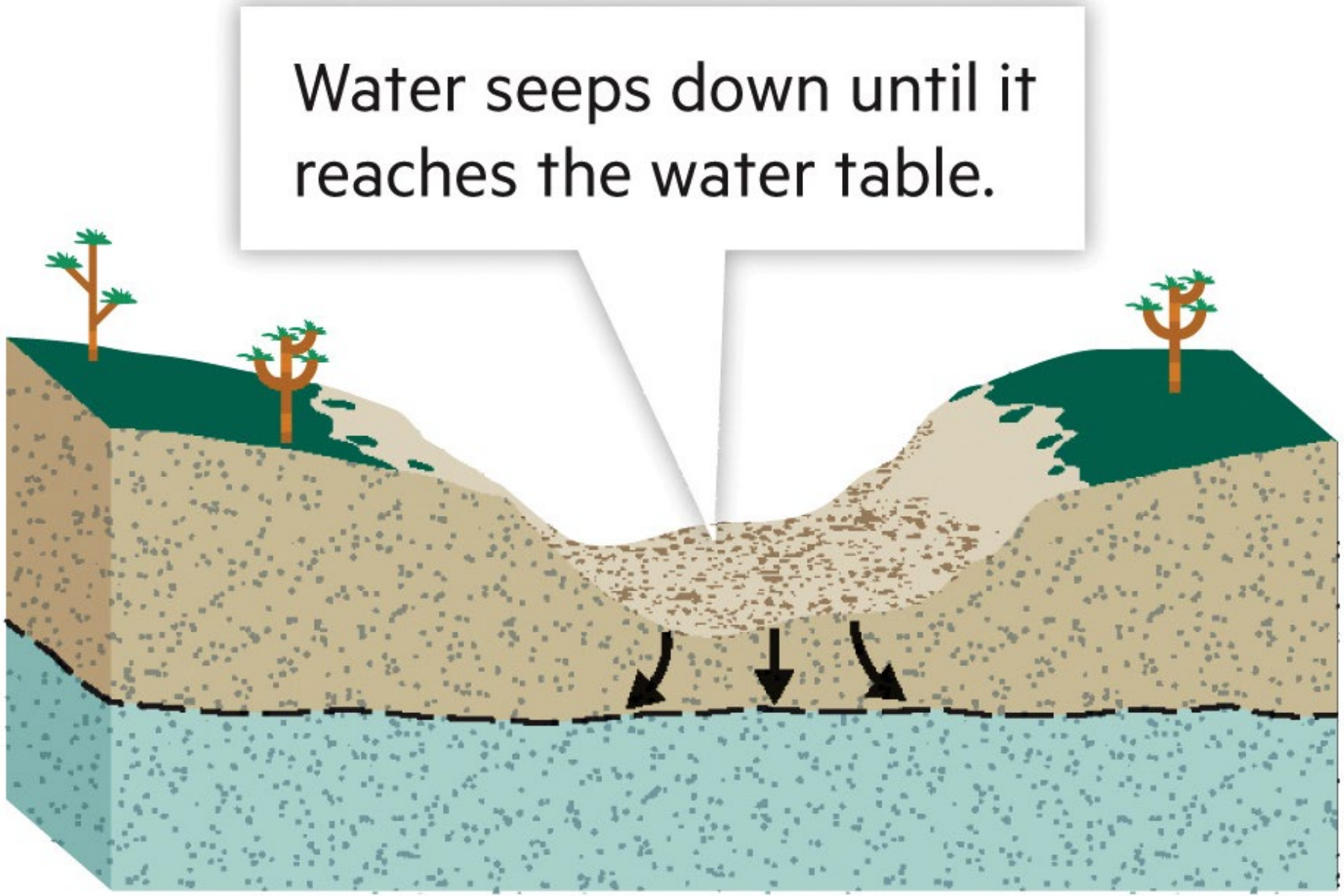

Rain
Rain
Streams
River
Wells
Bedrock recharge
Clay layers
Aquifer
Water table
Unsaturated zone
Saturated zone
Infiltration

Effluent



Adapted from Marshak and Rauber (2017)

Influent

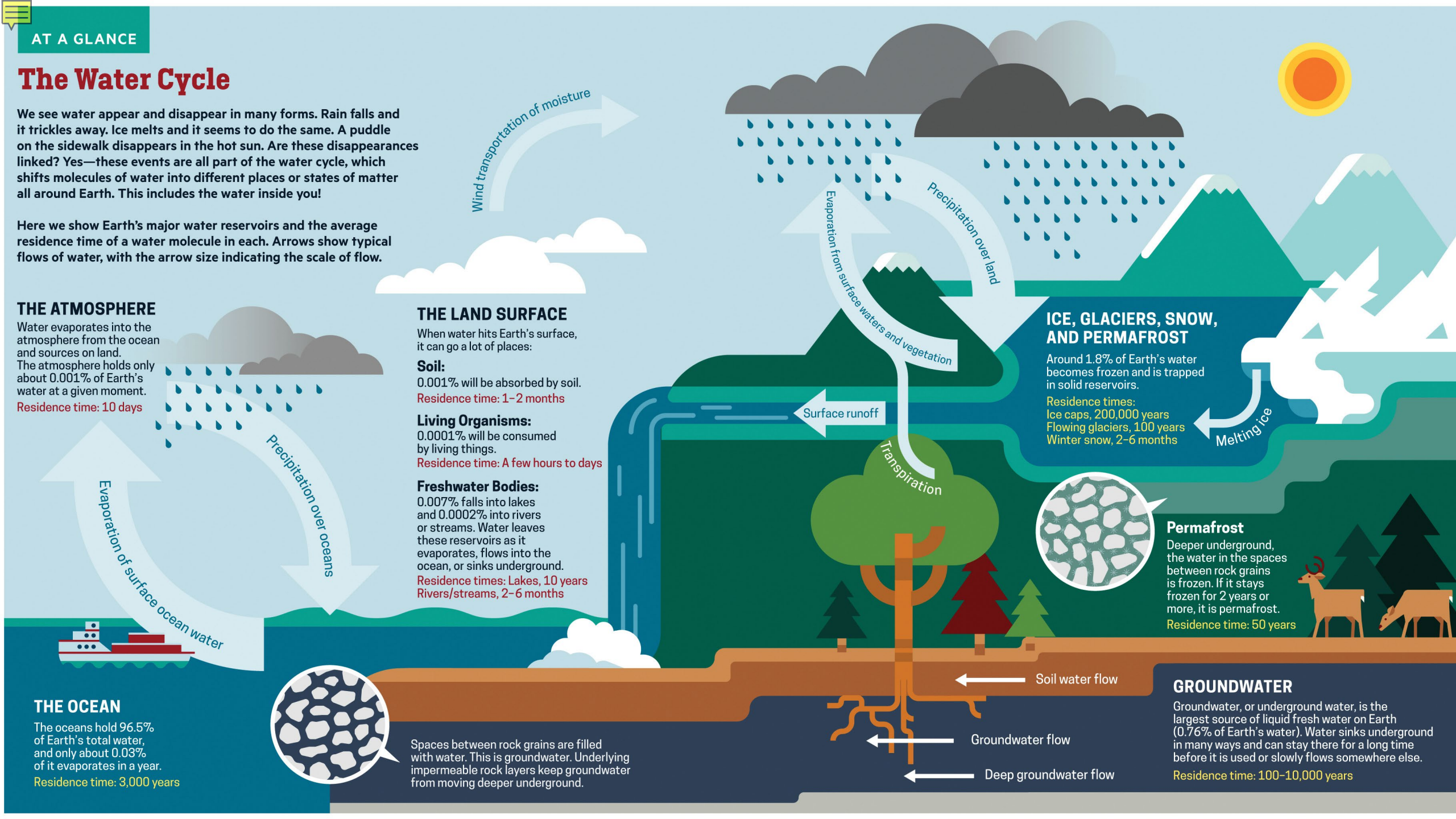


AT A GLANCE

The Water Cycle

We see water appear and disappear in many forms. Rain falls and it trickles away. Ice melts and it seems to do the same. A puddle on the sidewalk disappears in the hot sun. Are these disappearances linked? Yes—these events are all part of the water cycle, which shifts molecules of water into different places or states of matter all around Earth. This includes the water inside you!

Here we show Earth's major water reservoirs and the average residence time of a water molecule in each. Arrows show typical flows of water, with the arrow size indicating the scale of flow.



THE ATMOSPHERE

Water evaporates into the atmosphere from the ocean and sources on land. The atmosphere holds only about 0.001% of Earth's water at a given moment.

Residence time: 10 days

THE LAND SURFACE

When water hits Earth's surface, it can go a lot of places:

Soil:
0.001% will be absorbed by soil.
Residence time: 1–2 months

Living Organisms:
0.0001% will be consumed by living things.
Residence time: A few hours to days

Freshwater Bodies:
0.007% falls into lakes and 0.0002% into rivers or streams. Water leaves these reservoirs as it evaporates, flows into the ocean, or sinks underground.
Residence times: Lakes, 10 years
Rivers/streams, 2–6 months

ICE, GLACIERS, SNOW, AND PERMAFROST

Around 1.8% of Earth's water becomes frozen and is trapped in solid reservoirs.

Residence times:
Ice caps, 200,000 years
Flowing glaciers, 100 years
Winter snow, 2–6 months

Permafrost

Deeper underground, the water in the spaces between rock grains is frozen. If it stays frozen for 2 years or more, it is permafrost.

Residence time: 50 years

THE OCEAN

The oceans hold 96.5% of Earth's total water, and only about 0.03% of it evaporates in a year.

