EMERGENCY STREAM INTERVENTION

&

Reducing Storm Impacts On Stream Channels

UPPER SUSQUEHANNA COALITION

Prepared by
The Upper Susquehanna Coalition

SECTION I

AN OVERVIEW OF STREAM MORPHOLOGY

OR

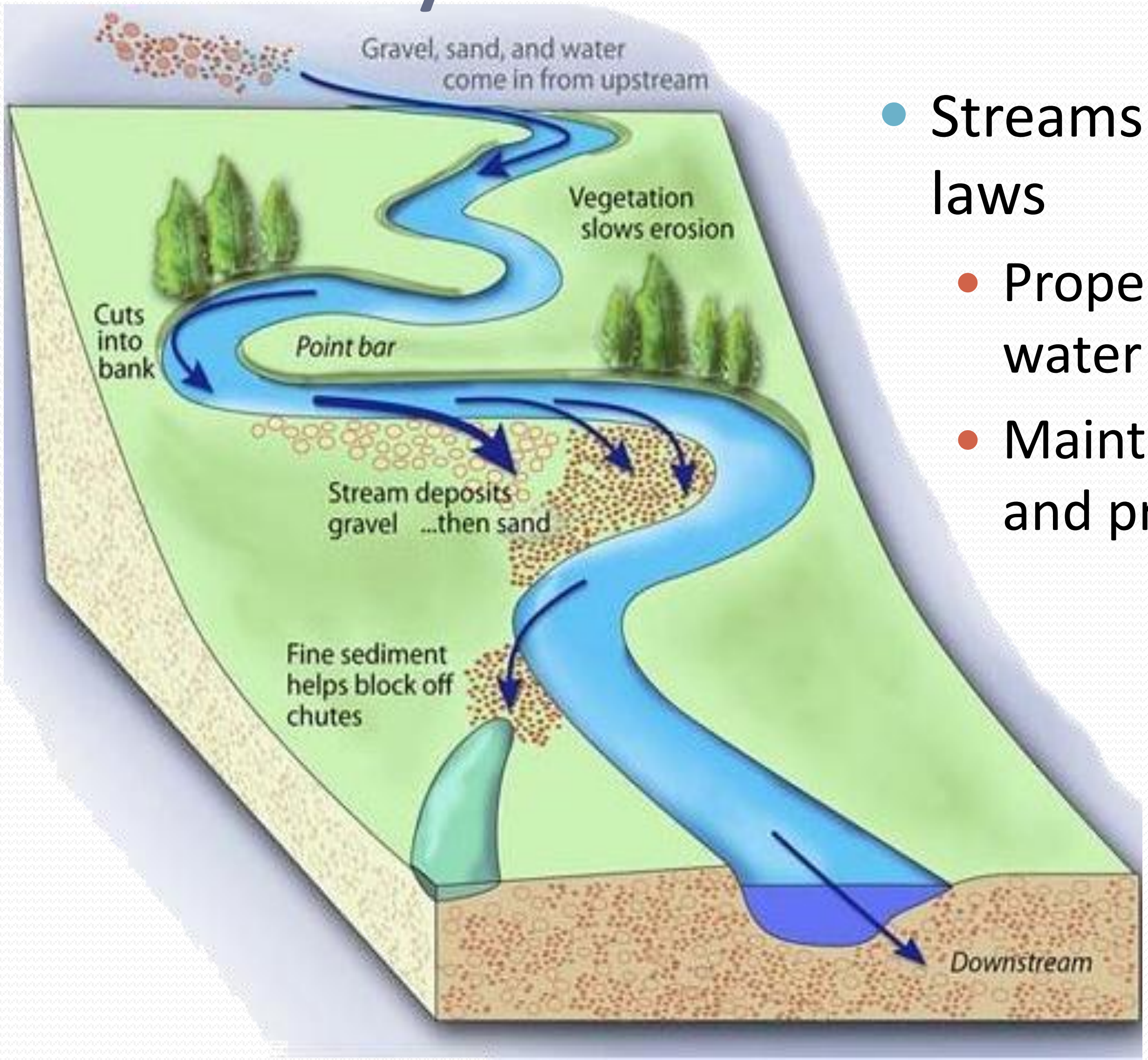
HOW STREAMS ARE FORMED, EVOLVE AND BEHAVE

Fluvial Geomorphology

- How a stream physically evolves over time
- Specific characteristics of similar stream types that allow them to maintain relative “stability” for a large variety of storm (runoff) event.

HOW A STREAM LOOKS, BEHAVES AND CHANGES CAN BE A VERY COMPLEX BALANCE OF PHYSICAL ELEMENTS

Primary Stream Features



- Streams obey certain physical laws
  - Properly size itself to transport water and sediment
  - Maintain its dimension, pattern and profile

Why Do Streams Look the Way They Do?

