What do you need for a Marathon?

Water and a snack?

What about just a normal day?

1 flush = 3.5 gallons

1 flush = 3.5 gallons
10 minute shower = 20 gal

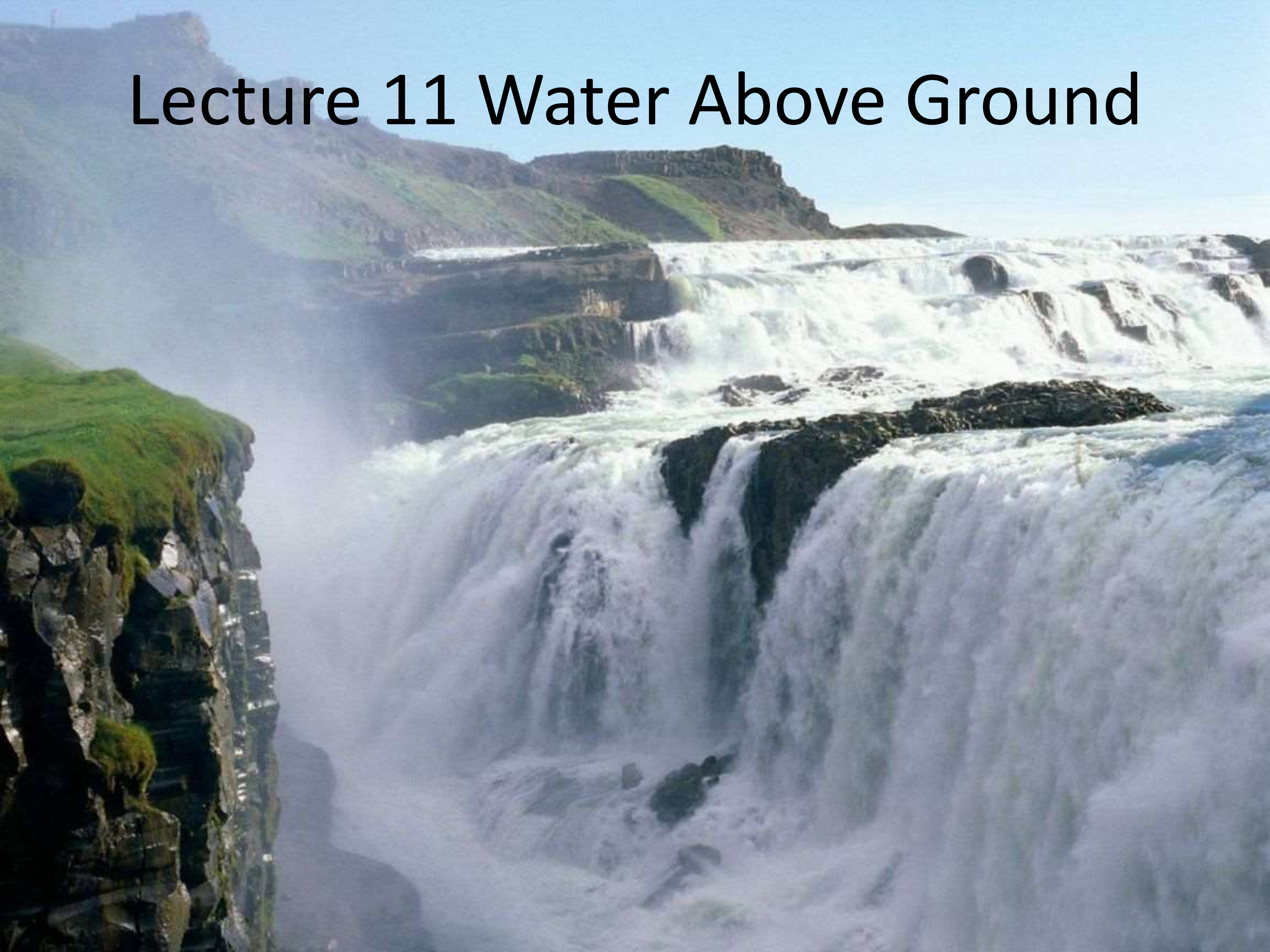
1 flush = 3.5 gallons
10 minute shower = 20 gal
Jeans = 2,900 gal
T-shirt = 530 gal

1 flush = 3.5 gallons
10 minute shower = 20 gal
Jeans = 2,900 gal
T-shirt = 530 gal
8 oz. coffee = 70 gal
2 slices bread = 21 gal

What are some flaws in thinking here?

1 flush = 3.5 gallons
10 minute shower = 20 gal
Jeans = 2,900 gal
T-shirt = 530 gal
8 oz. coffee = 70 gal
2 slices bread = 21 gal

Lecture 11 Water Above Ground



Types of water?

Which ones are important to humans?
Which ones play big roles in geology?
When do rocks play a role in the water?

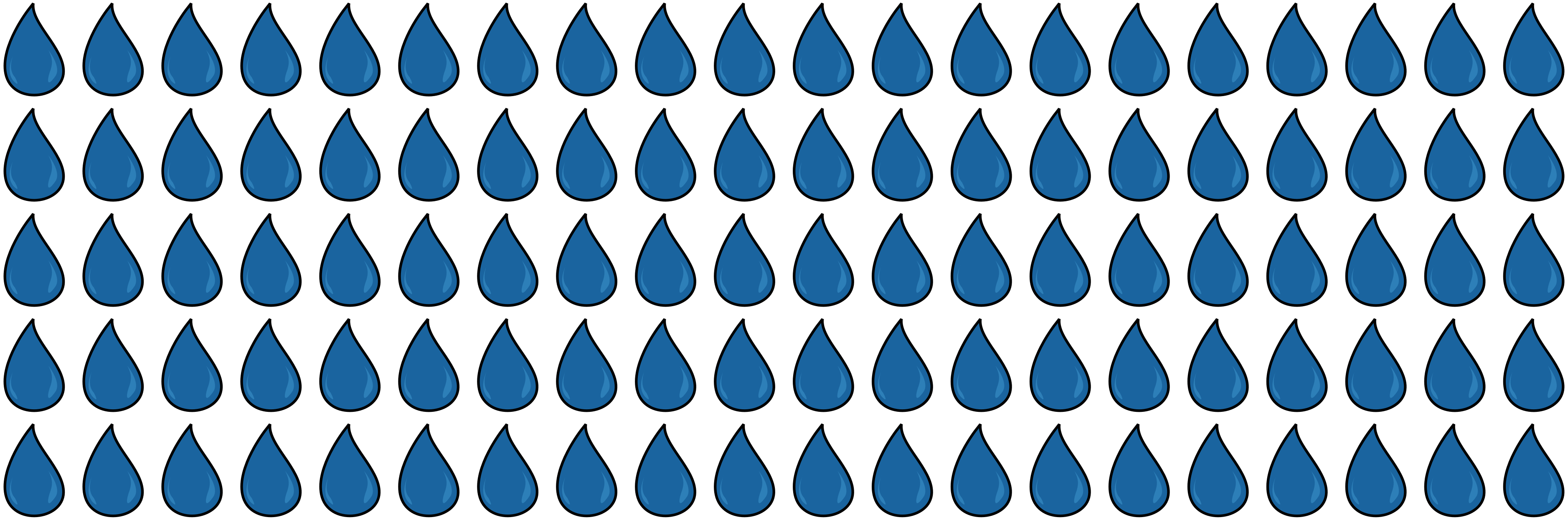
Earth: The Blue Marble

- Water exists on Earth’s surface in 3 forms:
  - Solid
  - Vapor
  - Liquid
- Water plays a key role in geological processes that shape Earth’s surface:
  - Weathering
  - Erosion
  - Sediment transport & deposition

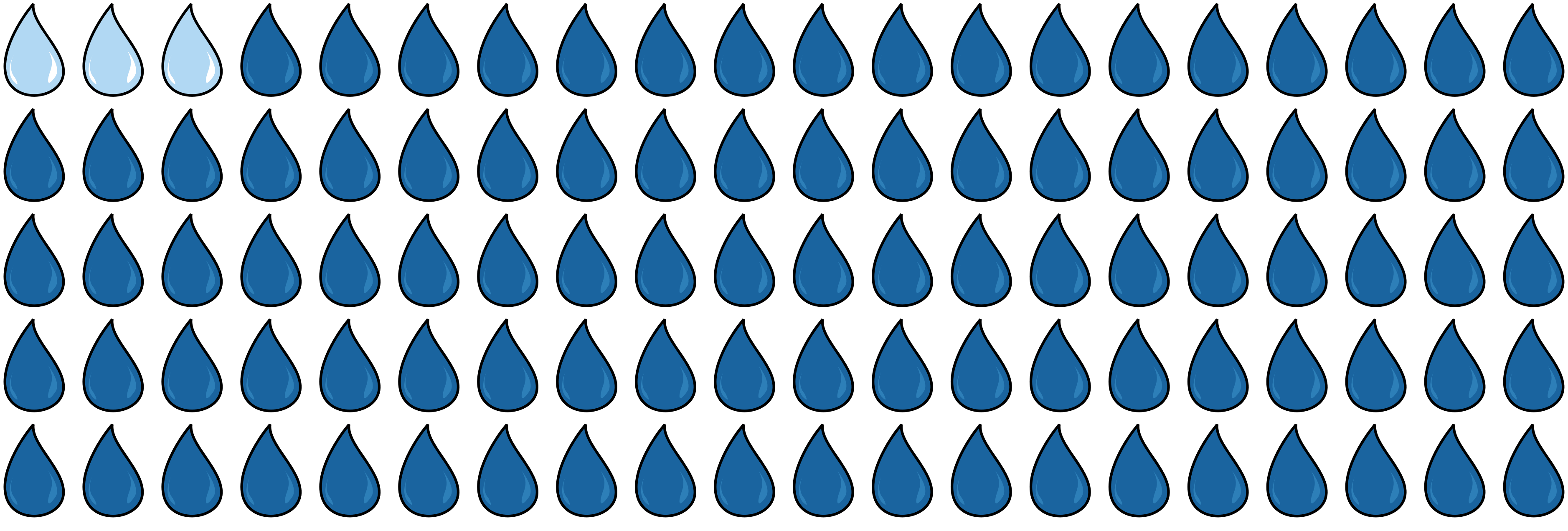
- Water exists on Earth’s surface in 3 forms:
  - Solid
  - Vapor
  - Liquid

- Water exists on Earth's surface in 3 forms:
  - Solid
  - Vapor
  - Liquid

How much water on Earth is not salty?



Around 3%

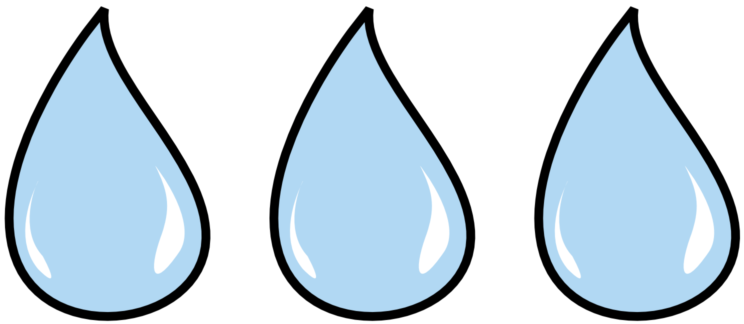


Where is the water on Earth?

of all water on surface:

3%   as freshwater

97% in oceans



Fresh water on surface:

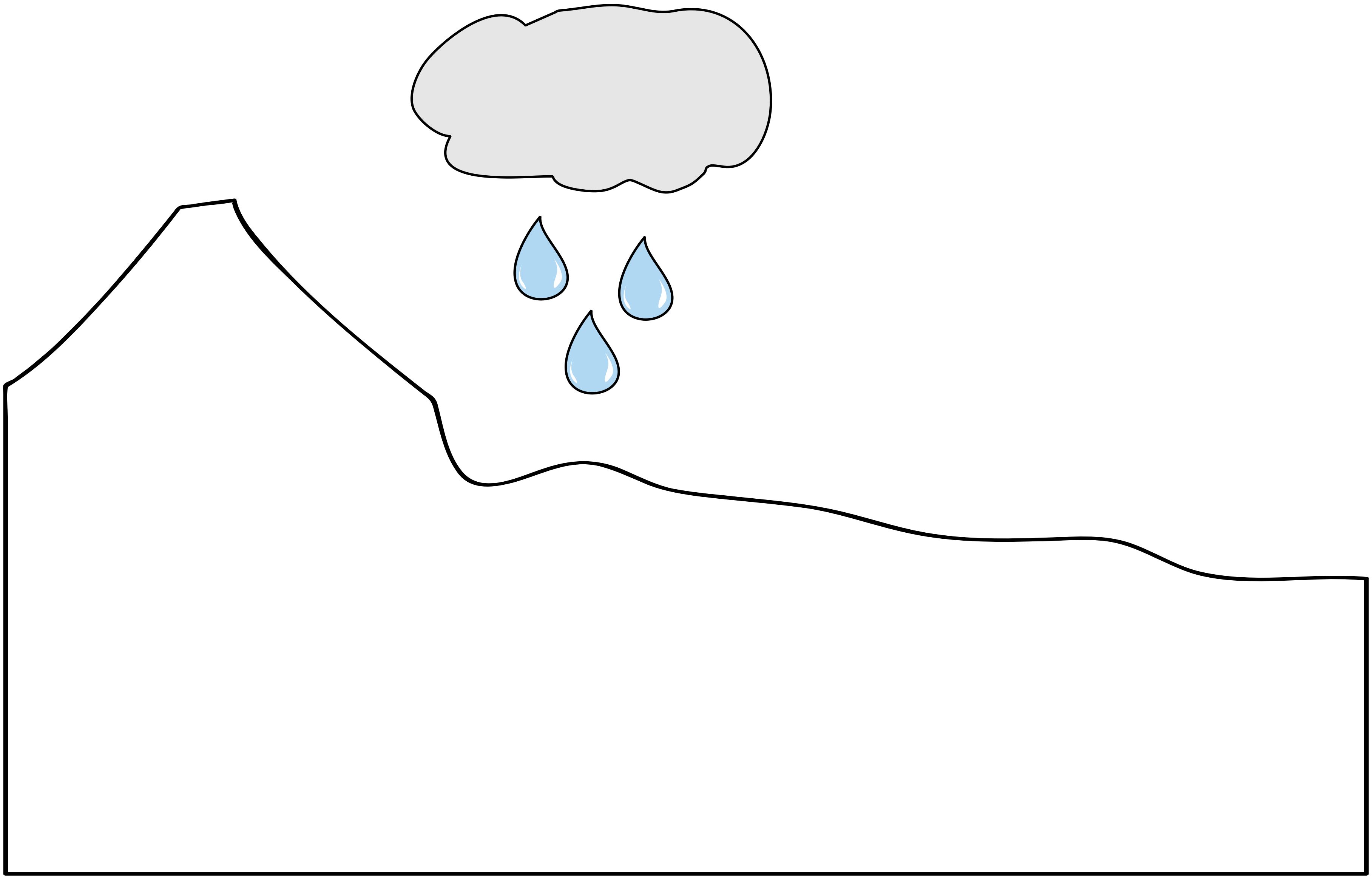
<1% lakes, rivers, etc…

30% ground water

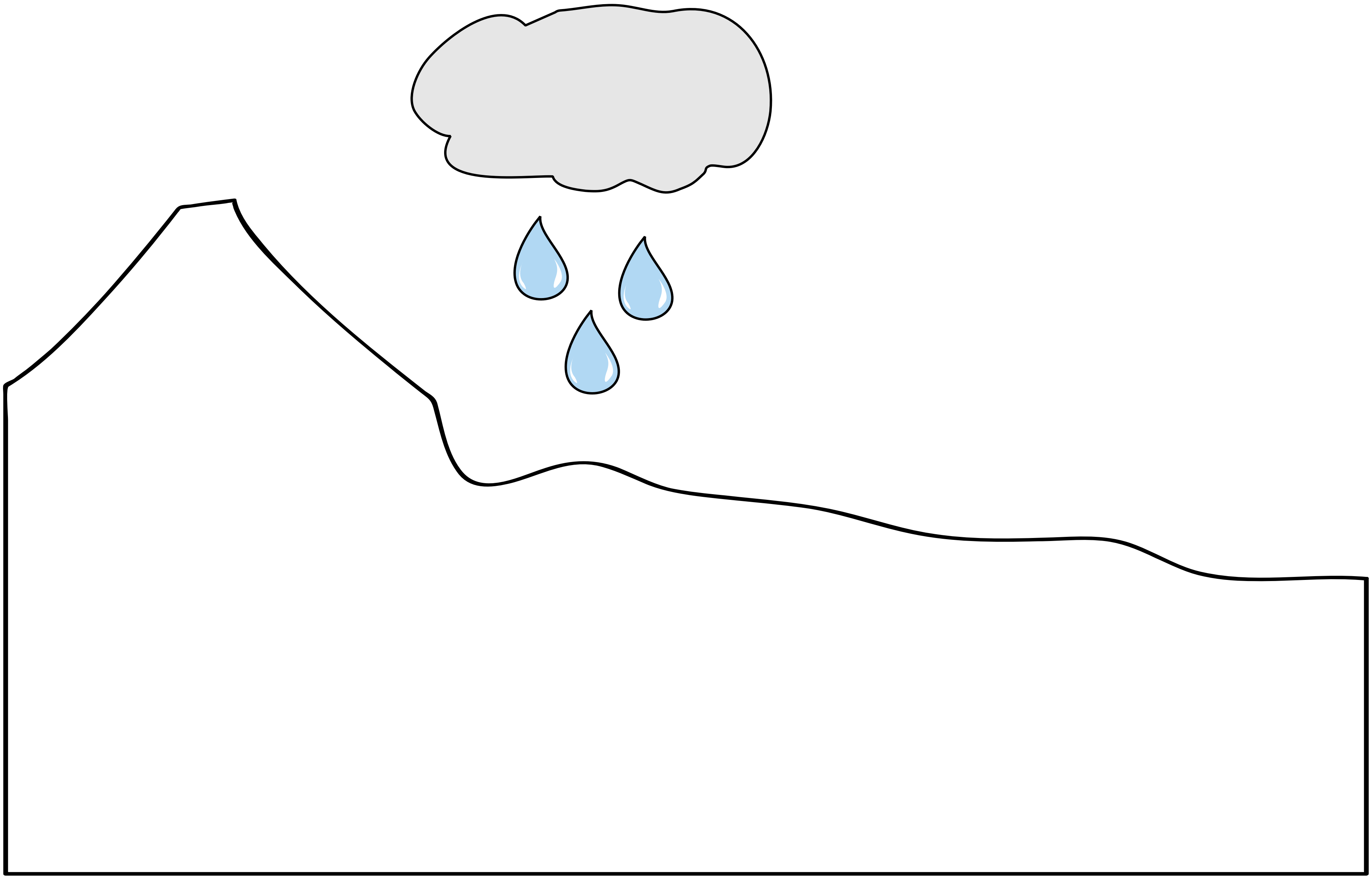
69% in cryosphere

http://ga.water.usgs.gov/edu/earthwherewater.html

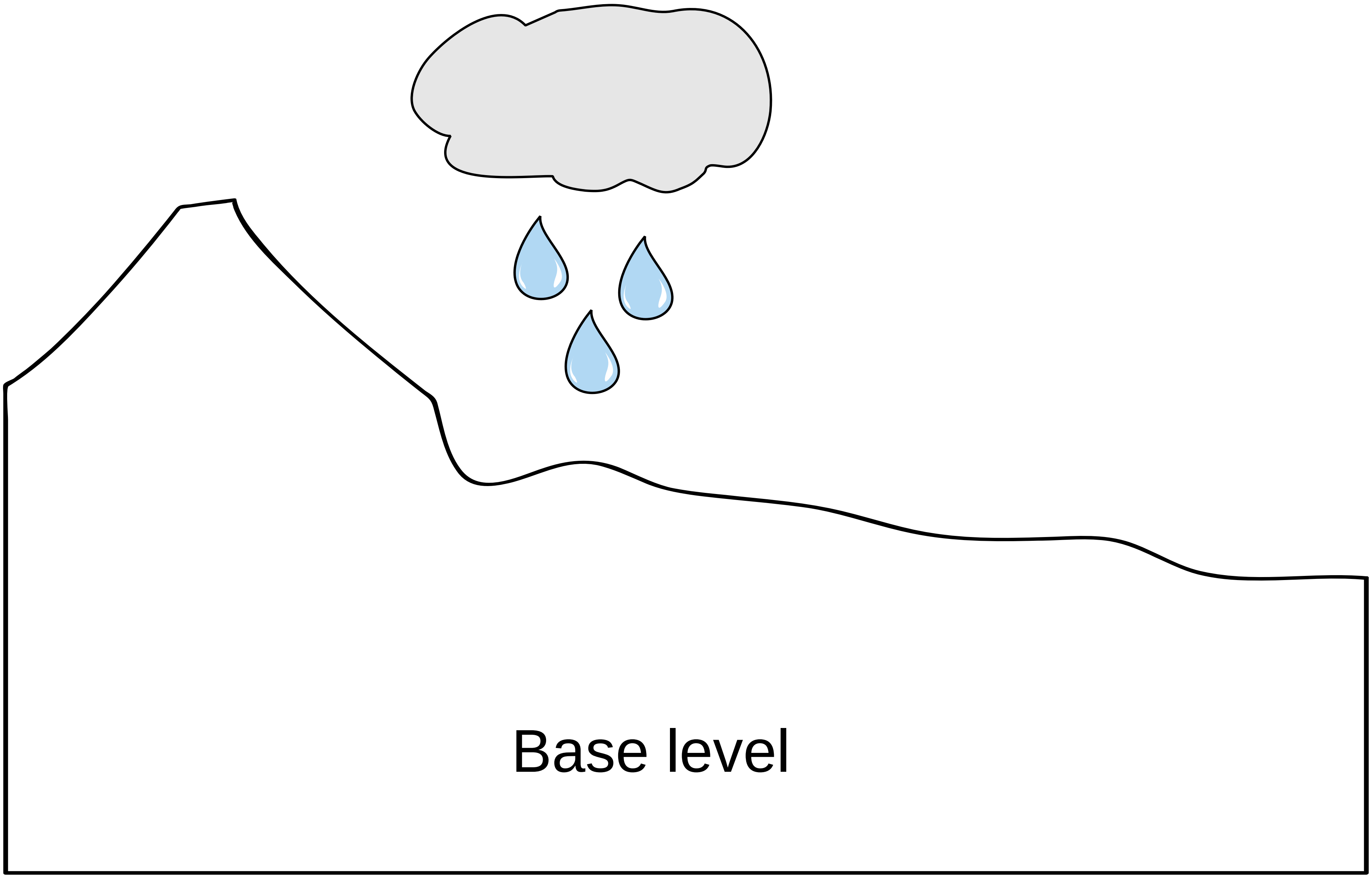
What happens to water?



When does water stop flowing?

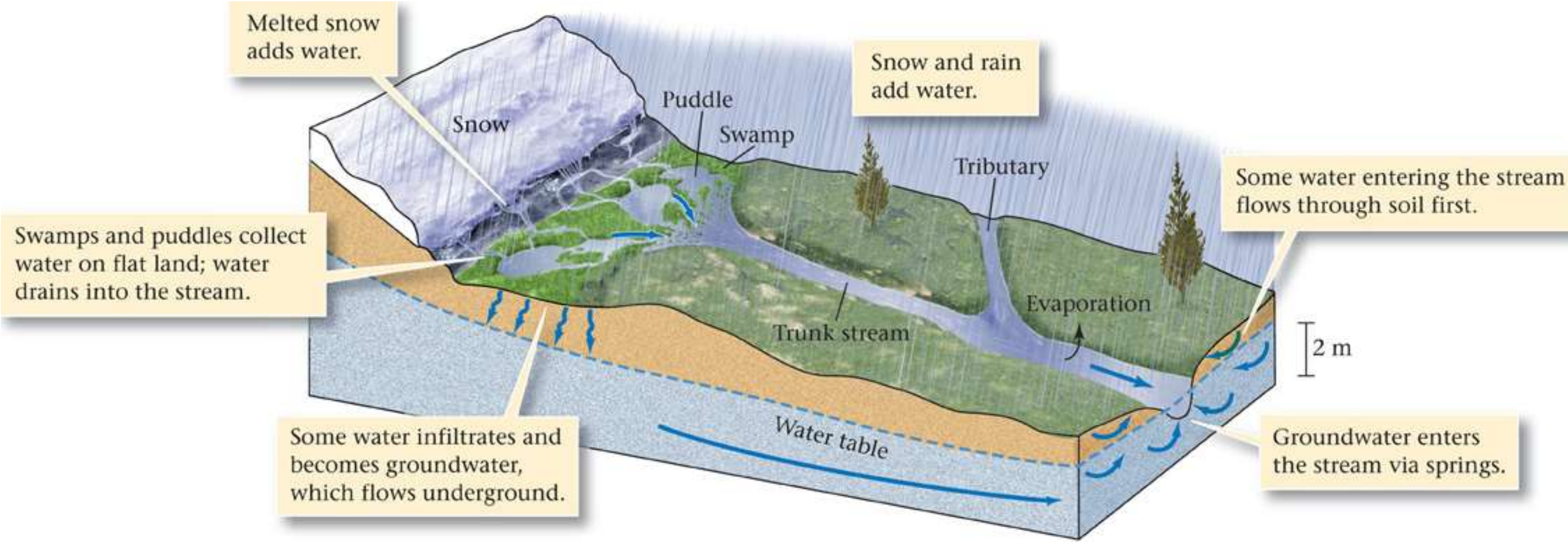


When does water stop flowing?

