



*Napa Valley Groundwater Advisory Committee
February 23, 2012*



A Tradition of Stewardship
A Commitment to Service

Groundwater and Groundwater – Surface Water Interaction: How Does It Work?



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Overview



- What is groundwater?
 - How much groundwater is there?
 - How fast does groundwater move?
 - How do we measure groundwater?
- Where does groundwater come from and where does it go?
- How do Californians use it?
- Groundwater management and groundwater quality

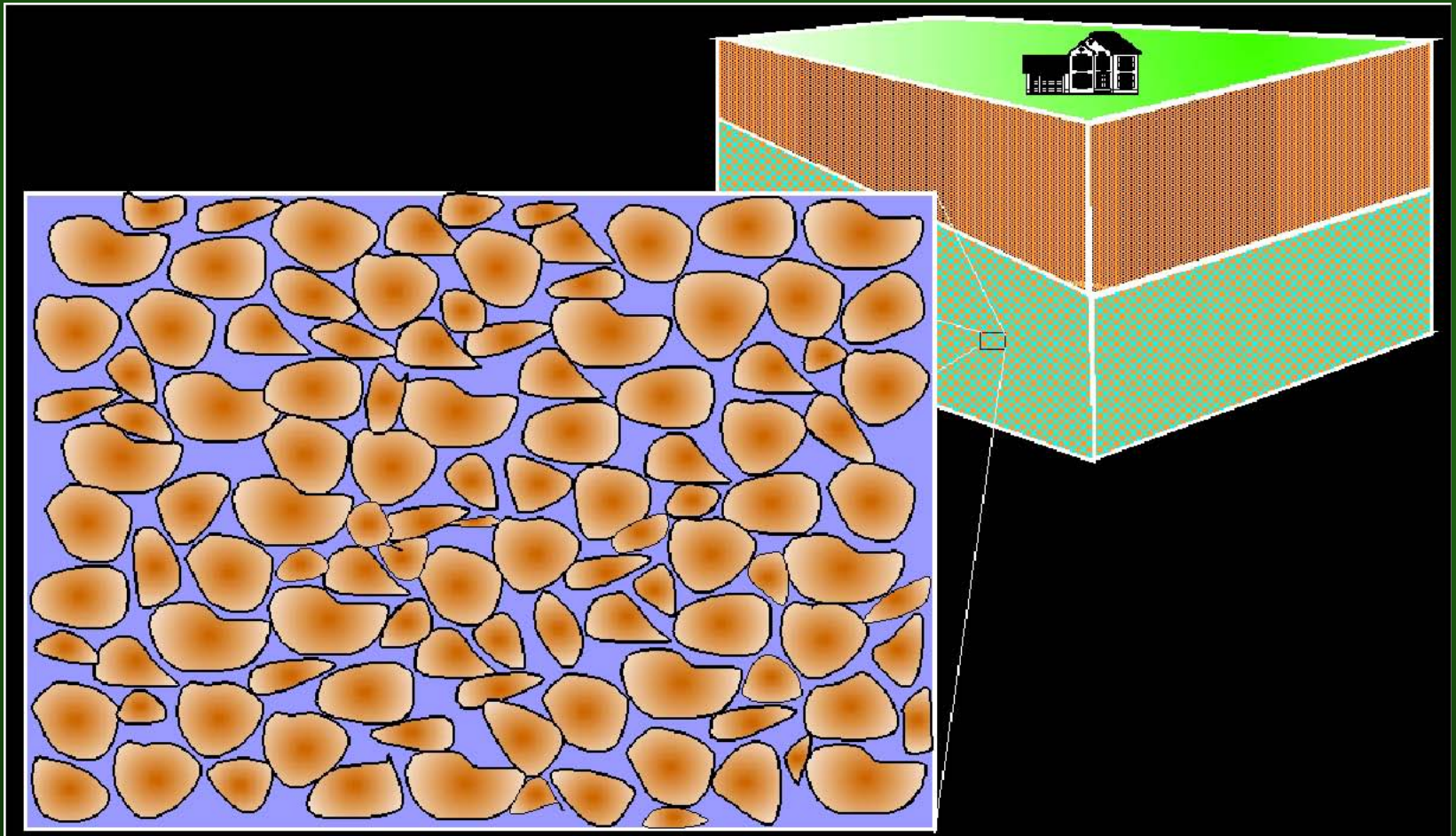


What is Groundwater?

- An underground lake?
- A network of underground rivers?
- A rectangular network of pipelike water arteries?
- A giant sponge?

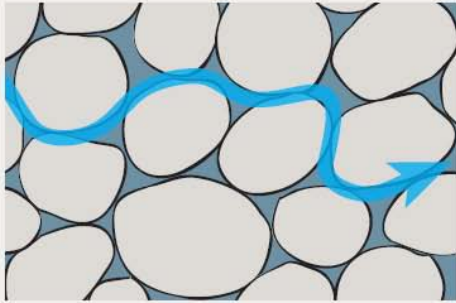


Groundwater = Water completely filling Pores/Fractures

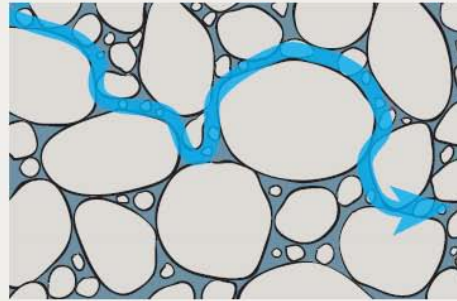




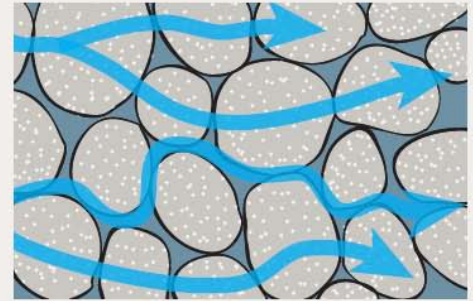
Groundwater in Different Sediments and Rocks



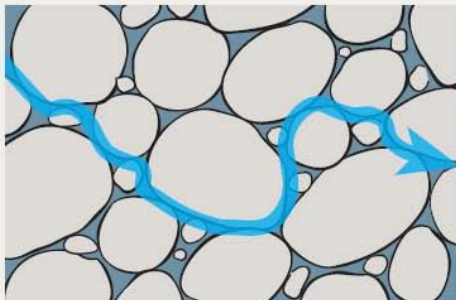
Well-sorted sediment



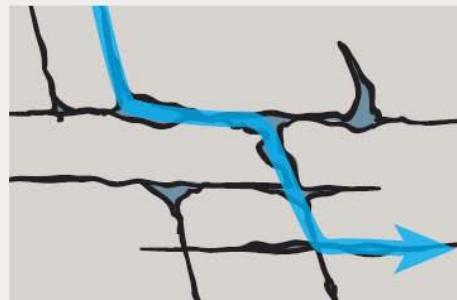
Poorly sorted sediment



Porous sediment



Consolidated sediment



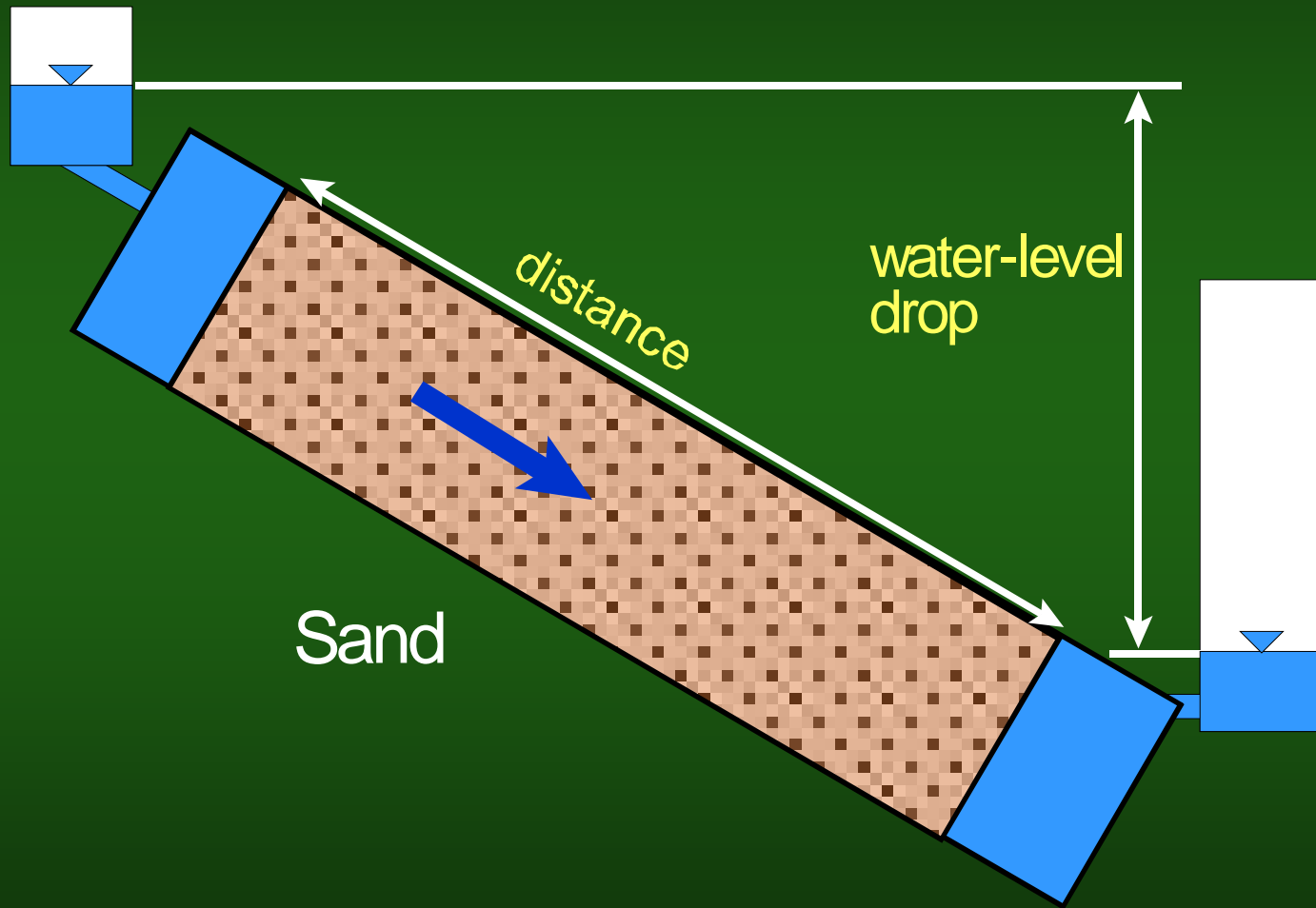
Dissolution of rock



Rock fractures

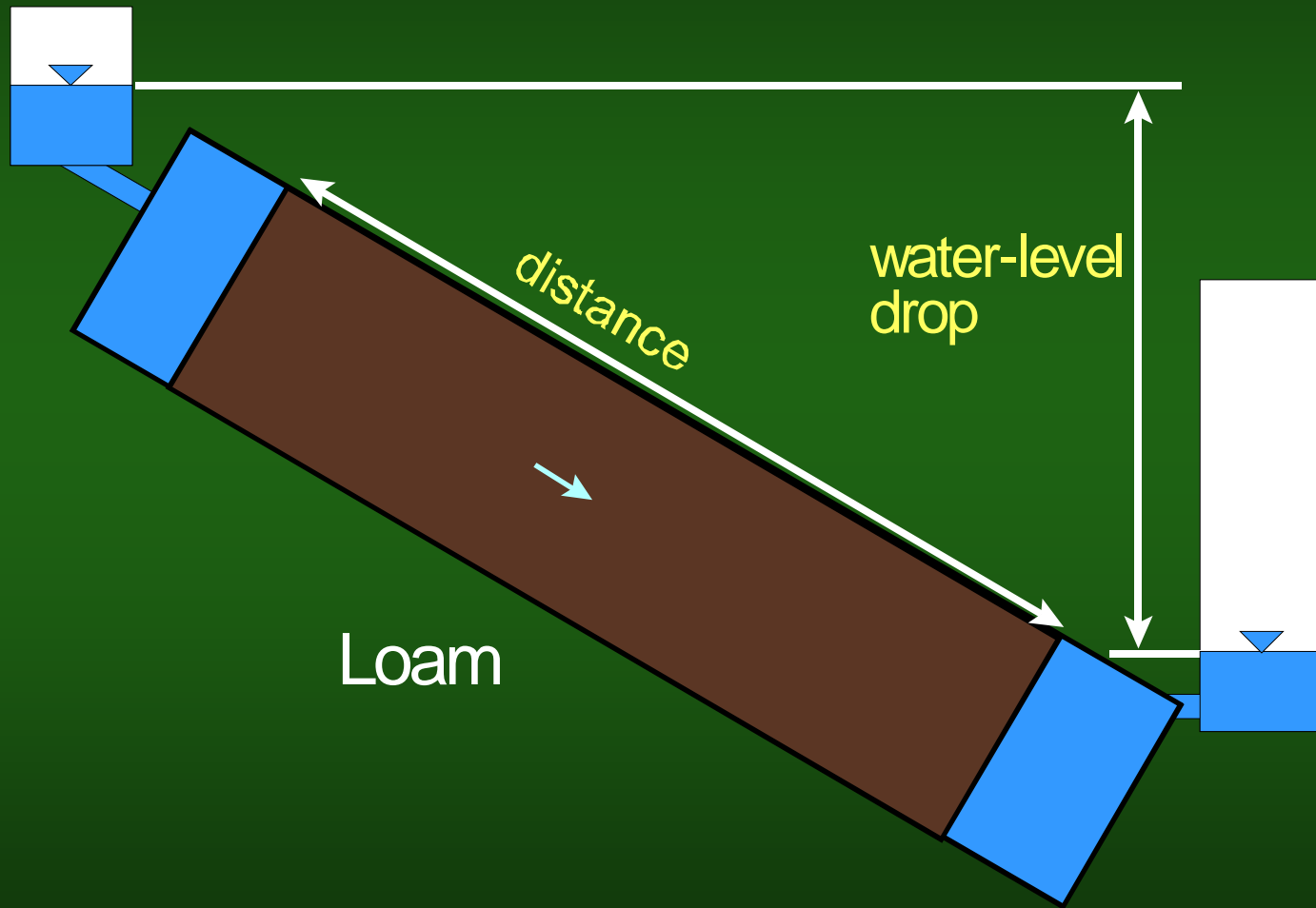


How fast does water flow?



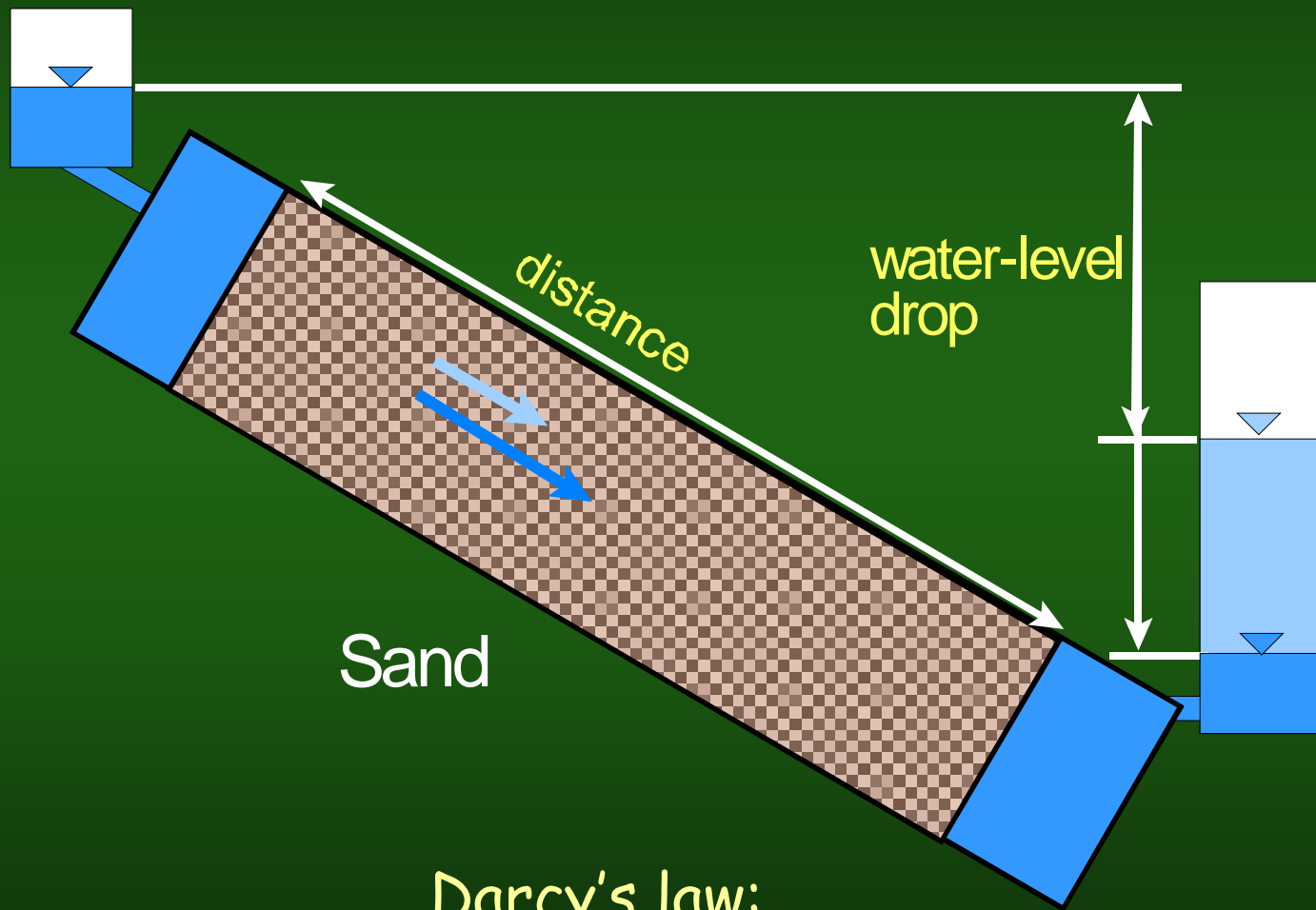


How fast does water flow?





How fast does water flow?

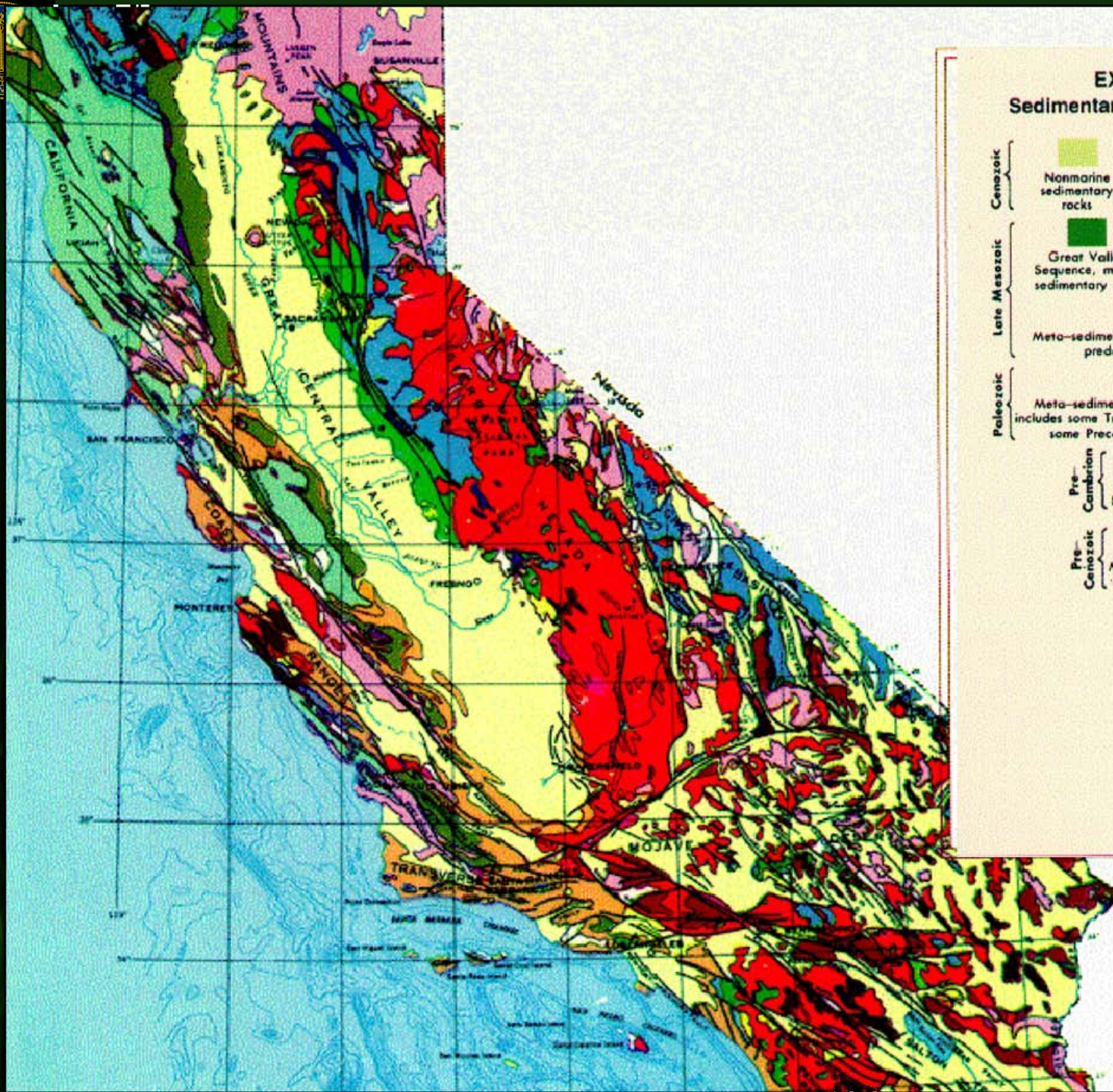


Darcy's law:
groundwater flow = hydraulic conductivity \times pressure gradient



How do we measure hydraulic conductivity?

- Estimate based on sediment type (gravel, sand, silt, clay, fractured rock):
 - => **well logs** (geologic logs, geophysical logs)
- Measure on sediment/rock **cores** in laboratory
- Estimate from specific capacity of wells:
 - ratio of pumping rate to well **water level drawdown**
- Measure using an aquifer test:
 - 1-day to 7-day well **pumping tests**
- Estimate from groundwater models:
 - => **matching model results** to measured water levels, groundwater flows



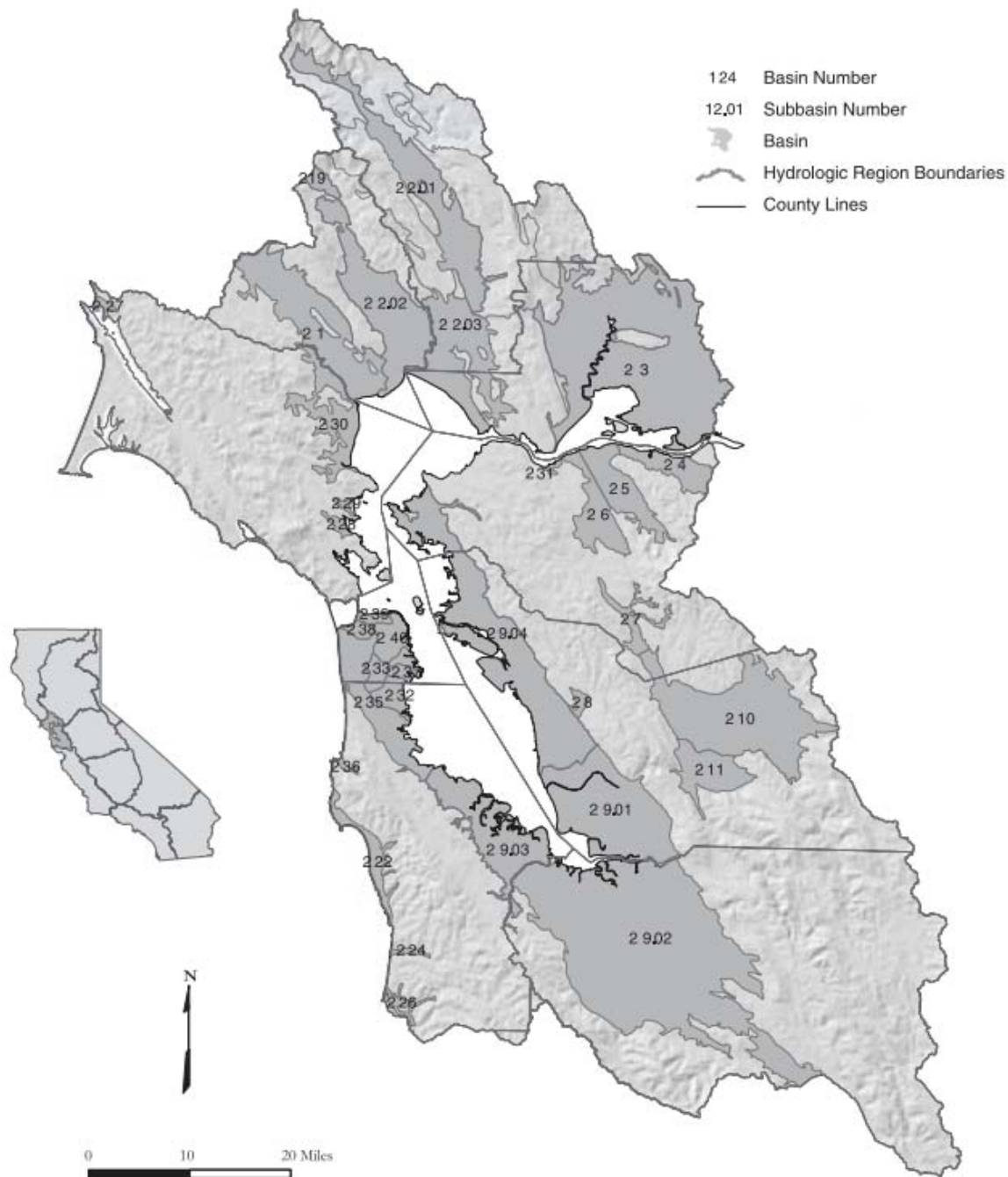
EXPLANATION Sedimentary and Volcanic Rocks

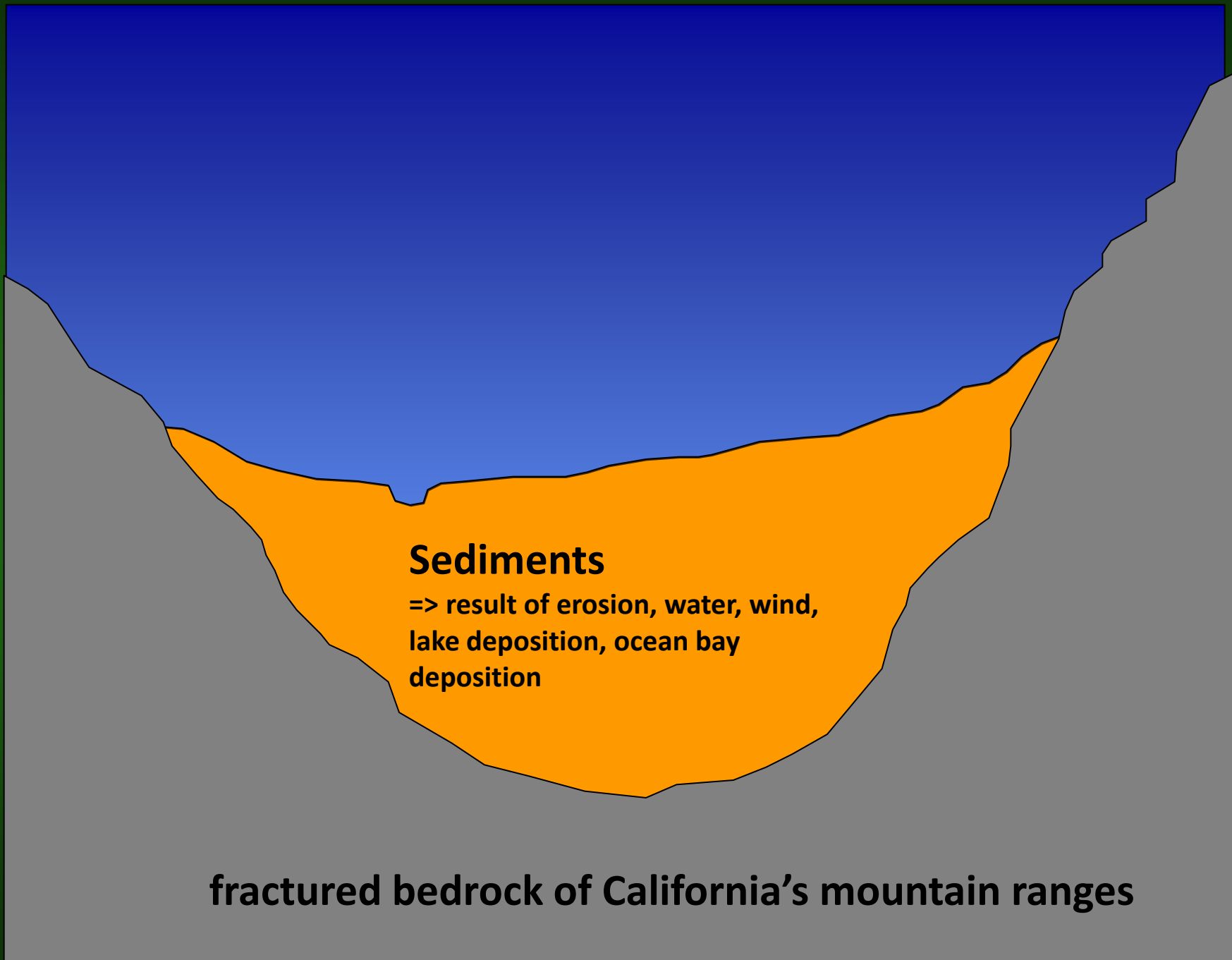
- Cenozoic**
 - Nonmarine sedimentary rocks
 - Marine sedimentary rocks
 - Volcanic rocks
- Late Mesozoic**
 - Great Valley Sequence, marine sedimentary rocks
 - Franciscan Complex including coastal belt rocks (early Tertiary in part)
 - Meta-sedimentary and meta-volcanic rocks predating granitic intrusions
- Paleozoic**
 - Meta-sedimentary and meta-volcanic rocks; includes some Triassic rocks in Klamath Mountains; some Precambrian rocks in Great Basin
- Pre-Cambrian**
 - Rocks of all types
- Pre-Cenozoic**
 - Metamorphic rocks of unknown age