- Geology
  - Slope
  - Soils
- Amount of water
  - Timing
  - Duration
  - Magnitude
- Landuse
  - Vegetation
  - Infrastructure

> *"The river is the carpenter of its own edifice"*
> -- Luna Leopold, 1994

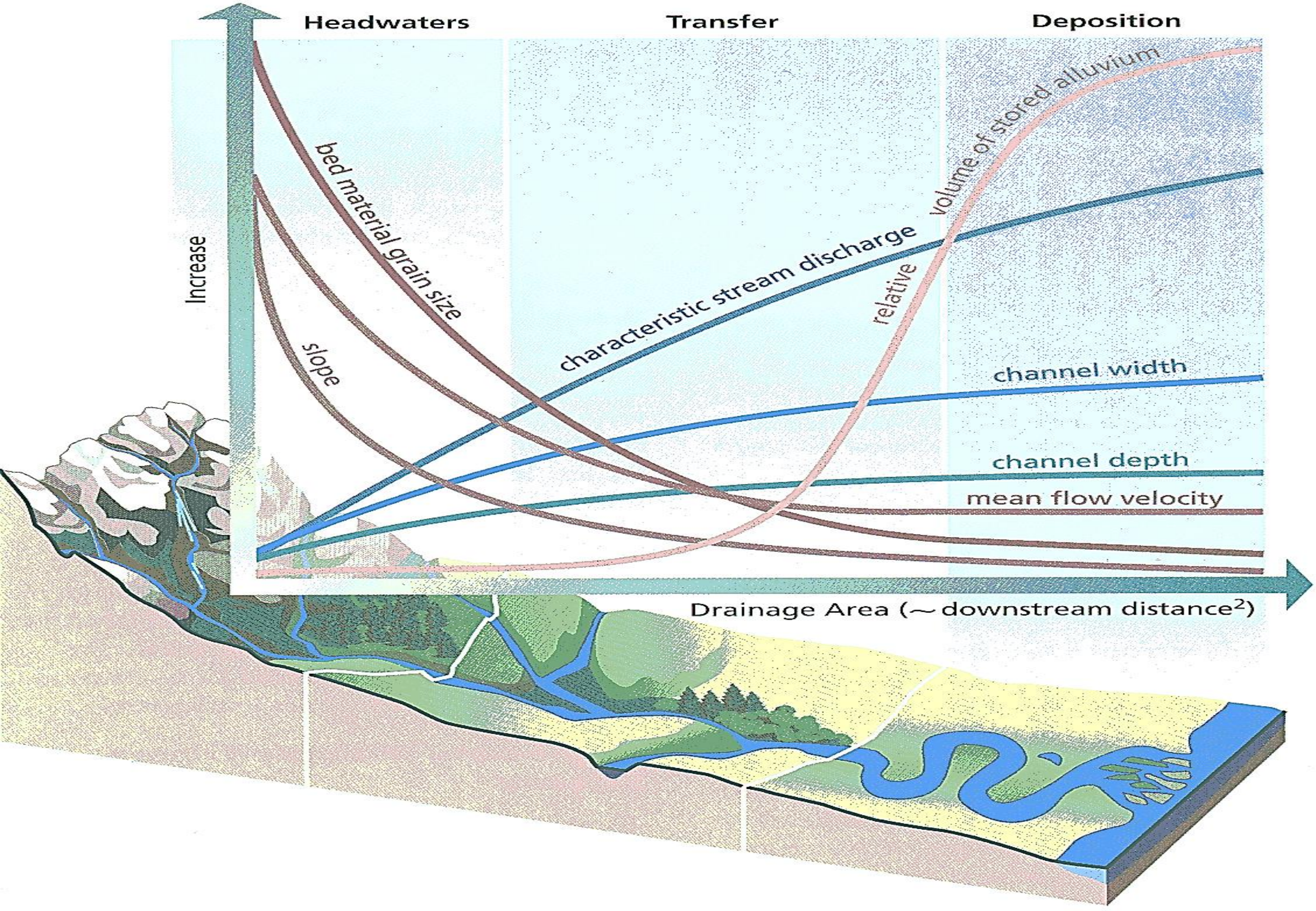


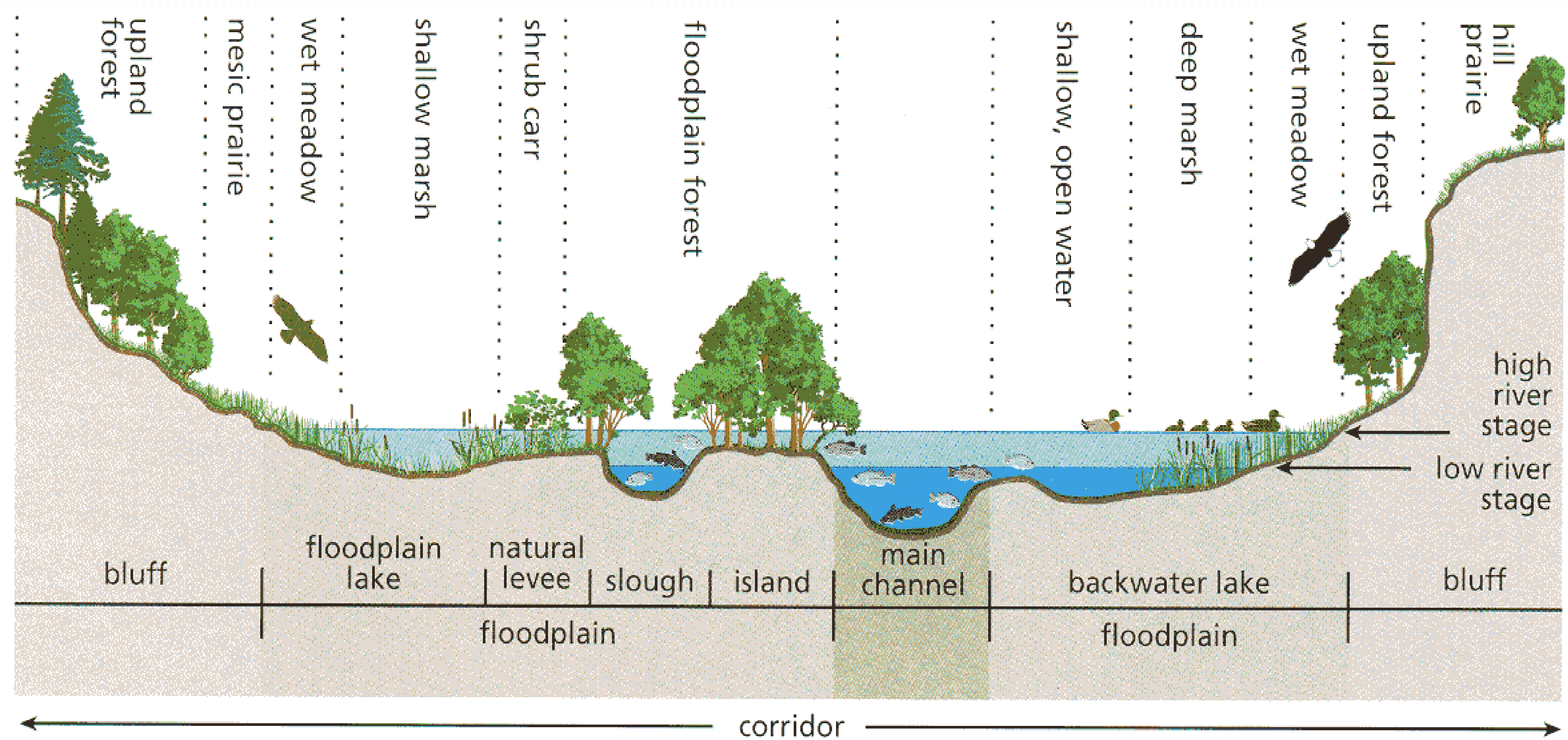
Figure 1.28: Changes in the channel in the three zones. *Flow, channel size, and sediment characteristics change throughout the longitudinal profile.*