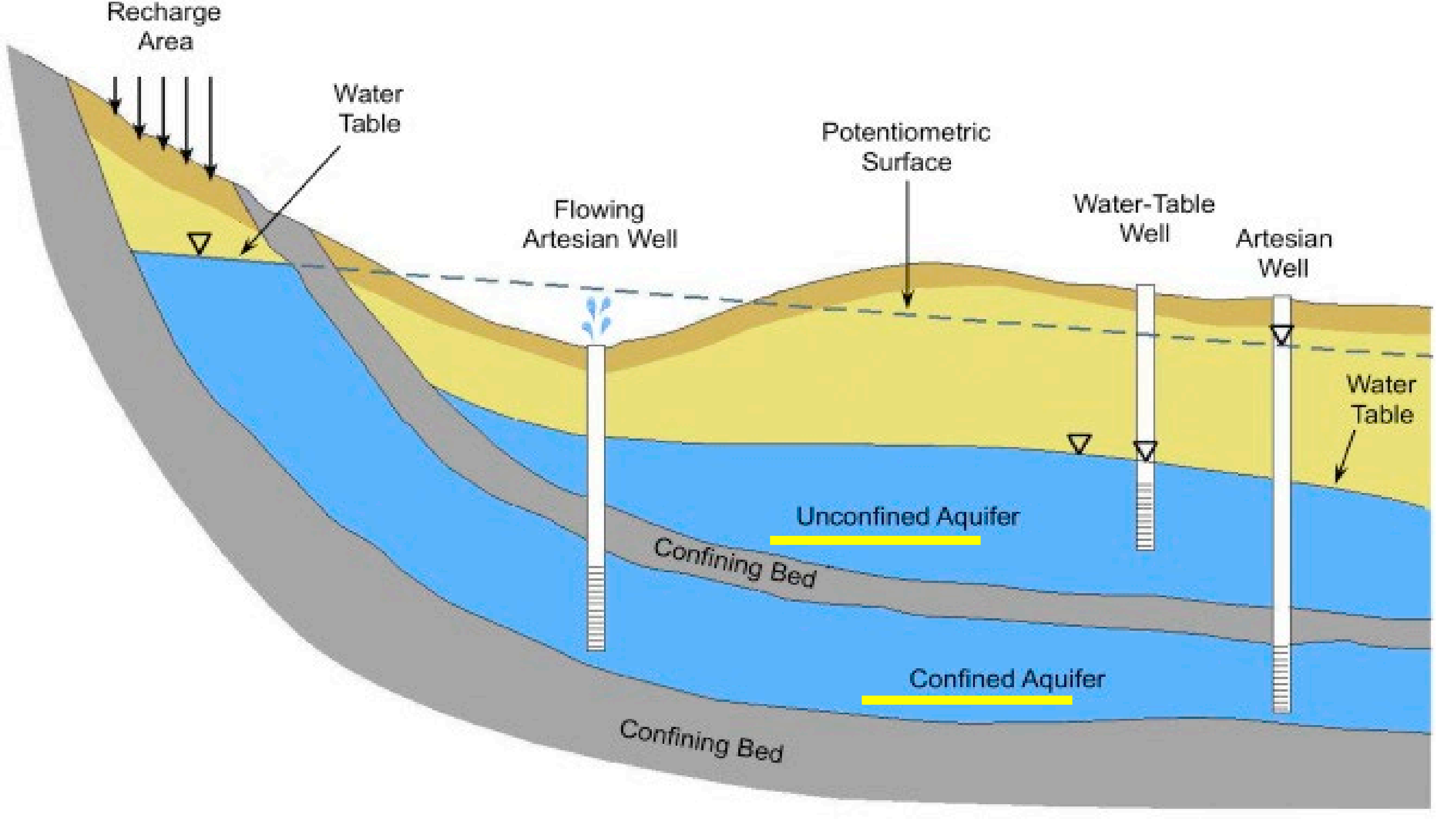
Residence time: 3,000 years

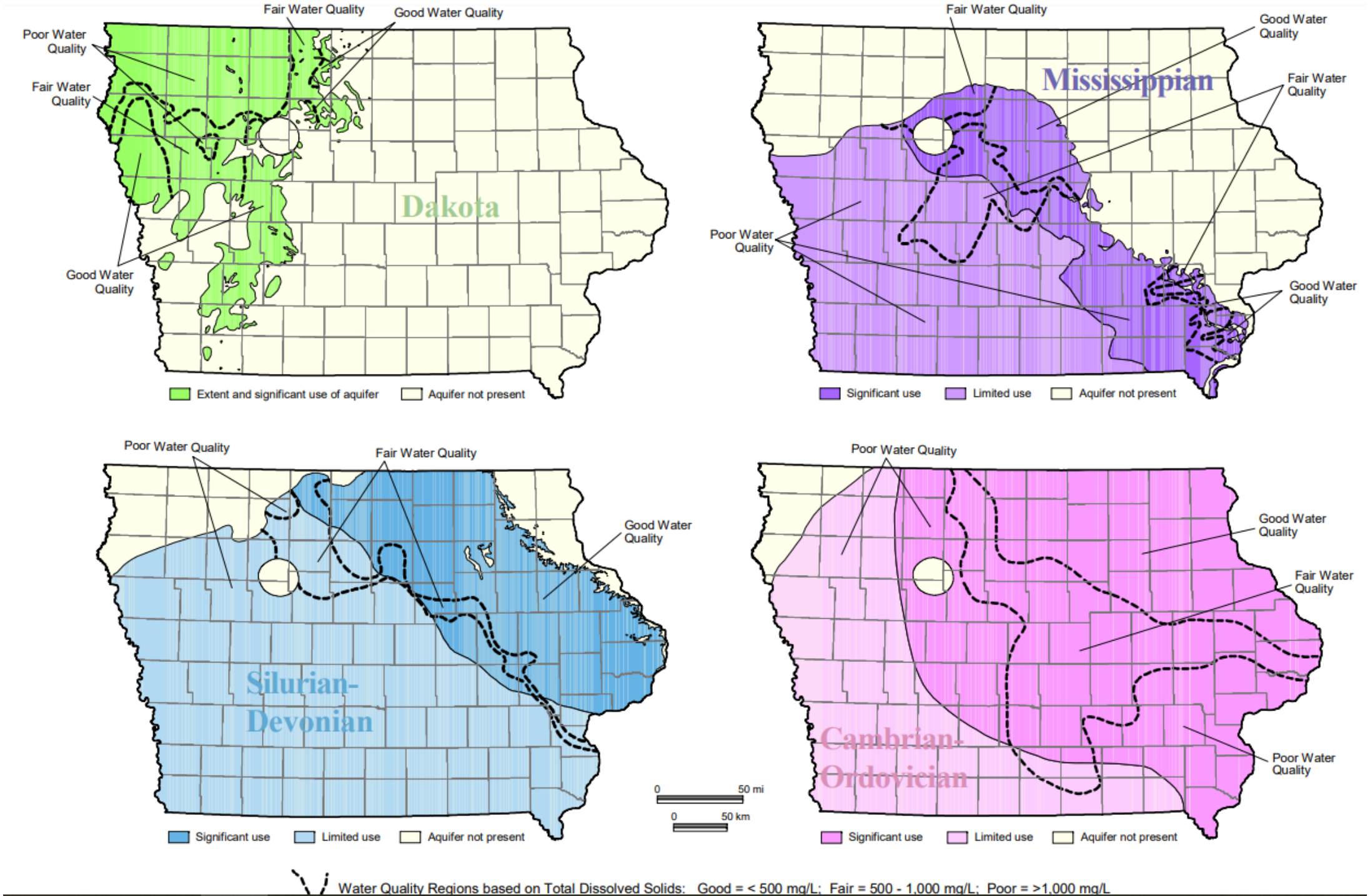
Spaces between rock grains are filled with water. This is groundwater. Underlying impermeable rock layers keep groundwater from moving deeper underground.

GROUNDWATER

Groundwater, or underground water, is the largest source of liquid fresh water on Earth (0.76% of Earth's water). Water sinks underground in many ways and can stay there for a long time before it is used or slowly flows somewhere else.

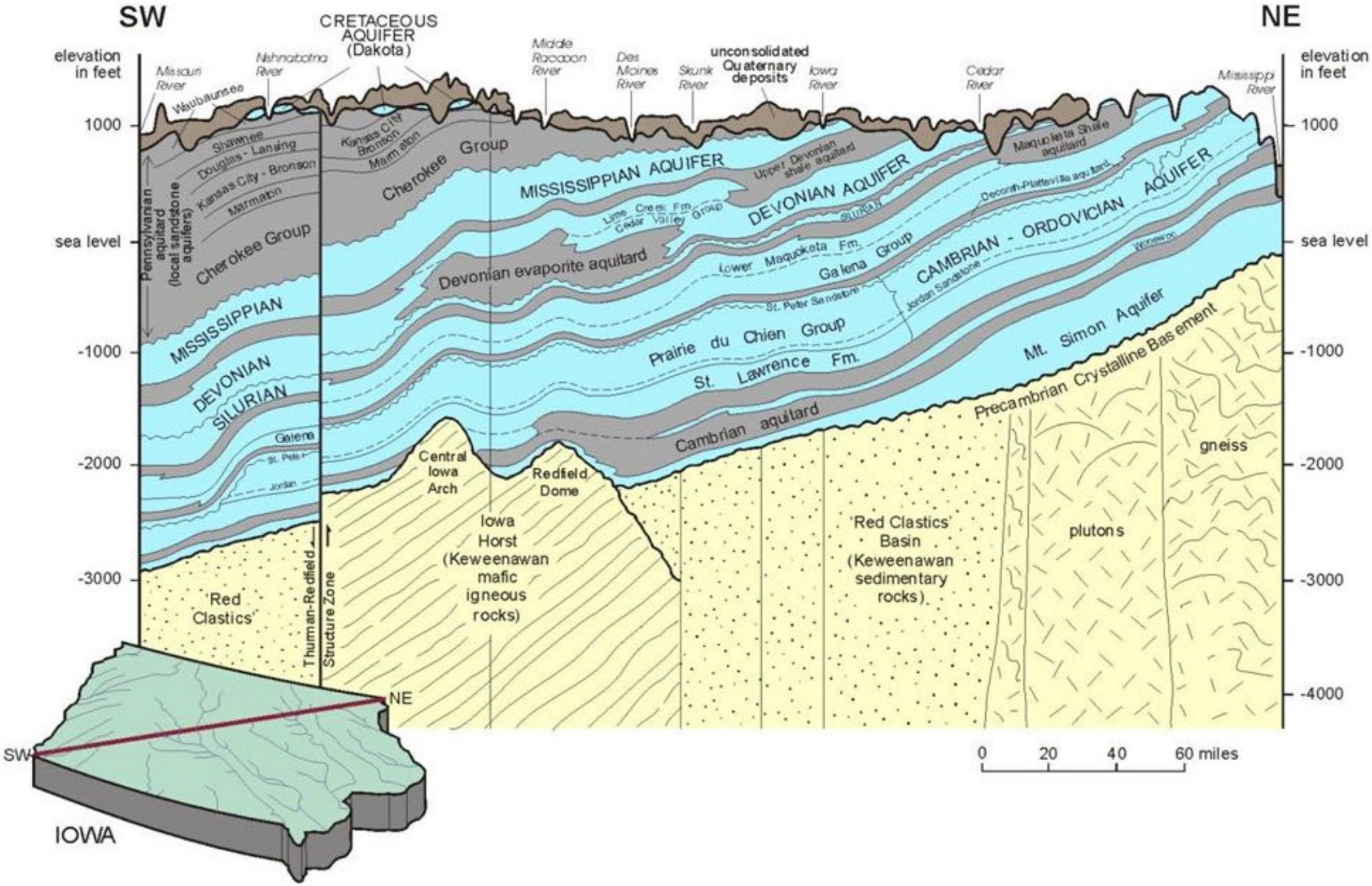
Residence time: 100–10,000 years


Recharge Area
Water Table
Flowing Artesian Well
Potentiometric Surface
Water-Table Well
Artesian Well
Water Table
Unconfined Aquifer
Confining Bed
Confined Aquifer
Confining Bed