Intrusive Igneous Rocks

- Chiefly Mesozoic**
 - Granitic rocks
 - Ultramafic rocks

Geological boundary
Fault

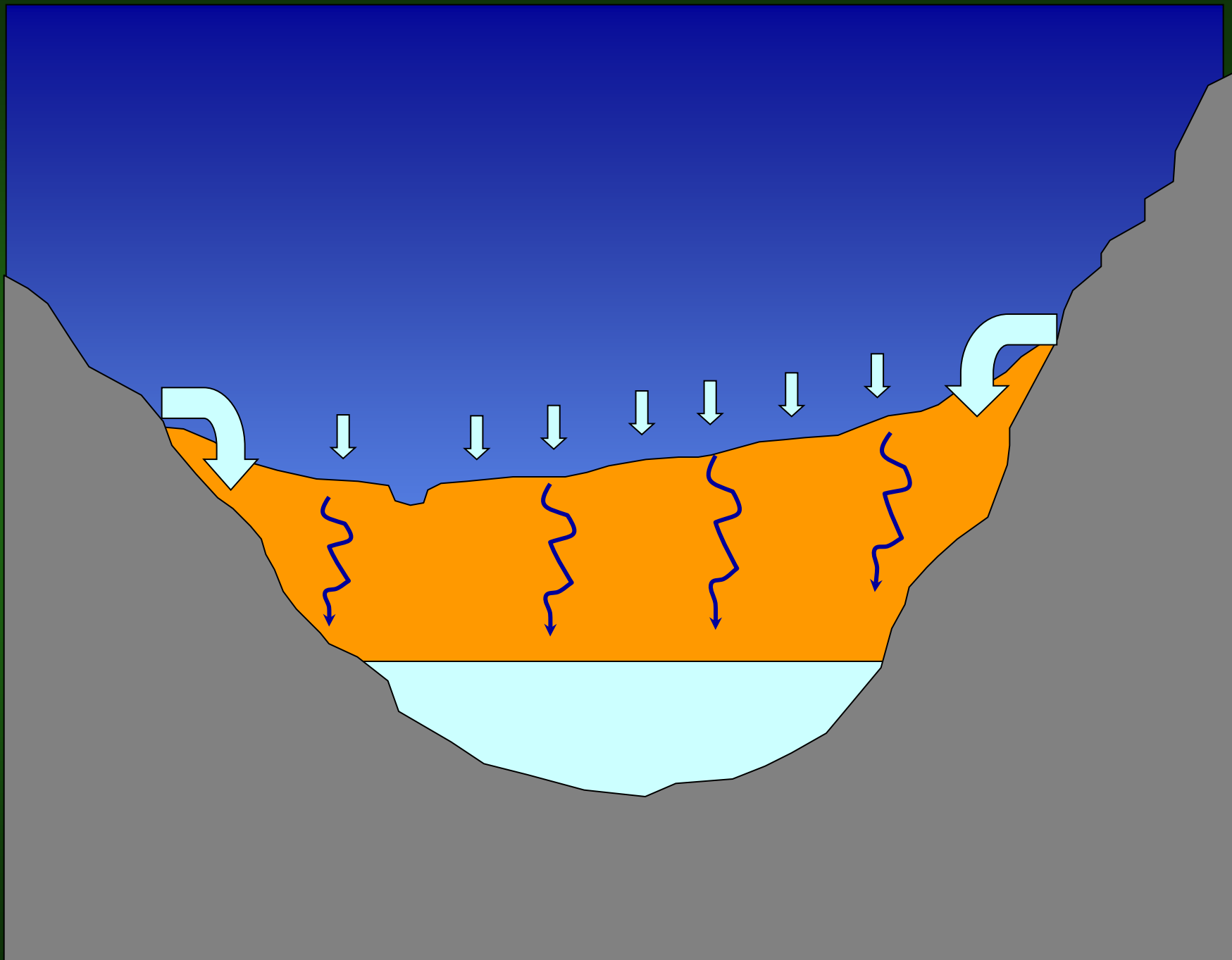




Sediments

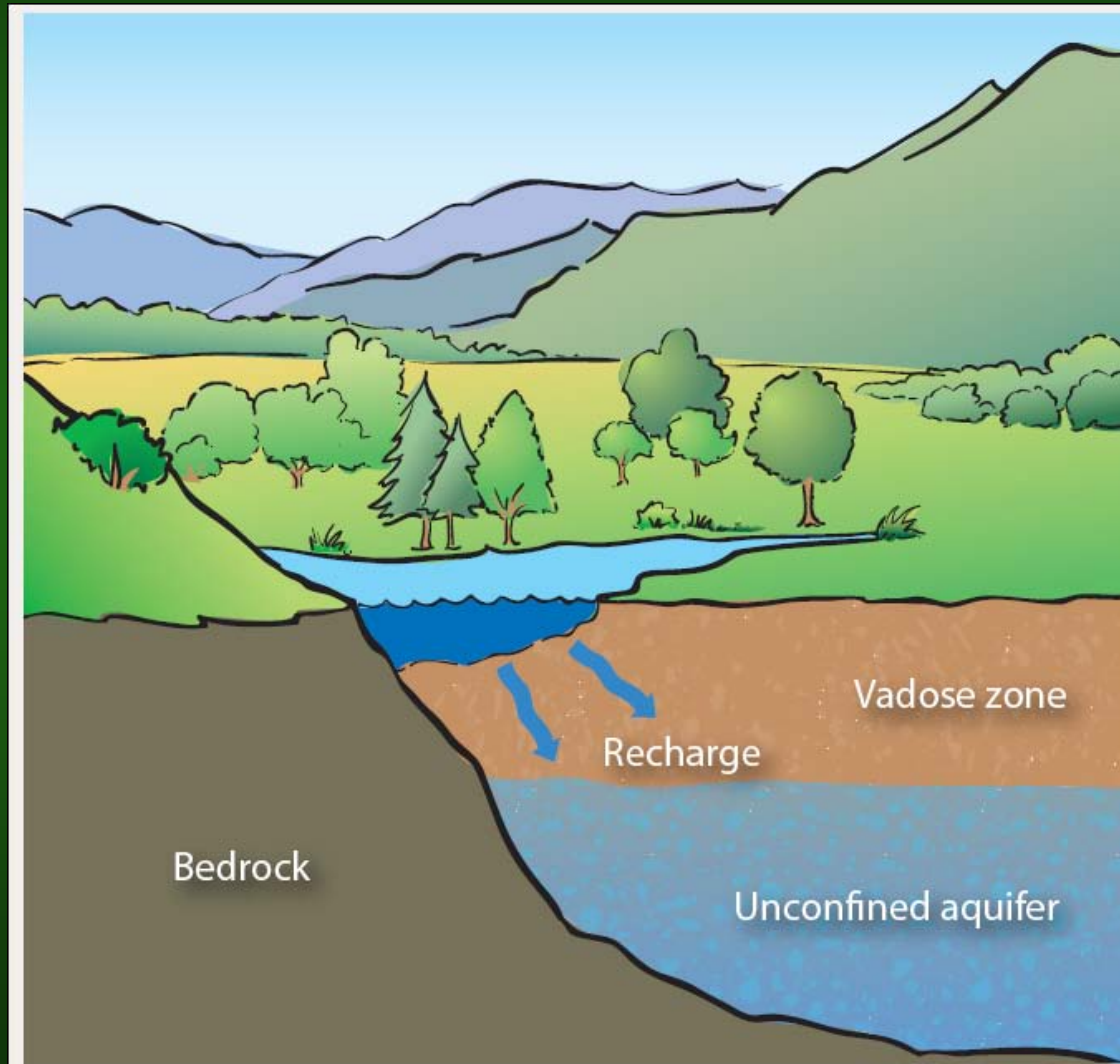
=> result of erosion, water, wind,
lake deposition, ocean bay
deposition

fractured bedrock of California's mountain ranges





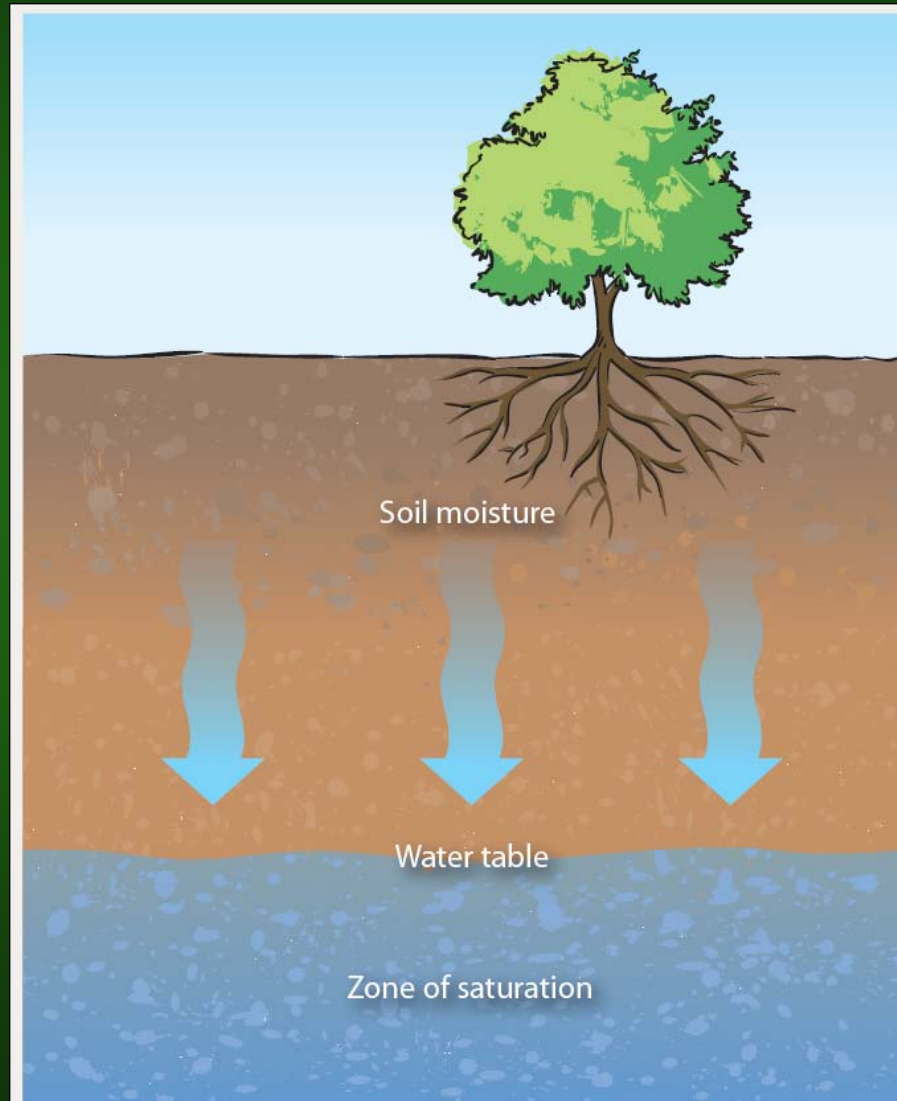
Unconfined Aquifer

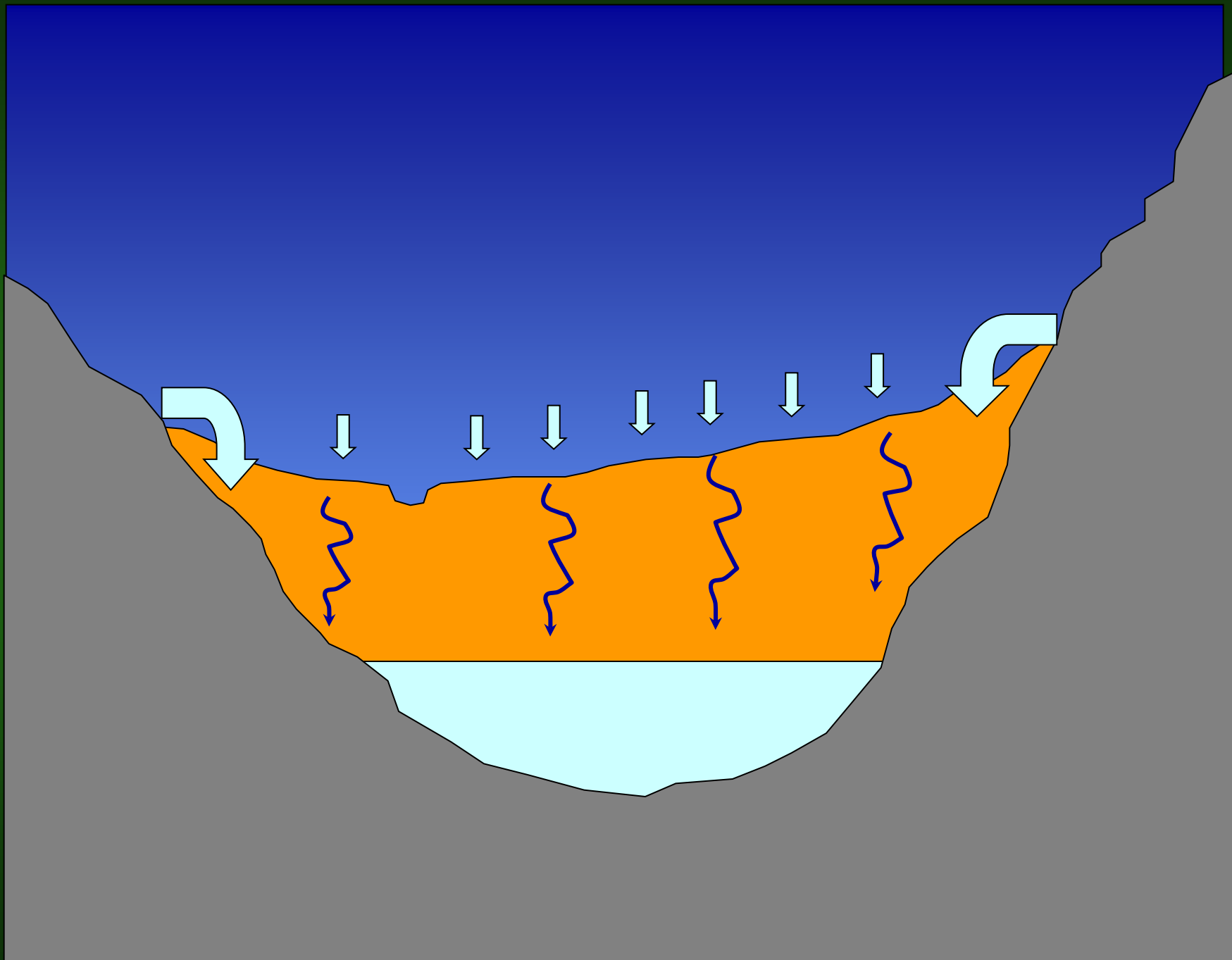


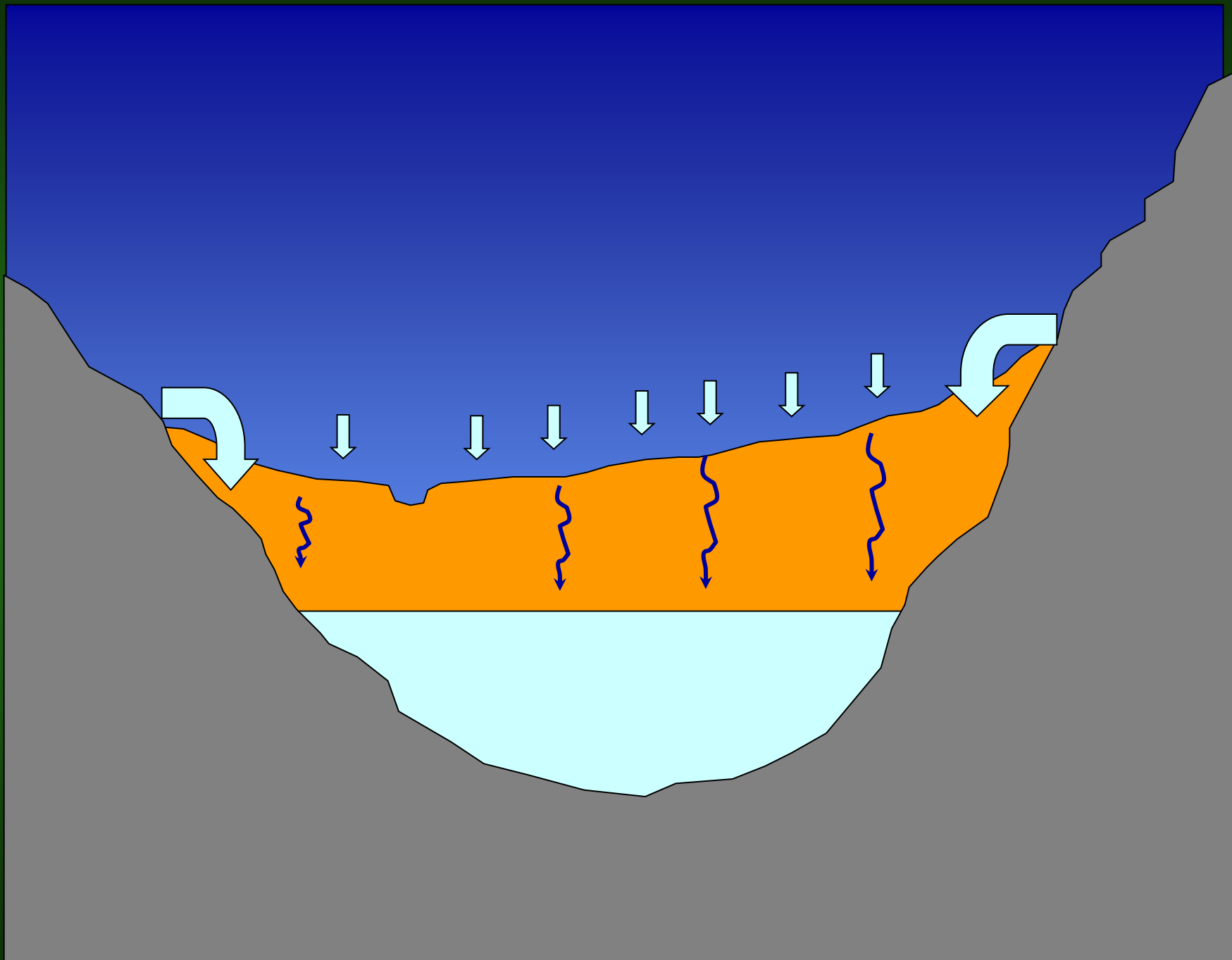
Losing
stream

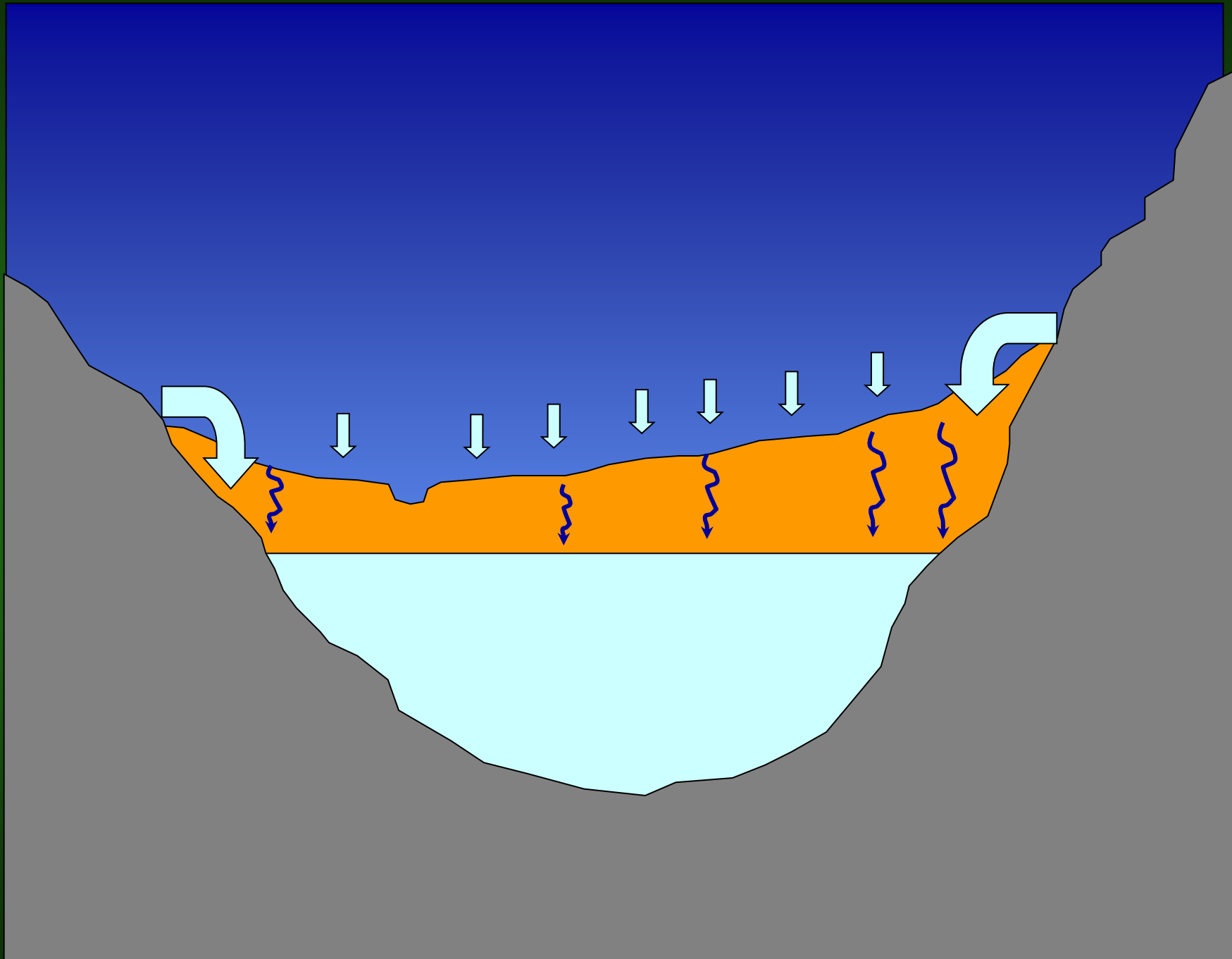


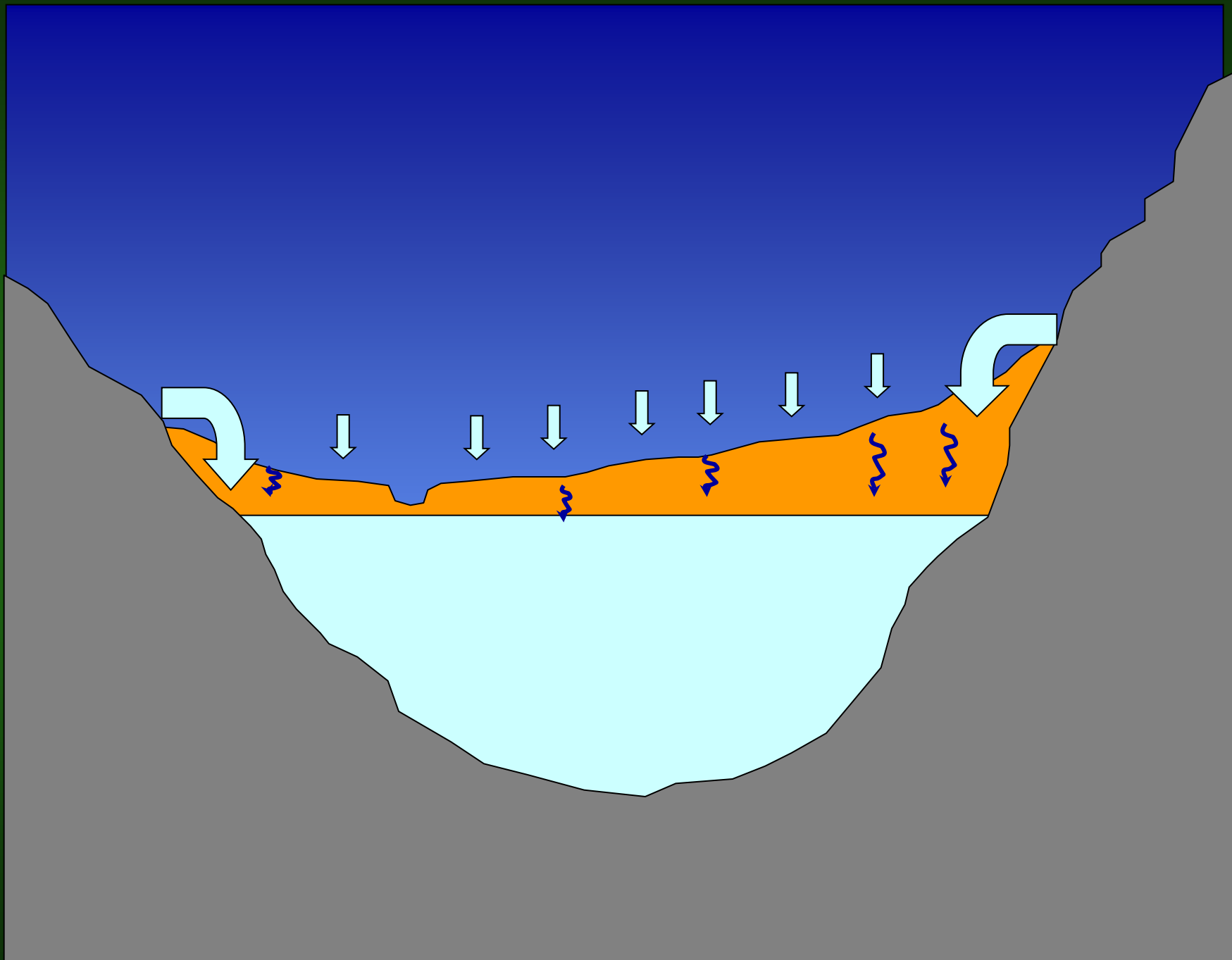
What is Groundwater?