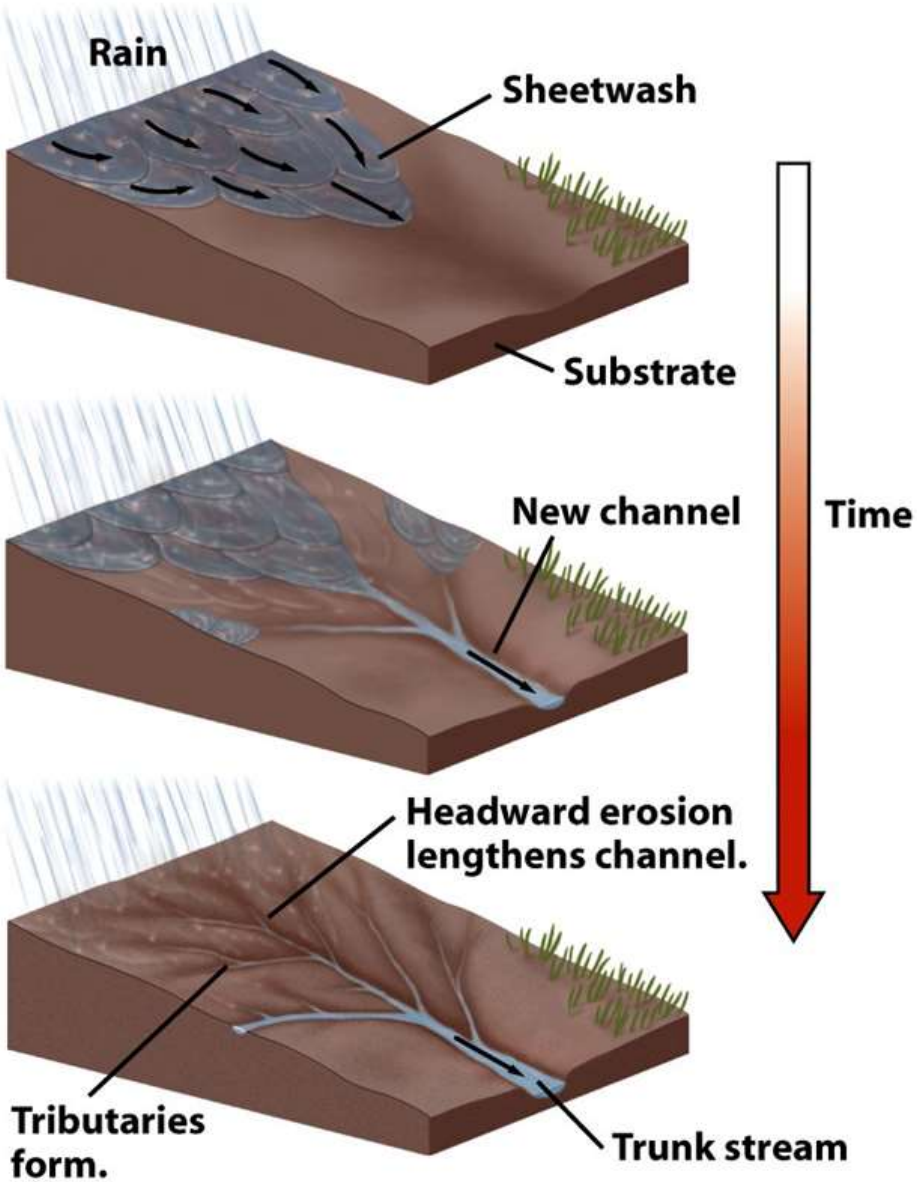


Drainage Divides of North America

Runoff vs Infiltration



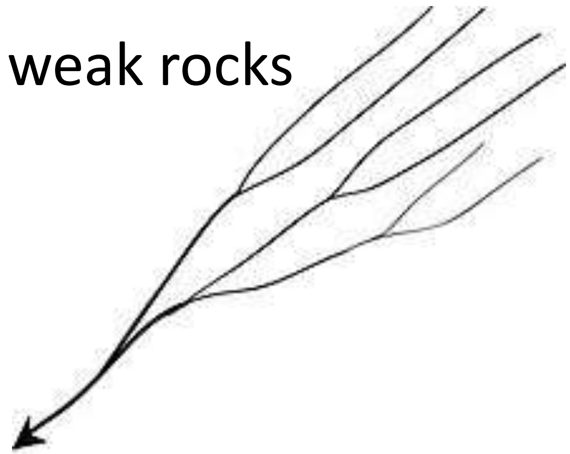
Forming Streams

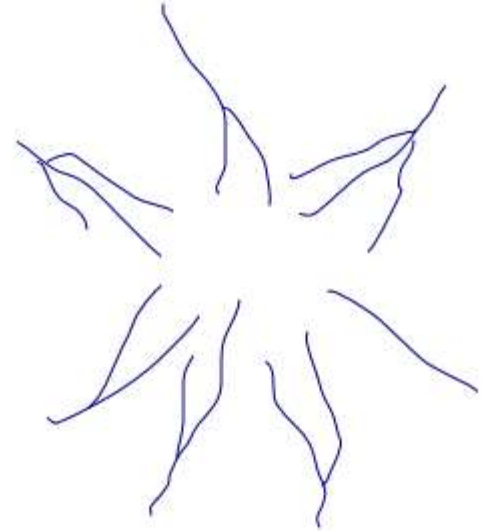


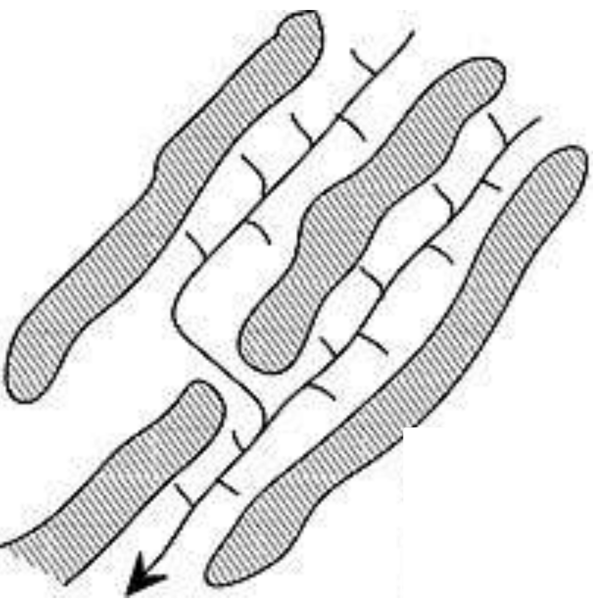
Drainage networks

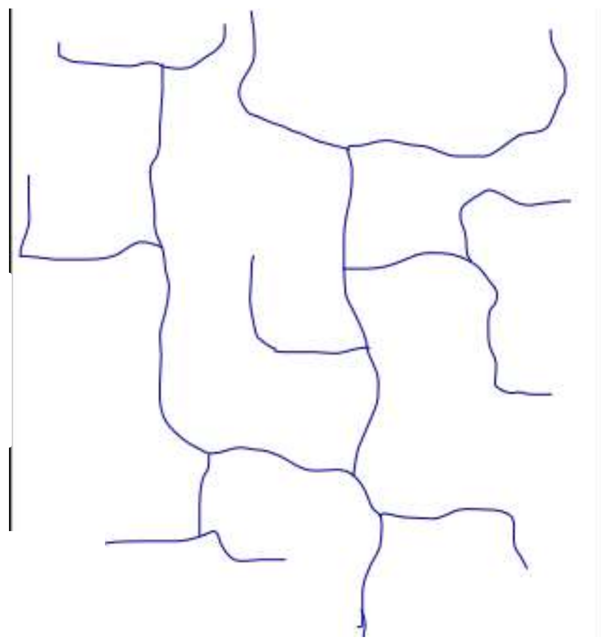
- Array of linked channels = drainage network
- Drainage networks change over time and often form geometric patterns reflecting underlying geology

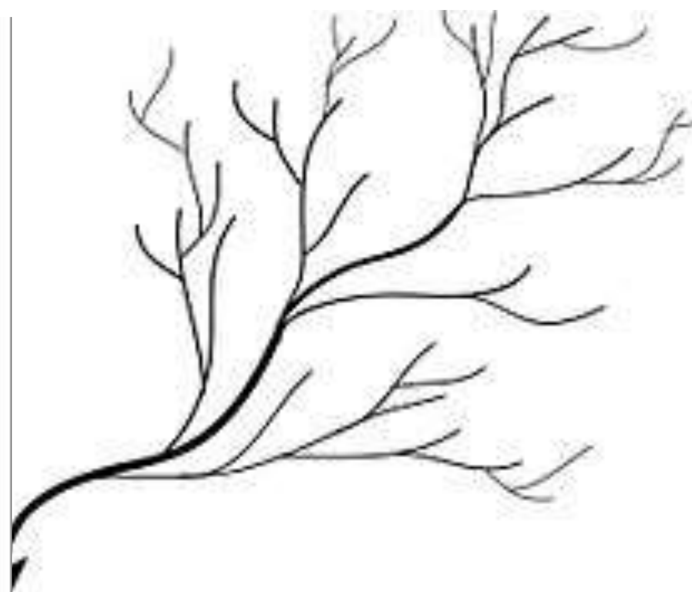
- cone shaped mountain e.g. volcano
- jointed rocks
- alternating resistant and weak rocks
- uniform slope
- uniform material





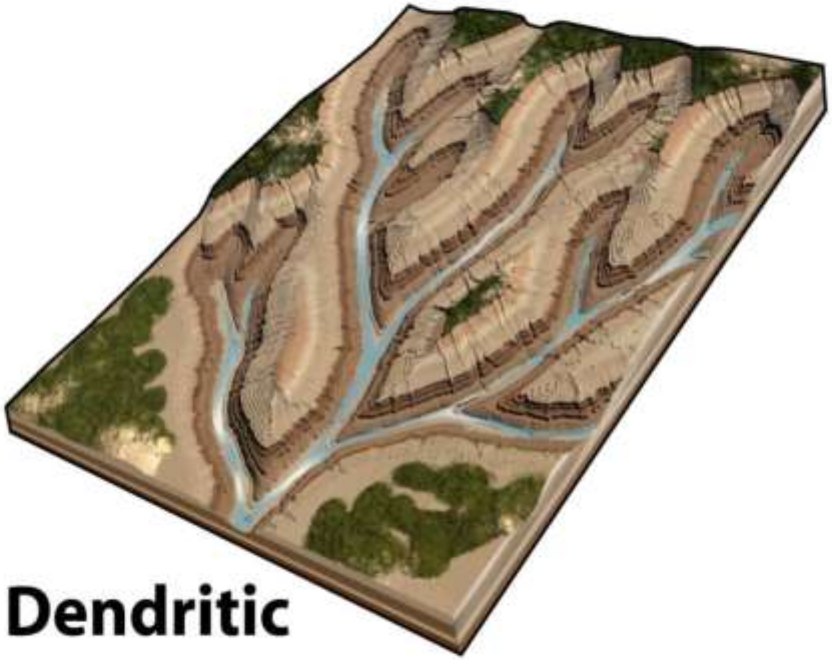






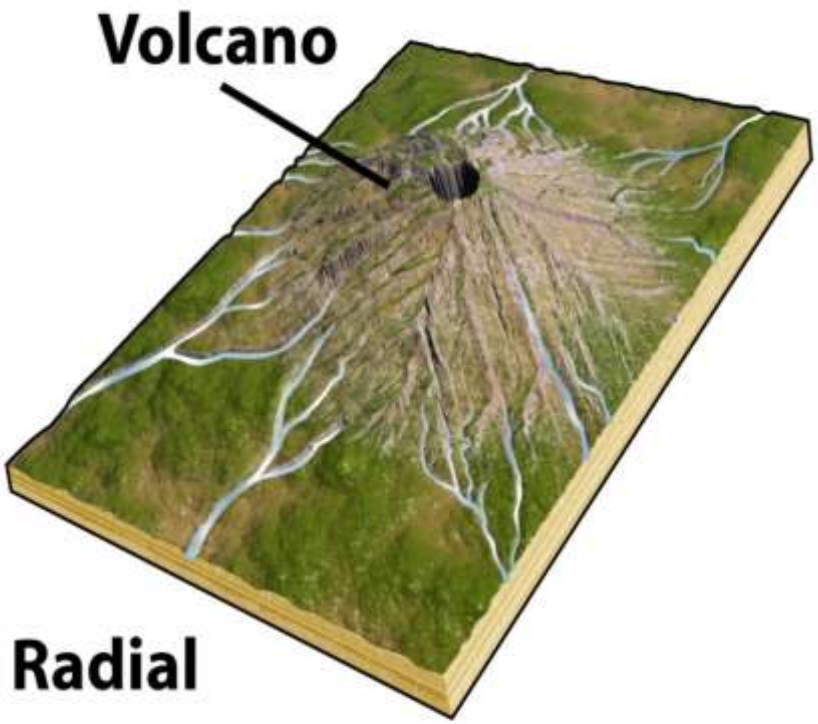
Drainage Networks

- Common drainage patterns
  - Dendritic – Branching, “treelike” due to uniform material



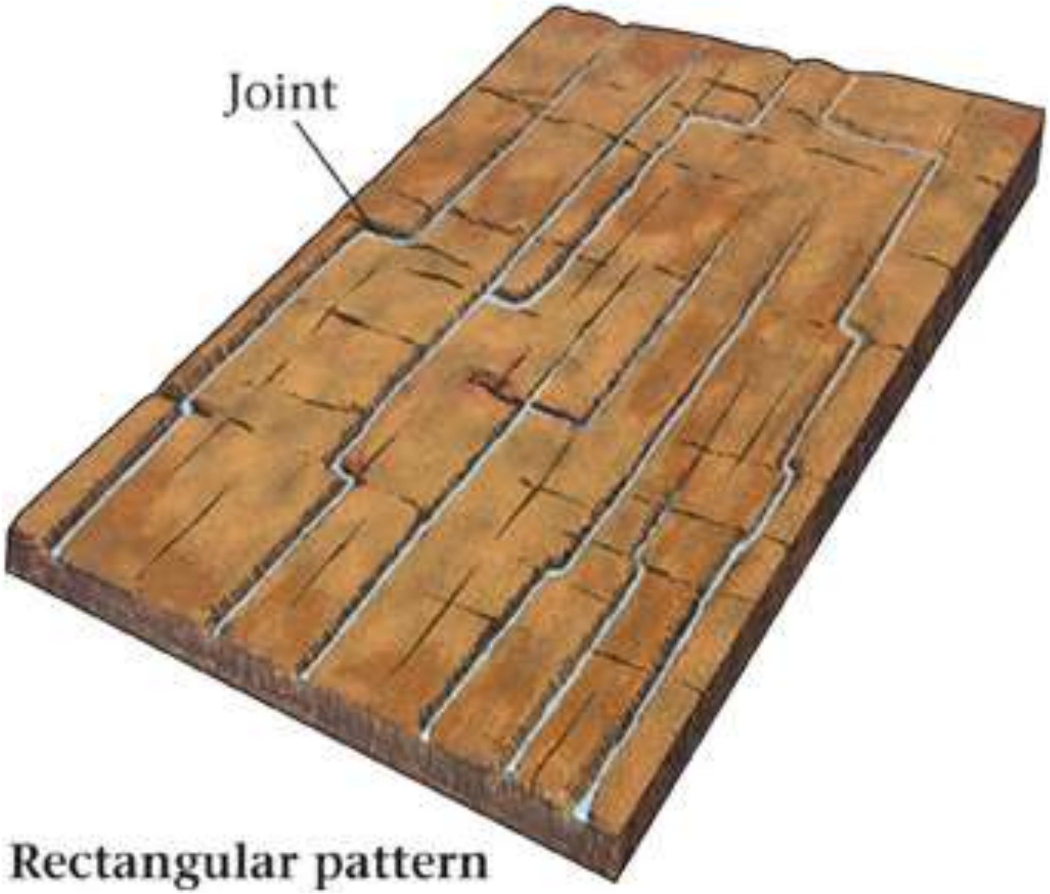
Drainage Networks

- Common drainage patterns
  - Radial – form on the surface of a cone shaped mountain, usually a volcano



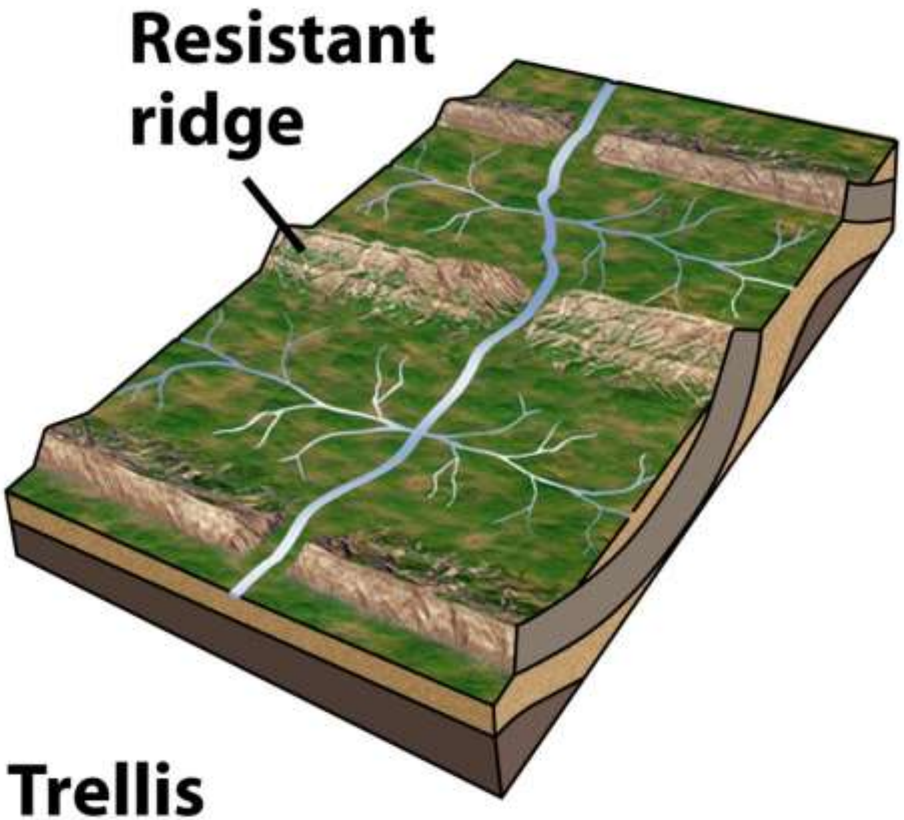
Drainage Networks

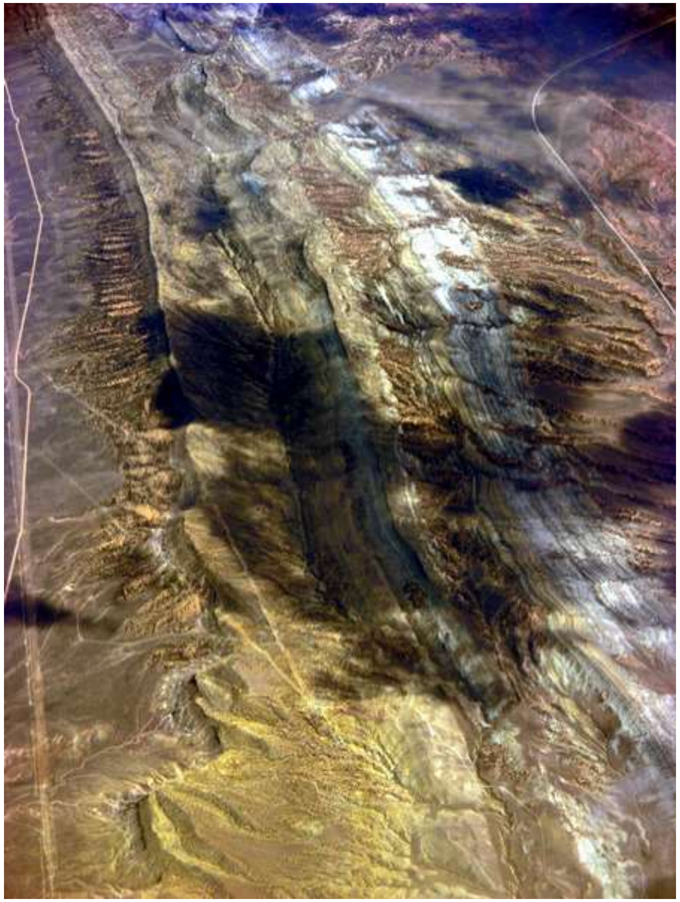
- Common drainage patterns.
  - Rectangular – Controlled by jointed rocks.



