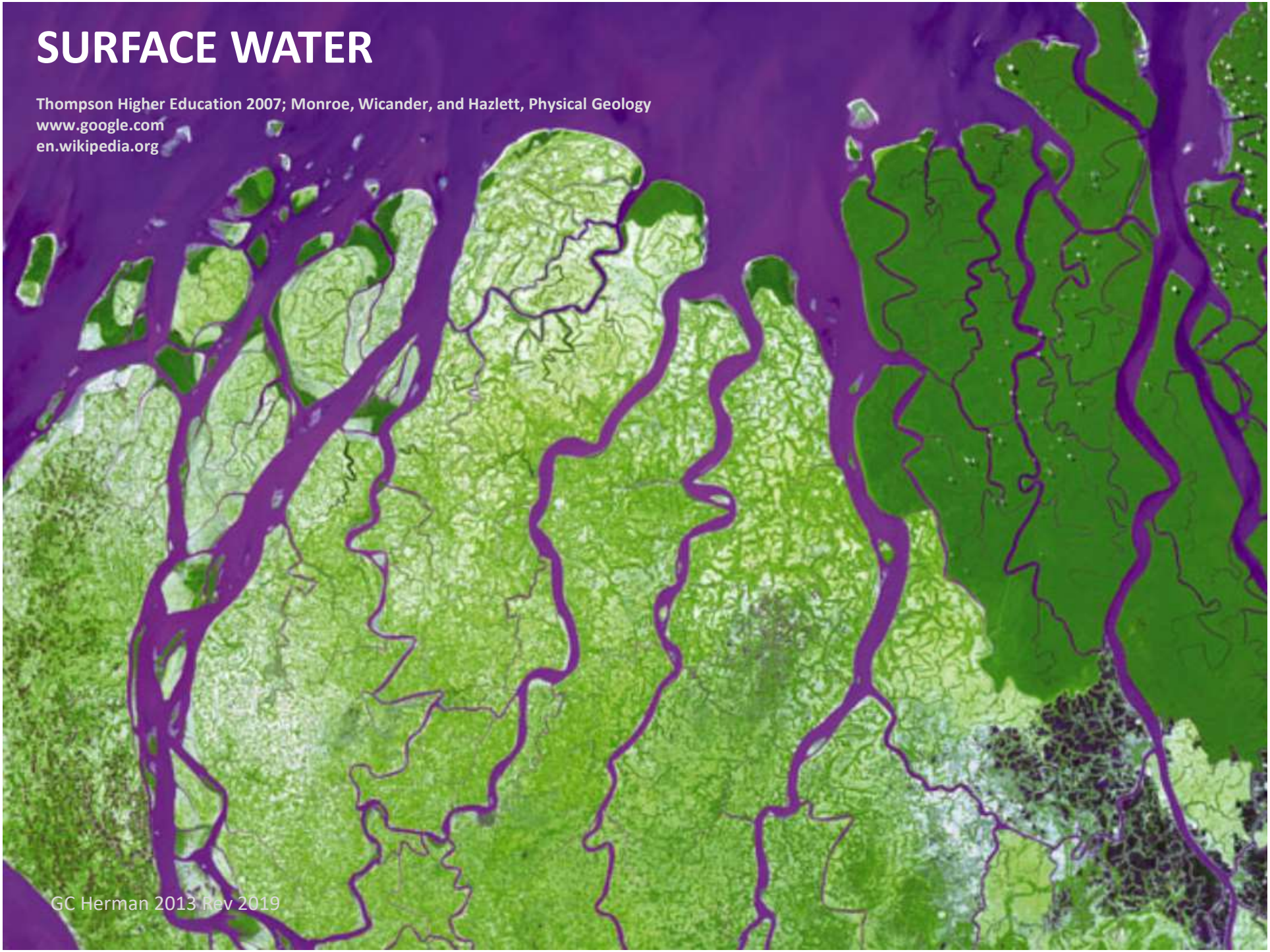
SURFACE WATER



Thompson Higher Education 2007; Monroe, Wicander, and Hazlett, Physical Geology
www.google.com
en.wikipedia.org

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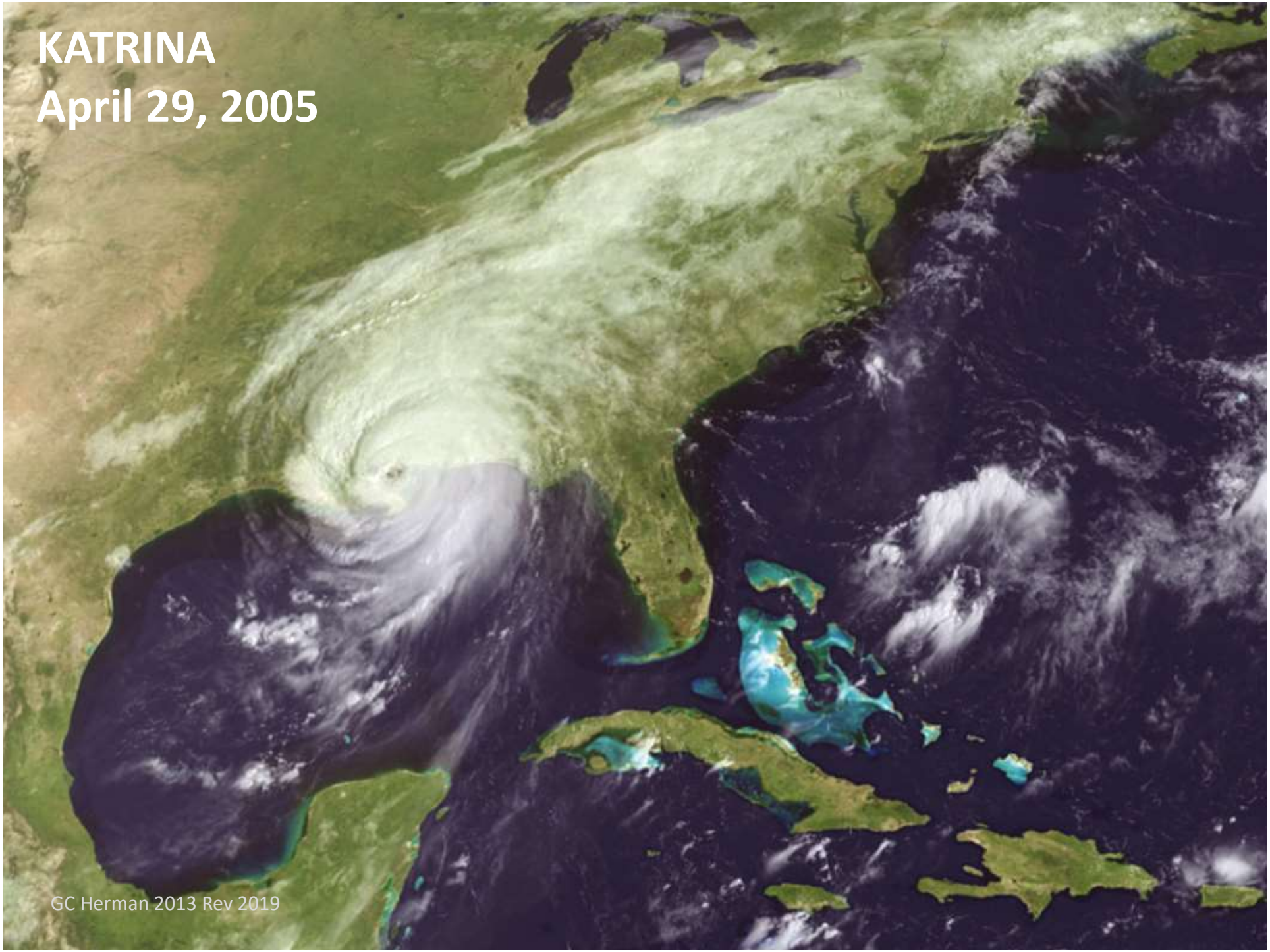

KATRINA
April 29, 2005
GC Herman 2013 Rev 2019

GC Herman 2013 Rev 2019


Golden Canyon,
Death Valley, California
• Only 6 cm rain in 4 days can cause flash flooding
GC Herman 2013 Rev 2019

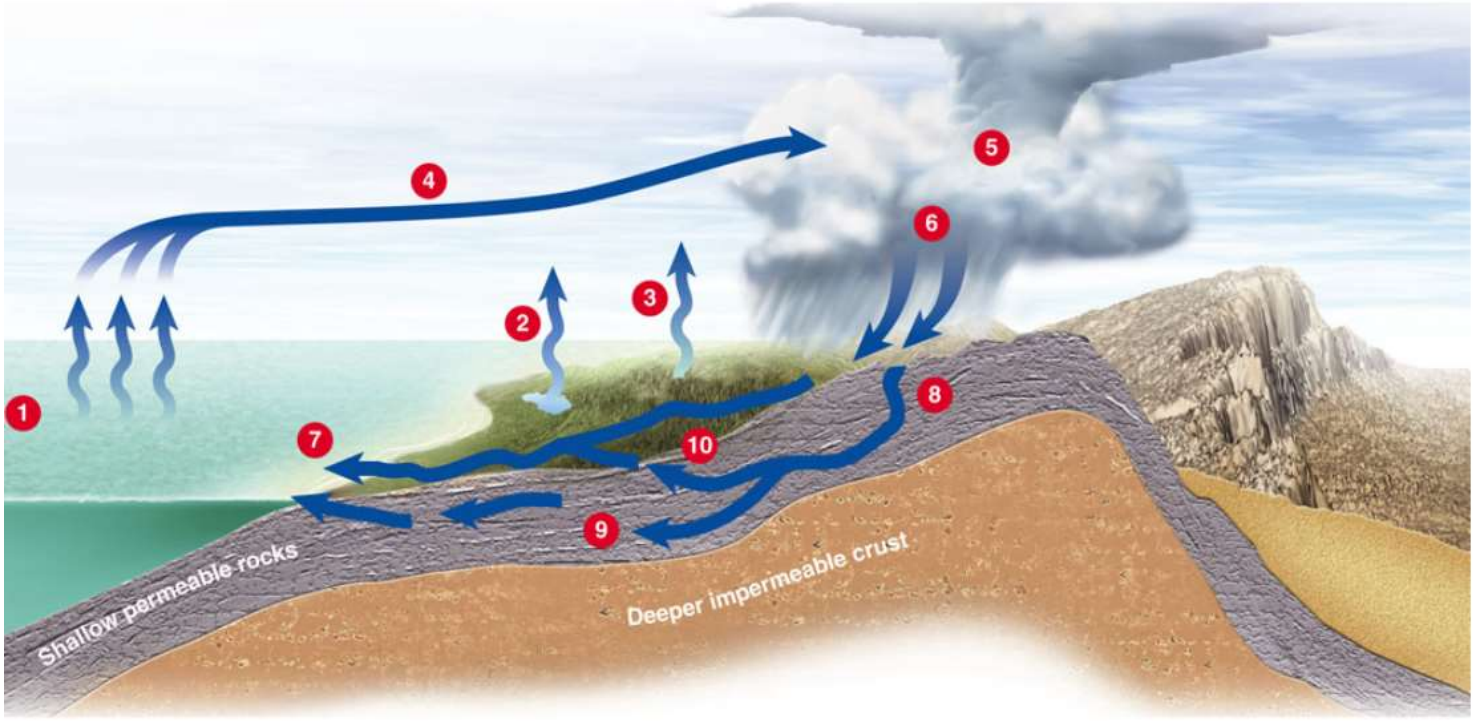
Delaware Water Gap

SURFACE WATER AND GROUNDWATER

- Introduction
- Water on Earth and the Hydrologic Cycle
- Rivers, Streams, Lakes, Reservoirs, and Ponds
- Running Water and Erosion
- Surface Water Sediment Deposition and Transport
- Drainage Systems and the Evolution of Valleys

Water on Earth and the Hydrologic Cycle

Water is in a continuous cycle of movement and phase change; evaporated from the ocean to rise as water vapor, then condensed and precipitated, about 20% falls on land and eventually returns to the oceans largely by surface runoff.



Stages of the hydrologic cycle

1. Evaporation from the sea
2. Evaporation from streams, rivers, lakes, and soil
3. Evapotranspiration from plants
4. Movement by wind of moisture-laden air masses
5. Condensation into clouds as air rises
6. Precipitation
7. Runoff of rainfall, snow, and ice-melt back to the sea via rivers
8. Infiltration of some surface waters
9. Groundwater flow back toward the sea
10. Emergence of some groundwater as springs that feed streams and rivers

The Hydrologic Cycle *is powered by thermal energy from the sun*, it is a global system where *the atmosphere provides the link between the oceans and continents*.

How does this happen?

1st Water enters the atmosphere as vapor from land surface by **evaporation, transpiration, or volcanism.**

Evaporation: water that occurs in oceans, lakes or soil is converted by thermal energy into vapor that enters atmosphere

Transpiration: the release of water vapor into the atmosphere by plants

2nd Water vapor in the atmosphere is transported by wind currents and rises to form clouds through **condensation**

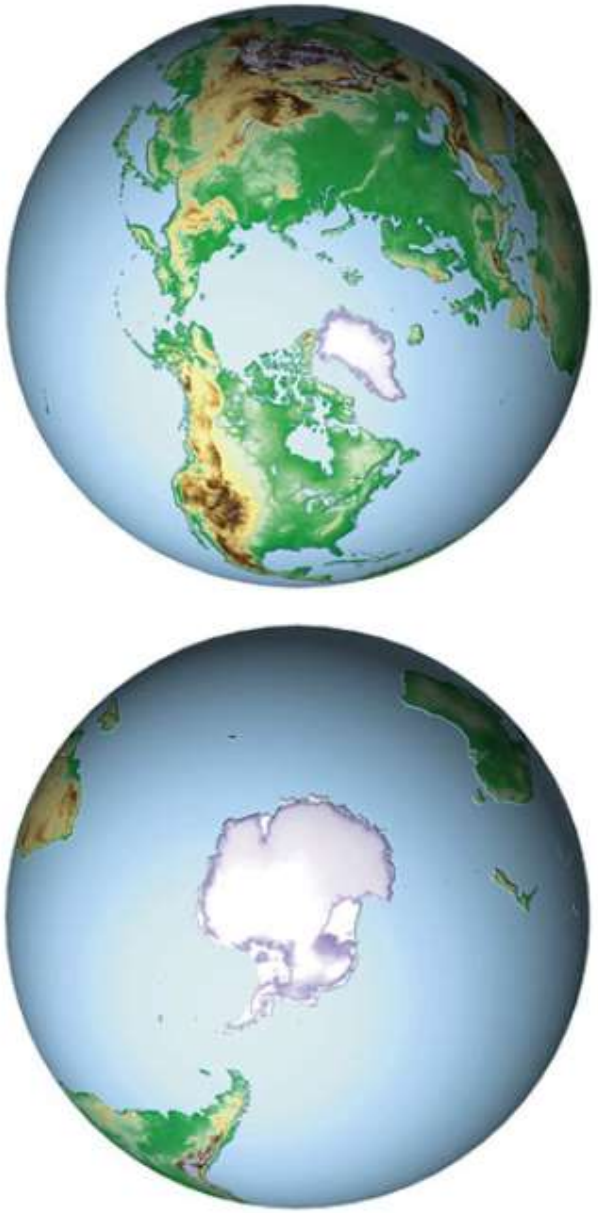
3rd Saturated clouds yield **precipitation** (rain, snow, hail, sleet, and fog)

4th Water that flows atop the land to the ocean is called **runoff**, that which runs in streams, rivers, etc. is running water

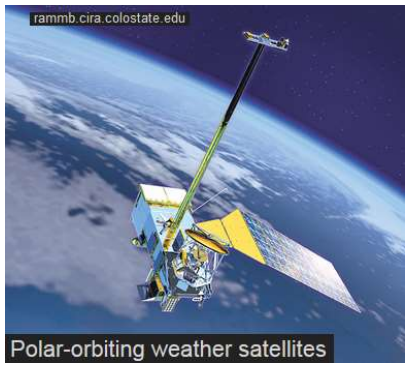
5th Water that *infiltrates* into the rocks or soil through cracks and pore spaces is **groundwater**, which eventually discharges to surface-water bodies

Water on Earth

- 71% of Earth's area consists of oceans and marginal seas like Caribbean and Mediterranean Sea.
- Most of the ocean waters are in the are in the Southern Hemisphere, about 81 % of the surface water.
- Oceans hold 97% of Earth's 1.4 billion km^3 total water
- Most of the remaining 3% is in land glaciers and less than 1% is in atmosphere, surface and groundwater systems at any one time.



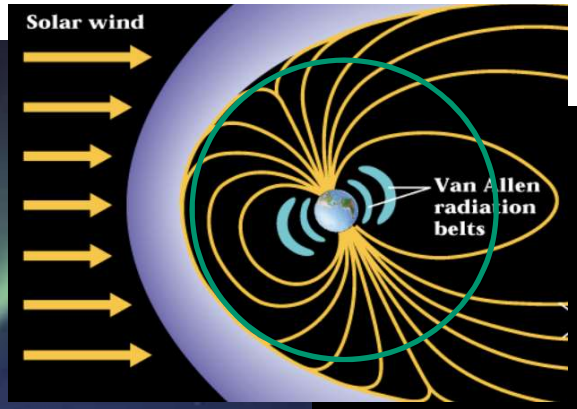
Earth Sweats

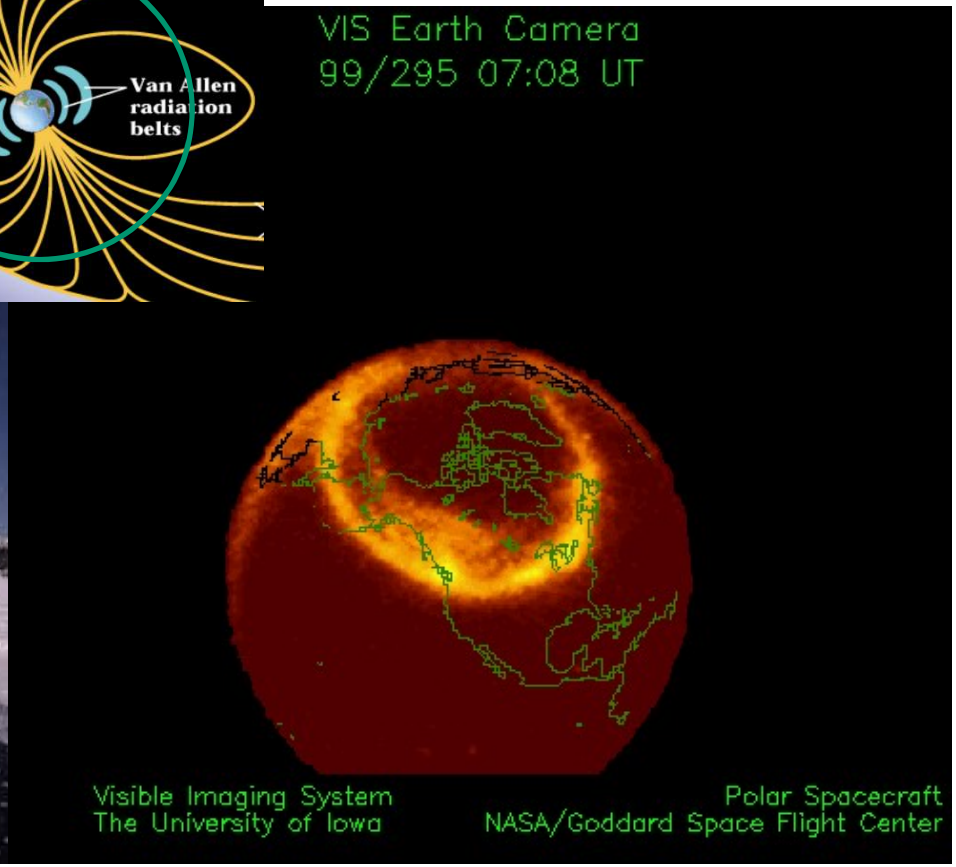


• Data from the POLAR satellite shows that water vapor and other atmospheric gases are dragged outward at Earth's poles through the ionosphere by solar winds

• They calculate that one thousand gallons of water per day is being lost, practically nothing given the vast amount of water in the oceans.