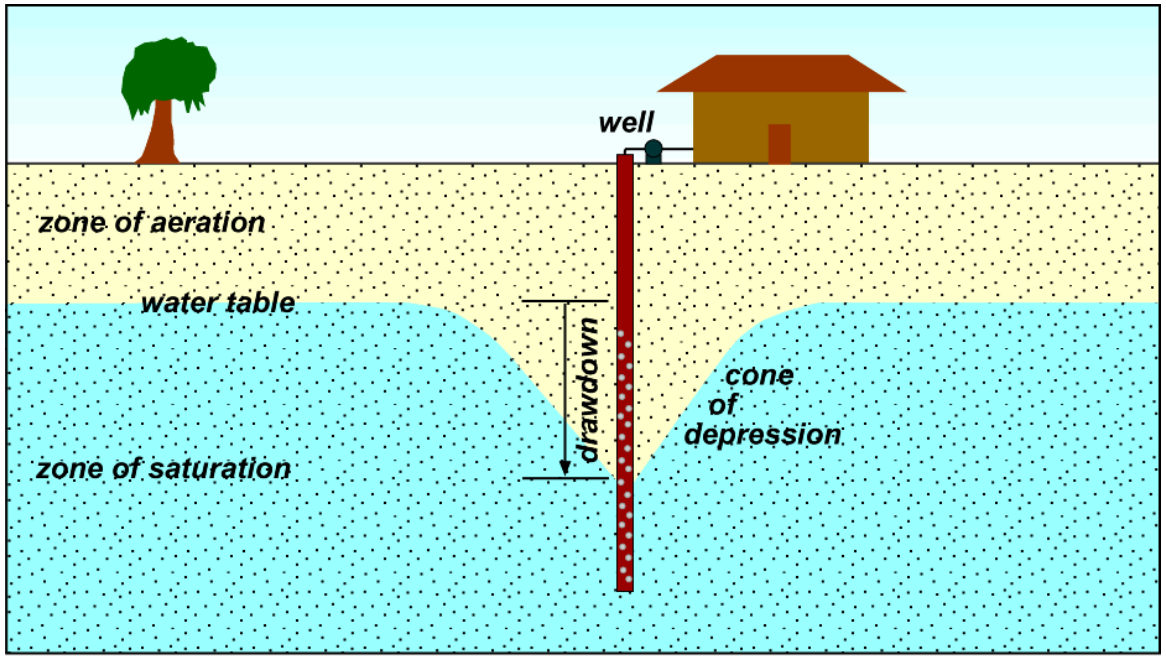

Fair Water Quality
Good Water Quality
Poor Water Quality
Fair Water Quality
Dakota
Good Water Quality
Extent and significant use of aquifer
Aquifer not present
Fair Water Quality
Good Water Quality
Mississippian
Fair Water Quality
Poor Water Quality
Good Water Quality
Significant use
Limited use
Aquifer not present
Poor Water Quality
Fair Water Quality
Good Water Quality
Silurian-
Devonian
Significant use
Limited use
Aquifer not present
0
50 mi
0
50 km
Poor Water Quality
Good Water Quality
Fair Water Quality
Cambrian-
Ordovician
Poor Water Quality
Significant use
Limited use
Aquifer not present
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