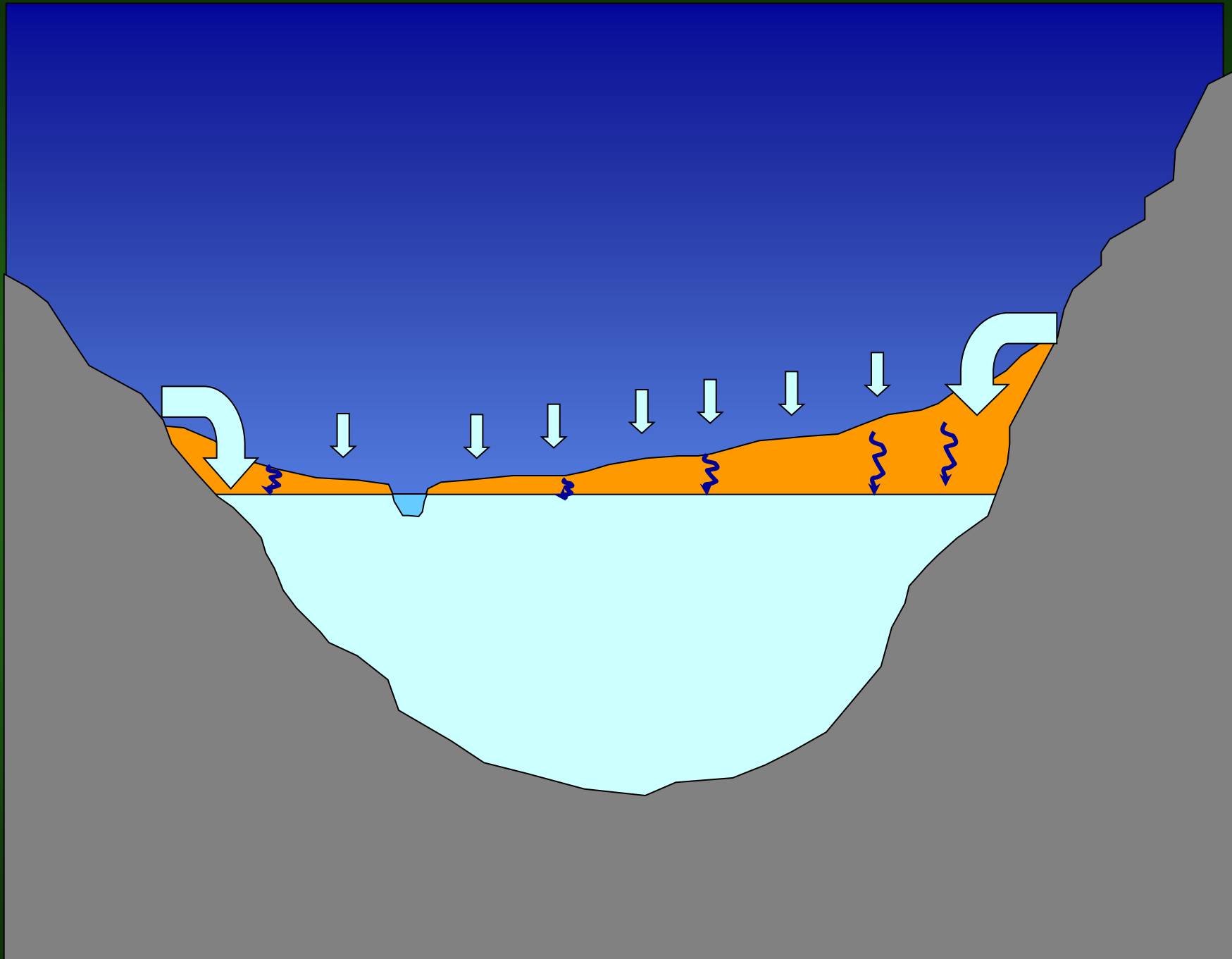


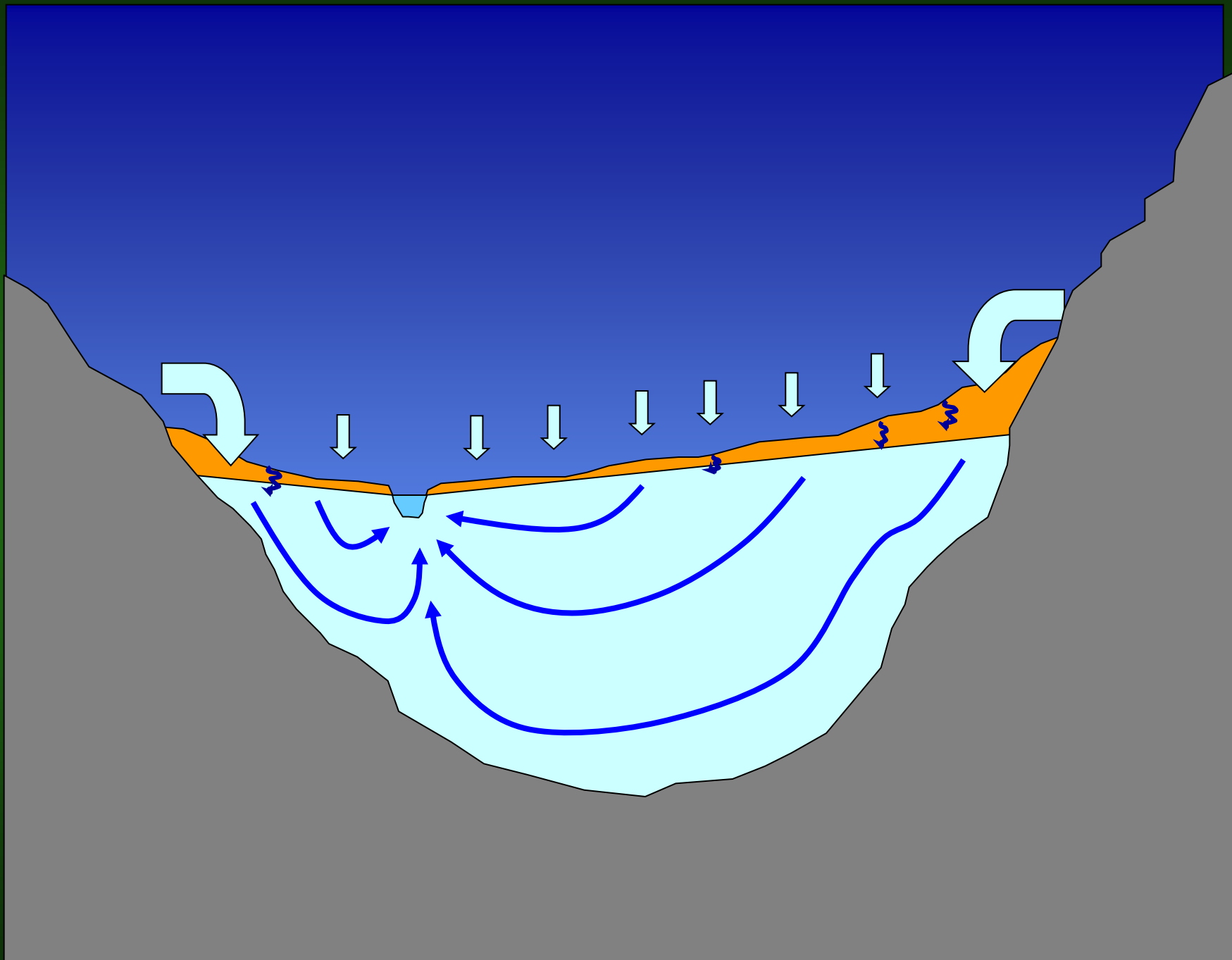






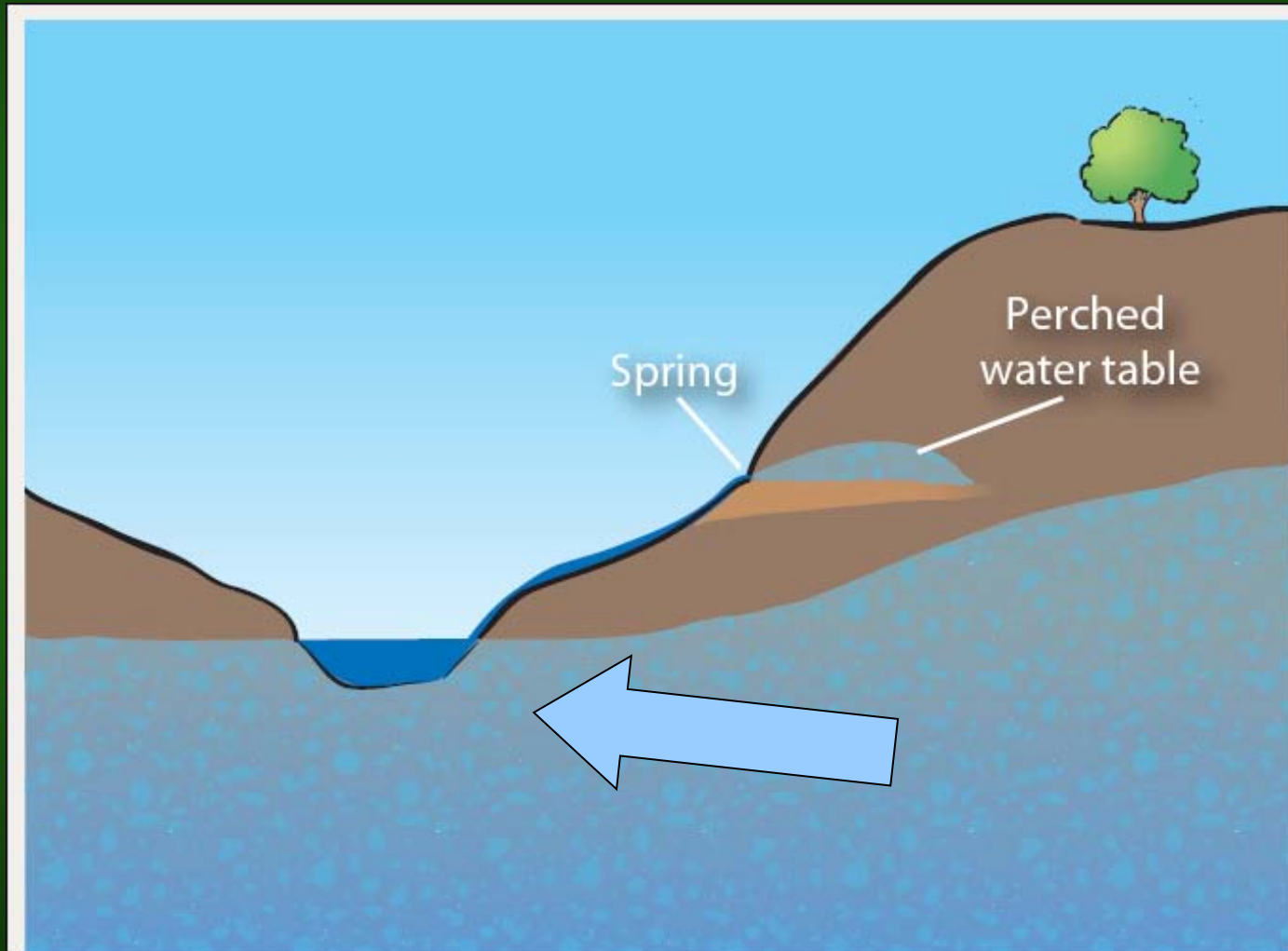








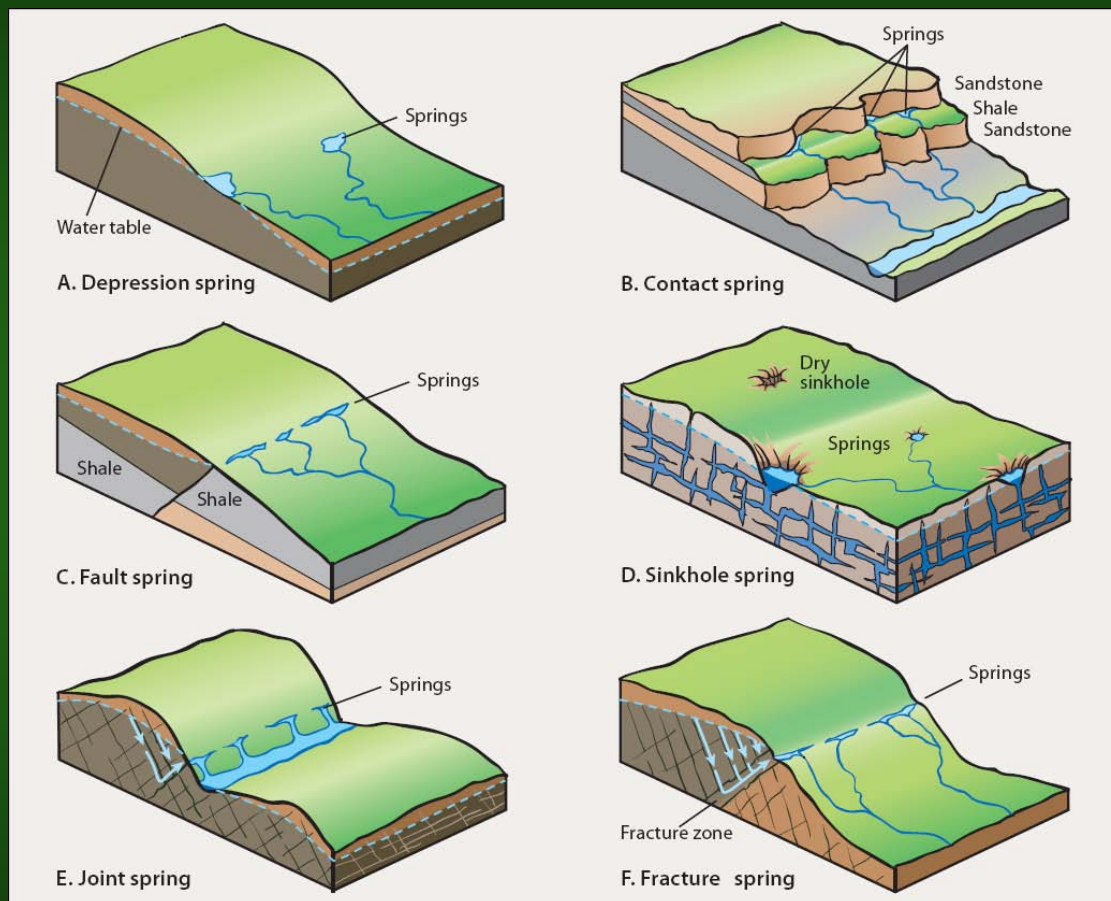
Unconfined Aquifer



Gaining
stream



Springs



From: Harter and Rollins, Watersheds, Groundwater, and Drinking Water - A Practical Guide. University of California Agriculture and Natural Resources Publication 3497, 2008; <http://anrcatalog.ucdavis.edu/items/3497.aspx>



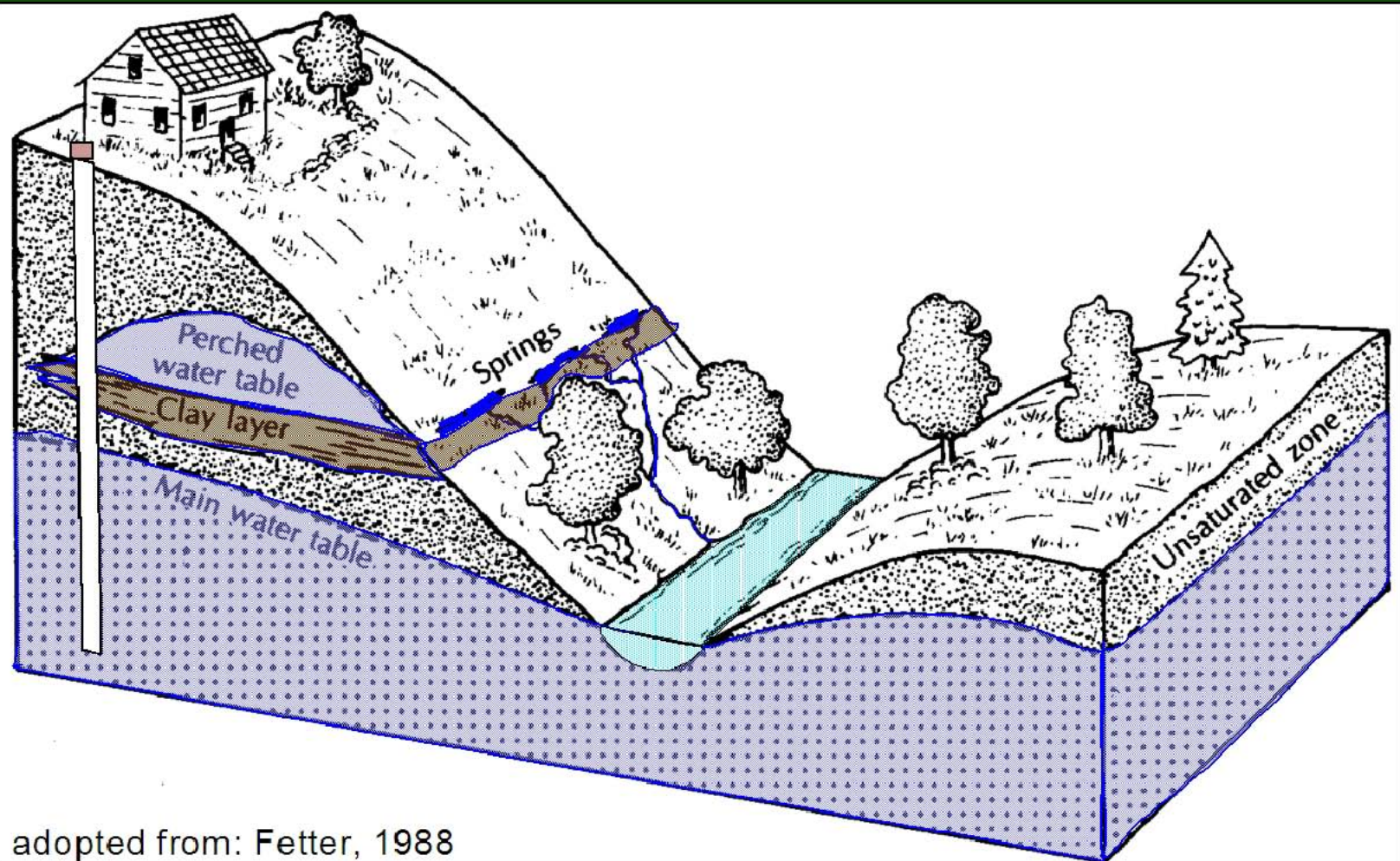
Fall River, NE California

Basalt-flow





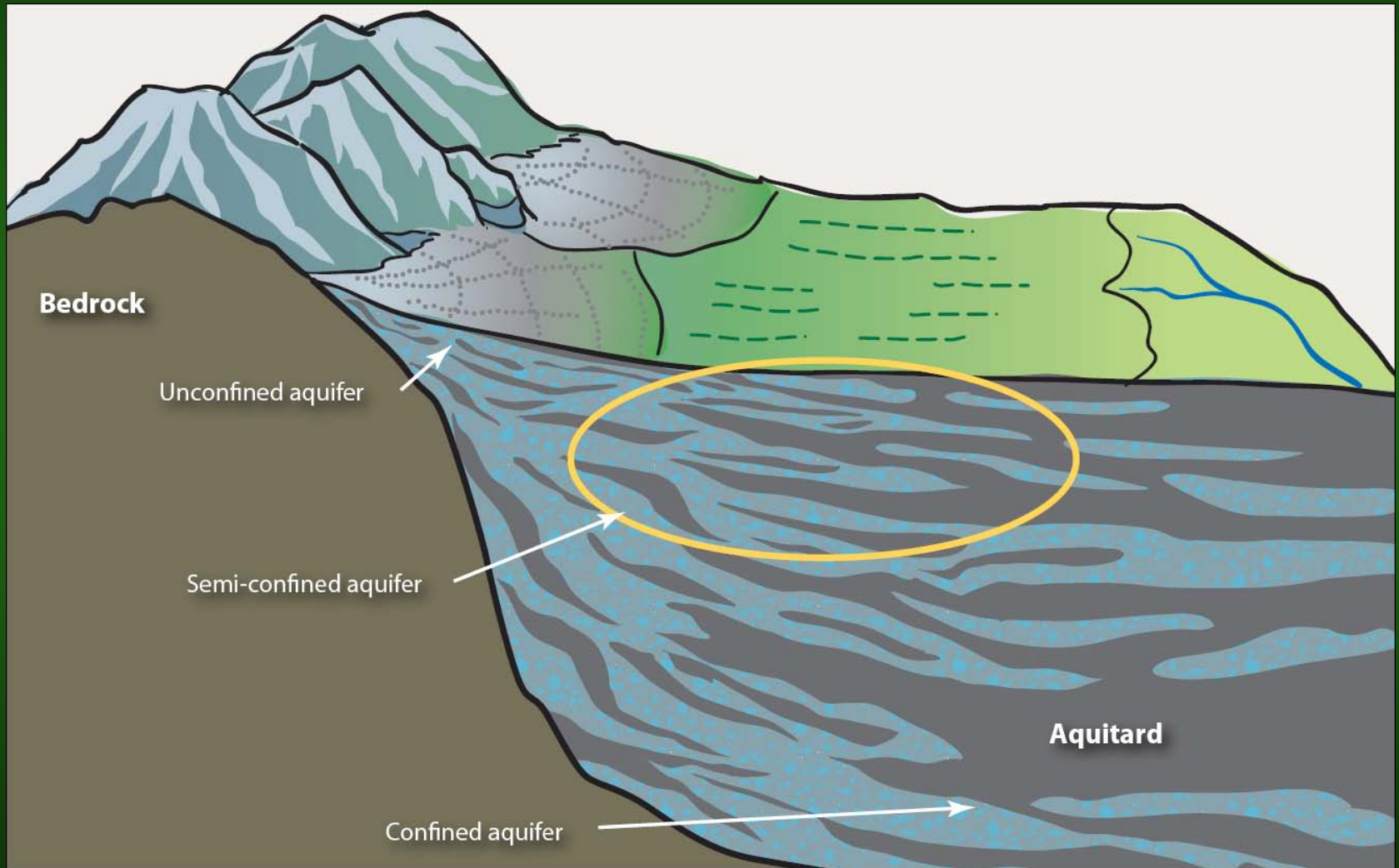
Perched Water Table



adopted from: Fetter, 1988



(Semi-) Confined Aquifer





Artesian Well (Confined Aquifer)



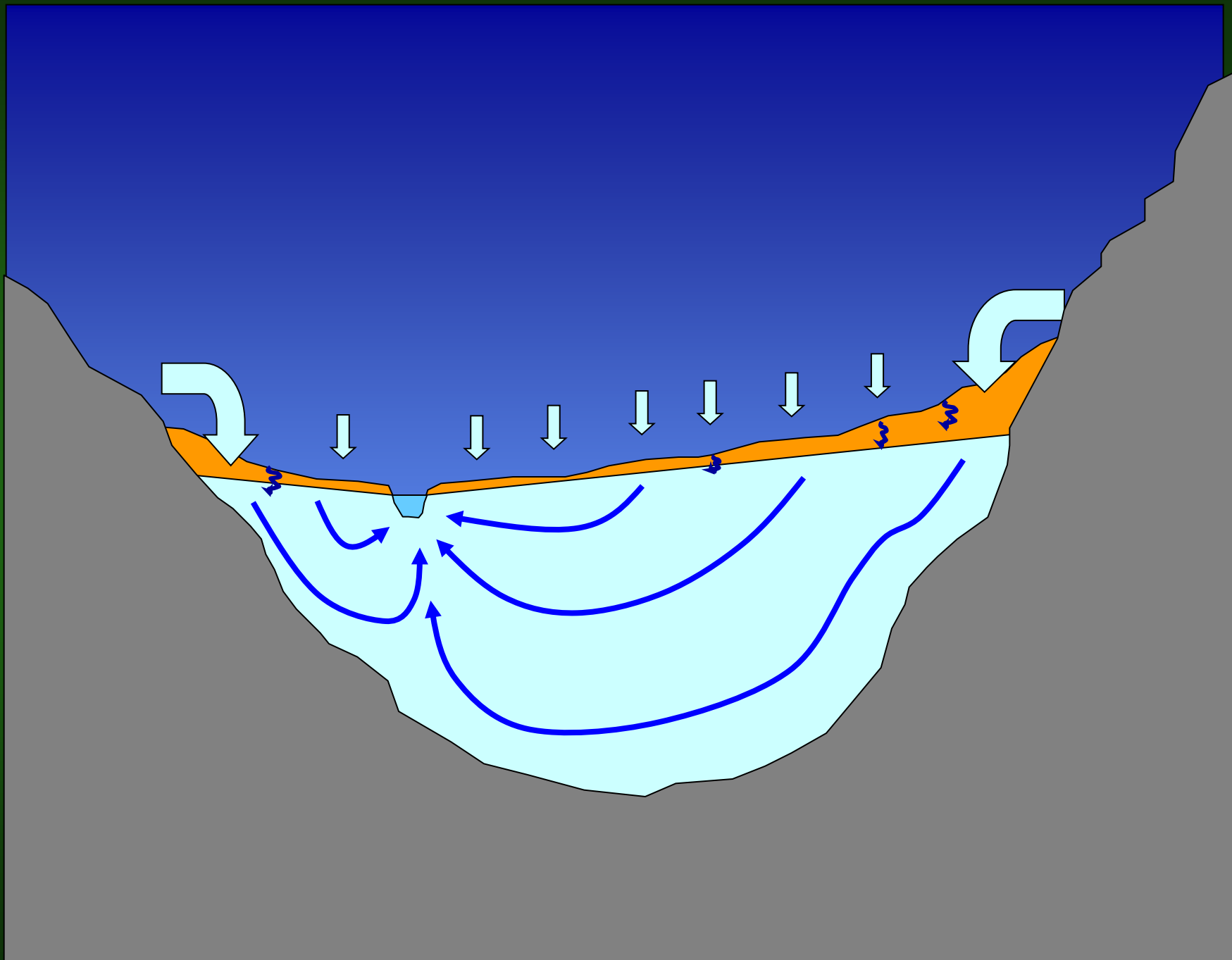


Vernal Pools

aka

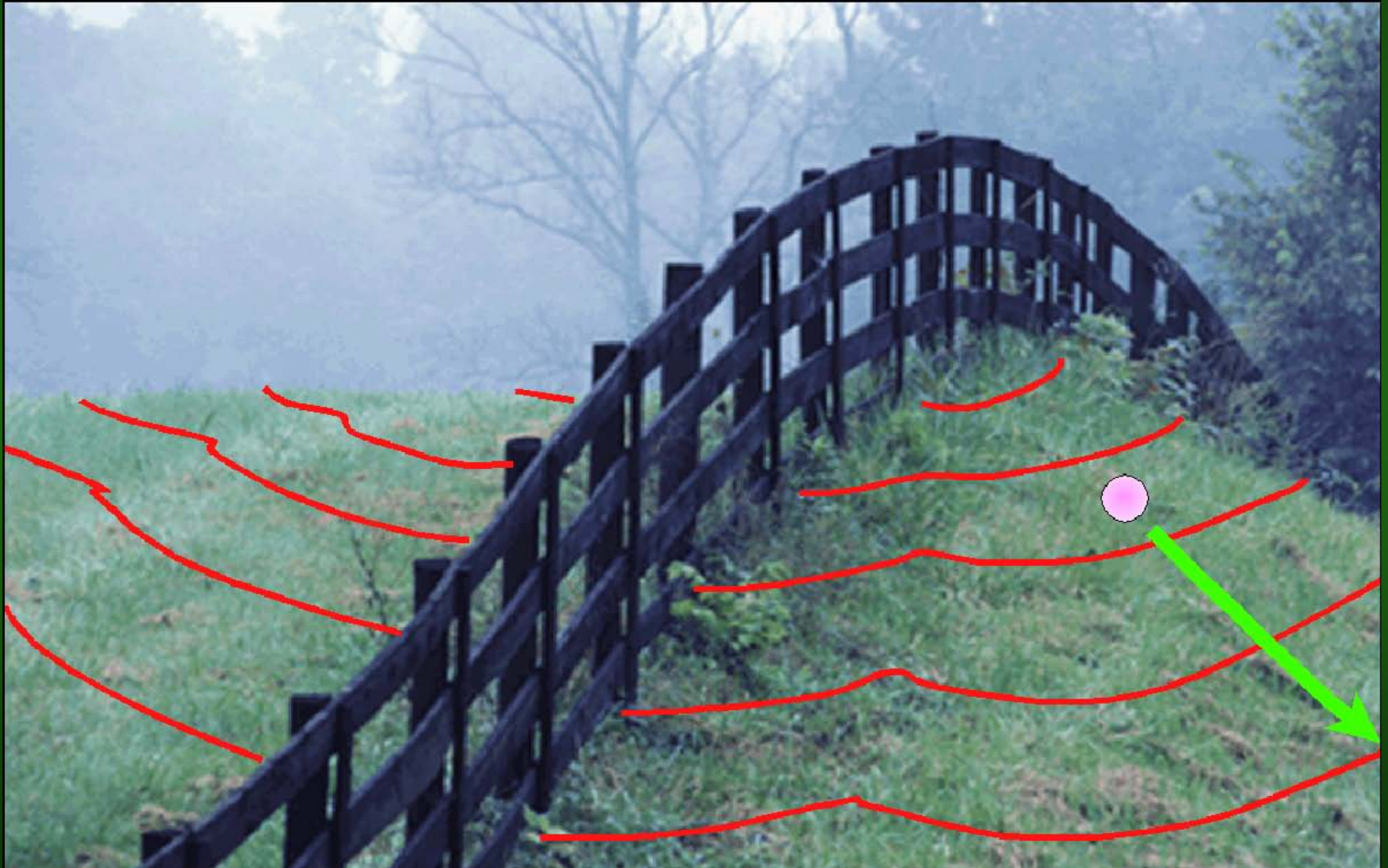
Seasonal Wetlands







Direction of Groundwater Flow?





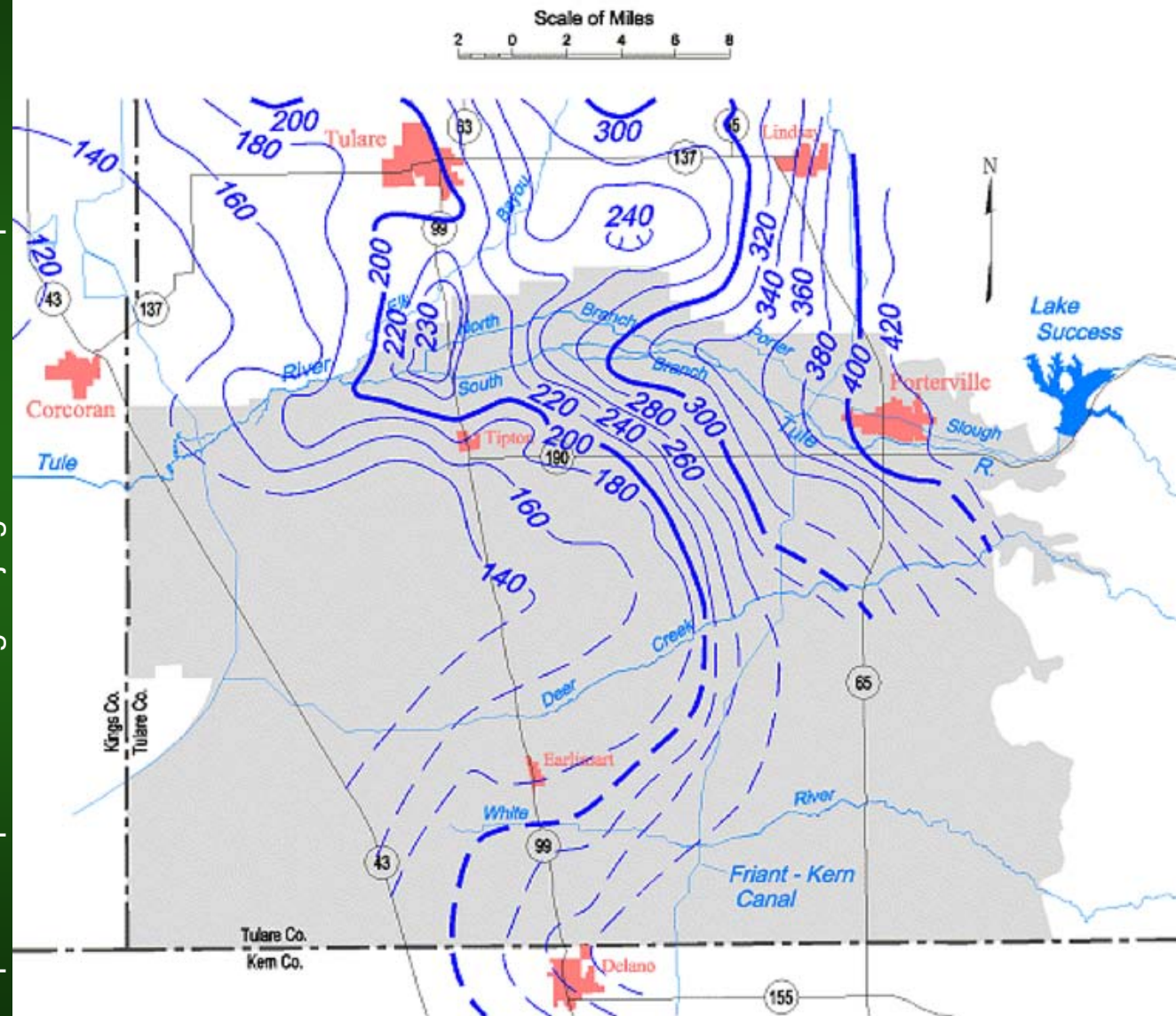
Direction of Regional GW Flow

Map from:

<http://www.dpla.water.ca.gov/sjd/groundwater/tle-emap99.html>

Tule Groundwater Basin

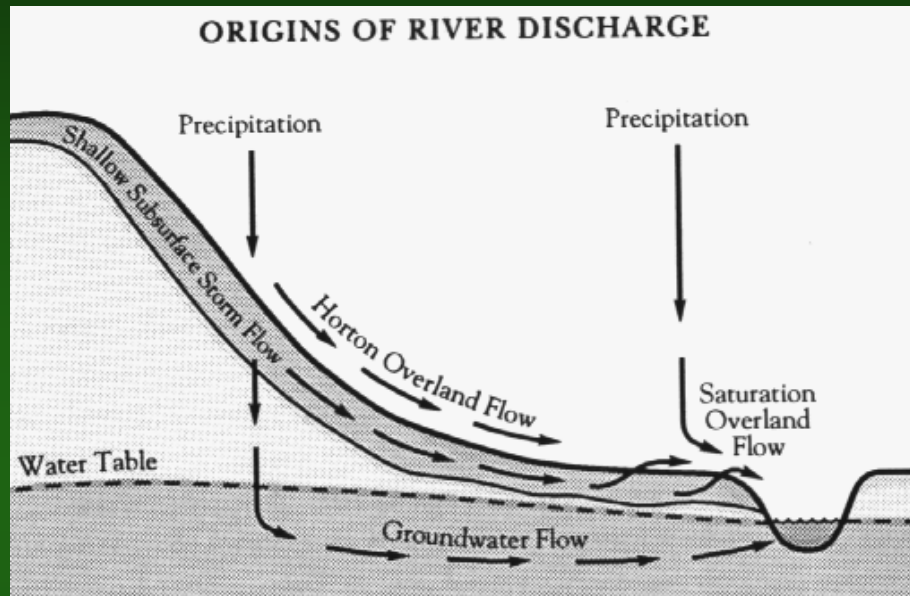
Spring 1999, Lines of Equal Elevation of
Water in Wells, Unconfined Aquifer



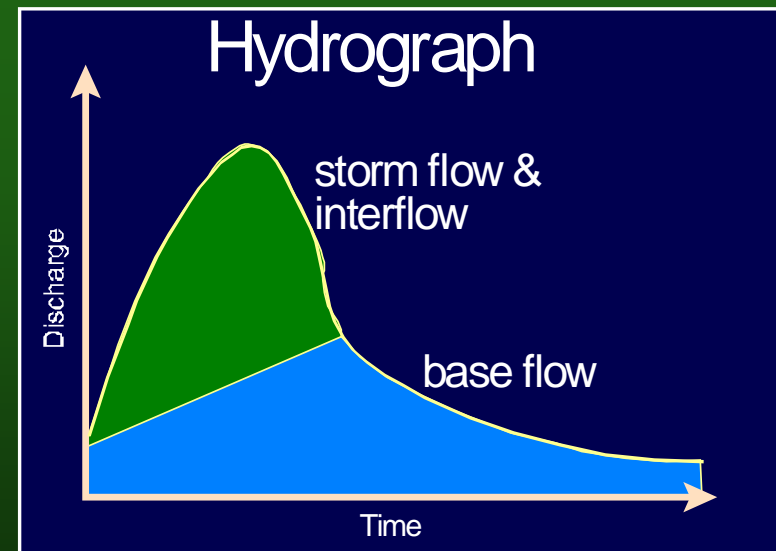
Contours are dashed where inferred. Contour interval is 10 and 20 feet.