Drainage Networks

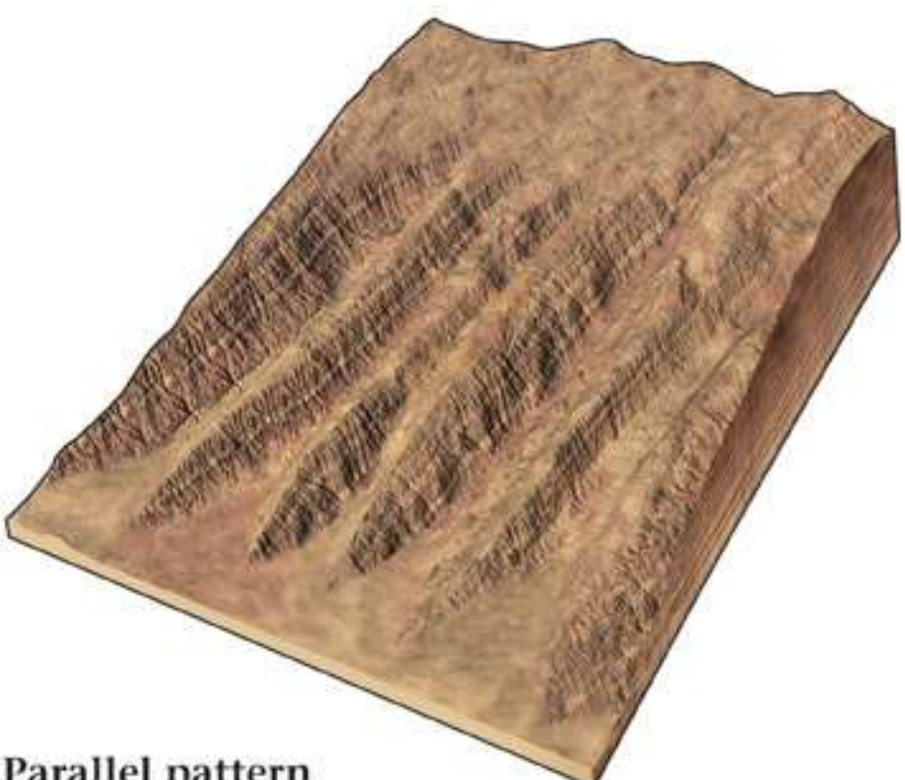
- Common drainage patterns
  - Trellis – Alternating resistant and weak rocks





Drainage Networks

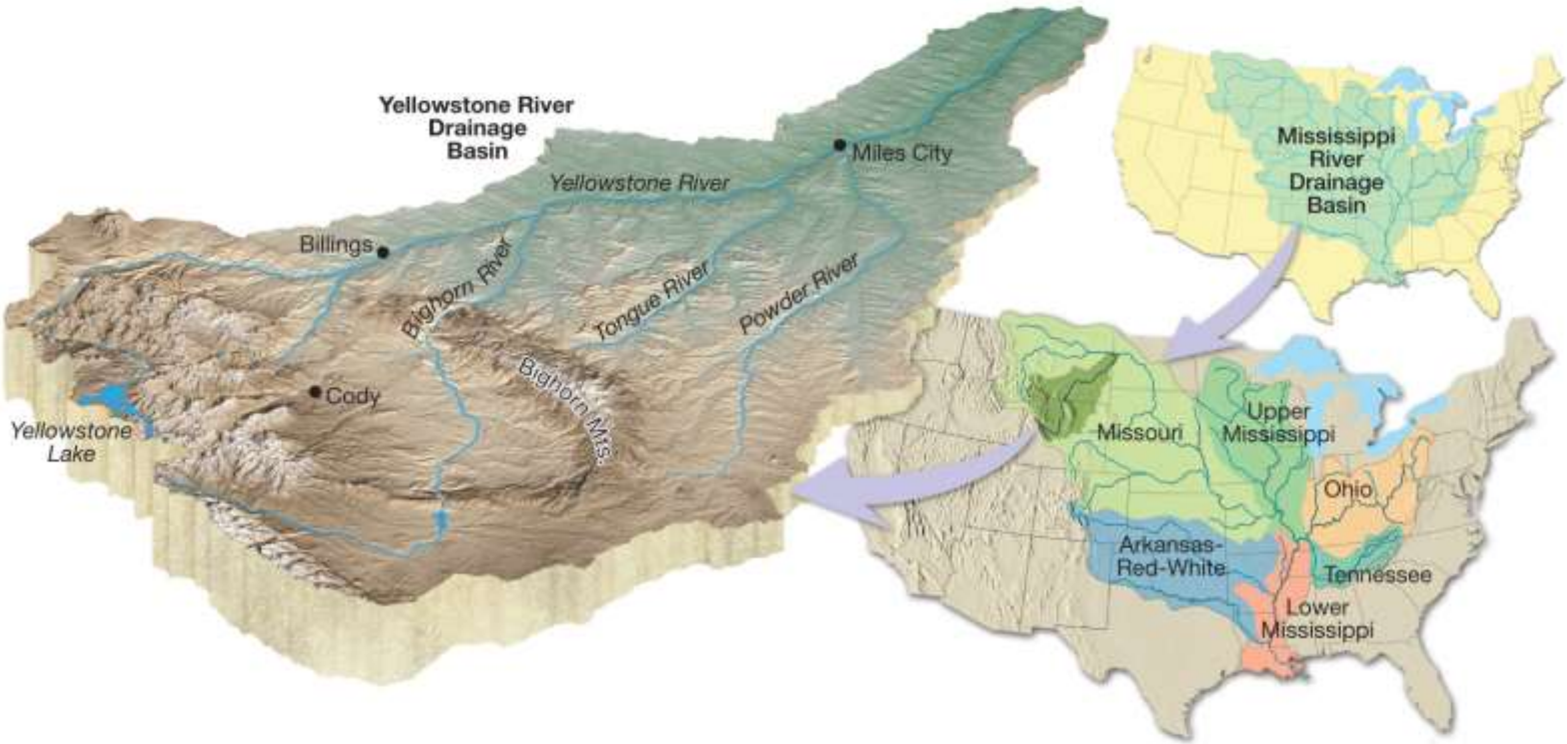
- Common drainage patterns
  - Parallel – Streams developed on a uniform slope



Parallel pattern

Drainage Basins

All land area from which water flowing by gravity on the surface would pass through a given cross-section of a stream channel

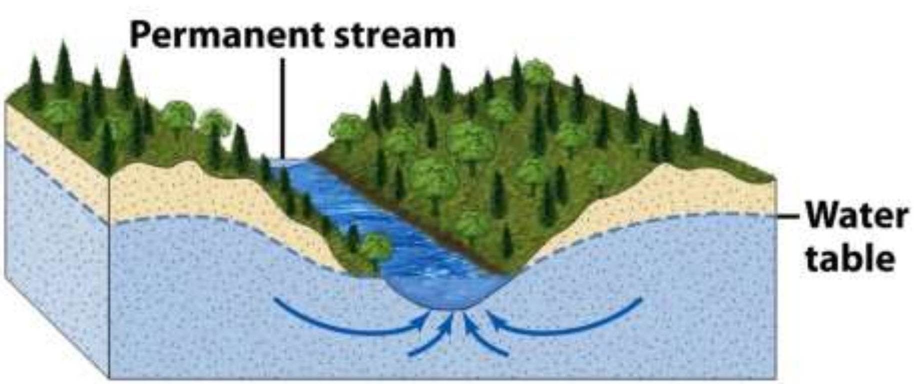


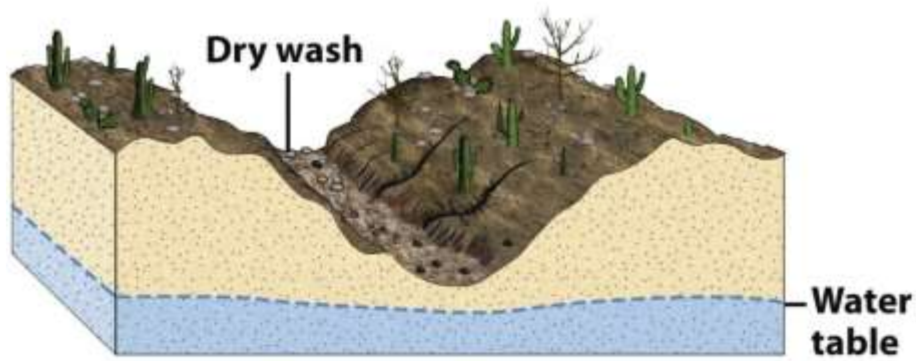
Drainage Basins

Permanent vs. Ephemeral Streams

- Permanent streams
  - Water flows all year
  - At or below water table
  - Humid or temperate
    - Sufficient rainfall
    - Lower evaporation
  - Seasonal discharge variation

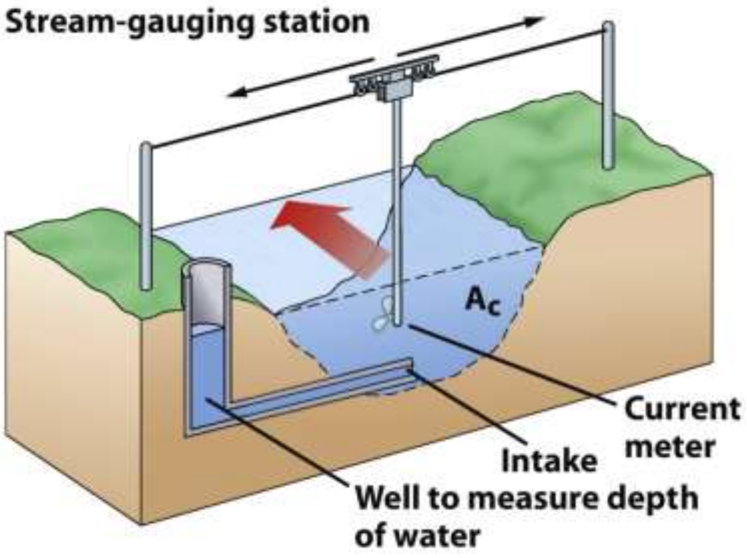
- Ephemeral Streams
  - Do not flow all year
  - Above the water table
  - Dry climates
    - Low rainfall
    - High evaporation
  - Flow mostly during rare flash floods





Discharge

- The amount water flowing in a channel
- Units?



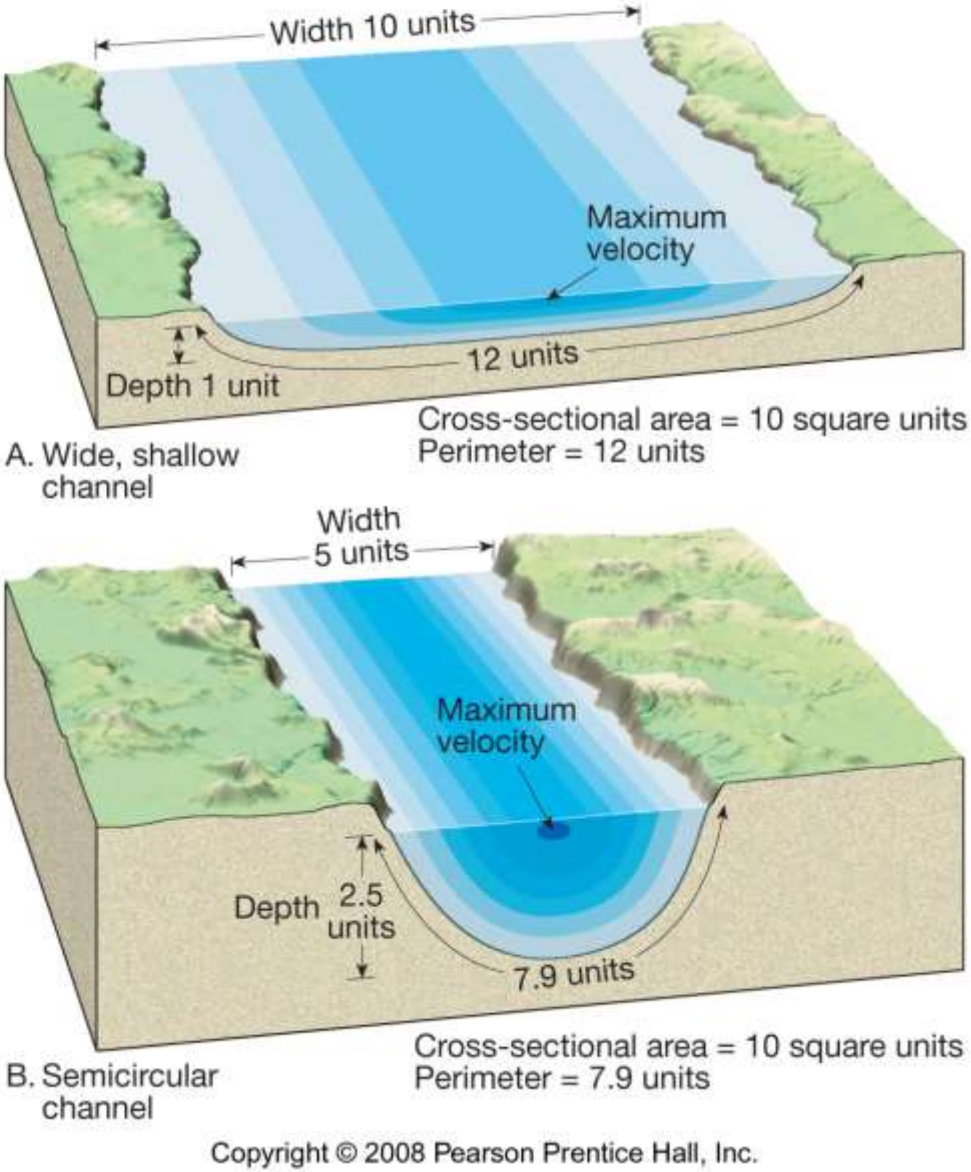
Group question

If you were white-water rafting or kayaking down this river and wanted to go fastest where would you go?

