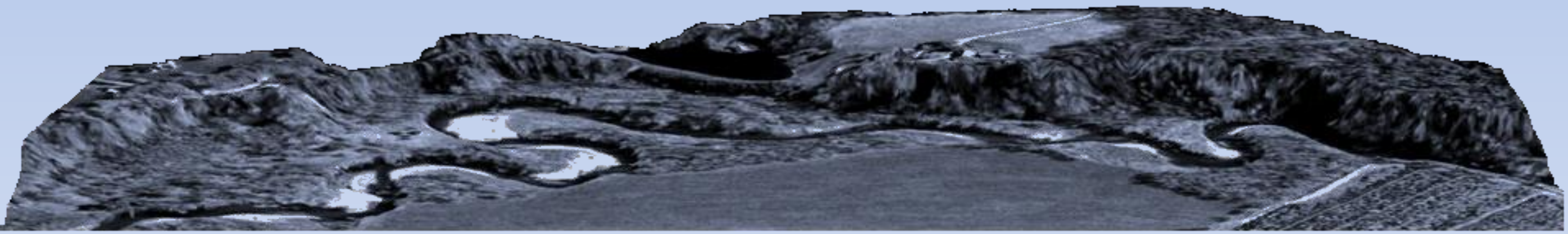
Stream Geomorphology

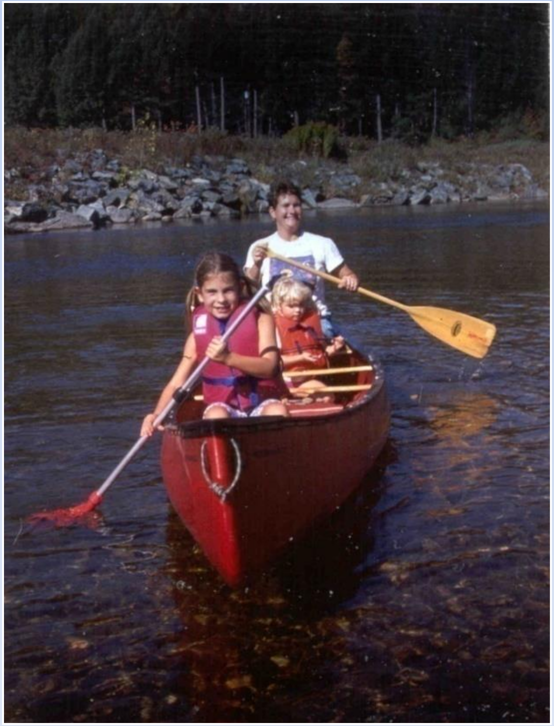


Leslie A. Morrissey UVM

July 25, 2012

What Functions do Healthy Streams Provide?

- Flood mitigation
- Water supply
- Water quality
- Sediment storage and transport
- Habitat
- Recreation
- Transportation
- Aesthetic qualities



When streams go wild

In Vermont, most flood damage is caused by **fluvial erosion**

History of River Management

- Transportation
- Power
- Agriculture

How DYNAMITE streamlines streams

Practically every farm in the heavy crop-producing areas of the United States needs some ditching, and there is hardly a stream in the entire boundary of the Union that does not need to be corrected to give better service in discharging the large amounts of waste water from heavy rains, and to protect low lands.

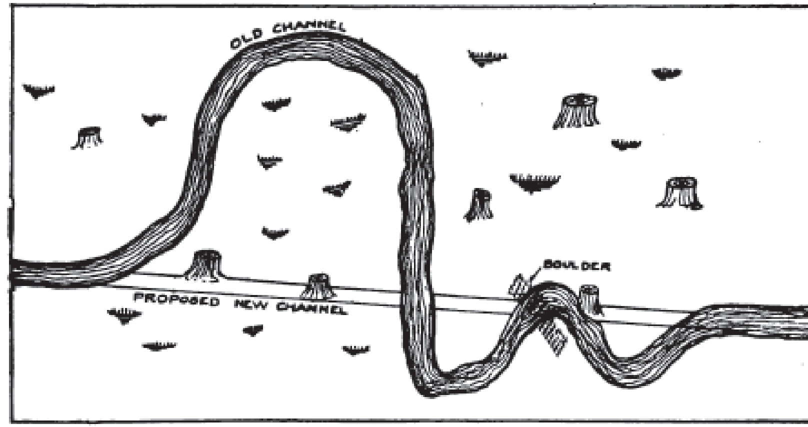


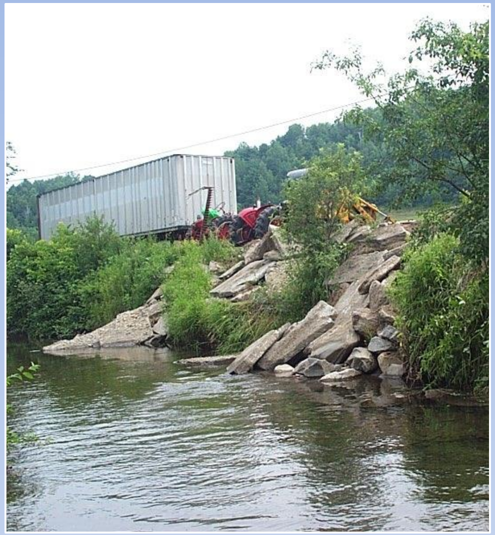
FIG. 54. DIAGRAM OF STREAM TROUBLES THAT MAY BE CORRECTED BY BLASTING.

CROOKED STREAMS are a menace to life and crops in the areas bordering on their banks. The twisting and turning of the channel retards the flow and reduces the capacity of the stream to handle large volumes of water. Floods result. Crops are ruined. Lives are lost. Banks are undermined, causing cave-ins that steal valuable acreage.

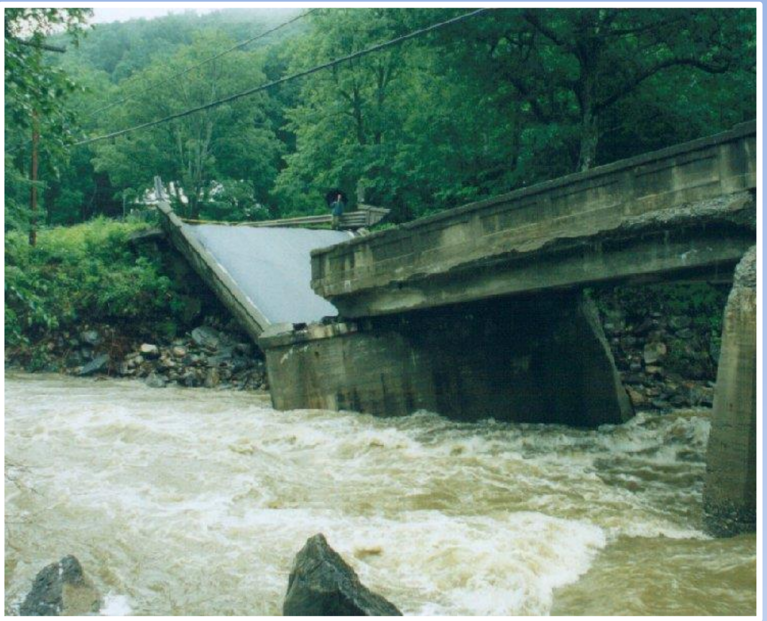
Traditional River Management

- Goal - contain flow within straight channel
- Stream channels were:
    - dredged
    - bermed
    - armored