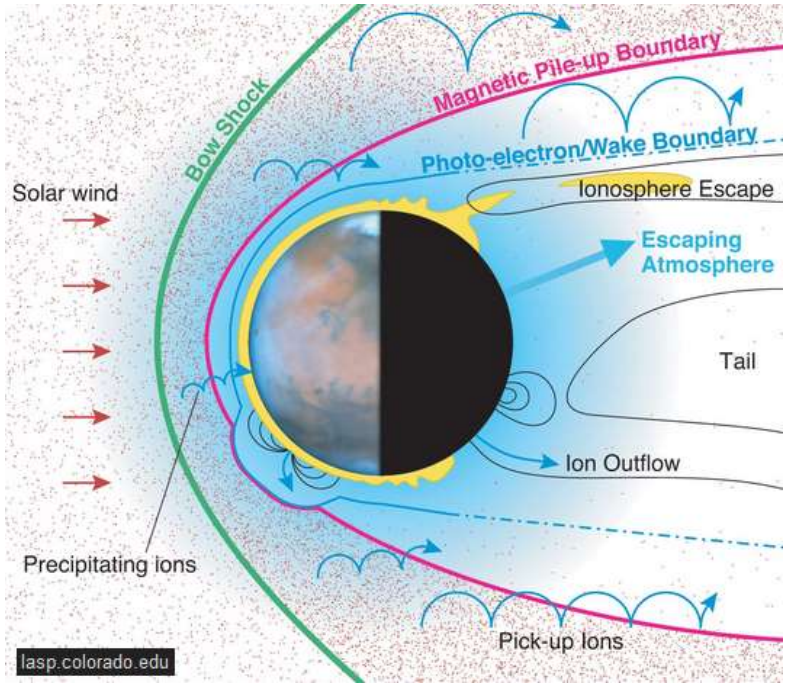
EOS, August 5, 1997

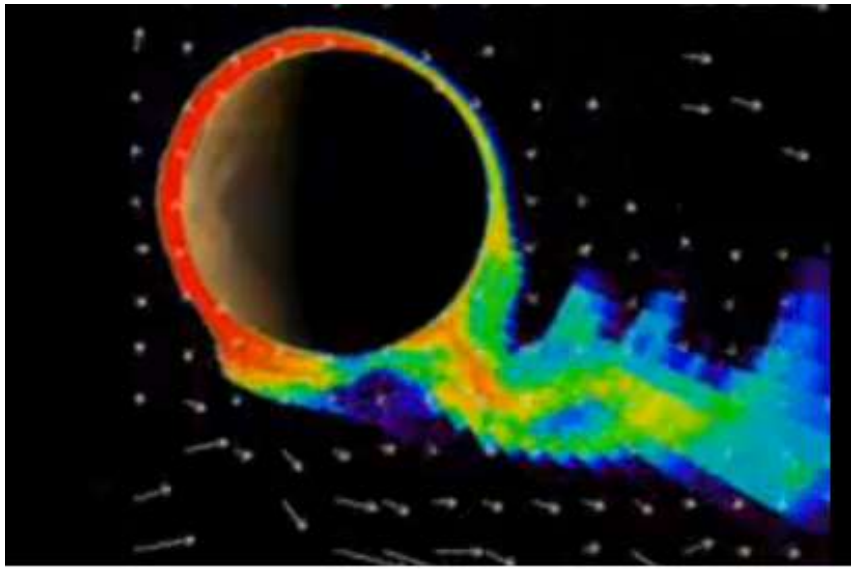




Mars Ablates

•*Ablation* is removal of material from the surface of an object by vaporization, chipping, or other erosive processes





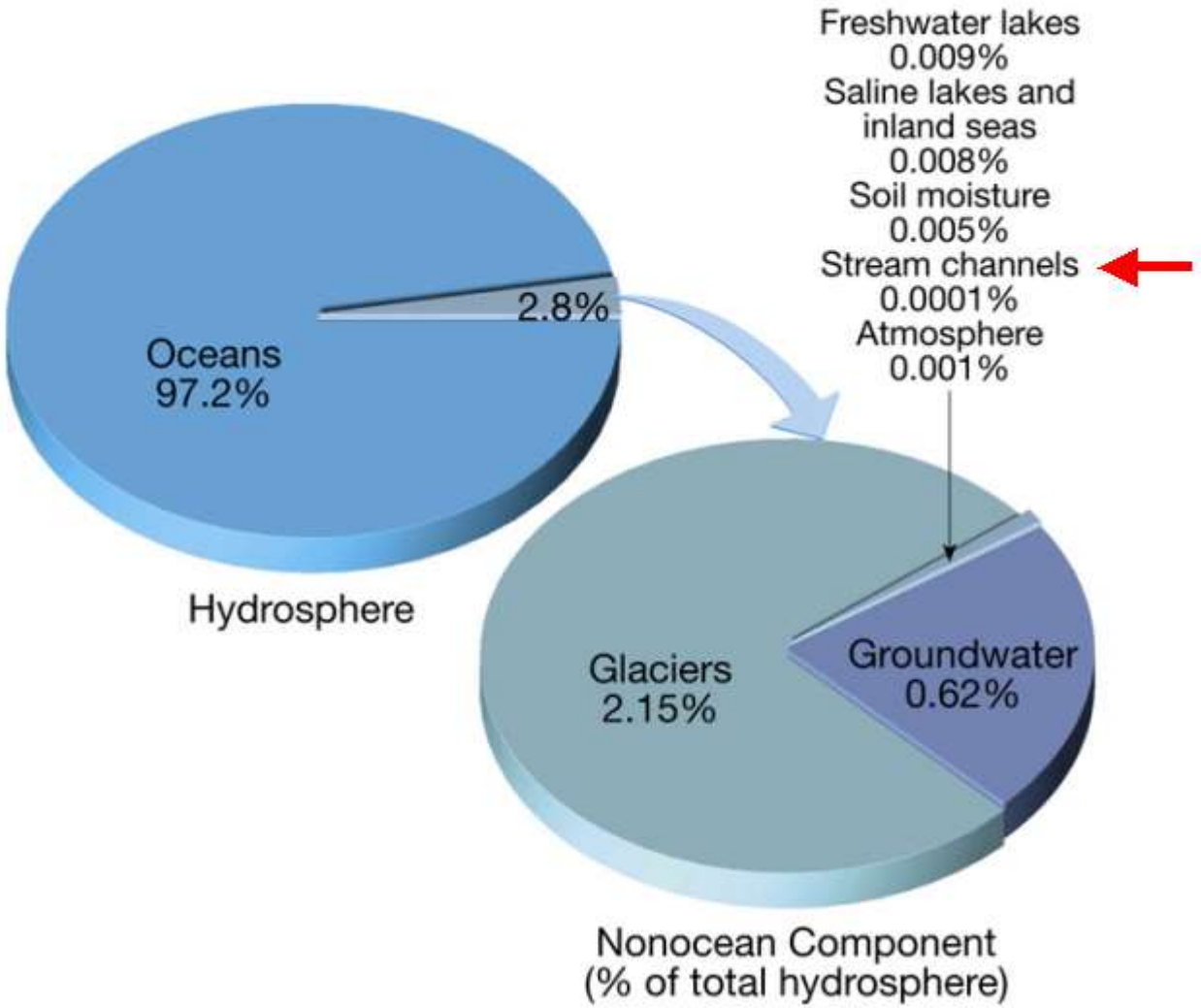
Martian Atmosphere Interacting with the Solar Wind

Uploaded on Aug 11, 2007

Mars possesses no significant intrinsic magnetic field. The absence of magnetic protection allows the supersonic solar wind flow to directly interact with the Martian ionosphere (an almost fully ionized region of the Mars upper atmosphere). When the velocity of the solar wind increases, the Martian ionosphere is compressed and the ionopause (a boundary layer between the ionosphere and the solar wind) is displaced to lower altitudes. The ions of planetary origin such as O+ and O2+ escape from the upper atmosphere of Mars due to solar wind induced scavenging processes.

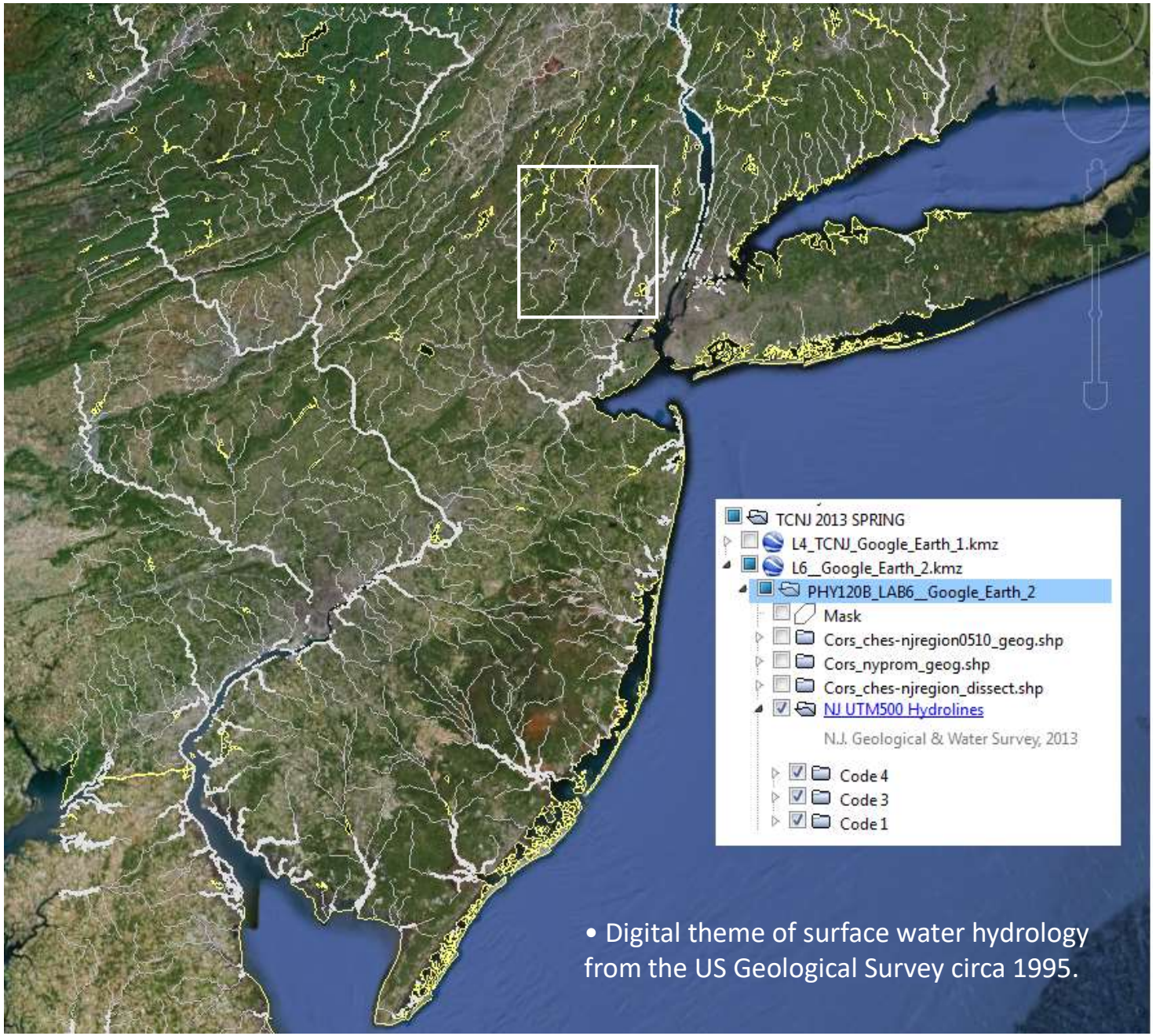
Water on Earth

- Stream channels hold less that 1/10,000 % of the water at any time.
- Channels of all dimensions and volumes are known as streams, and river is usually reserved for large bodies of running water.



Rivers, Streams, Lakes, Reservoirs, and Ponds

- A *reservoir* (French réservoir a "storehouse") is an artificial lake, storage pond or impoundment from a dam that is used to store water

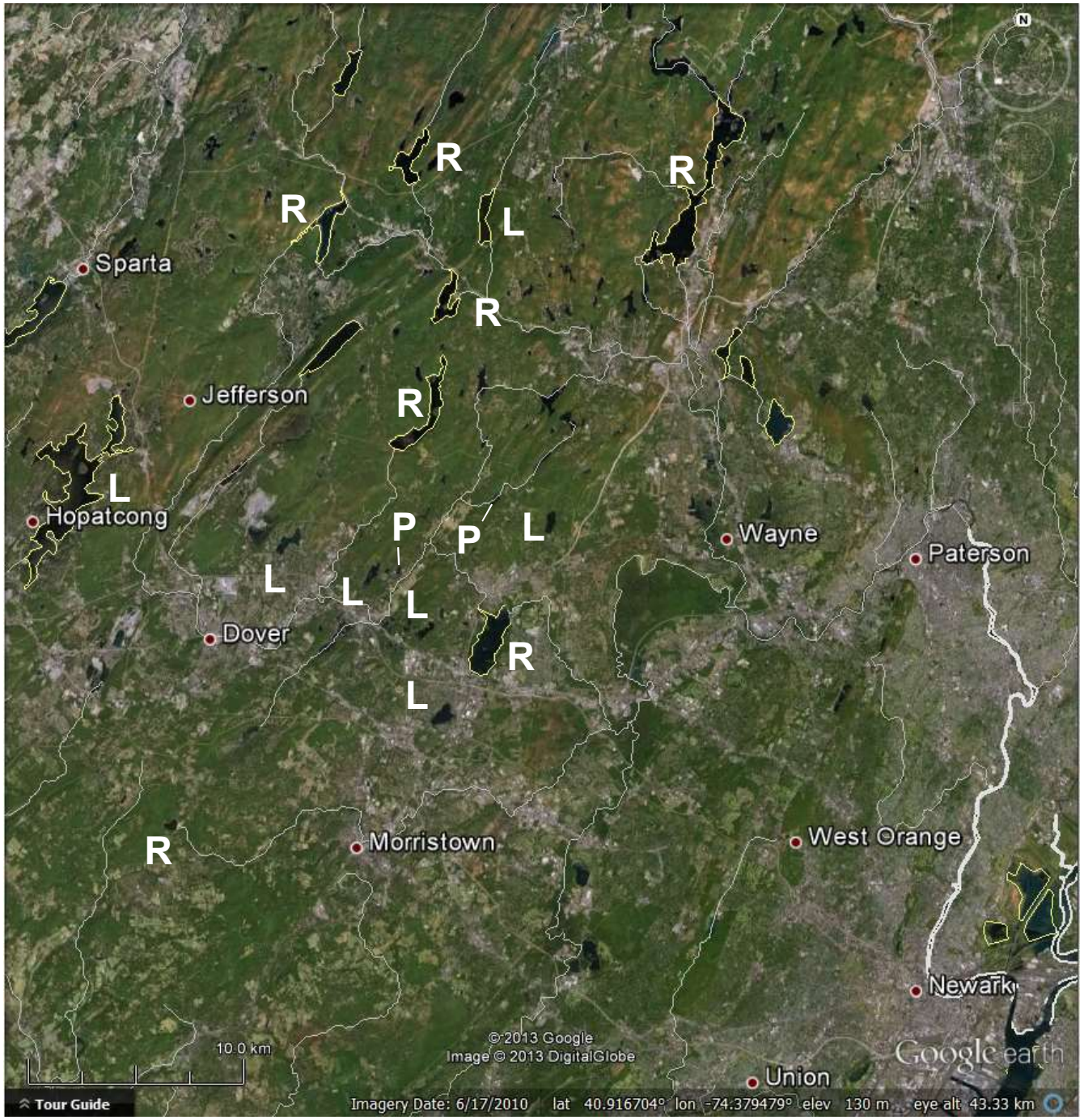


- Digital theme of surface water hydrology from the US Geological Survey circa 1995.

Lakes, Reservoirs, and Ponds

- A *lake* is a large body of fresh water.

- A *pond* is a body of water shallow enough to support rooted plants.