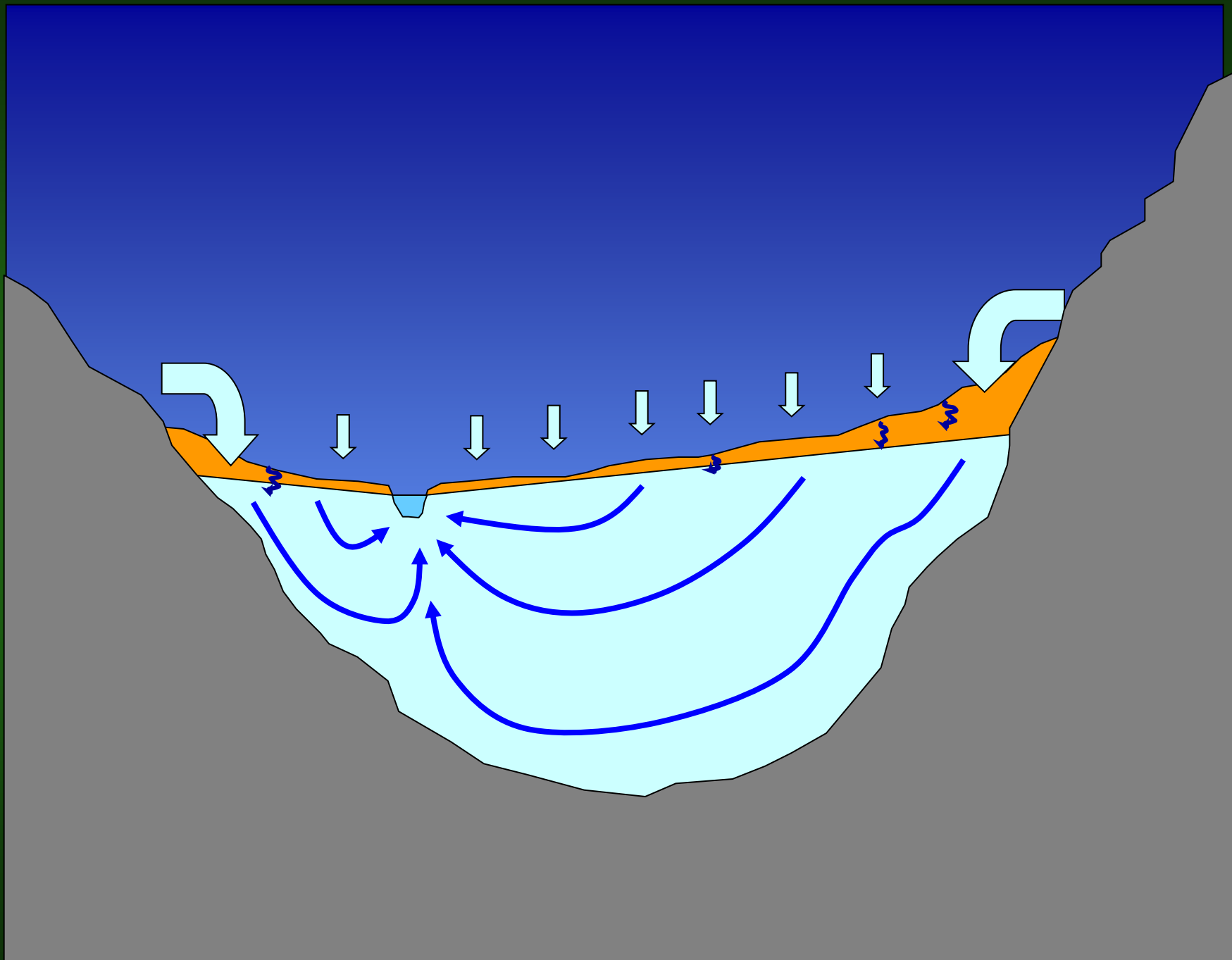


The Classic Hydrology View



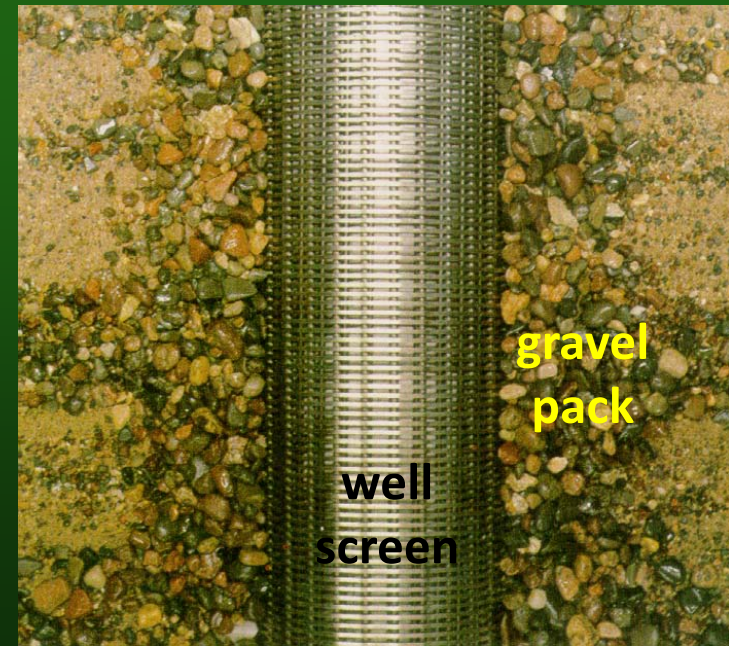
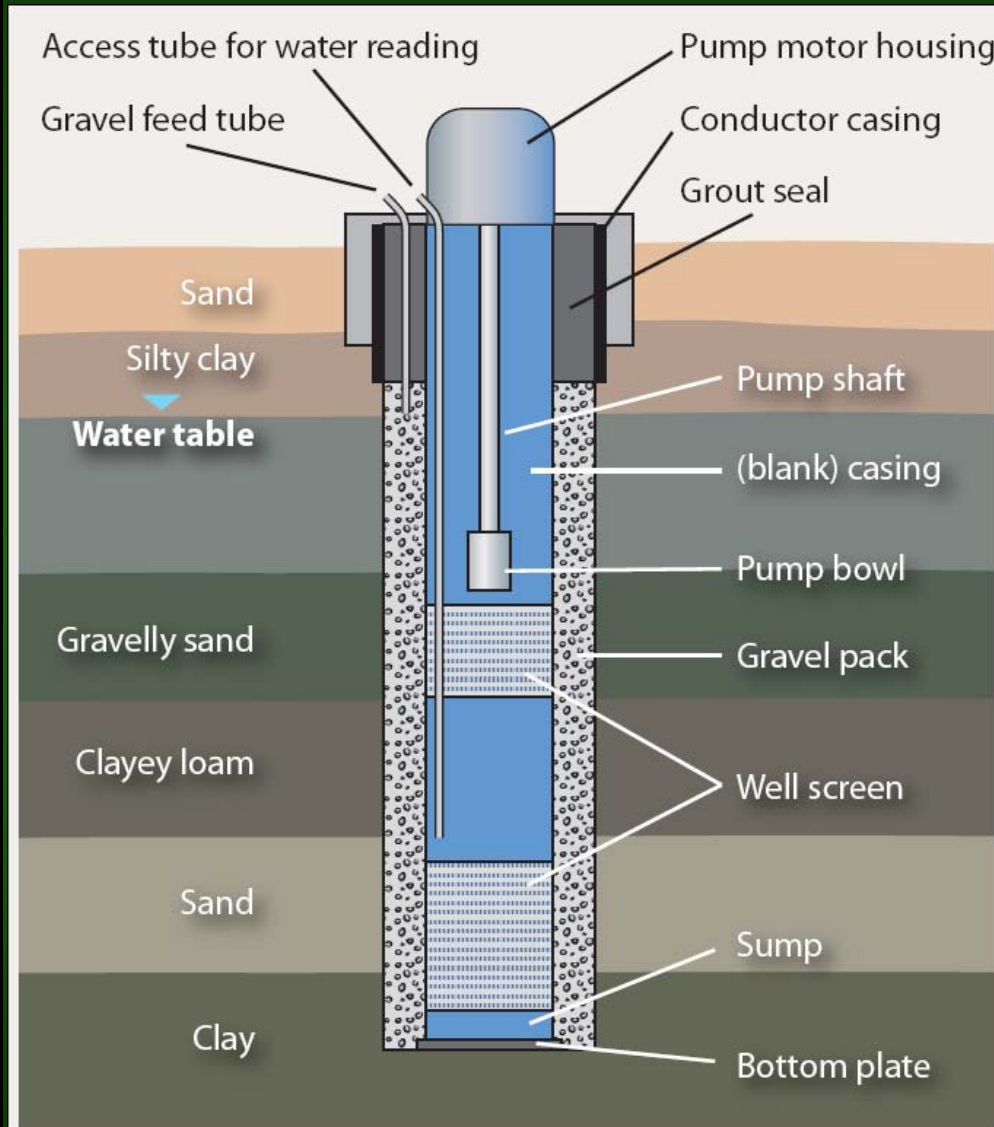
From: Jeff Mount "California Rivers and Streams"

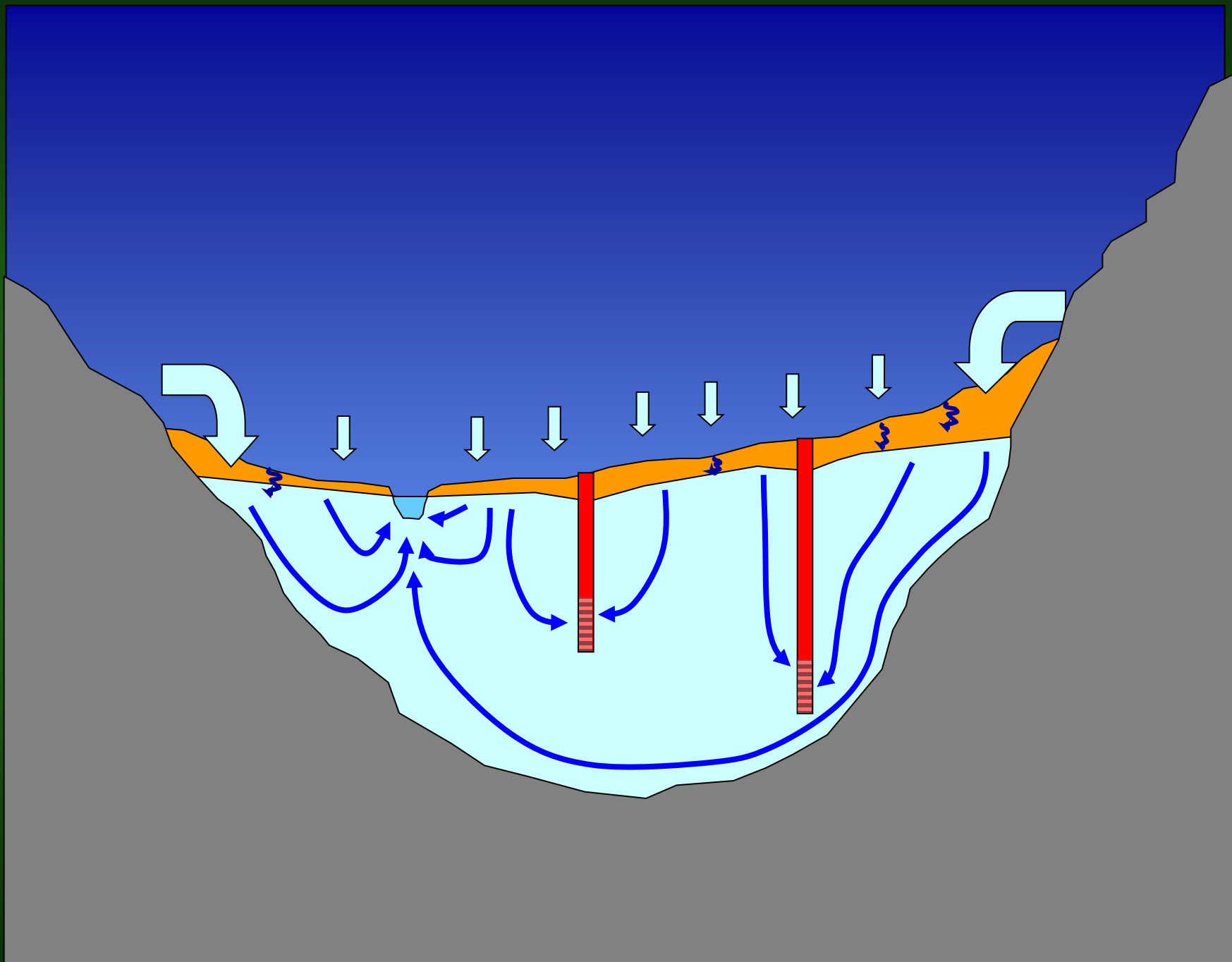






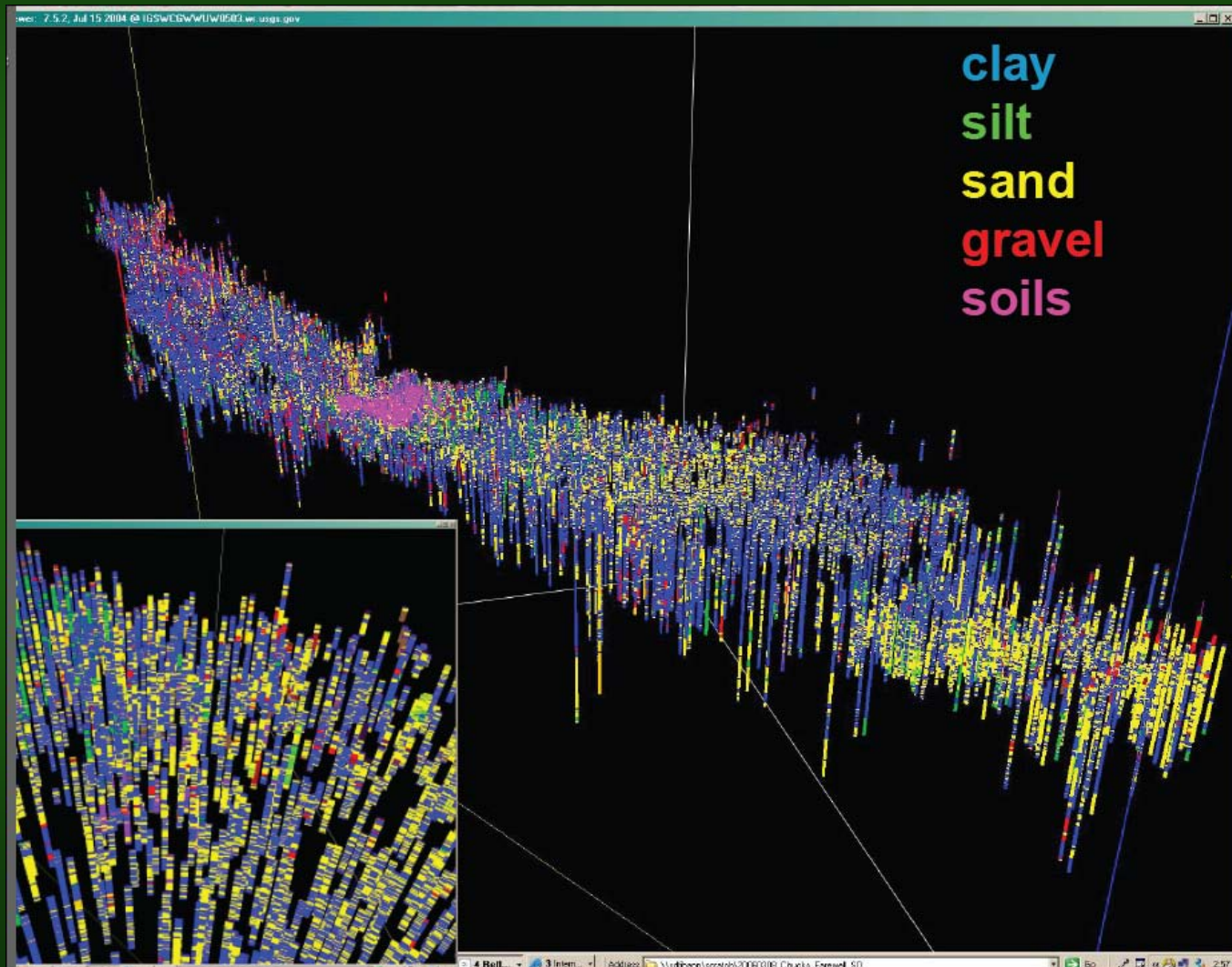
A Groundwater Well







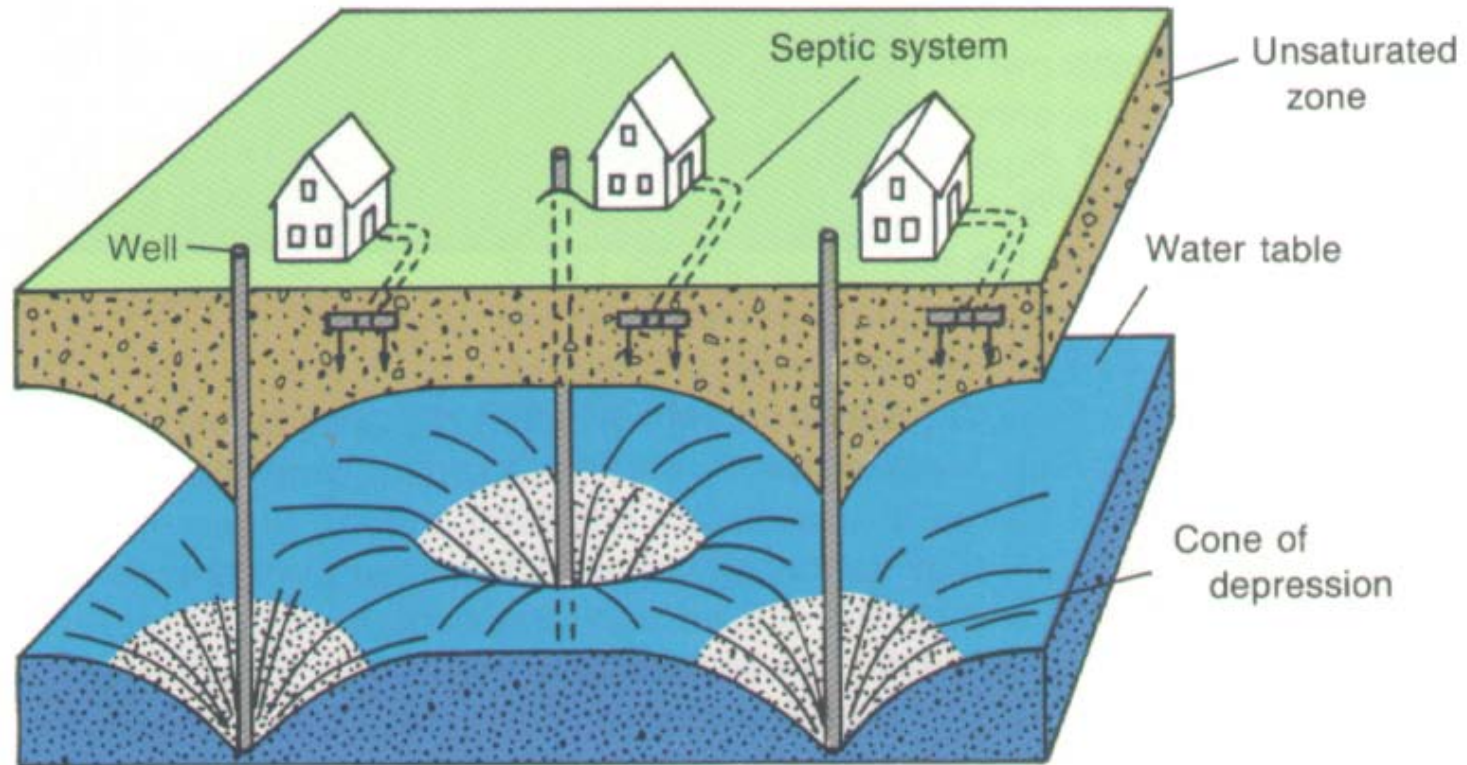
Hydraulic Conductivity from Borehole Logs (Estimated)



Courtesy, Claudia Fawn, USGS, 2008



Cone of Depression near a Well

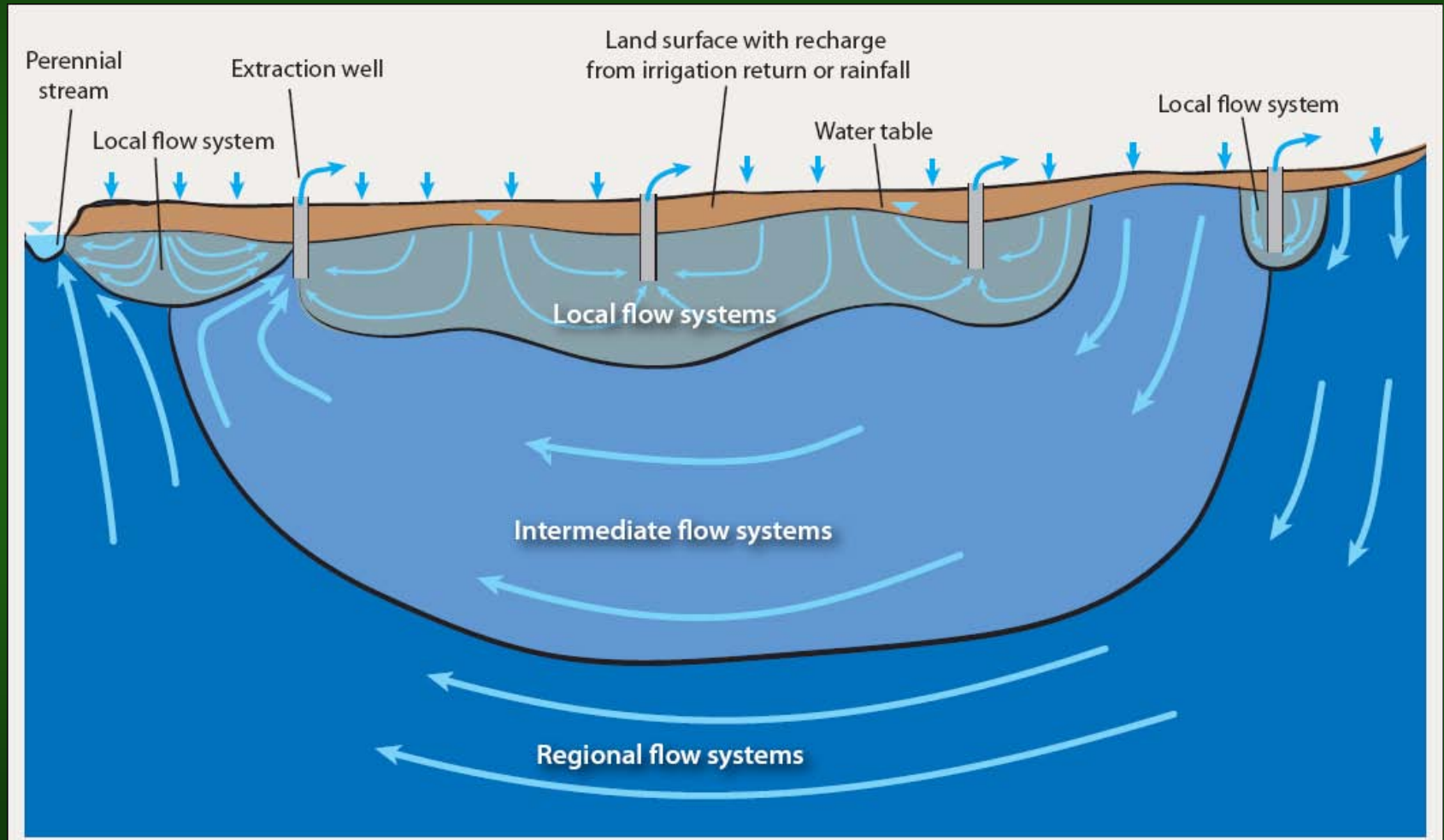


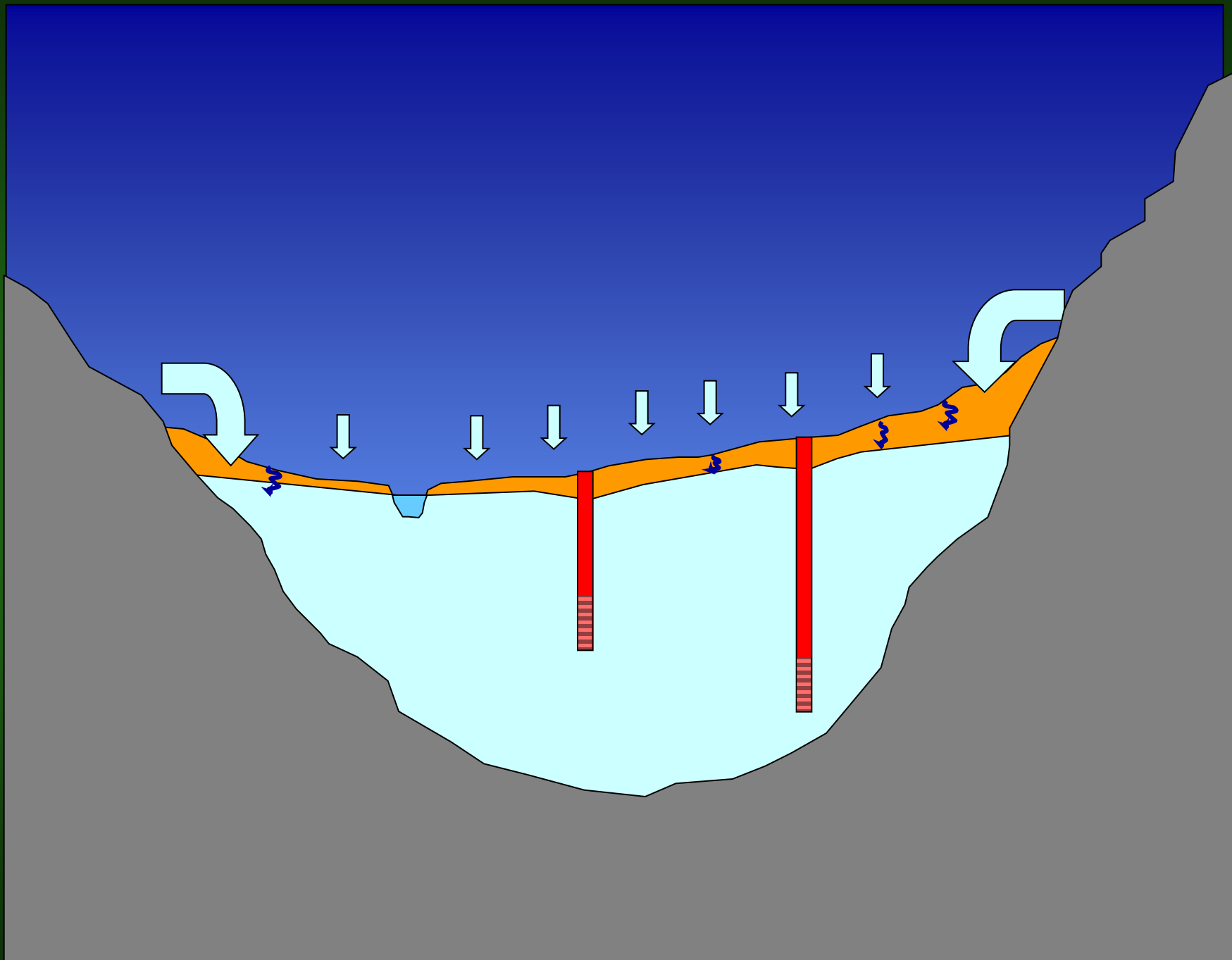
Effect of concentrated housing on ground-water level.