  to withstand the increased stream power

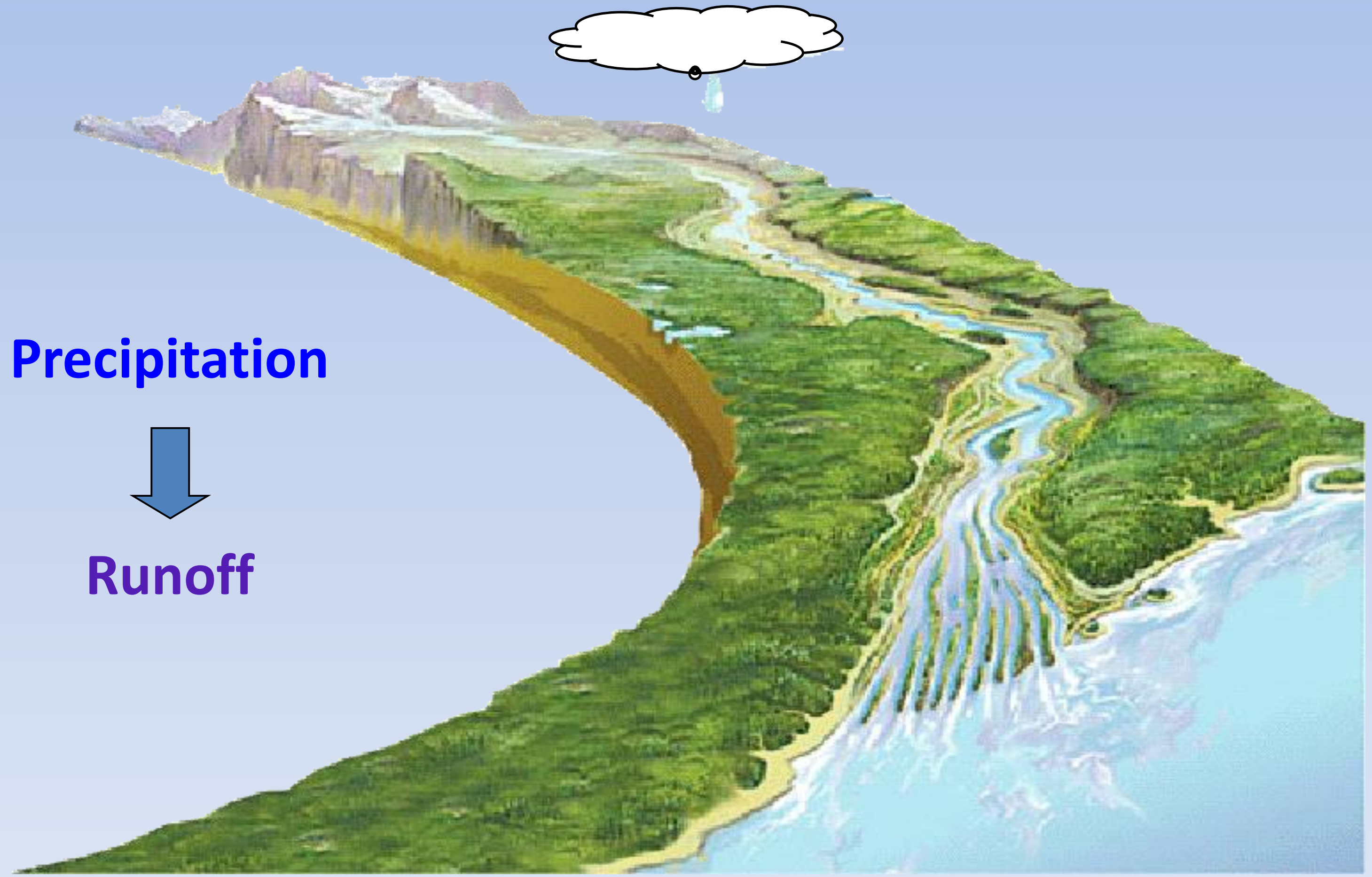


Disaster Can Result



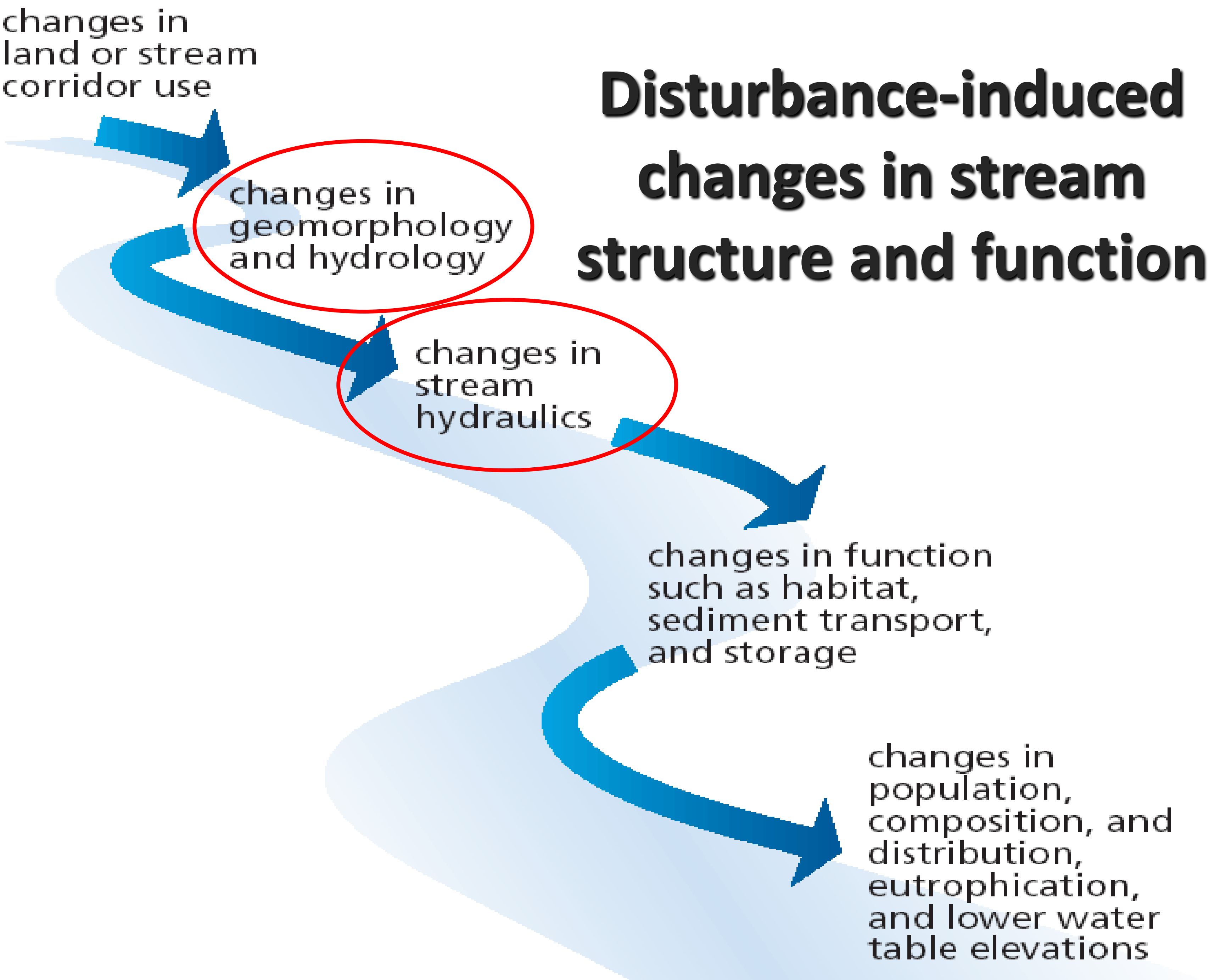
Energy kept in the channel during flooding can cause catastrophic damages downstream

Streams are Indicative of Watershed Condition



A change in the watershed will impact the stream network

Disturbance-induced changes in stream structure and function



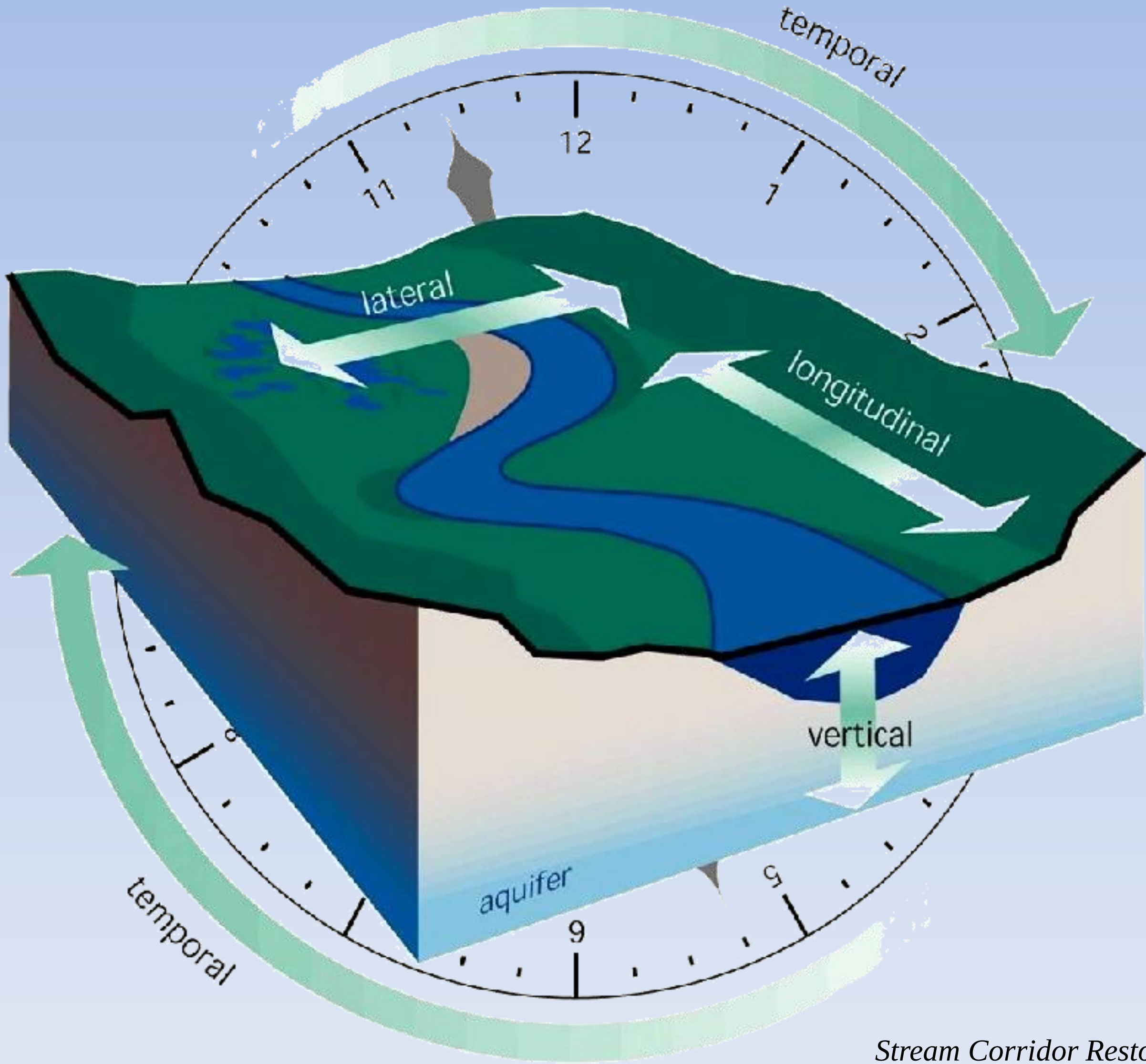
Fluvial Geomorphology

Channel characteristics (e.g., sinuosity, width, depth) are determined by stream discharge and sediment

Influenced by:

- Watershed area
- Land use and land cover
- Soils and geology
- Topography
- Climate
- Human impacts

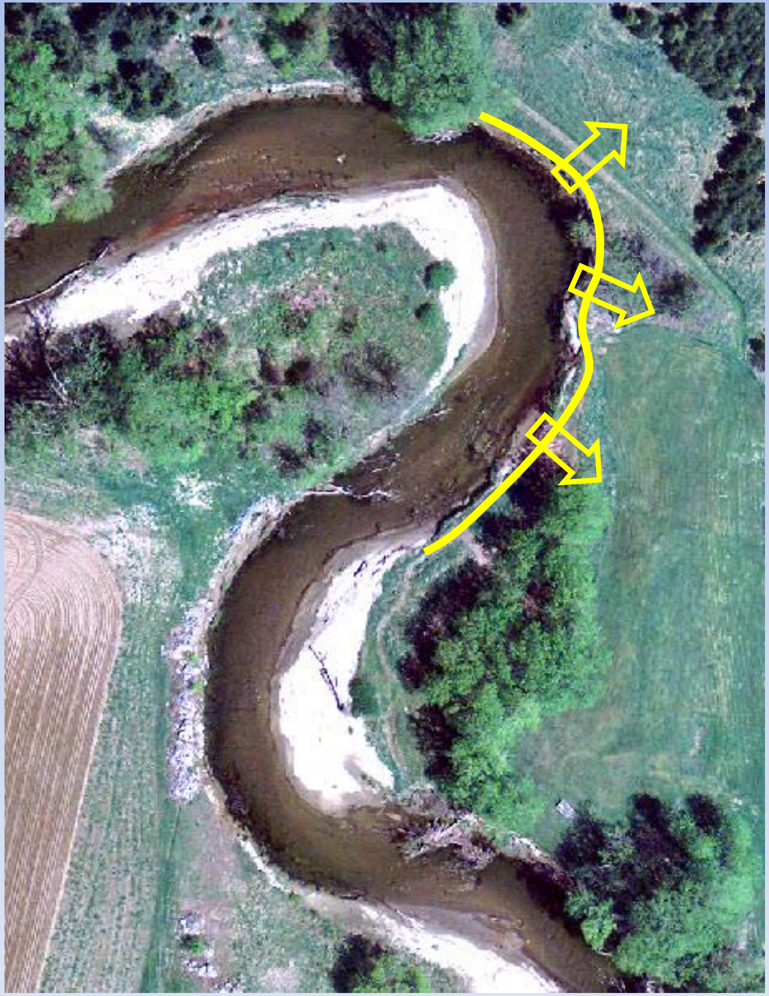
Streams Adjust to Changing Conditions



1. Lateral
2. Vertical
3. Longitudinal
4. Temporal

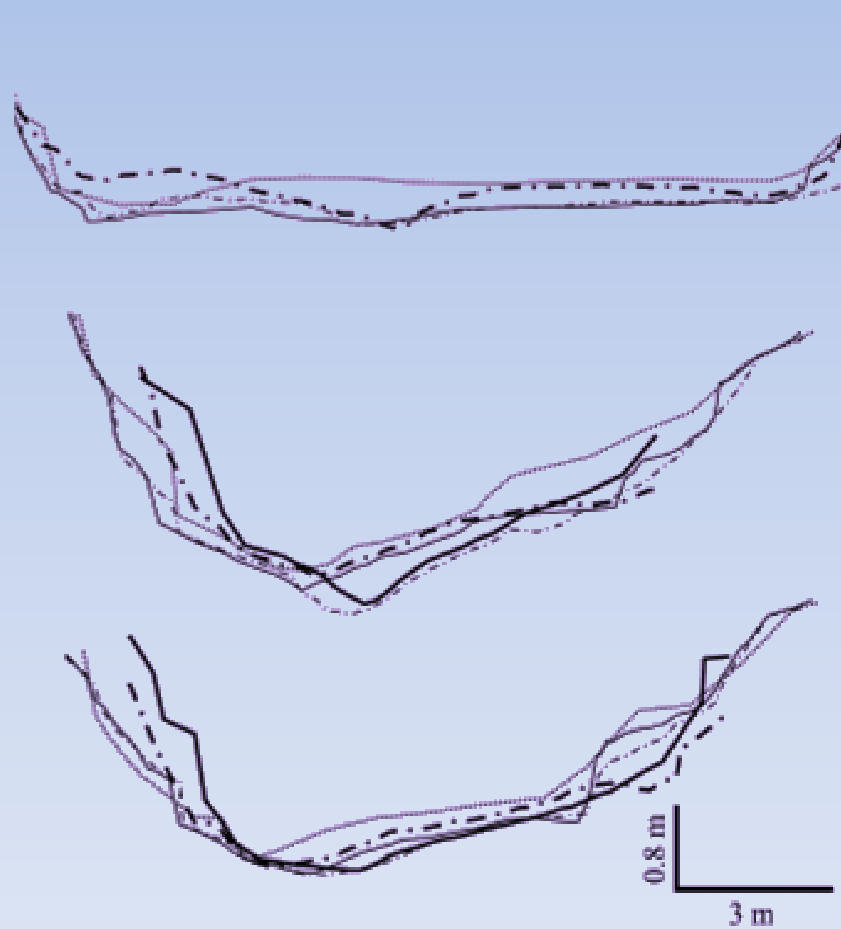
Stream Corridor Restoration: Principles, Processes, and Practices. 1998. Federal Interagency Stream Restoration Working Group.