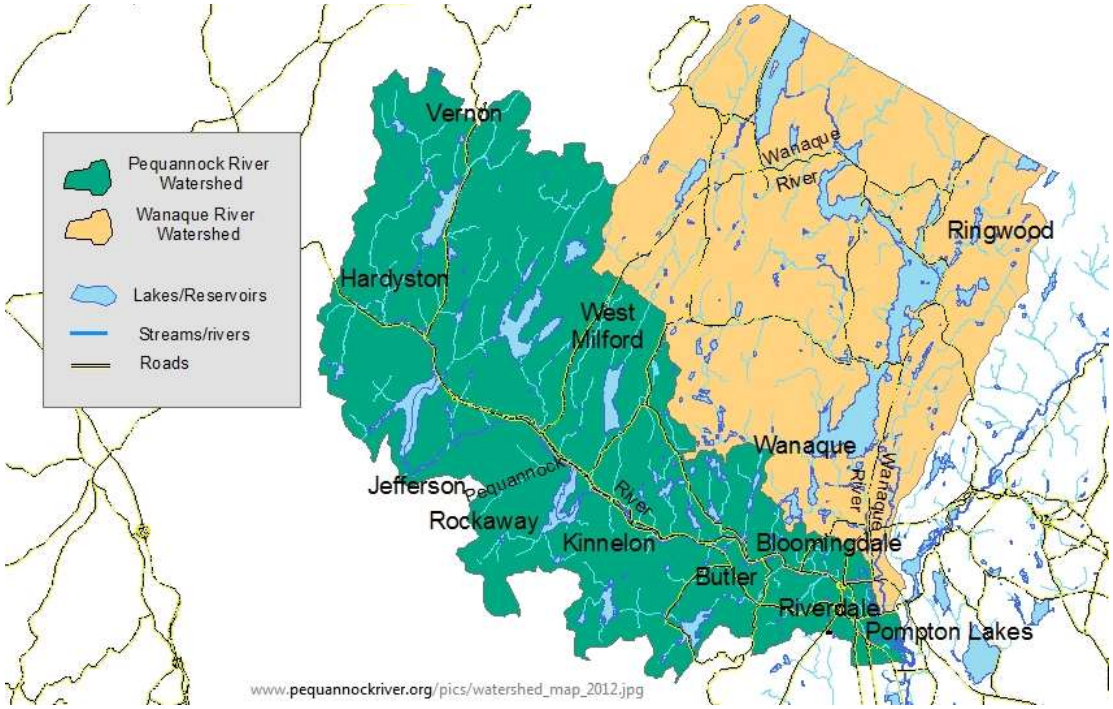


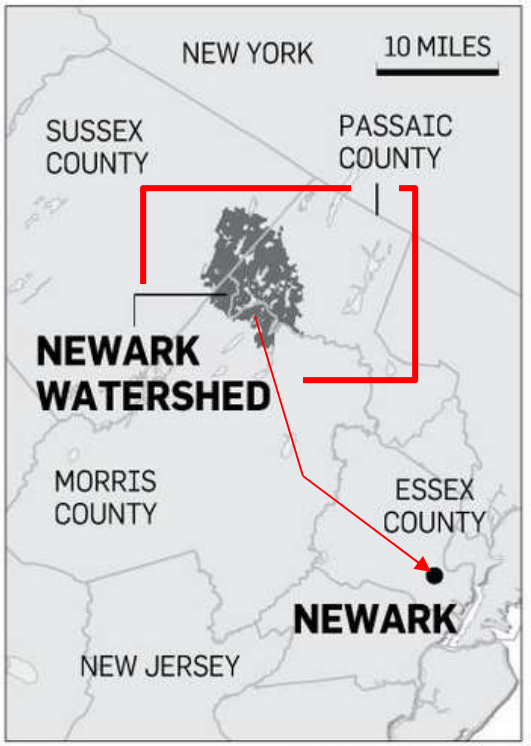
Surface Water Reservoirs

• The volume of water retained in reservoirs today is so large that if they didn't exist, sea level would be 3 cm higher.

• These storage bodies have a combined surface area of 500,000 square kilometers, about twice the area of the Great Lakes.

EOS, July 19, 1994.





Running Water and Erosion

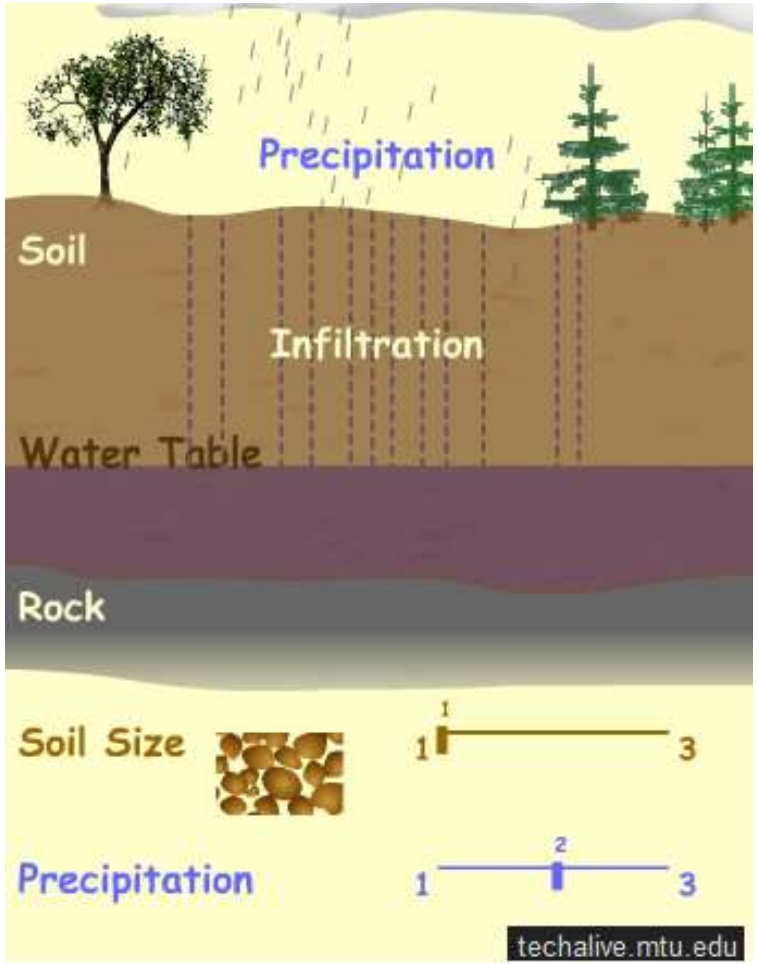
- Runoff occurs when rainfall intensity exceeds *infiltration capacity* of the soil.

- It occurs as either sheet flow or channel flow.

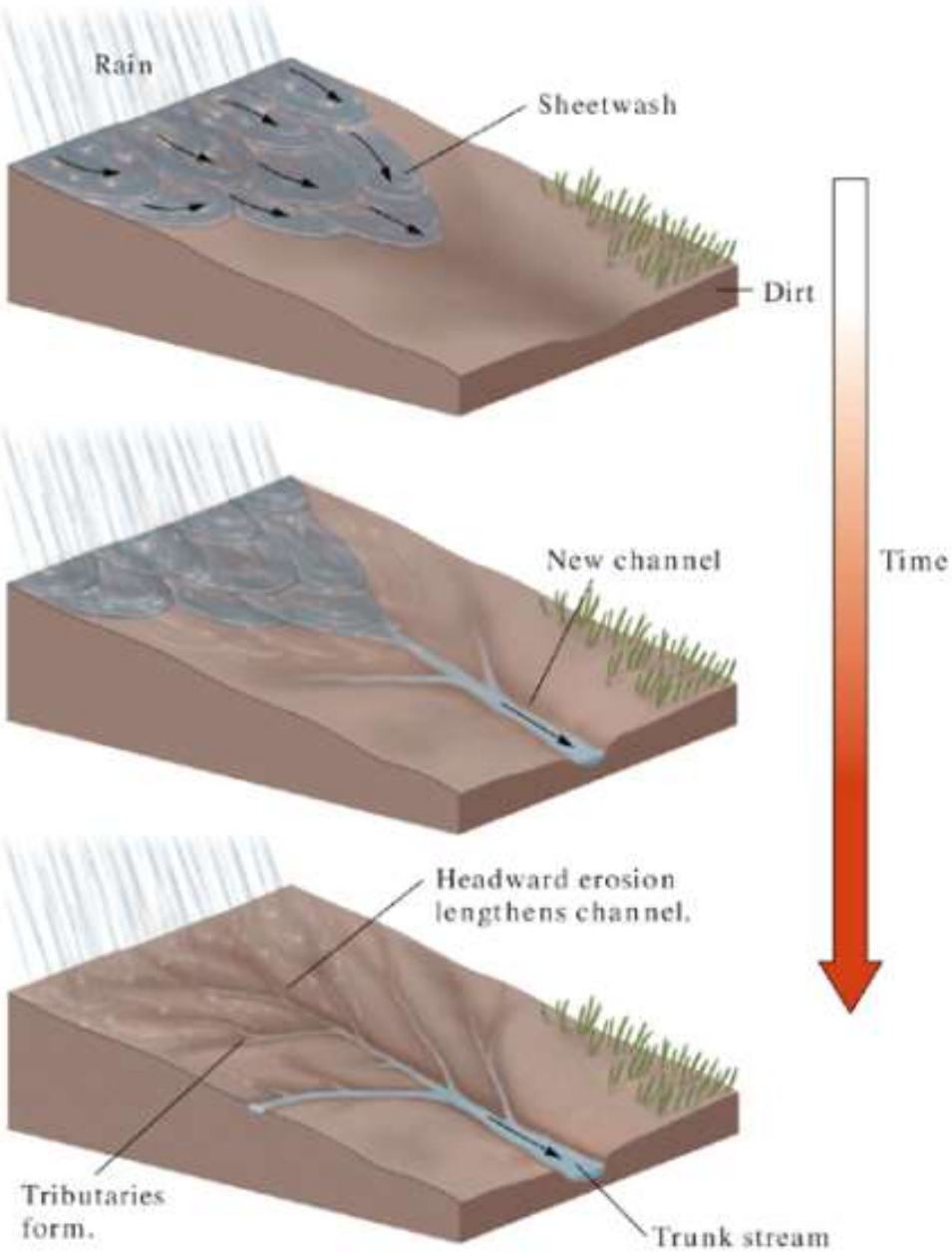
Infiltration Capacity determines how much water will run into streams.

Various factors control infiltration capacity:

1. The intensity and duration of rainfall
2. Prior wetted condition of the soil
3. Soil Texture (size of the soil particles)
4. Slope of the land
5. The nature of the vegetative cover

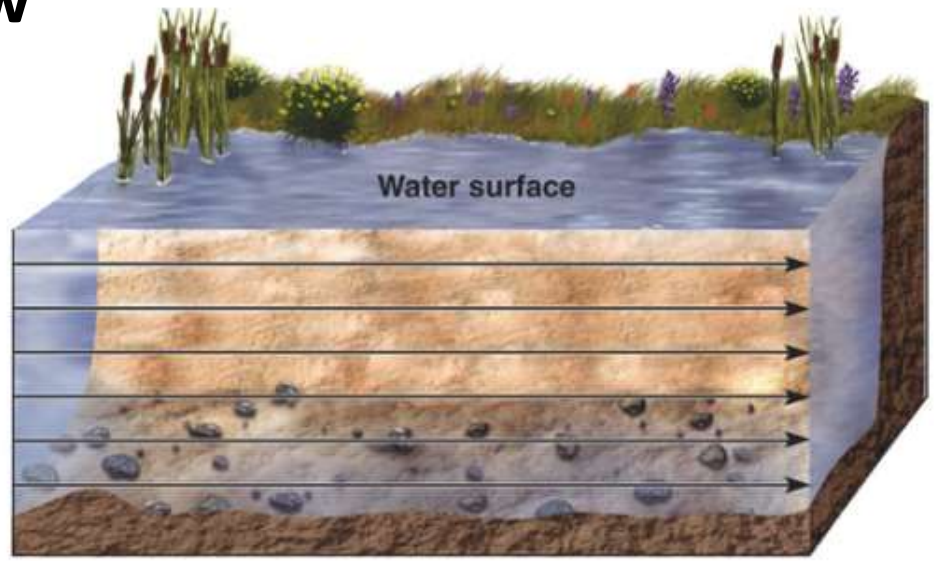


Development of a stream

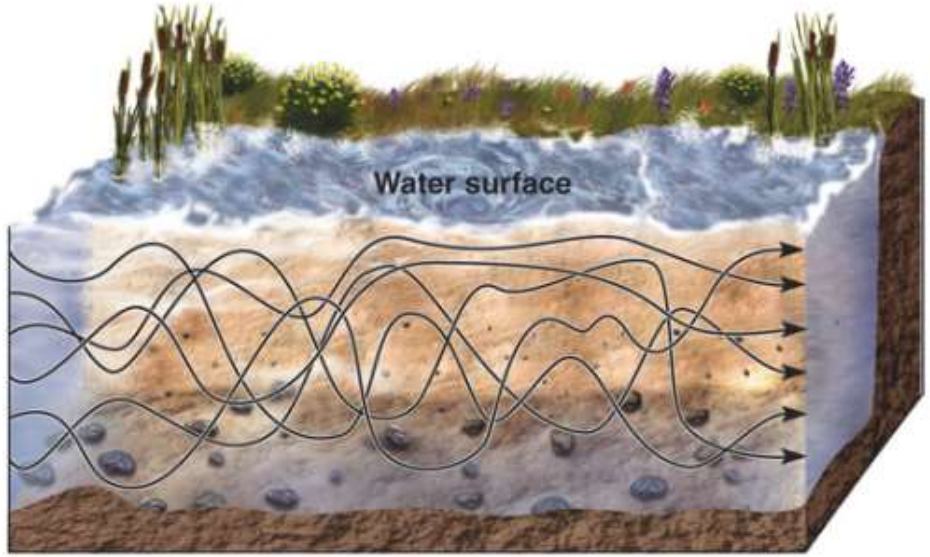


Laminar and turbulent flow

• Running water moves either by laminar flow in which flow lines parallel one another, or by turbulent flow in which flow lines are complexly intertwined.

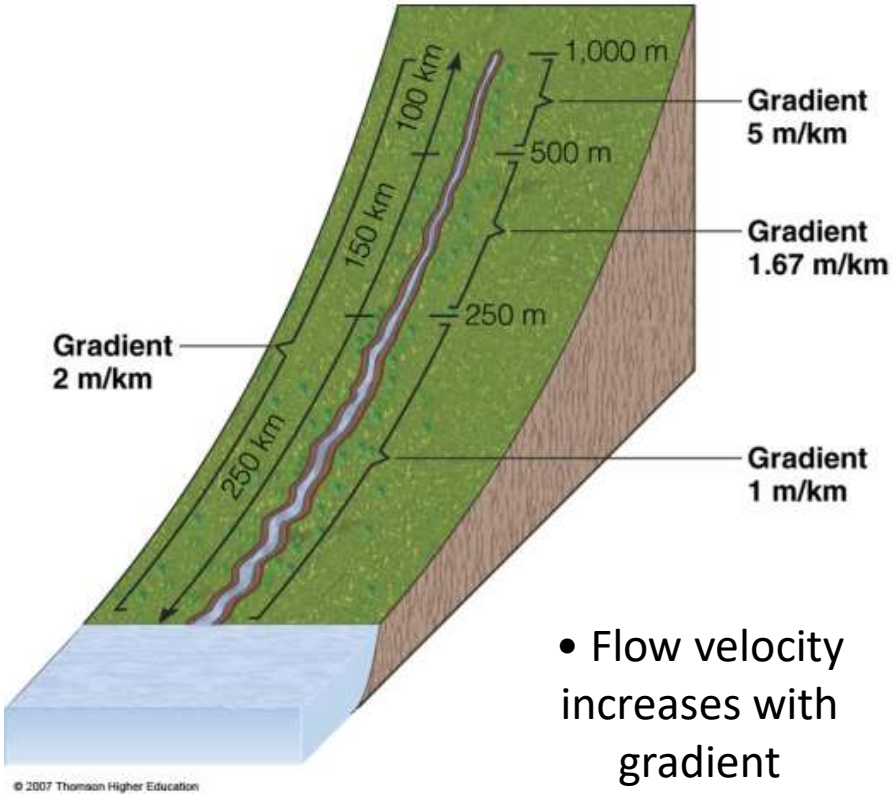


•Most stream flow is turbulent.



Stream Gradient

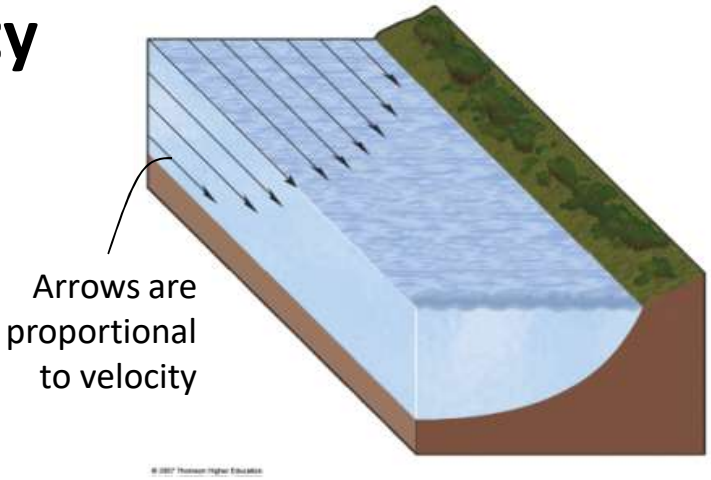
• A stream's gradient varies from steep to gentle along its course, being steepest near its head and gentlest toward its mouth.



• Flow velocity increases with gradient

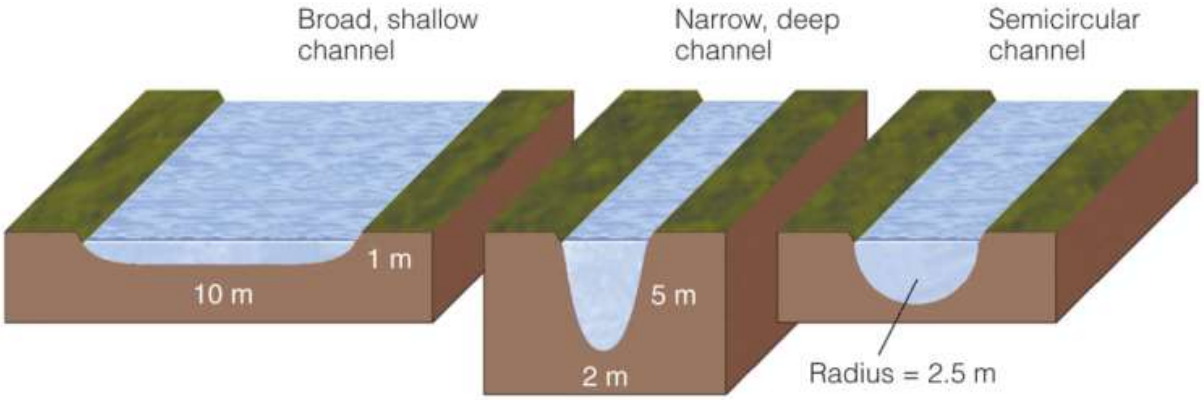
Channel shape and stream velocity

- Flow velocity varies downstream as well as along a cross-section of a stream in response to changes channel roughness, width, and depth, slope and discharge.



- Flow velocity is the greatest in the center of a stream

- Semicircular shaped channels have less contact with stream water and thus less frictional resistance to flow



Cross-sectional area	10 m^2	10 m^2	10 m^2
Perimeter in contact with water	12 m	12 m	7.9 m

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Discharge generally increases downstream due to tributary inputs of water.