a) Close to the edges
b) In the middle
c) Between the middle and the edge

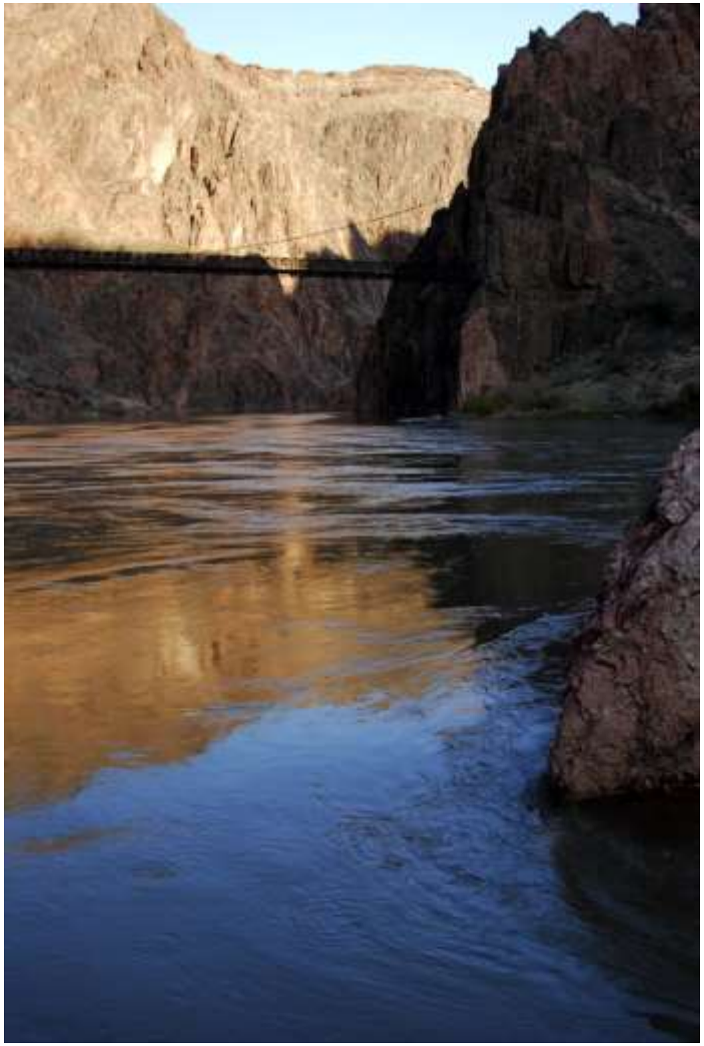
Channel shape affects stream velocity

- Velocity is not uniform in all areas of a channel



Streams flow in one of two ways:

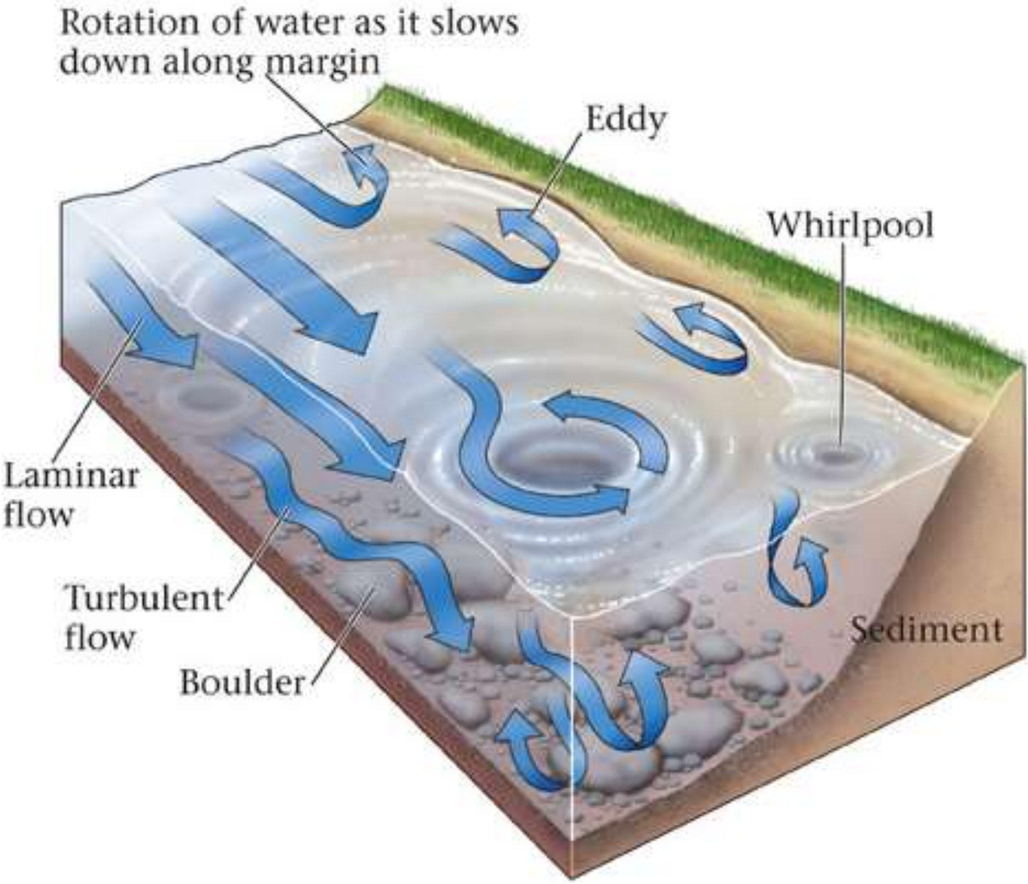
Laminar Flow



Turbulent Flow – most common!

Turbulent flow

- Stream flow is characteristically turbulent
  - Chaotic and erratic
  - Abundant mixing
  - Swirling eddies
- Turbulence caused by…
  - Flow obstructions
  - Shear in water
- Turbulent eddies scour the channel bed



The role of river systems

1. Erosion
2. Transport
3. Deposition

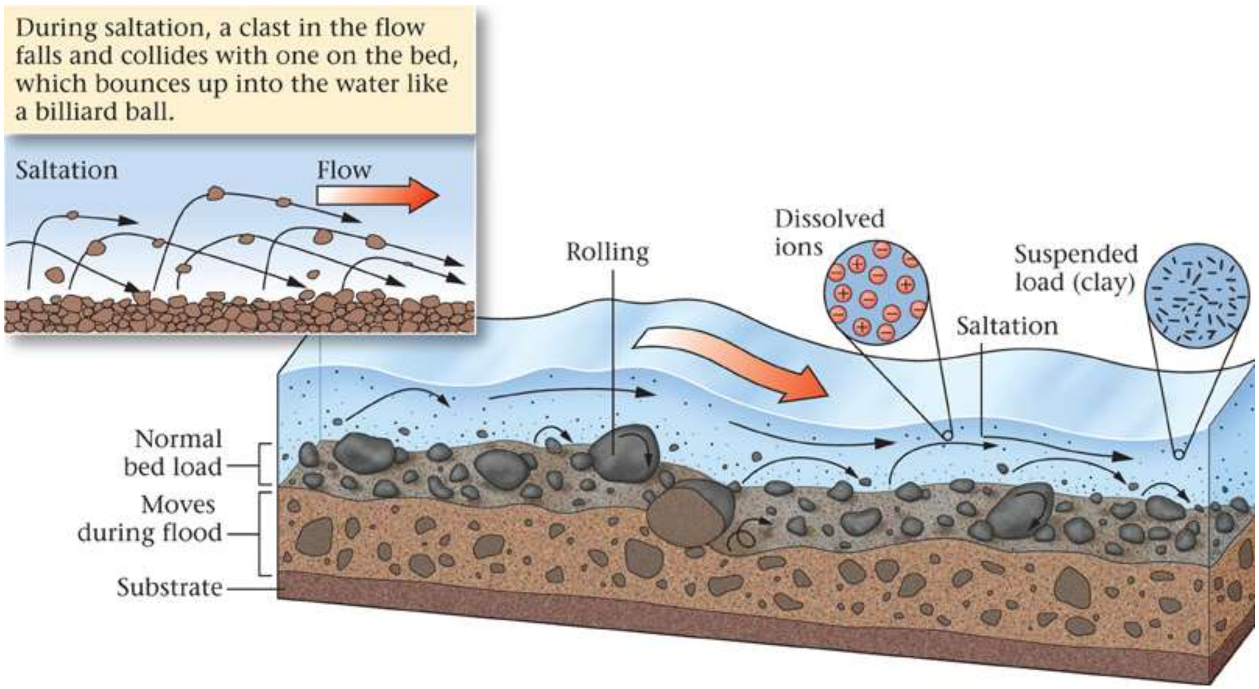
Through these processes, a wide variety of landforms are produced!

Erosional Processes

- Scouring
- Breaking and lifting
- Abrasion
- Dissolution


Sediment Transport

– Dissolved load – Ions from mineral weathering
– Suspended load – fine particles (silt and clay) in the flow
– Bed load – coarser particles that move along the stream bed



Group question

- Which sediment type is not affected by velocity?

a) Bed load
b) Dissolved load
c) Suspended load

How much sediment can streams carry?

- Competence
  - the maximum *size* of sediment that a stream can transport
  - Controlled by ……………
- Capacity
  - the *amount* of sediment a stream can transport
  - Controlled by ………….

Sediment Deposition

- When velocity changes so does competence
    - Gravel settles in channels
    - Sands drop out in near channel environments
    - Silts and clays only settle out in very calm water

Group question

- Put the following images into order from near its source to near the ocean/sea.

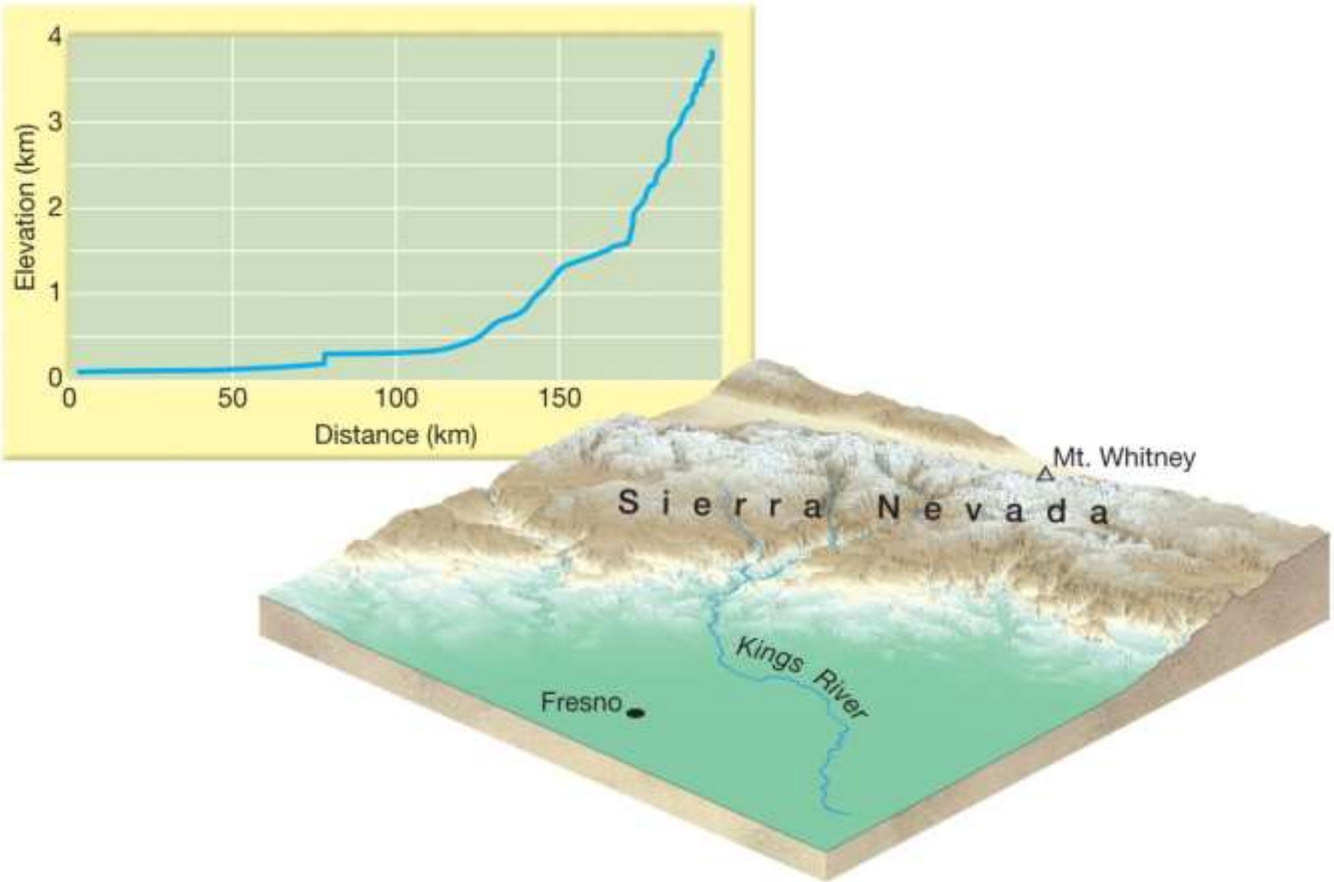
A) 1-2-3
B) 3-2-1
C) 3-1-2
D) 2-3-1

Longitudinal Changes

- The character of a stream changes with flow distance

Longitudinal Changes

Cross-sectional view of a stream gradient from source (headwaters) to mouth



Longitudinal Changes

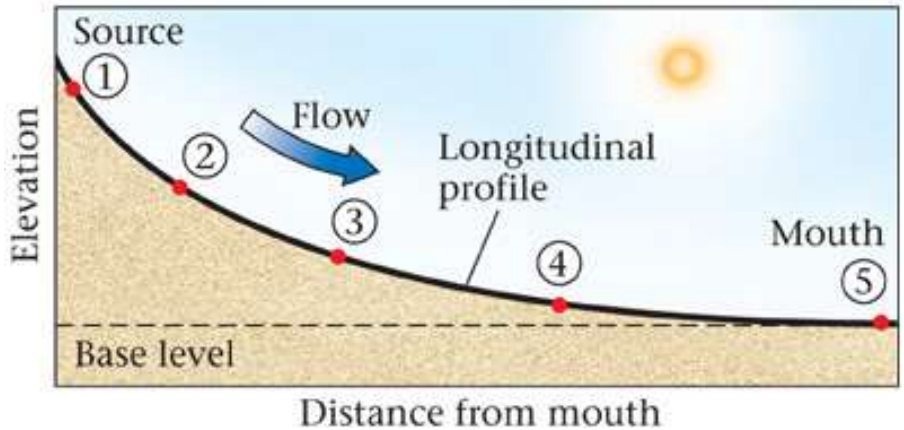
- The character of a stream changes with flow distance
  - Near the headwater source of stream…
    - Gradient is steep
    - Discharge is low
    - Sediments are coarse
    - Channels are straight and rocky