Lateral Channel Migration

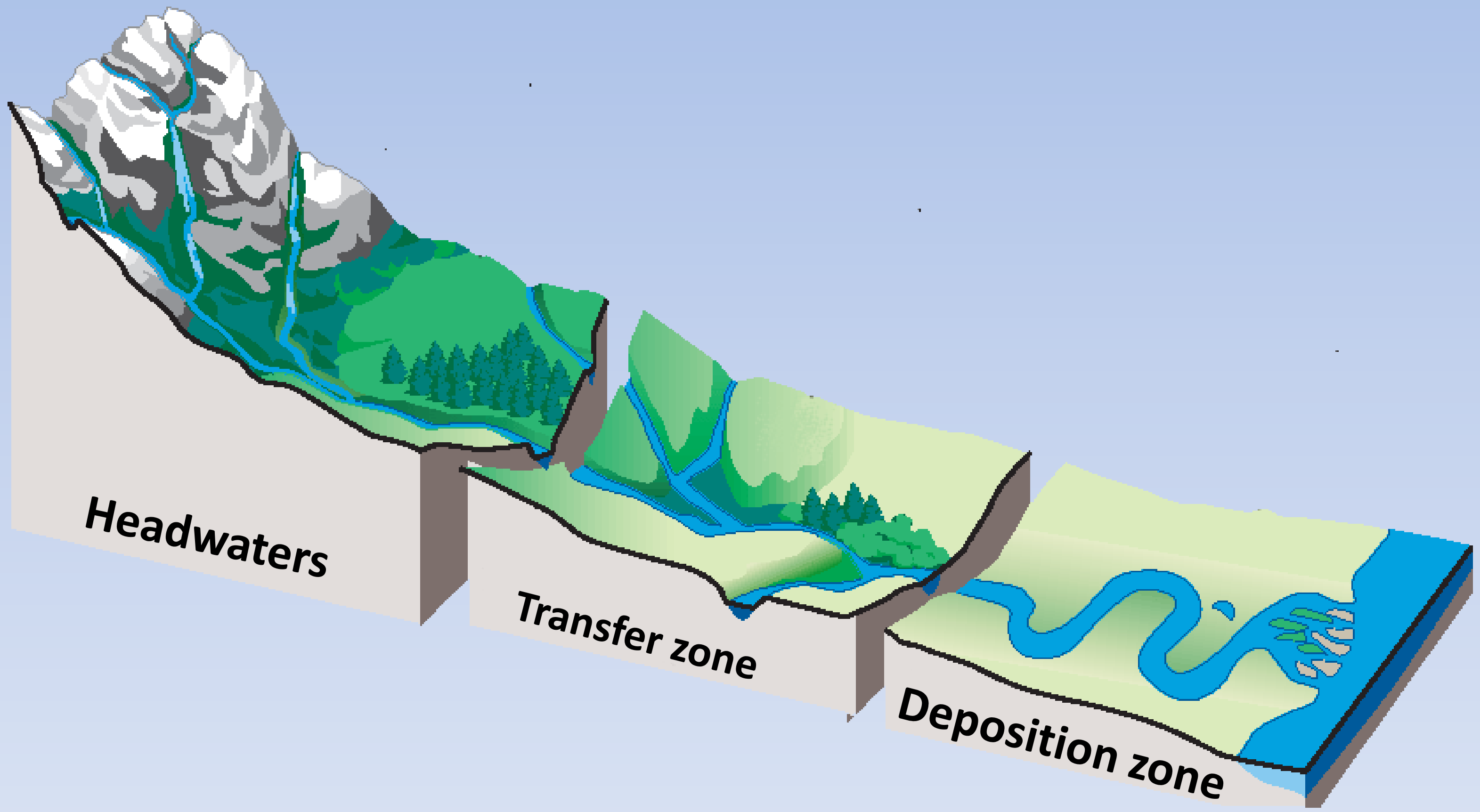


Vertical Movement of Stream Channel

1992 - 2007

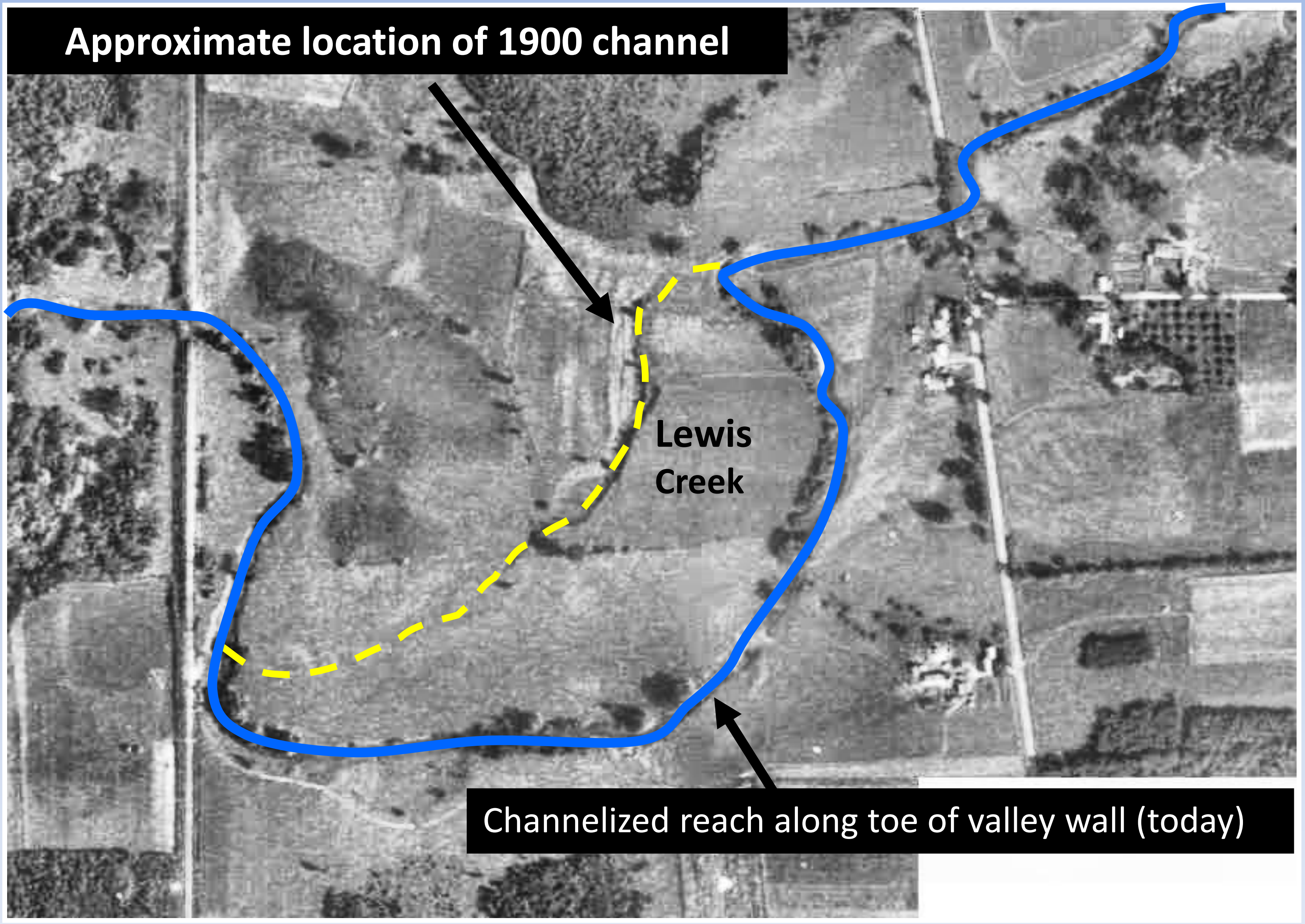


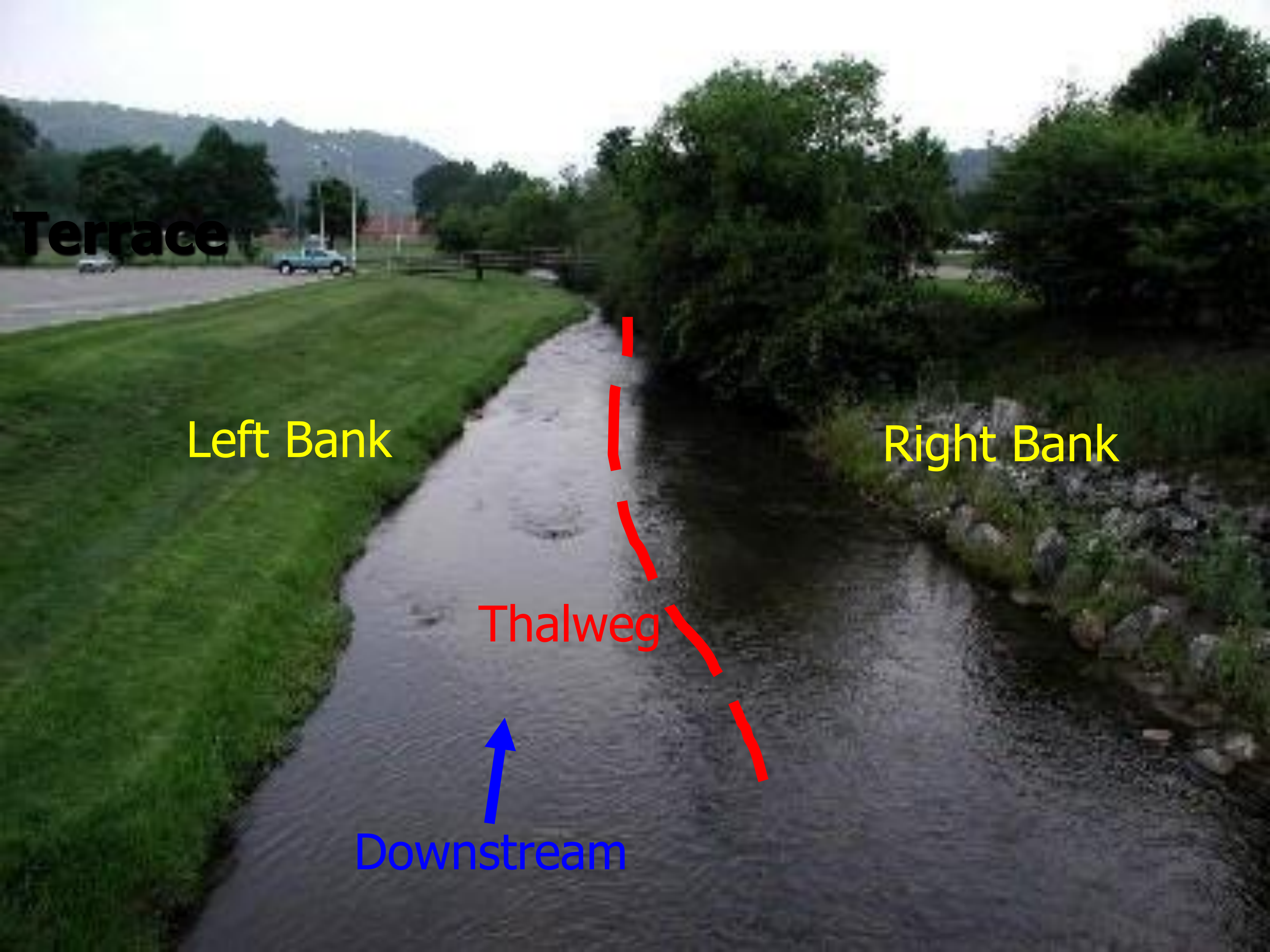
Stream Corridor Longitudinal Profile
(dominated by slope)