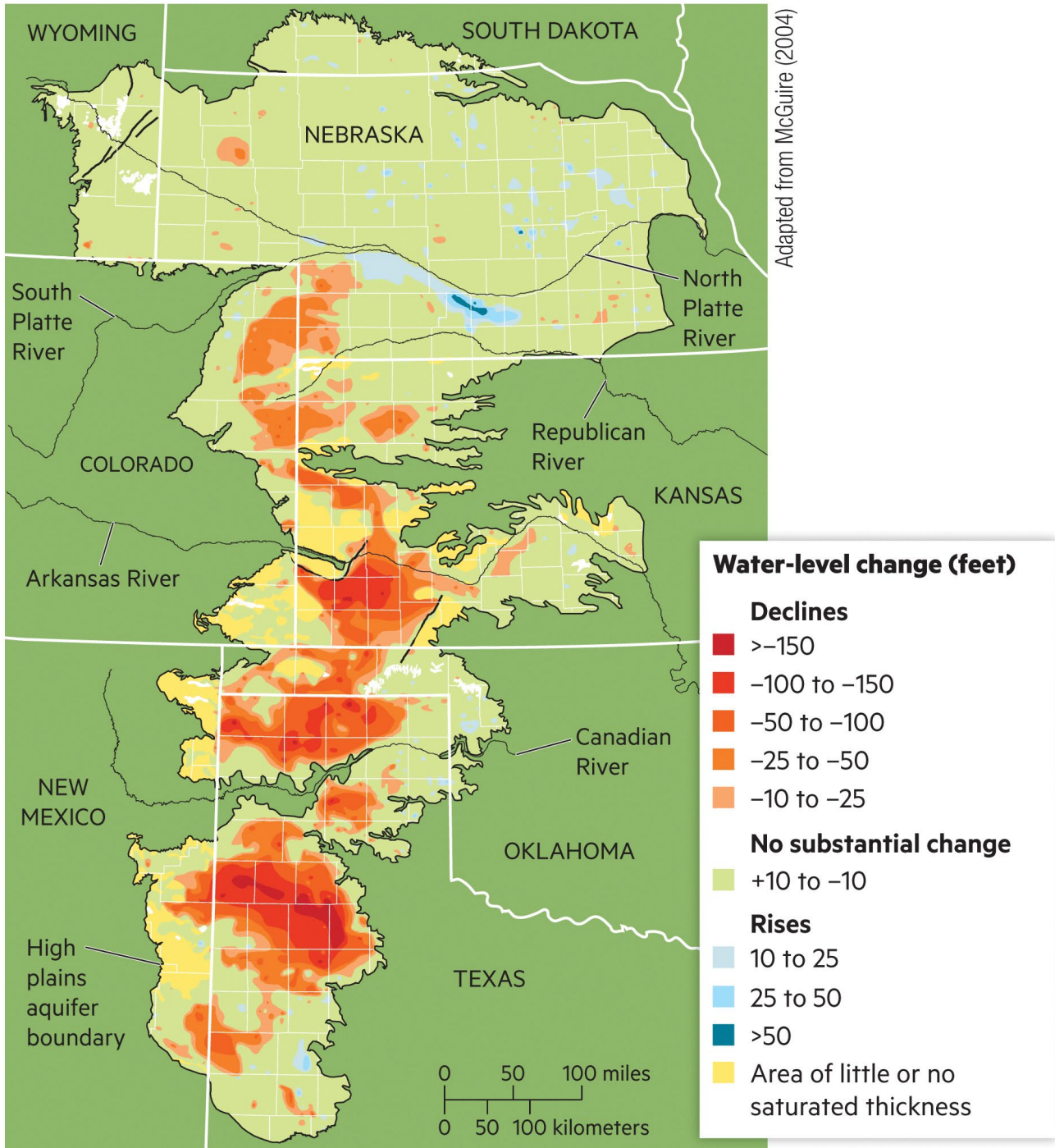


Ogallala Aquifer – Unconfined

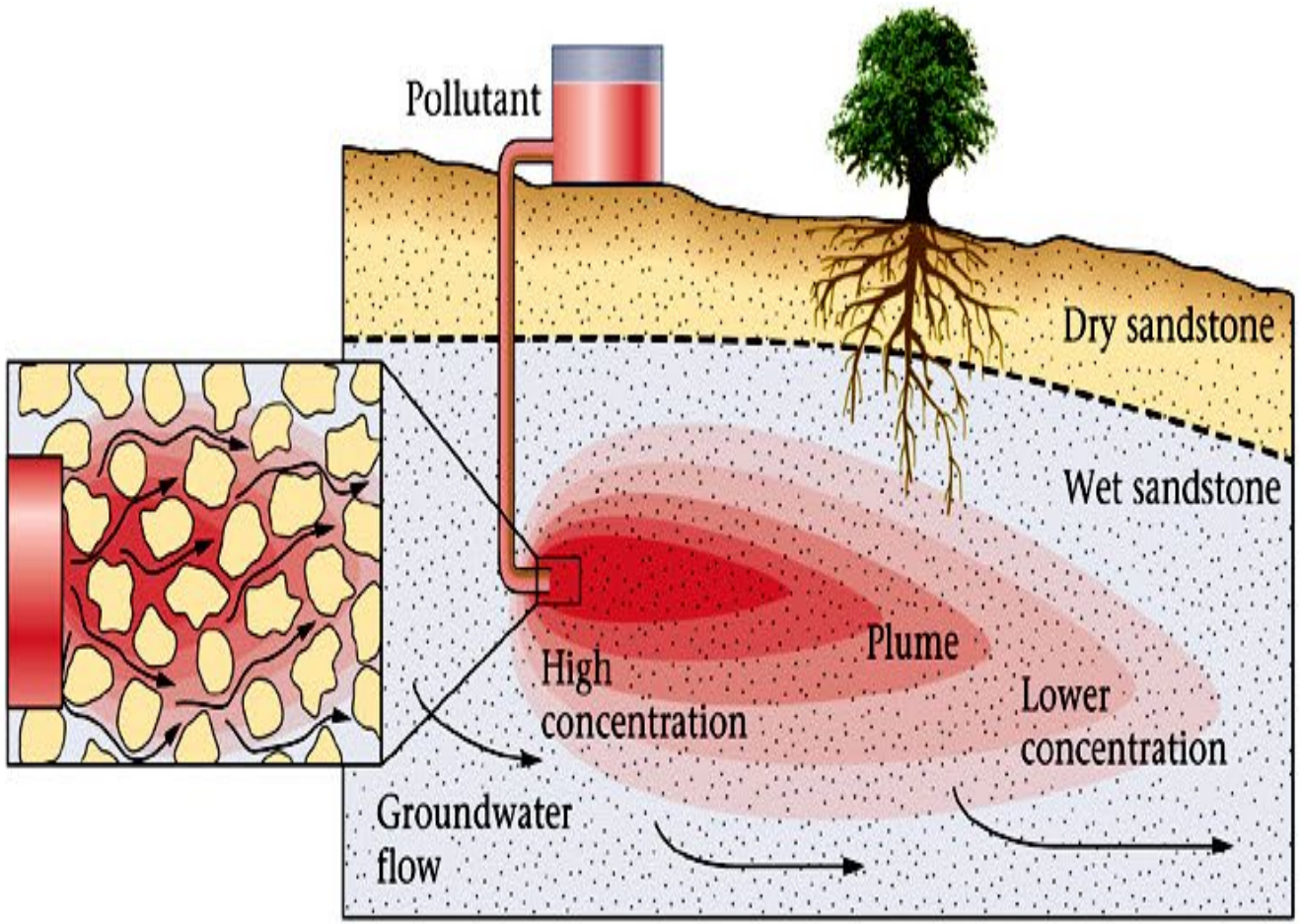


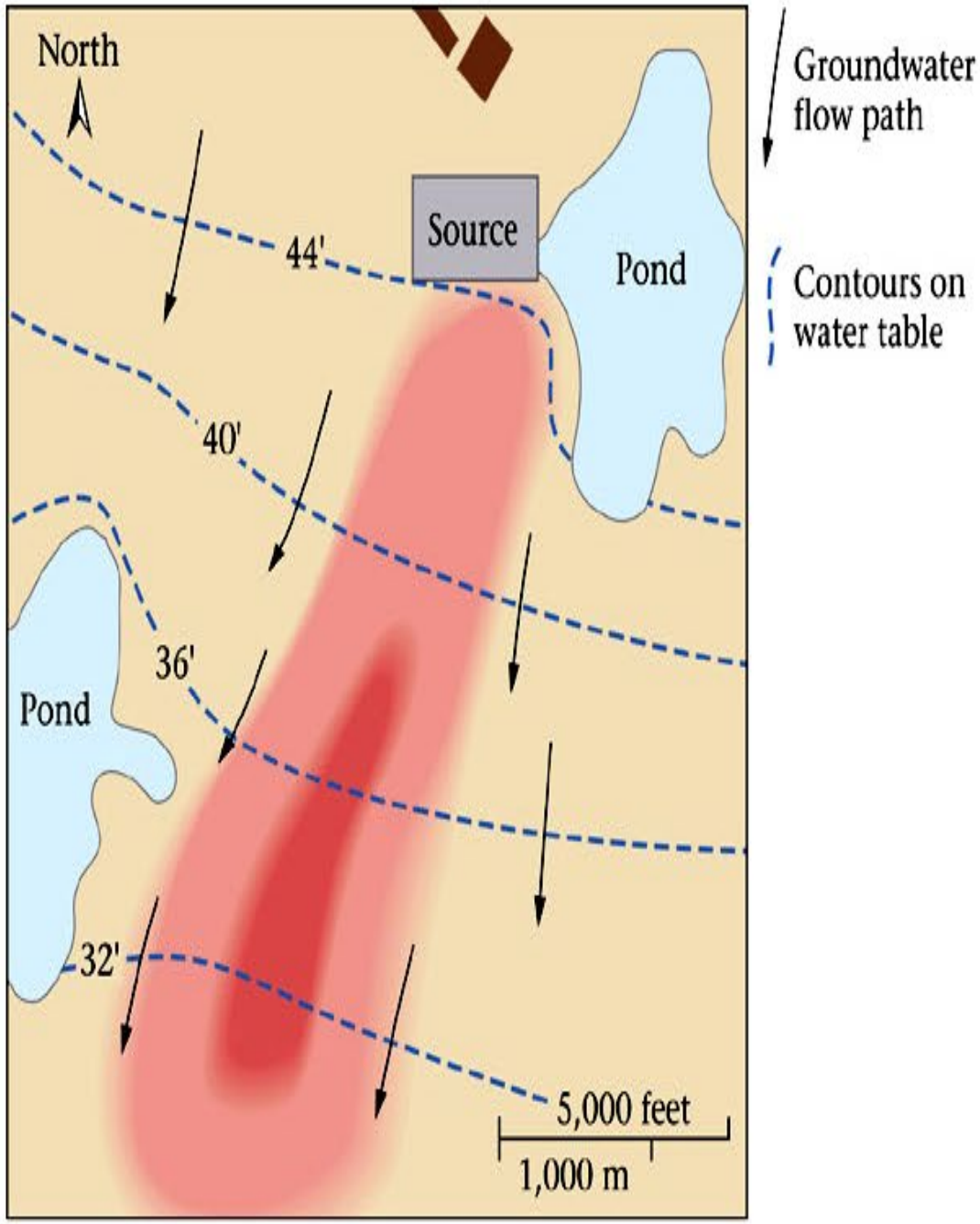
Cone of Depression

Water mining



Contaminant Plume





Streams and Rivers

Rivers and streams form as water flowing downhill collects along a common path.

Along smaller streams, trees shade sunlight, keeping water cool. Dead organic matter is eaten and broken down by insect larvae.

The gradient is steep in this region, and riffles, rapids, and waterfalls are common.

The gradient decreases, the flow deepens, and fallen woody debris forms pools and sediment accumulates.

As the gradient of the stream decreases, the flow deepens and the stream widens. This allows more sunlight to reach aquatic plants, allowing them to flourish along with a greater diversity of insects and fish.

Wetlands dominated by grasses and cattails are called **marshes**.

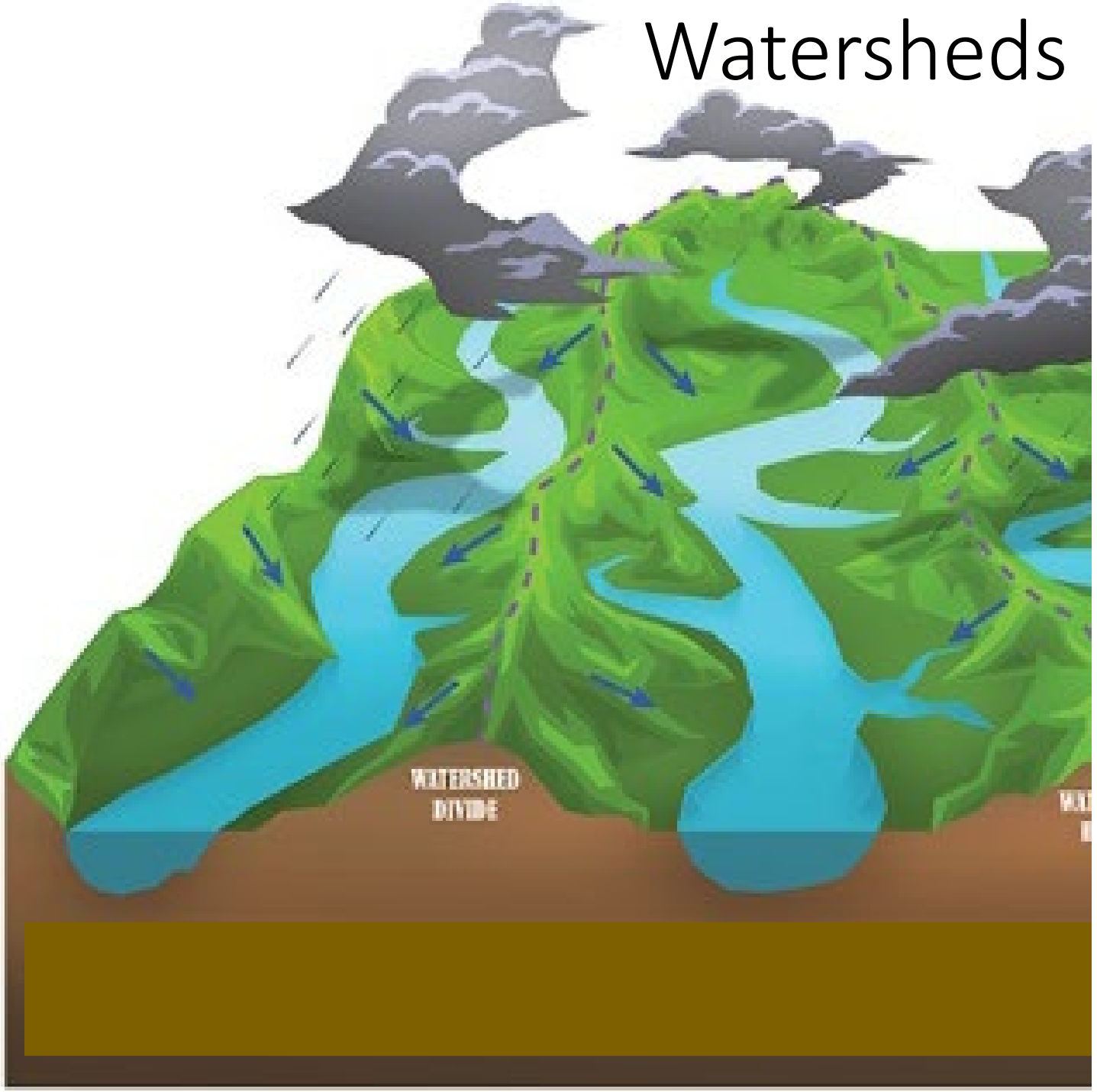
Wetlands that are forested are called **swamps**.

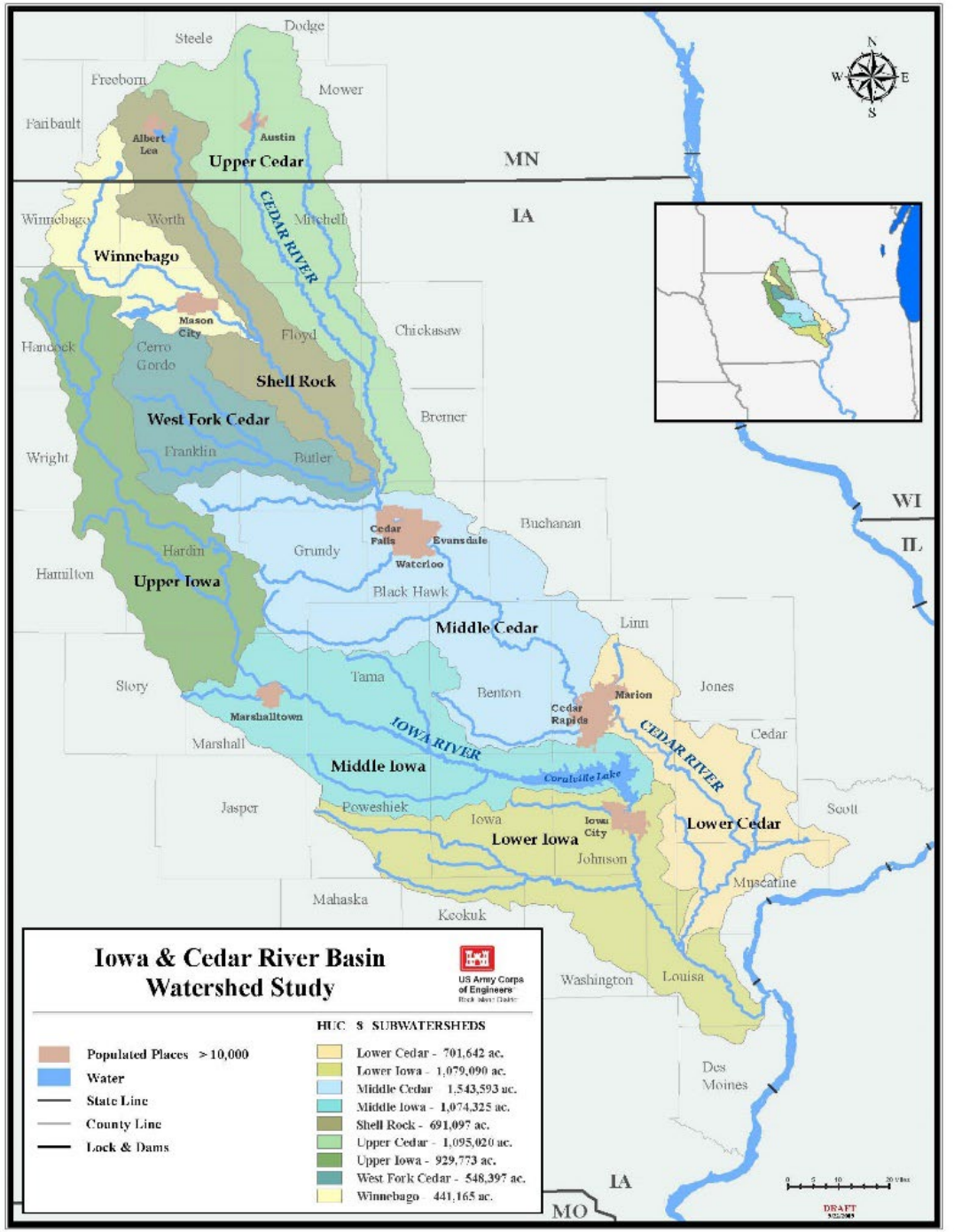
Groundwater-fed **wetlands** where organic matter accumulates faster than it decomposes causes anaerobic conditions.

