

Learning Objectives (LO)

Lecture 23: Surface Water

Read: Chapter 17

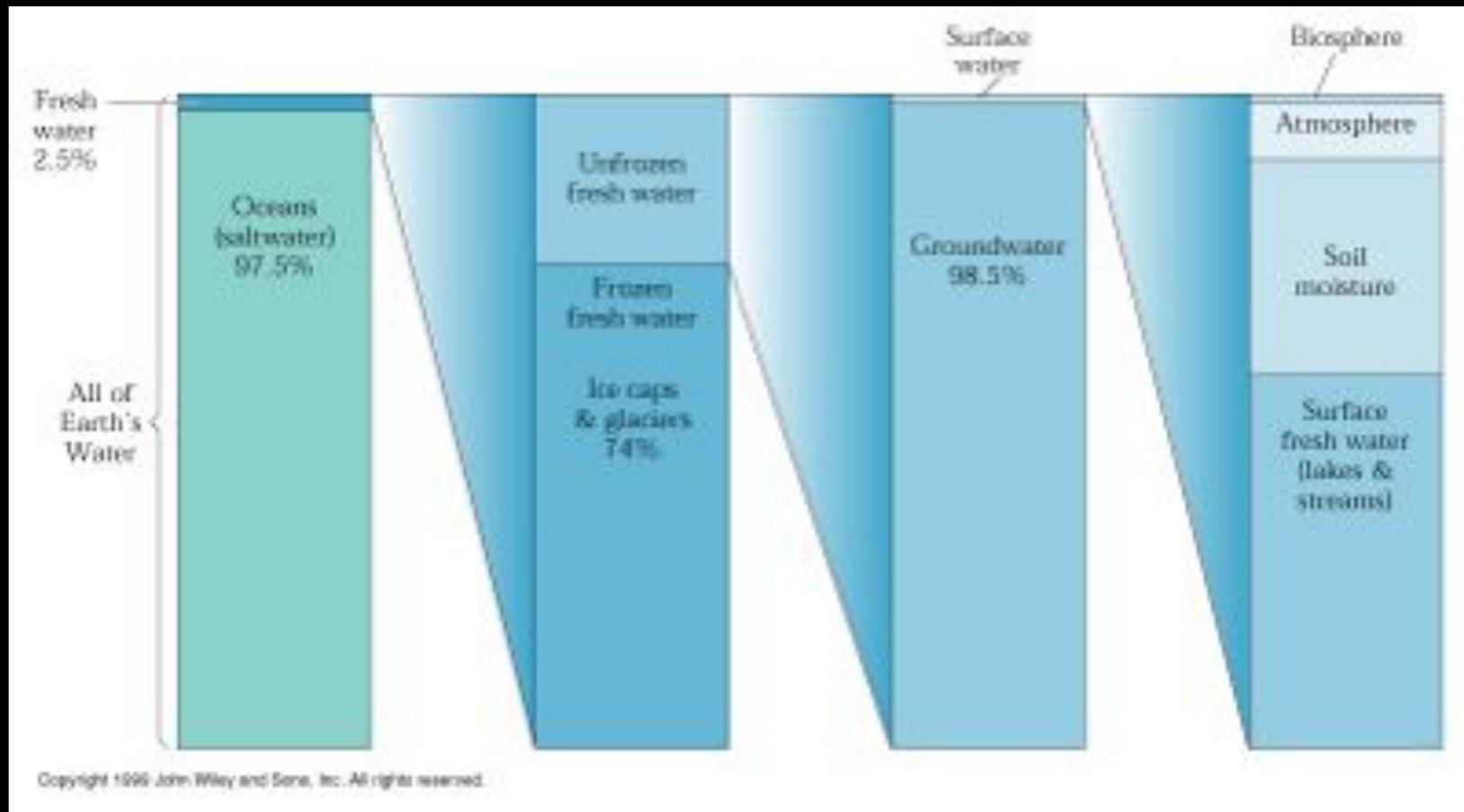
Homework due Thursday Nov. 19



What we'll learn today:

- 1. Processes of the hydrological cycle*
- 2. Drainage systems*
- 3. Causes of flooding and influence of base level changes*

Water where?



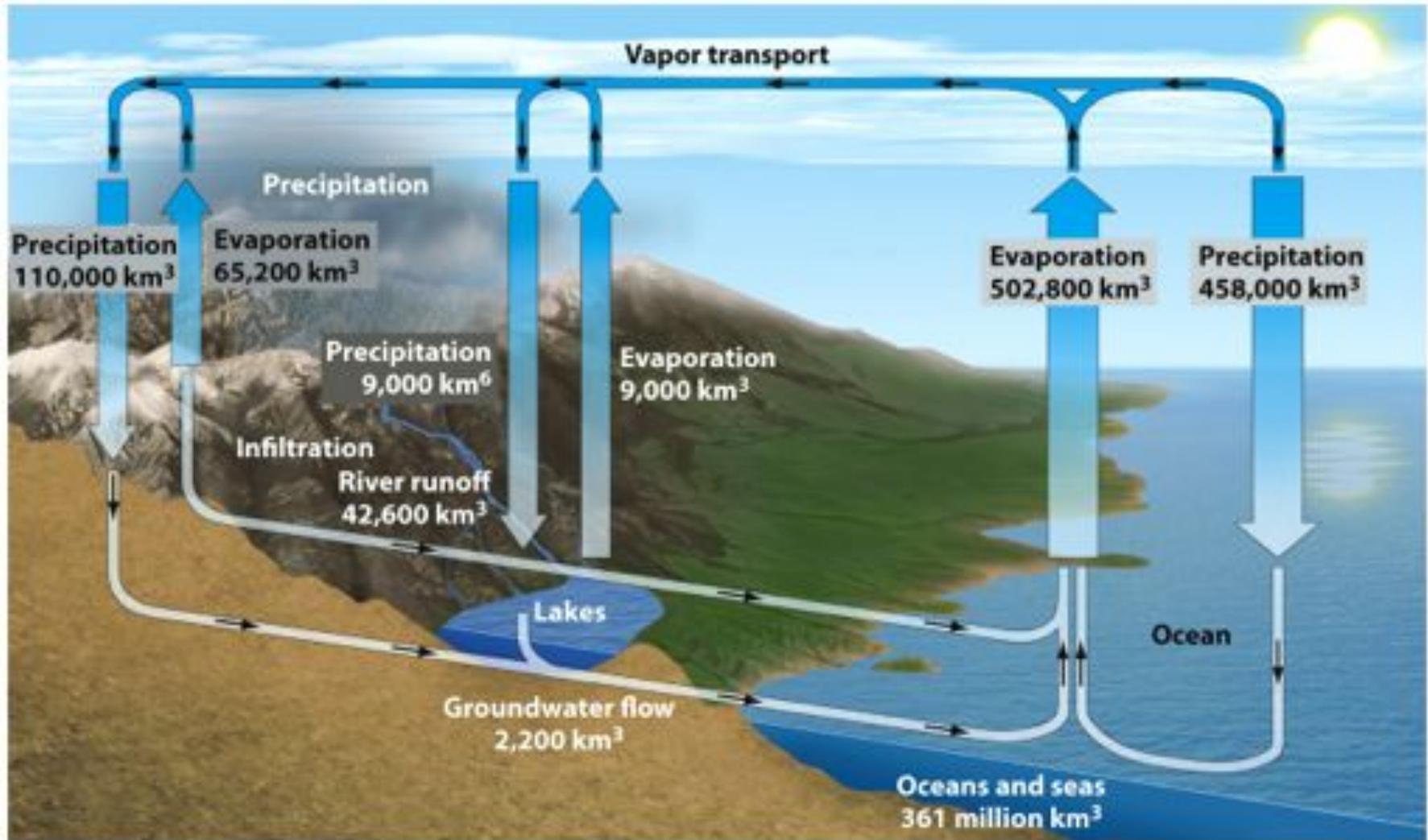
Mostly in the oceans, majority of fresh water in ice



Water covers 71% of Earth's surface and is the dominant agent governing environmental processes.

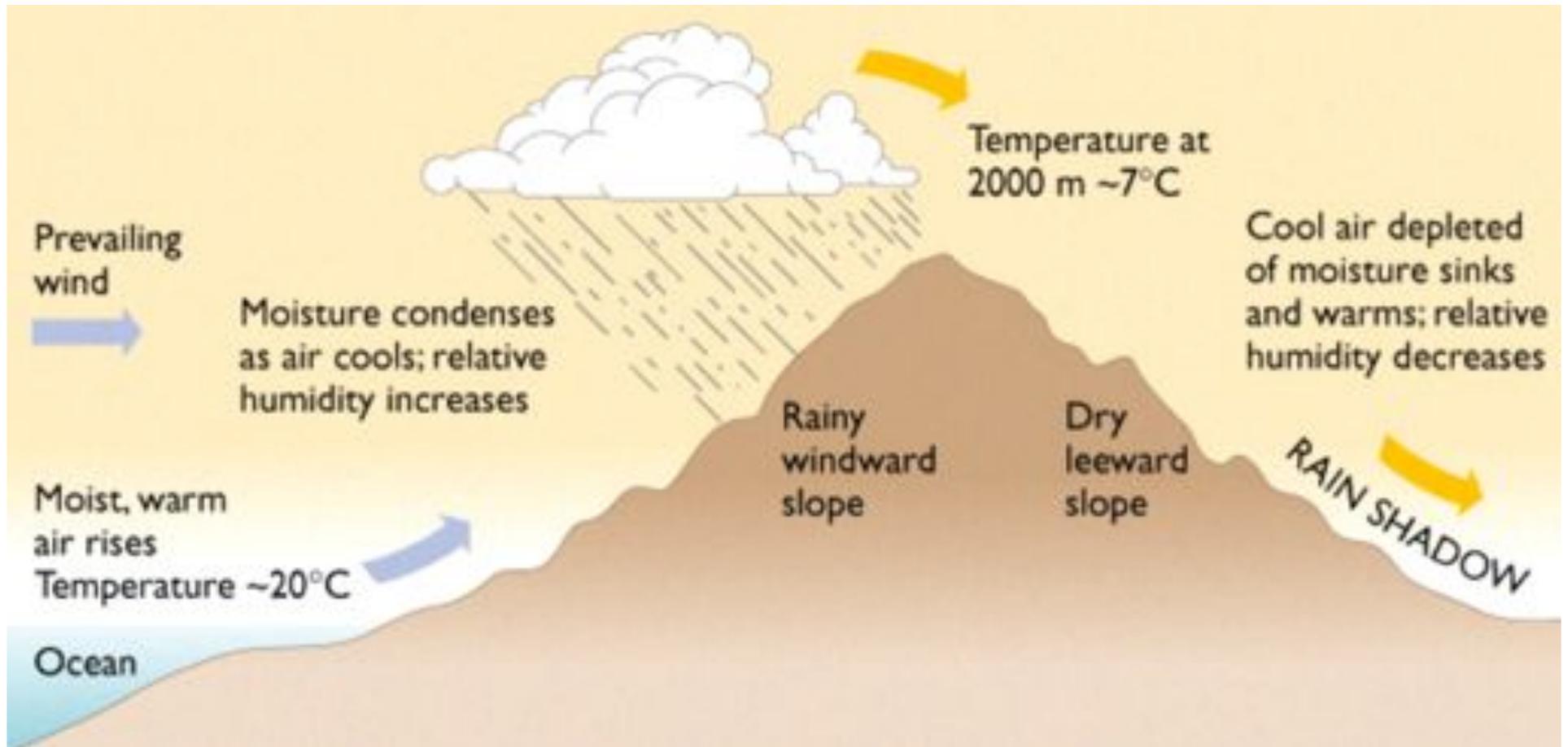


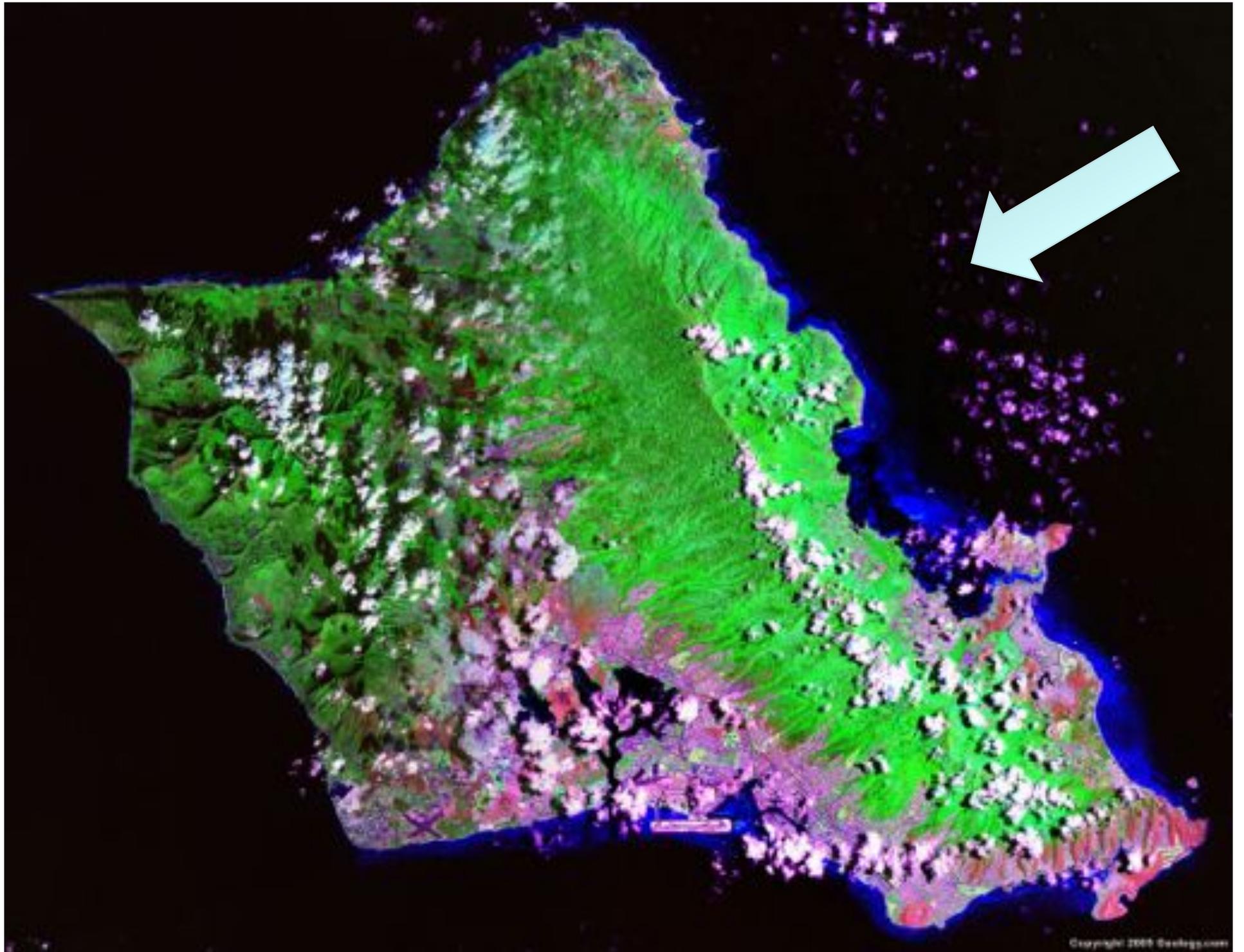
The **Hydrologic Cycle** moves water between the Atmosphere, the Ocean, and the Crust.