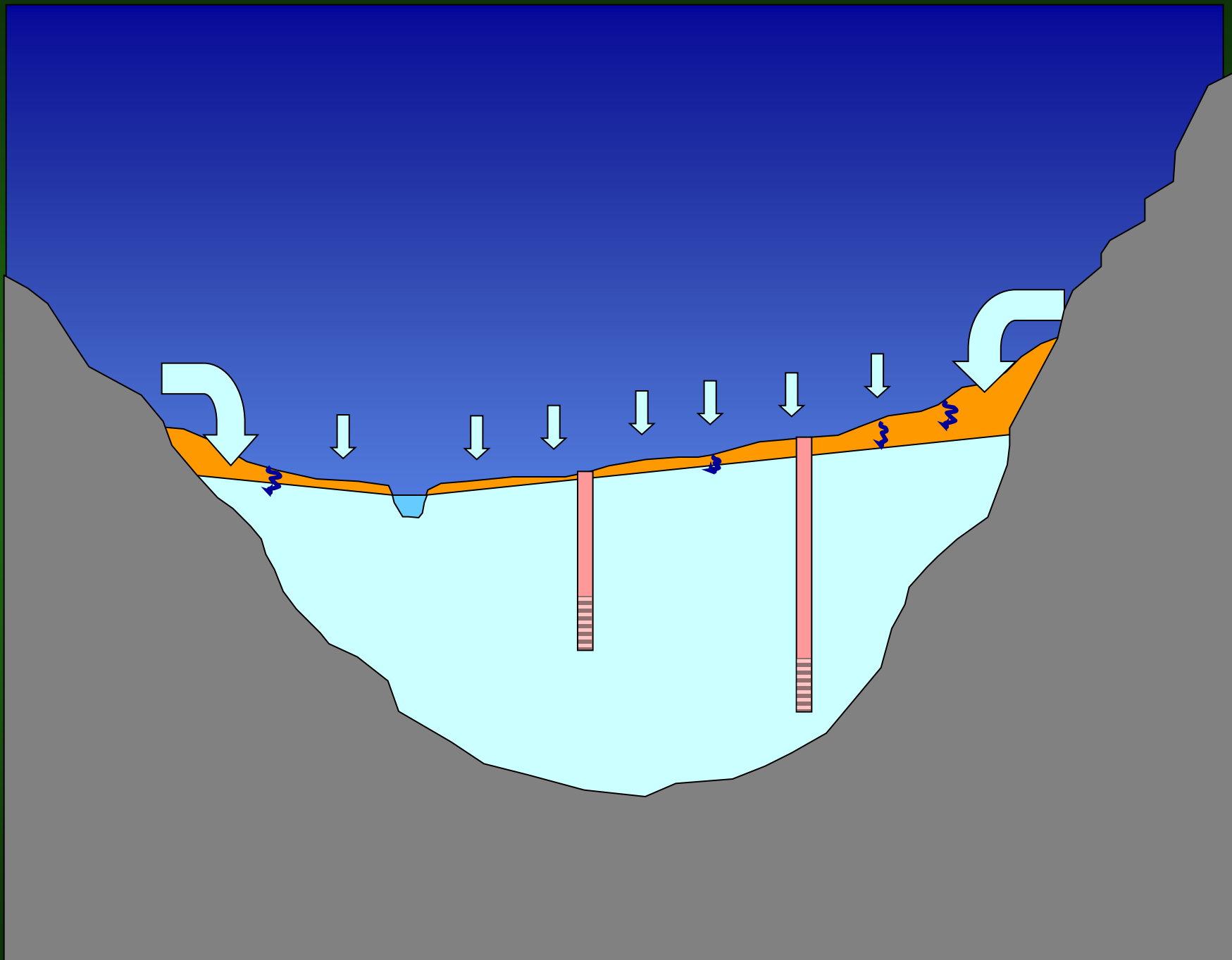
from: U.S. Geological Survey, 'Ground Water and the Rural Homeowner'