Miller, 1990

Temporal Changes in Stream Channel

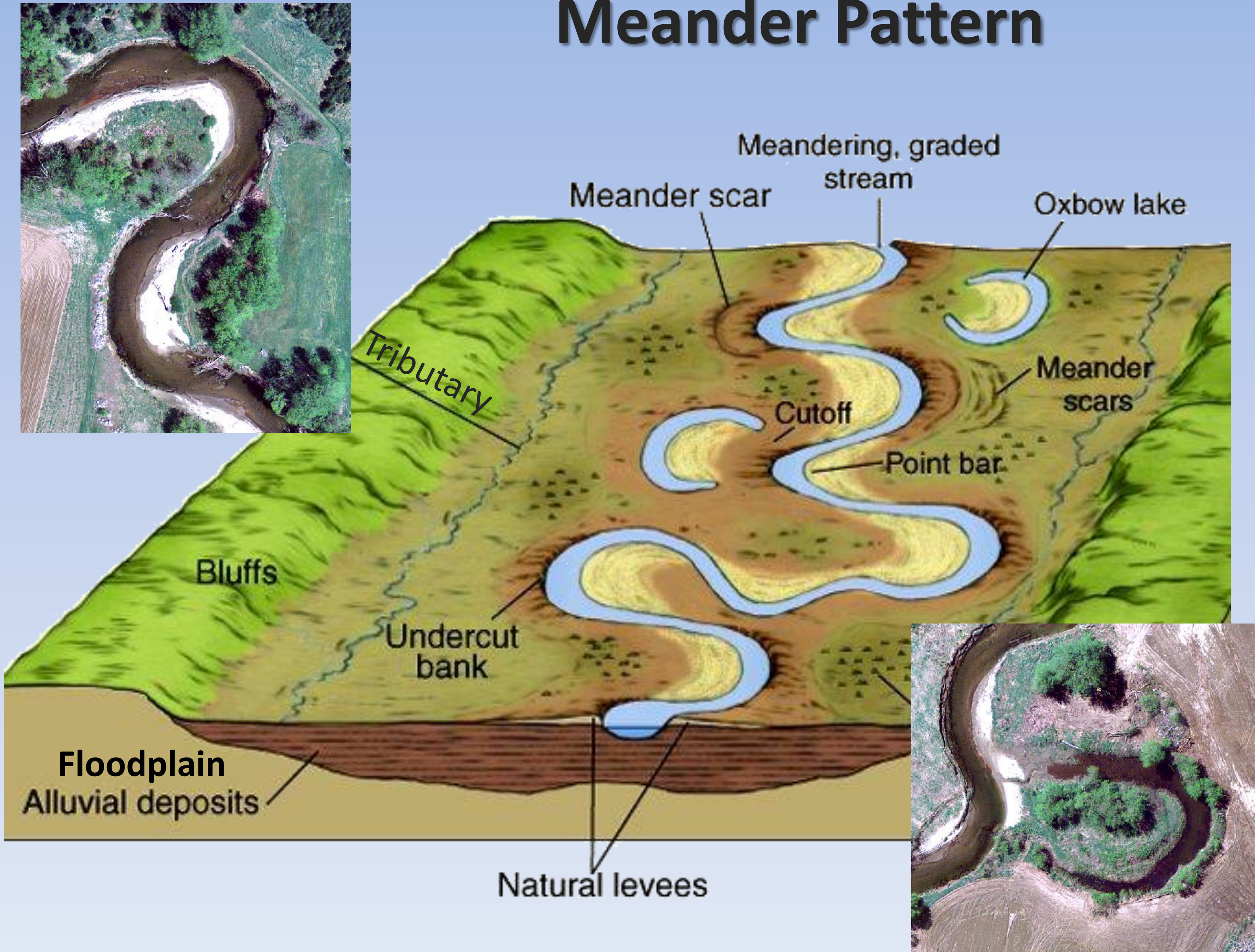



Terrace
Left Bank
Right Bank
Thalweg
Downstream

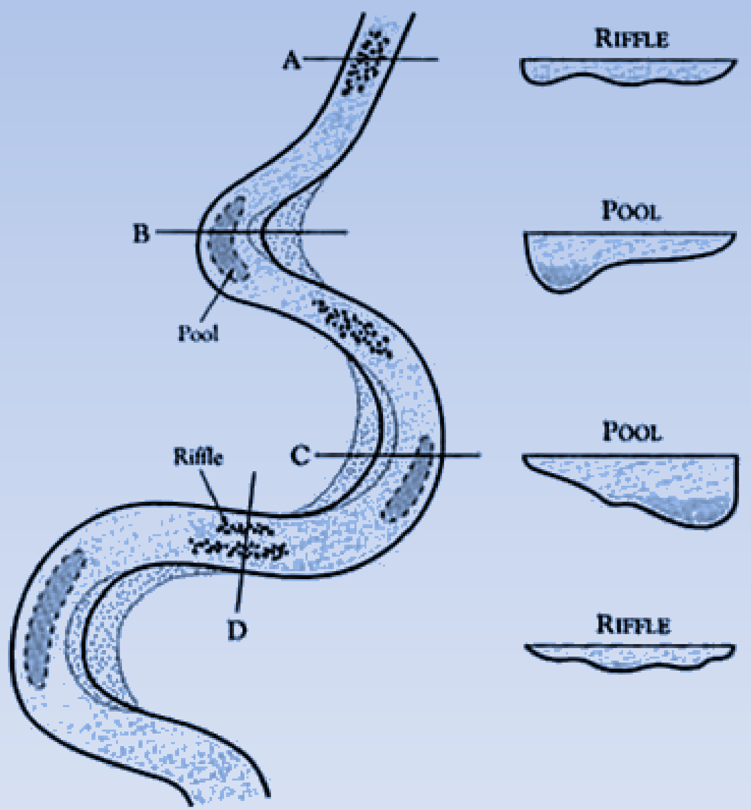
Stream Channel Patterns

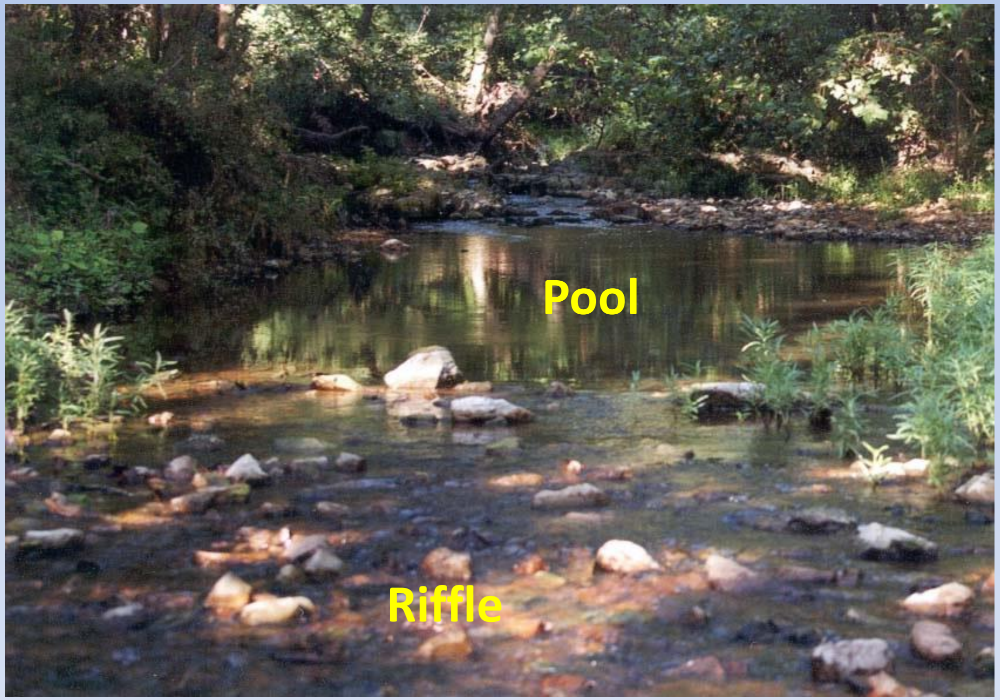
- Straight channels →
  - indicative of strong geologic structure (bedrock) or human control
- Braided streams ↘
  - multiple interwoven channels
- Meandering channels ↓
  - highly variable, sinuous