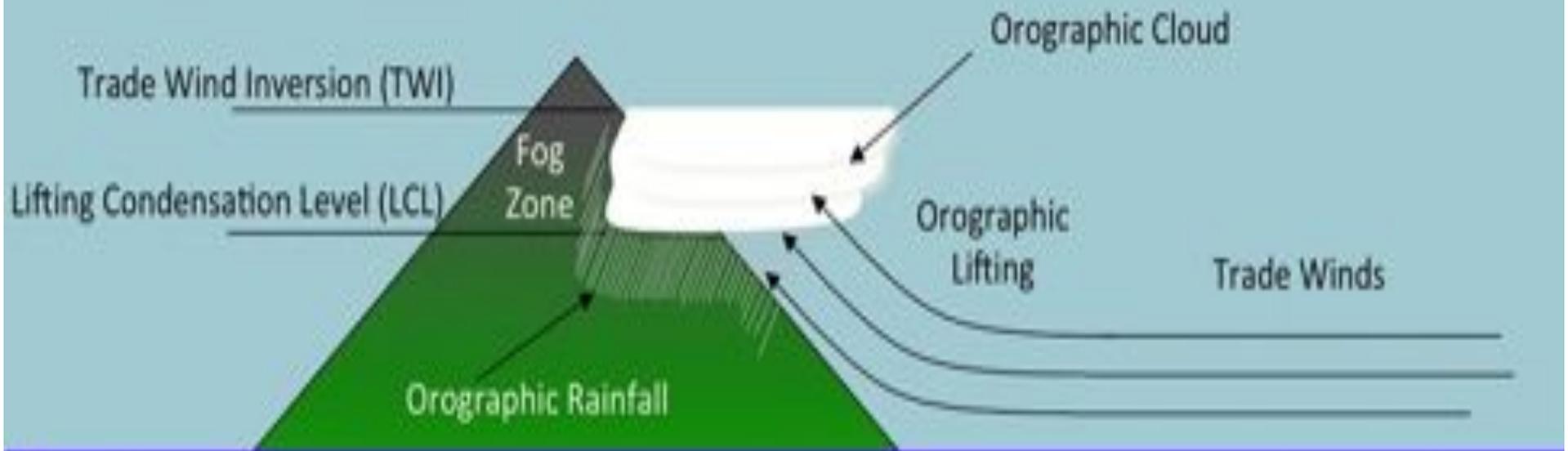
Orographic effect

- A mountain range forces the prevailing winds to rise up
- Rising air cools, forming clouds & precipitation



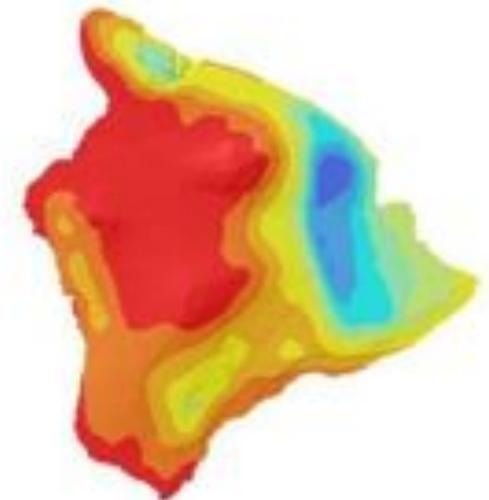
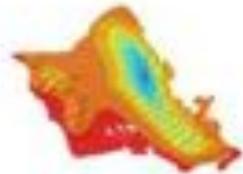
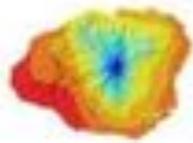


Rainfall in Hawaii: The Orographic Cloud

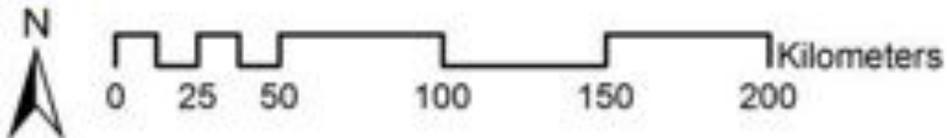
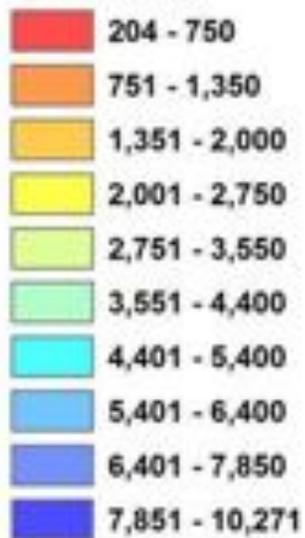


Mean Annual Rainfall State of Hawai'i

2011 Rainfall Atlas of Hawai'i
Department of Geography, University of Hawai'i at Mānoa

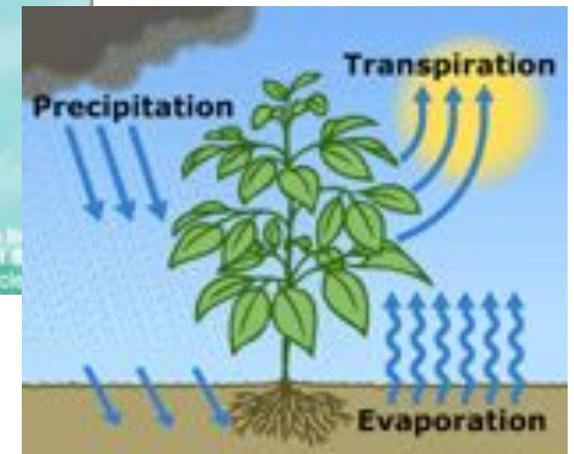
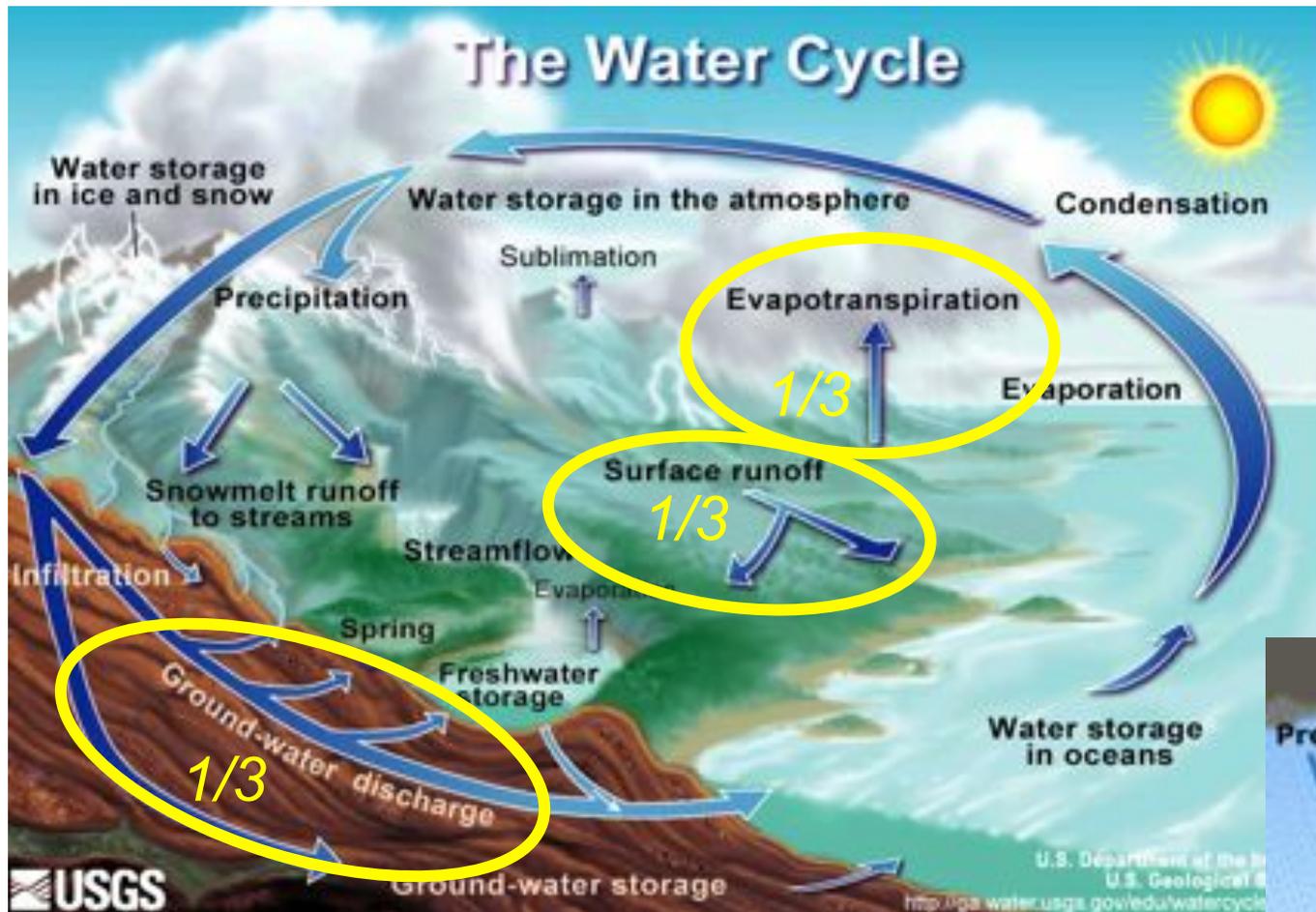


Annual Rainfall (mm)



Rainfall atlas of Hawaii:

<http://rainfall.geography.hawaii.edu/interactivemap.html>



evapotranspiration

Of all the rain that falls on Oahu, about:

- 1/3 is taken by plants (evapotranspiration)
- 1/3 is absorbed into the groundwater
- 1/3 runs off into the ocean

Follow the Manoa Stream



Follow the Manoa Stream



What are the factors that control:

- Rate of flow
- Amount of sediment
- Slope of streambed
- Flooding
- Human water use
- Pollution

Drainage Systems

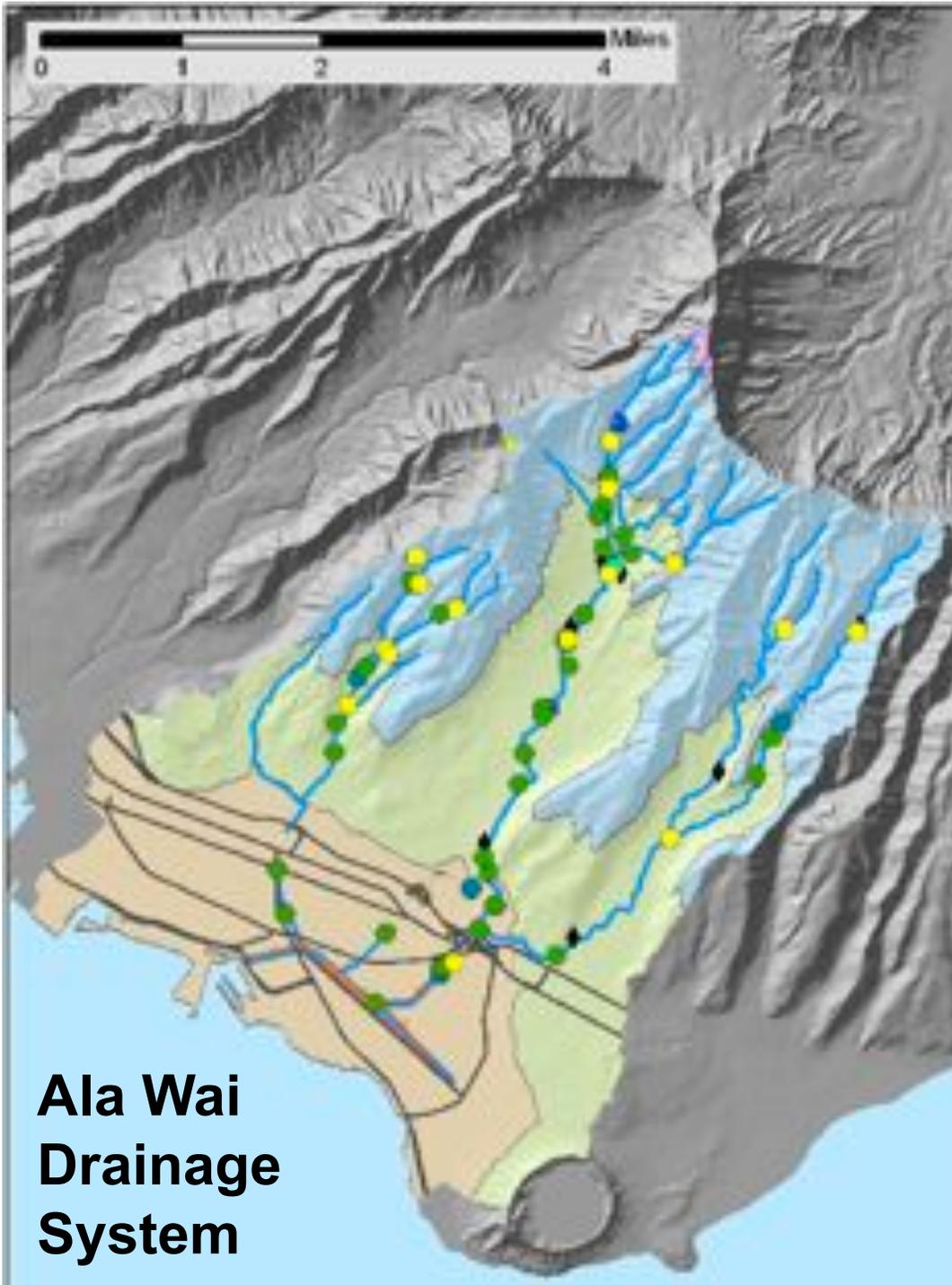


A **Stream** is any flowing body of water following a channel.

A **River** is a major branch of a stream system.

A **Drainage System** is a network of channels.

The total area feeding water to a stream is the **Watershed**.



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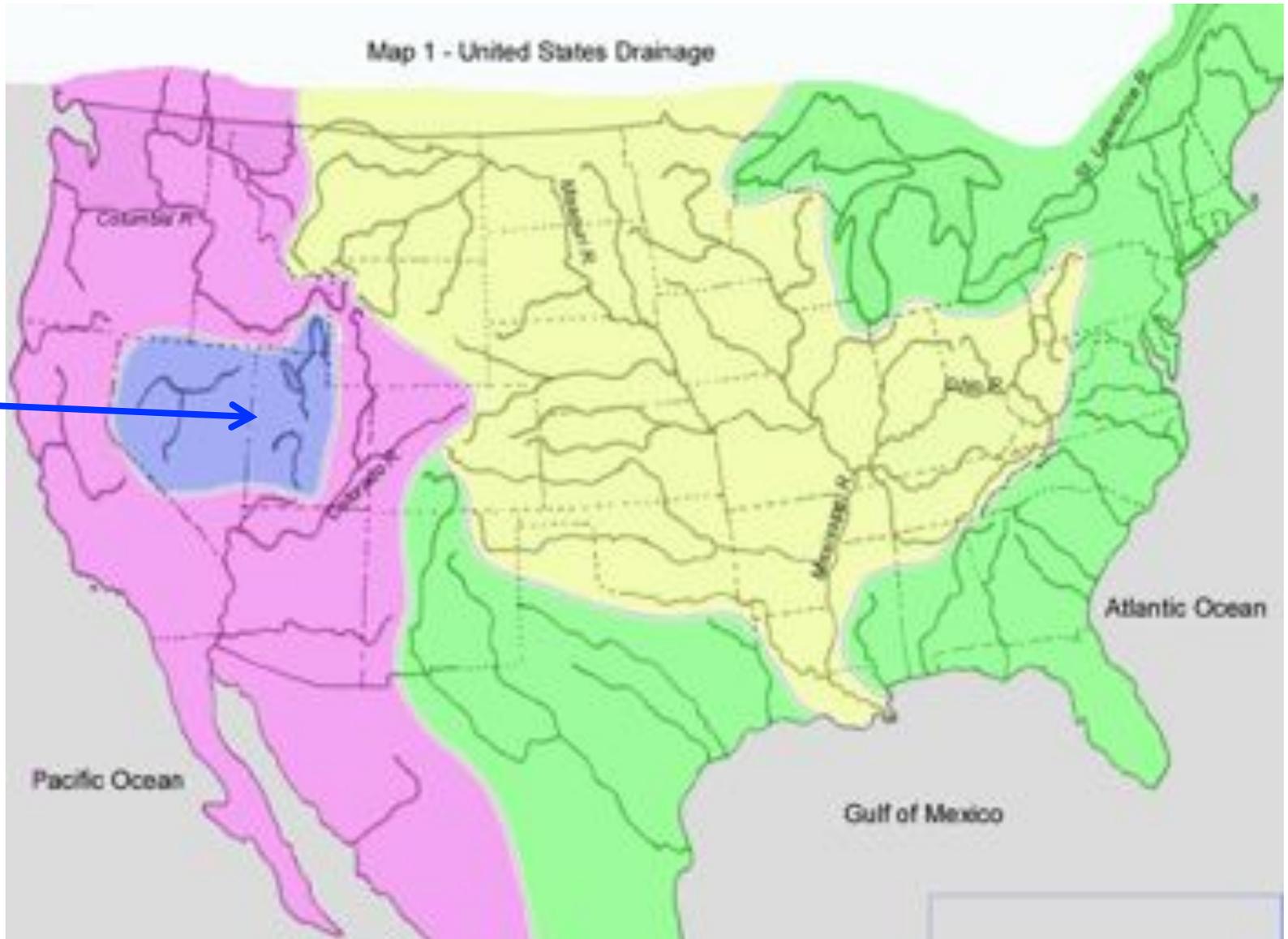
The total area feeding water to a stream is the **Watershed**.