- Discharge (Q) is calculated using weirs and similar methods with reported flows in m^3 or ft^3 per unit of time (sec, hour, or day)

Discharge = flow velocity (V) x cross-sectional area (A)

where area (A) = width x height for a rectangular area

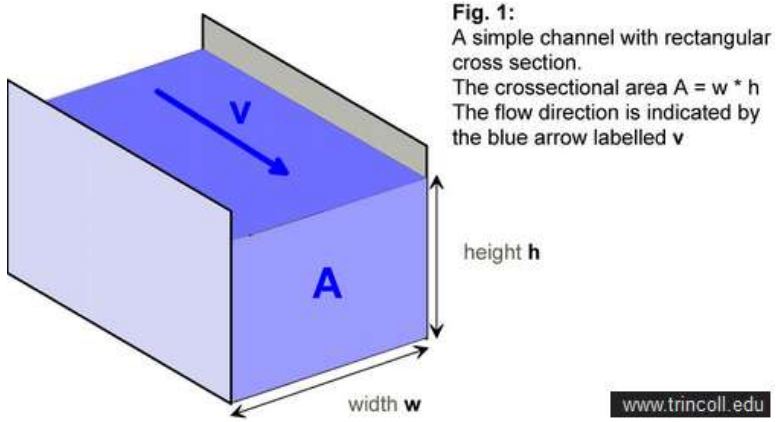
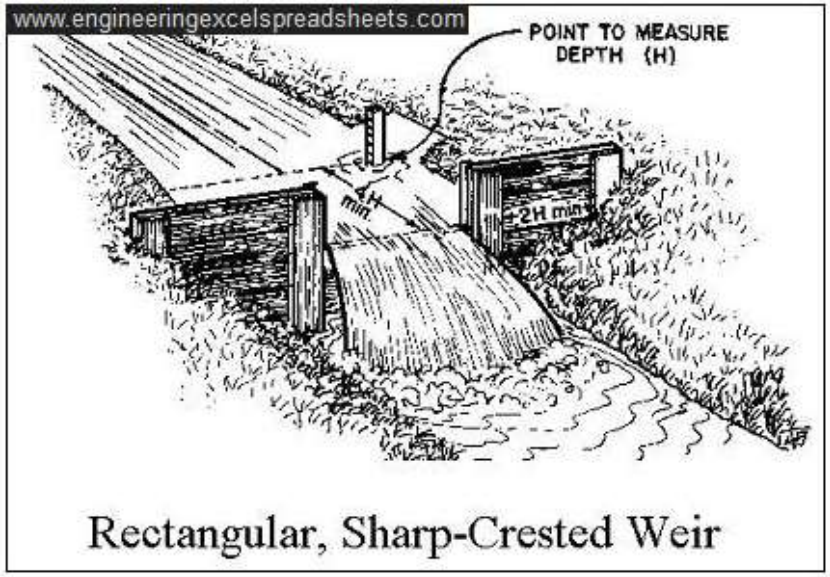
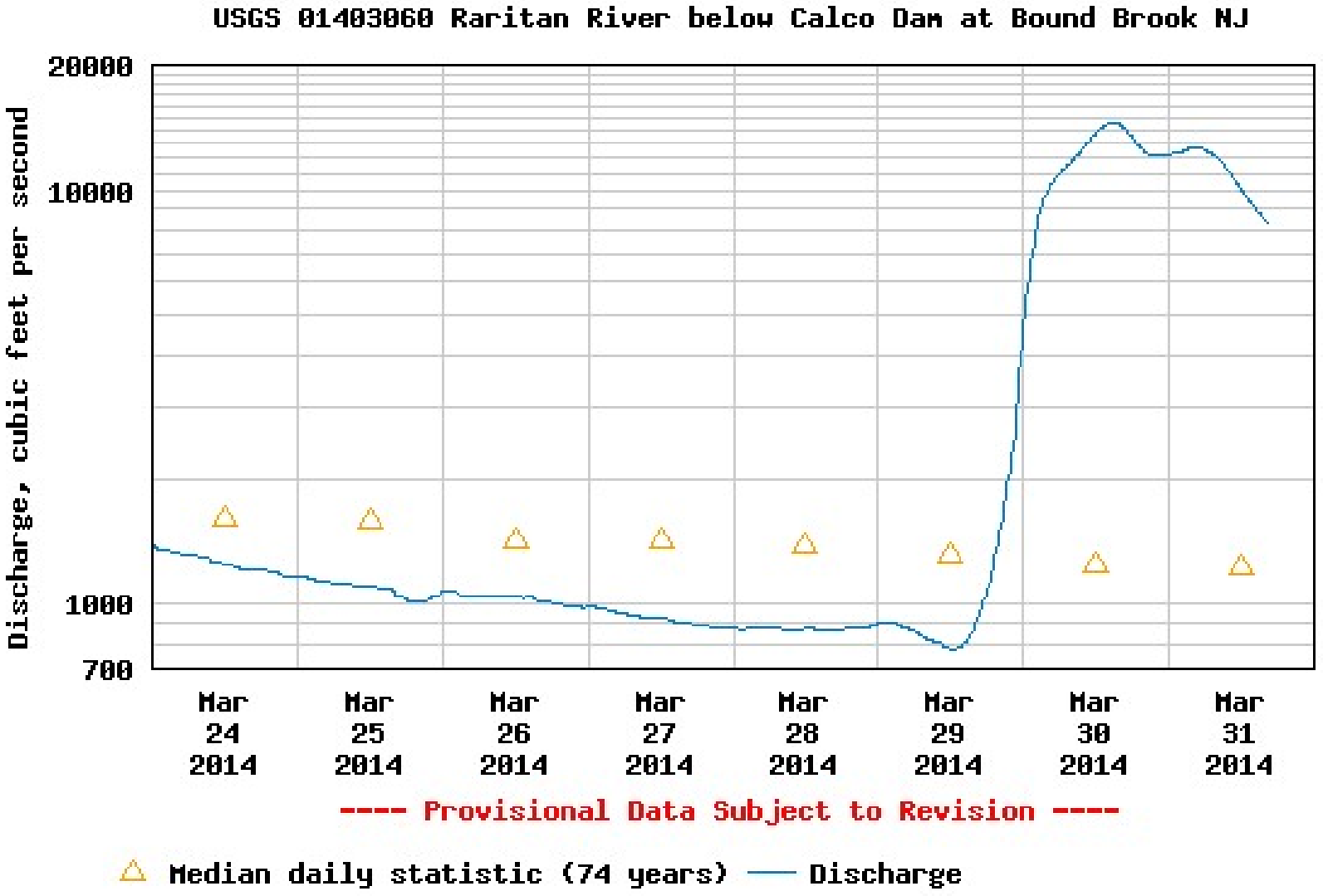


Fig. 1:
A simple channel with rectangular cross section.
The crossectional area A = w * h
The flow direction is indicated by the blue arrow labelled **v**



Most recent instantaneous value: 8,380 03-31-2014 16:15 EDT



Erosion is the wearing away of rock and soil along the river bed and banks

- Streams erode sediment and rock by hydraulic action, abrasion, and dissolution of soluble rocks.
- *Hydraulic action* is when the river forces air into cracks and crevices, gradually wearing the riverbank away.
- *Abrasion* is where rocks get carried along by the river, wearing down its bed and banks.
- *Attrition* is when rocks, carried by the river, smash together and break into smaller, smoother particles.
- *Solution* is when particles of rock dissolve into, and are transported by streams.

rounding through abrasion

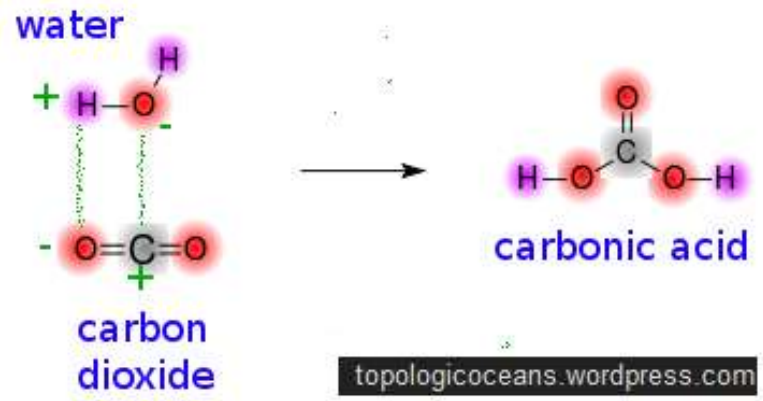
Chemical Weathering

- Chemical weathering processes include ***solution, oxidation, and hydrolysis***

  - **Solution** is when ions in minerals of a solid substance separate, or dissolve when coming into contact with a liquid.

    A common example is when *limestone* (impure calcium carbonate) is dissolved by contact with slightly acidic water, like rainwater.

• Rainwater and shallow groundwater commonly contain small amounts of carbon dioxide (CO_2), thereby liberating the hydrogen ions in carbonic acid.

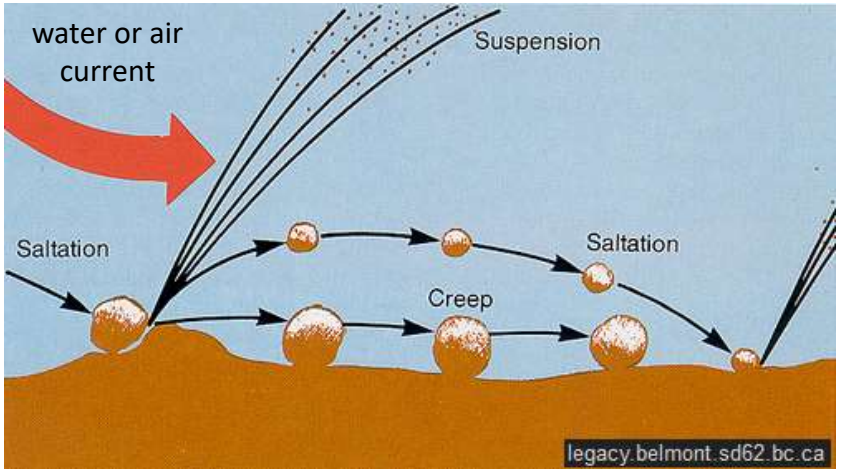


Karst and Caves

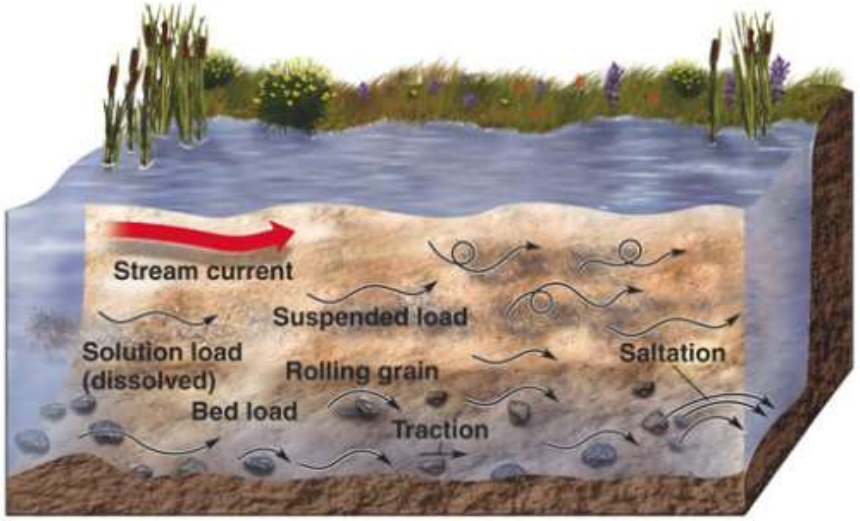
- **Karst topography** is a geological formation shaped by the dissolution of a layer or layers of soluble bedrock, usually carbonate rock such as limestone or dolomite, but has also been documented for weathering-resistant rocks, such as quartzite, given the right conditions.

Surface Water Sediment Transport

- Rivers also transport material by *suspension, traction and saltation*.
  - *Saltation* is when small pebbles and stones bounce along the river bed.
  - *Suspension* is when fine light material gets carried along.
  - *Traction* (or creep) is when large boulders and rocks roll along the river bed.



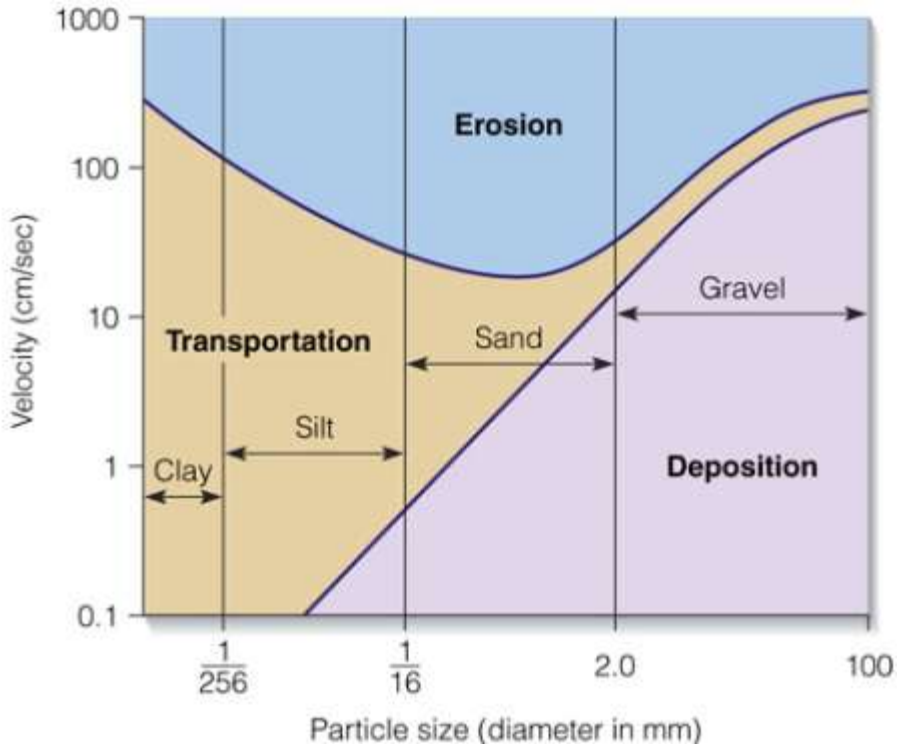
- The *bed load* of a stream is the coarser sediment component moved along the stream bed, while the finer component which is moved within the water column is known as the *suspended load*.
- The dissolved load is those ions which are transported in solution.



Surface Water Sediment Deposition and Transport

• A stream's competence is a measure of the maximum sediment size which can be carried by a stream, that depends on its velocity.

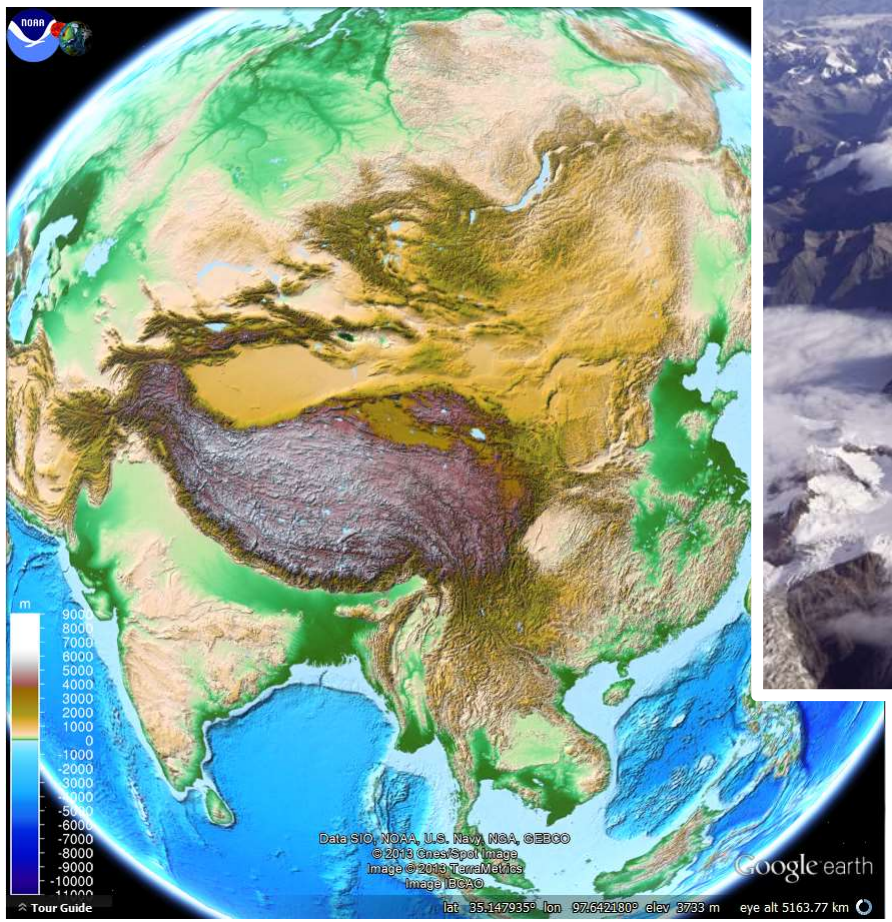
• Stream capacity is a measure of the total load transported and is related to the stream's discharge; with greater discharge more sediment can be carried.



Roof of the World

The Himalayan-Tibet region supplies freshwater for more than one-fifth of the world's population, and accounts for one quarter of the global sedimentation budget.

EOS, October 1, 1996



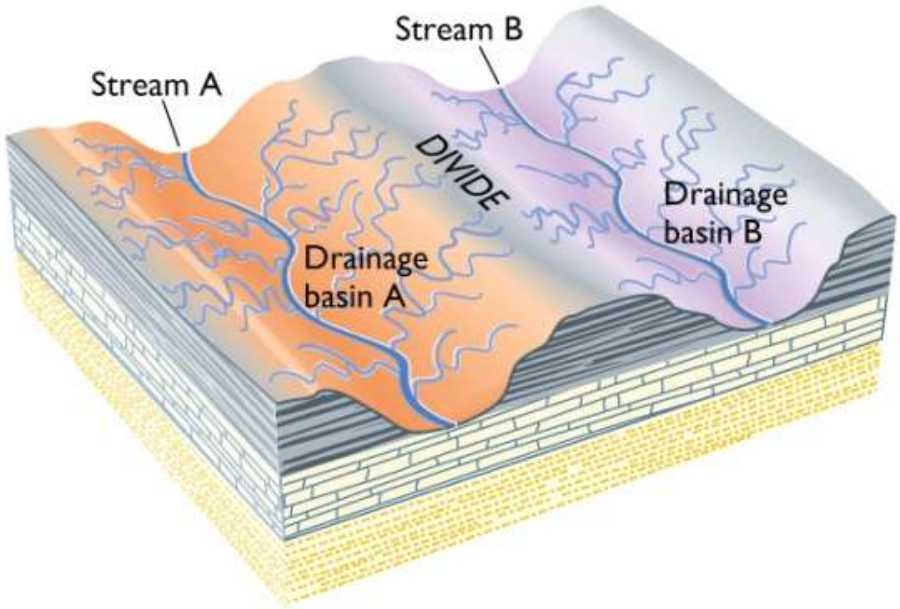
Drainage Basins and Topographic Divides

- Each drainage basin is separated from others by topographic drainage divides.
- Streams and their tributaries carry runoff from the stream's drainage basin.