Meander Pattern

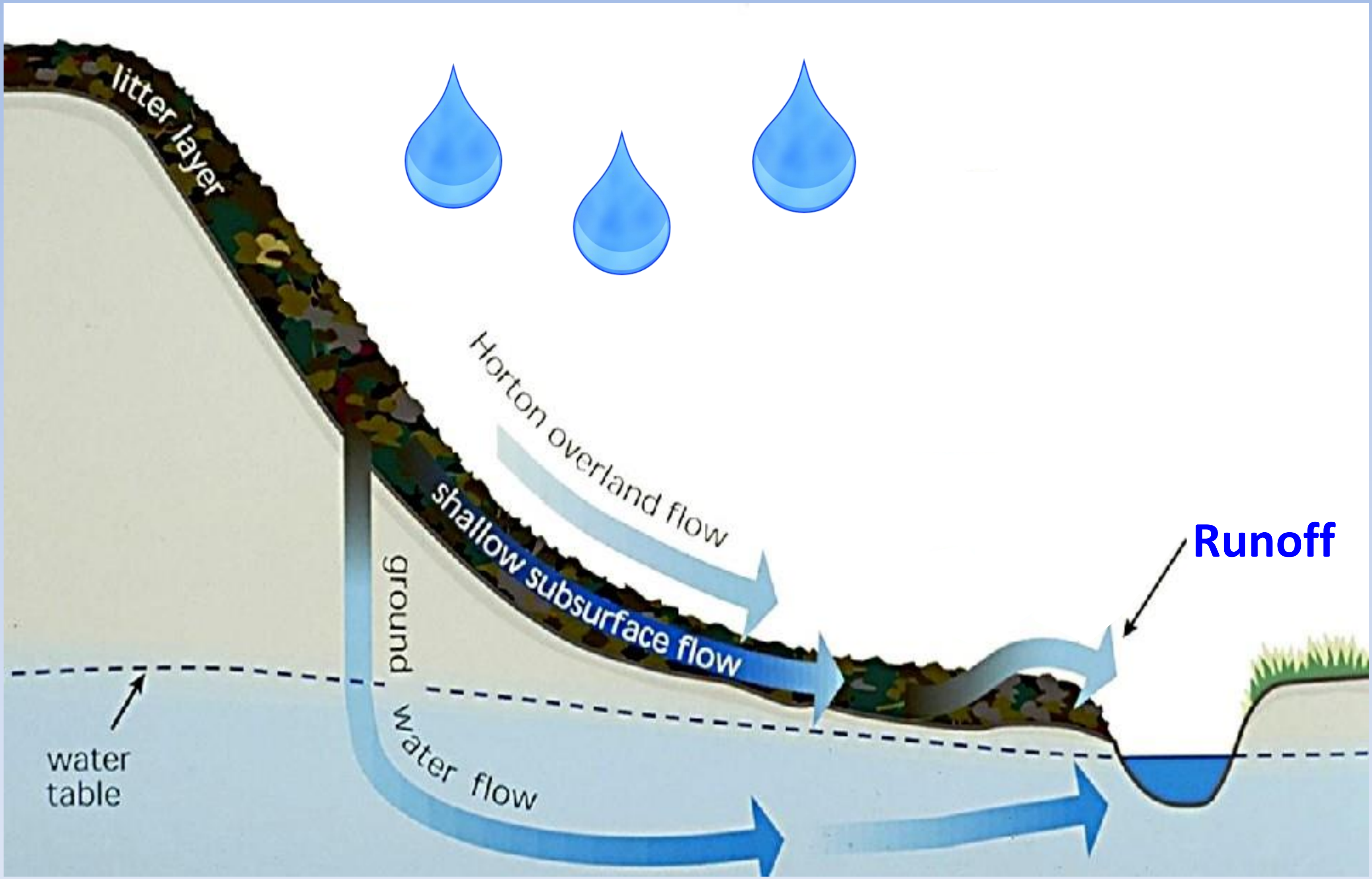


Pool and Riffle Sequence

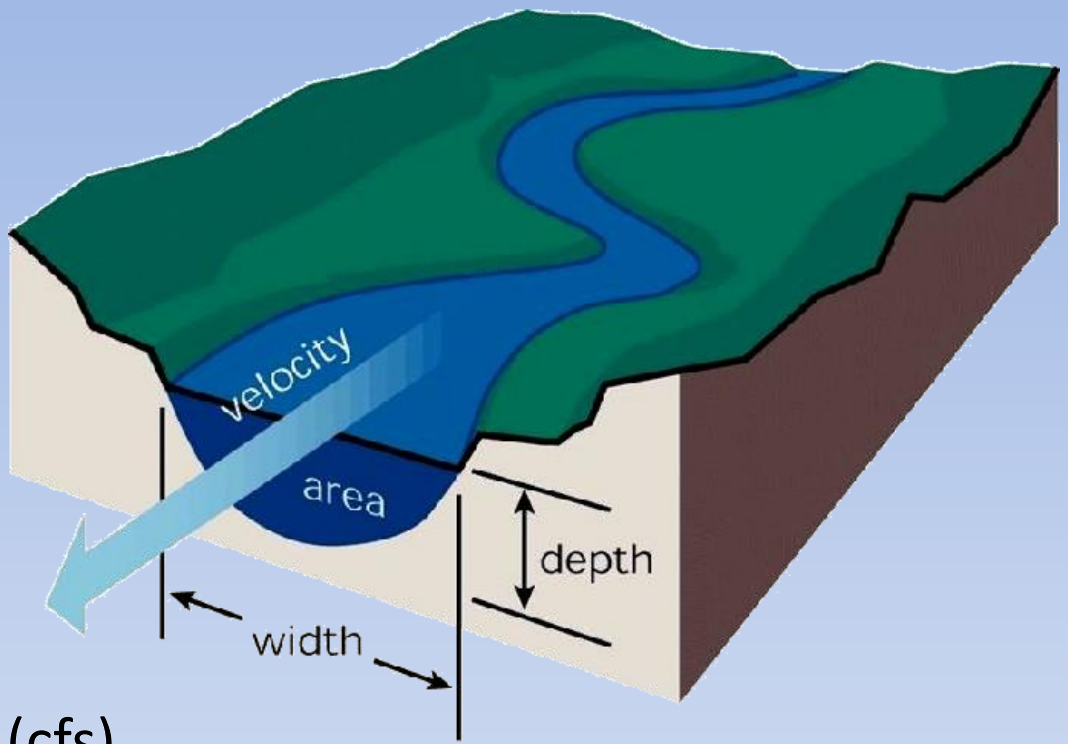




Water is the Driver



Velocity vs. Discharge



Q = v x A = Discharge (cfs)

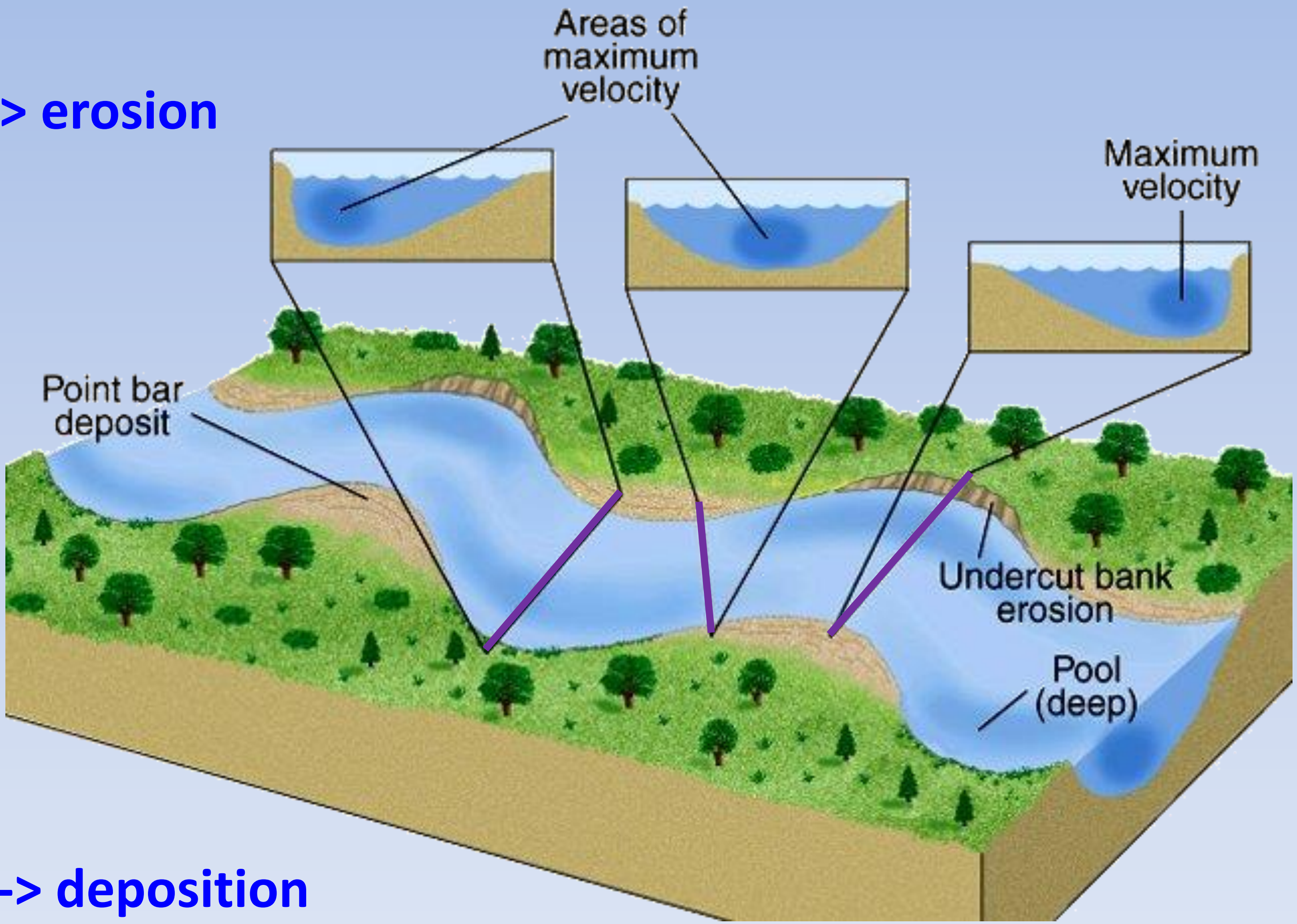
v = Velocity (ft/s)

A = Cross-Section Area (ft^2)

Stream Corridor Restoration: Principles, Processes, and Practices. 1998. Federal Interagency Stream Restoration Working Group