The Mississippi River drains about 2/3 of the Continental US



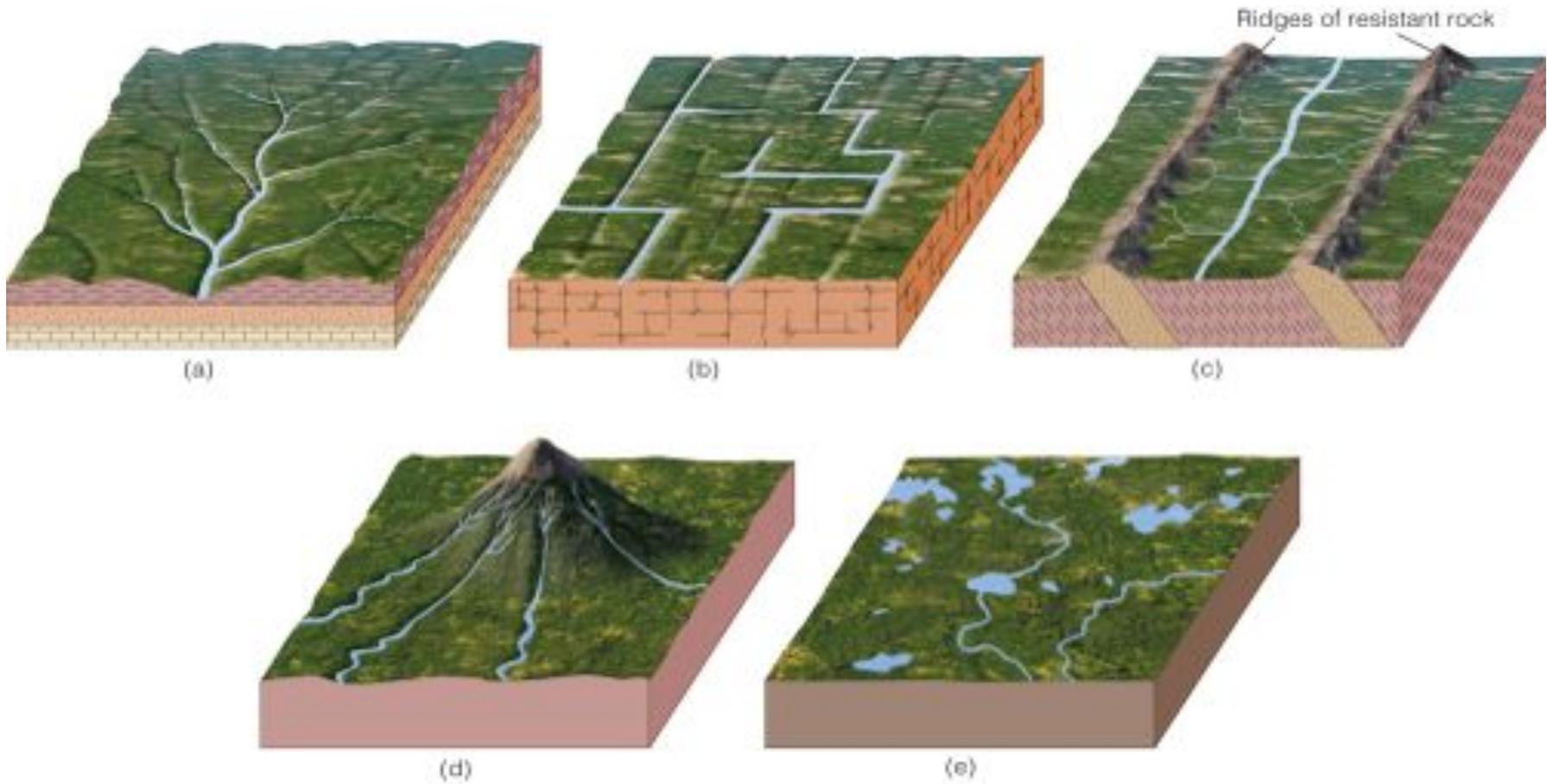
Major Drainage Basins of the Continental US

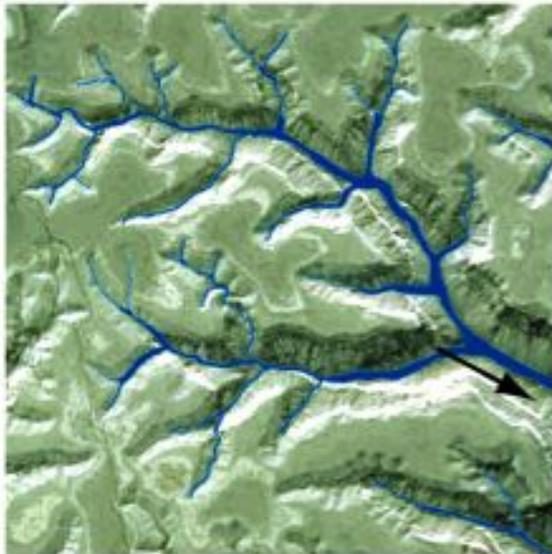
Great Basin:
Internally
draining



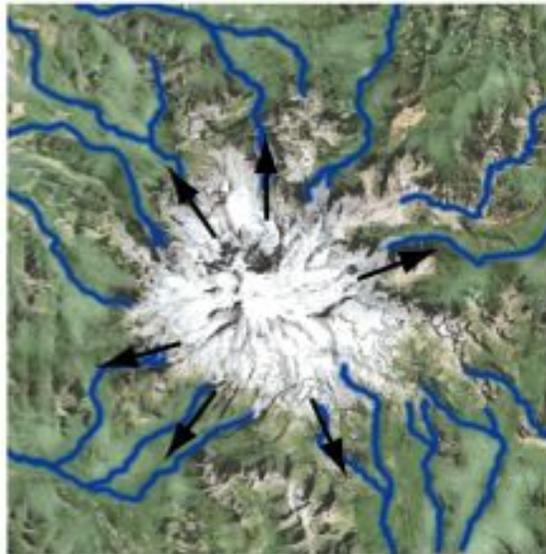
Drainage Patterns

Geology may determine where stream flows

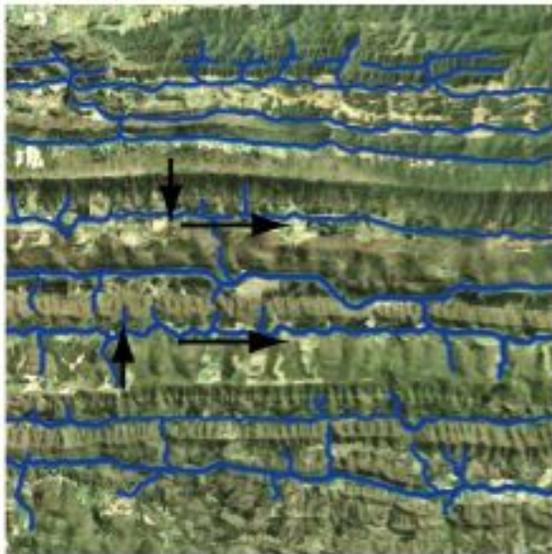




Dendritic



Radial



Trellis

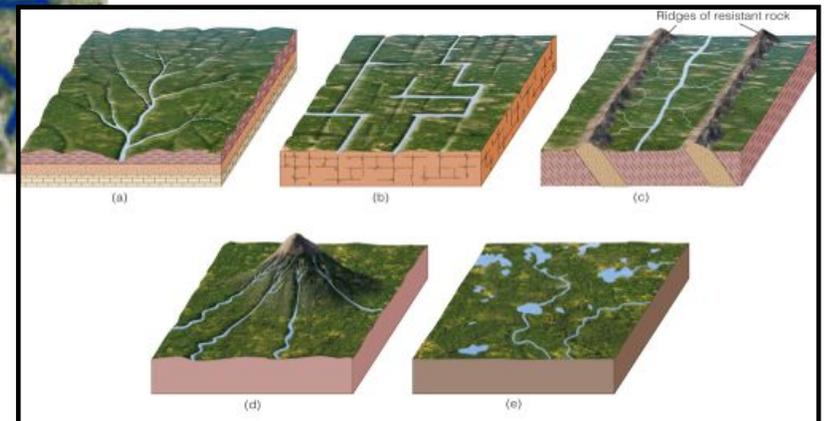


Rectangular

Dendritic is most common.

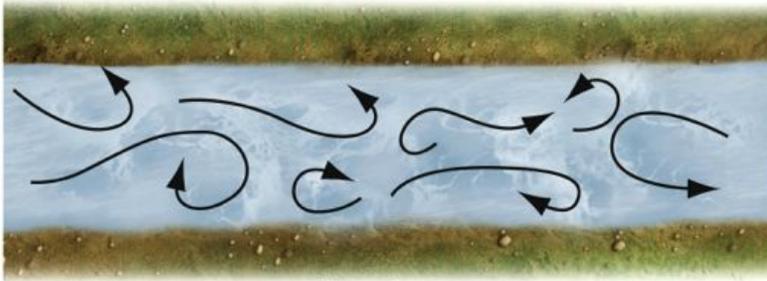
Radial occurs on a mountain or hilltop.

Trellis and **Rectangular** result from regular folds or fractures of bedrock.

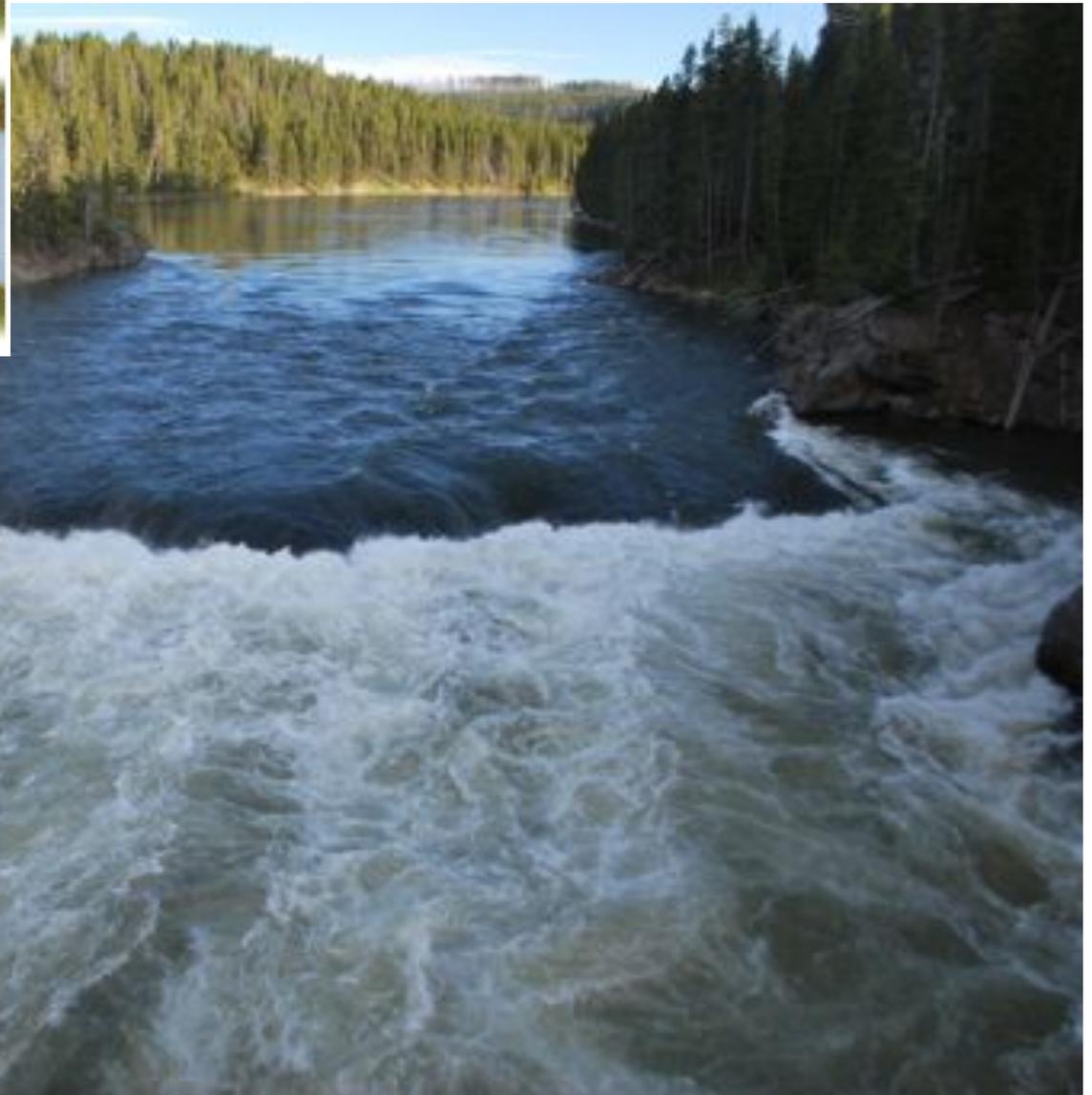
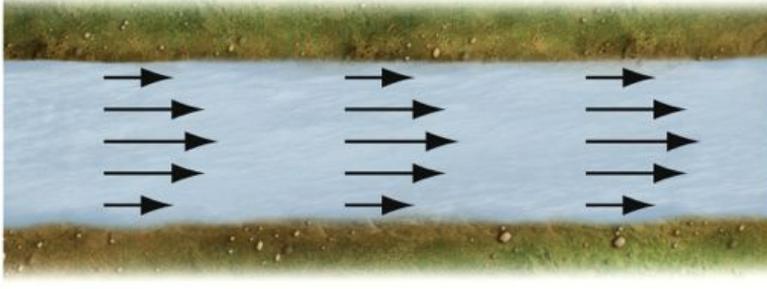


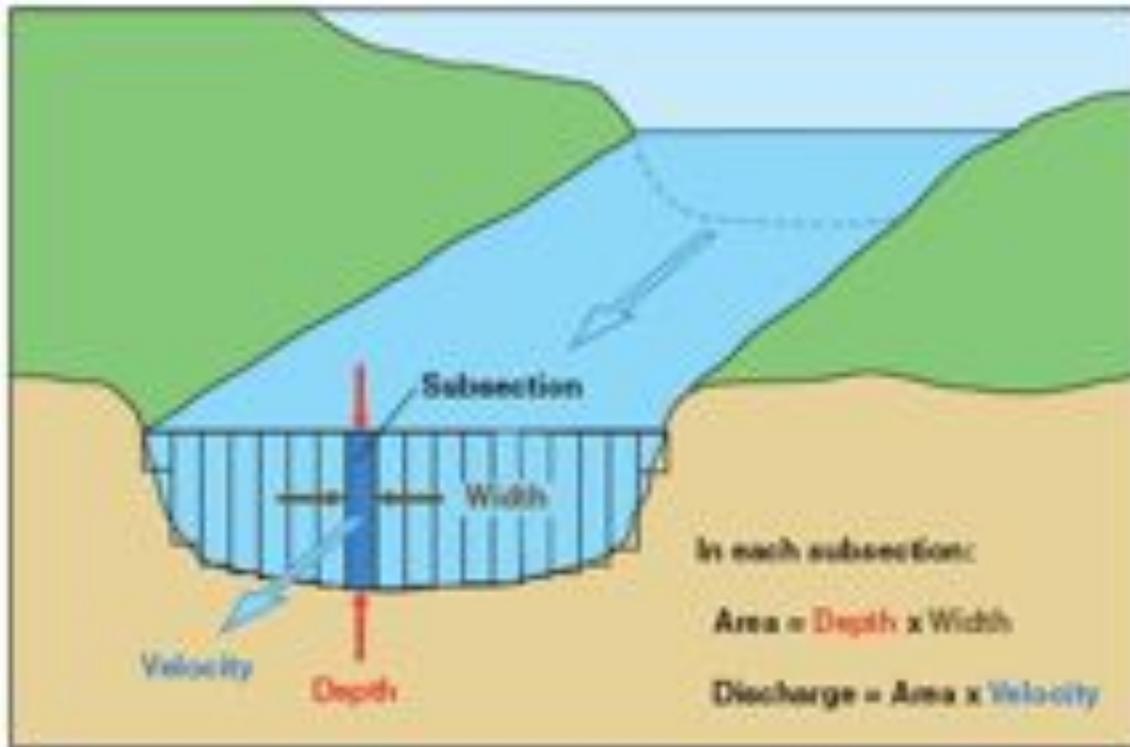
Types of Flow: Turbulent and Laminar

Turbulent



Laminar





Current-meter discharge measurements are made by determining the discharge in each subsection of a channel cross section and summing the subsection discharges to obtain a total discharge.



Discharge is the amount of water passing a given point in a in a measured period of time. (volume/time)

Discharge increases downstream,
with the addition of tributaries



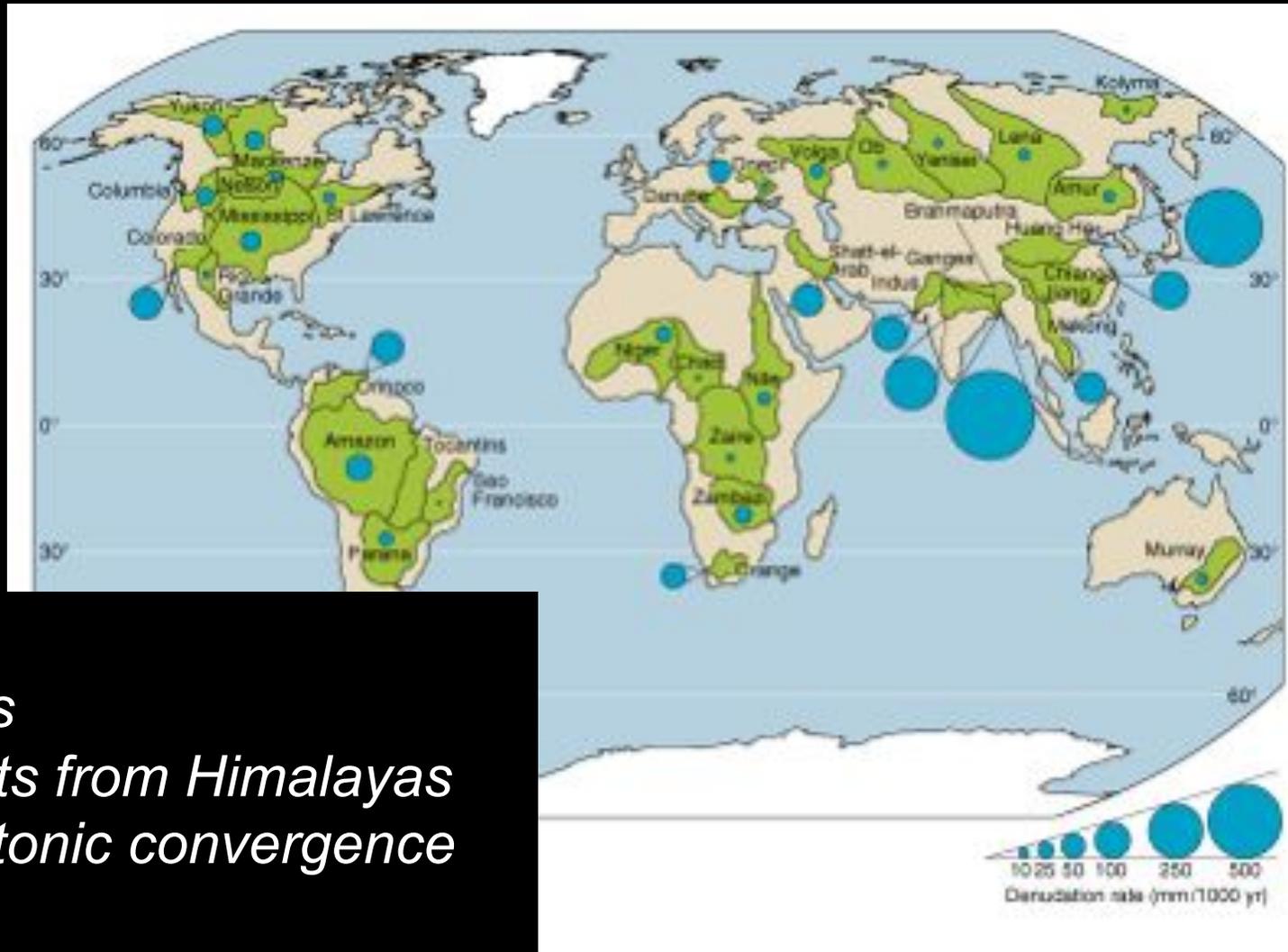
Minnesota



Louisiana

iClicker Question

River erosion is extremely high in northern India? Why do you think this is?