Estuaries are where fresh water meets salt water. The more dense salt water is on the bottom while less dense fresh water floats on top.

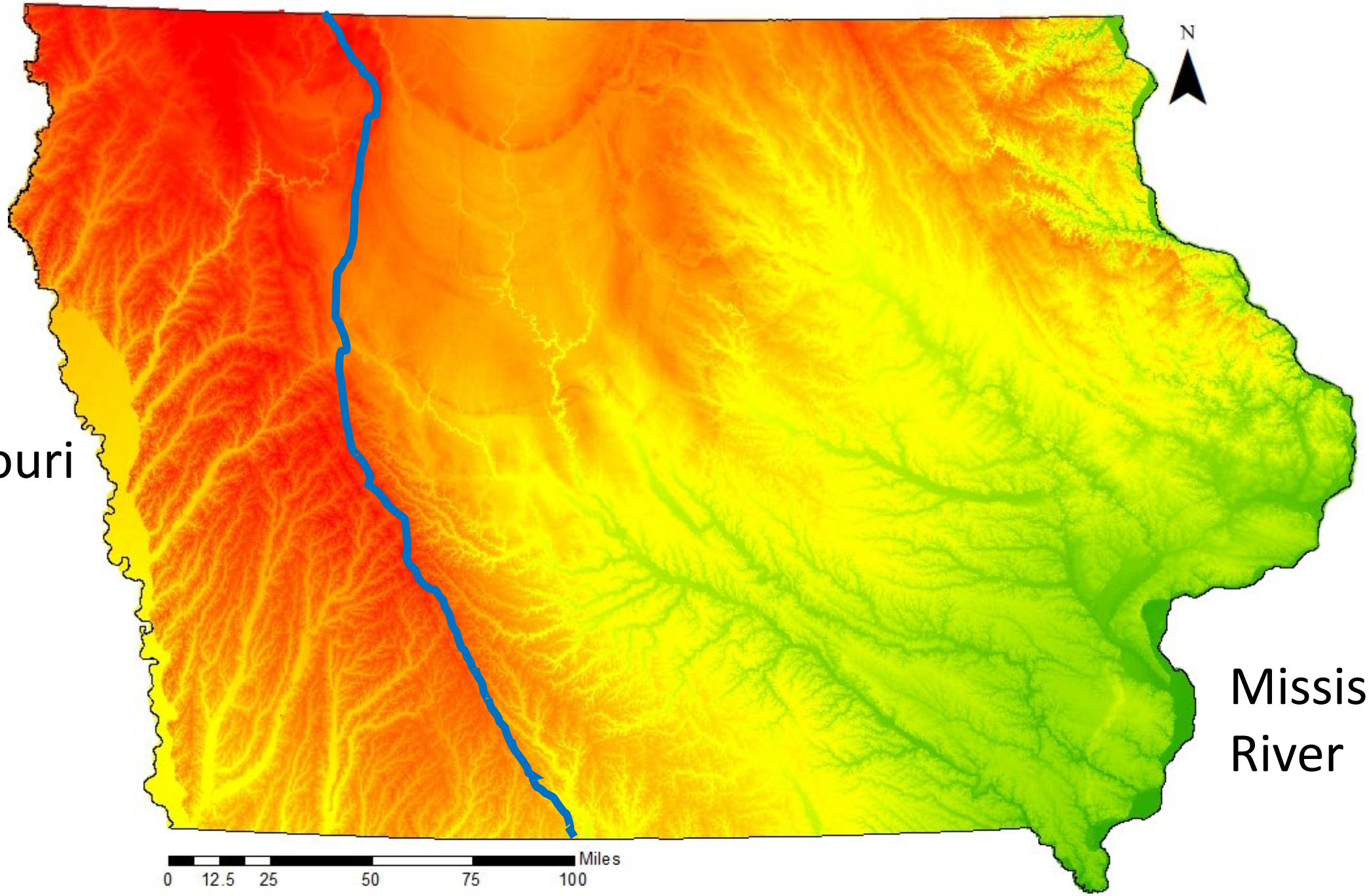
(top left): Sompol/Shutterstock; (top right): Valerii_M/Shutterstock; (center left): Ba8389/Alamy Stock Photo; (center right): Rosanne Tackaberry/Alamy Stock Photo; (bottom left): Martyn Williams/Alamy Stock Photo; (bottom right): Peter Martin Rhind/Alamy Stock Photo

Watersheds


WATERSHED
DIVIDE

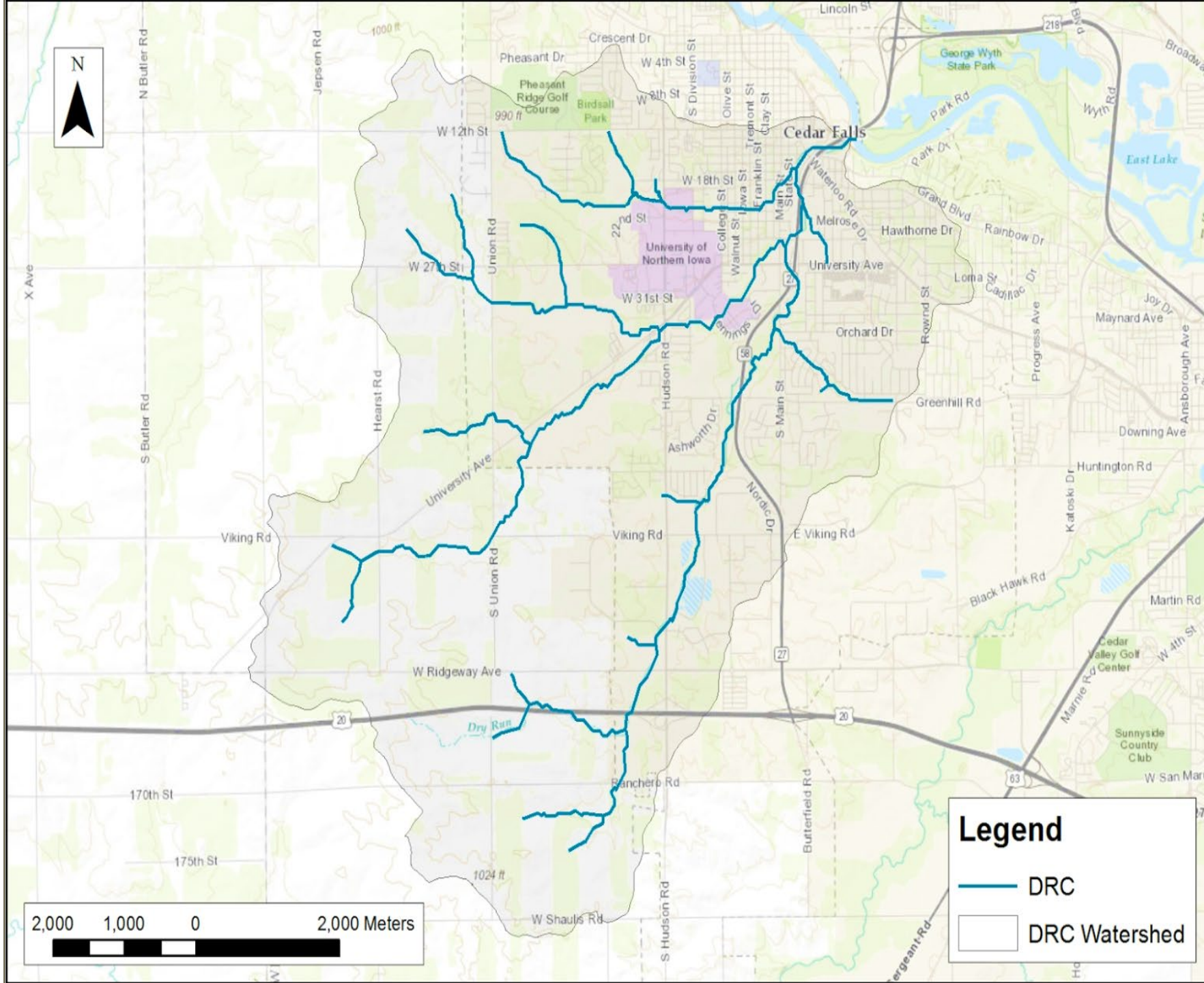

Iowa & Cedar River Basin
Watershed Study
US Army Corps of Engineers
Populated Places >10,000
Water
State Line
County Line
Lock & Dams
HUC 8 SUBWATERSHEDS
Lower Cedar - 701,642 ac.
Lower Iowa - 1,079,090 ac.
Middle Cedar - 1,543,593 ac.
Middle Iowa - 1,074,325 ac.
Shell Rock - 691,097 ac.
Upper Cedar - 1,095,020 ac.
Upper Iowa - 929,773 ac.
West Fork Cedar - 548,397 ac.
Winnebago - 441,165 ac.
Upper Cedar
Shell Rock
West Fork Cedar
Winnebago
Upper Iowa
Middle Cedar
Middle Iowa
Lower Iowa
Lower Cedar
CEDAR RIVER
IOWA RIVER
Albert Lea
Austin
Mason City
Cedar Falls
Evansdale
Waterloo
Marshalltown
Cedar Rapids
Marion
Iowa City
Coralville Lake
MN
IA
WI
IL
MO
Dodge
Steele
Freeborn
Mower
Faribault
Winnebago
Worth
Mitchell
Hancock
Cerro Gordo
Floyd
Chickasaw
Wright
Franklin
Butler
Bremer
Hardin
Grundy
Buchanan
Hamilton
Black Hawk
Linn
Story
Tama
Benton
Jones
Marshall
Jasper
Poweshiek
Iowa
Johnson
Cedar
Scott
Muscatine
Mahaska
Keokuk
Washington
Louisa
Des Moines
DRAFT

Water Resource Regions


N
Missouri River
Mississippi River
Miles
0 12.5 25 50 75 100

Dry Run Creek

- 15,177 acres
- Four main branches
- 30 miles total
  - 14 urban
  - 16 rural
- Max. Relief = 150 ft