Streams Work to Return to a Natural Pattern & Dimension

Stream Morphological Features

- Floodplains
- Cross sectional area
- Width & depth
- Sinuosity
- Slope
- Entrenchment
- Longitudinal features

FLOODPLAINS & STREAM CORRIDOR

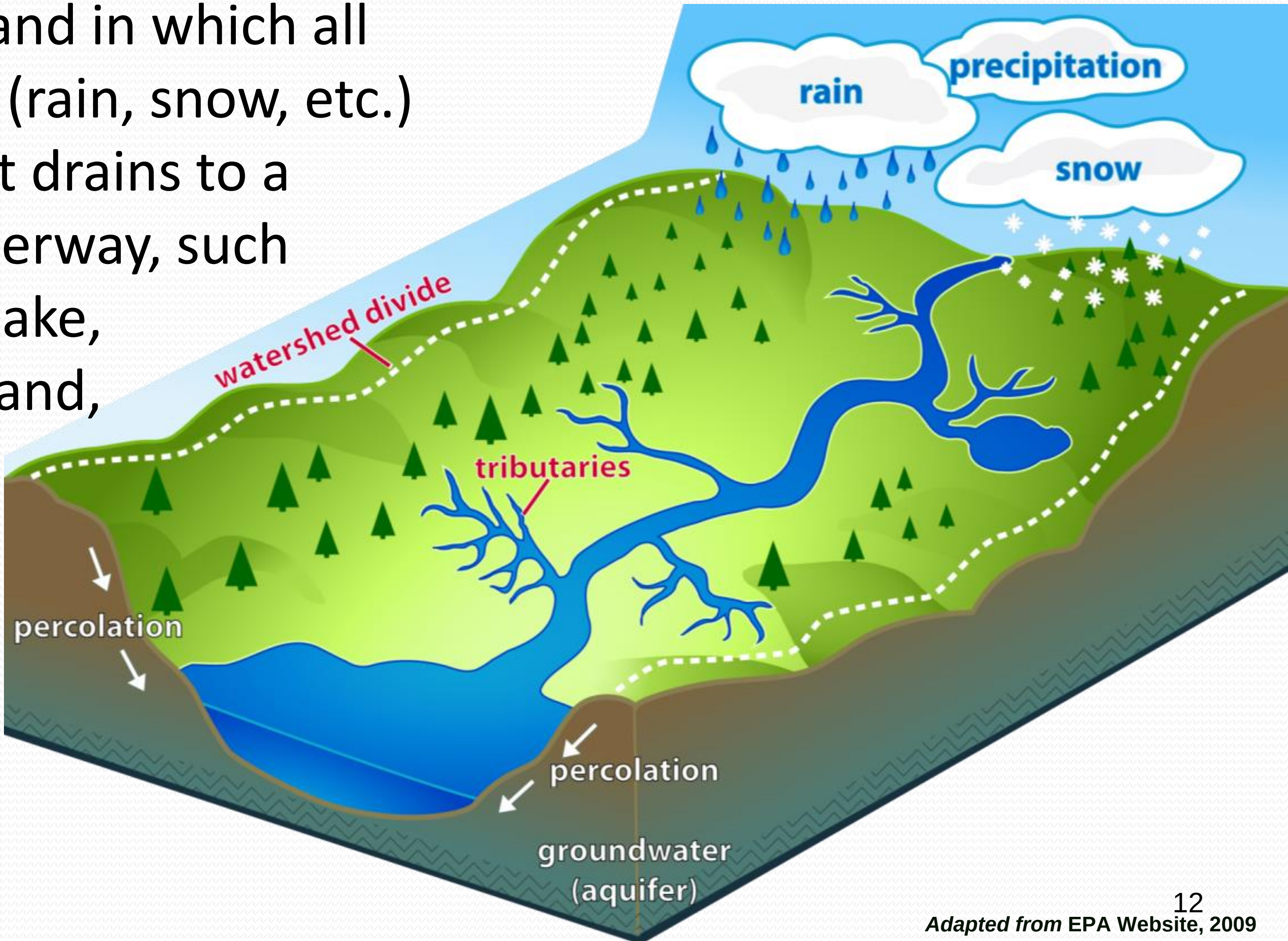


Influences on Stream "MORPHOLOGY"

- Watershed
- Land forms
- Weather
- Man's influence/ activities
- "Boundary conditions"

What is a Watershed?