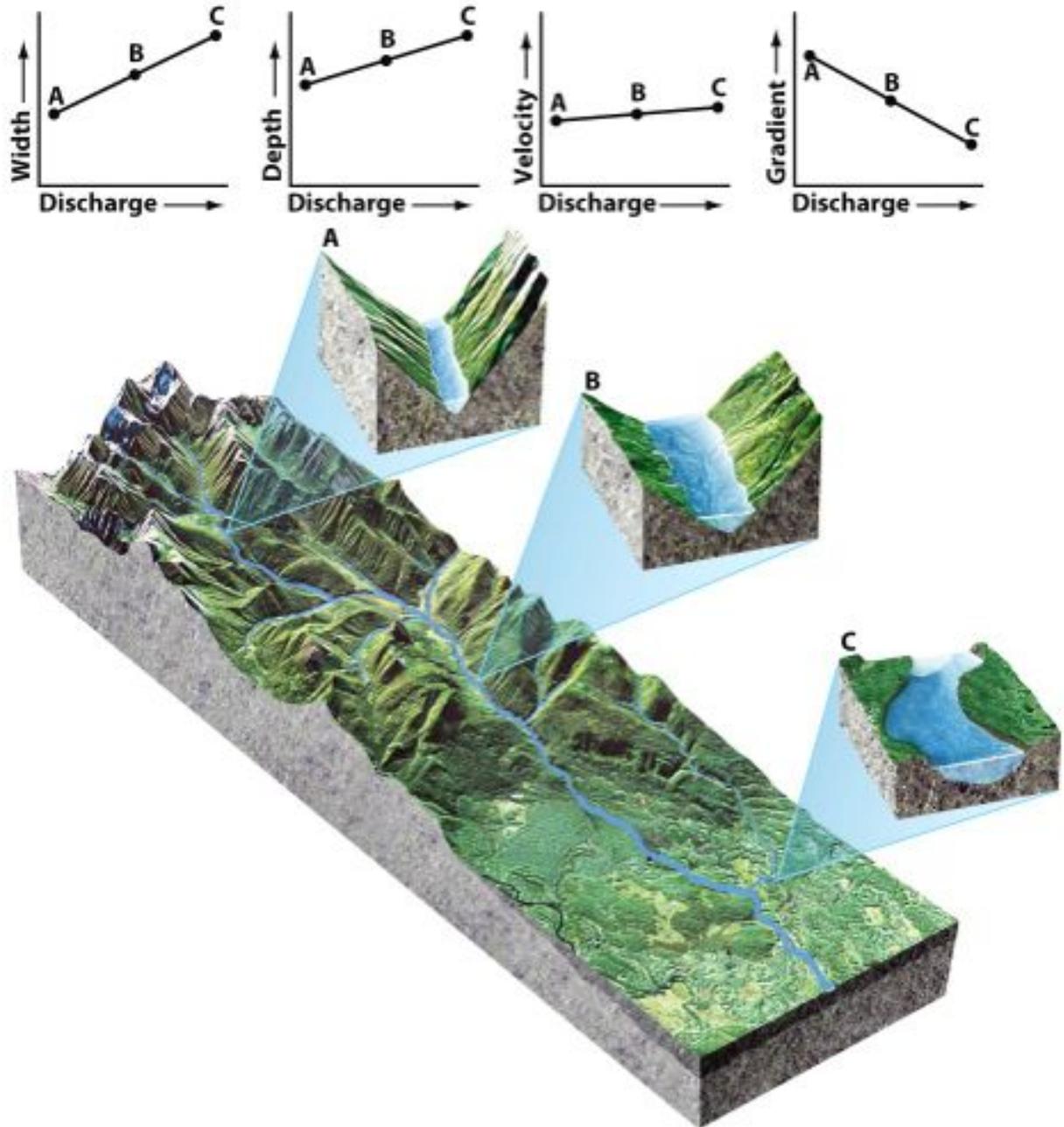
- a. Gravity*
- b. Typhoons*
- c. Sediments from Himalayas*
- d. Plate tectonic convergence*

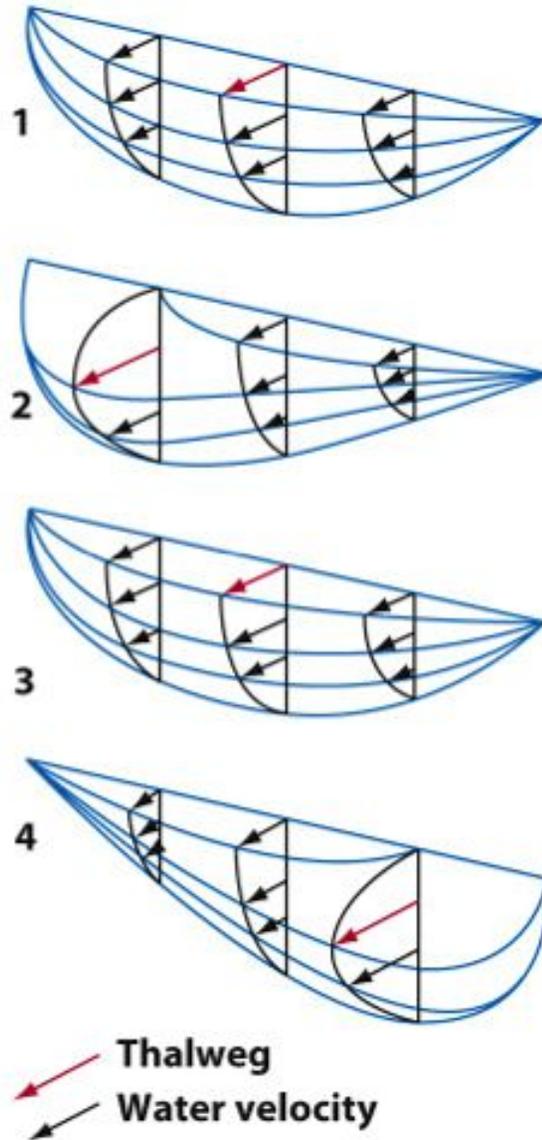
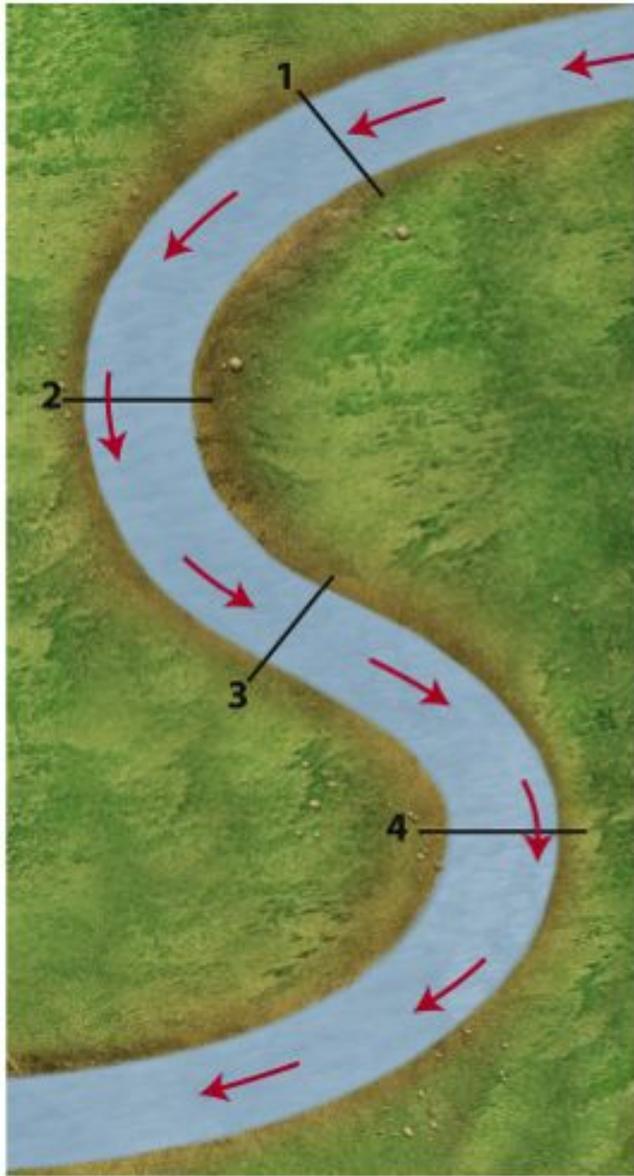
Characteristics of Channels

As discharge increases:

- Width increases
- Depth increases
- Velocity increases slightly
- Gradient decreases

Base Level is the lowest possible level to which the stream will erode (level of the outlet)

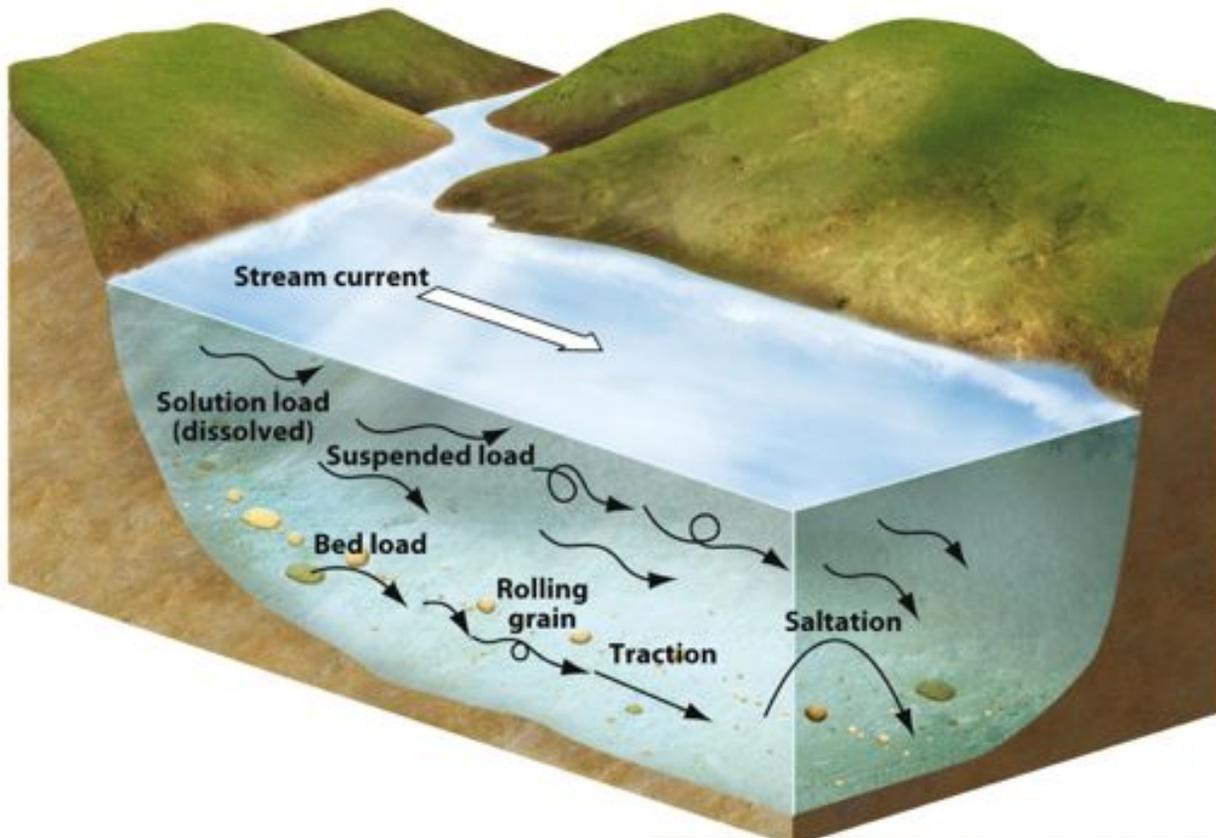




Thalweg is the natural direction of a watercourse.

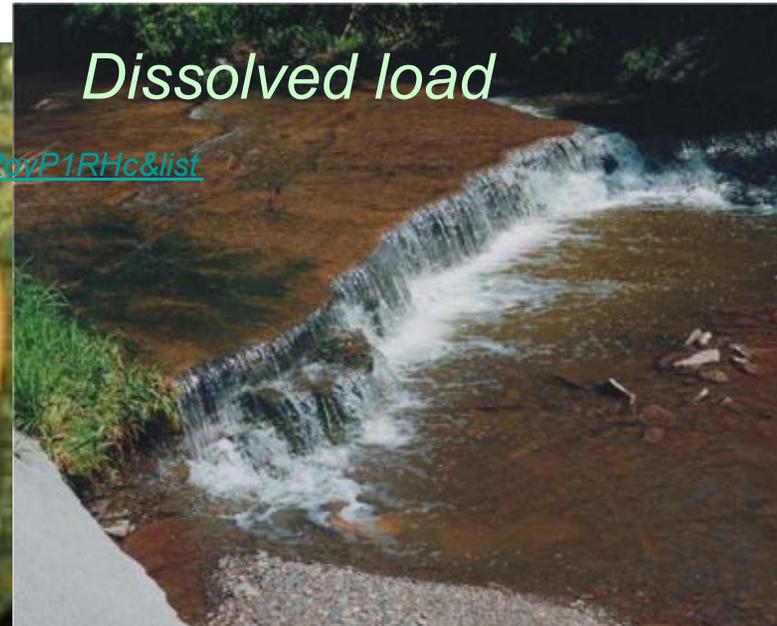
The fastest part of the stream follows the thalweg (it follows the outside of the curves).

Faster running water erodes more sediment.



The sediment load can be divided into three parts:

- Suspended Load
- Bed Load
- Dissolved Load



Bed Load



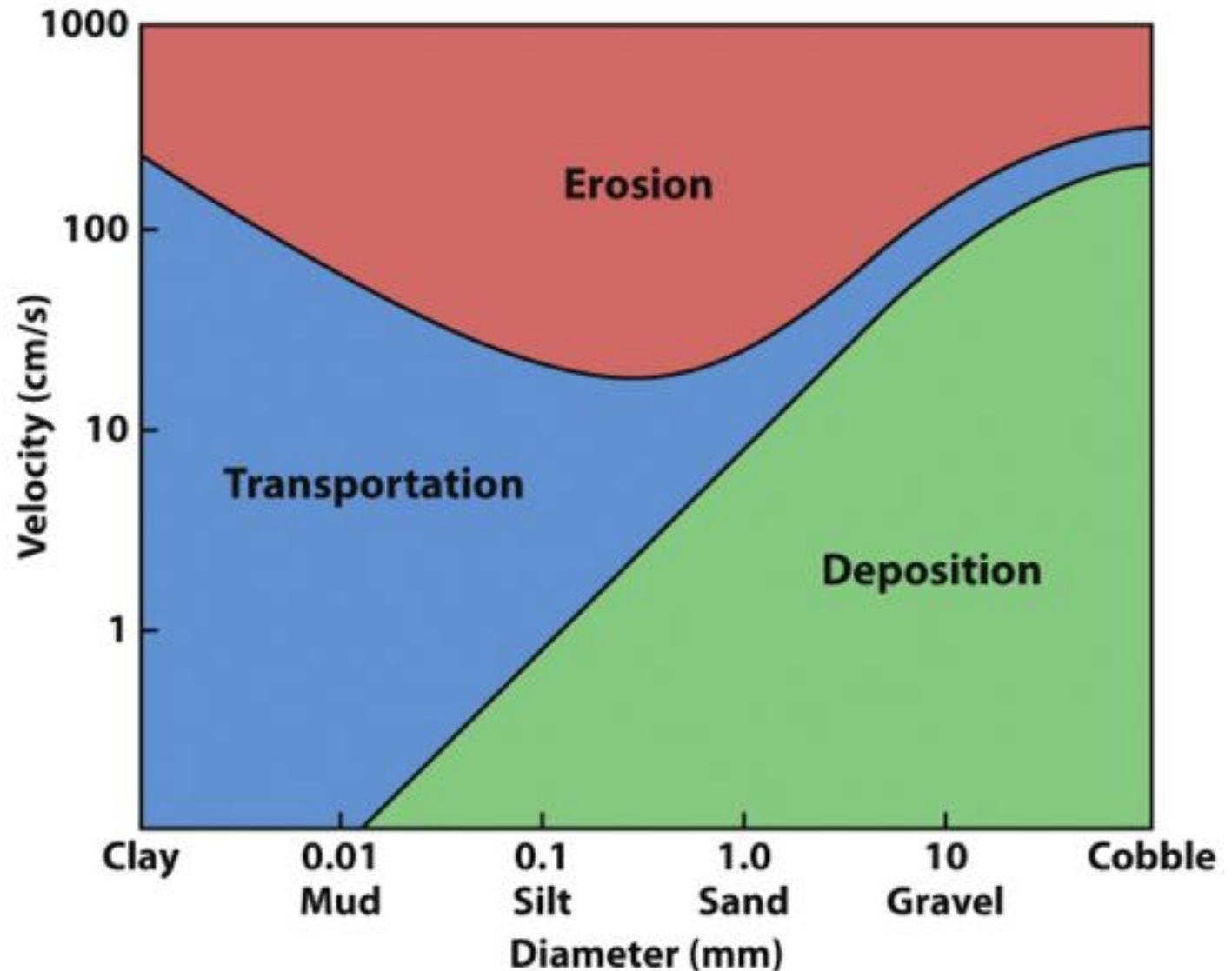
<http://www.youtube.com/watch?v=EGfRoyP1RHc&list>

The **Hjulstrom Diagram** plots the relationship between water, velocity, and sediment size.