Continental Divides of North America

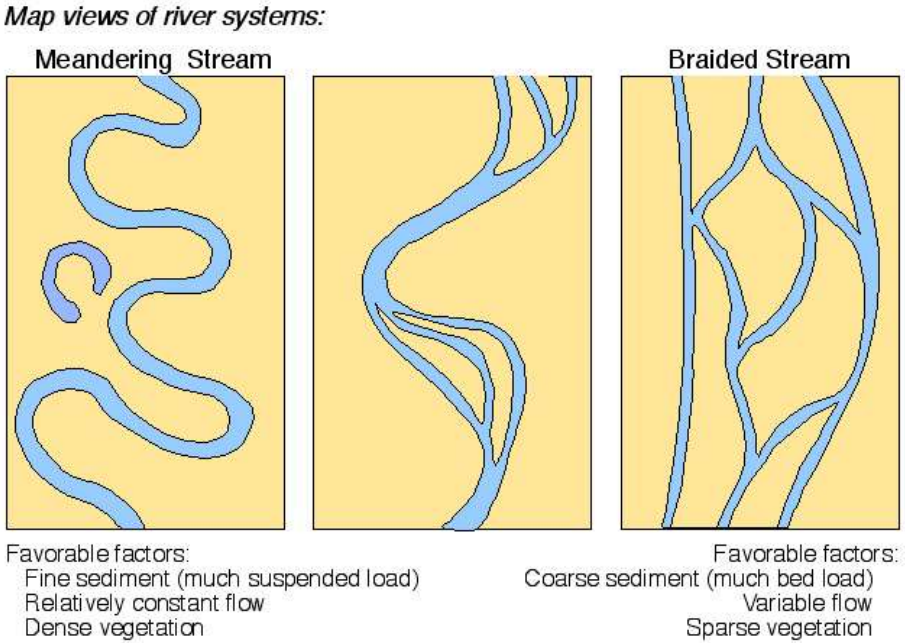
Coordinates taken from the KMZ file available on the Commission for Environmental Cooperation "Watersheds" page at http://www.cec.org/Page.asp?PageID=924&ContentID=2866 Downloaded February 15, 2013. CEC data for oceanic watersheds were converted to line data for the continental divides of interest. For further info contact earlecj@gmail.com

Drainage Divides are continuous topographic highs (ridges) that divide and separates water flow from one drainage basin or 'watershed' into another.



Alluvium and Drainage Systems

• River and stream sedimentary deposits are called *alluvium*.



• Streams are generally categorized as *braided* or *meandering*

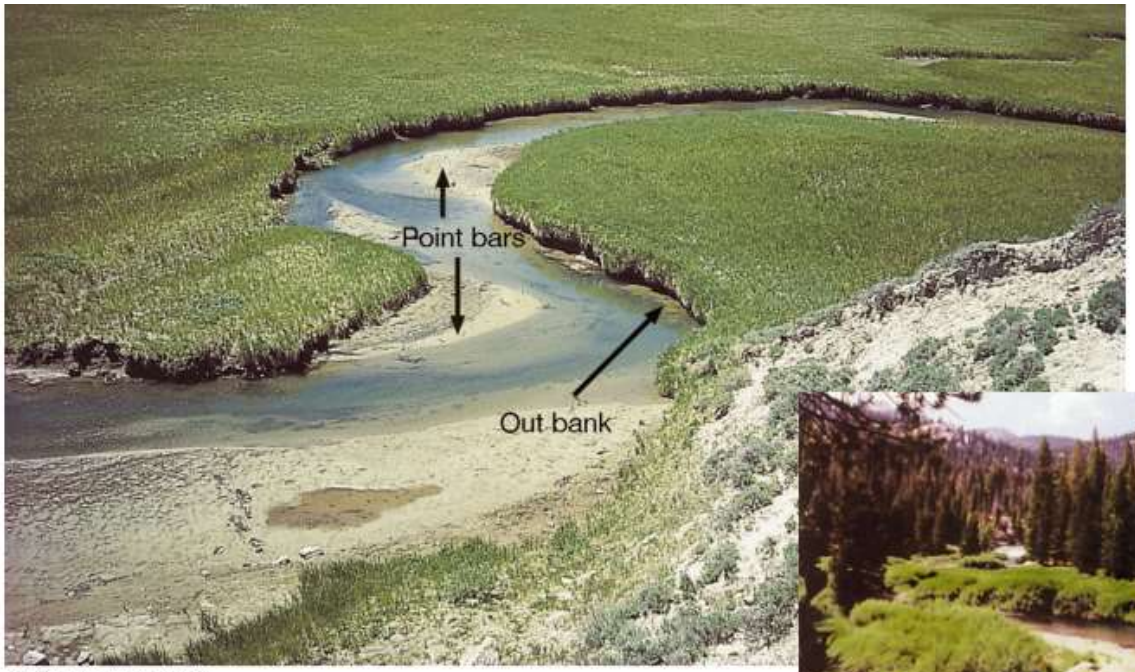
Braided Streams have complex divisions and joining of channels

- Common in arid or semi-arid regions having sparse vegetation and high erosion rates
- Such stream patterns form where the supply of sediment to stream exceeds its capacity to transport it.
- Also glacial outwash plains because there is so much sediment

Sand and Gravel Bars

- Bedload sediment is deposited as sand and gravel bars within the stream's channels.

Meandering Streams have single channels that are sinuous looping curves

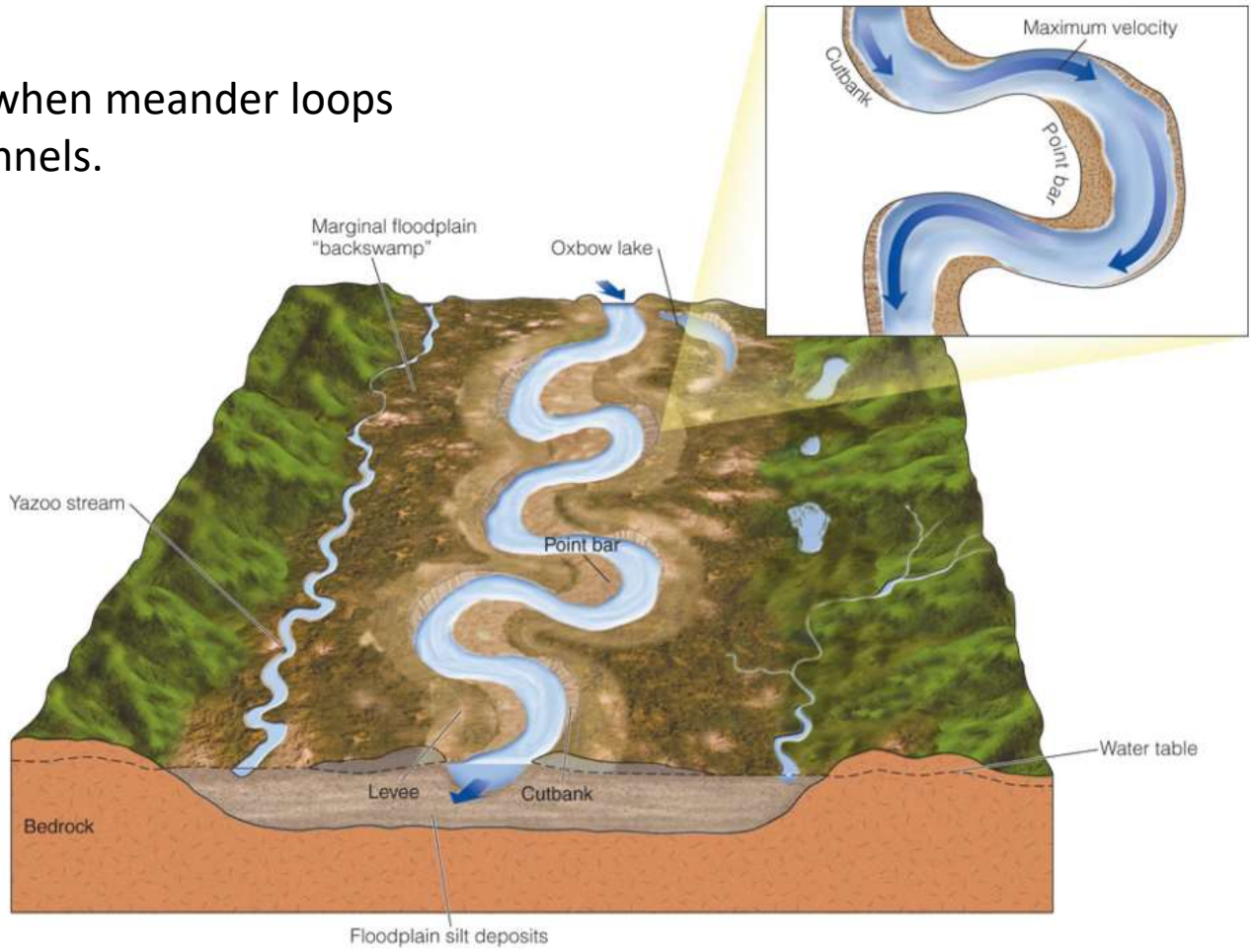


• Meanders migrate by erosion on the cut bank (the outer bank of the meander loop) and deposition on the point bar (the inner bank of the meander loop)

Meandering Streams

- Oxbow lakes are formed when meander loops are cut off from stream channels.

- Fine sediment and organic matter accumulates in such lakes.

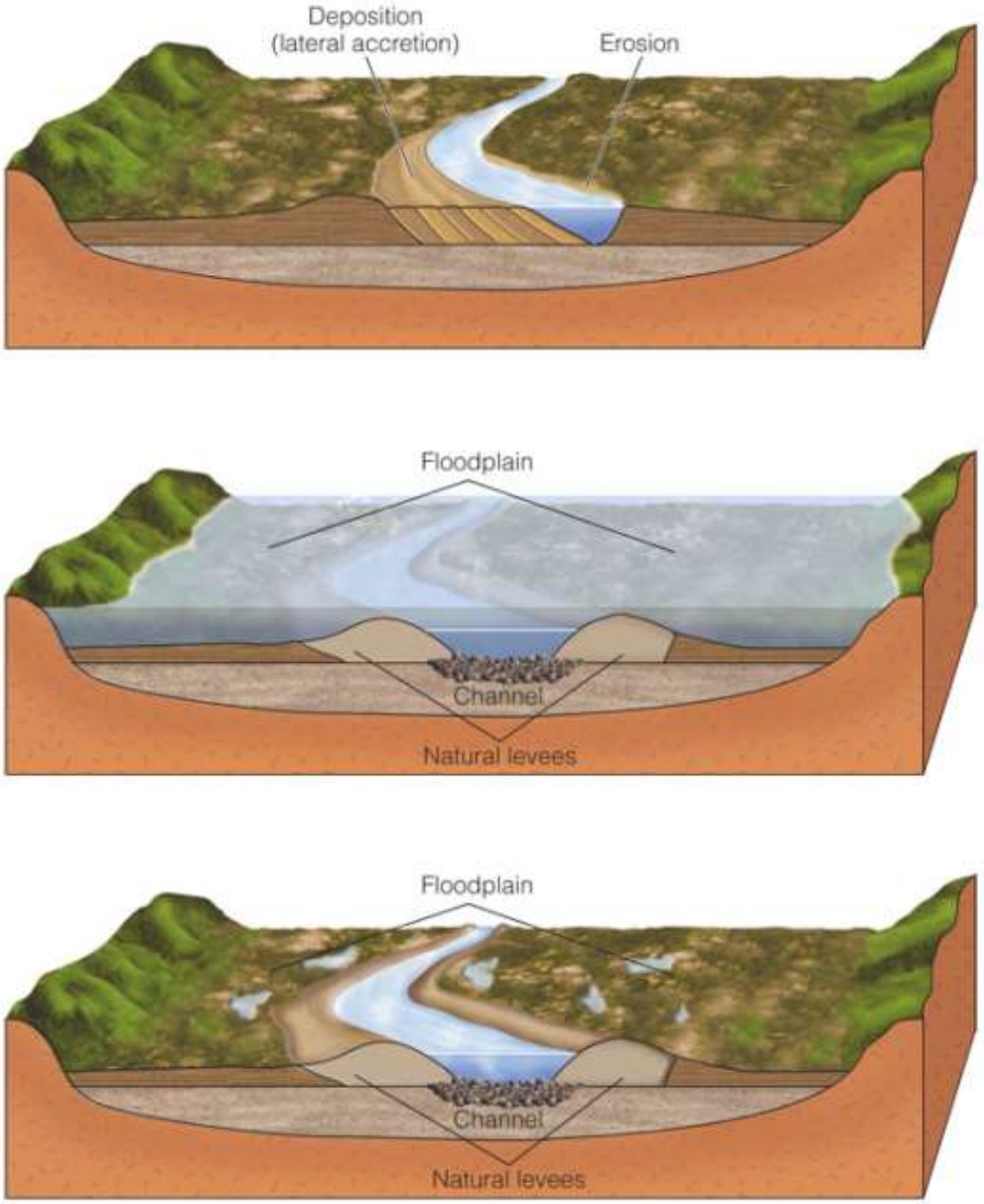


Meandering Streams

A meander loop on the Colorado River

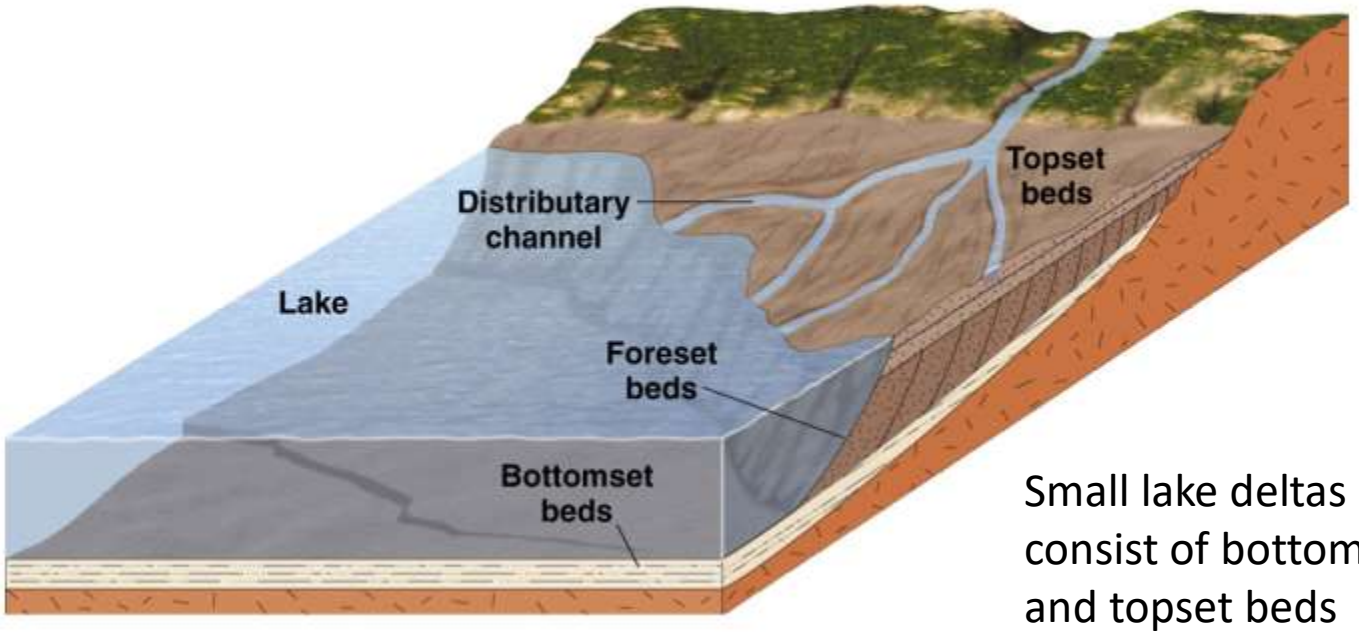
Floodplain Deposits

- *Floodplains* are the flat lowland areas paralleling streams.
- Those formed lateral accretion of point bas are mostly made of sand.
- During floods, streams deposit natural levees, and silt and mud settle from suspension on the floodplain
- Floodplains can therefore be composed of laterally accreted point bars or the vertical accumulation of fine grained flood-borne deposits.



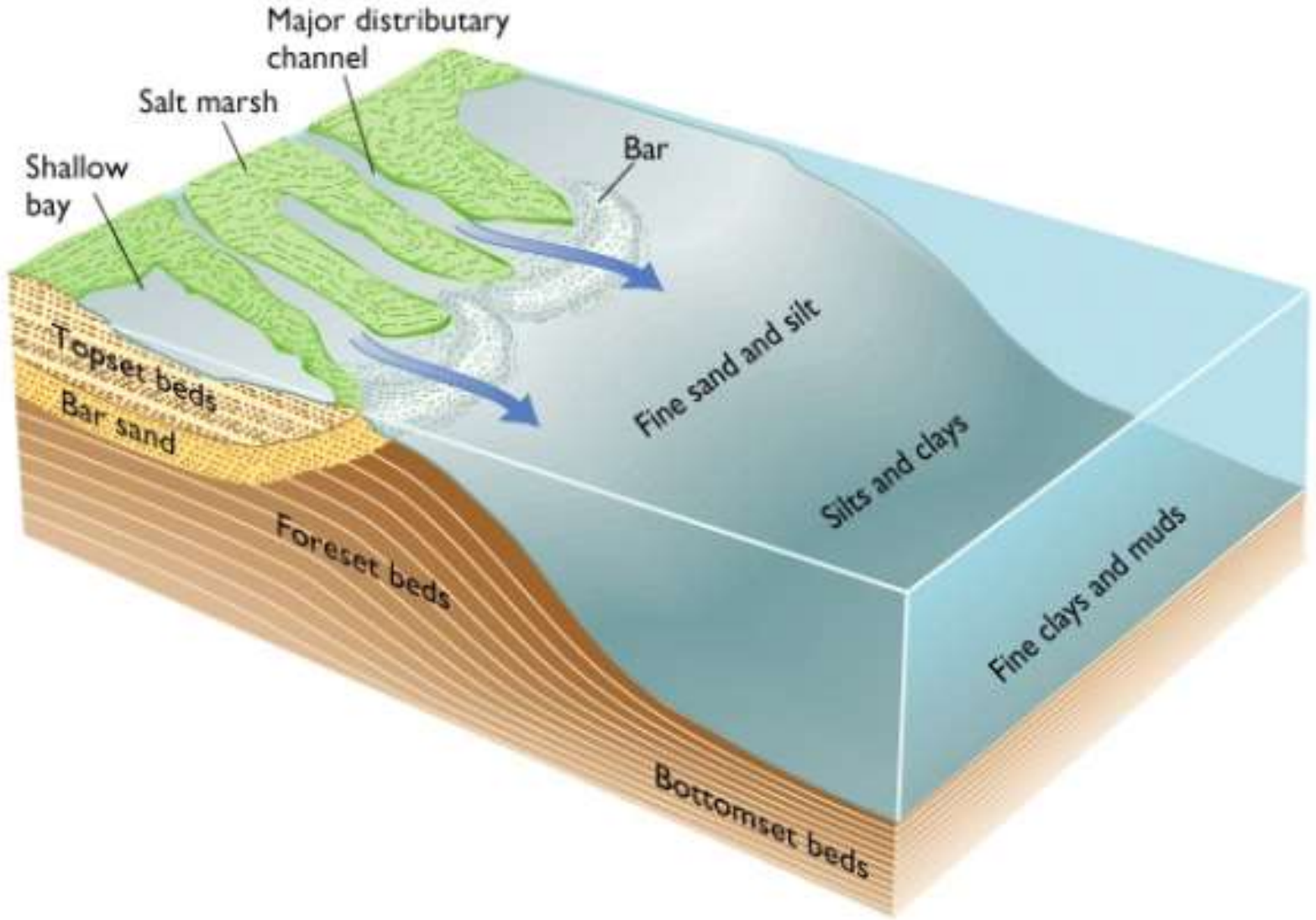
Deltas are alluvial landforms at the mouth of a river, where the river flows into an ocean, sea, estuary, lake, or reservoir.