The area of land in which all precipitation (rain, snow, etc.) that falls on it drains to a common waterway, such as a stream, lake, estuary, wetland, aquifer, or even the ocean.



Adapted from **EPA Website, 2009**

Watershed

- Topographic features - slopes
- Geology
- Soils that affect infiltration
- Land use
  - Vegetation
  - Development of watershed

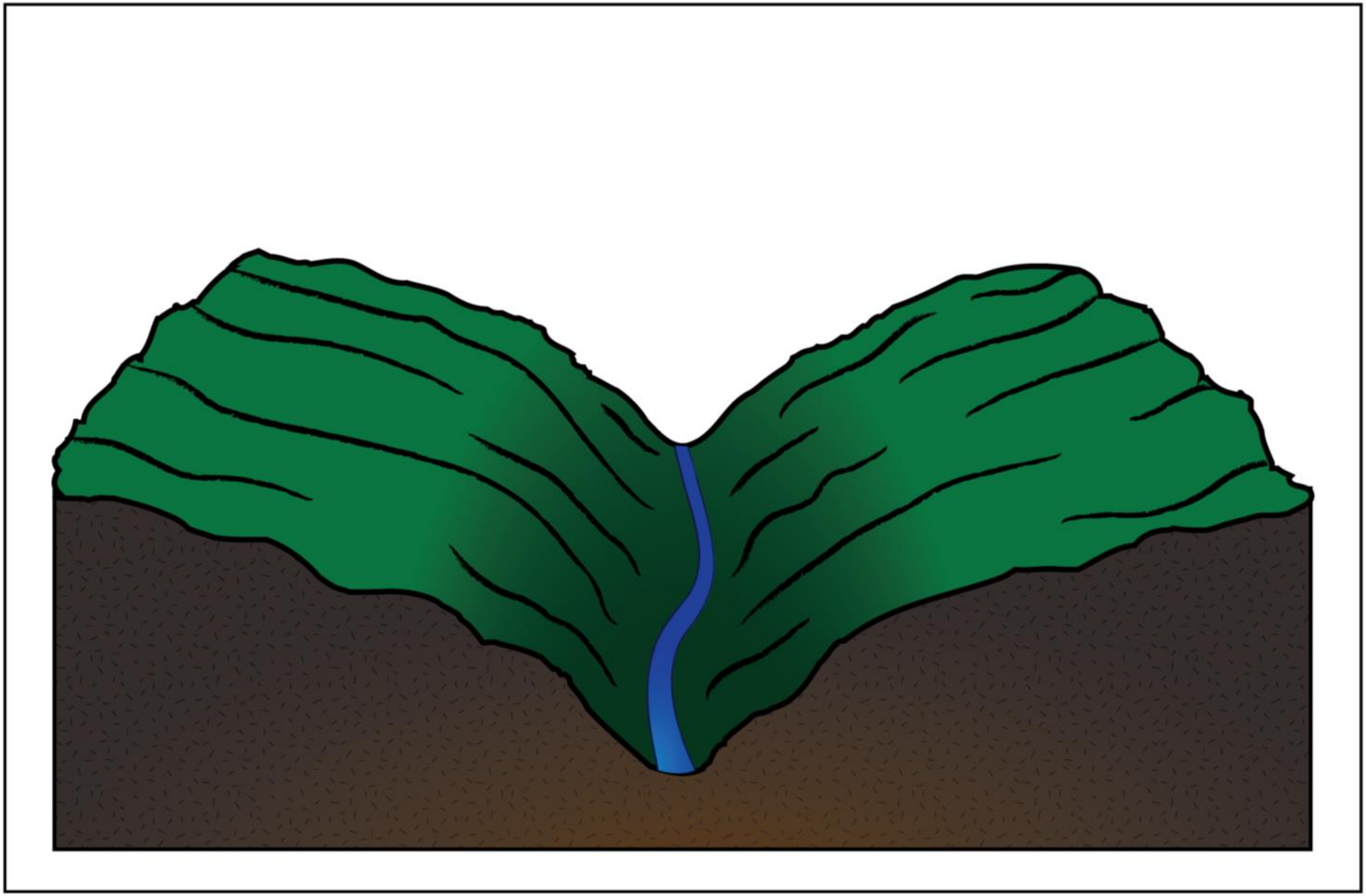


FIGURE 4b. Valley Type I, “V” notched canyons, rejuvenated sideslopes.