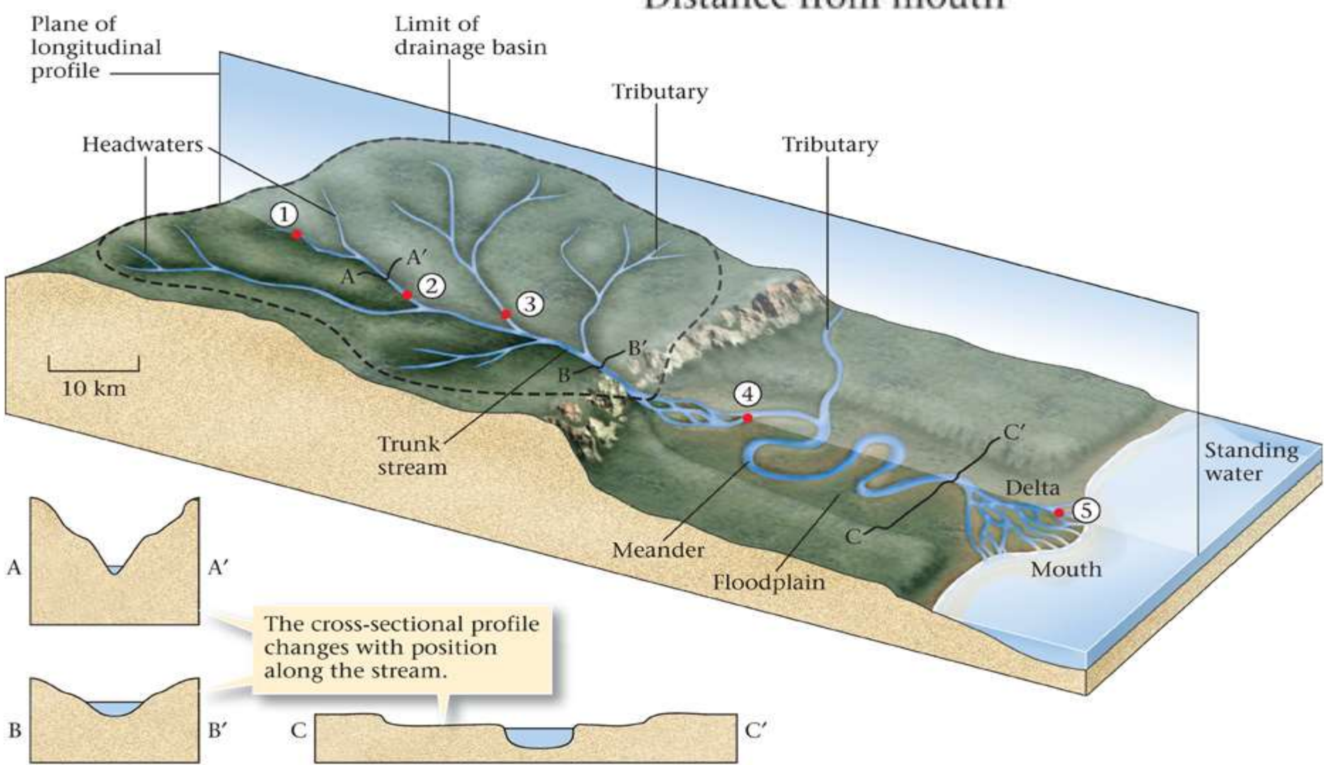
Longitudinal Changes

- Toward the mouth…
  - Gradient flattens
  - Discharge increases
  - Grain-sizes are smaller
  - Channels describe broad meander belts

Streams and related landscape features

- Valleys and canyons
- Rapids and waterfalls
- Alluvial fans and braided streams
- Meandering streams and floodplains
- Deltas





Valleys and Canyons

- Land far above base level is subject to downcutting

Valleys and Canyons

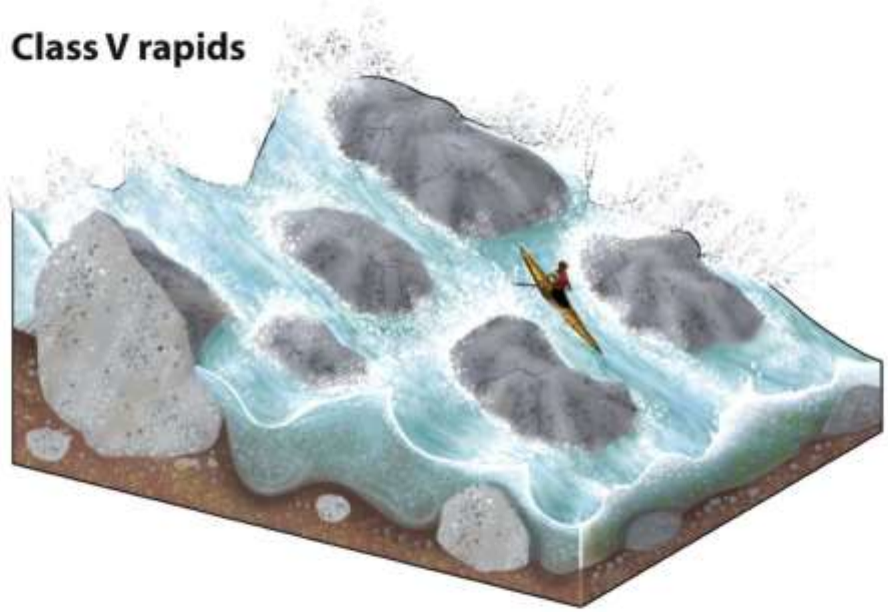
- Which of these images is of a location with harder rock?

Valleys and Canyons

- Stratigraphic variation often yields a stair step profile

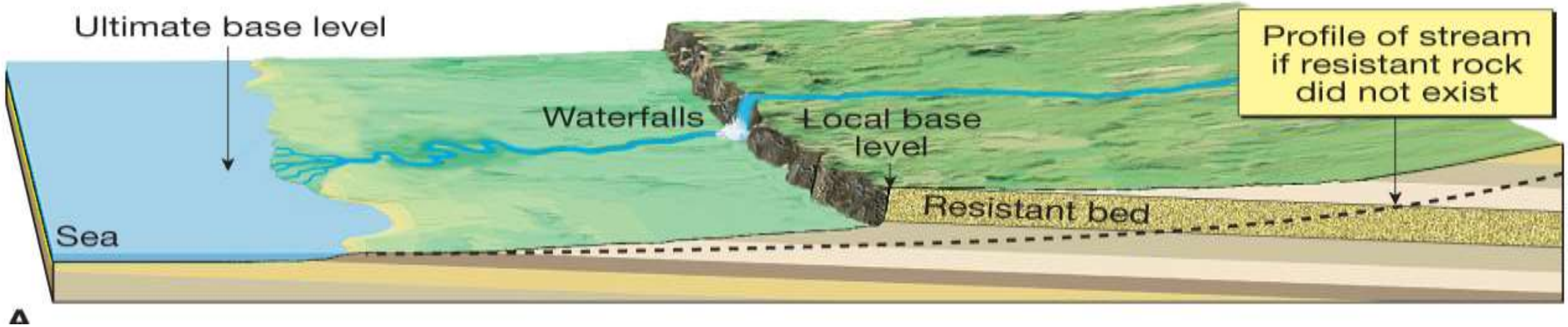
Rapids

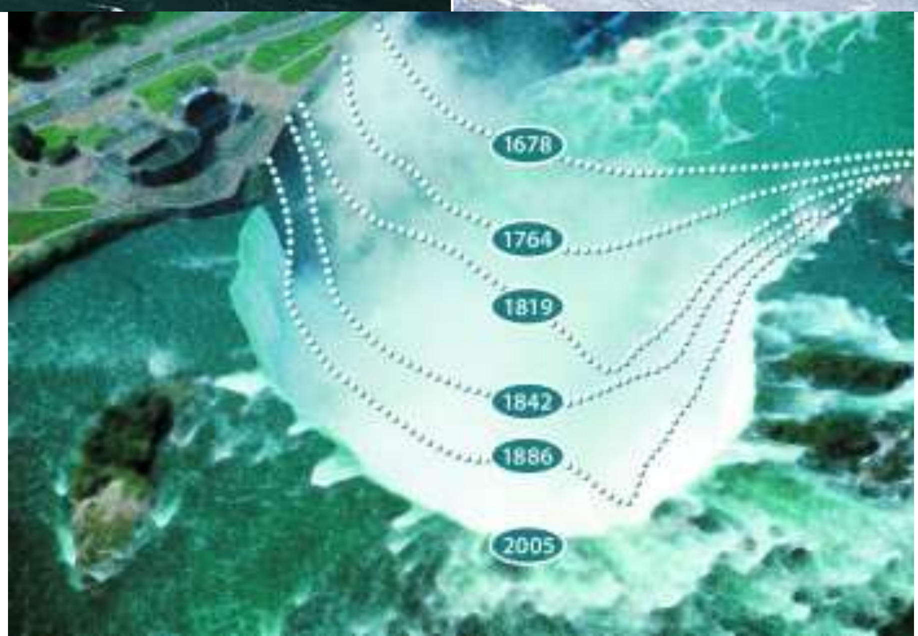
- Rapids are turbulent, rough water
- What might cause them?



Waterfalls

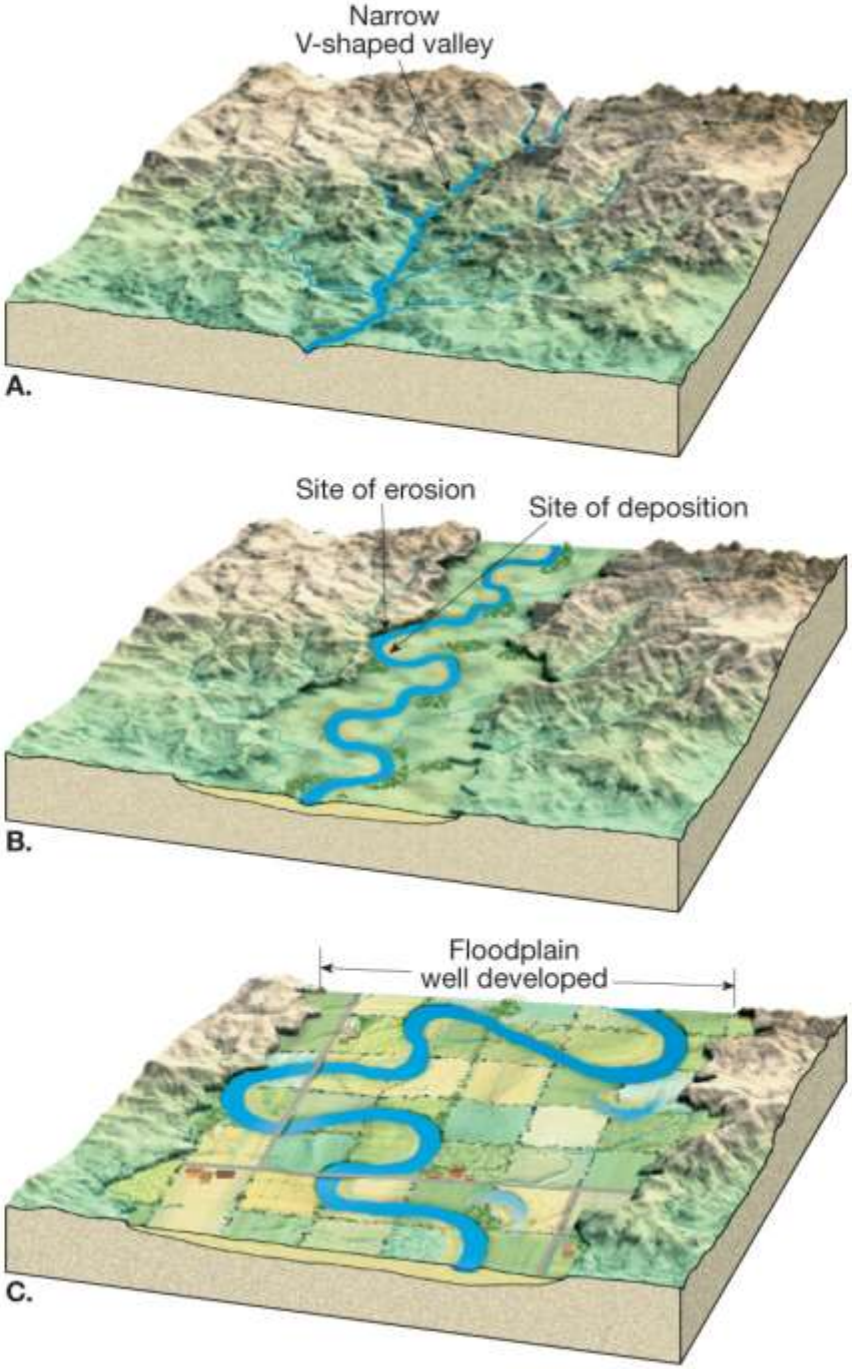
- Waterfalls are caused by temporary local base levels
- Where is the most erosion happening?




1678
1764
1819
1842
1886
2005

Braided Streams

- Form where channels are choked by sediment
- Flow occupies multiple channels across a valley
- How stable are sand/gravel bars?



Wide Valleys

- Once a stream is closer to base level
- Less downward erosion, more lateral erosion
- Lateral erosion forms wide, flat valley floors (floodplains!)