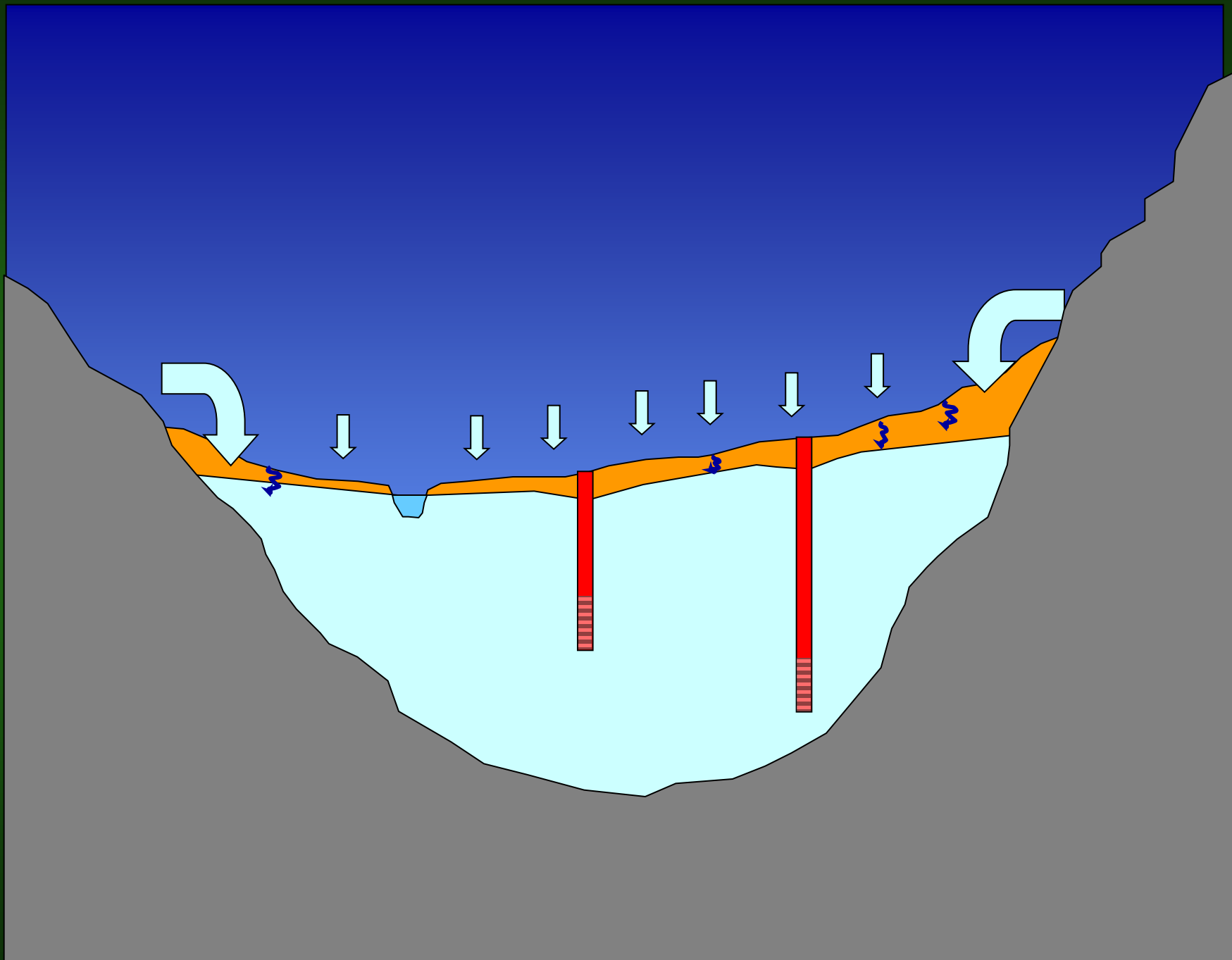


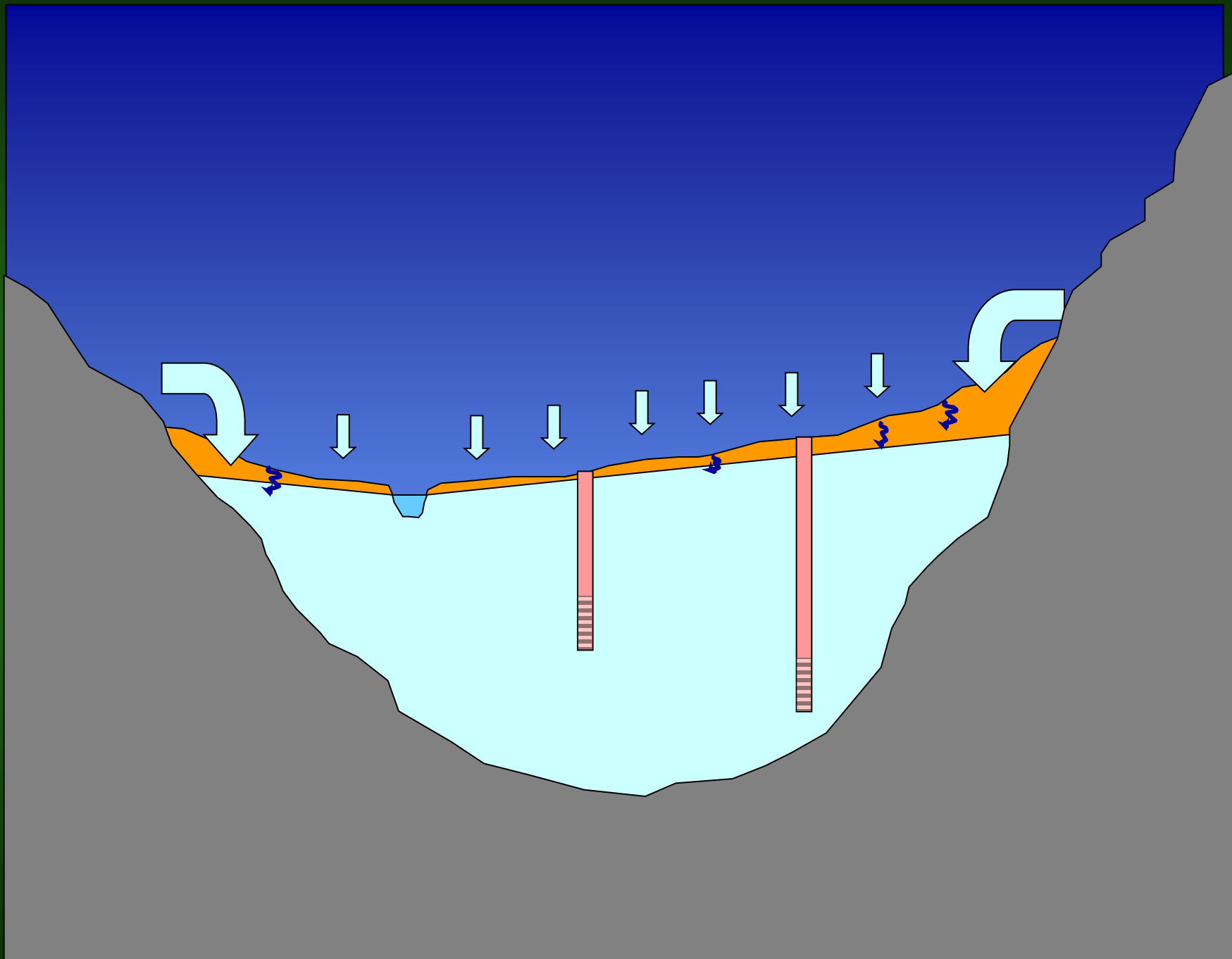
Local & Regional Groundwater Flow

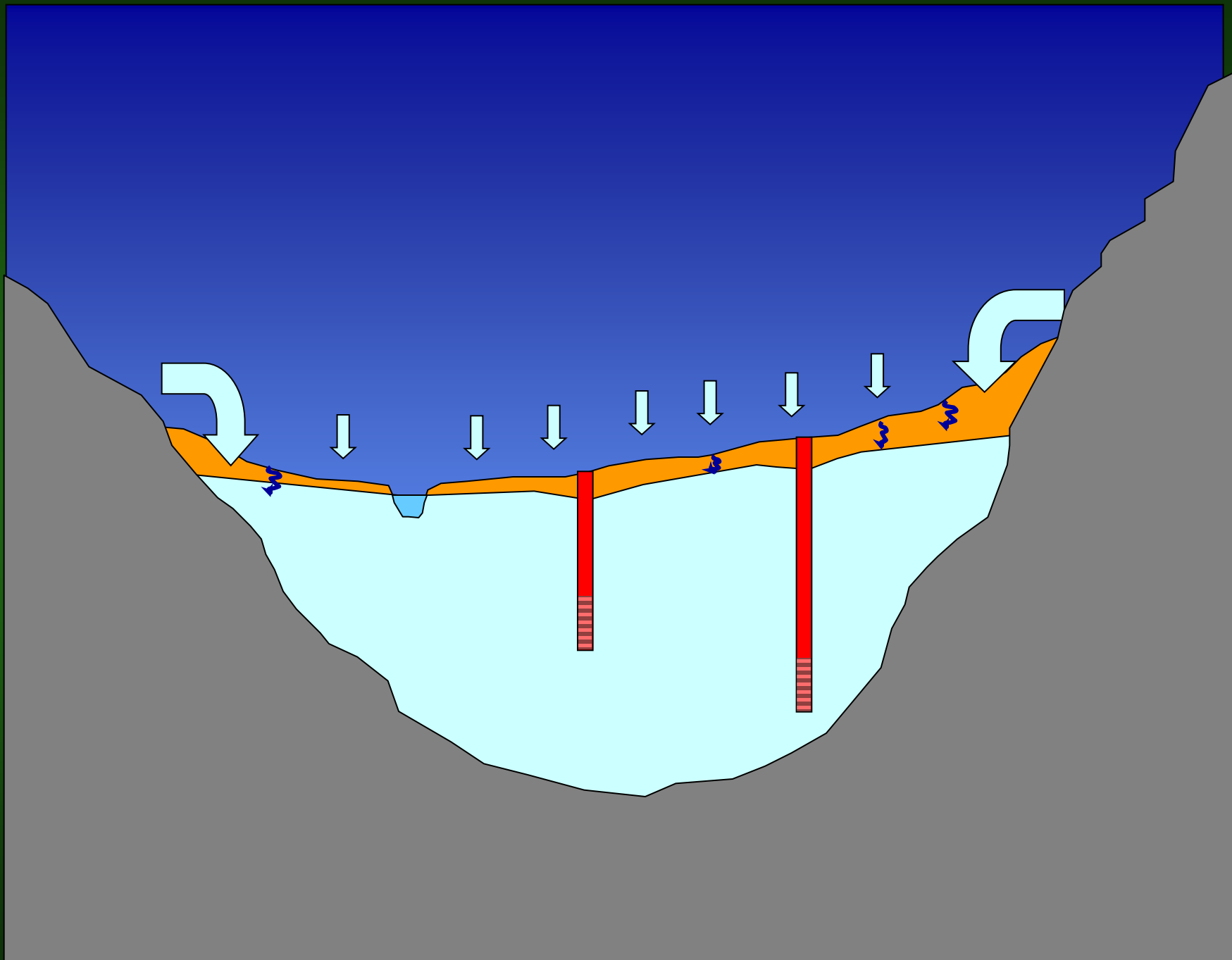


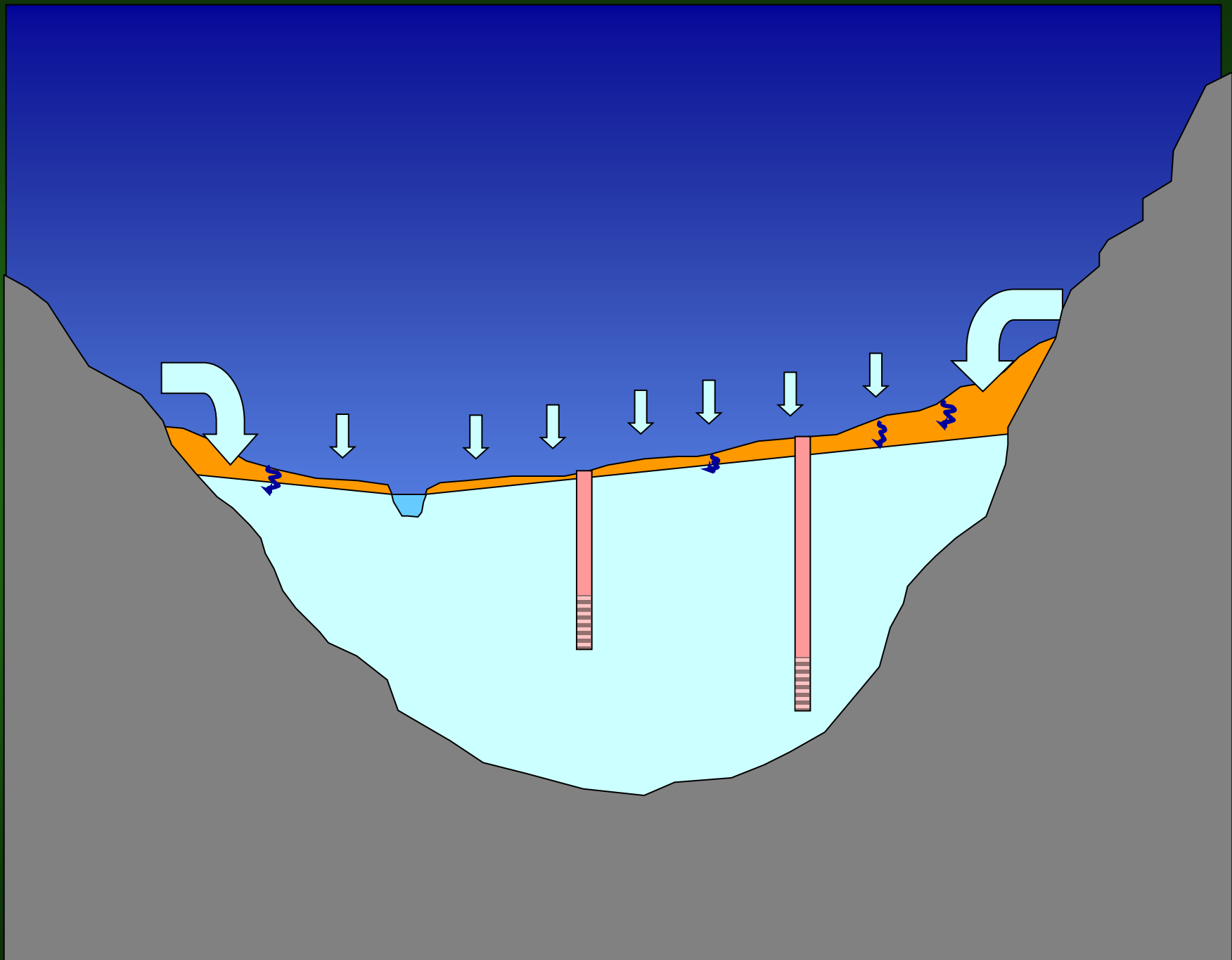


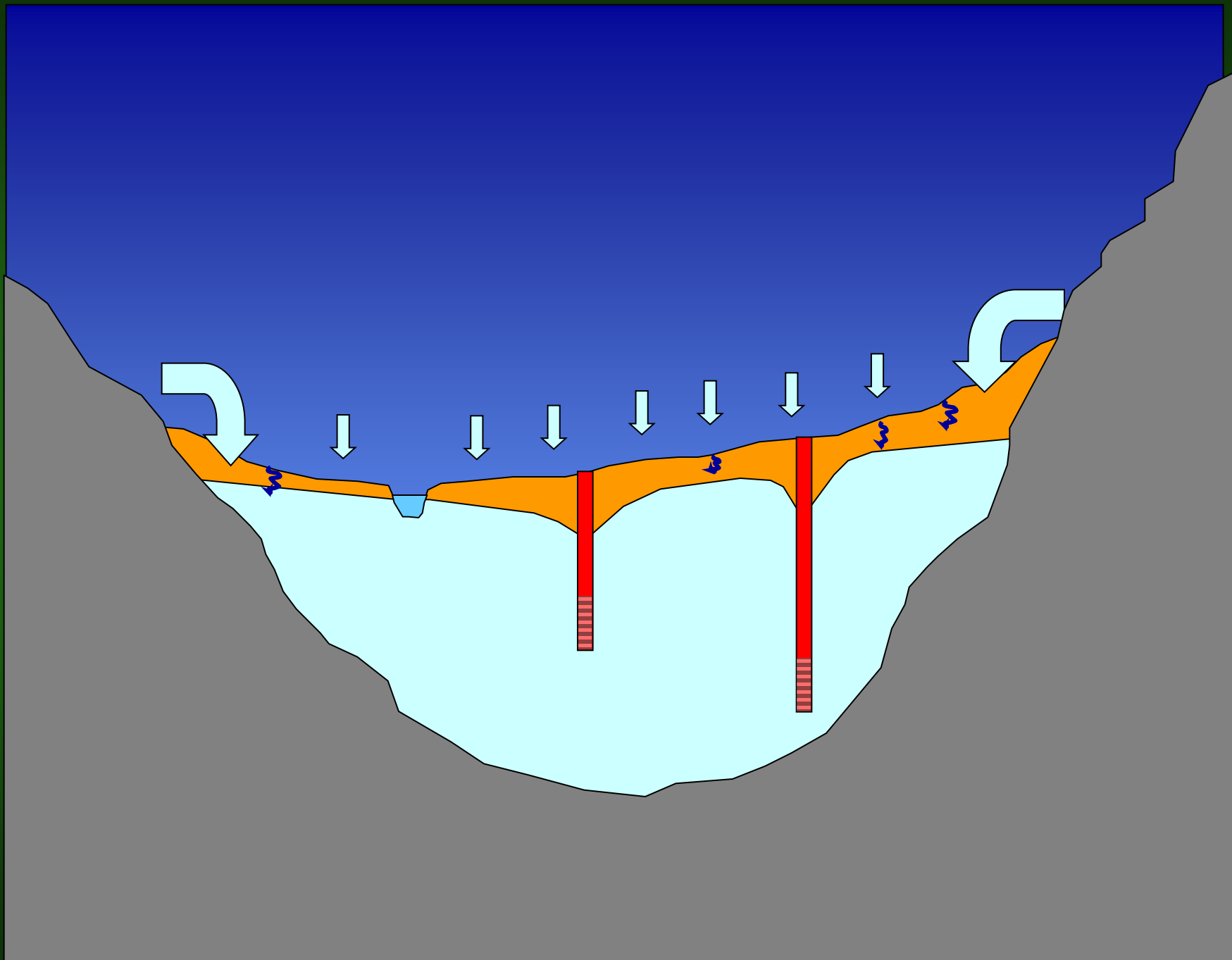


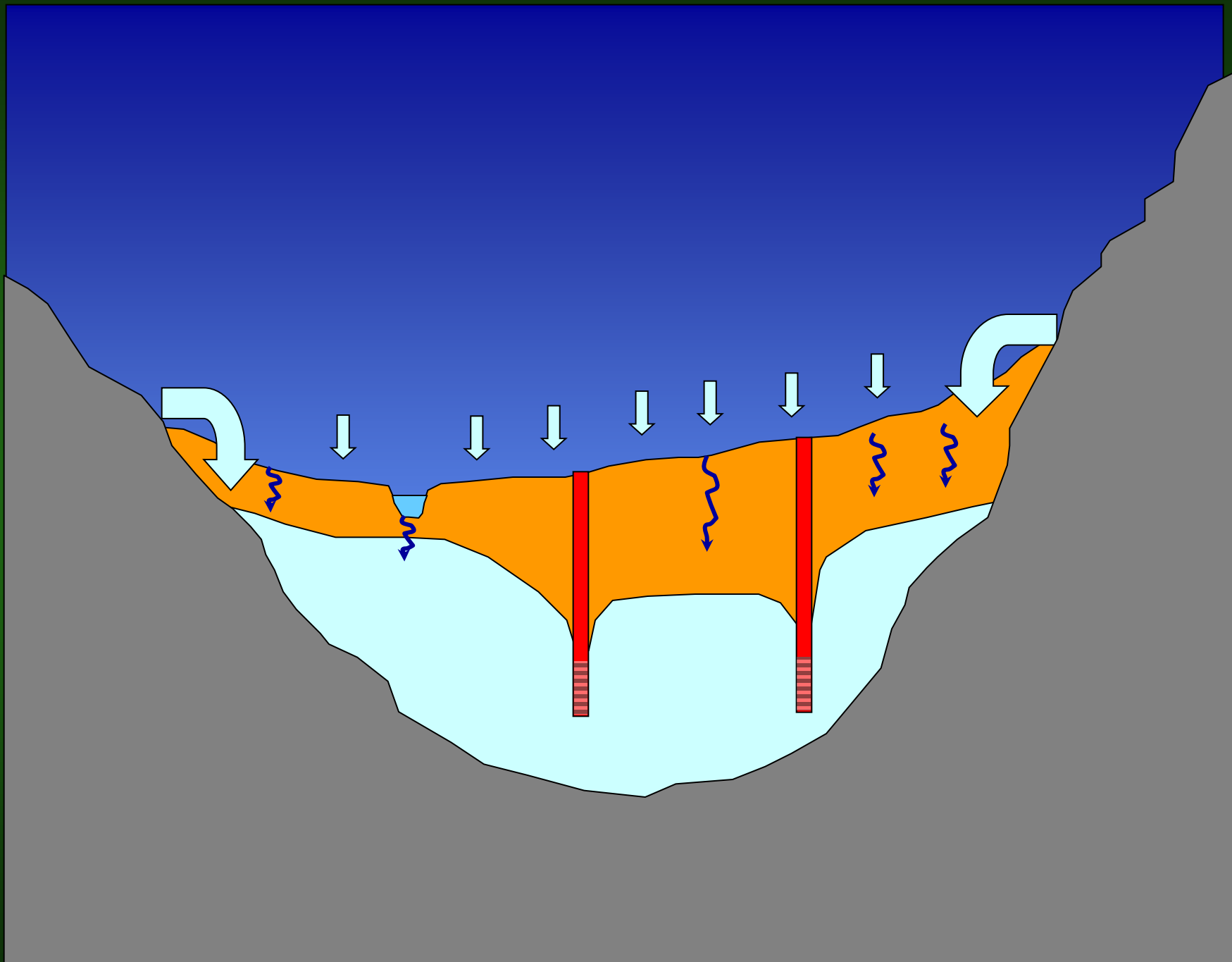


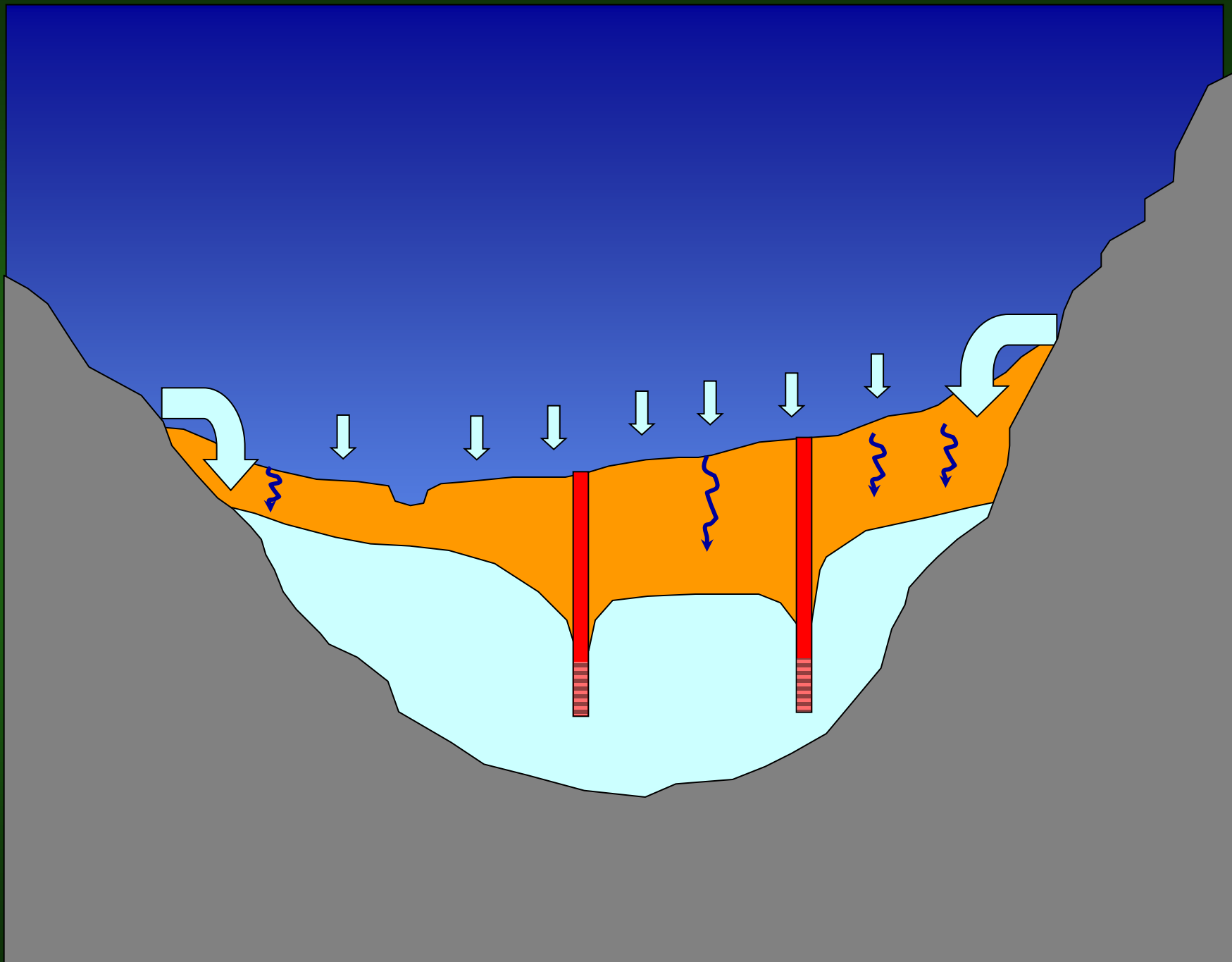














Gaining Stream



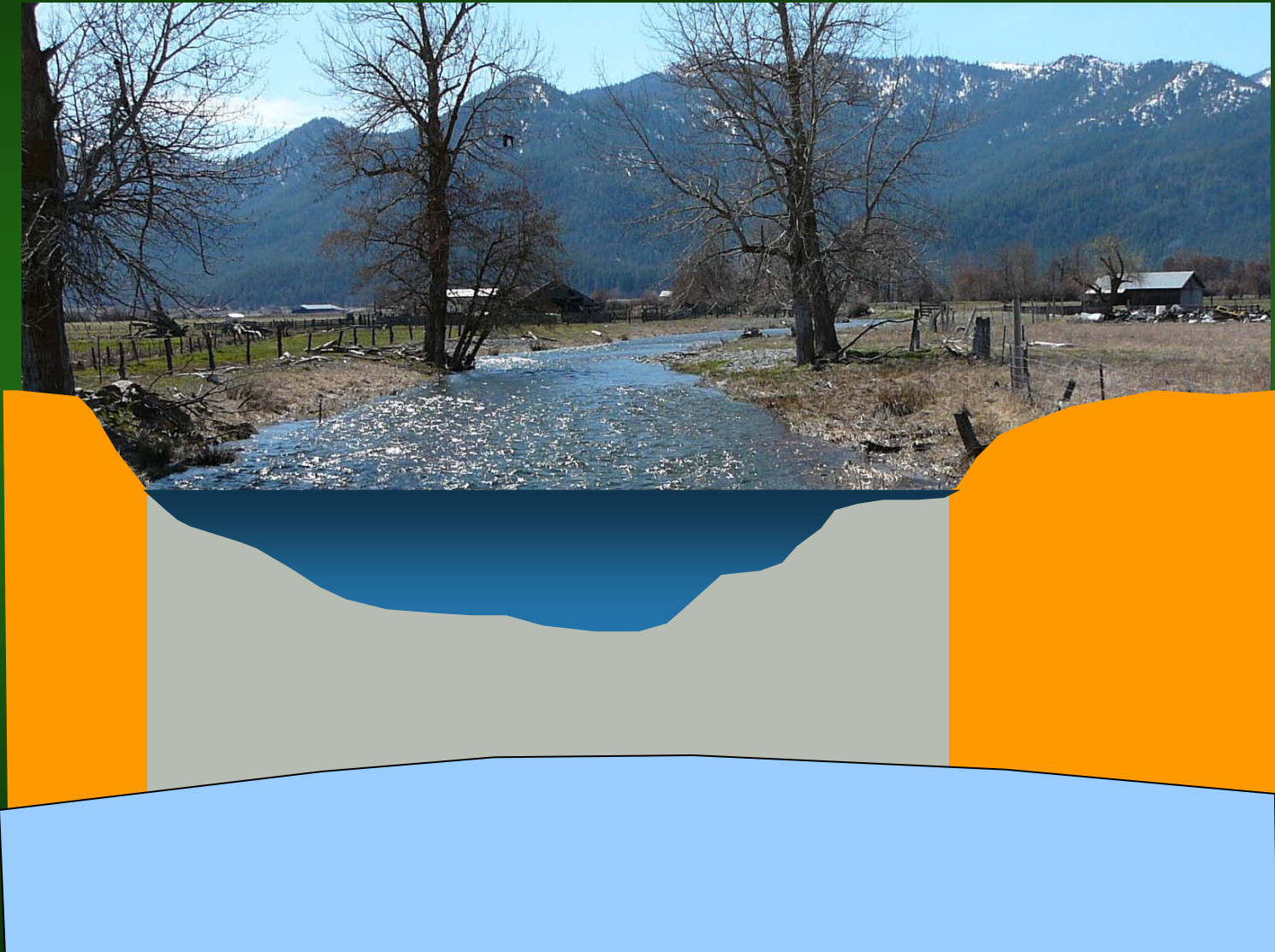


Losing Stream



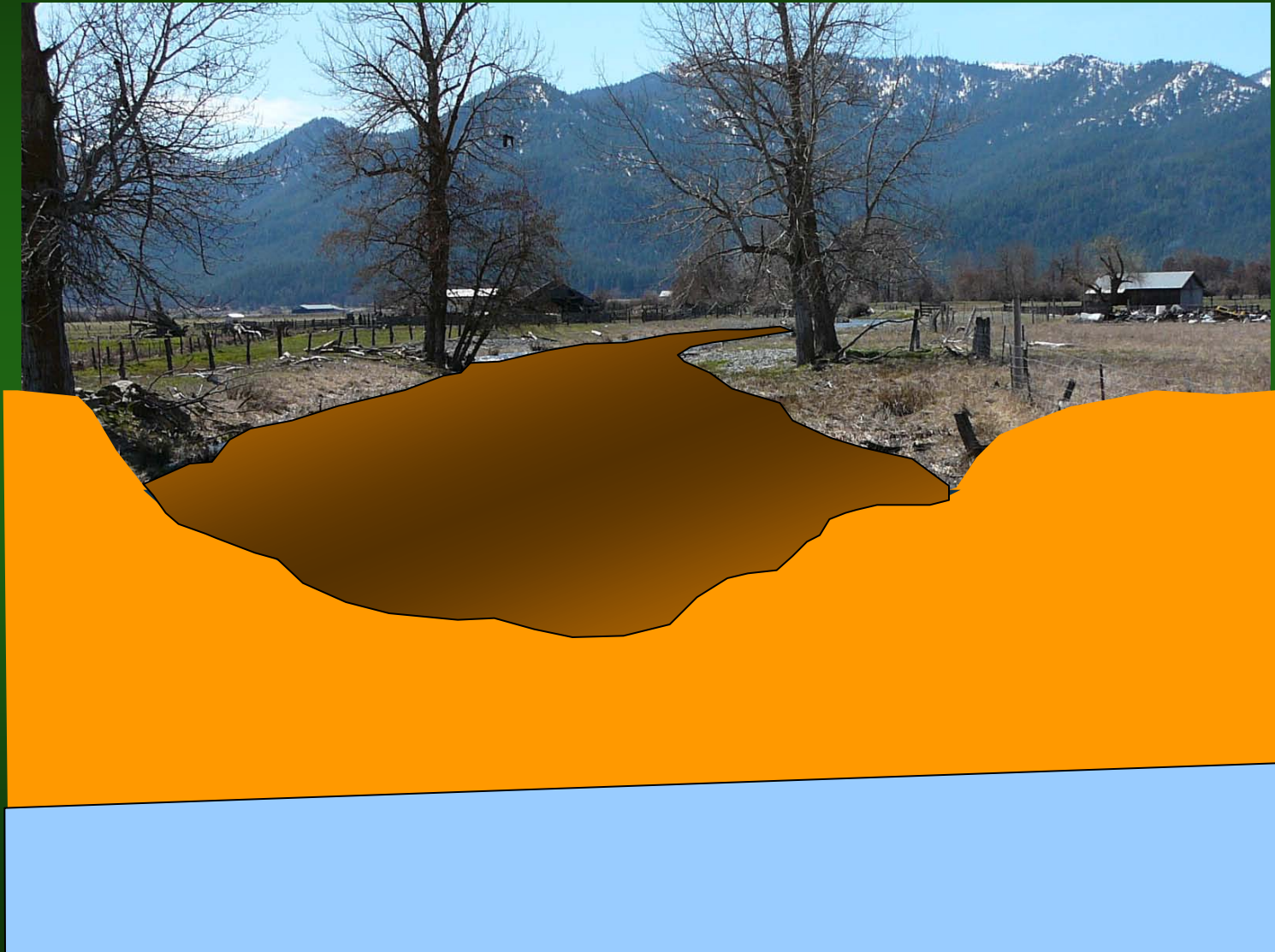


Disconnected Stream





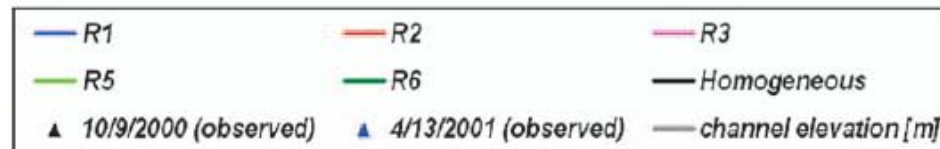
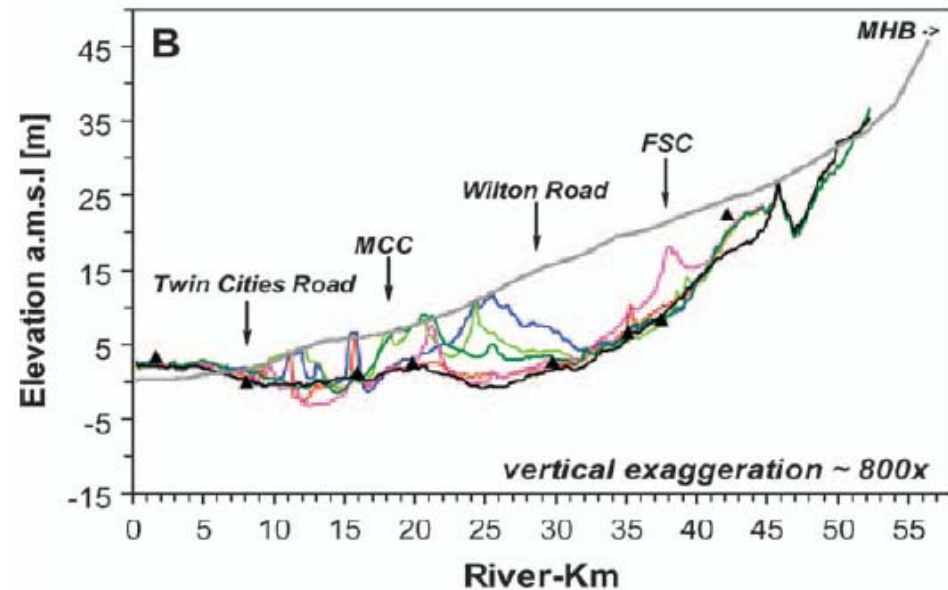
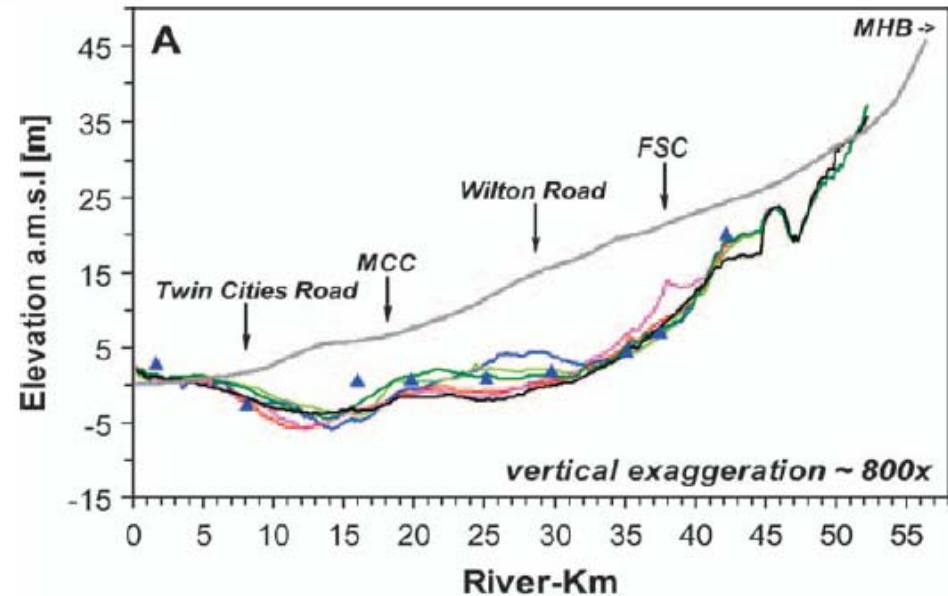
Dry Stream





Reconnecting Groundwater to Surface Water:

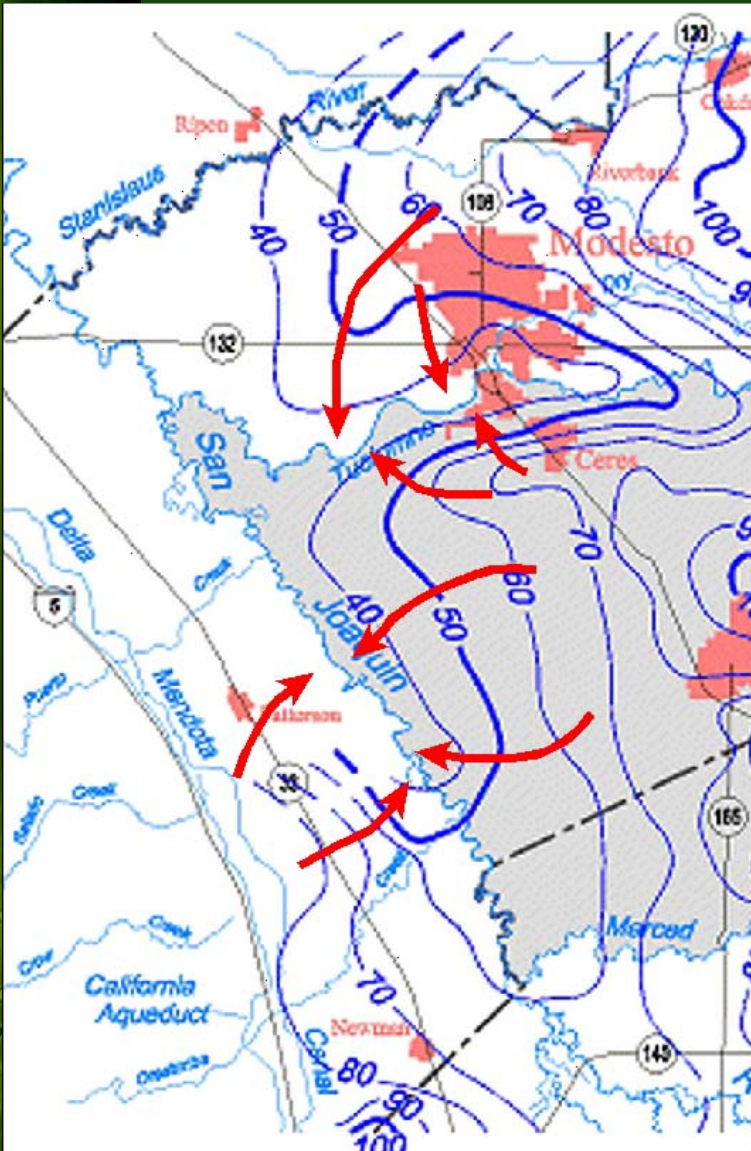
Role of Aquifer Heterogeneity



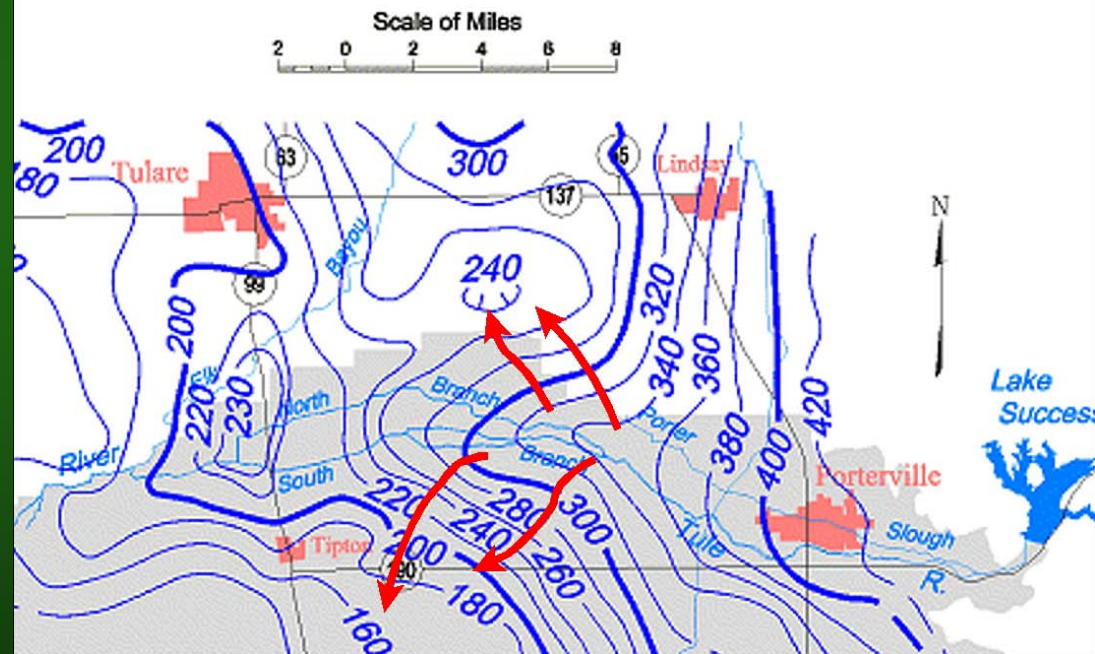


Stream-Aquifer Connection at the Regional Scale

Gaining Stream



Spring 1999, Lines of Equal Elevation of Water in Wells, Unconfined Aquifer



Losing or Disconnected Stream

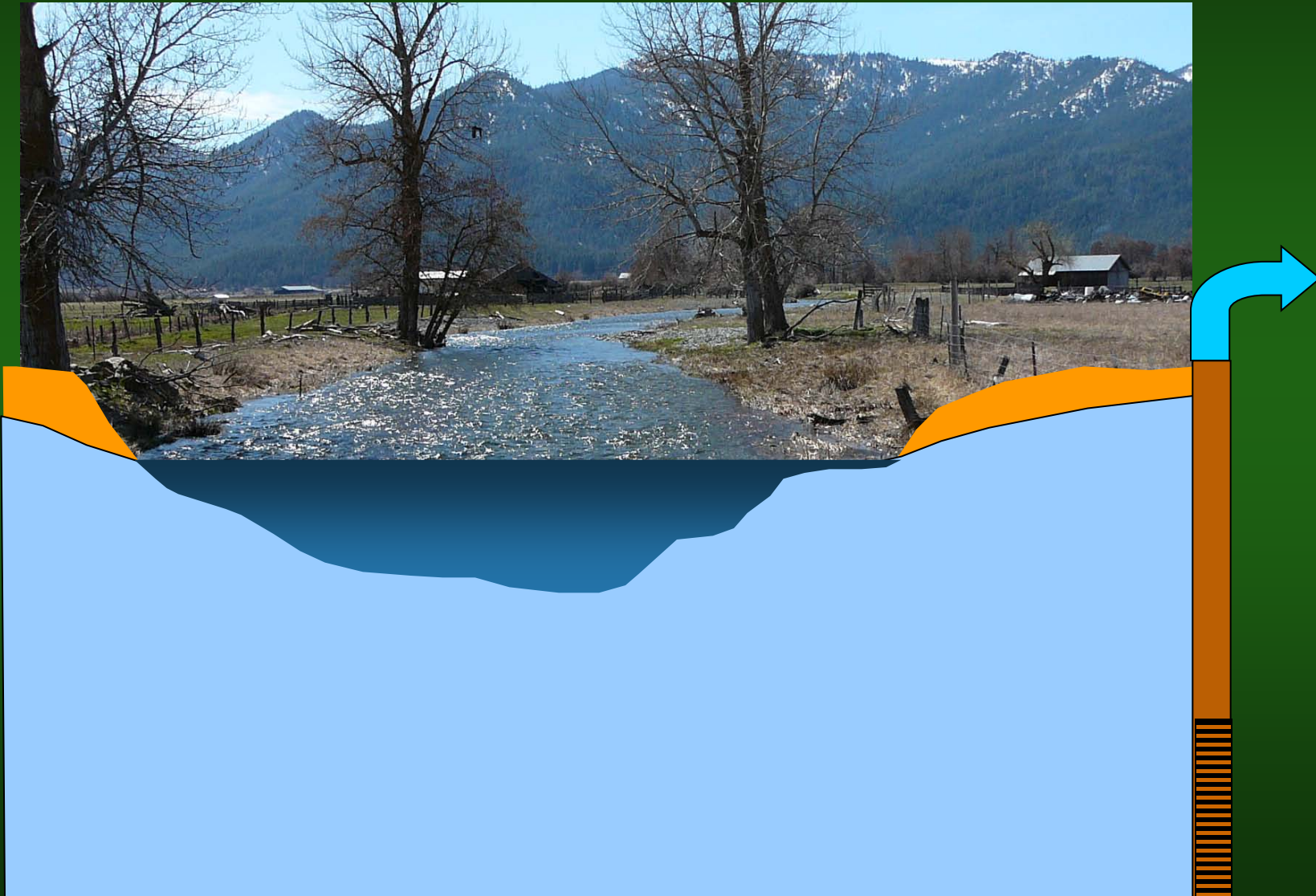


Well Near a Stream





Well Near a Stream



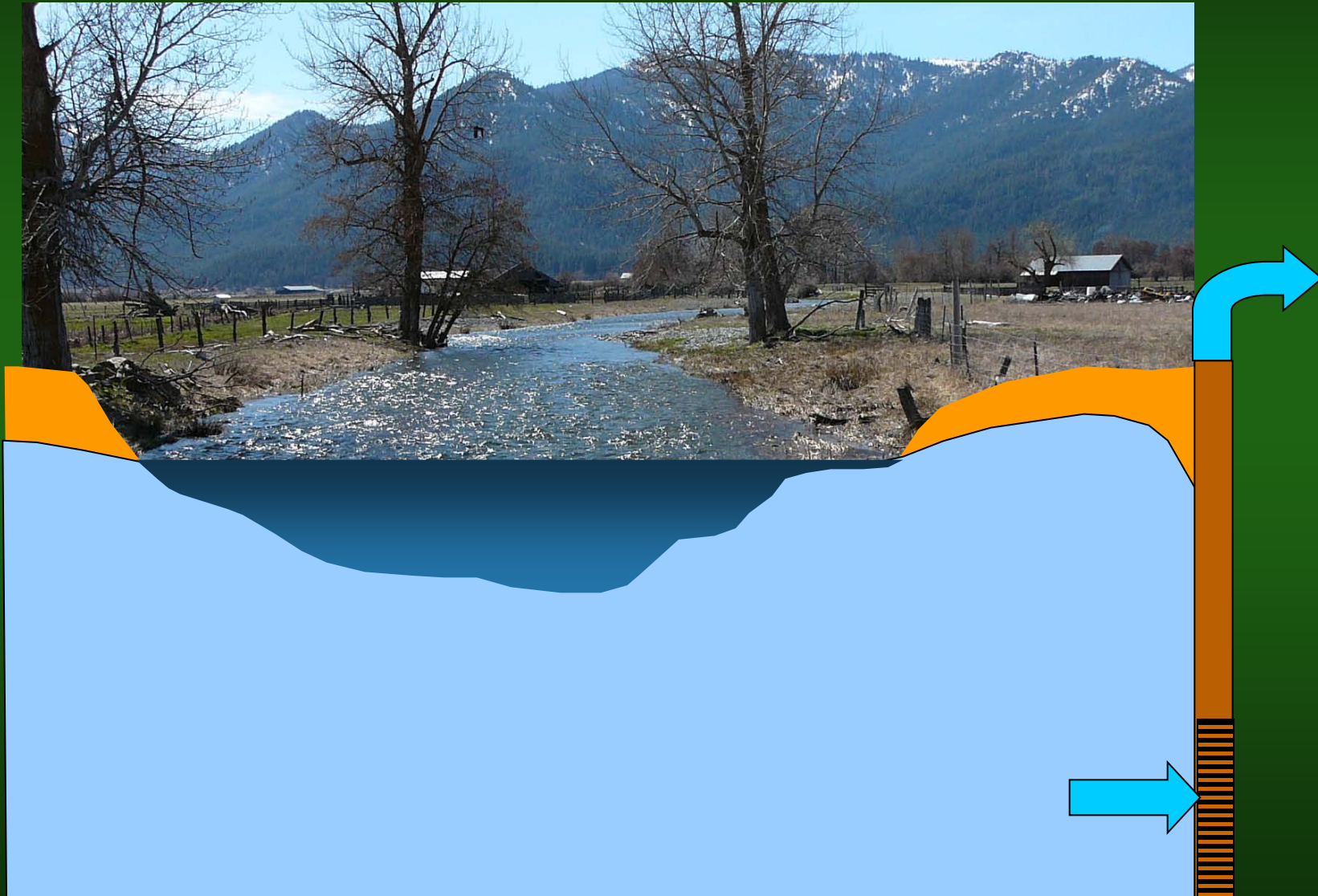


Well Near a Stream



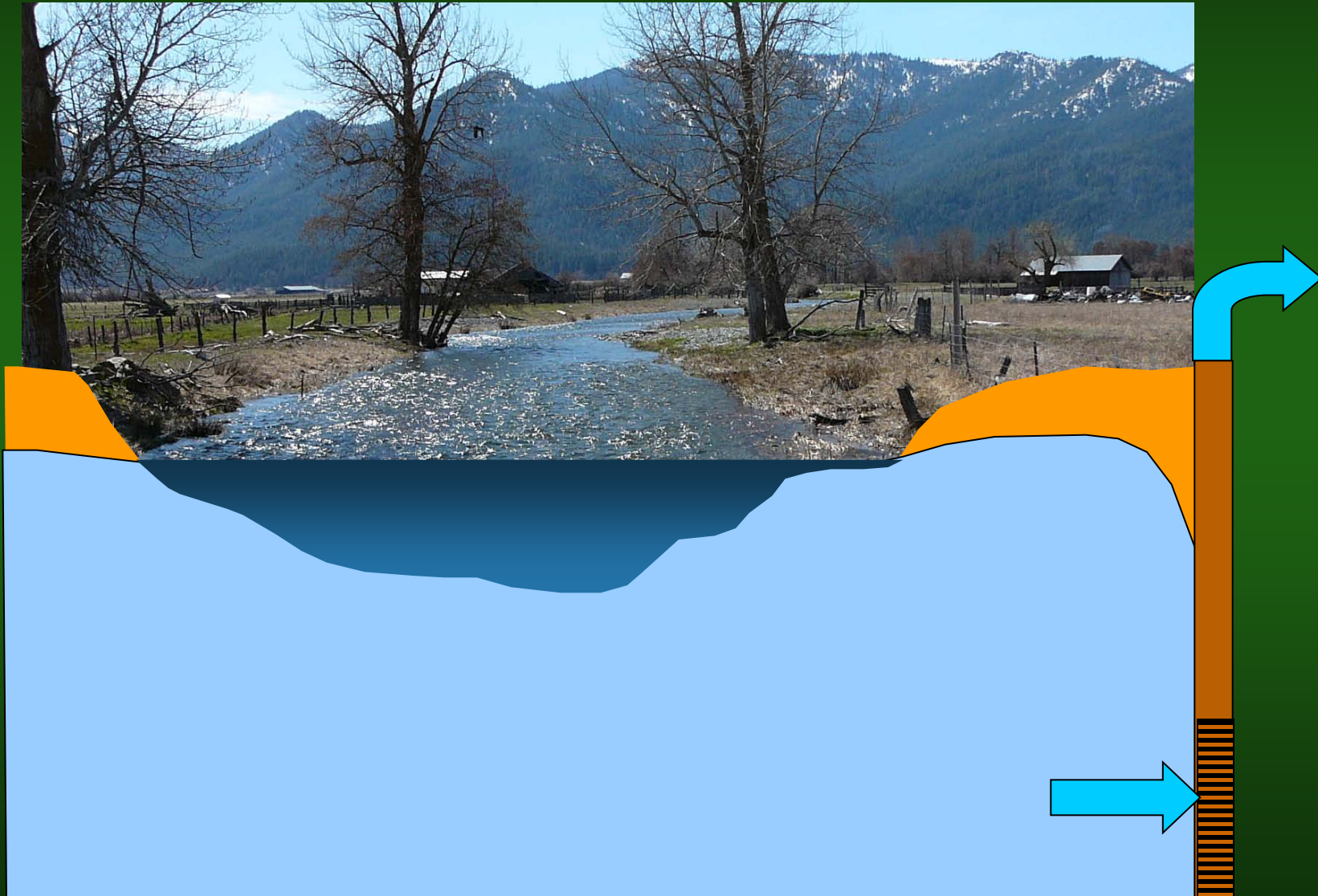


Well Near a Stream



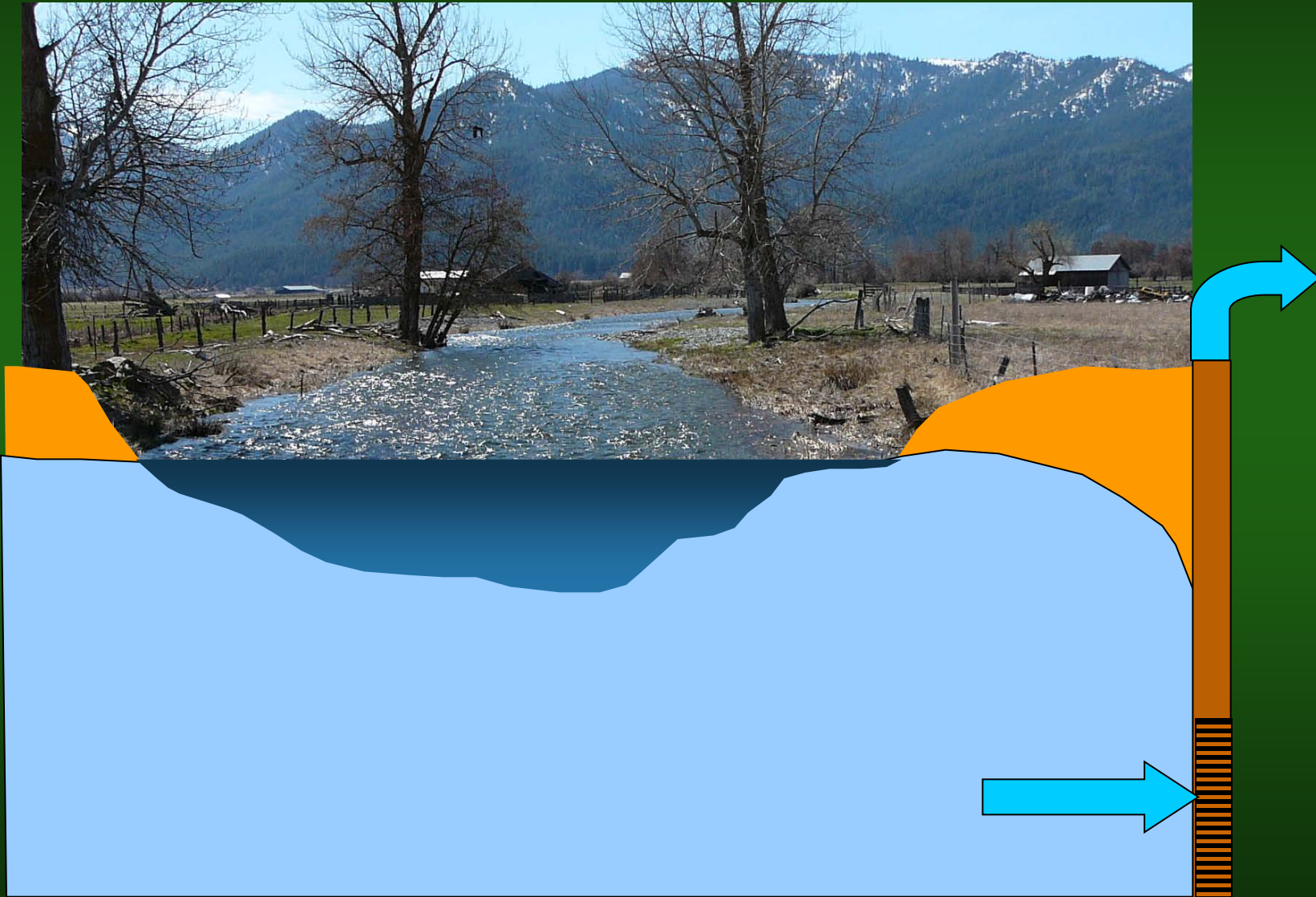


Well Near a Stream



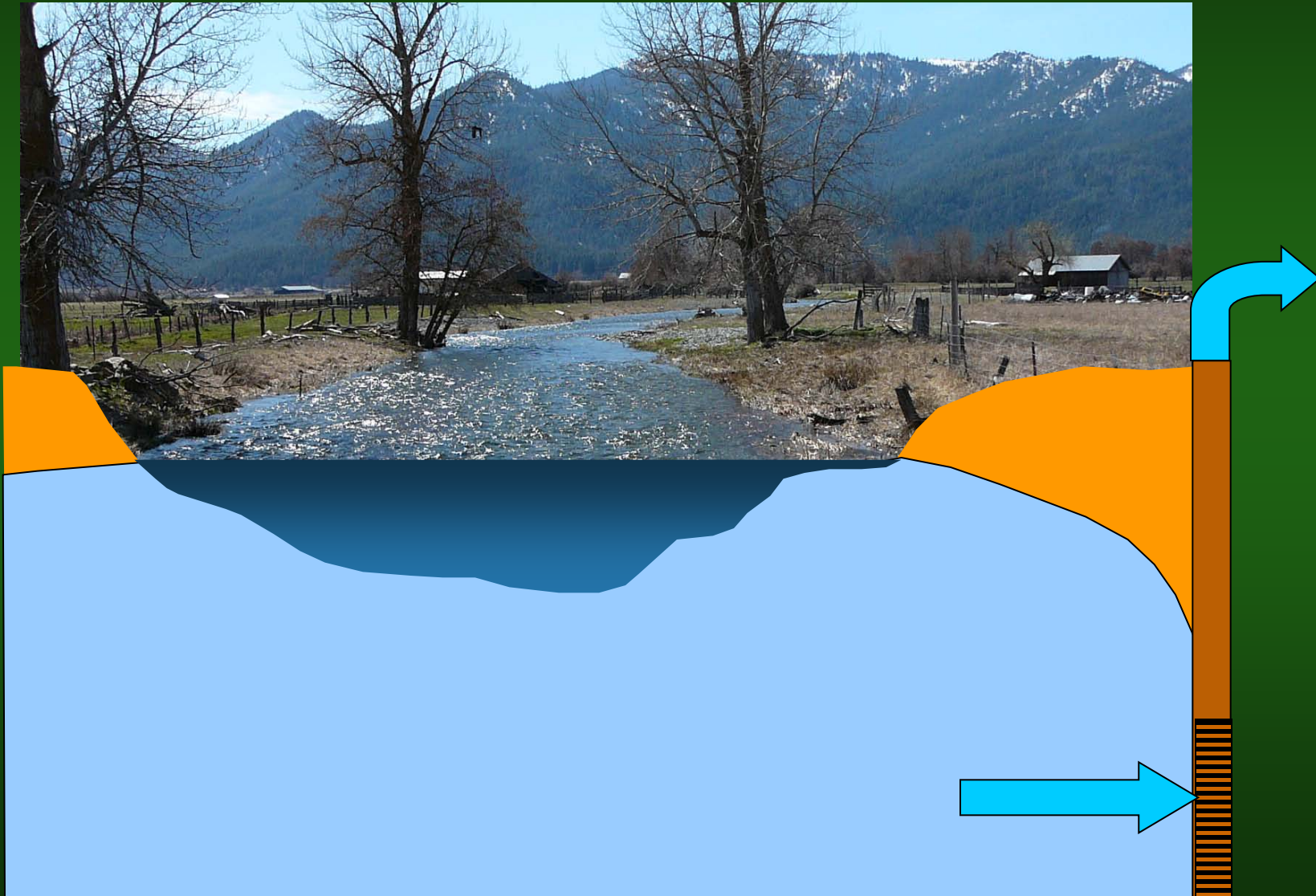


Well Near a Stream



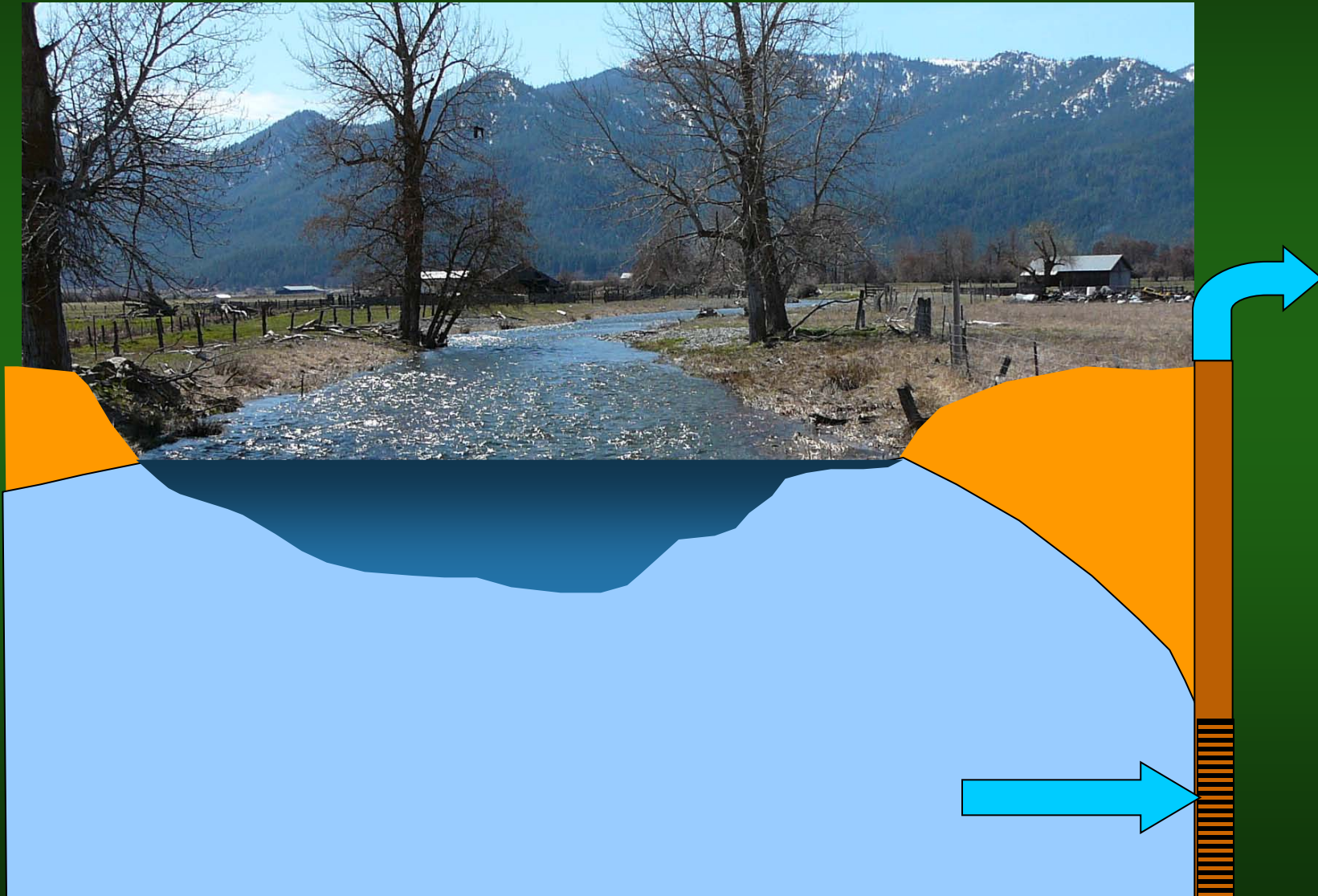


Well Near a Stream



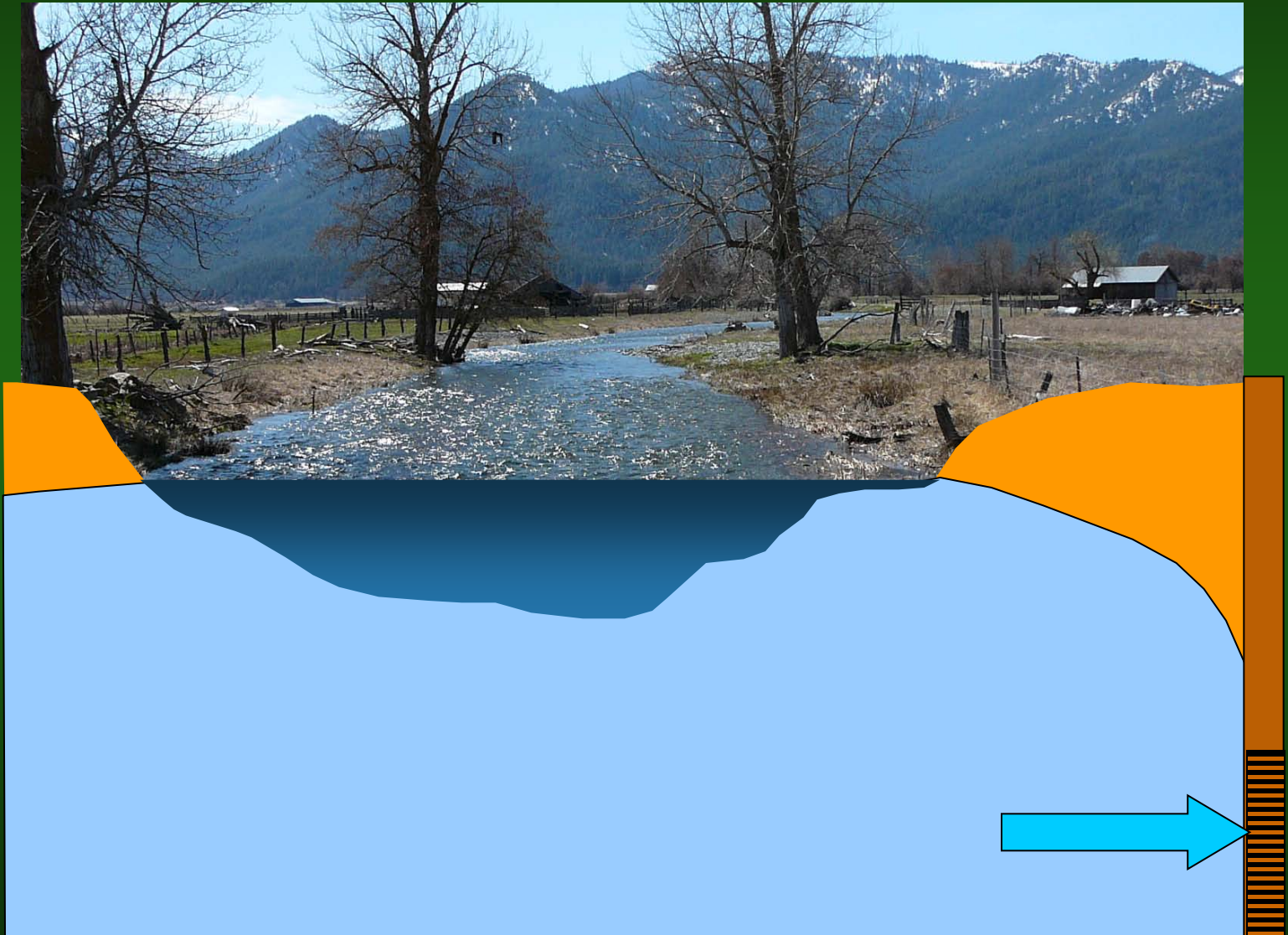


Well Near a Stream



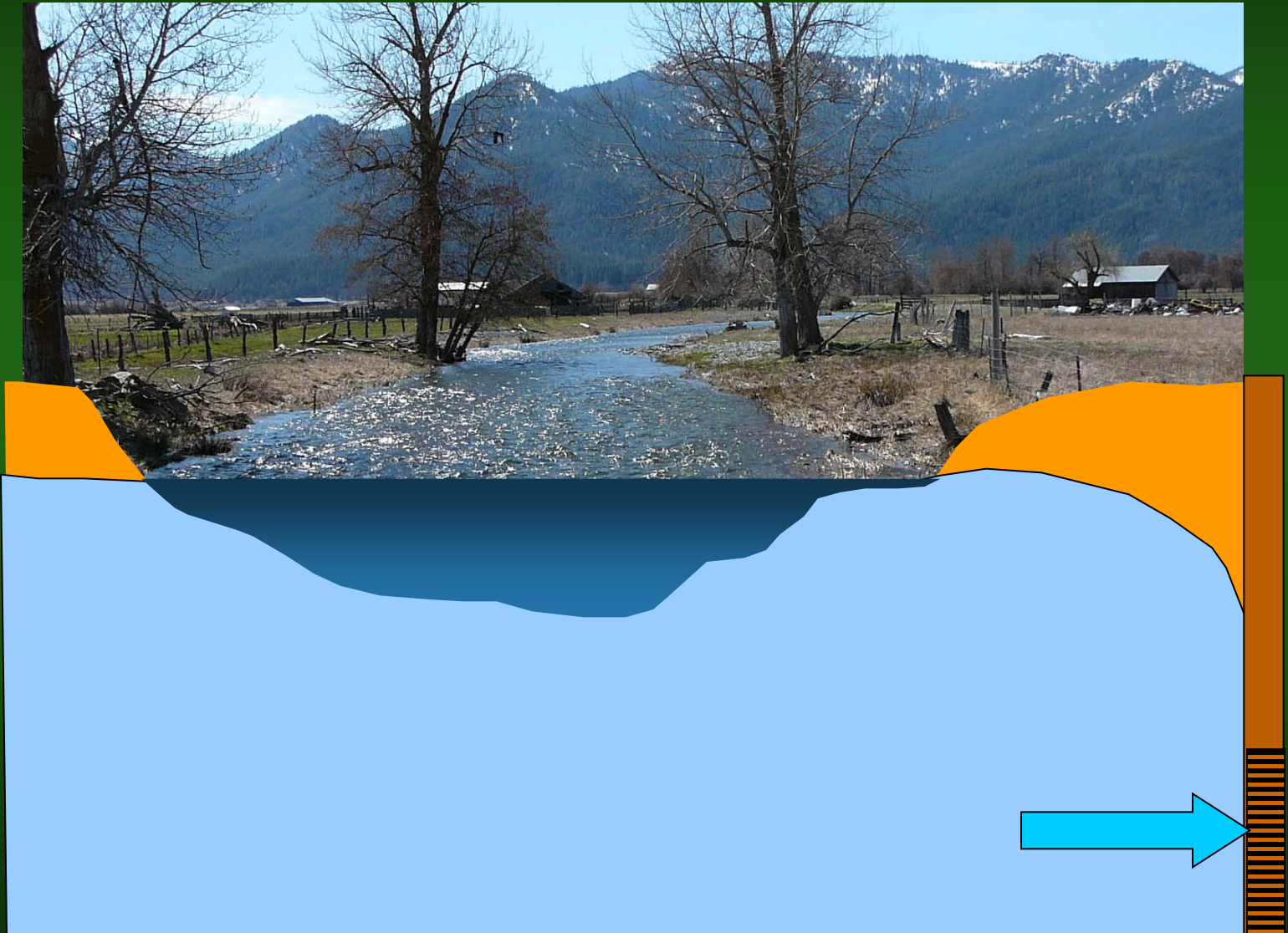


Well Near a Stream



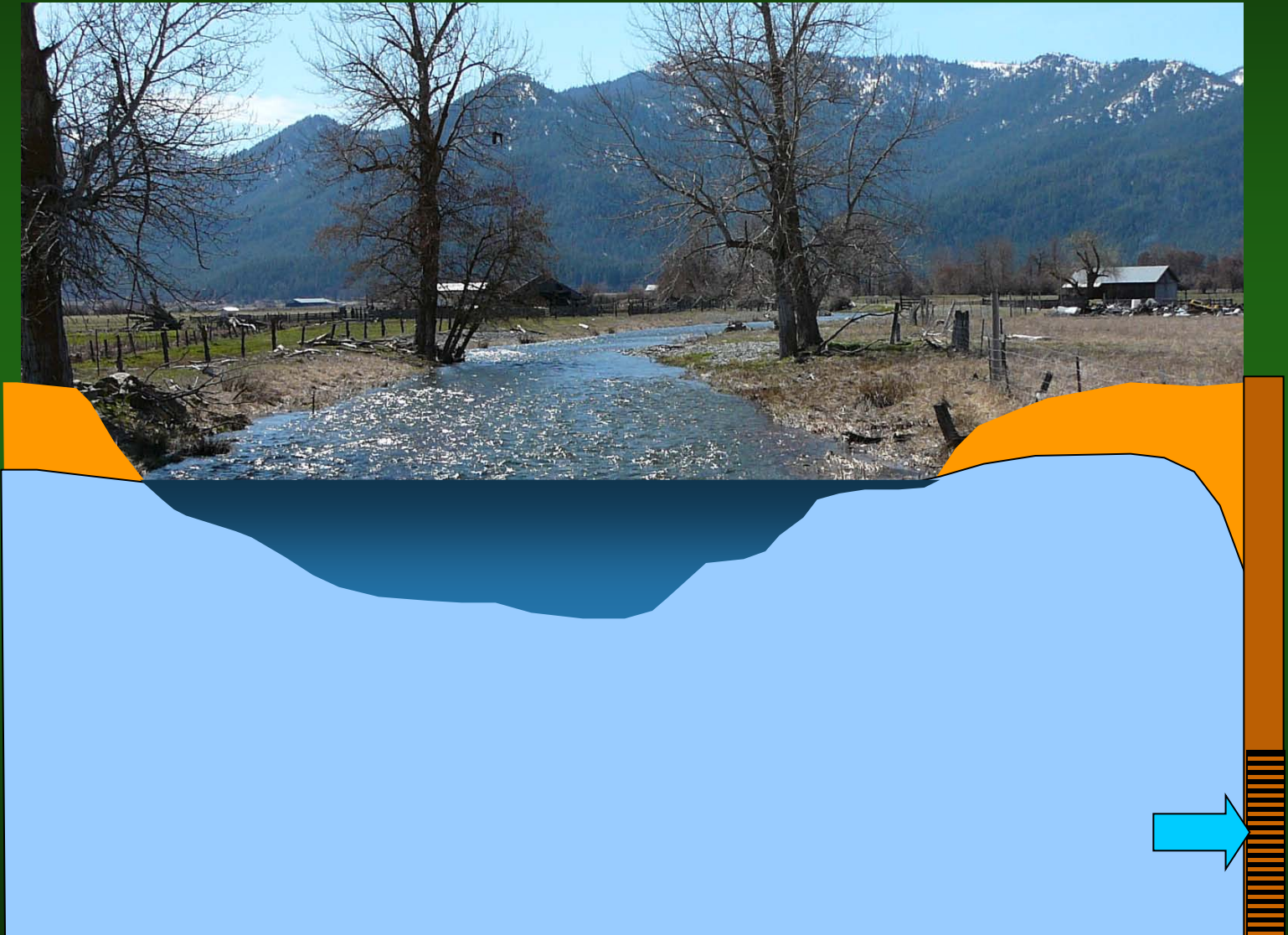


Well Near a Stream





Well Near a Stream





Well Near a Stream





Well Near a Stream





Well Near a Stream





Groundwater Dependent Ecosystems And the GW – SW Interface



Etna, California

3

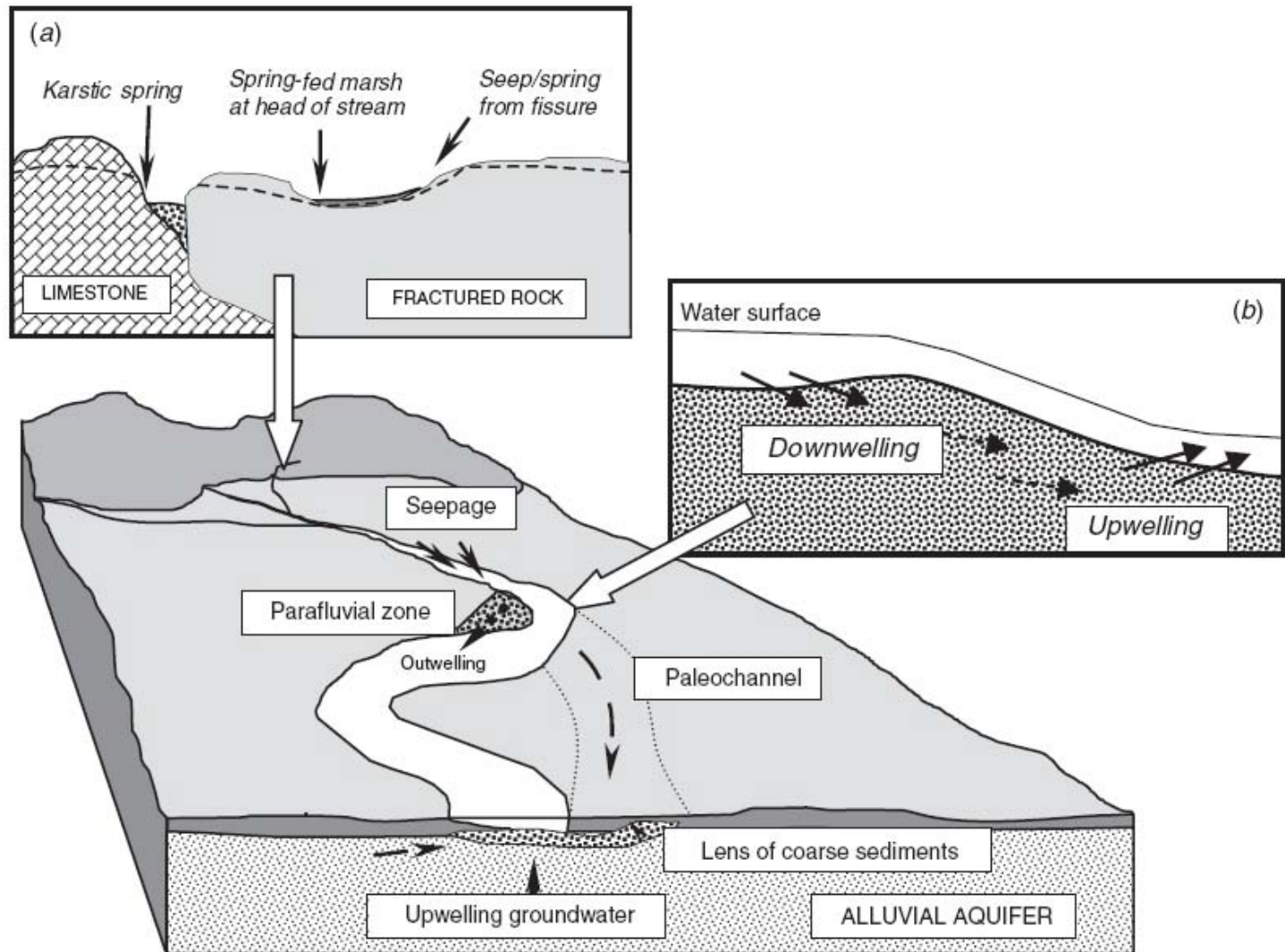


Conjunctive Use



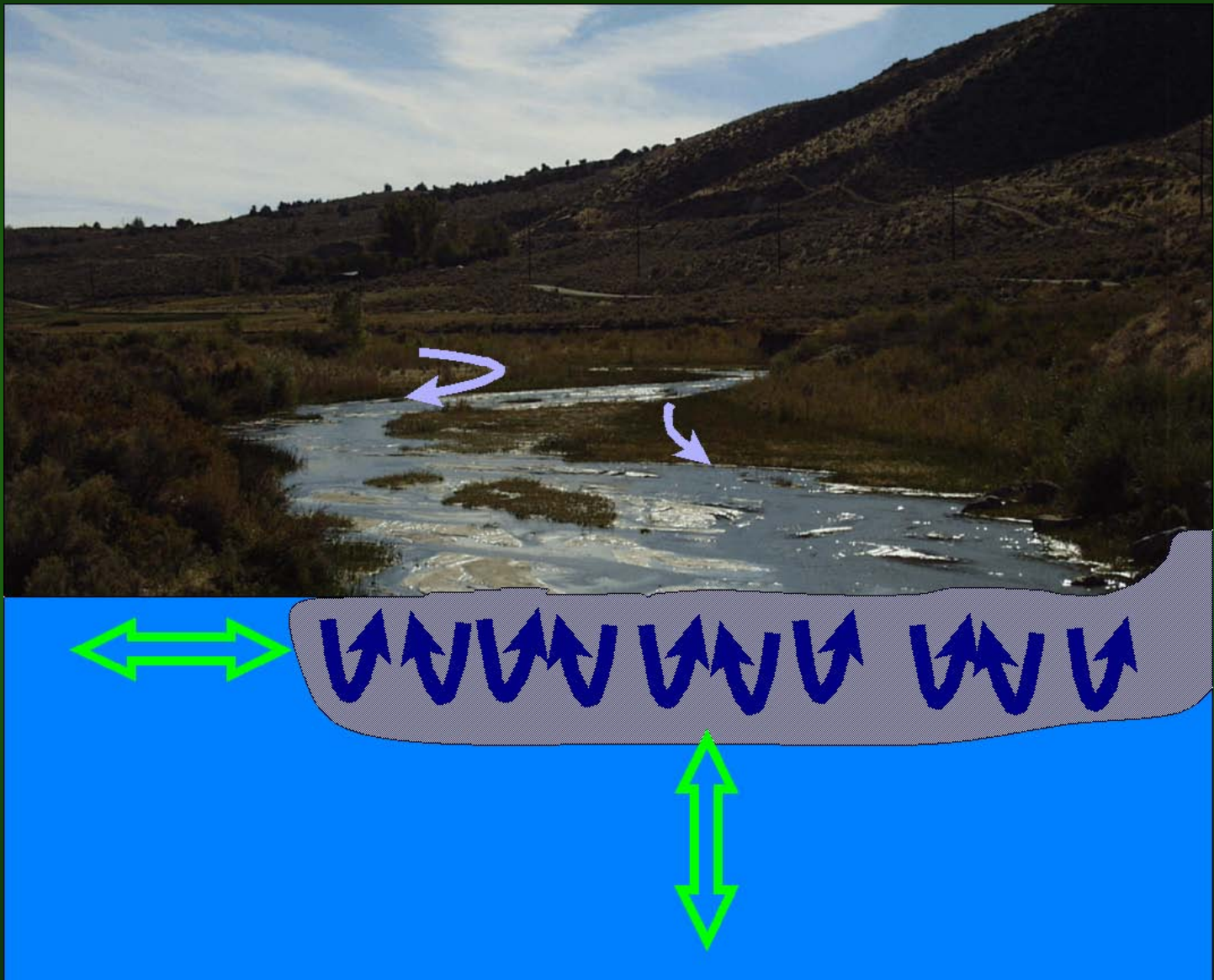


Meandering Streams & Paleochannels



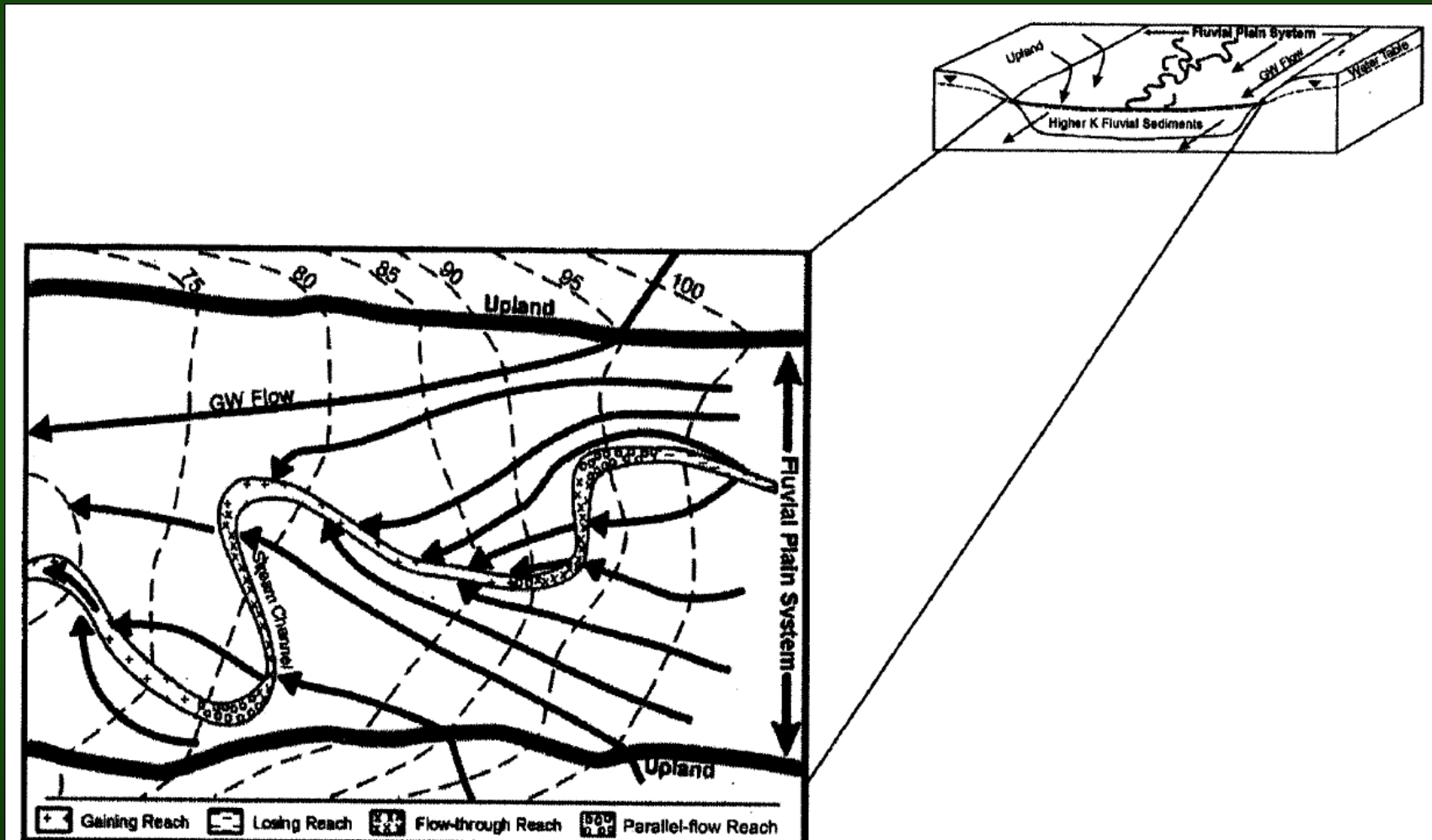


The Hyporheic Zone





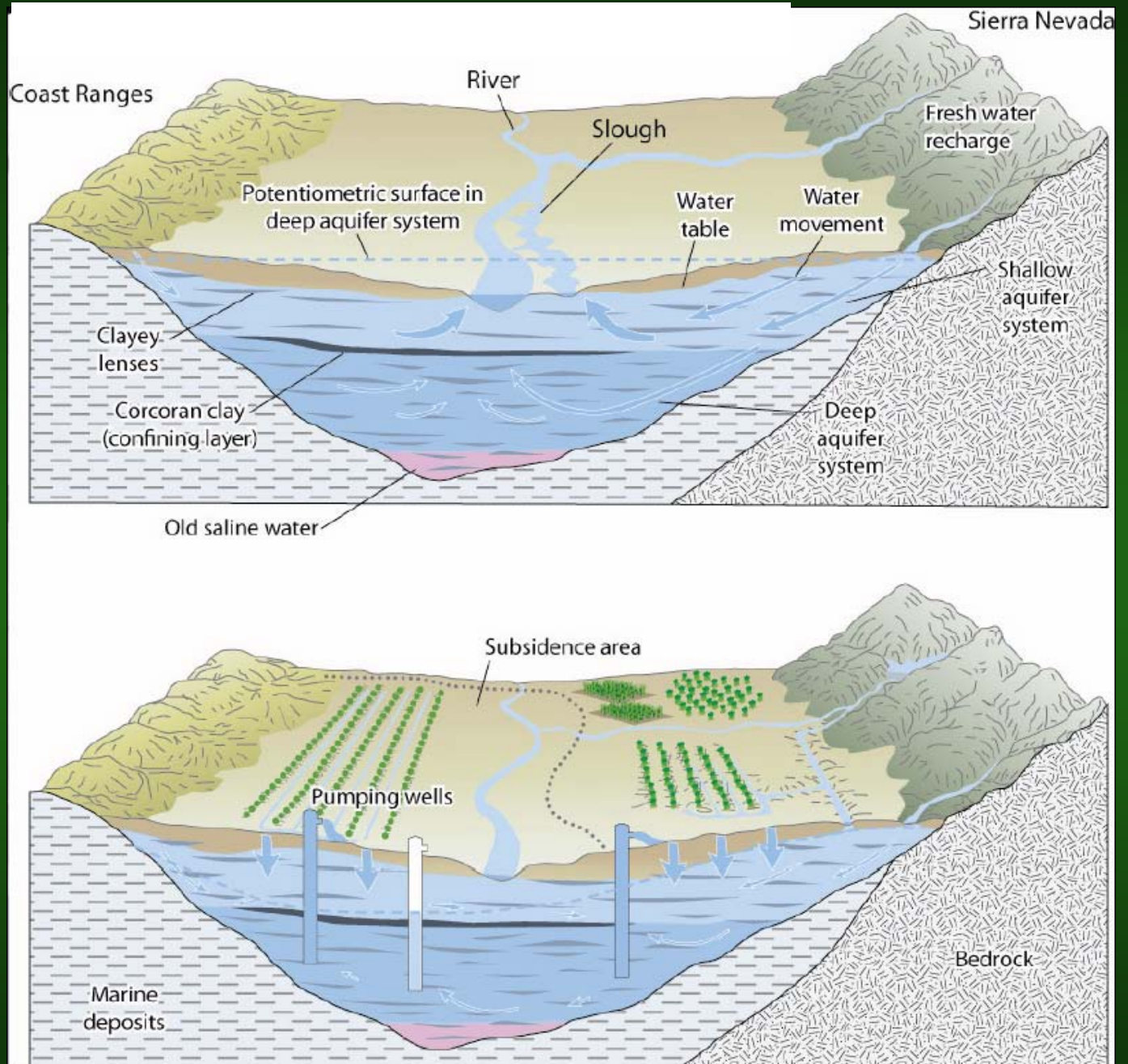
Losing – Gaining – Flow Through





Where does groundwater come from and where does it eventually go?