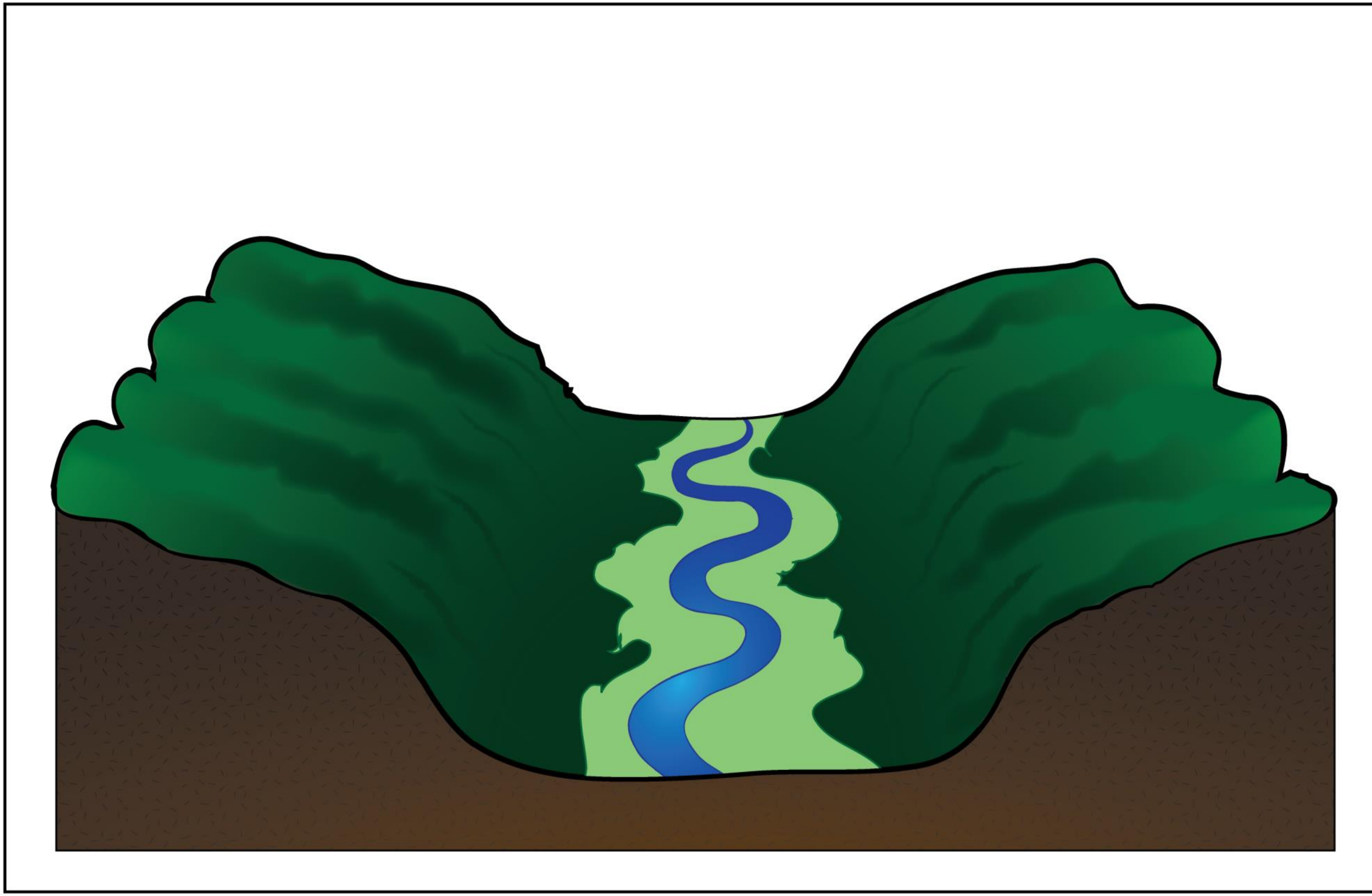


FIGURE 8b. Valley Type V, moderately steep valley slopes, "U" shaped glacial trough valleys.

Hydrology

- The amount of water available to the stream
- Influenced by
  - Precipitation
  - Infiltration
  - Evaporation
  - Transpiration
  - Runoff