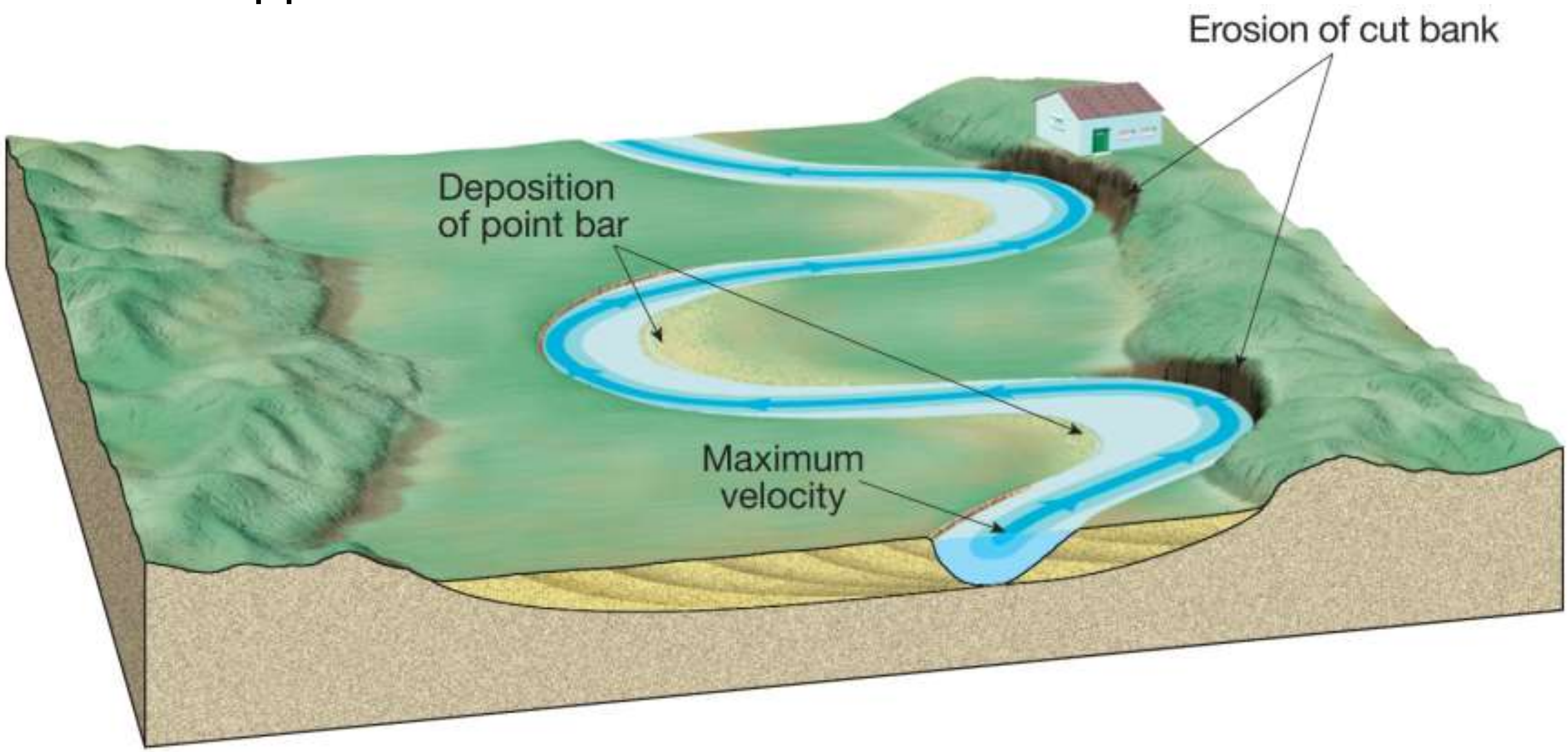
Meandering Streams

- Channels can form intricately looping curves if….
  - low gradient
  - streams travel over a broad floodplain
  - substrates are soft and easily eroded


A
B
C

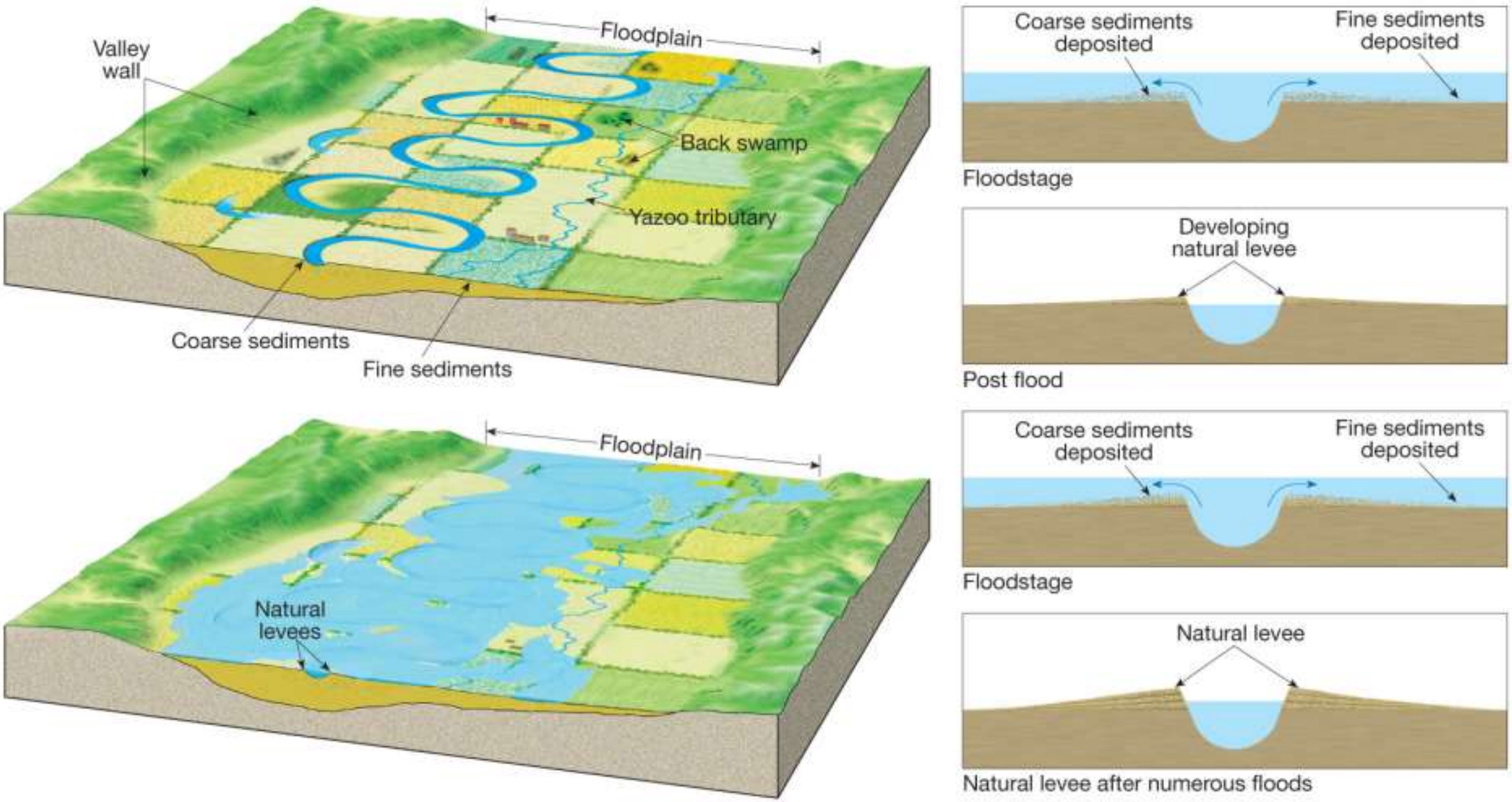
Meandering Streams

- Maximum velocity swings back and forth across flow
  - Fast water erodes one stream bank
  - The opposite bank collects sediment



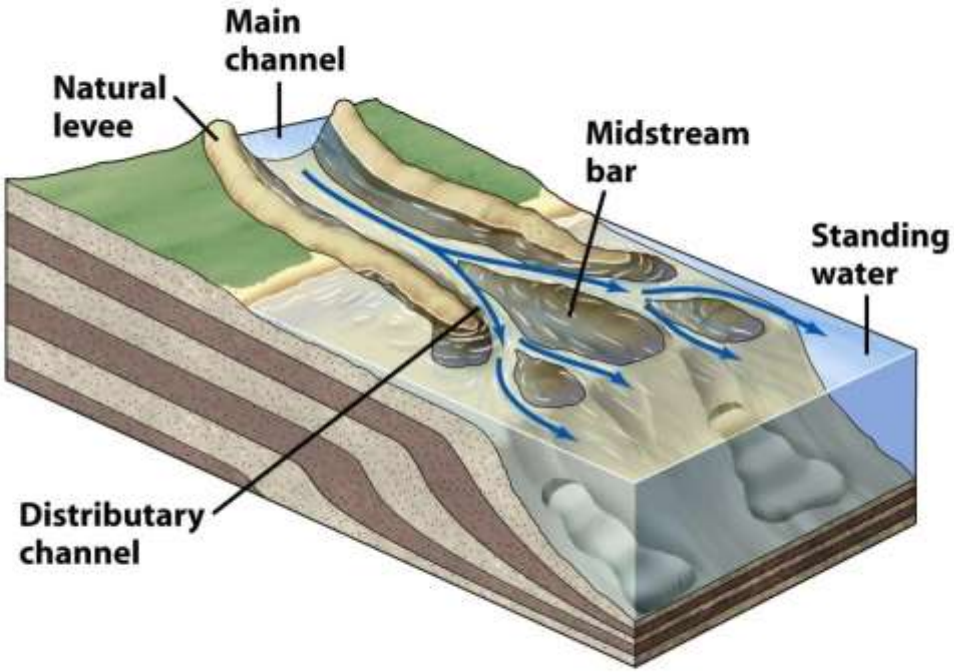
Meandering Streams

Natural levees and floodplains



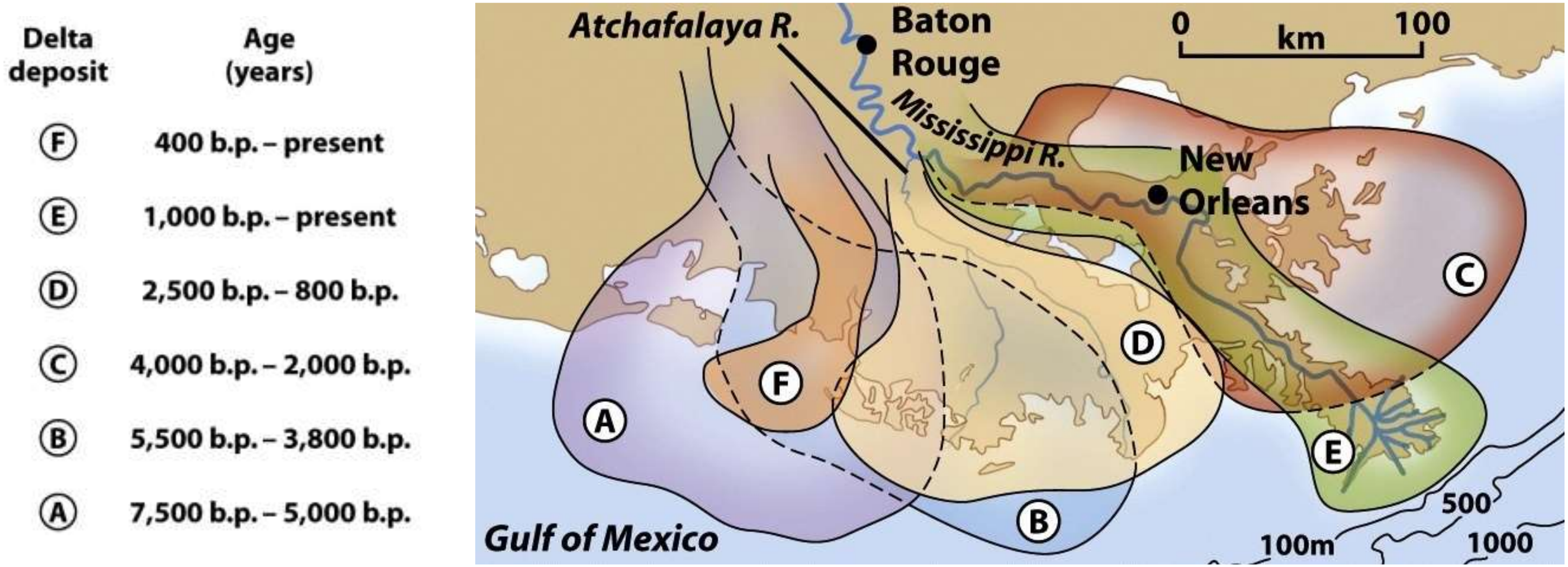
Deltas

- Deltas form when a stream enters standing water
  - Current slows and loses competence; sediments drop out
- Stream divides into a fan of small distributaries
- Shape due to the interplay of flow, waves, and tides



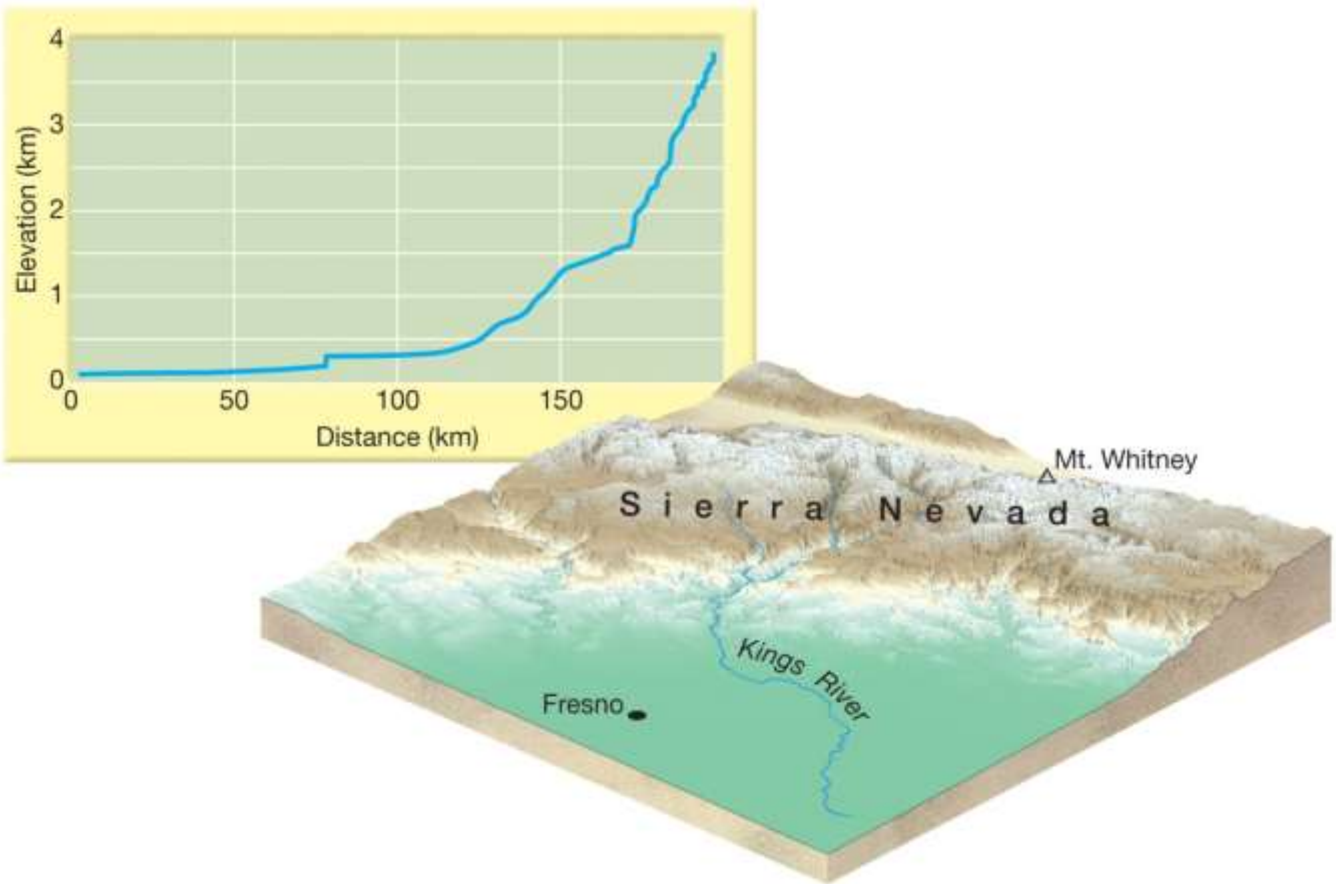
Deltas

- Distinct lobes preserve past Mississippi Delta history
- Why does it change?