- They are formed from the deposition of the sediment carried by the river as the flow leaves the mouth of the river.



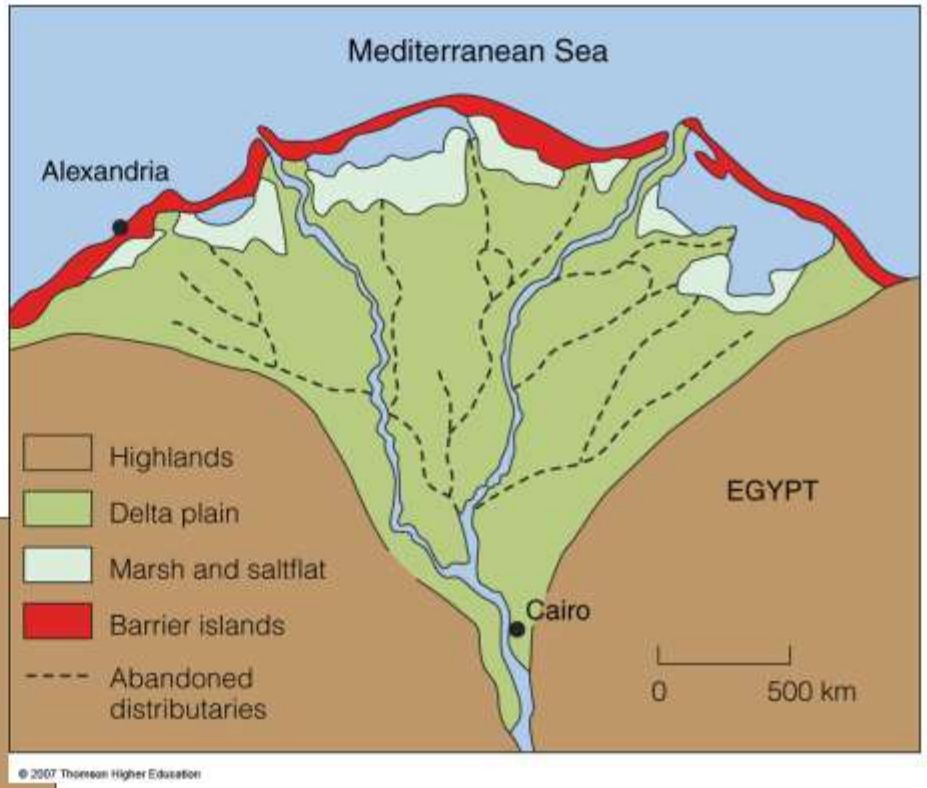
Small lake deltas usually consist of bottomset, forset, and topset beds

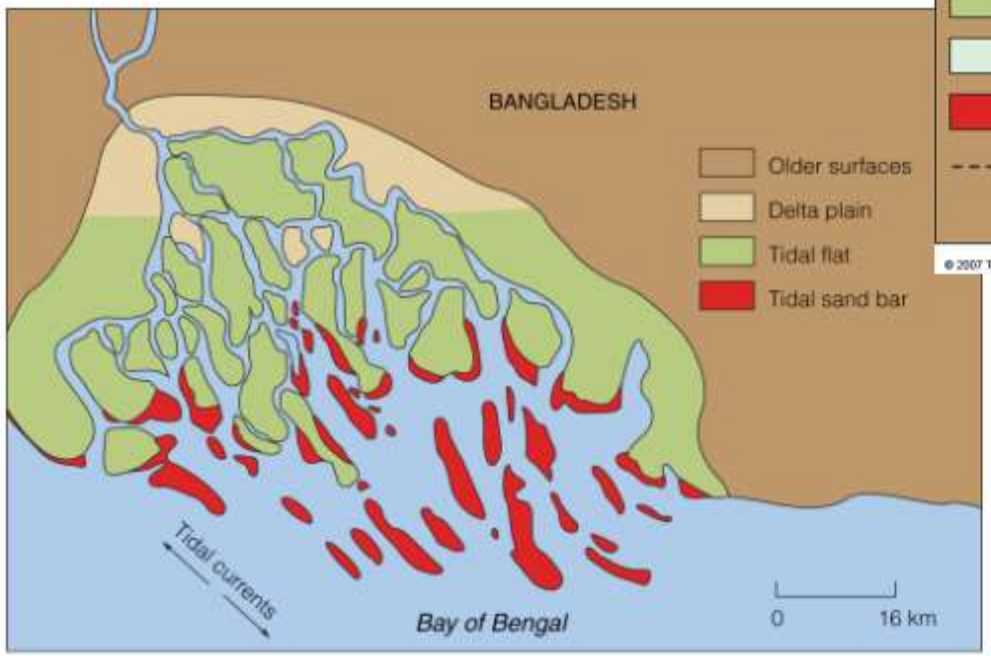
Marine Deltas consist of more complex geometries of facies, and are either stream-, tidal- or wave-dominated.



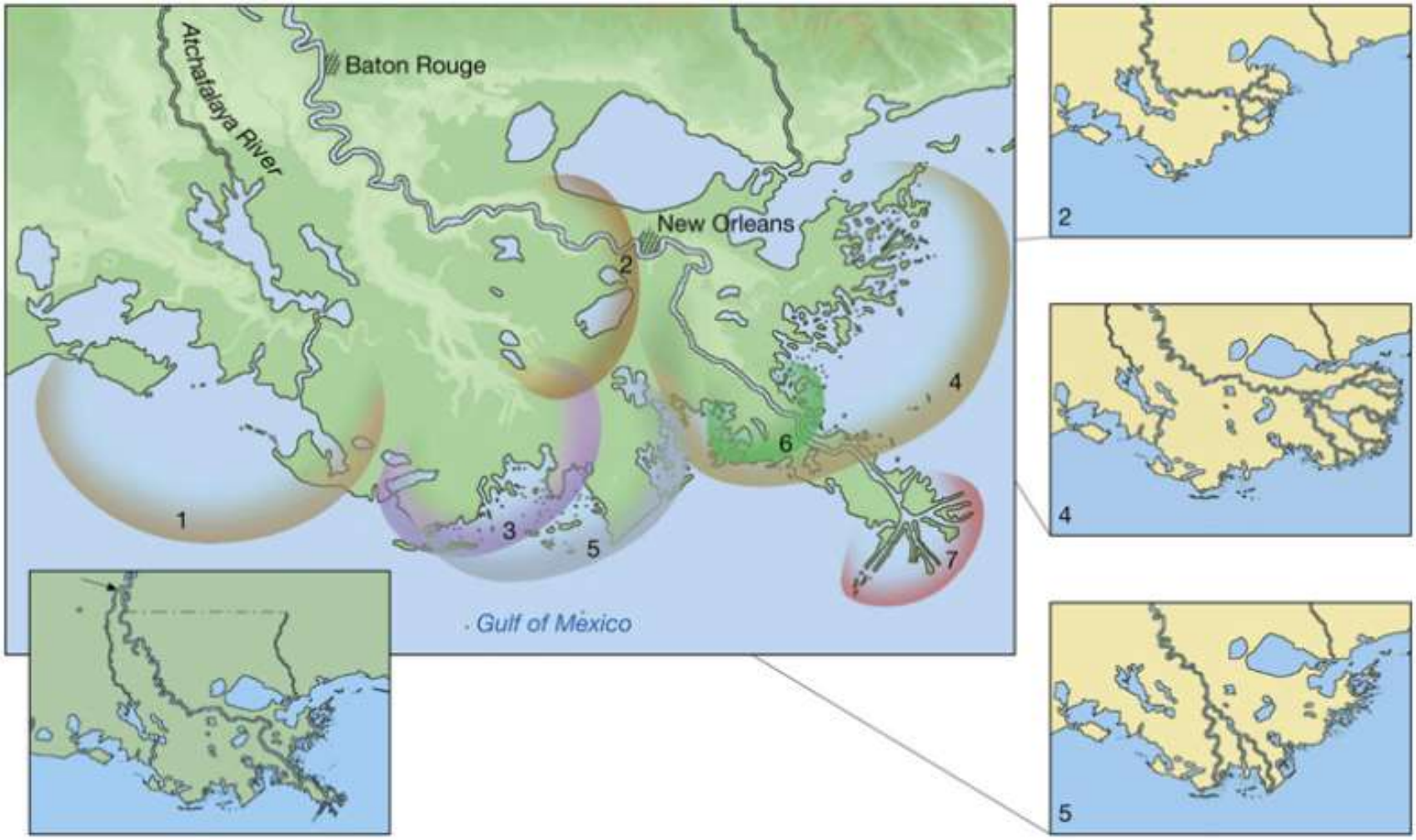
Deltas

• Over long periods of time, sedimentary deposition results in the characteristic geographic pattern of a river delta.

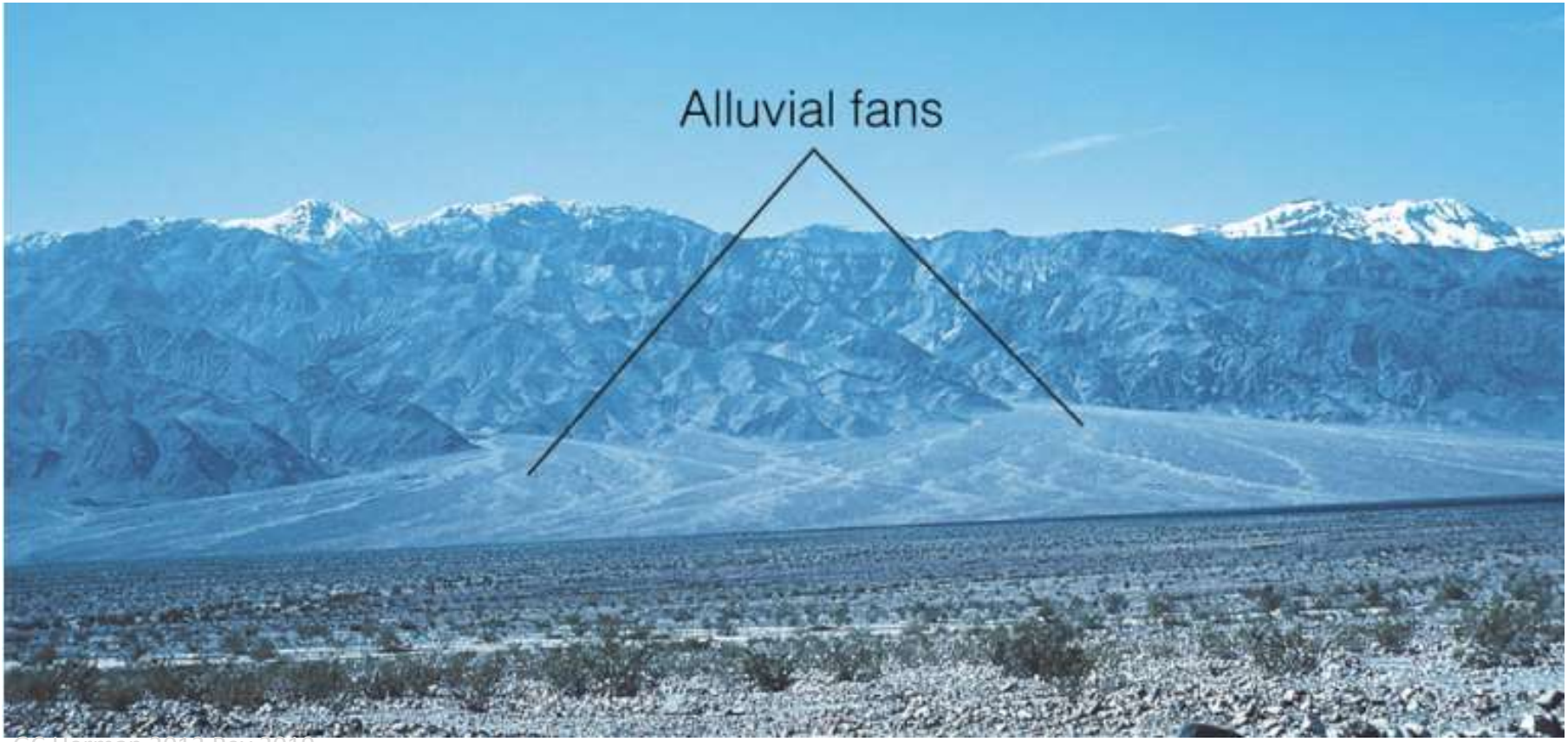




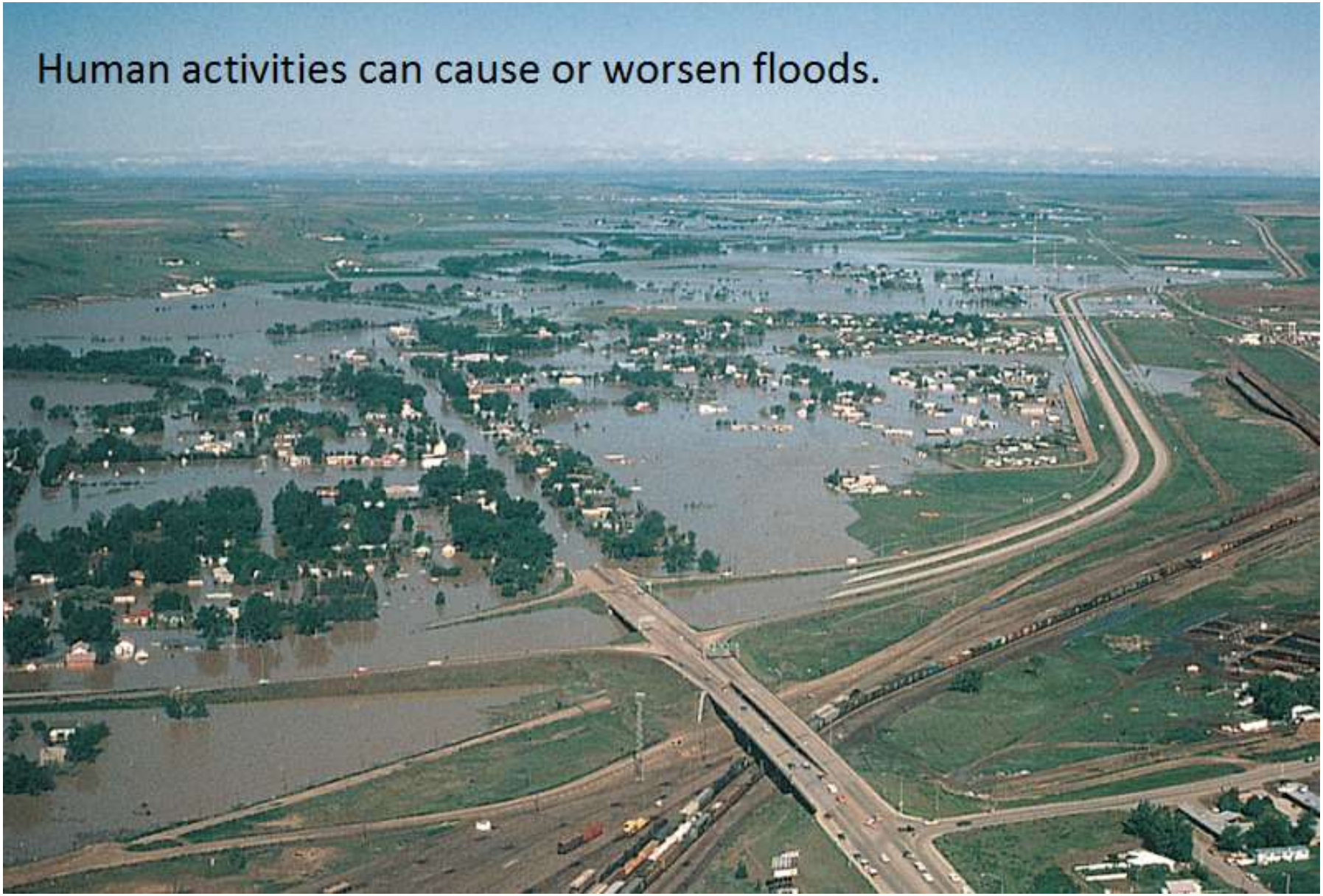
Mississippi Delta Growth



Alluvial Fans are lobate deposits of gravel and sand deposited on land are known as alluvial fans.



Floods are triggered by heavy rain and/or snow melt.



Flood Hydrograph

The USGS has installed and maintains over 11,000 stream-gauging stations across the country

Floods

Johnstown Flood of 1889 2200 fatalities

Year	Discharge (m^3/sec.)	Recurrence Rank	Interval
1900	133	23	3.35
1901	103	35	2.20
1902	16	69	1.12
1903	362	2	38.50
1904	22	66	1.17
1905	371	1	77.00
1906	234	10	7.70
1907	249	7	11.00
1908	61	45	1.71
1909	211	13	5.92
The greatest yearly discharge is given a magnitude rank (m) ranging from 1 to N (N = 76 in this example), and the recurrence interval (R) is calculated by the equation $R = (N + 1)/m$.			
1974	22	64	1.20
1975	68	43	1.79

Source: U.S. Geological Survey Open-File Report 79–681.

TABLE 15.1

Types of Floods

Type of Flood	Comments
Stream/River Flood	Streams and rivers overflow their banks when they receive too much water in a short time.
Coastal Flood	Caused by wind-generated waves and storm surge (see Chapter 19) and tsunami (see Chapter 10).
Urban Flood	Former field and woodlands are paved over reducing their infiltration capacity leading to increased flooding. Backed up storm drains also contribute.
Flash Flood	A normally dry gully quickly fills with fast-moving water. Flooding may take place far from where precipitation fell.
Ice Jam Flood	Floating ice in cold climates may accumulate and form an ice dam, causing flooding upstream from the obstruction.

The Flood of ‘93

• The Jet stream dipped over the Midwest during June and July of 1993 rather than shifting North into Canada as usual.