HYDROLOGIC CYCLE

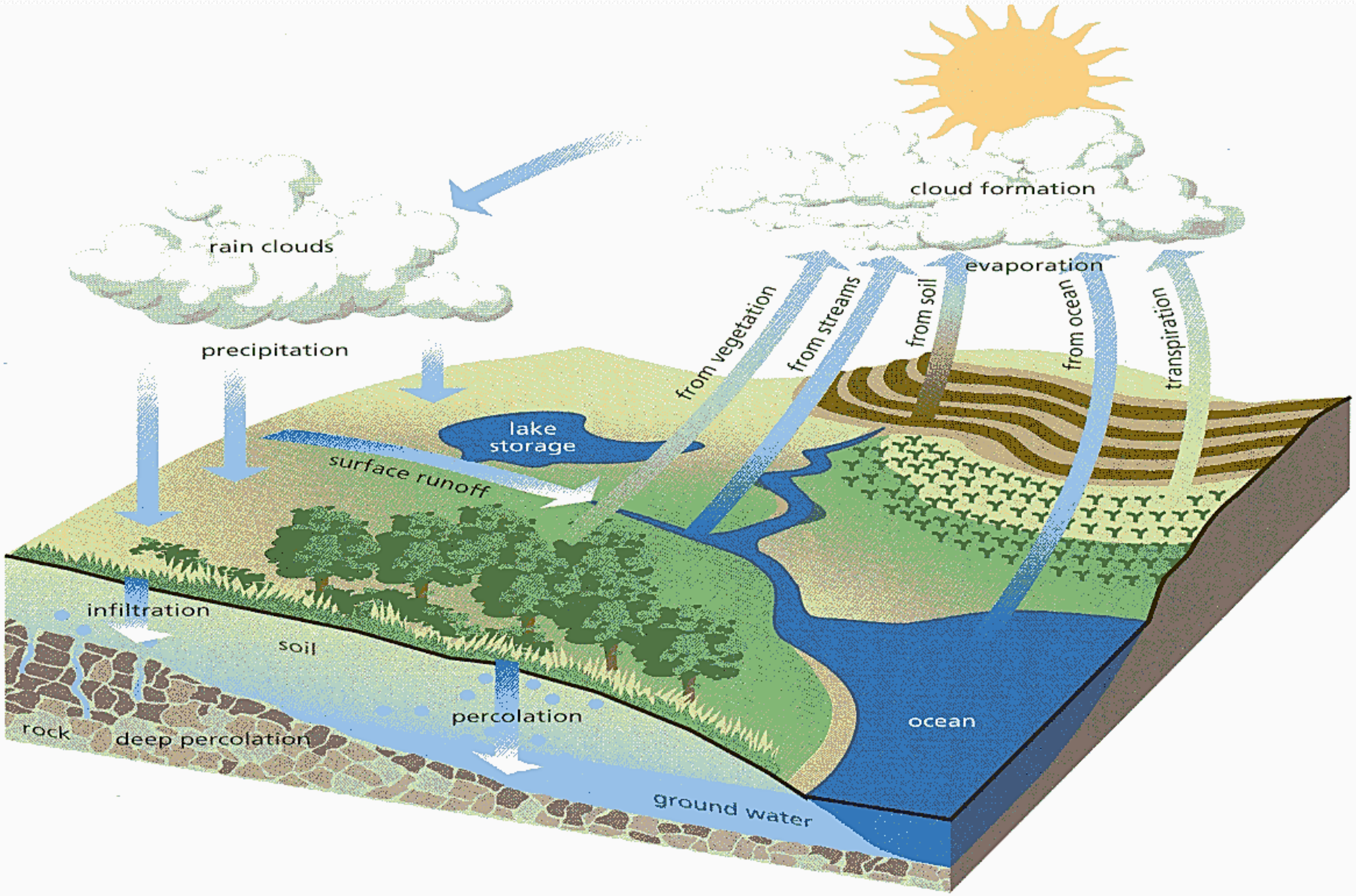


Figure 2.2: The hydrologic cycle. *The transfer of water from precipitation to surface water and ground water, to storage and runoff, and eventually back to the atmosphere is an ongoing cycle.*

LANDUSE

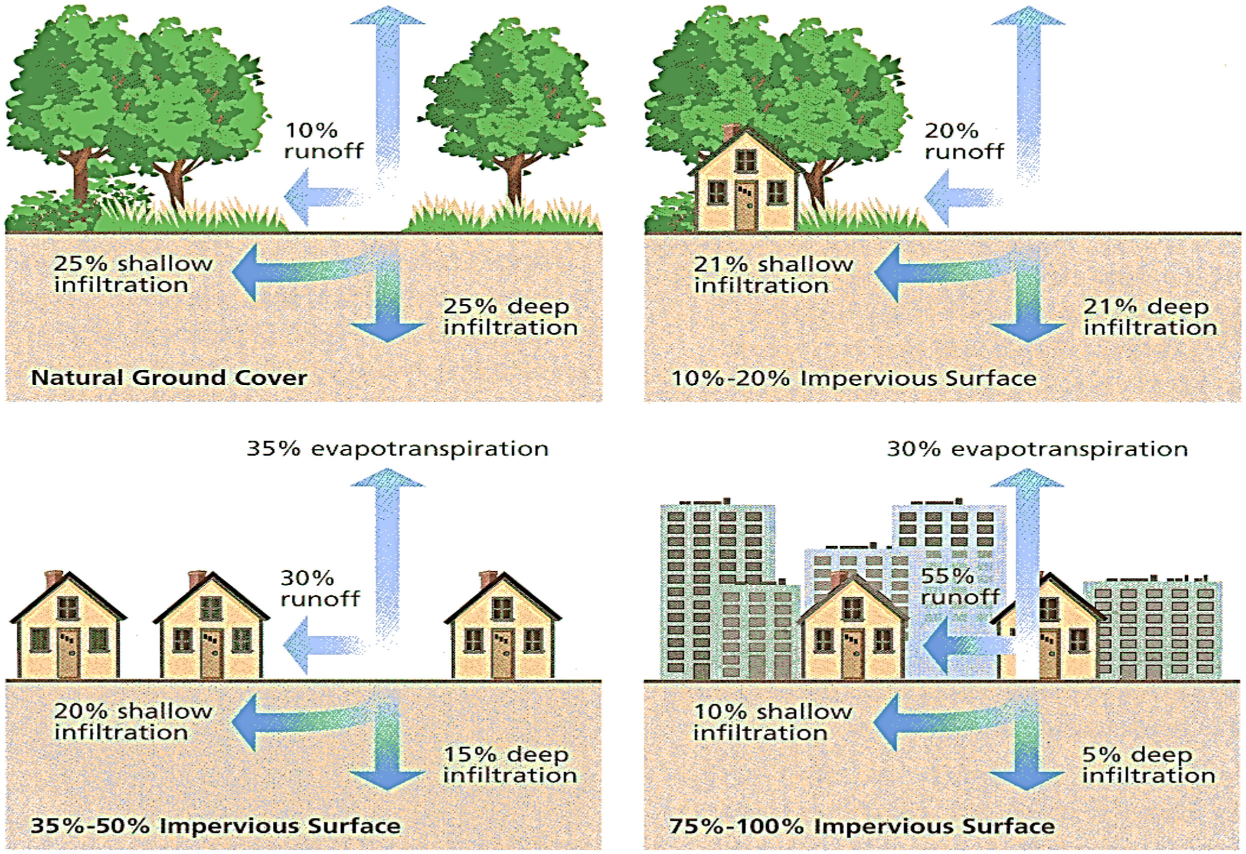


***Figure 3.21: Relationship between impervious cover and surface runoff.** Impervious cover in a watershed results in increased surface runoff. As little as 10 percent impervious cover in a watershed can result in stream degradation.*