Velocity affects erosion and deposition

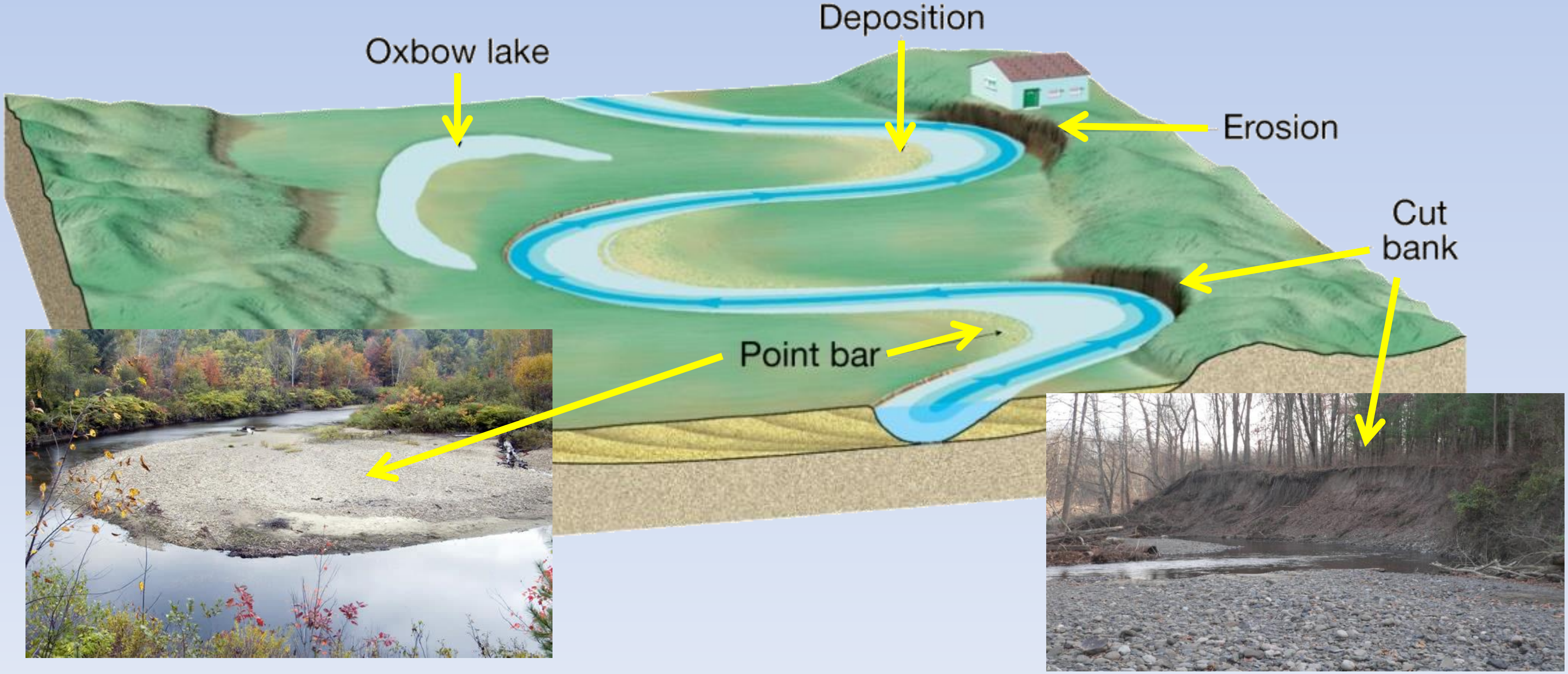
Faster flow -> erosion



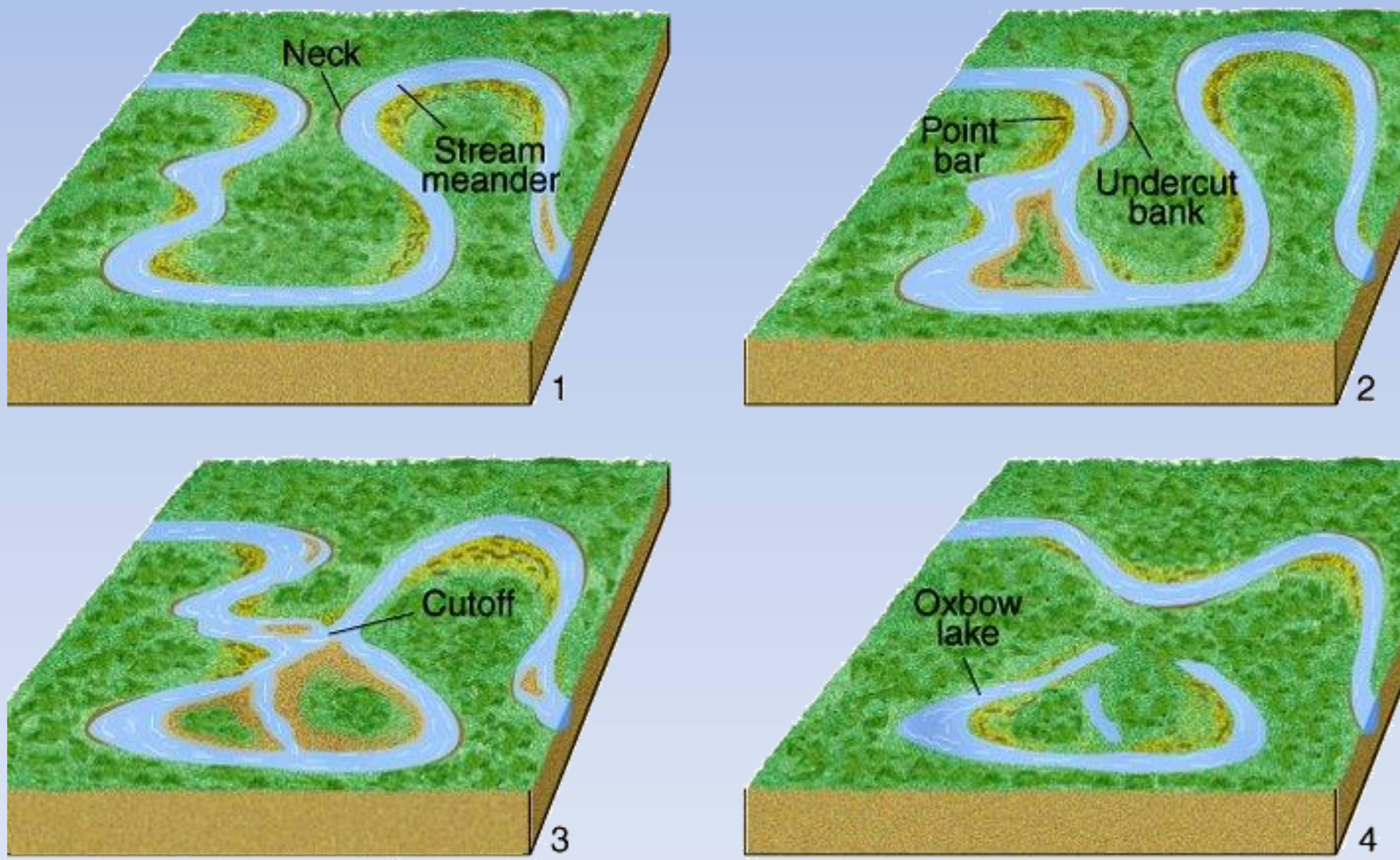
Slower flow -> deposition

Shaping and Reshaping of Channels

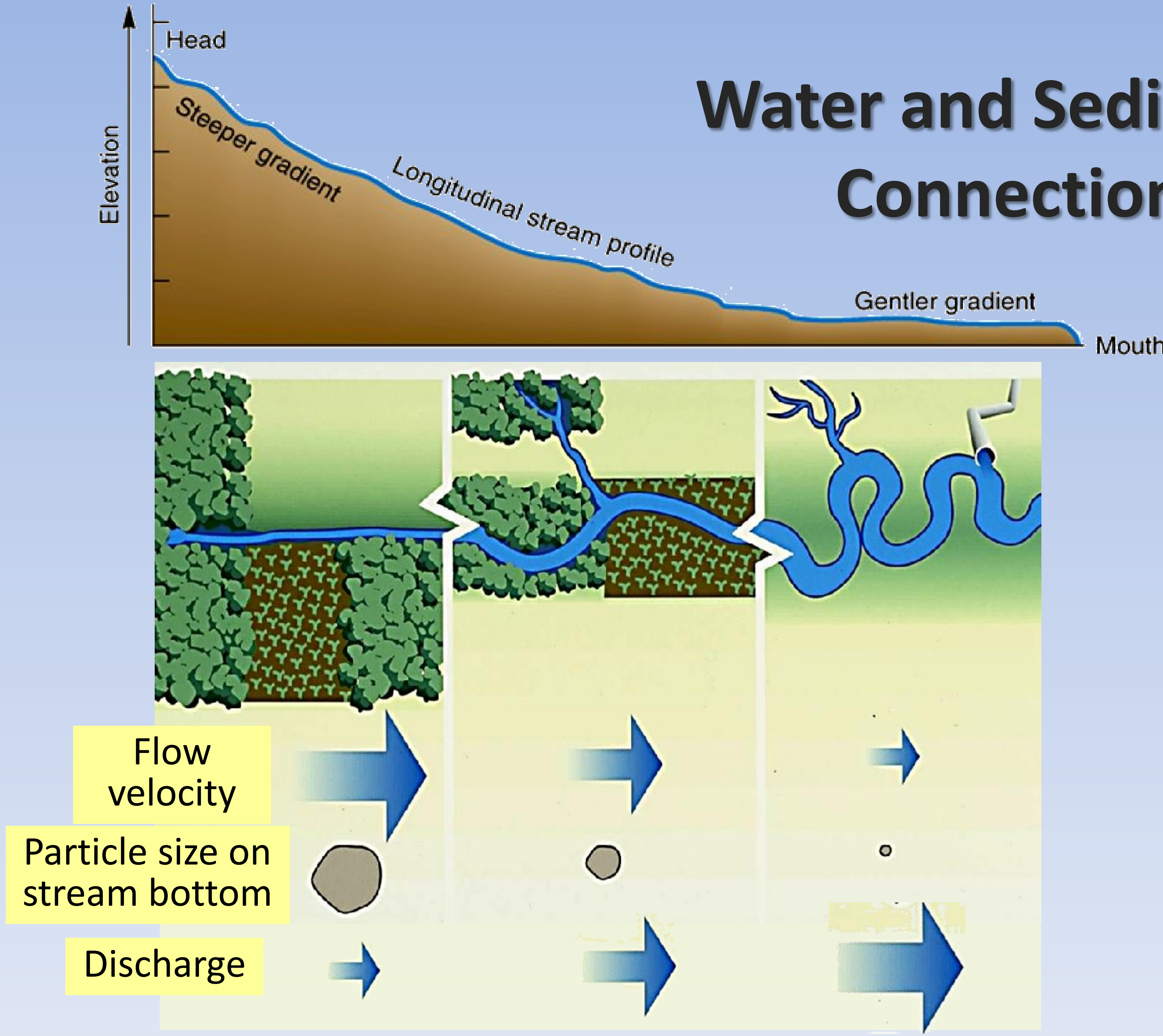
- As gradient (slope) decreases, stream flow meanders -> lateral erosion
- Since flow is faster around the outside of a bend, meanders shift sideways by eroding their outer bank
- Since flow is slower on the inner bank, sediment is deposited



Channel Migration Process
(Planform Change)



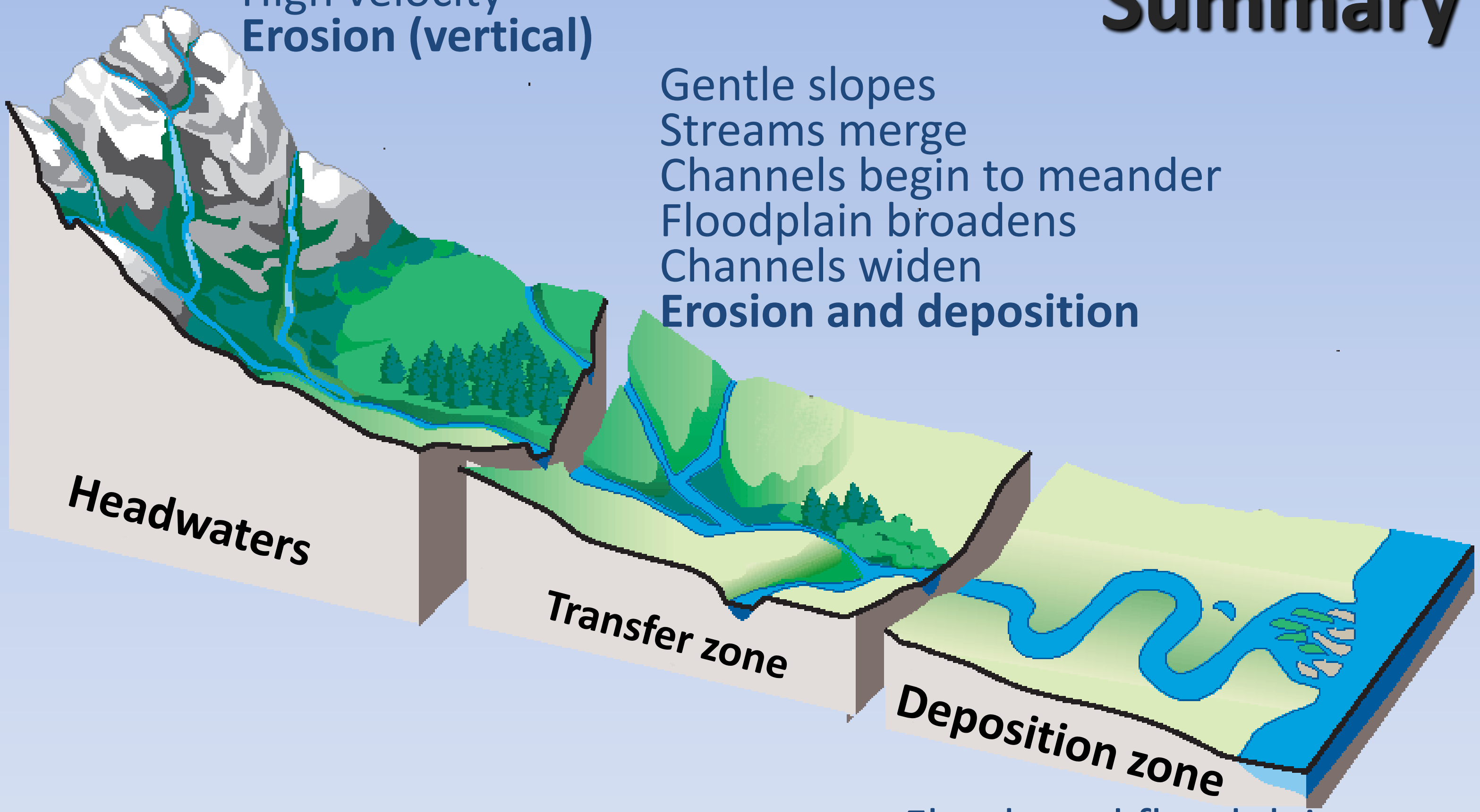
Water and Sediment Connection



Longitudinal Summary

High elevation
Steep slopes
V-shaped valleys
Narrow channels
High velocity
Erosion (vertical)

Gentle slopes
Streams merge
Channels begin to meander
Floodplain broadens
Channels widen
Erosion and deposition