Longitudinal Changes

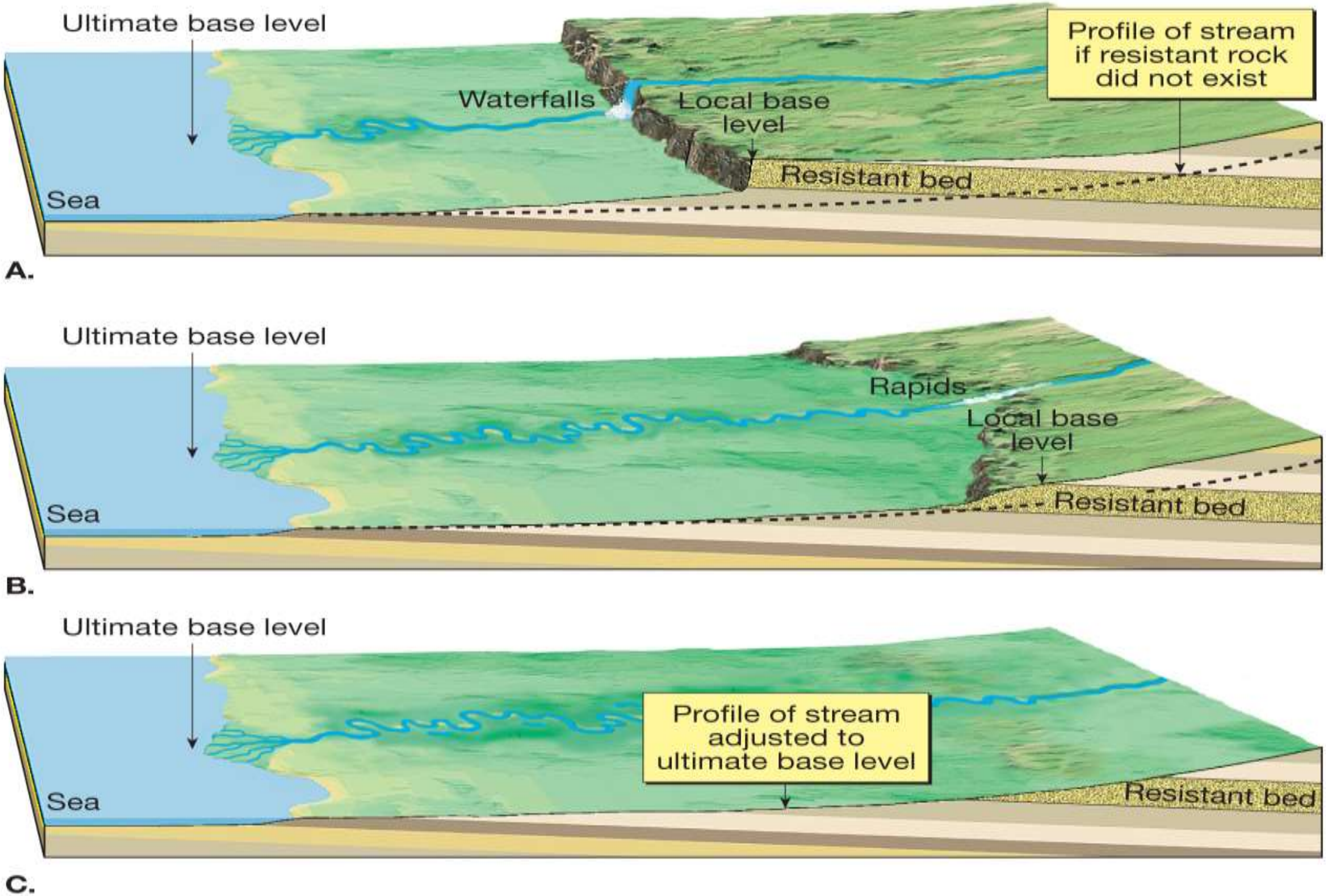
Cross-sectional view of a stream gradient from source (headwaters) to mouth



Base level

- Base level is the lowest point to which a stream can erode (e.g. a resistant rock layer, a lake, or the ocean)
- Two general types of base level
  - Ultimate (sea level)
  - Local or temporary (lakes, resistant rock layers, etc)
- Streams adjust to changes in base level:
  - Raising base level causes deposition
  - Lowering base level causes erosion

Adjustment of base level to changing conditions



Floods and flooding

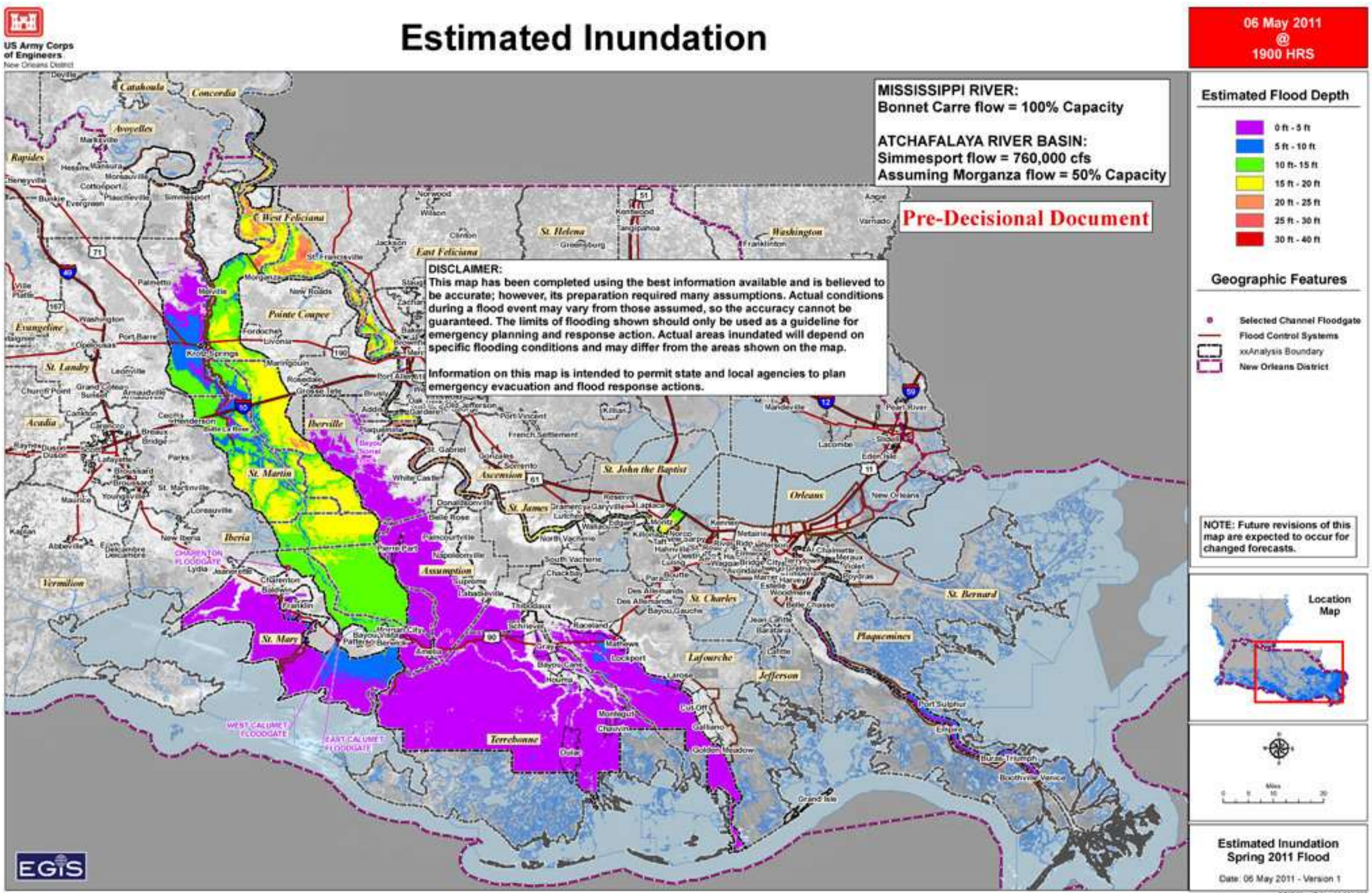
- Flooding occurs when discharge exceeds the channel capacity
- Floods are the most common and most destructive geologic hazard!
  - But part of natural stream behavior…
- How could floods occur?

Living with Floods

- Flood control is expensive and sometimes futile
- How do we try to control flooding?

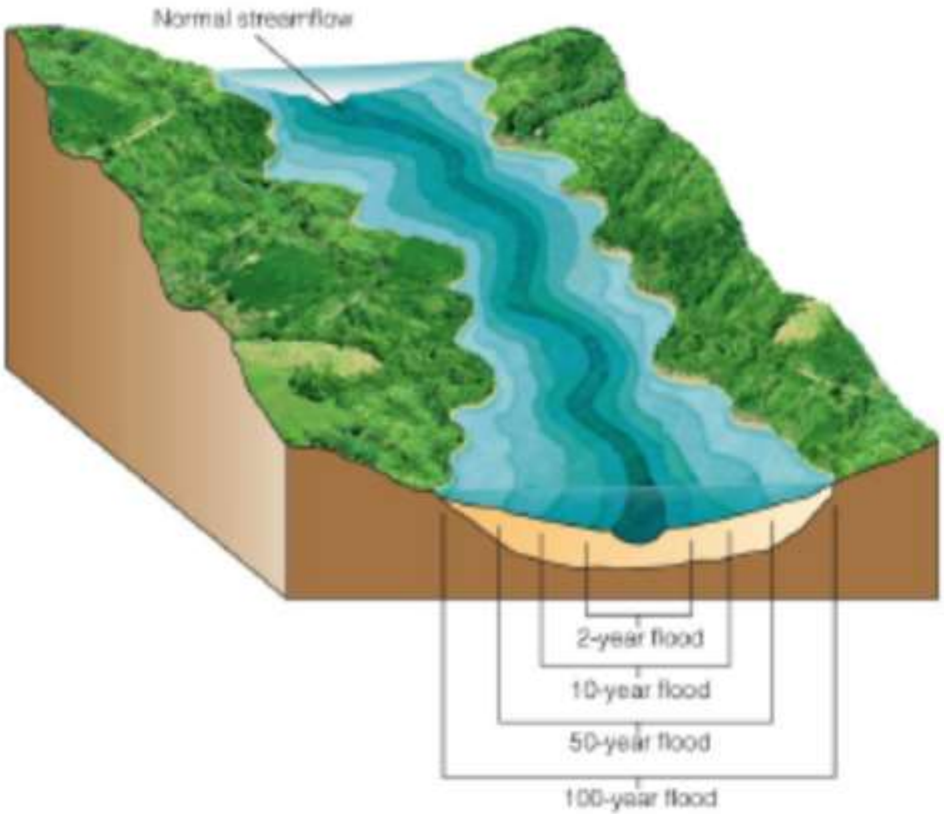
Streams and Channels - Floods

Example of flood management during Mississippi River flooding of 2011



Recurrence interval

- Land use planning requires understanding the frequency (how often) and magnitude (how big) of floods
  - Humans and natural processes can affect these
- Scientists study past flooding and use computer modeling to estimate the recurrence interval of floods



Question

- What chance is there that a 100-year flood will happen this year?

a) 1 in 100
b) 1 in 10
c) 1 in 1000
d) 50%

Streams and Channels – California "Superstorms" and flooding

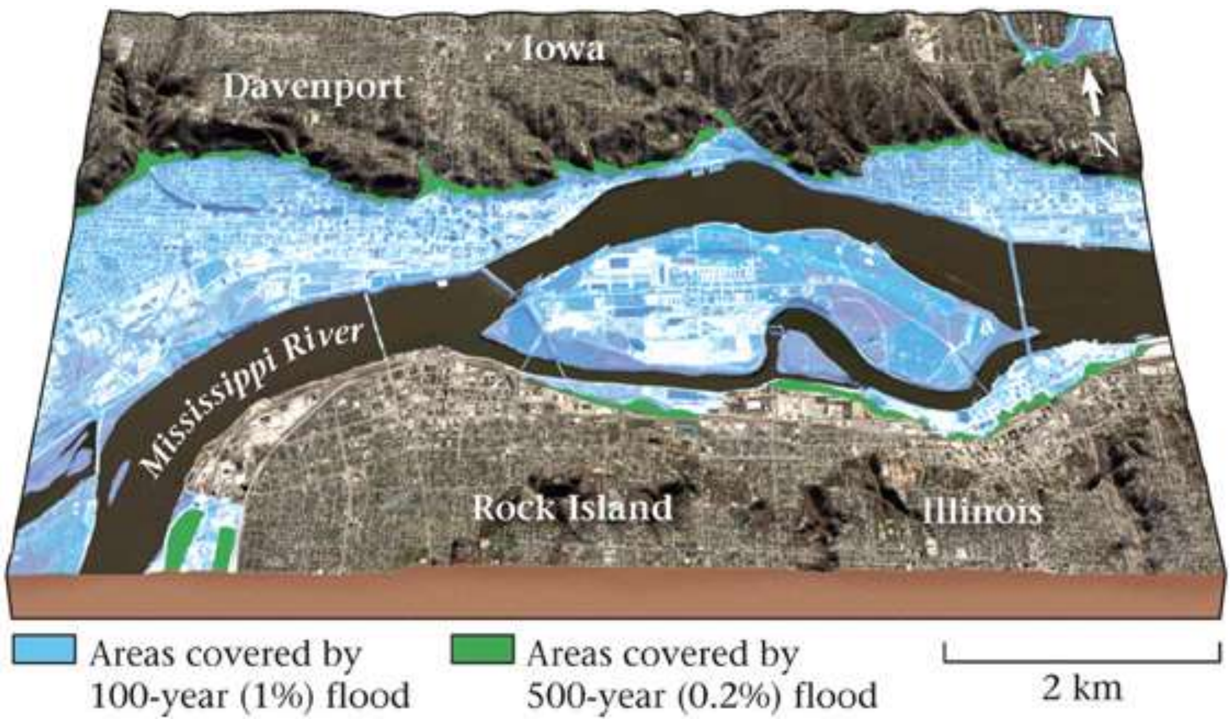
- Thought to occur every 150-400 years
- Last occurred in 1861-62

A photograph of downtown Sacramento at the height of the flood in January 1862. Photo from the Bancroft Library collection, Univ. of California, Berkeley.

Figure 8. Blue areas indicate ARkStorm flooding as projected by models used in the scenario.

More home-buying tips

- Flood risks are borne by homeowners, insurance companies, lenders, and government agencies
- Hydrologic data are used to produce flood risk maps
- Maps allow regulatory agencies to manage risks
- Building in flood-prone settings is tightly regulated



A Vanishing Resource?

- Rivers have directed human settlement patterns
  - Drinking water, food, transport, energy, recreation, and waste disposal
- In spite of their importance, rivers have been abused
  - Urbanization
  - Agriculture
  - Pollution
  - Dams