SOILS

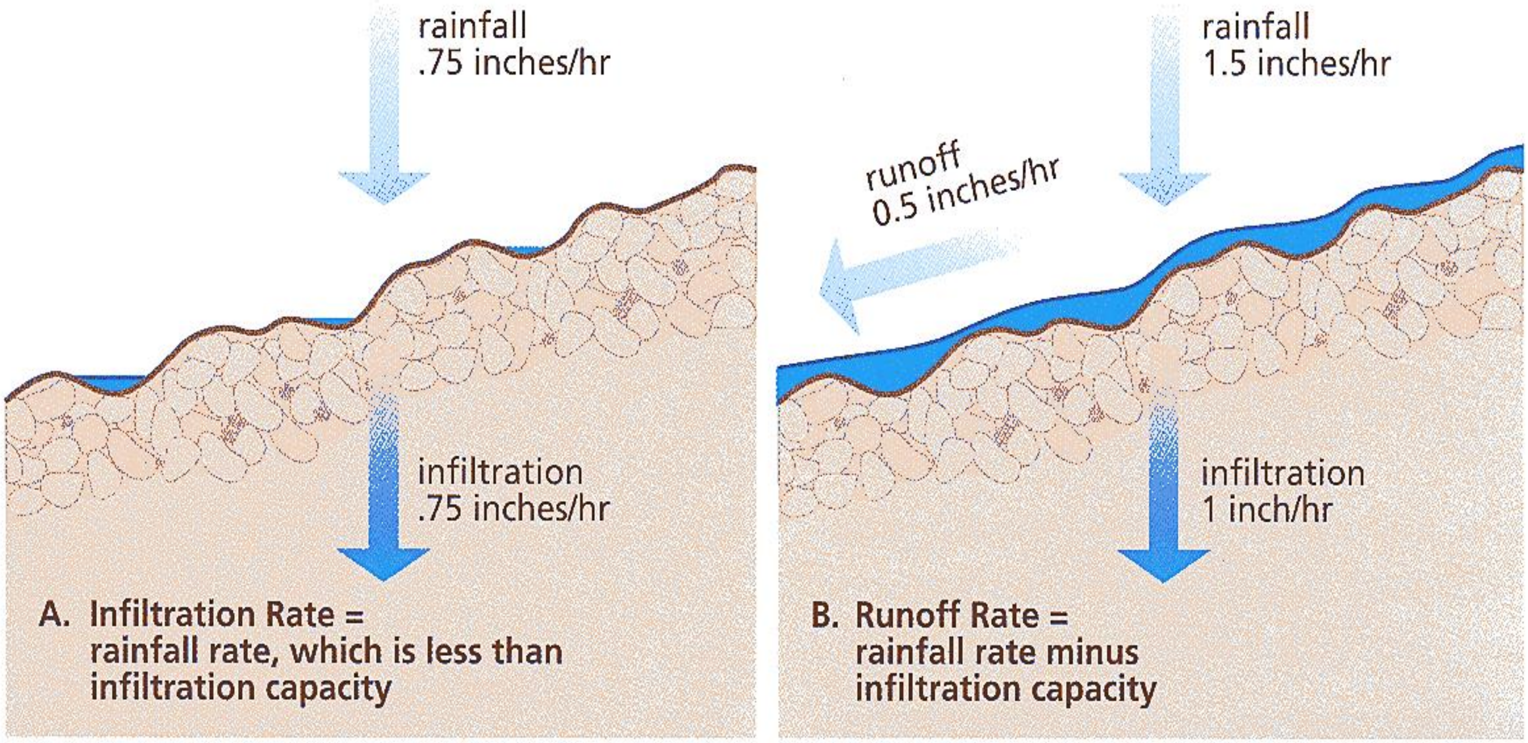
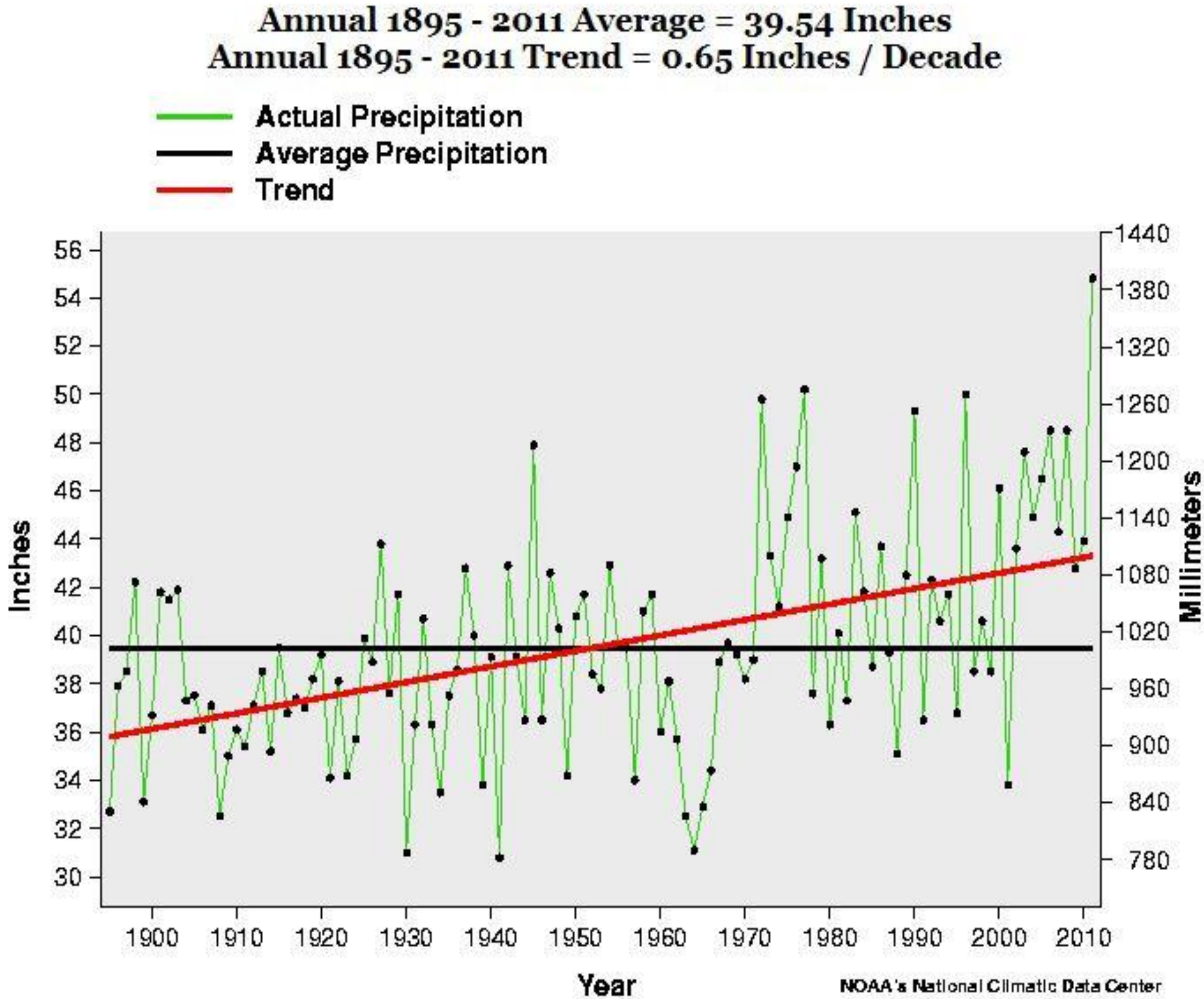