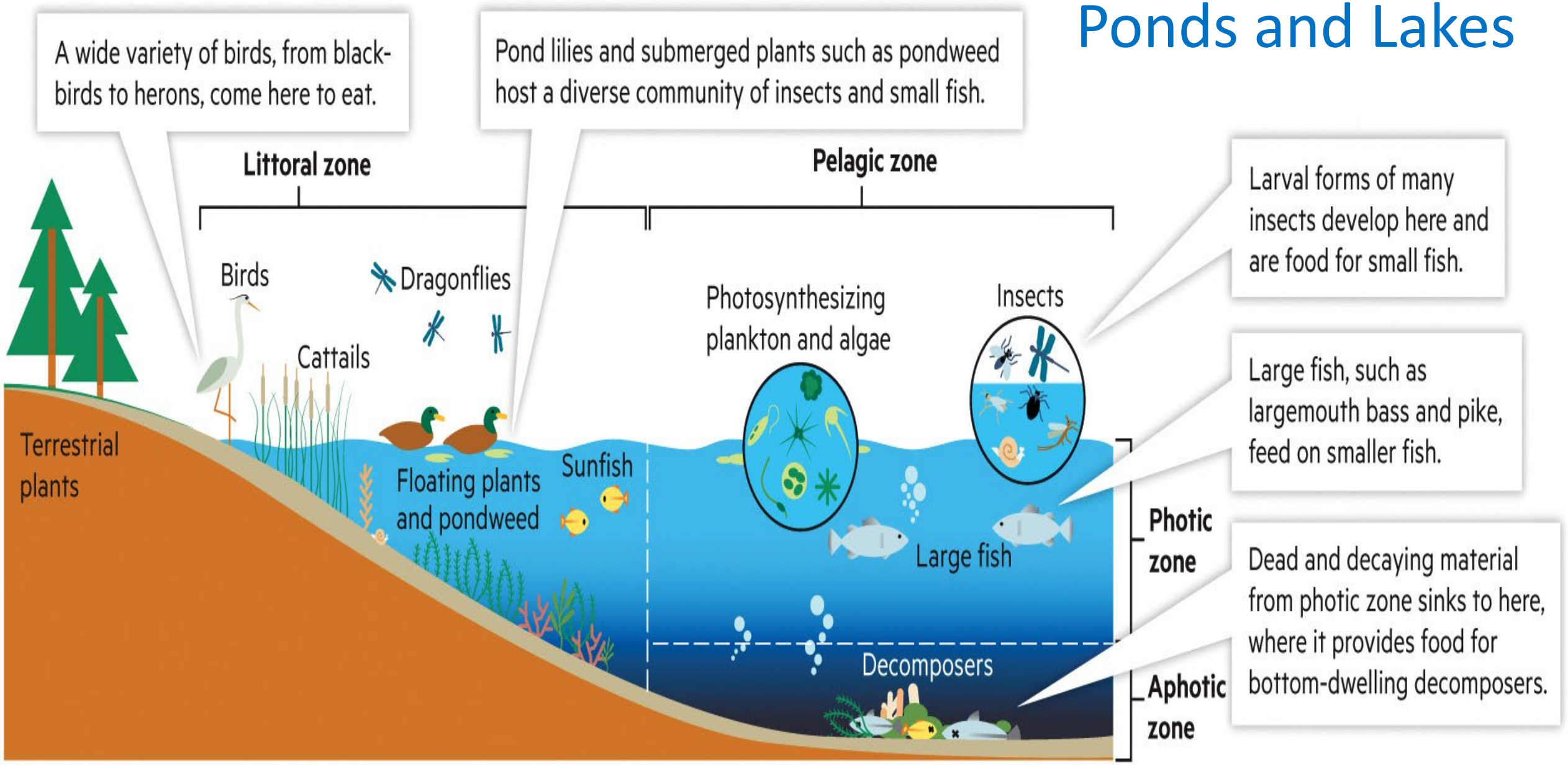


CEDAR FALLS OXBOW WETLAND RESTORATION

- Subwatershed 5
- 2.6 acre drainage area
- 13,950 ft^2 of wetland
- 3 tons of sediment annually
- 4 lbs. of Phosphorus annually
- Construction fall 2018
- $28,843 The Nature Conservancy

Best Management Practices

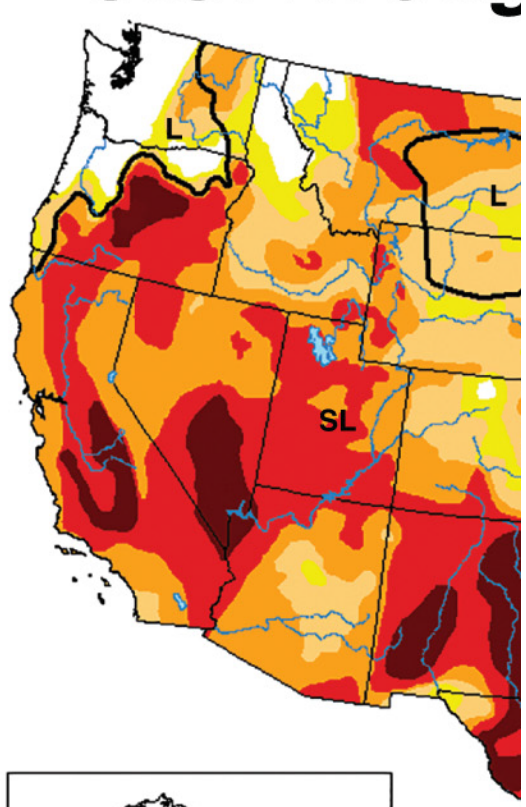
Ponds and Lakes

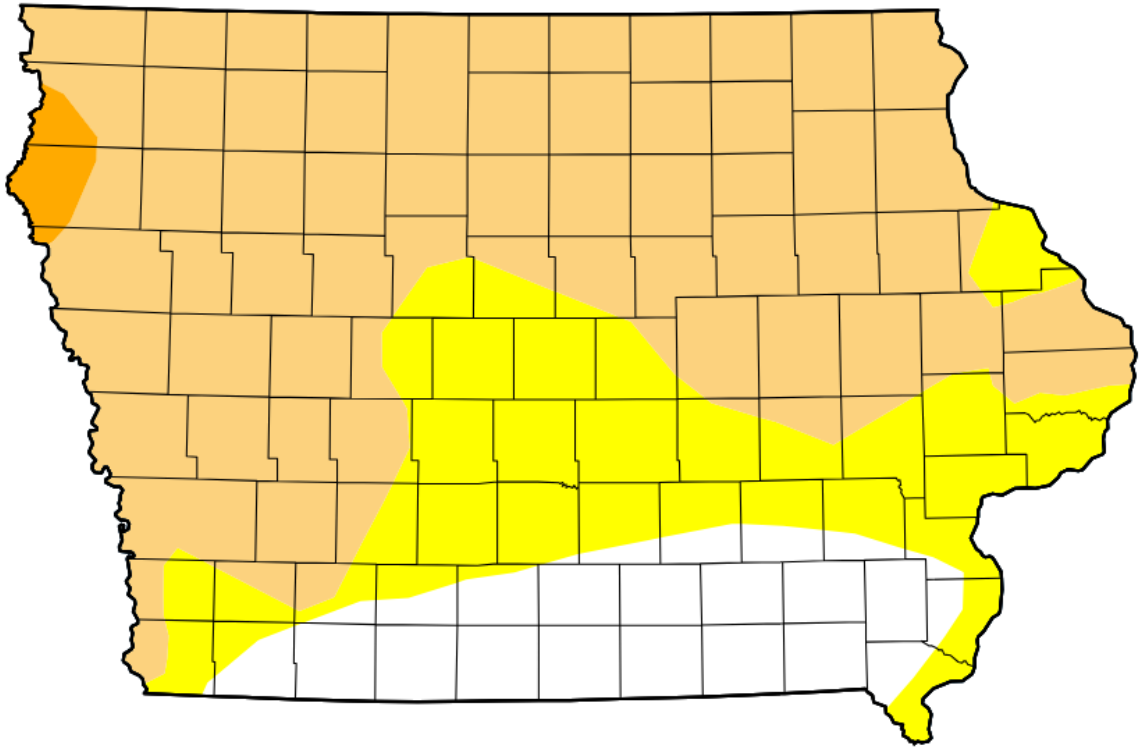


THE DEATH AND LIFE OF THE GREAT LAKES

DAN EGAN

U.S. Droug





Data valid: February 18, 2025 at 7 a.m. EST

Intensity

- None
- D0 (Abnormally Dry)
- D1 (Moderate Drought)
- D2 (Severe Drought)
- D3 (Extreme Drought)
- D4 (Exceptional Drought)
- No Data

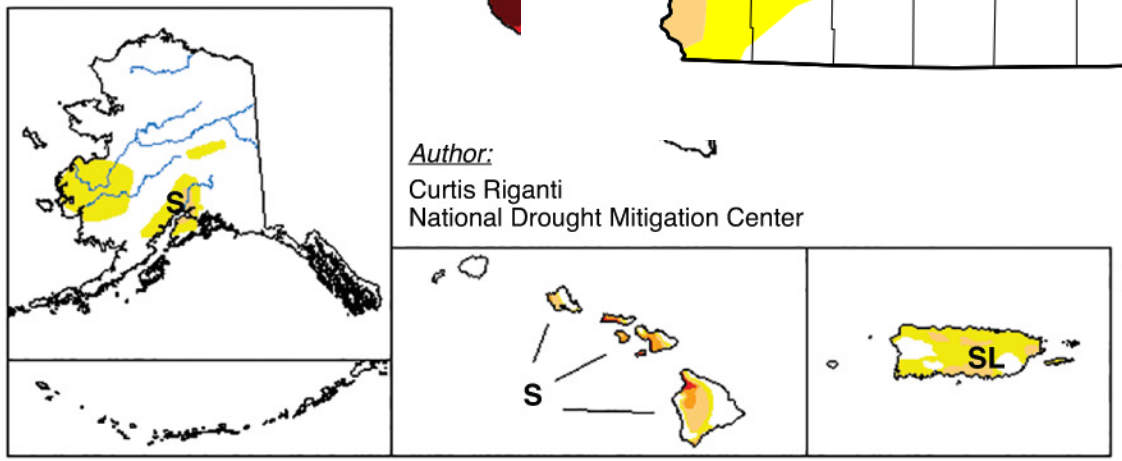
Authors

United States and Puerto Rico Author(s):

Brian Fuchs, National Drought Mitigation Center

Pacific Islands and Virgin Islands Author(s):