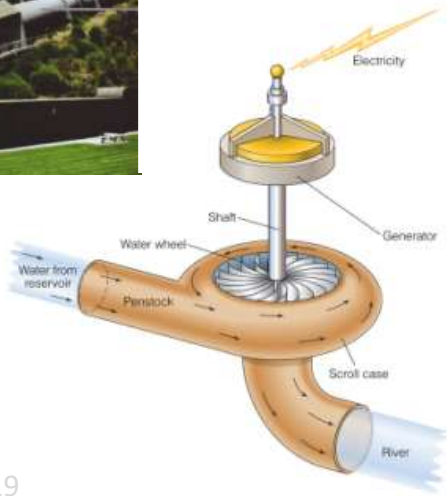
•Large, repeated thunderstorms developed from convergence of warm, moist air from the Gulf with cool, dry, air from the North.

• Satellite images show the difference between normal conditions (1988) and flood conditions at the convergence of the Missouri, Mississippi, and Illinois Rivers

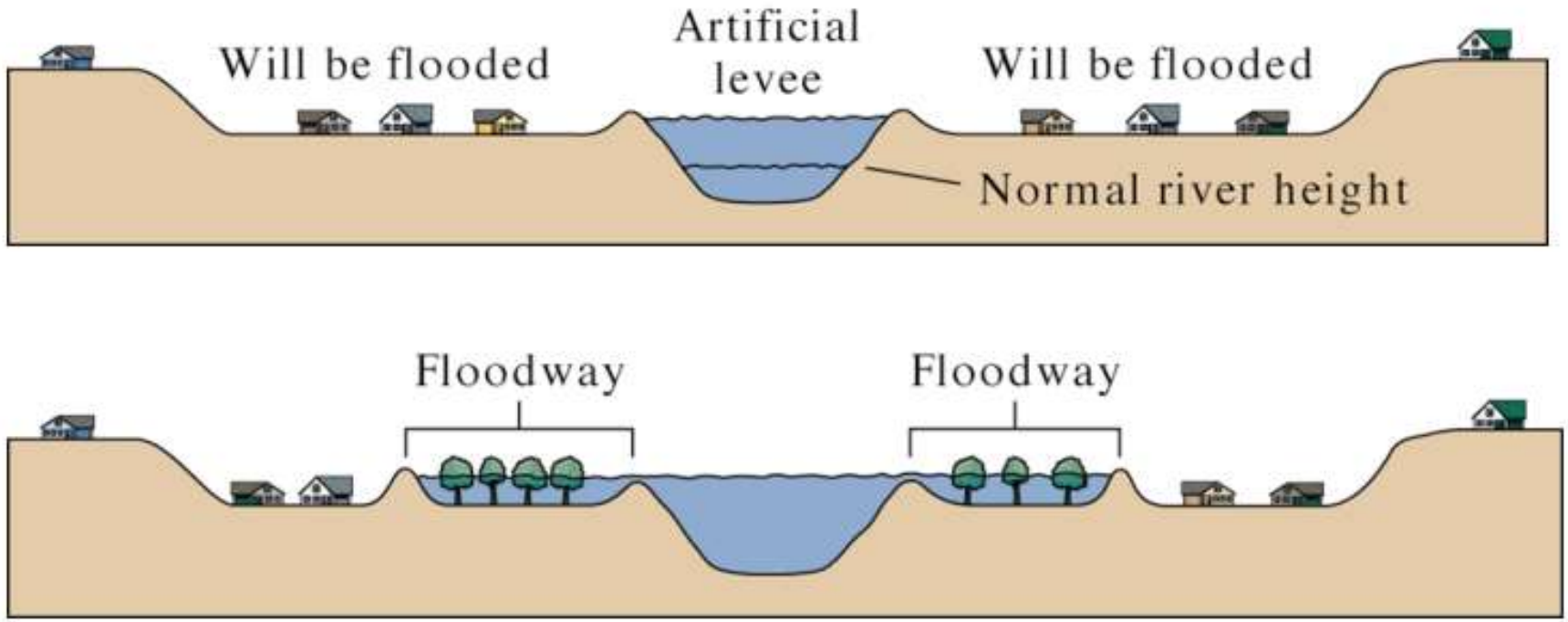
Flood Control Measures

- DAMS are used for water- supply, power generation, and flood control

- ARTIFICAL LEVEES and CHANNELIZATION are designed primarily for flood control



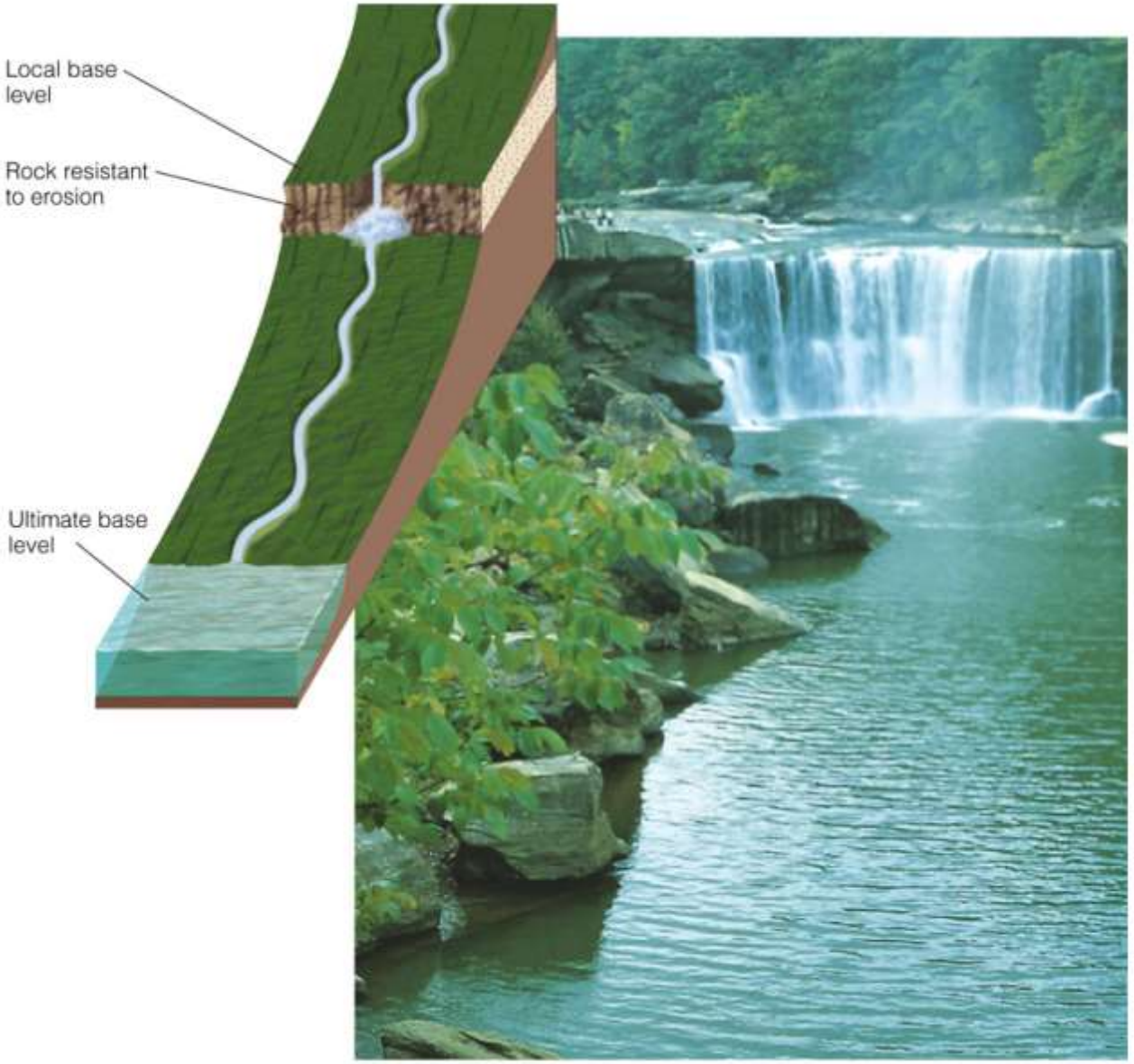
Flood Control Measures



Base Level

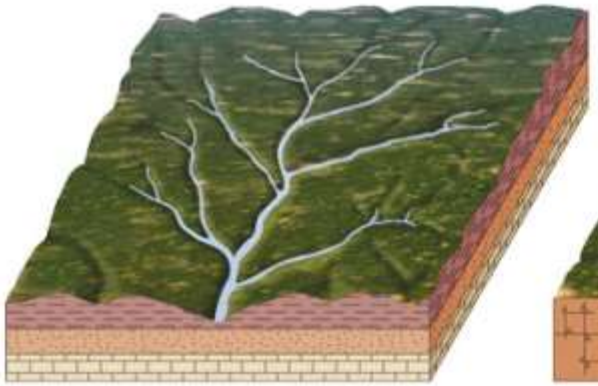
- Streams commonly have *local base levels* formed by lakes, other streams and resistant bedrock.

- The lowest level to which streams can erode is sea level, which is known as *ultimate base level*.



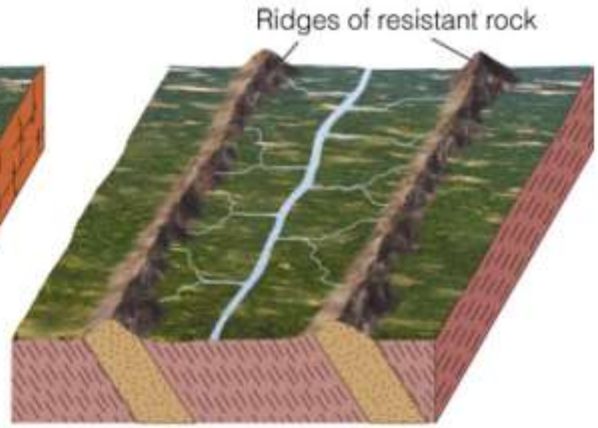
Drainage Patterns

Dendritic

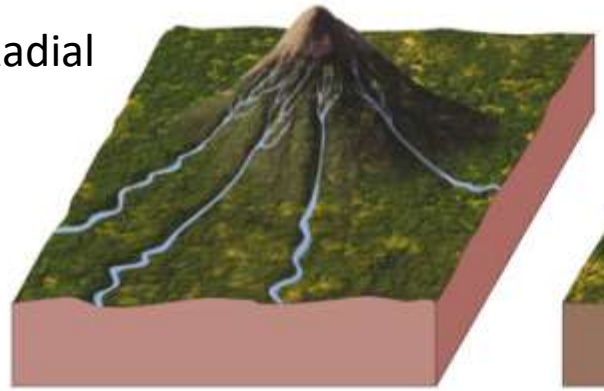


Rectangular

Trellis



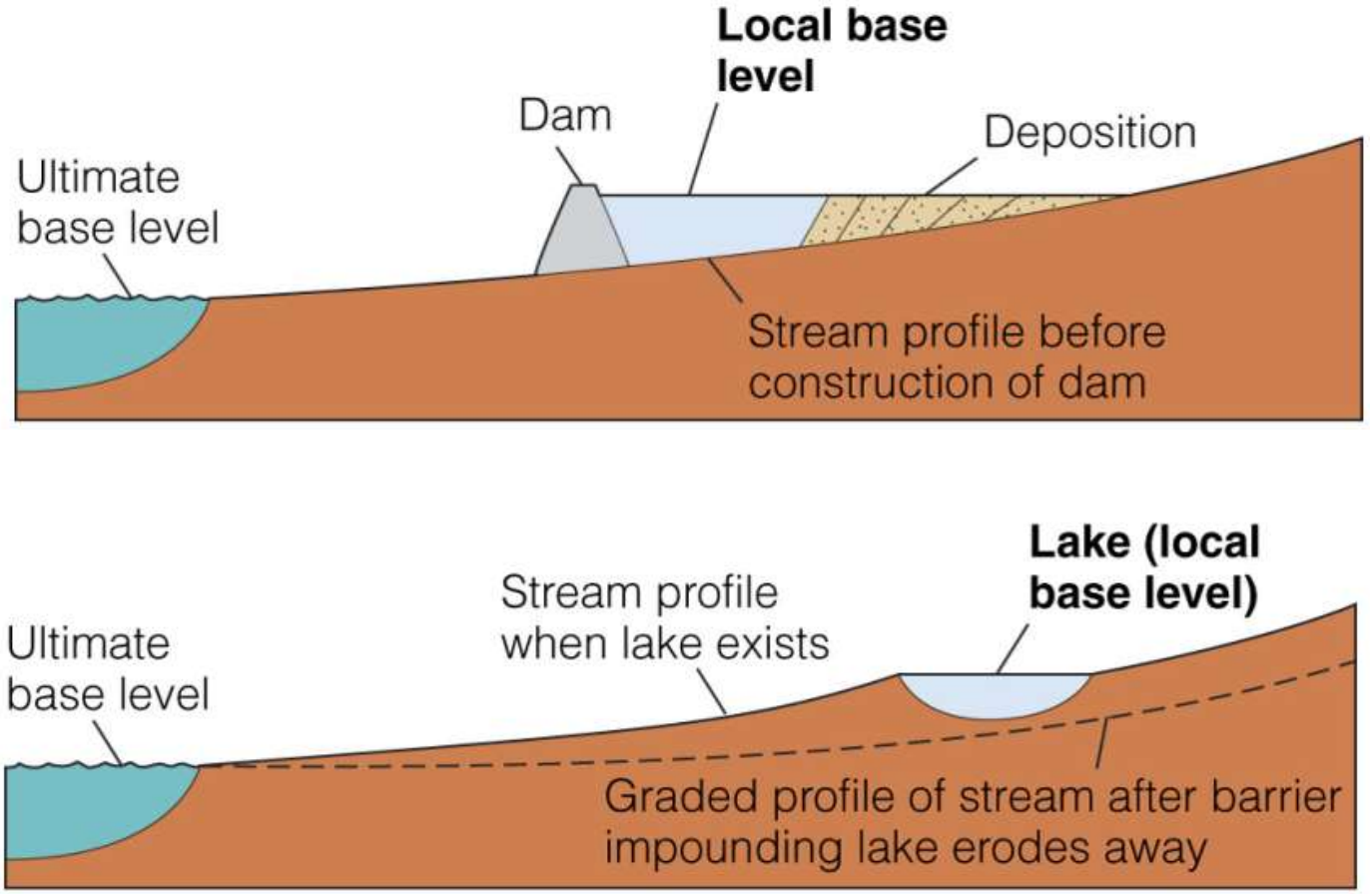
Radial



Deranged

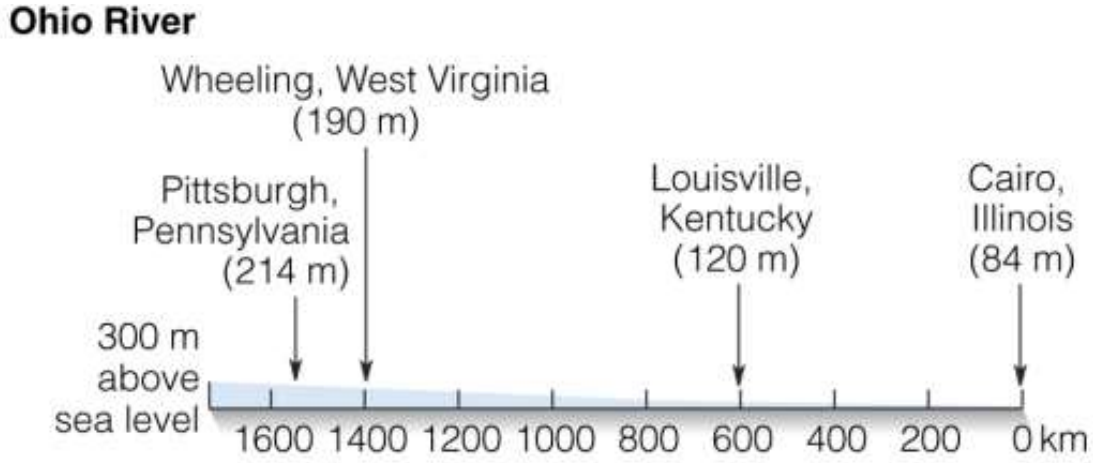
Graded Streams *have gradient, discharge, flow velocity, channel characteristics, and sediment load balanced* so that little or no net deposition or erosion occurs in its channel.

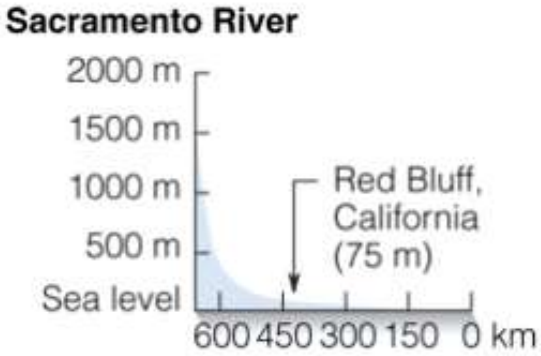
- A change in any of the above parameters upsets the graded condition.

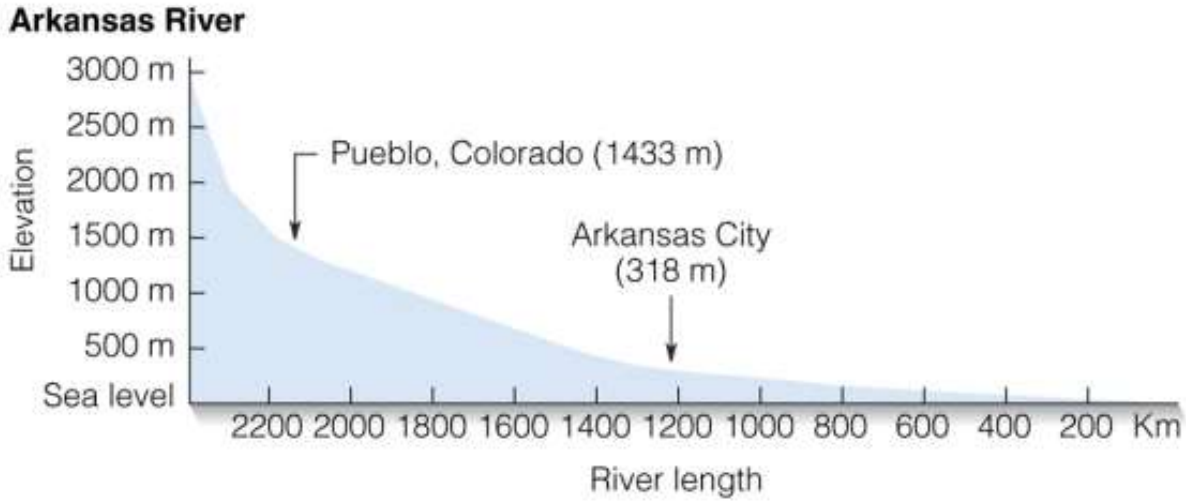


Graded Streams

- Stream erosion and deposition tend toward an equilibrium in which the channel profile is smoothly concave.