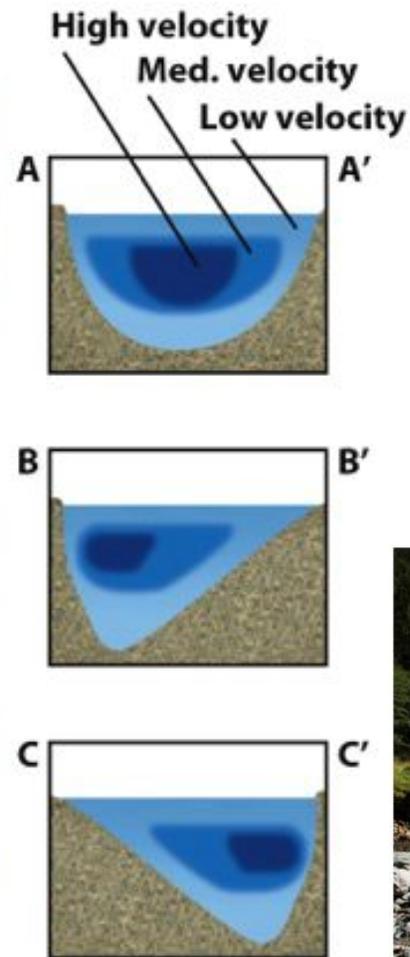
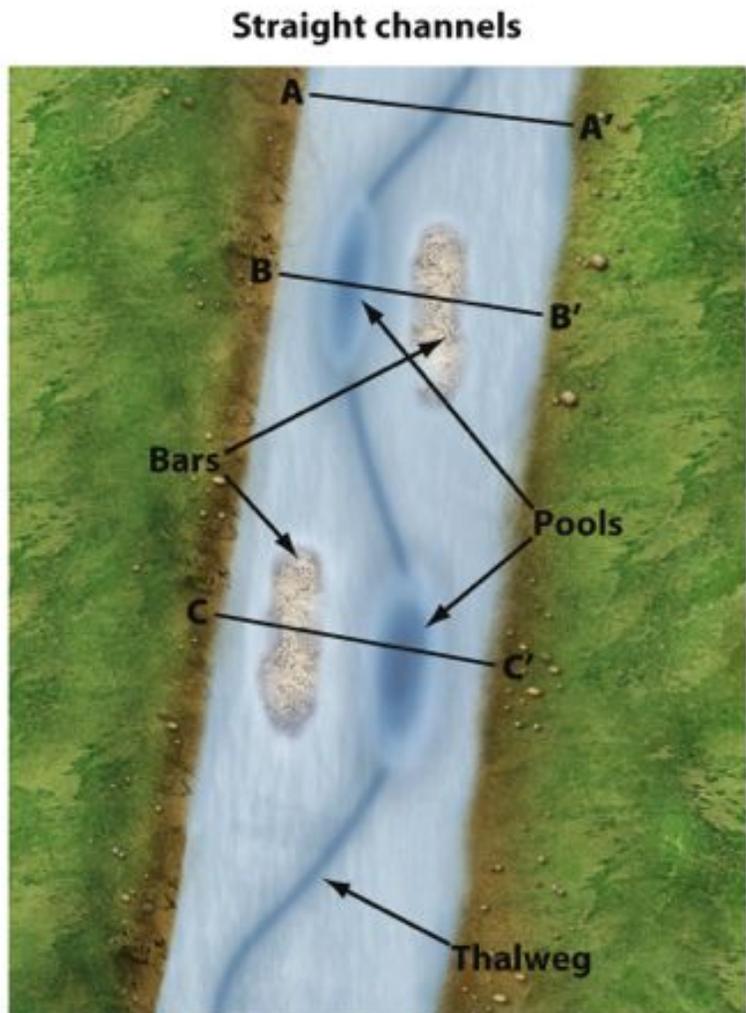
Faster flow usually means more erosion and less deposition.

Bigger particles usually require faster velocity to erode.

Exception:
Clay and mud are cohesive and therefore hard to erode.



Three Types of Stream Channels: **Straight**, Meandering, and Braided



Straight Channels:

- Rare
- Short segments
- Highest velocity channel migrates side-to-side



Why Do Rivers Curve?



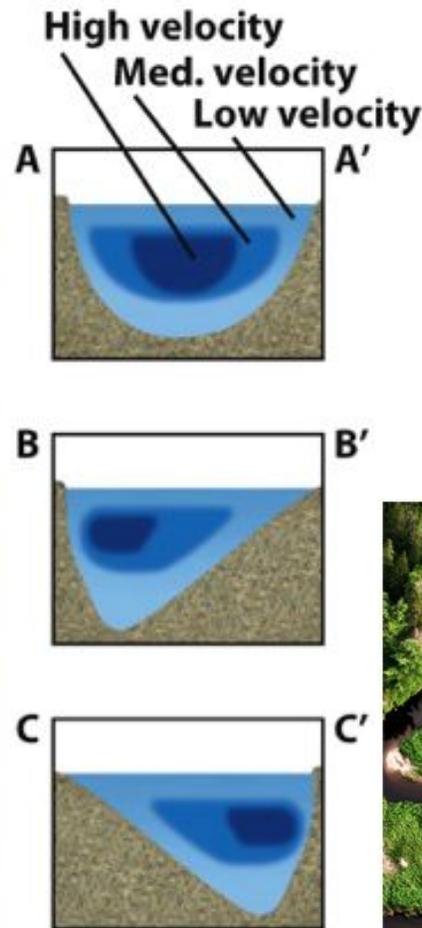
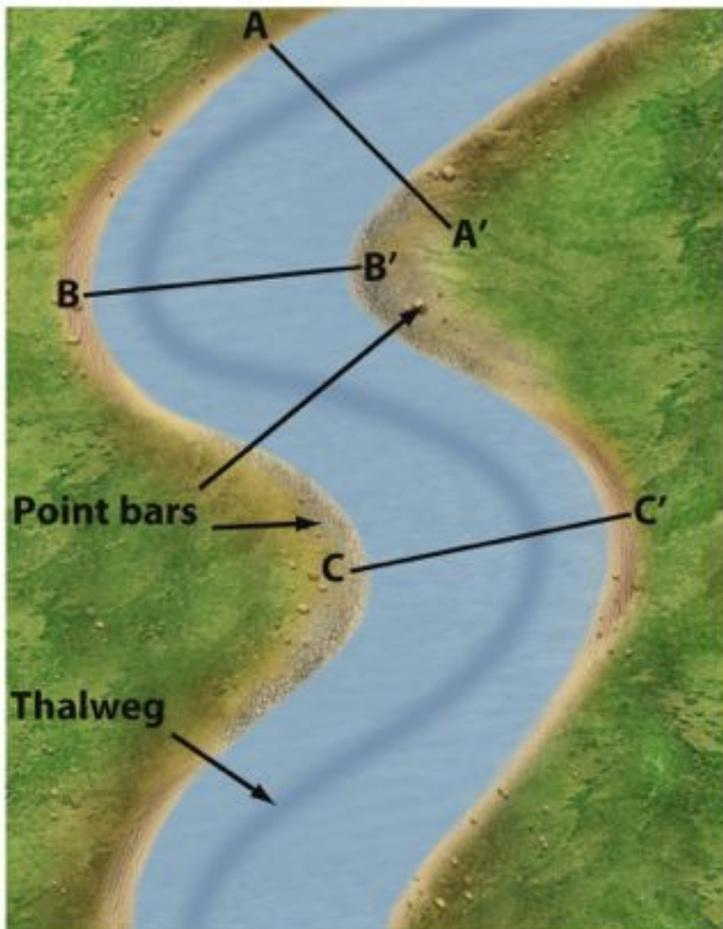
Minute
Earth

Courtesy of Minute Earth

<https://www.youtube.com/watch?v=8a3r-cG8Wic>

Three Types of Stream Channels: Straight, **Meandering**, and Braided

Meandering channels



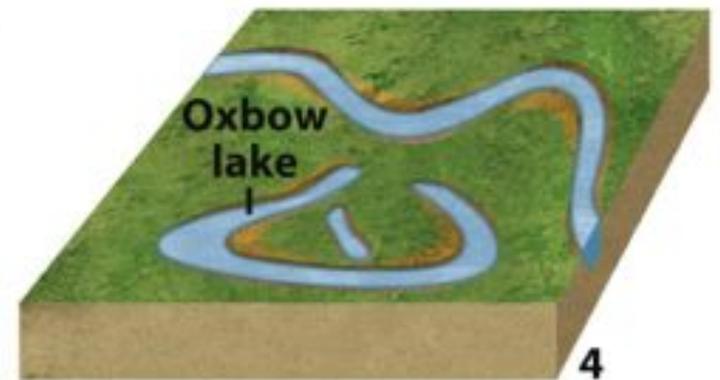
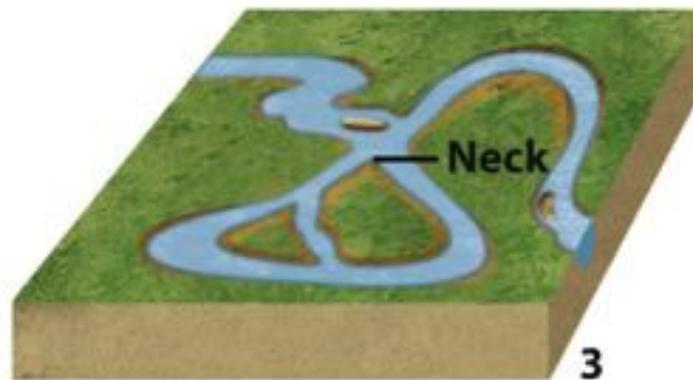
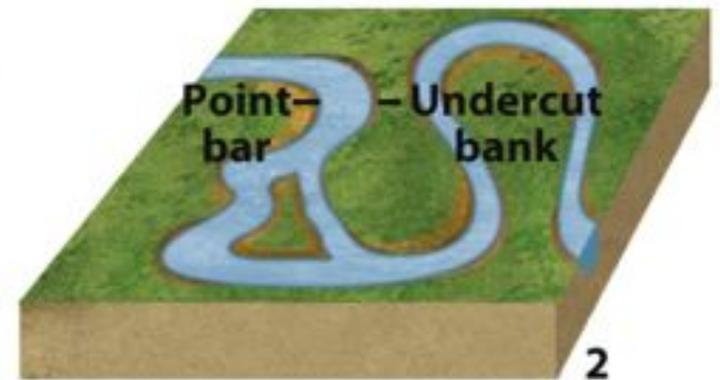
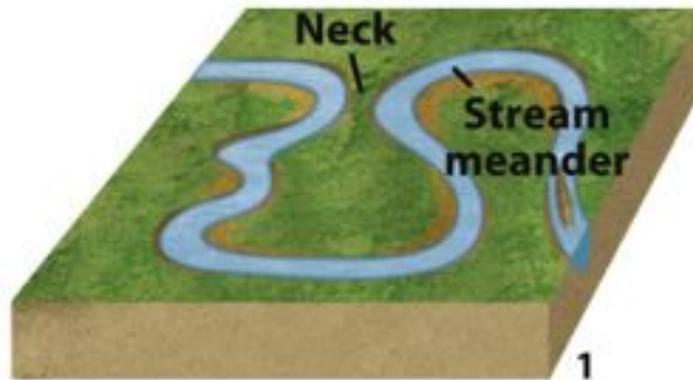
Meandering Channels:

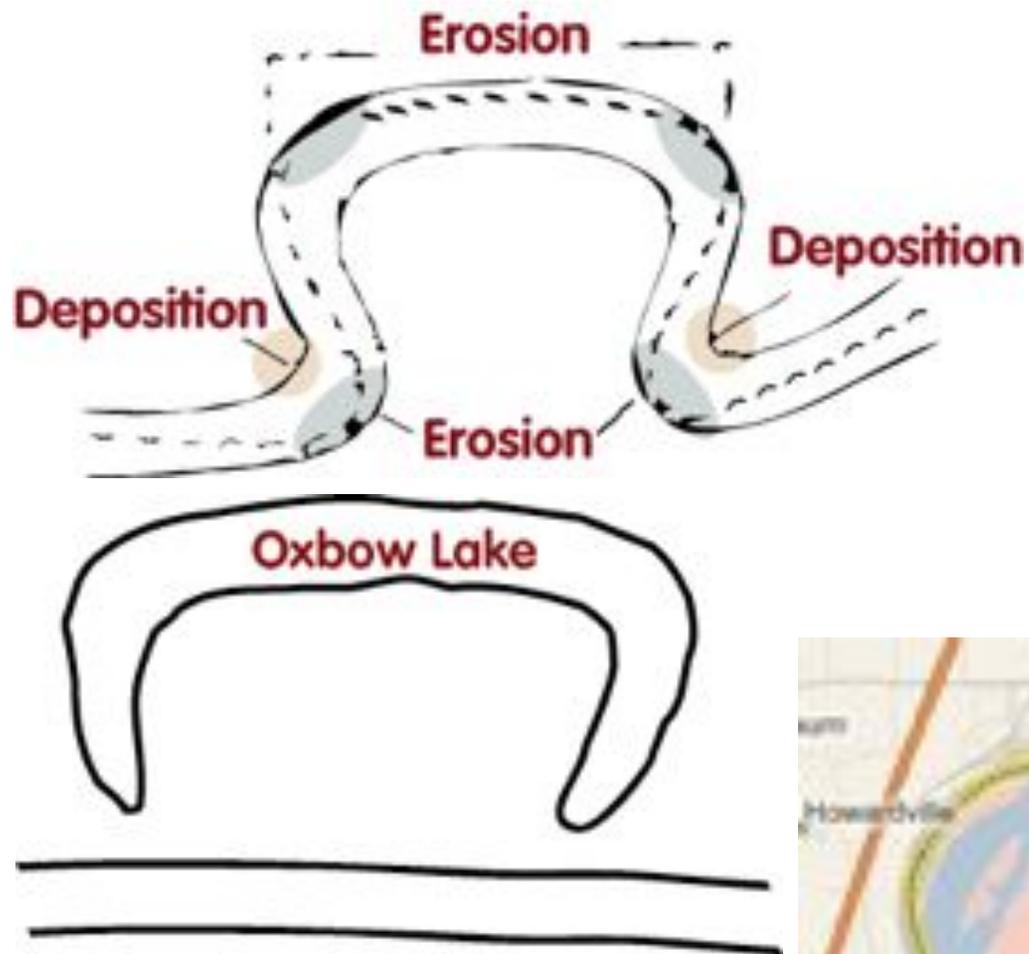
- Common in a wide valley floor
- Meander bends migrate outward