Rocky Bilotta, NOAA/NCEI



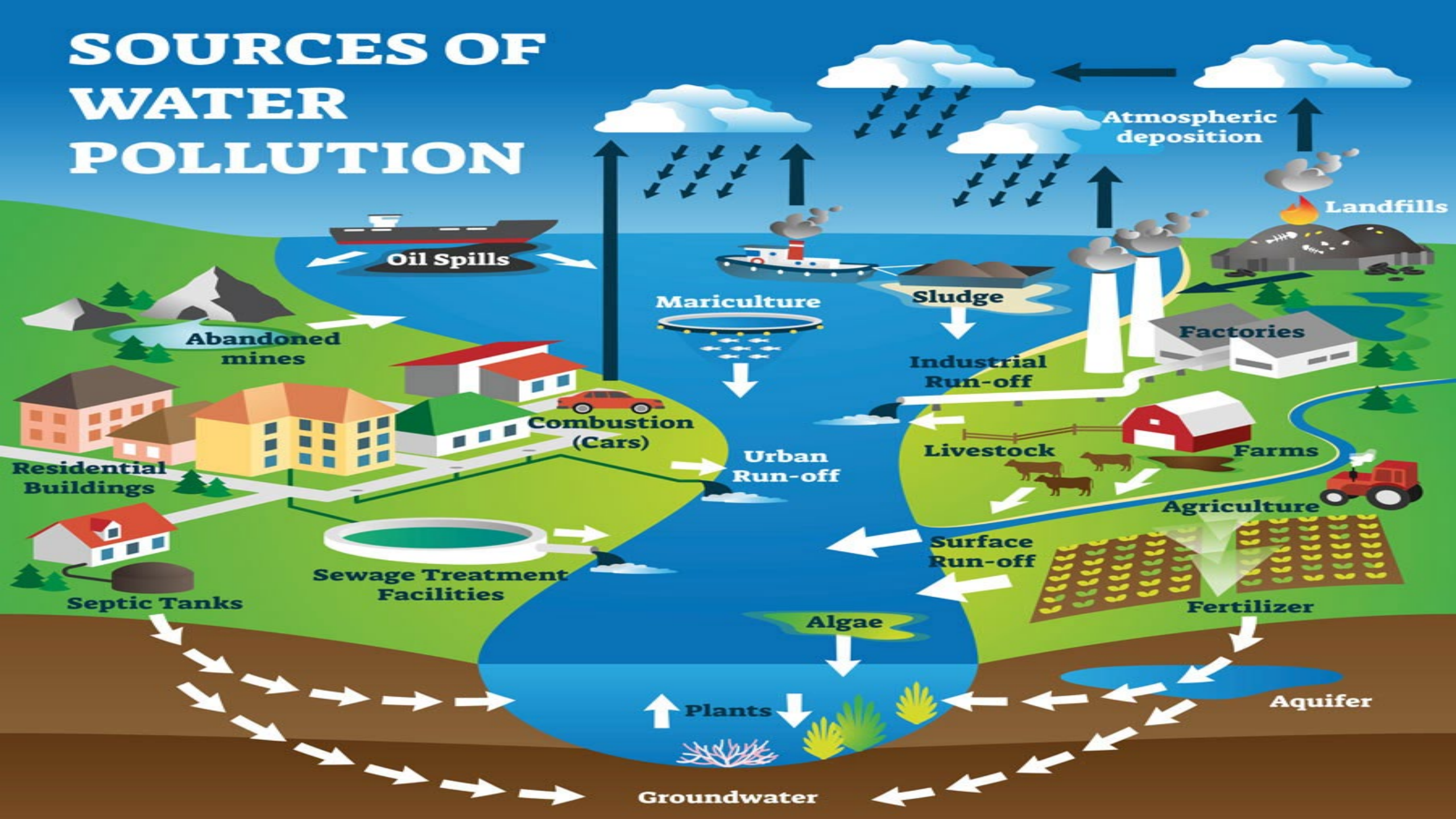
Author:
Curtis Riganti
National Drought Mitigation Center

D3 Extreme Drought
D4 Exceptional Drought

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. For more information on the Drought Monitor, go to https://droughtmonitor.unl.edu/About.aspx

droughtmonitor.unl.edu

https://droughtmonitor.unl.edu/CurrentMap/StateDroughtMonitor.aspx?IA


SOURCES OF WATER POLLUTION
Atmospheric deposition
Landfills
Oil Spills
Mariculture
Sludge
Factories
Abandoned mines
Industrial Run-off
Combustion (Cars)
Urban Run-off
Livestock
Farms
Residential Buildings
Agriculture
Surface Run-off
Sewage Treatment Facilities
Septic Tanks
Fertilizer
Algae
Aquifer
Plants
Groundwater

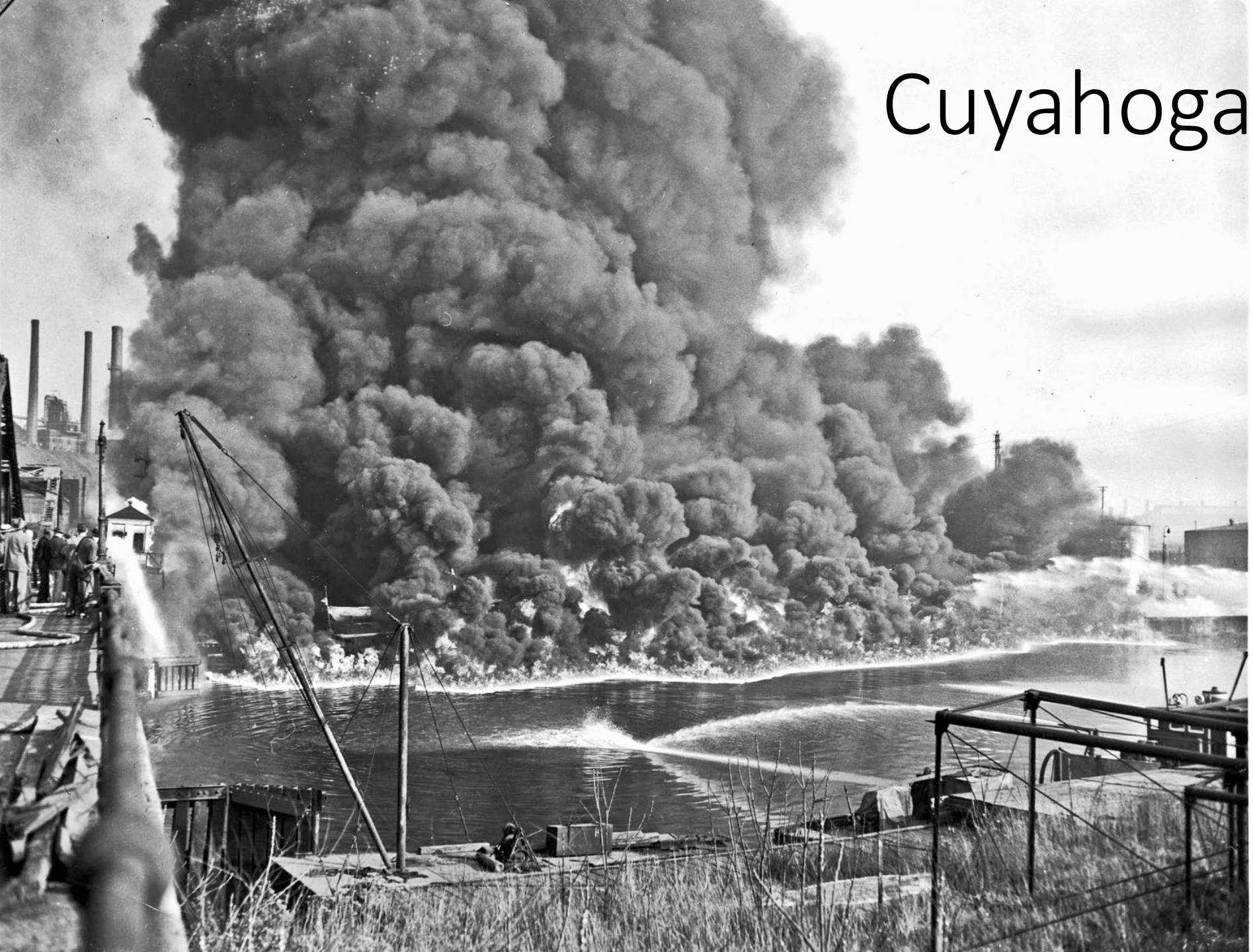
Contamination

Kevin Murch/Alamy Stock Photo

(a) Point Source

TMI/Alamy Stock Photo

(b) Non-Point Source



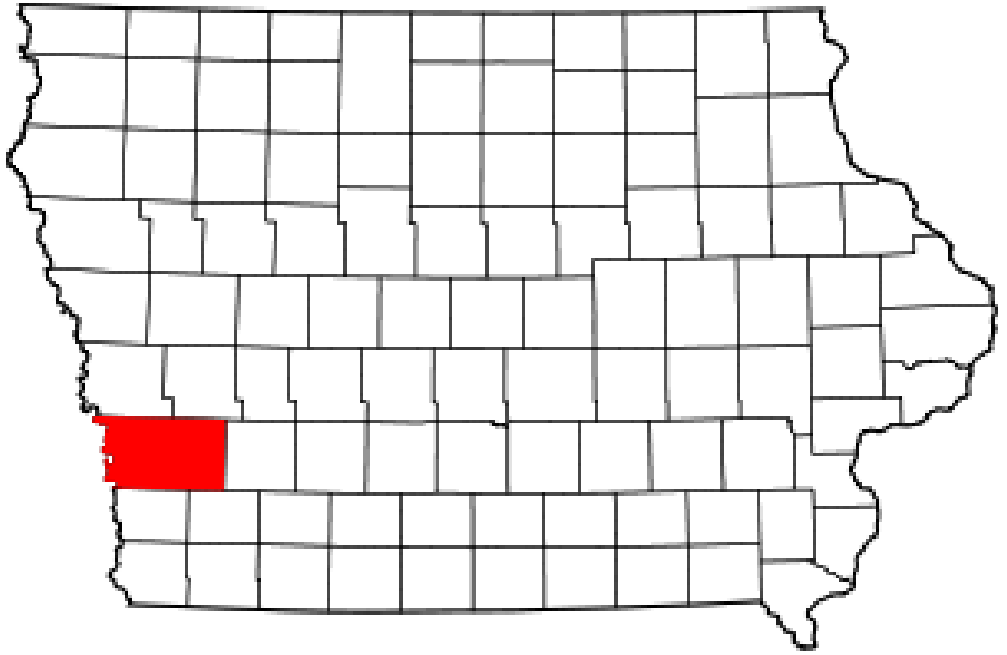
Cuyahoga River

1868, 1883, 1887,
1912, 1914, 1922,
1930, 1936, 1941,
1948, 1949, 1951,
1952, 1969

Cuyahoga River
August, 2020

Pottawattamie County, Iowa

- **Iowa Officials Find Animal Parts Strewn Across 2 Fields**
- **Environmental officials are considering what actions to take against a southwestern Iowa feedlot after finding animal parts and the contents of slaughtered cattle stomachs strewn across two open fields.**
- By Associated Press, Wire Service Content March 11, 2021, at 3:45 p.m.



(a)

The Process of Eutrophication

Nutrients in the water increase and accumulate.

This buildup stimulates algae growth and blooms of aquatic plants.

The dying plants and organisms use oxygen as they decompose.

Decomposition depletes the amount of oxygen in the water.