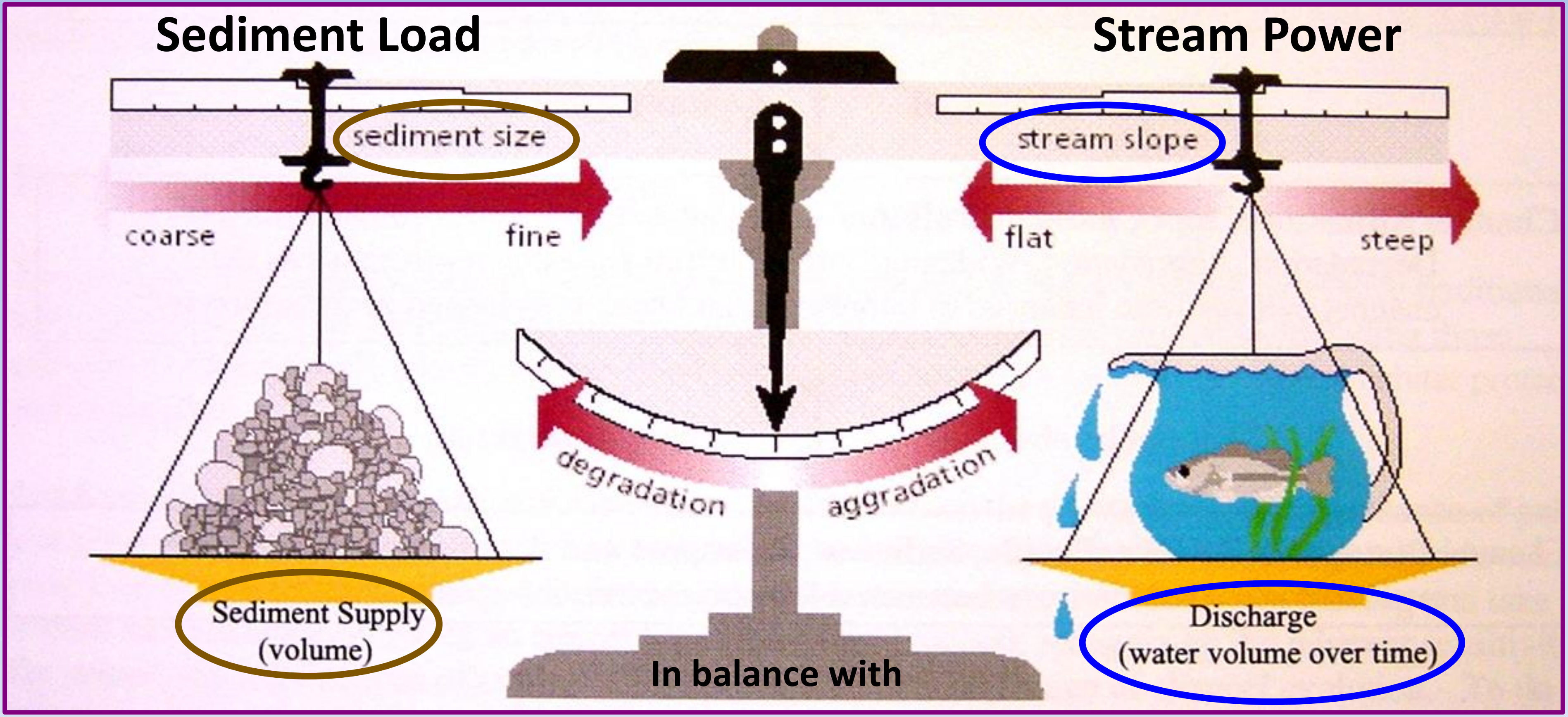


Flat, broad floodplain
Low slopes
Meandering channels
Lateral erosion
High discharge
Deposition dominates

Miller, 1990

Dynamic Equilibrium

A stable stream transports the water and sediment produced by its watershed, such that over time it maintains its dimension, pattern, and profile, while neither degrading nor aggrading. However, if any factor changes, the other variables must change to reach a new equilibrium.



The amount of sediment and the size of the sediment particles that can be transported in a stream are directly related to the gradient (slope) of the stream channel and amount of water flowing in the stream channel at a particular time.

Lane (1955)

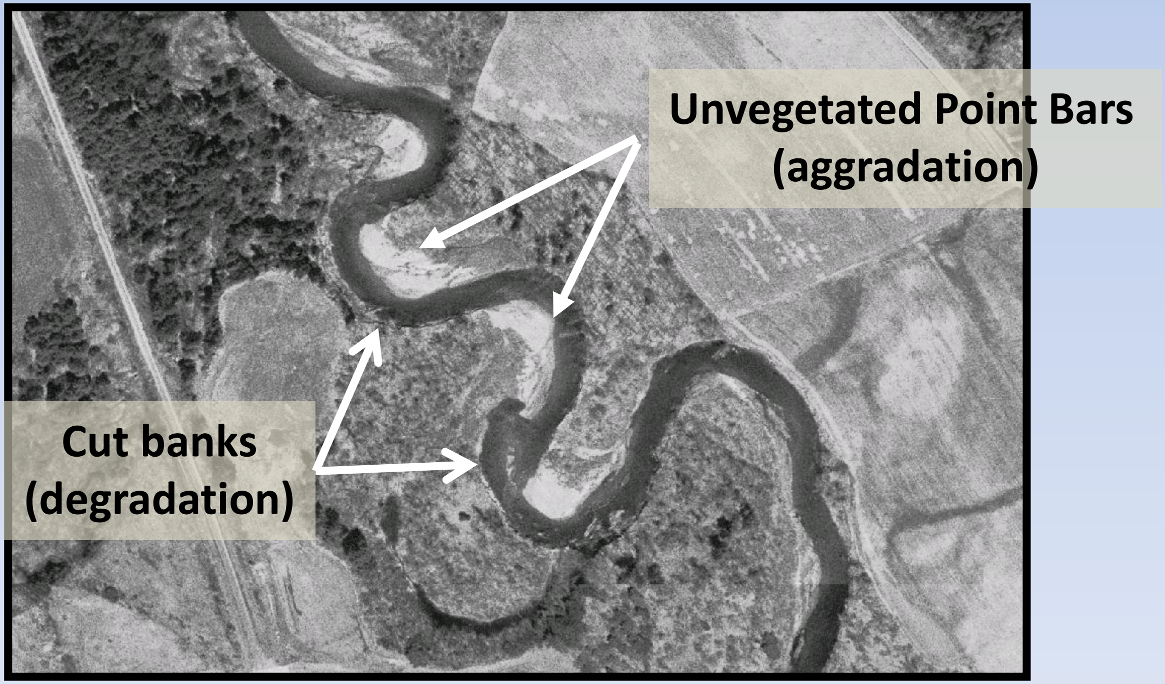
Storm > ↑ Discharge >>> Degradation

Road Construction
(assume no change in stream power)


Upstream Dam

Out of Balance

- When a stream is unstable, i.e. out of balance, it is either **aggrading** (gaining sediment along its bed and banks) or it is **degrading** (deepening or widening due to the removal of sediment)



What Can Change Streamflow?
(Dynamic equilibrium)

- Vegetative Clearing
- Channelization
- Streambank armoring
- Development
- Bare soil
- Irrigation or drainage
- Overgrazing
- Roads and railroads
- Dams
- Water withdrawal

- Storms

Examples

Culverts
Agricultural ditches
Channel straightening
Rerouting

Constrictions

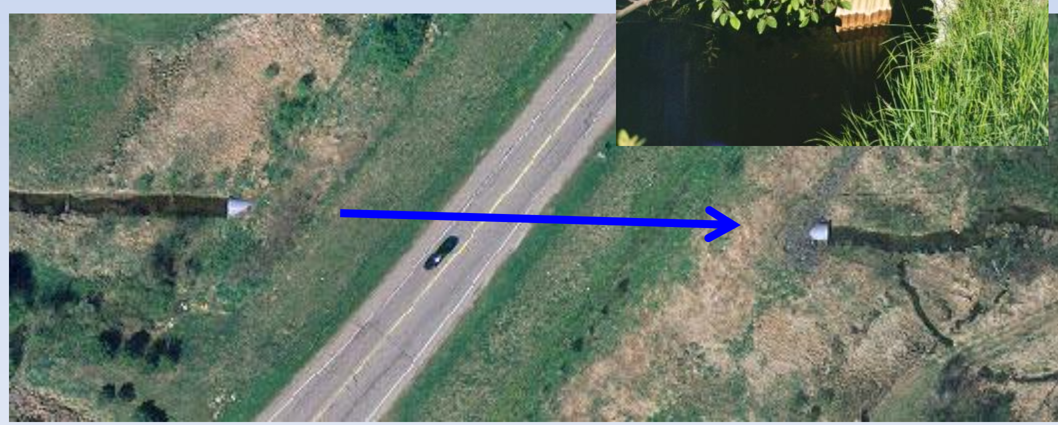
Stream crossings
- roads
- railroads
- bridges