Cut-off meander bends form Oxbow Lakes



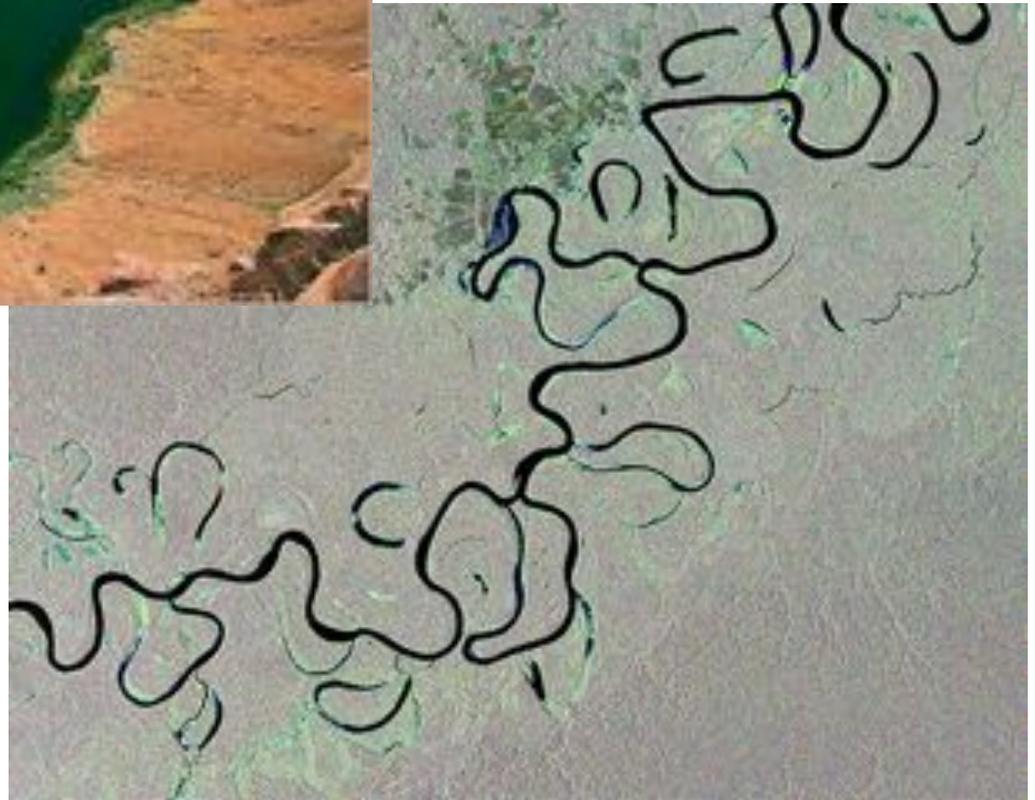


**Kentucky Bend:
An Oxbow Lake**

Oxbow Lakes



*Horseshoe bend,
Colorado River (Arizona)*



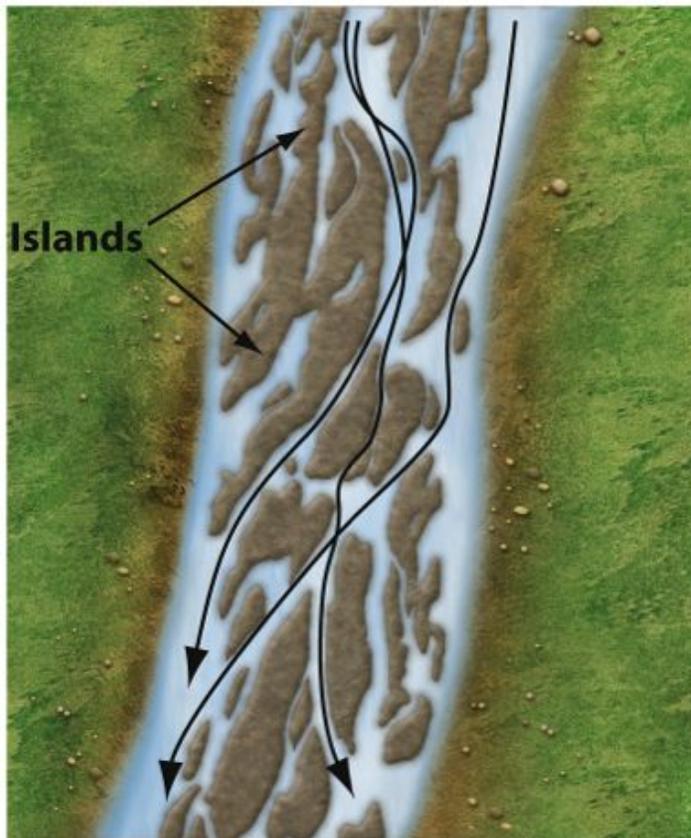
The Jurua River in western Brazil

Three Types of Stream Channels: Straight, Meandering, and **Braided**

Braided Channels:

- Stream contains more sediment than it can transport
- Transport volumes are variable
- Coarse sediment (much bed load)
- Sparse vegetation

Braided Channel





Braided rivers often form near sources of coarse sediment:

- Young mountains
- Glaciated regions



*Braided Rivers
in Alaska*

Flooding is a natural process in healthy streams



Cedar Rapids, Iowa 2008

Flooding in Cedar Rapids Iowa

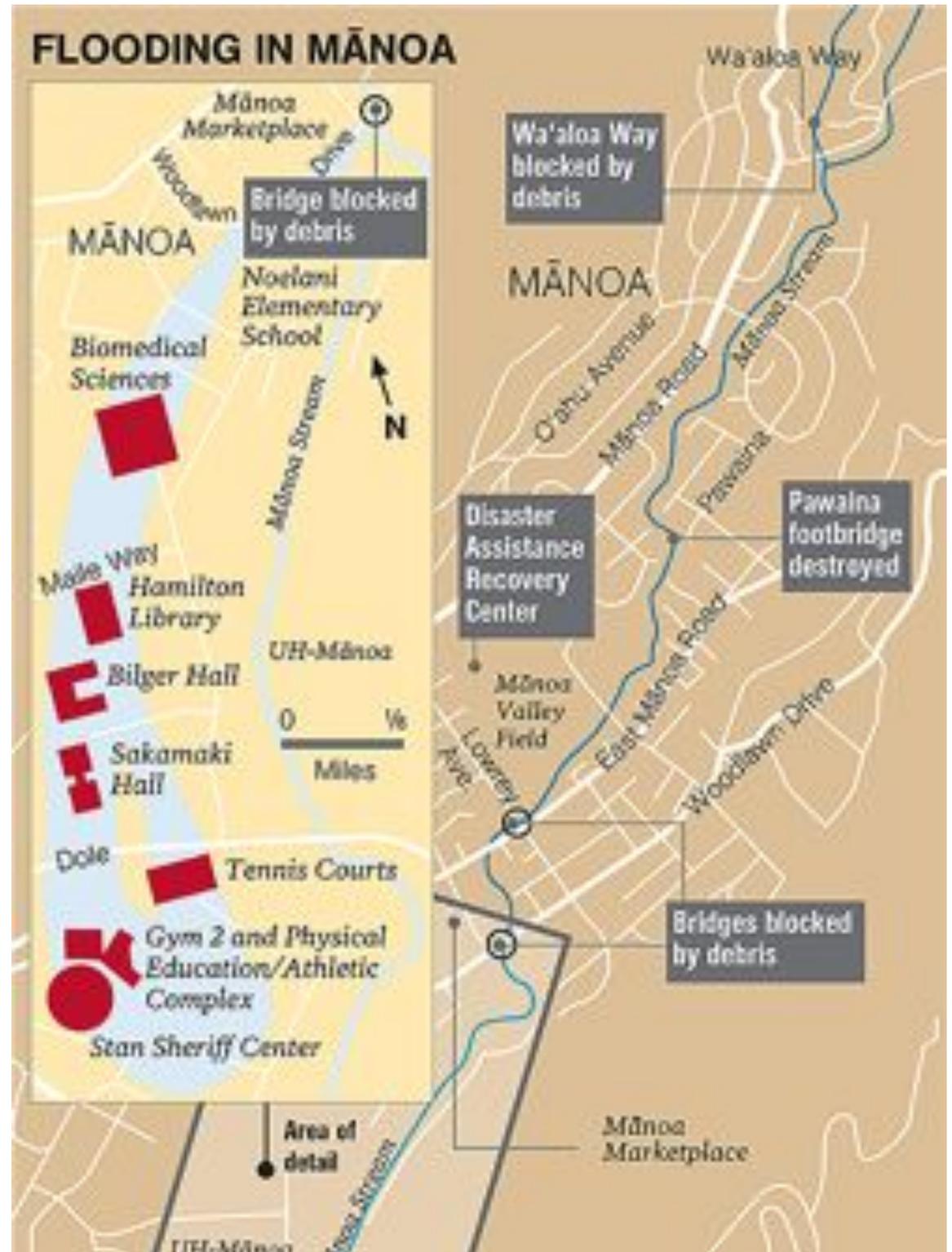
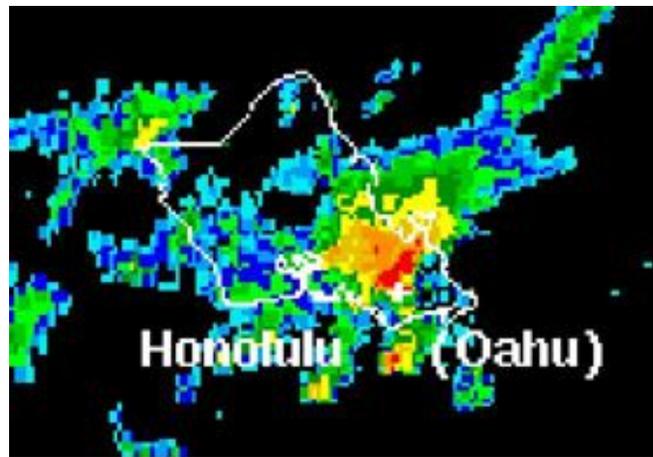


Ground: <http://www.youtube.com/watch?v=Cxq8BbtOxSo>

Air: <http://www.youtube.com/watch?v=4v4DxnTsucM>

Manoa Valley Flooding: October 30th, 2004

Rainfall in 12 hr period:
10.07 inches at Lyon
Arboretum



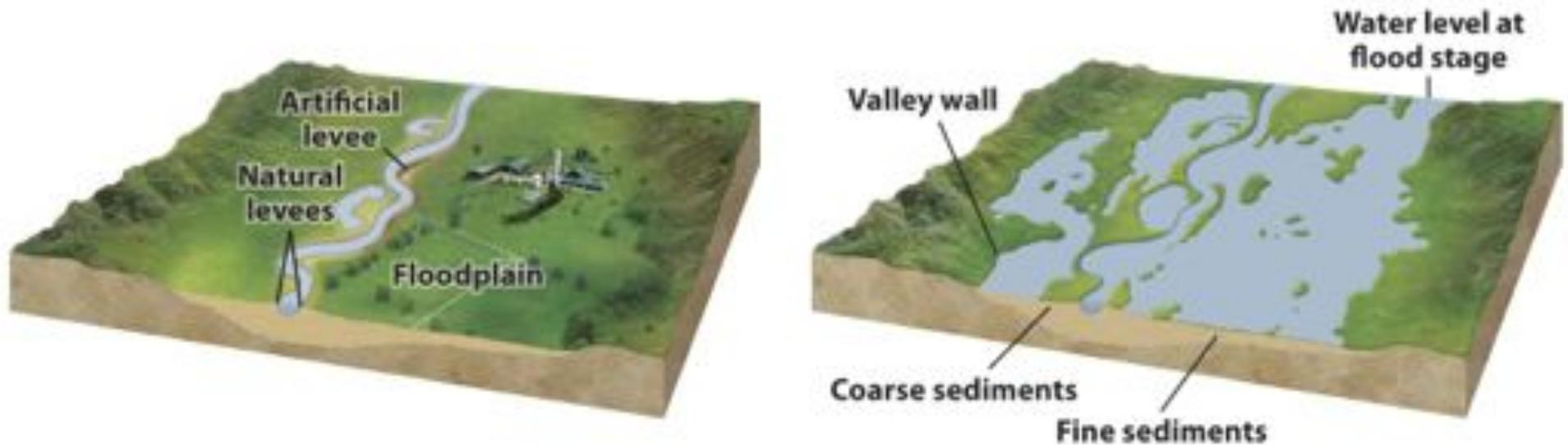
Manoa Stream Flooding



<http://www.youtube.com/watch?v=oX5aOgG00D8>



OCT



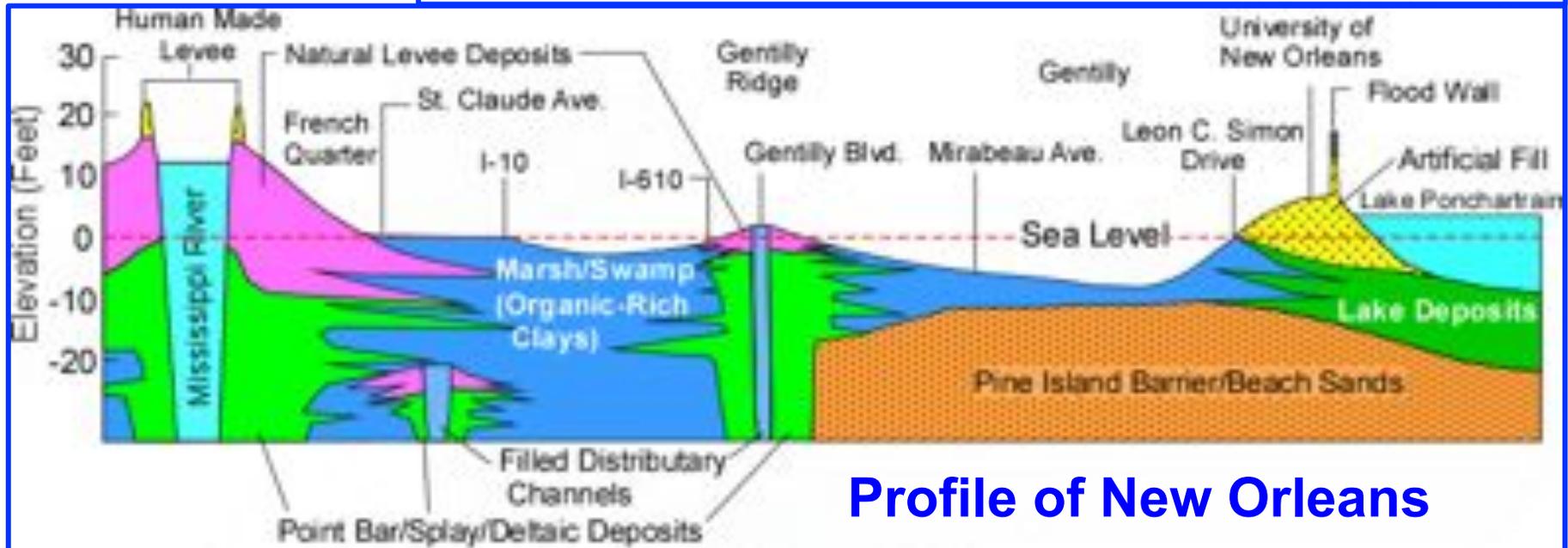
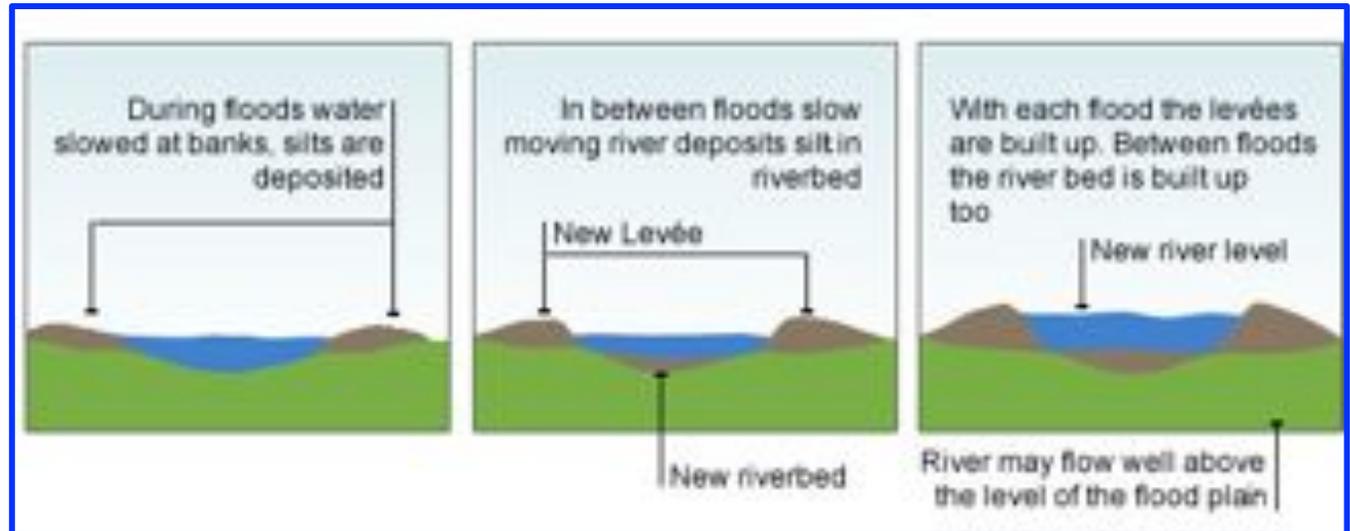
Features of a Floodplain

- **Alluvium** is sediment left behind after a flood
- **Floodplains** are an integral part of the river system



Natural Levees

- **Flow velocity** decreases as the river overflows its banks
- **Natural Levees** are formed as a flooded river drops its sediment load
- **River level can climb above floodplain**