Stream Valleys develop by the combined processes of downcutting, lateral and headward erosion, mass wasting, and sheetwash.

- A *gulley* is a small steep-sided valley.

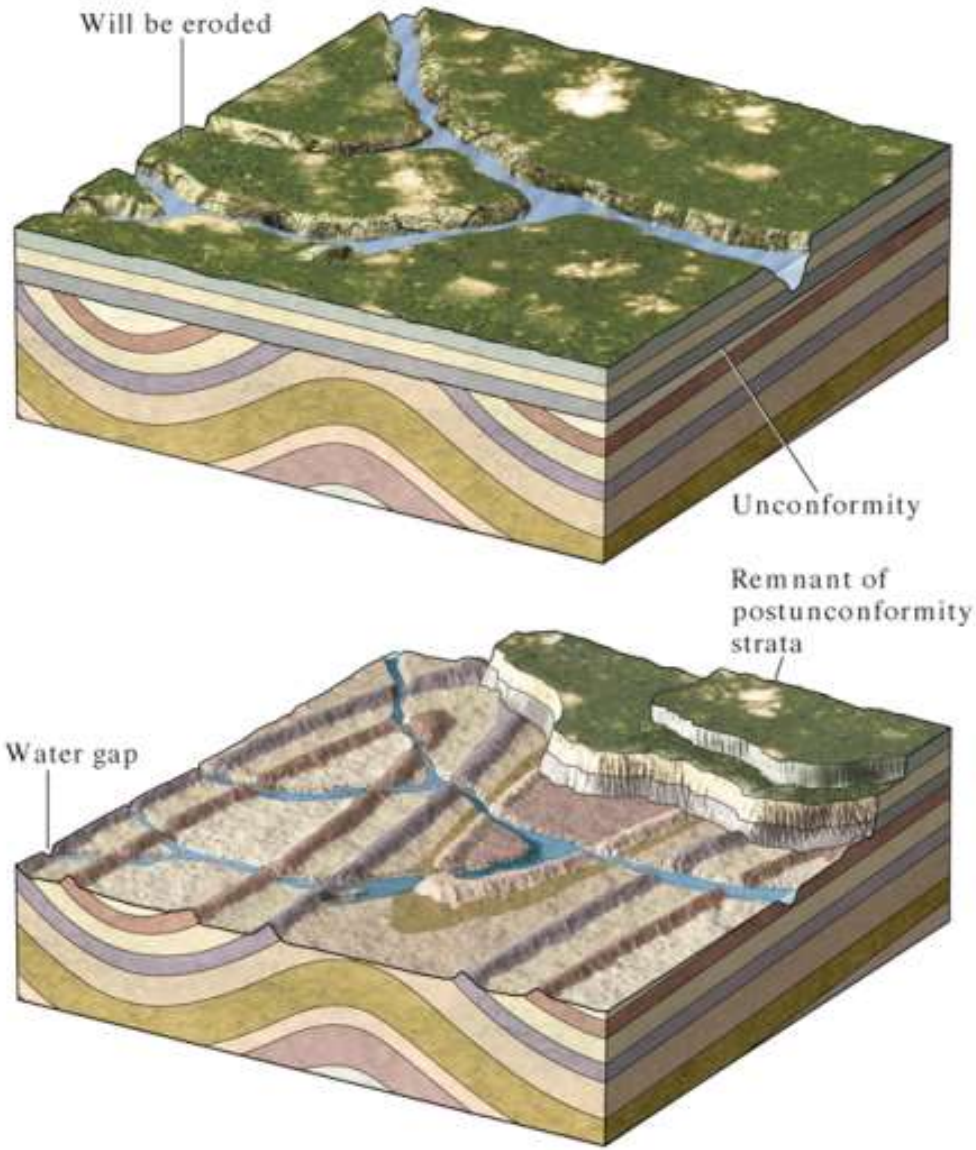
- A *canyon* is a vast valley with a steep walls or a series of clopes and clifs.

Pasture gulley

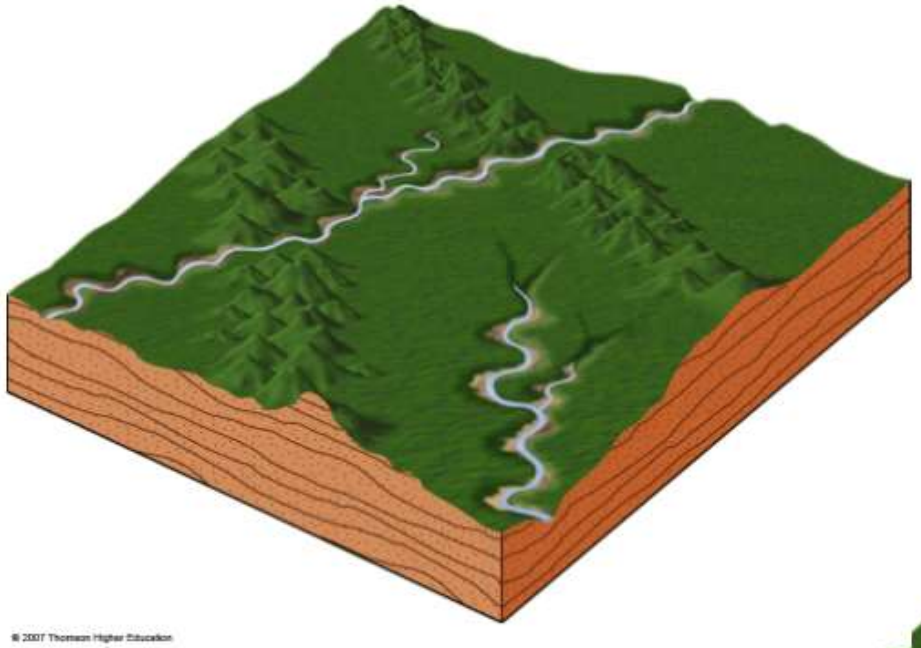
Colorado Canyon

Superimposed Strea

cut directly across bedrock ridges lying across their paths because they once flowed over a higher surface and have eroded downward to more resistant rocks.



Superimposed Streams can be pirated as larger streams in valleys cut down and headward to capture the drainage of smaller streams

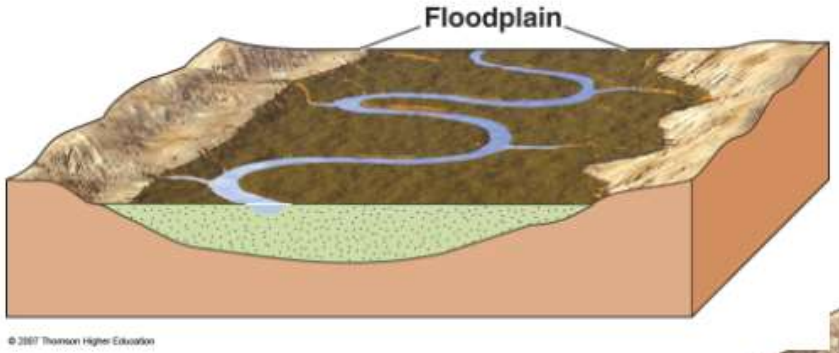


Drainage Systems Evolution

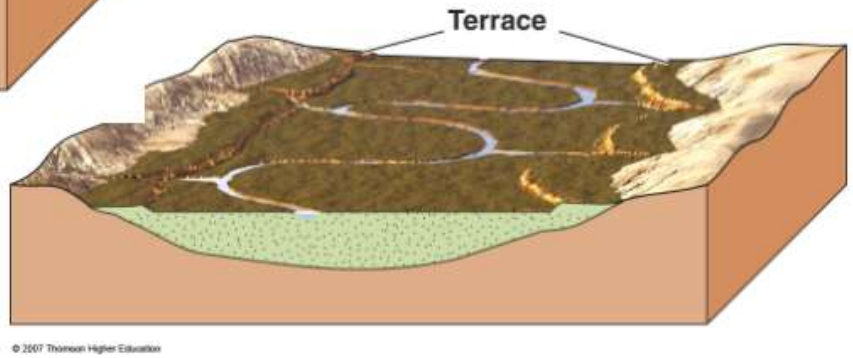
• Incised meanders occupy deep valleys generally as the result of renewed downcutting by meandering streams.

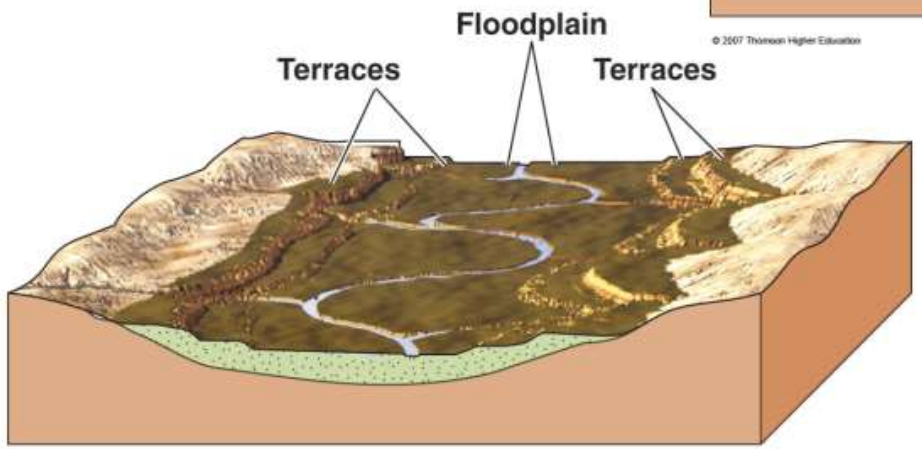
• Continuous stream downcutting through floodplain deposits commonly results in stream terraces, the remnants of the older higher elevation stream floodplains.

Drainage Systems Evolution



• Continuous stream downcutting through floodplain deposits commonly results in stream terraces, the remnants of the older higher elevation stream floodplains.





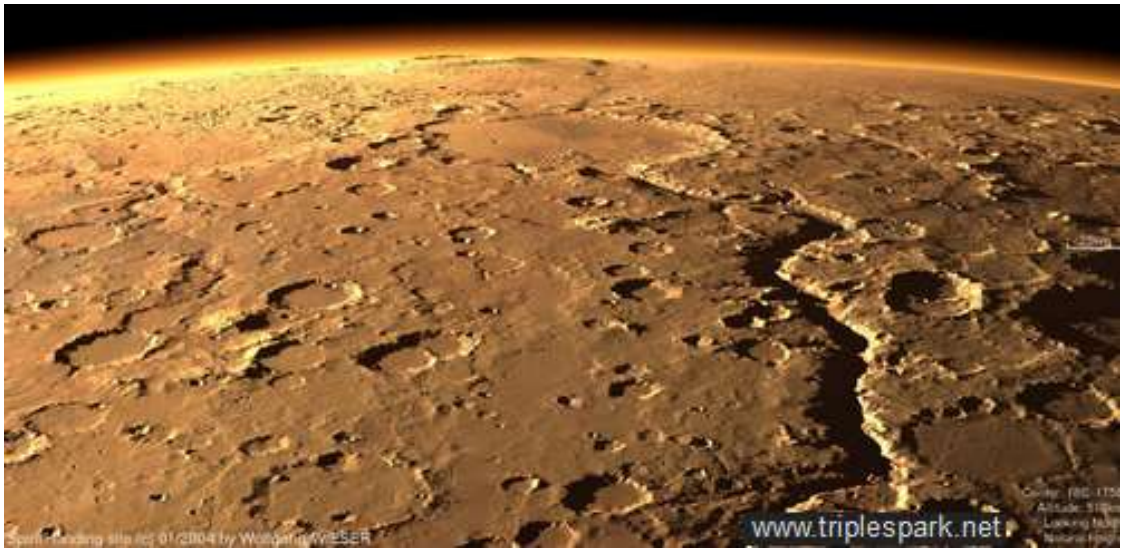
• Incised meanders occupy deep valleys generally as the result of renewed downcutting by meandering streams.

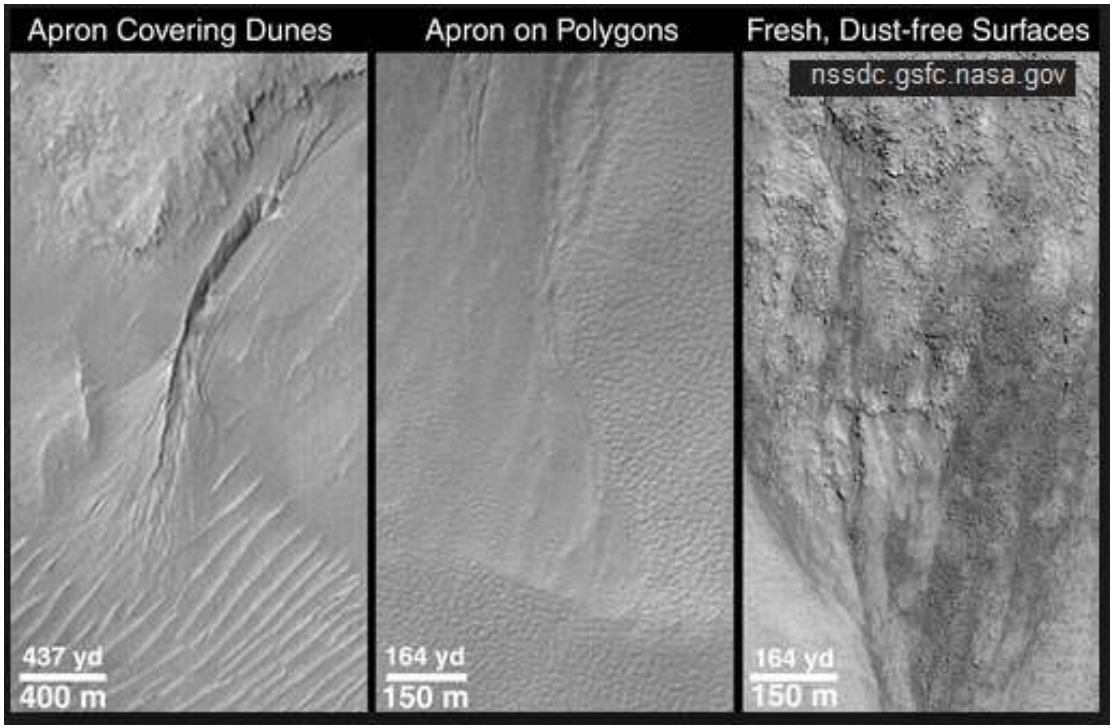

Stream terraces
Present
floodplain

Landforms Produced by Water on Mars

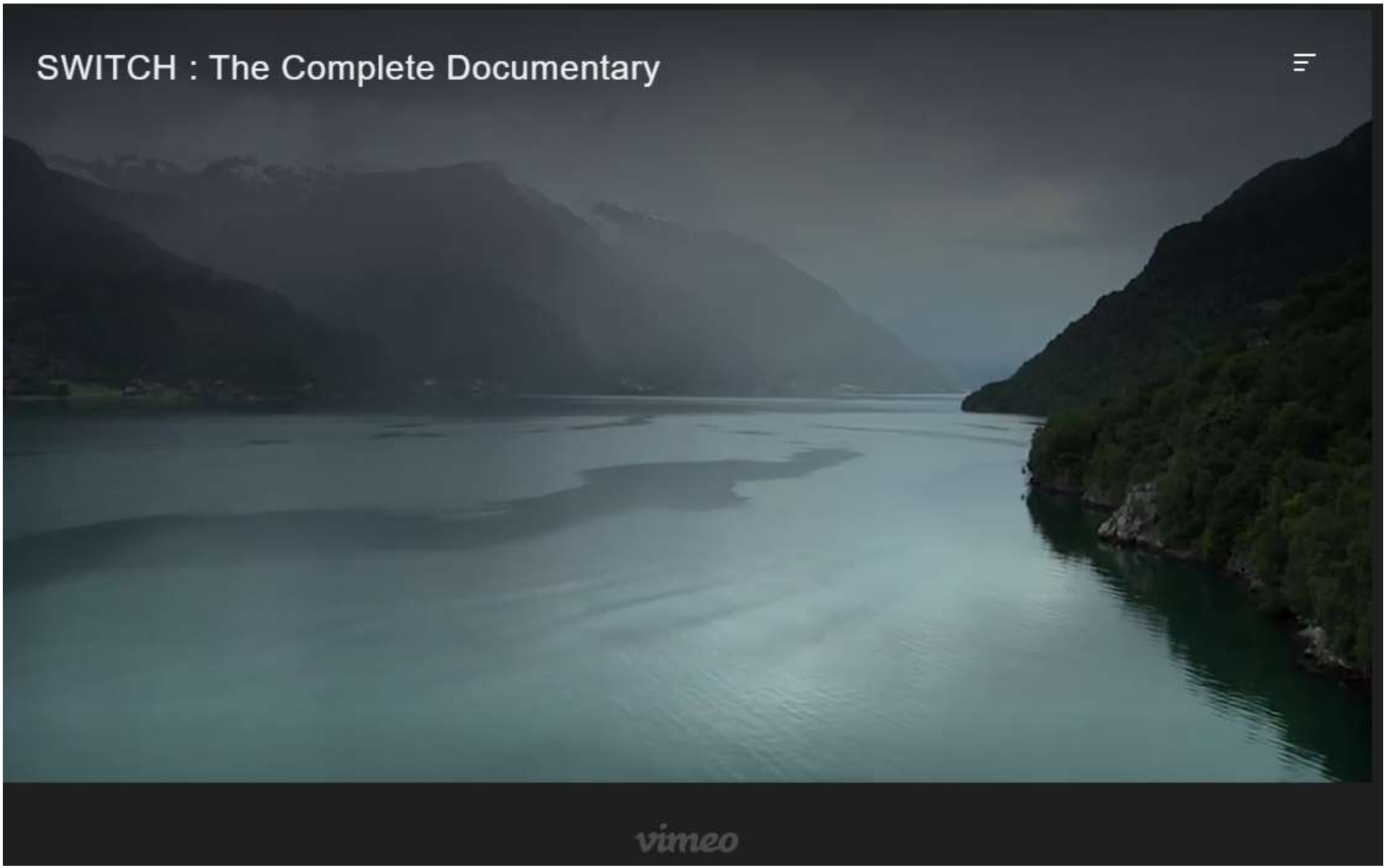
- Mars imagery show landforms that scientists have interpreted as being produced by running water.
- Among the features are gullies forming downslope from a potential seepage horizon and alluvial aprons and alluvial fans.

Science, June 30, 2000





Take-home LAB assignment



LAB 9 Two groundwater pollution cases

Case 1. Naturally-occurring Arsenic in groundwater

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	Spayd_overview.avi	11/14/2008 11:56 ... Video Clip	26,155 KB

(9 min)

Case 2. Rural to Suburban Dumping of Anthopogenic Industrial Waste and Subsequent Resdiential Development

Name	Date modified	Type	Size
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(13 min)