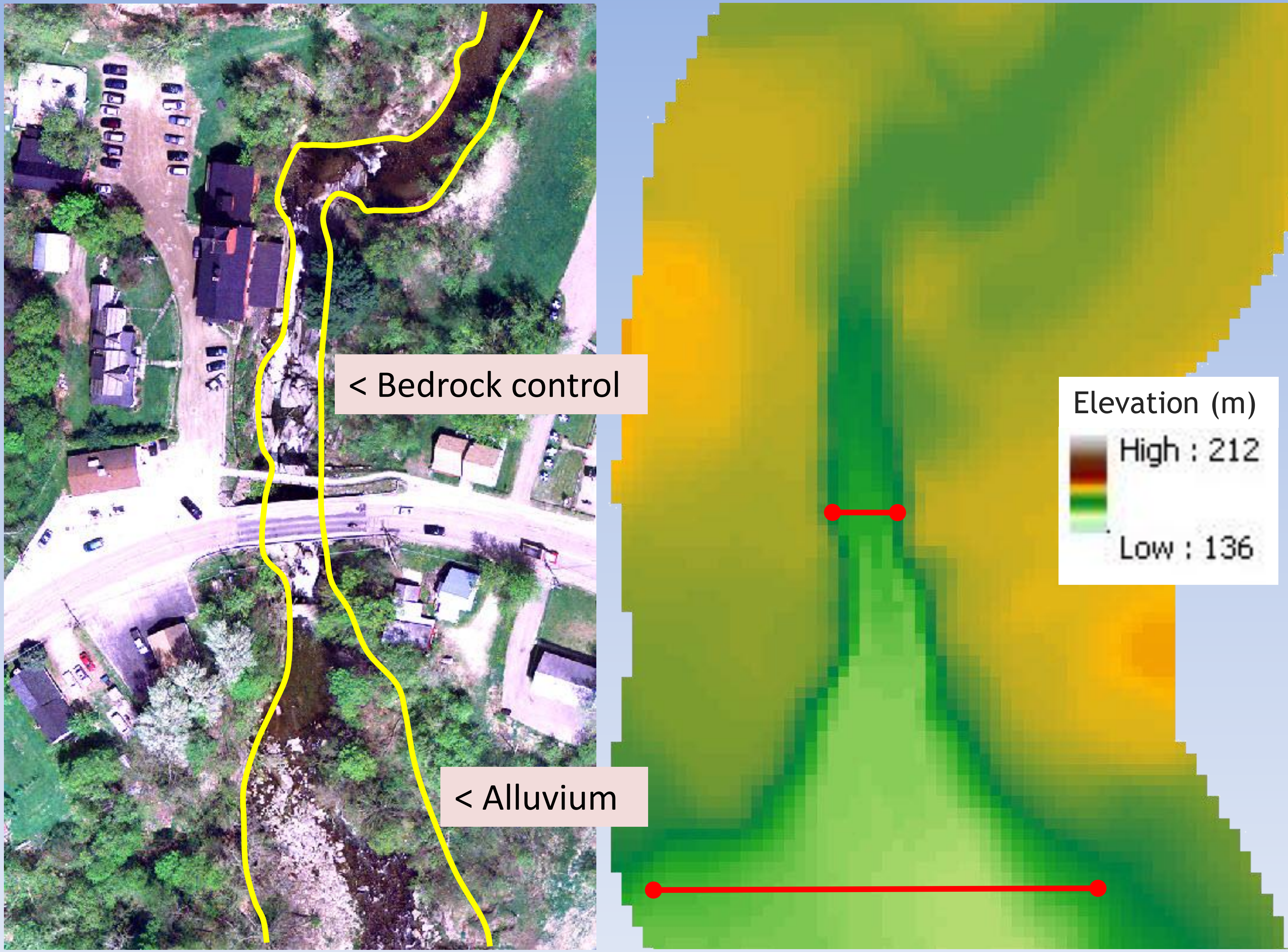
Road culverts

Channelization

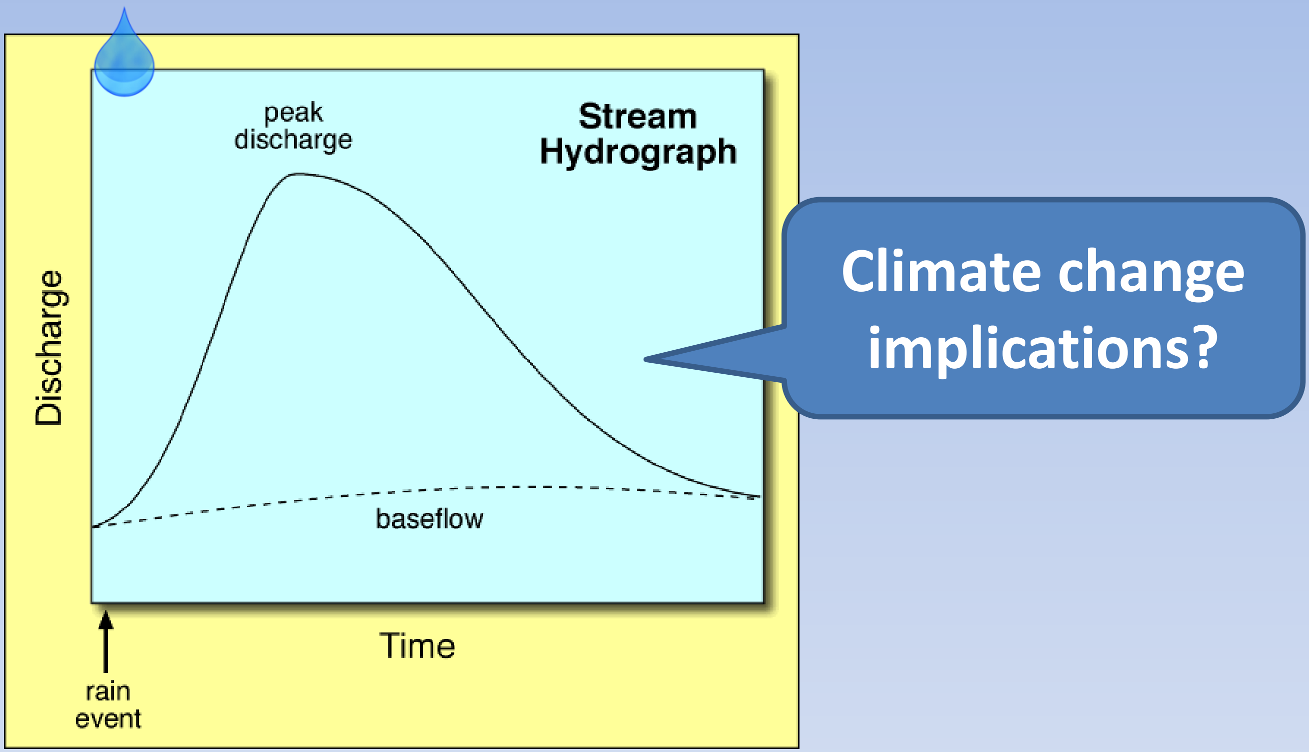
Dams

Bedrock




< Bedrock control
< Alluvium
Elevation (m)
High : 212
Low : 136

Storm events can trigger catastrophic floods



- **Baseflow** - sustained amount of flow in a stream when no precipitation event has occurred
- **Peak discharge** - stream flow attributed to a precipitation event

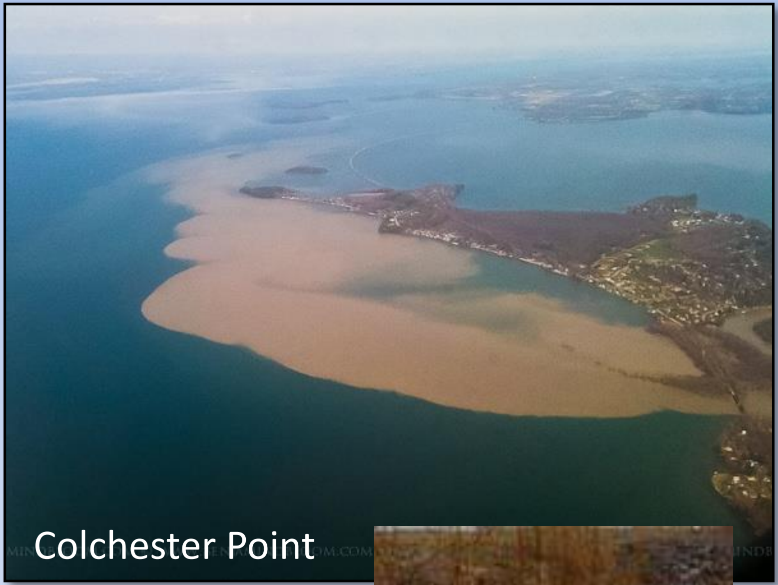
Greater runoff and higher in-stream velocities contribute to streambank erosion

<u>Causes of bank erosion</u>

- Lack of riparian buffers
- Channelization
- Dams
- Overgrazing
- Commercial dredging
- Piped discharge
  - (culverts, ditches)
- Development
  - Impervious surfaces

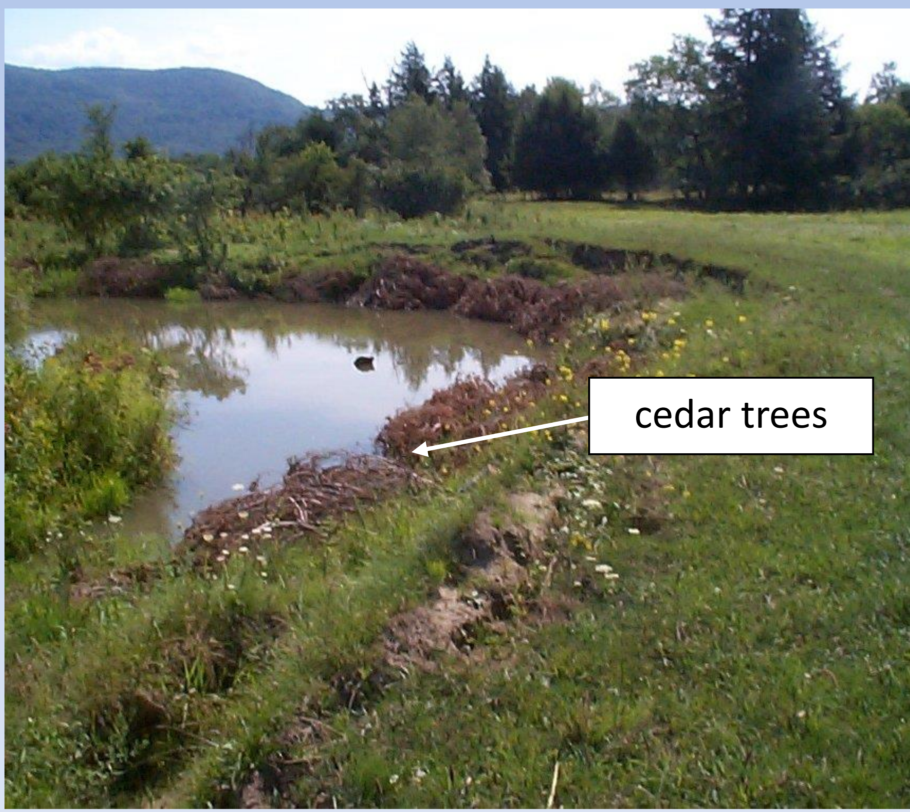
Sediment in Streams and Rivers

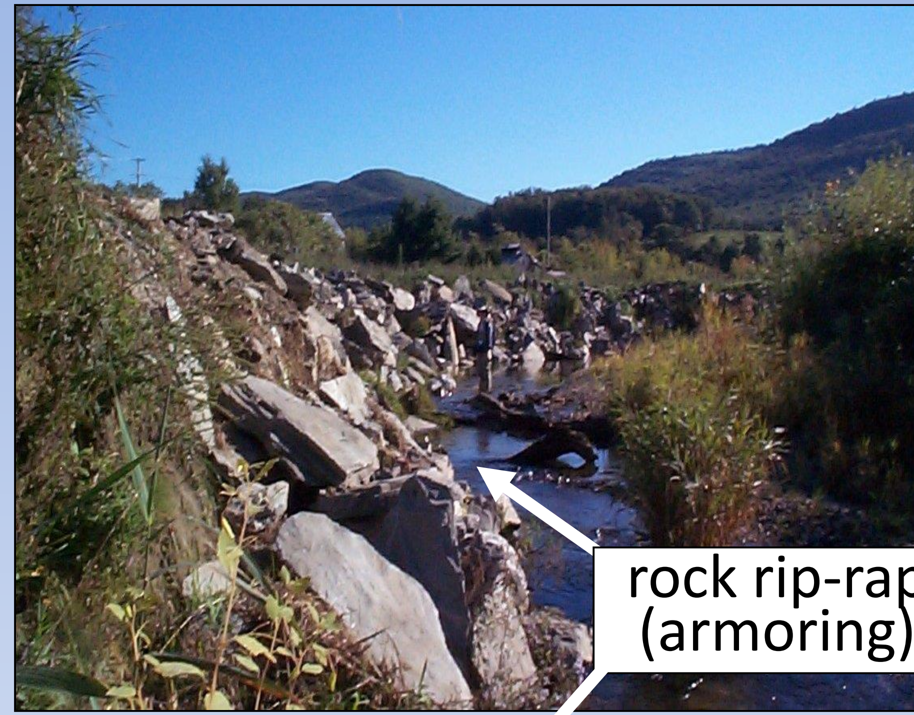
- Leading non-point source of pollution
- Largest source of impairment to streams and rivers worldwide (EPA)
- Decreased water quality
- Negatively impacts habitat health



Tropical storm Irene
(02 September 2011)

Bank Protection

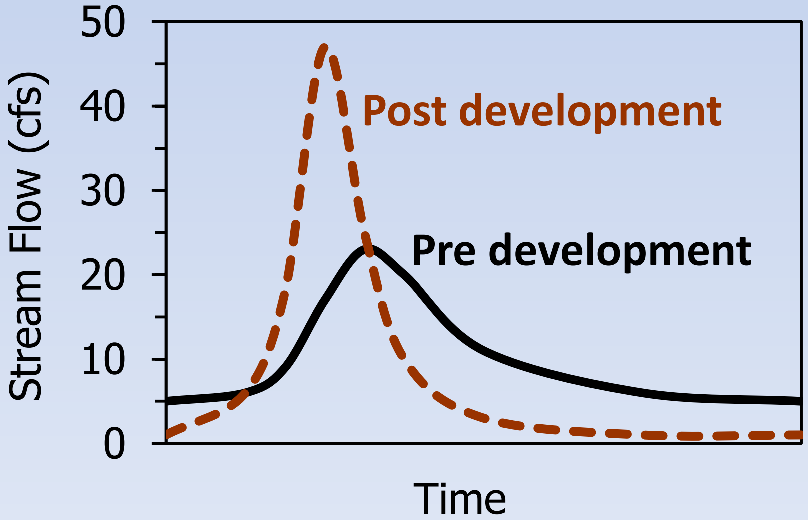





Armoring moves the problem downstream…

Development increases runoff

- ↑ Impervious surfaces
- ↓ Riparian buffers
- ↑ Stormwater inputs
- ↑ Peak discharge (flooding)
- ↑ Sediment loading



Google Earth Activity

1. Photointerpret stream features along Browns River
    - Stream features
        - erosion
        - deposition
    - Channel modifications
        - straightening, armoring, ditches, dams
    - Channel adjustments