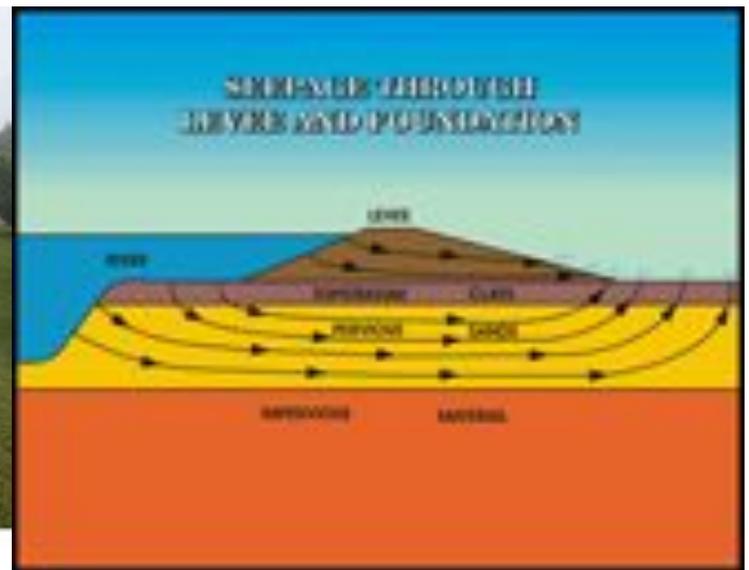
Profile of New Orleans

Artificial Levees

- Pass flooding to communities downstream
- Prevent deposition of sediment on floodplain
- Loss of sediment causes floodplain subsidence
- Levee failure can be catastrophic



Levee Photograph – note seepage occurring at landward toe



Catastrophic Levee Failure



- Home
- Weather
- Local News
- As Seen On KCRA
- Crime Tracker
- Morning News
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Hot Topics: Christina Aguilera Arrested | Justin Bieber | Share Your Kings Photos | Gas Prices | As Seen On KCRA

Homepage > SACRAMENTO NEWS

Army Corps Deems Central Valley Levees 'Unacceptable'

Levees in Marysville, Sacramento, Stockton Fail To Meet Standards

POSTED: 4:07 pm PST September 14, 2010

UPDATED: 5:06 pm PST September 14, 2010

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- Watched for you by our system
- Back From the Dead: Fake Death Failures (CNBC)
 - 20 in Mexico Killed in Riots (The New York Times)

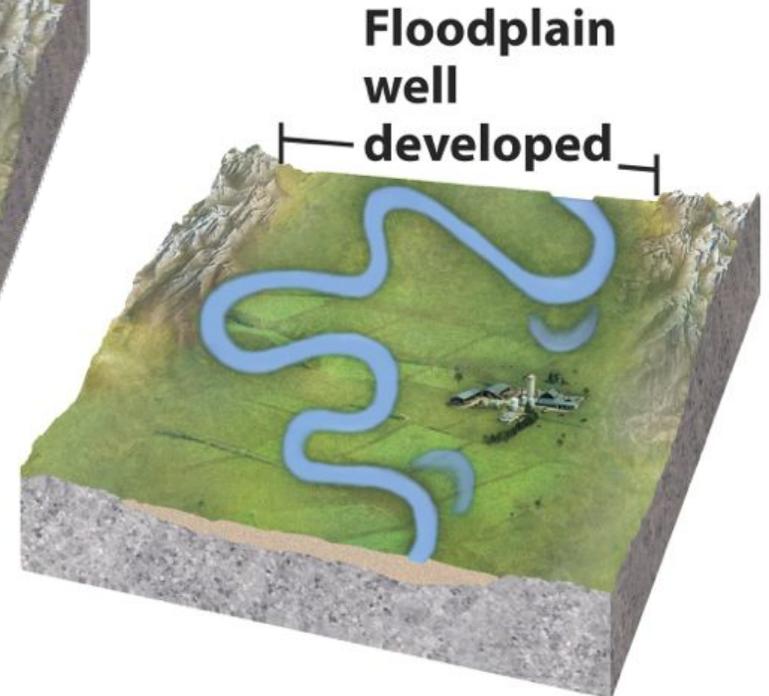
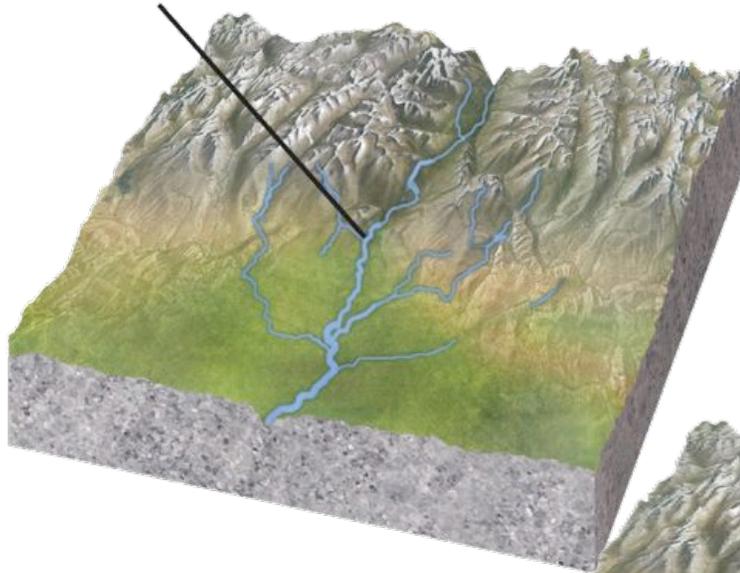
Most Read Most Watched Most Commented

- Man Arrested In 'Swirl' Case
 - Man Falls Into Meat Grinder, Dies
 - Christina Aguilera Arrested For Drunkenness
 - No New Signs Yet On Kings' Arena
- More Most Popular

Fluvial landscape evolution

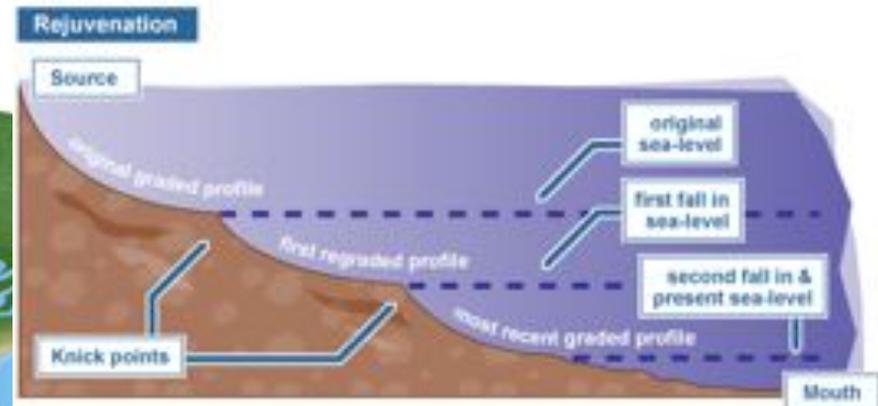
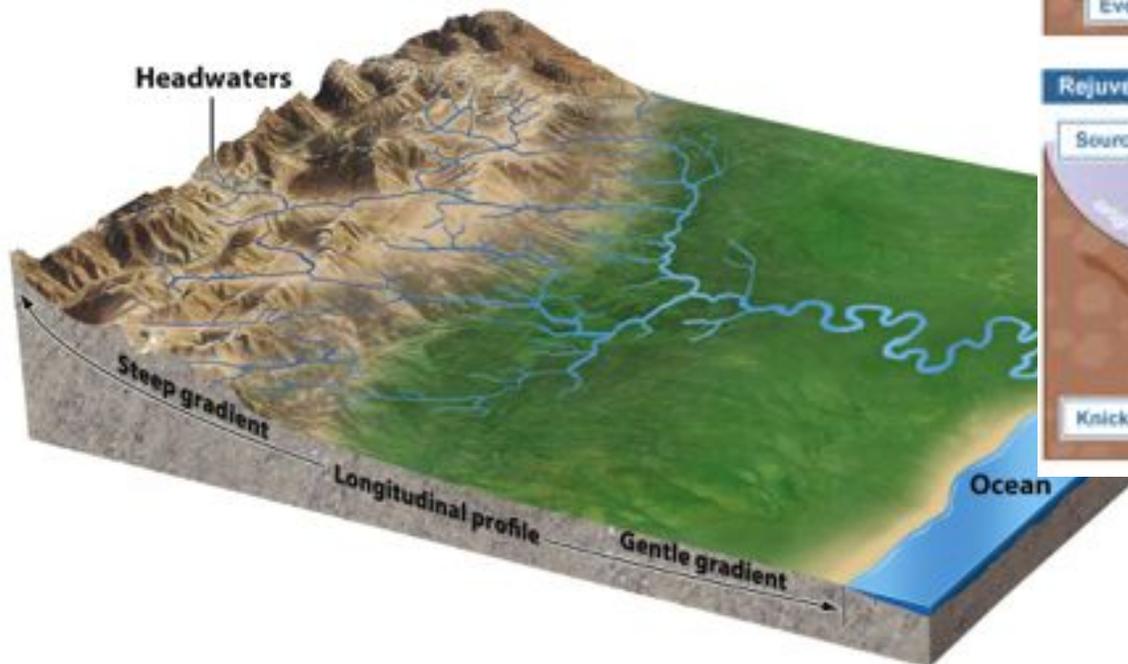
Narrow
V-shaped
valley

- Erosion of upper portions
- Deposition in lower portions
- Floodplain widens



Streams Develop a Graded Profile

- An equilibrium profile for a stream
- Stream profile adjusts until **sediment in = sediment out**
- Steep gradients are eroded down
- Equilibrium profile is **concave**
- Bottom of profile is **base level**



Incised Channels and Terraces are fluvial responses to changes in base level



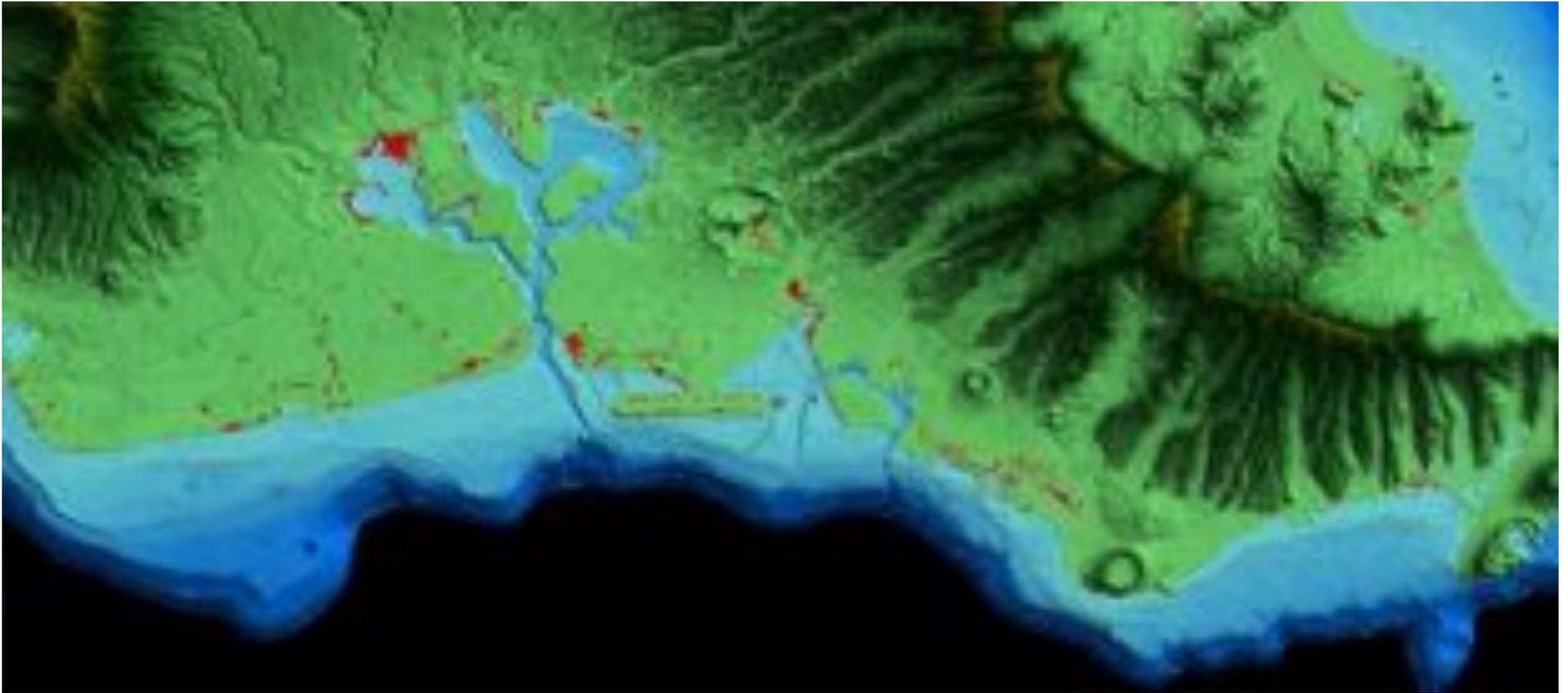
(a)



(b)

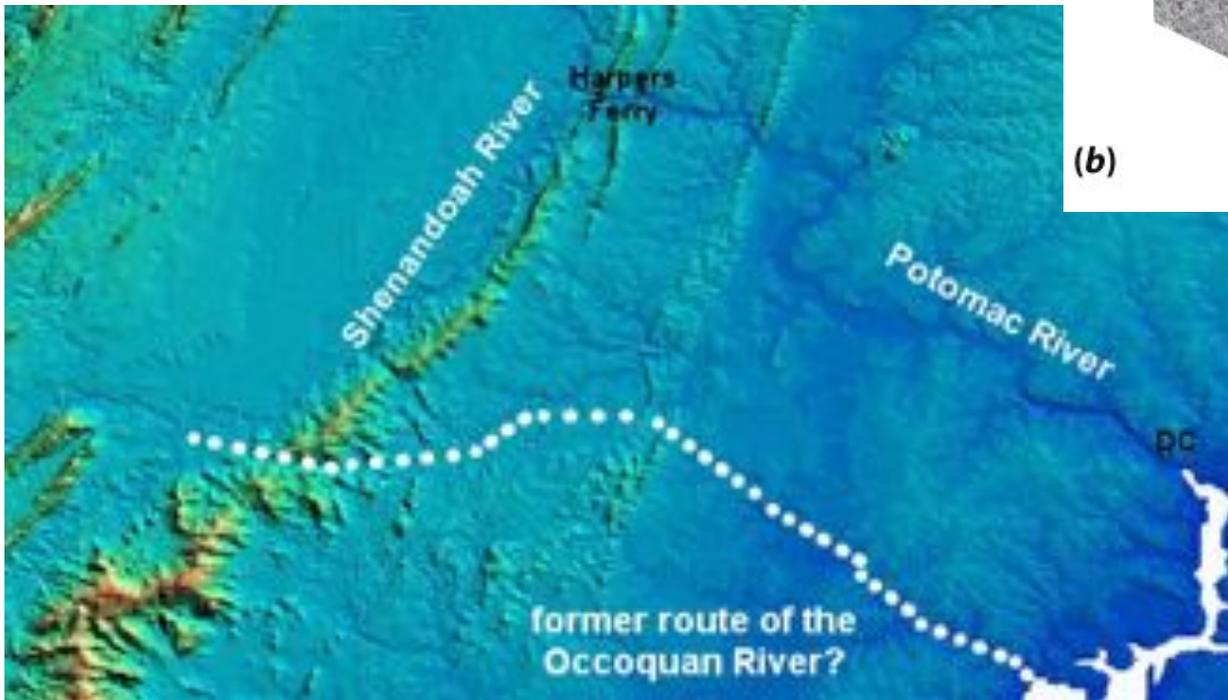
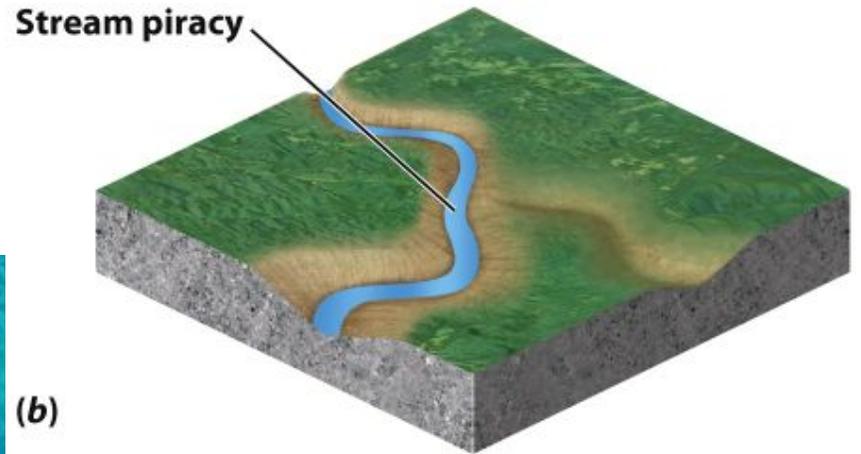
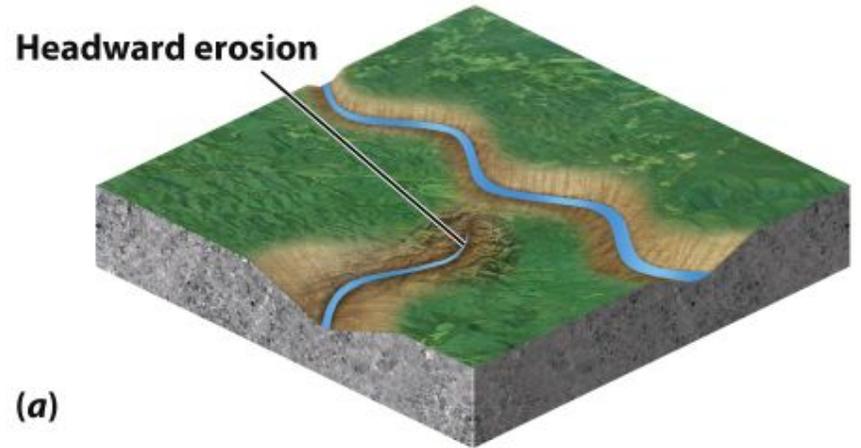