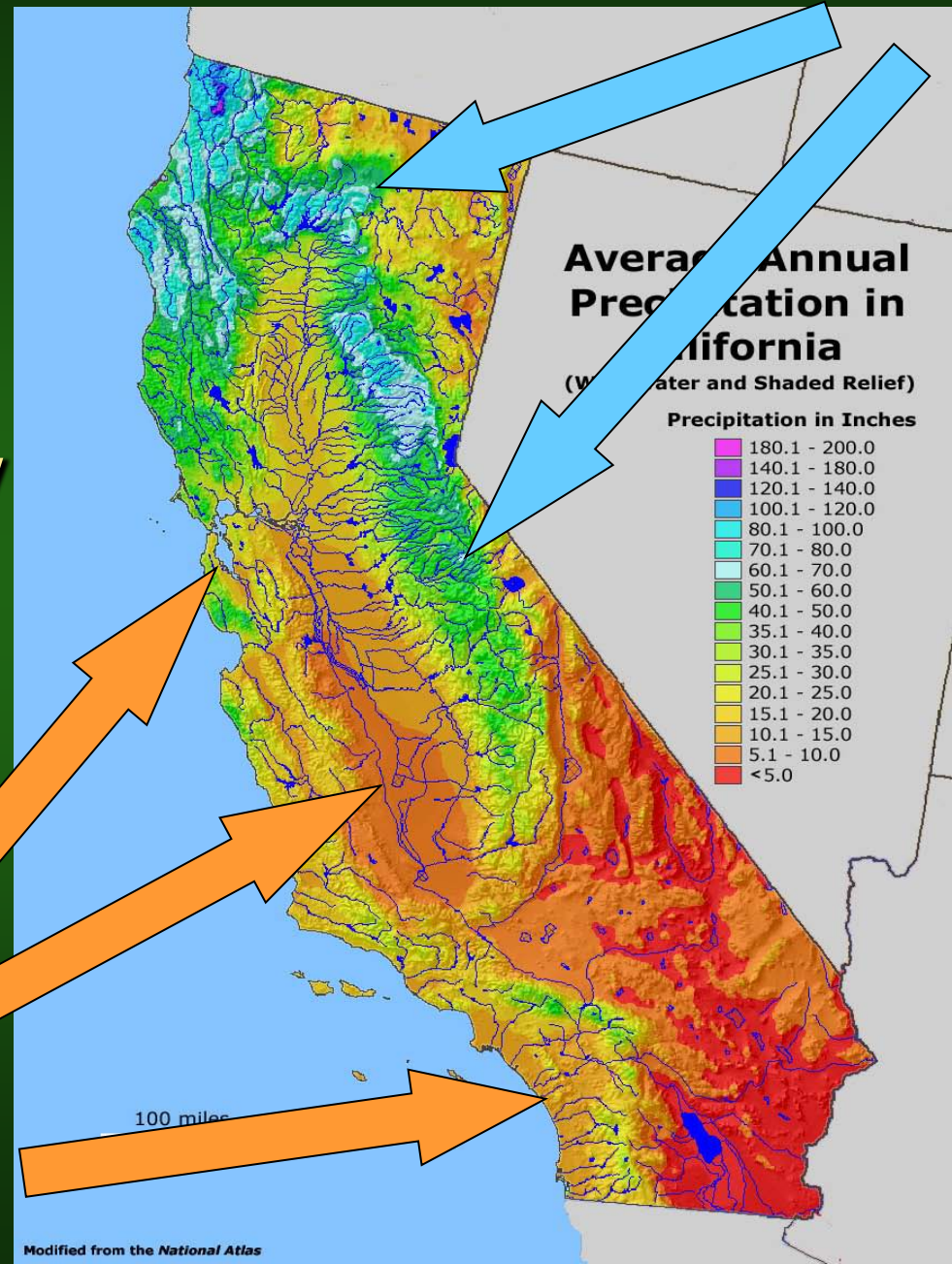
- The Hydrologic Cycle -





RAIN

Space and
Time
Disconnect
between
Water Supply
and
Water Use



WATER USERS

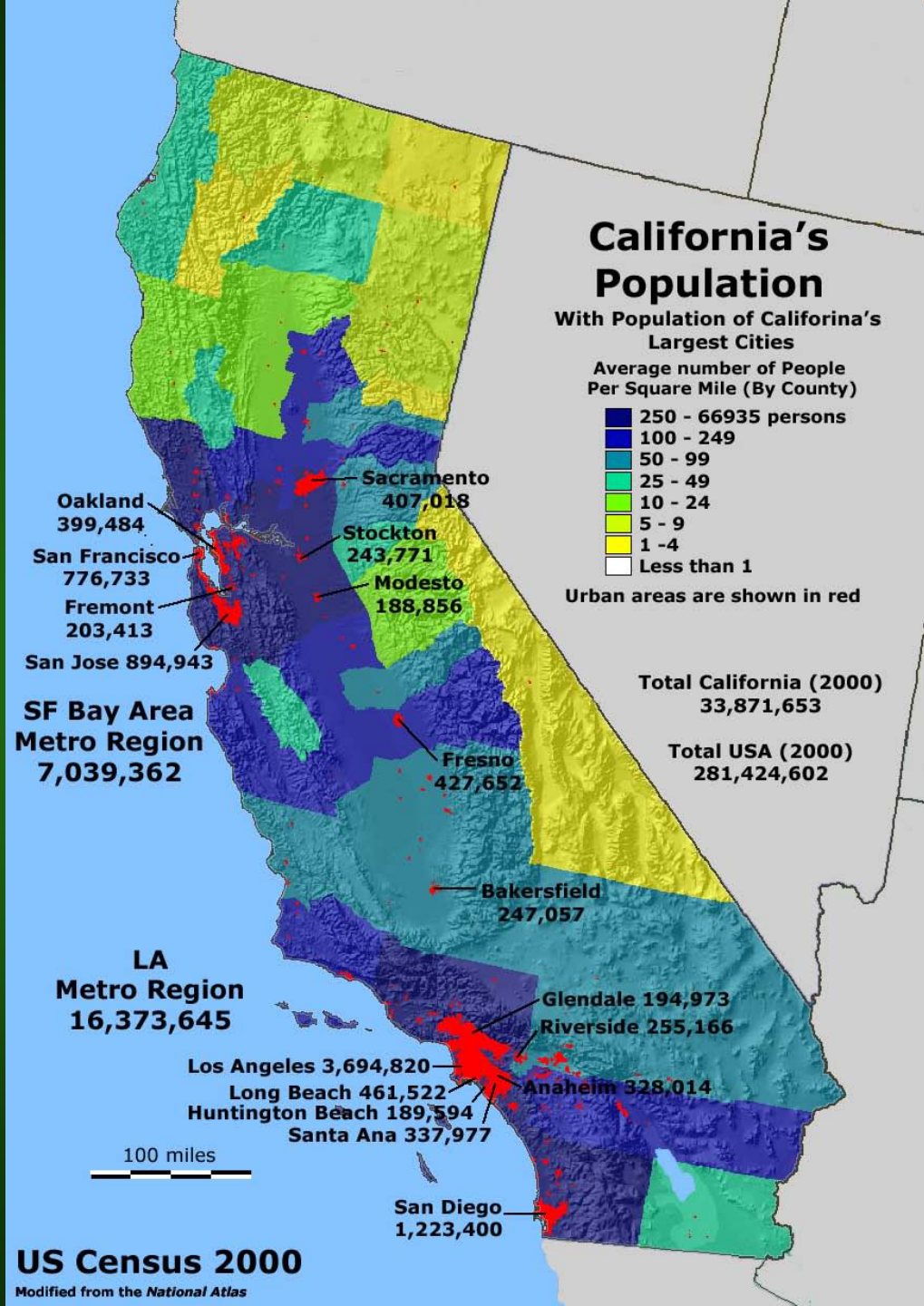


California's Urban Water Users

Population
(Year 2000):
34 million

Water Use:
8 - 9 MAF

MAF = million acre-feet





**Irrigated
Acreage
(Year 2000):
9.5 million
acres**

**Water Use:
27 – 35 MAF**

MAF = million acre-feet

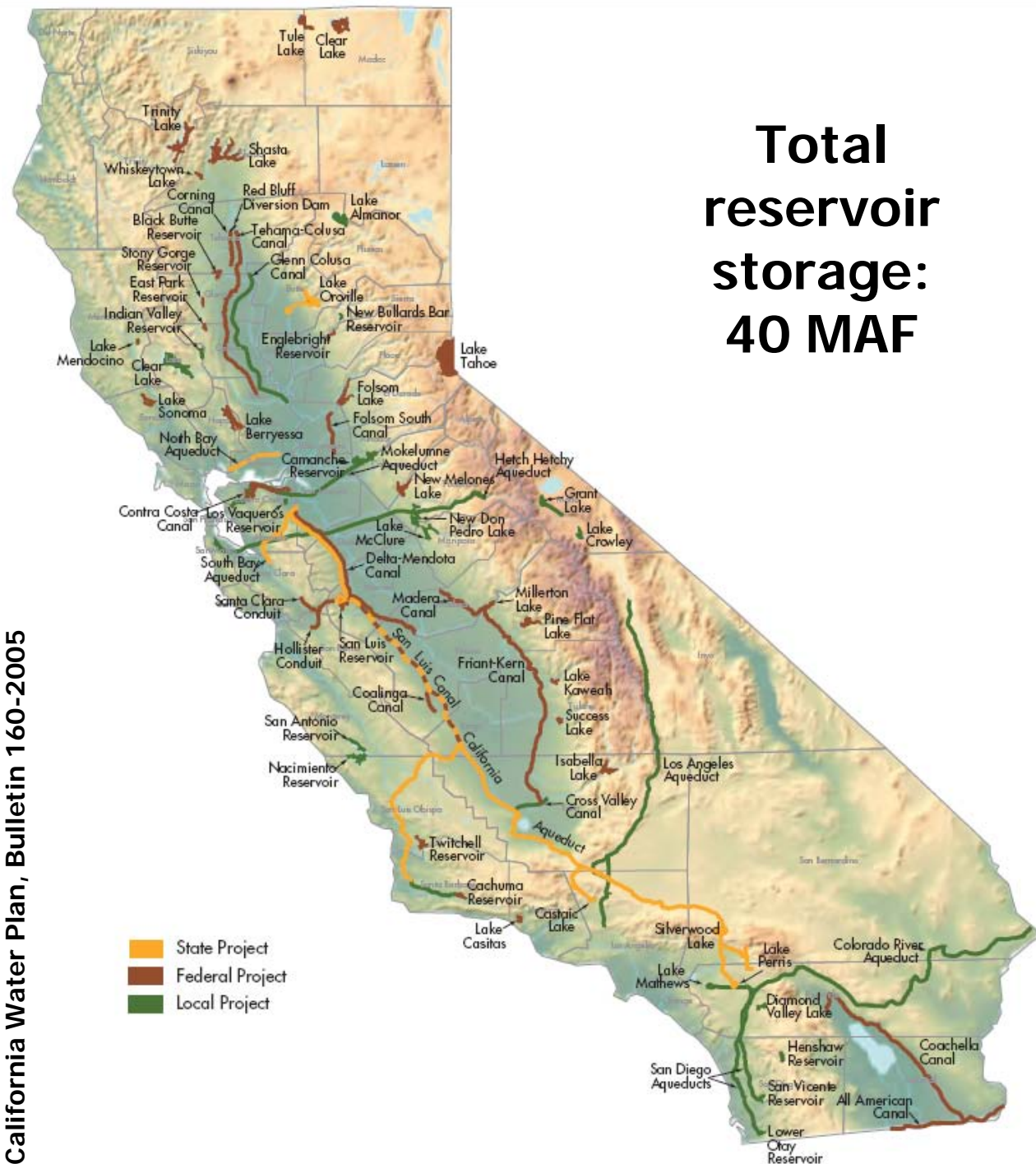




California Water Infra- structure

Bridging
the Spatial
and Temporal
Disconnect
between
SUPPLY
and
USE

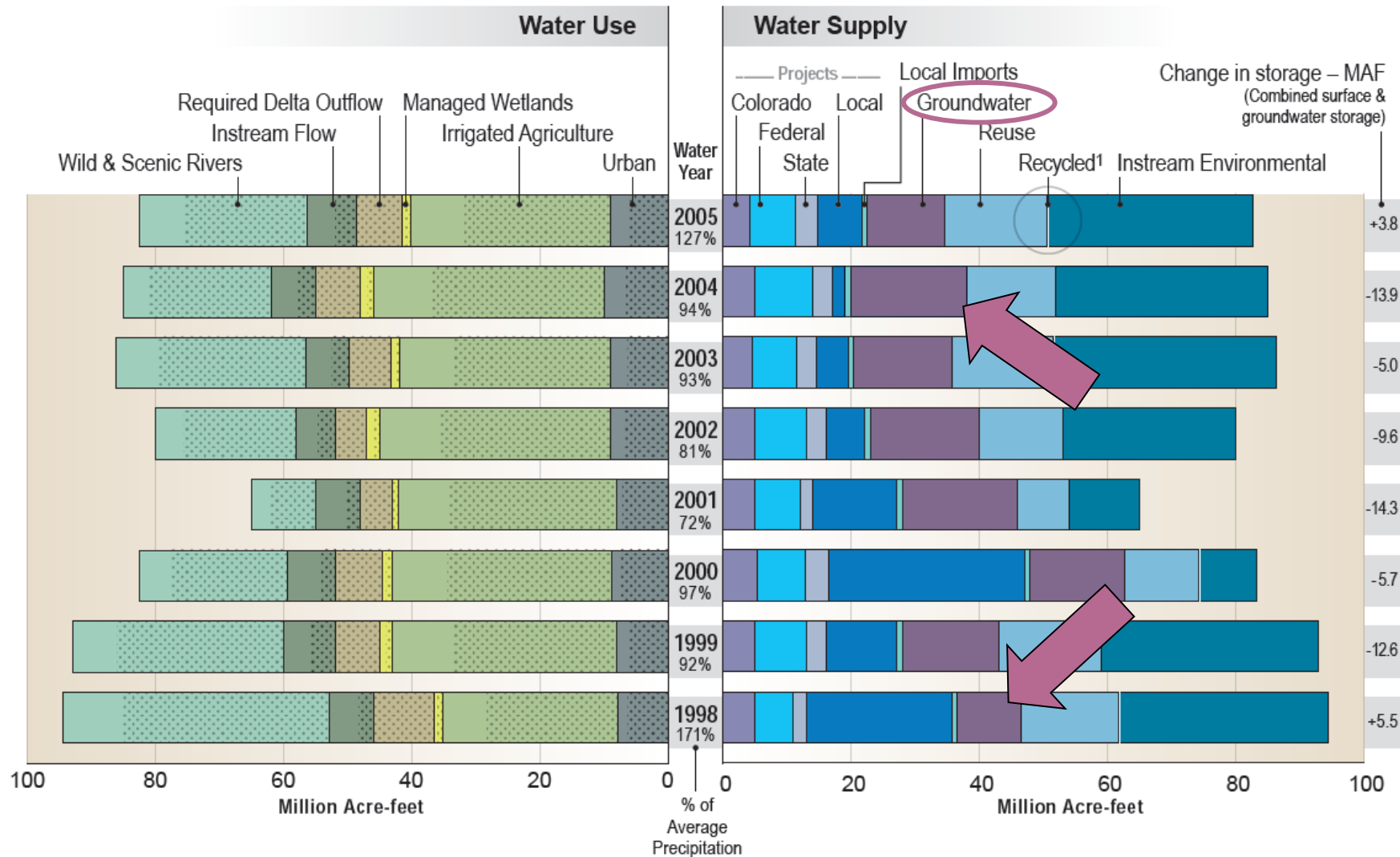
California Water Plan, Bulletin 160-2005



**Total
reservoir
storage:
40 MAF**



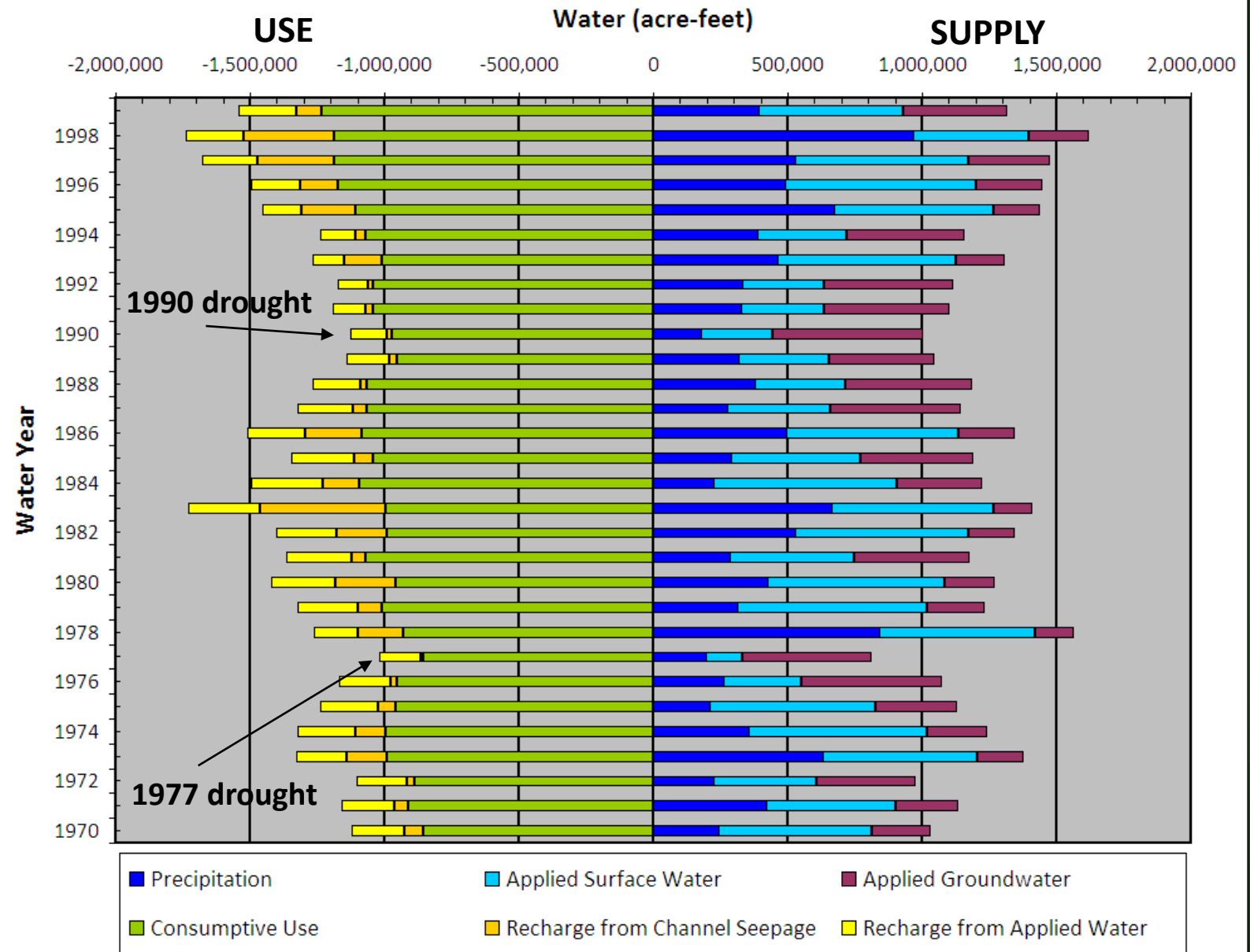
Groundwater Use in California: The Invisible Storage Reservoir



From: DWR California Water Plan 2009 (Bulletin 160-2009)

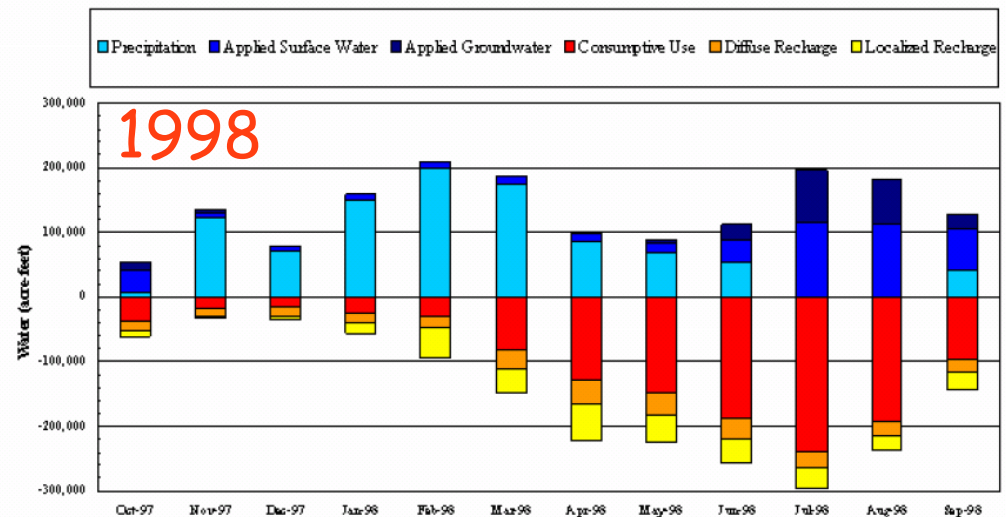
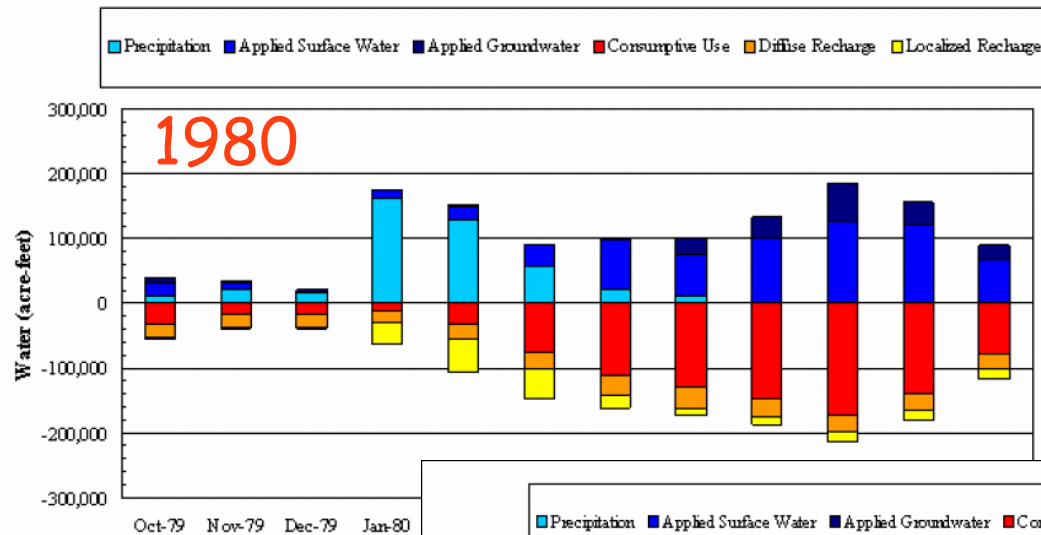
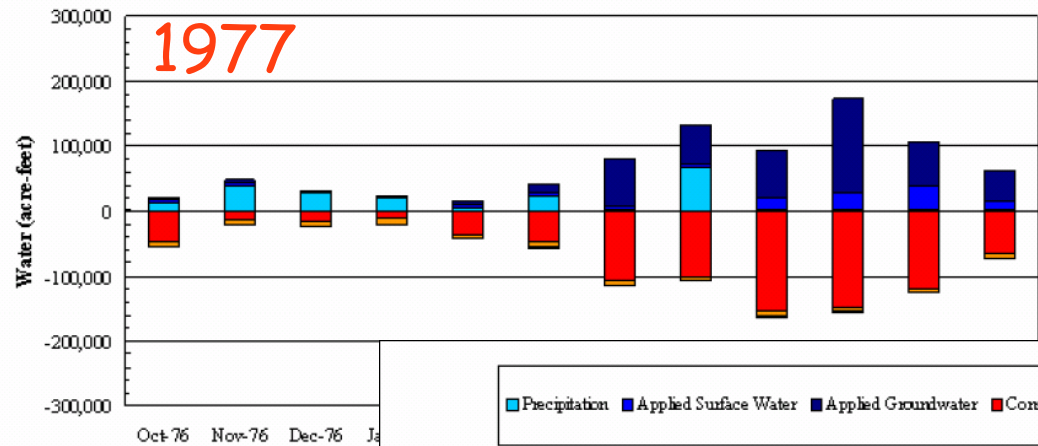


Southern Tulare County Water Budget



Tule River Basin: Monthly Water Budgets, Oct-Sep

Ruud, Harter et al., 2003, 2004





Irrigation Efficiency



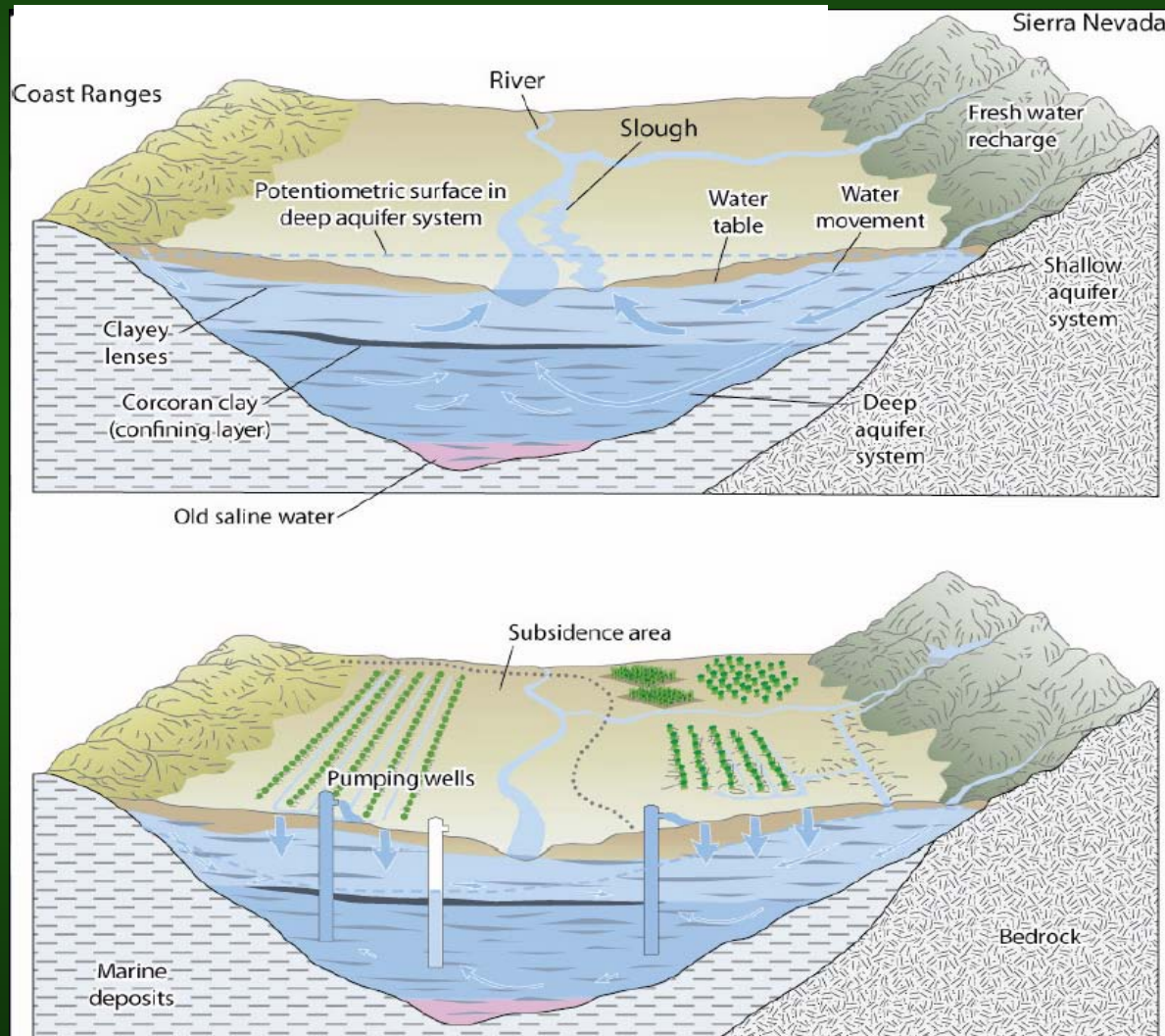


Irrigation Efficiency



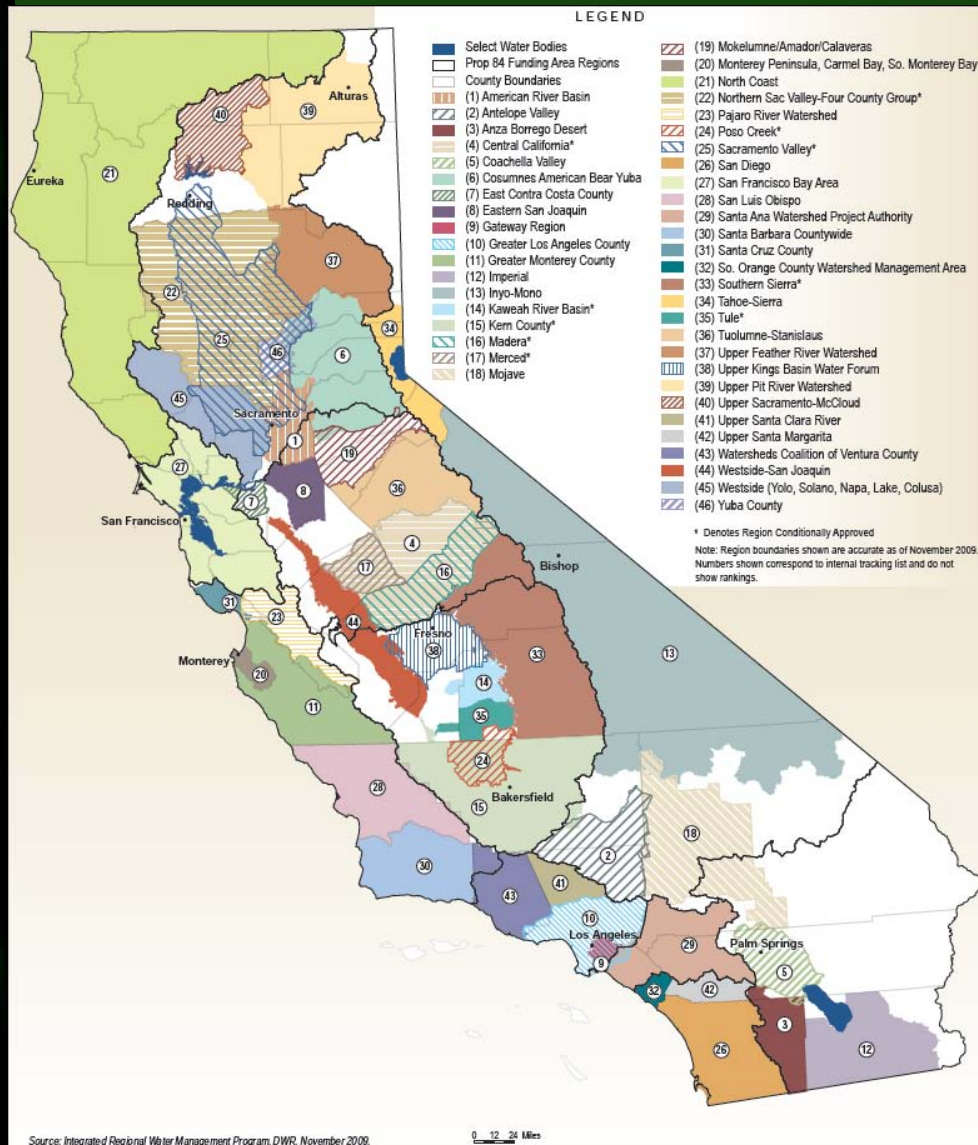


Groundwater Management and Groundwater Quality





Integrated Regional Water Management Planning



⇒ toward Integrated Resource Management Planning

- Groundwater
- Surface Water
- Air
- Soil quality
- Energy / Carbon
- Landuse planning

(Courtesy: Sarge Green, CSU Fresno)



Questions?