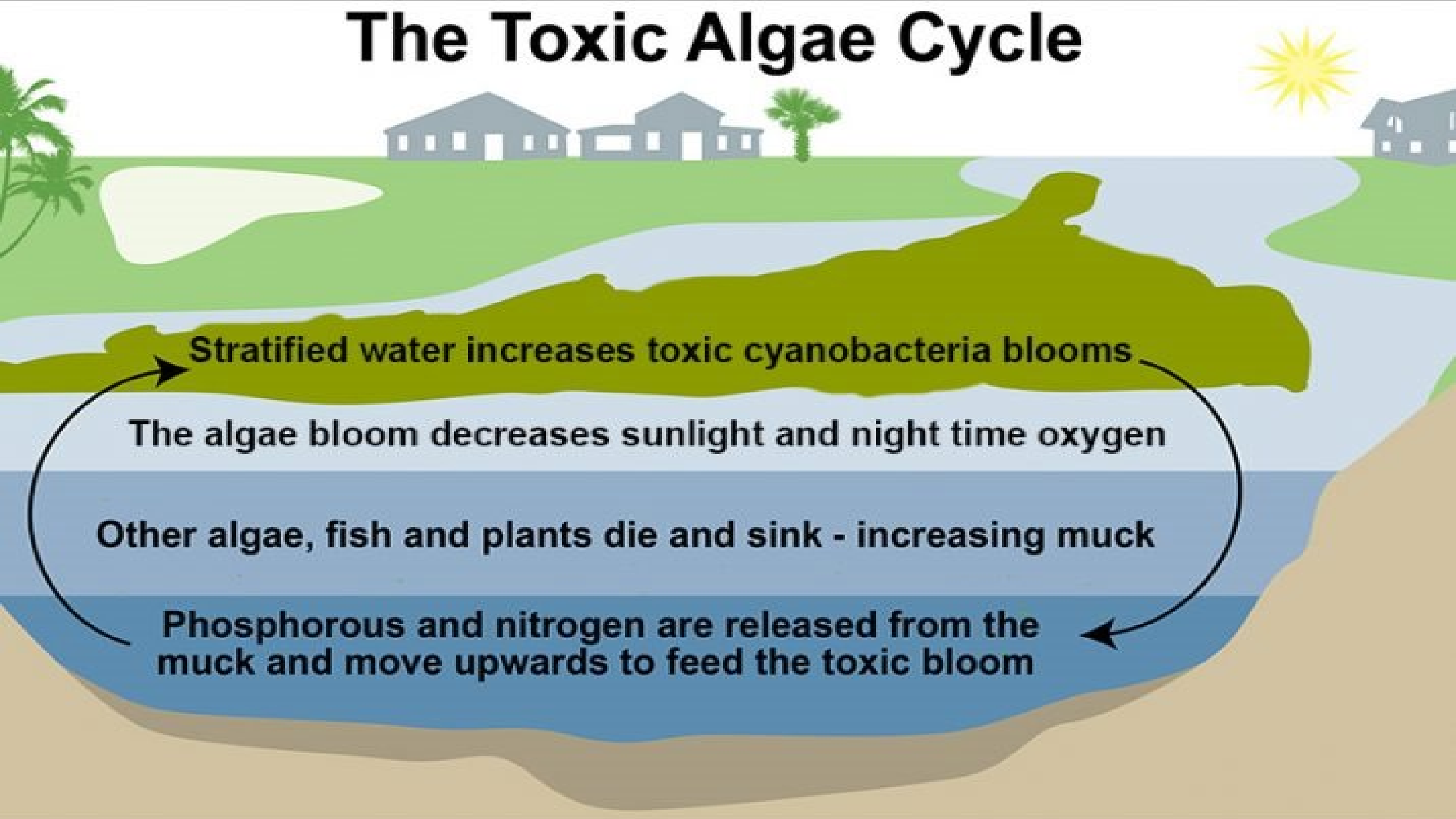
(b)

Geogphotos/Alamy Stock Photo

To notify the public about potentially dangerous water contamination in recreational areas, **public agencies may rely heavily or solely on signs posted at the affected beach.**

COURTESY MELISSA MARTIN / DENISE MINTZ

The Toxic Algae Cycle




Reported Fish Kills November 2018
Fish Kill
Diseased/Lesioned Fish
Other
FLORIDA
Miami

Fish Kill Event - East Nishnabotna River

- 265,000 gallons of liquid nitrogen
- 800,000 fish dead over a 60 mile length of the river
- $2 to 5 per gallon $530,000 to $1,325,000
  - Over flow shut off valve not installed? $12 part
- https://programs.iowadnr.gov/fishkill/Events/1045

The New York Times

Iowa Fertilizer Spill Kills Nearly All Fish Across 60-Mile Stretch of Rivers

Officials in Iowa and Missouri estimated that nearly 800,000 fish had died in waters that flow into the Missouri River.

https://www.nytimes.com/2024/03/29/us/iowa-spill-fish-kill.html

IWILL competes with NoWill? 2025 Will to Kill

- Lawmakers approved the creation of the Natural Resources and Outdoor Recreation Trust Fund in **2008 and 2009**. The next year, Iowa voters amended the state's constitution to include a framework for the fund: The next time the state passed a sales tax increase, three-eights of a cent of the tax would go toward water quality, outdoor recreation and wildlife conservation.
- Statewide voter support: 2010 - 63% , 2021 – 70%
- The issue: Iowa hasn't passed a statewide sales tax increase since then, leaving the fund empty for over 19 years and counting…

https://www.iowapf.net/iwill/ ,

https://www.inhf.org/what-we-do/conservation-policy/iowas-water-and-land-legacy/

Summary

- Scale – Agriculture & Urbanization development outpace Conservation
  - *Not sustainable*
- Regulations and enforcement
  - Voluntary is not working
- Education and awareness
  - Making progress, but not enough
- Must work with…
  - politicians/leaders
  - city planners/managers
  - developers/builders

Extra Resources

Algal Blooms

Warmer weather and increased runoff create ideal conditions for Harmful Algal Blooms (HABs) — the abnormal growth of blue-green algae in lakes. It is a complex problem with many harmful consequences.

Causes

Excess phosphorus and nitrogen from:
- Agricultural fertilizers
- Residential sewer/septic leakage
- Stormwater runoff (streets, roofs)
- Hog, cattle & poultry manure
- Industrial discharge
- Wind & rain deposition
- Shorebird droppings
- Soil erosion (storms and flooding)

Warmer water temperatures

Unfiltered sunlight

Stagnant water

Stratified water layers

Invasive mussels

Effects

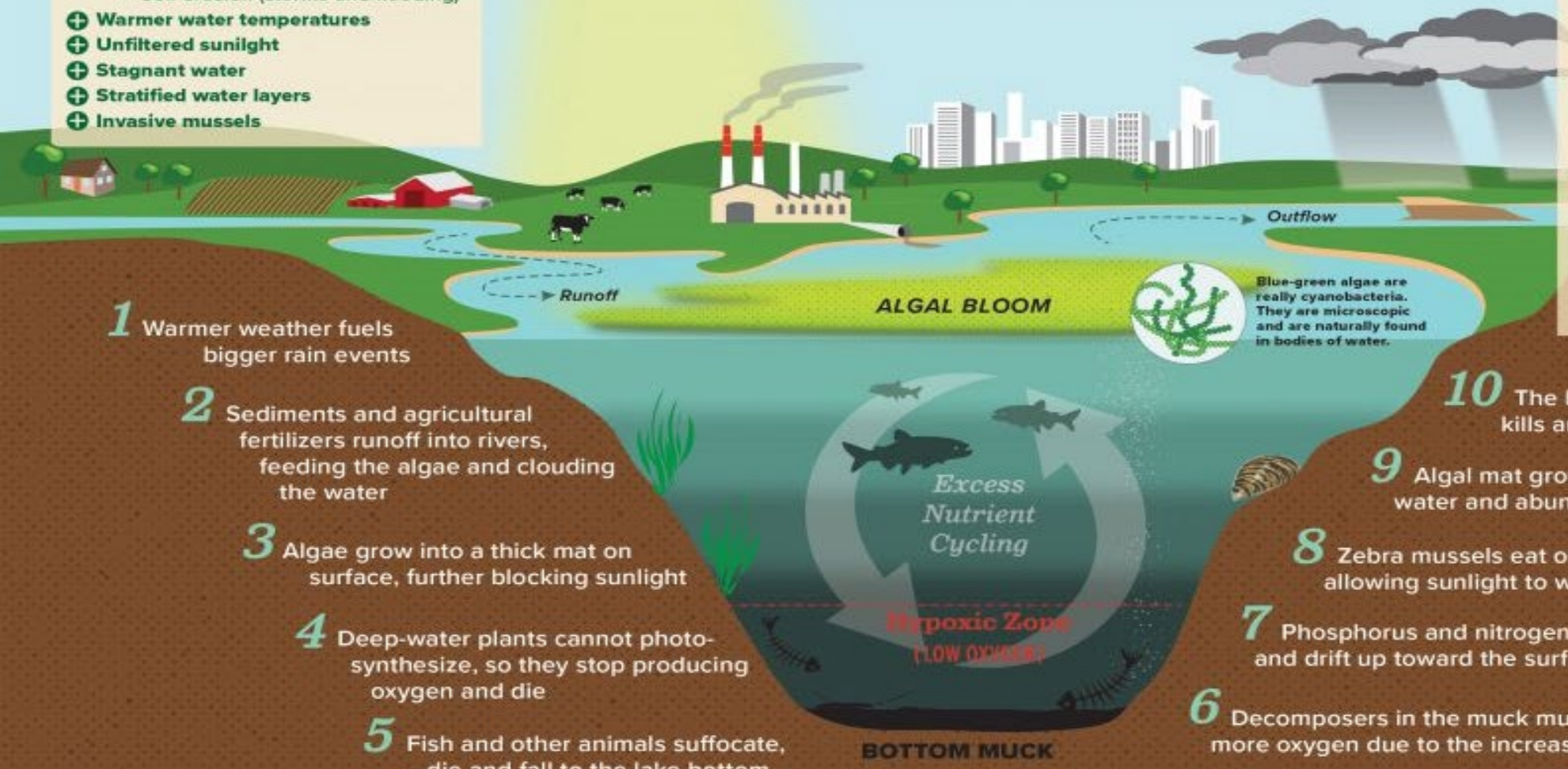
Human health:
- Skin rashes, illness (cyanotoxins)
- Noxious odors
- Drinking water contamination

Ecosystem:
- Healthy food web disruption
- Fish kills
- Shellfish toxicity

Environmental:
- Dead zones
- Acid rain
- Air pollution

Recreational:
- Beach closures
- Boating restrictions
- Fishing bans

Economic:
- Expensive water purification
- Commercial fishing losses
- Decreased tourism revenue
- Decrease in recreational business
- Decreased property values



1 Warmer weather fuels bigger rain events

2 Sediments and agricultural fertilizers runoff into rivers, feeding the algae and clouding the water

3 Algae grow into a thick mat on surface, further blocking sunlight

4 Deep-water plants cannot photo-synthesize, so they stop producing oxygen and die

5 Fish and other animals suffocate, die and fall to the lake bottom

6 Decomposers in the muck multiply and consume more oxygen due to the increased food supply

7 Phosphorus and nitrogen are released and drift up toward the surface

8 Zebra mussels eat only "good" algae, allowing sunlight to warm the lake depths

9 Algal mat grows larger and thicker with warmer water and abundant nutrients.

10 The bloom fouls drinking water, kills animals and causes human illness