Pearl Harbor: Rise of Base Level



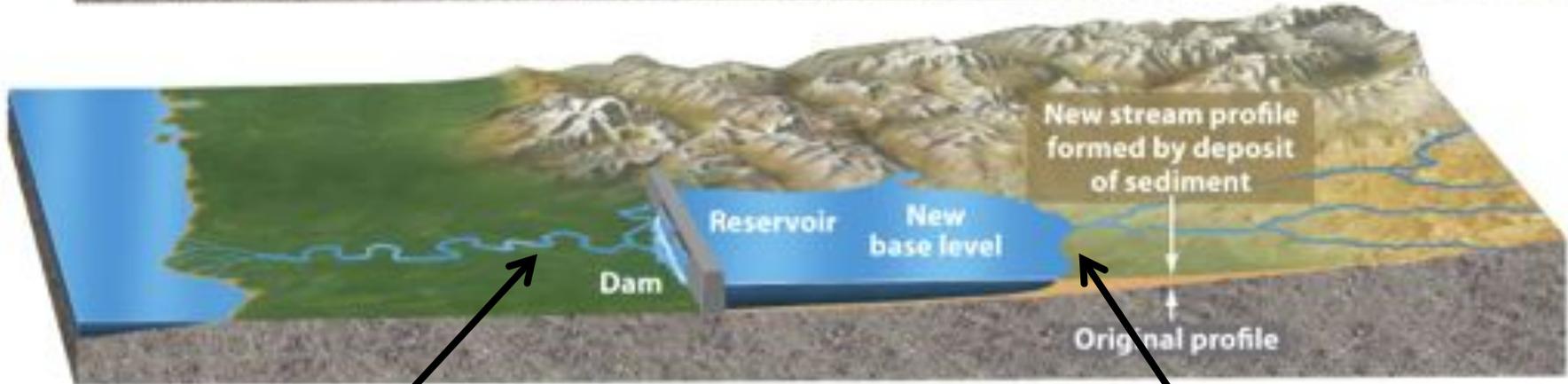
Pearl Harbor formed from a graded profile that has been flooded by sea level rise

Stream capture can result from erosion



The Patomac River captured the tributaries of the Occoquan River (Virginia)

Dams change the base level of a watercourse



Deprived of sediment

Deposition of sediment

Fluvial Sediments build **Alluvial Fans & Deltas**



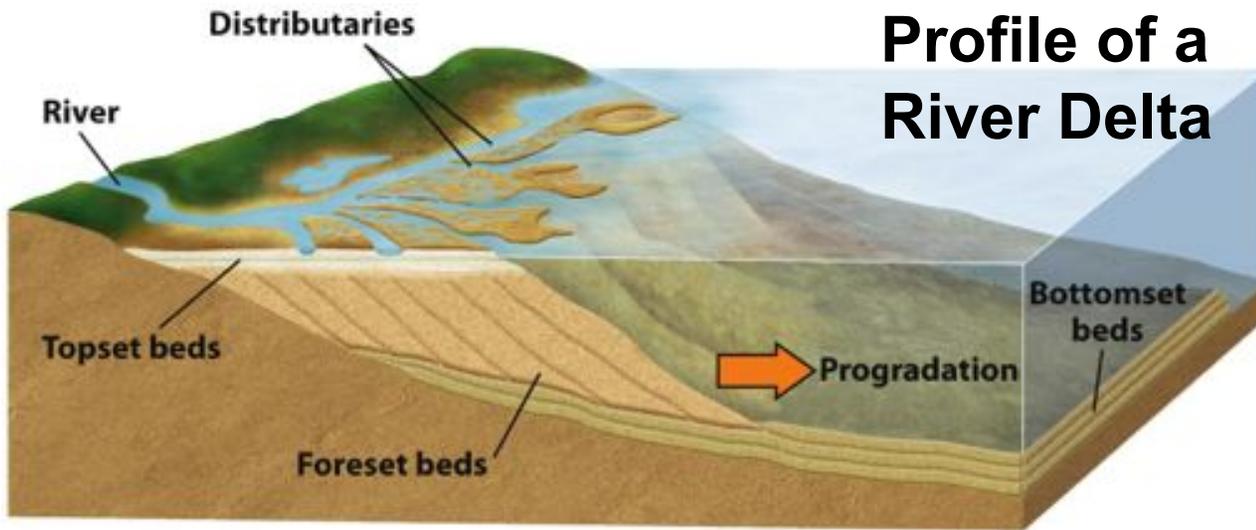
Alluvial Fan:

- Broad piles of sediment formed by flash flooding events
- Form in arid environments with variable flow.



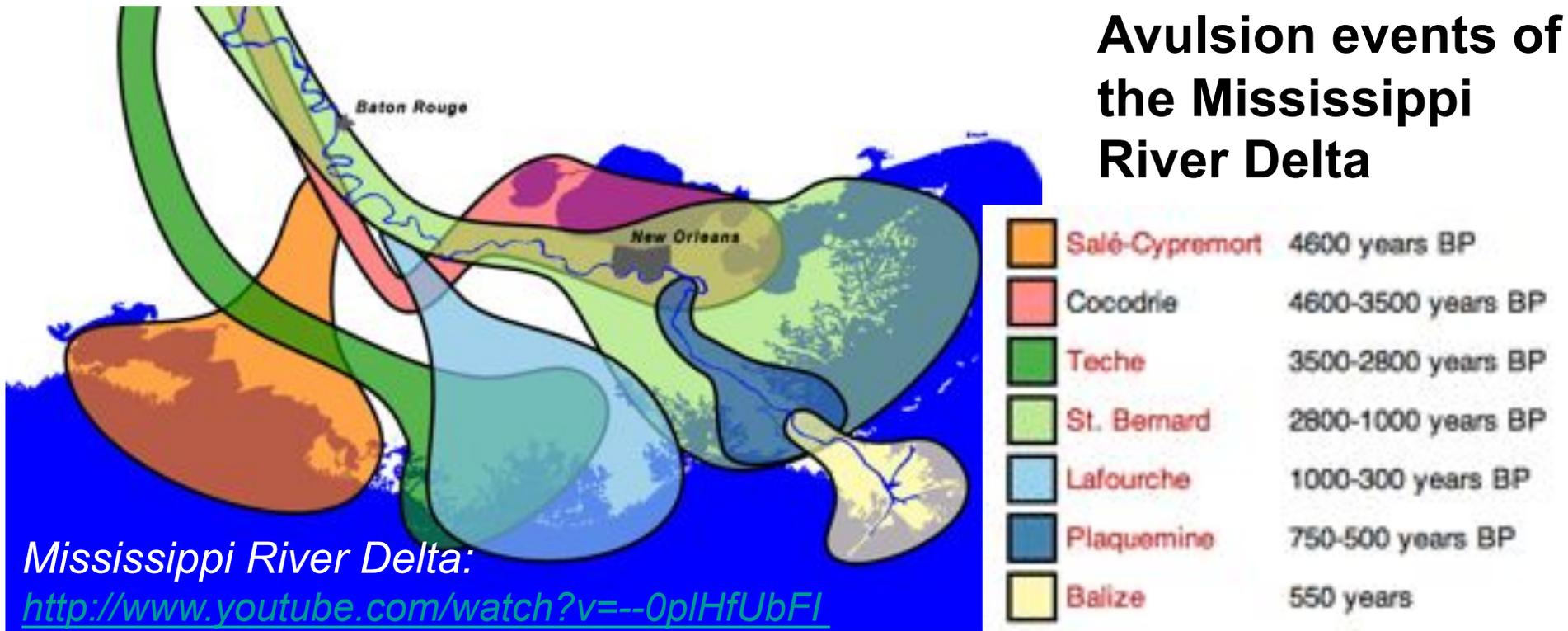
River Delta:

- Deposition of sediments into standing water
- Shaped like a Delta (Δ)
- Constantly changing



Profile of a River Delta

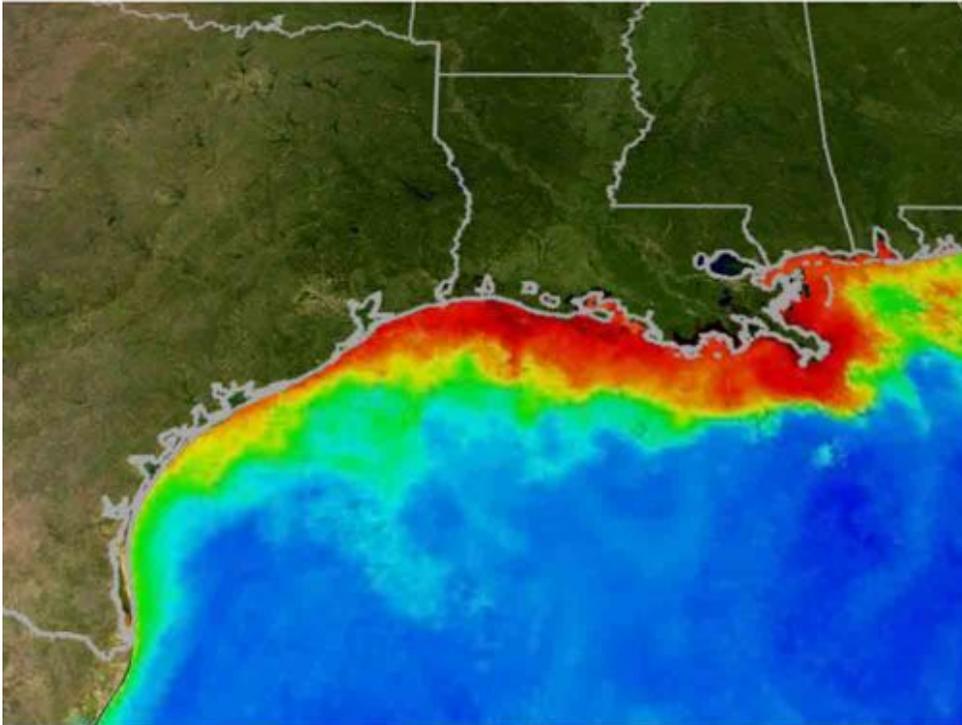
Avulsion is a change in the course of a stream due to deposition of sediment.



Mississippi River Delta:

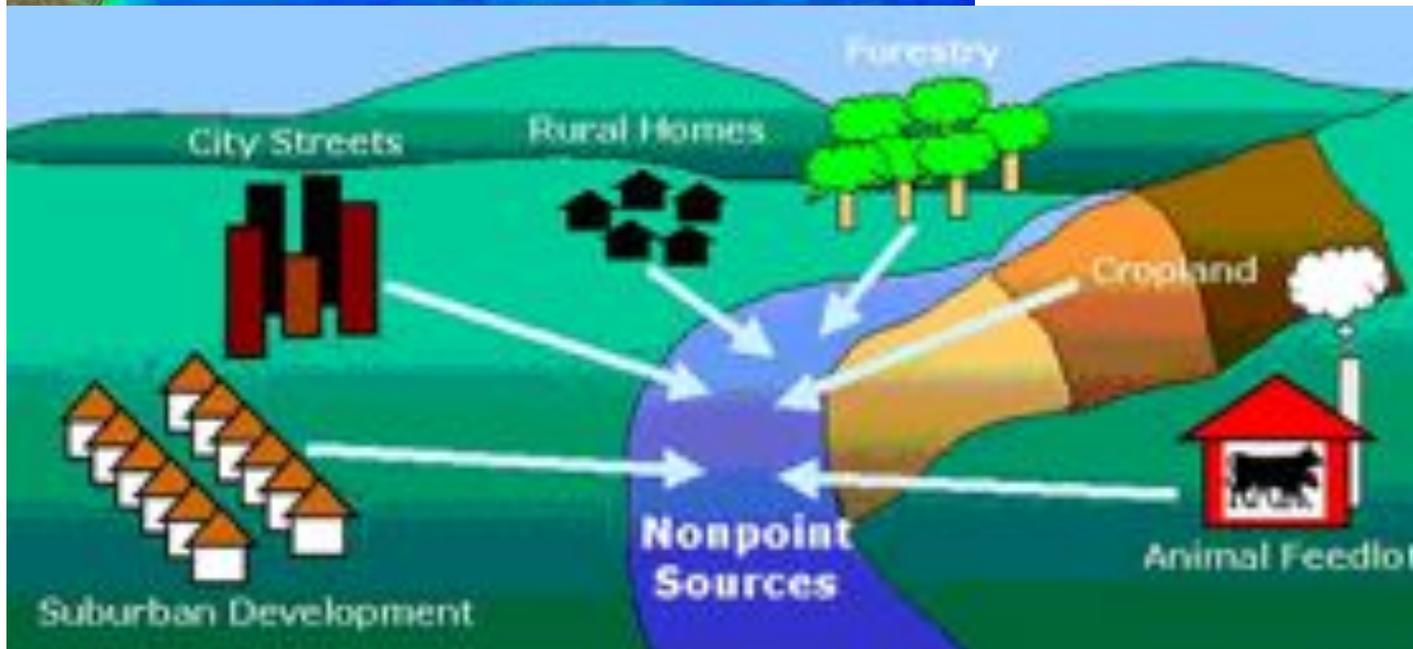
<http://www.youtube.com/watch?v=---0pIHfUbFI>

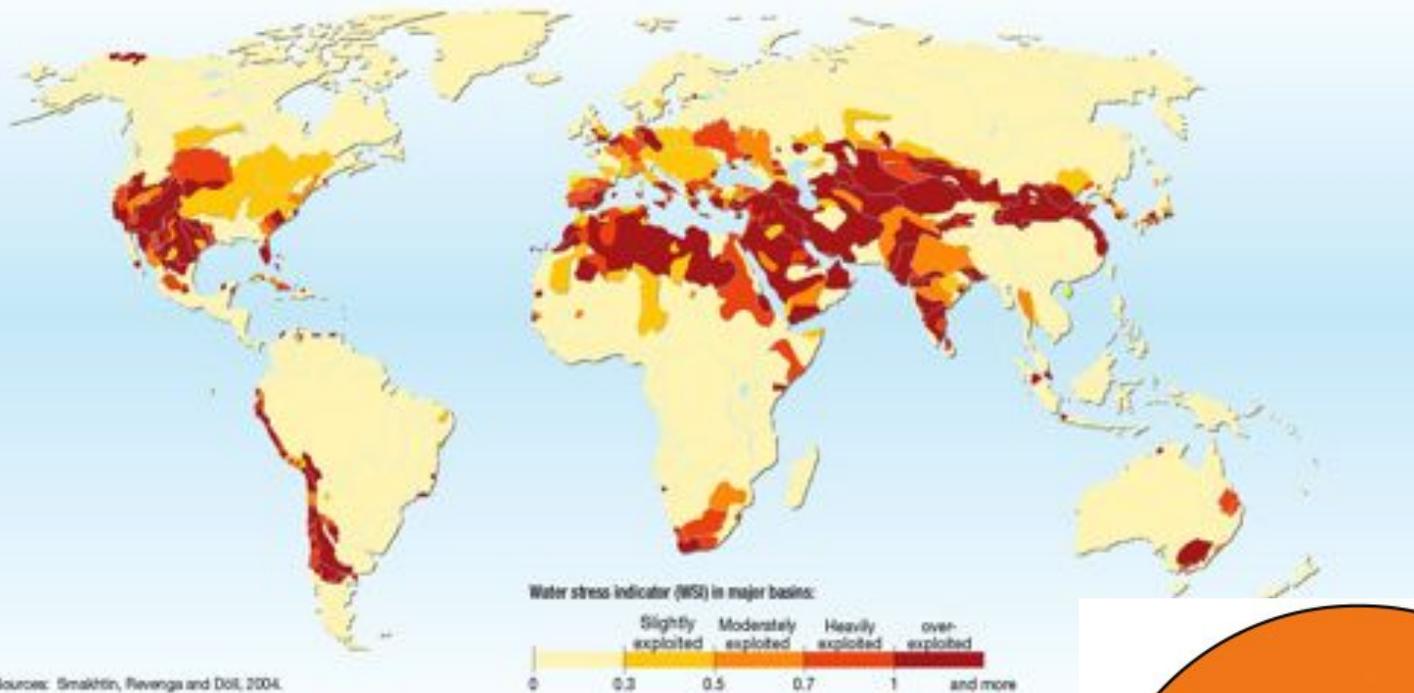
Mississippi Dead Zone, Gulf of Mexico, Summer 2006



Polluted Runoff

- Collects in streams, lakes, and ocean
- Nutrient buildup from fertilizers and sewage creates “dead zones”





Sources: Smakhtin, Revenga and Dol, 2004.

Water Scarcity occurs if a large fraction of available water is withdrawn for human use