Figure 2.6: Infiltration and runoff. *Surface runoff occurs when rainfall intensity exceeds infiltration capacity.*

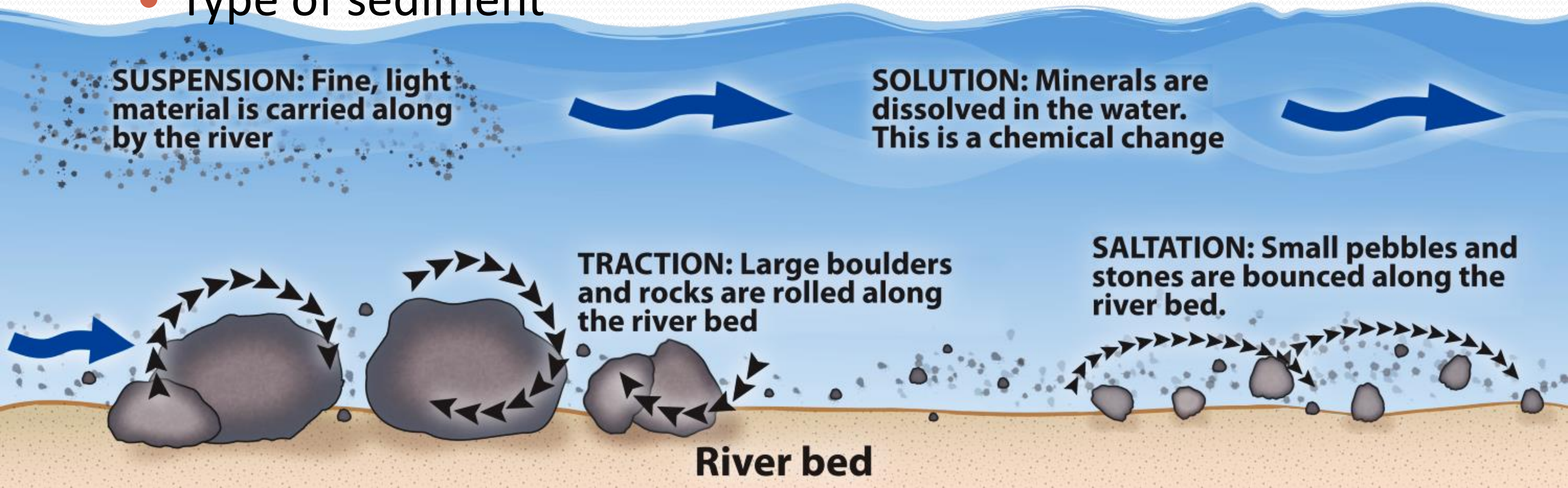
Climate (Precipitation)

- Climate change causes increasing precipitation levels and variability (more extremes)
  - Streams are adjusting to increase flows
- Difficult to predict local severity of forecasted rain event


Annual 1895 - 2011 Average = 39.54 Inches
Annual 1895 - 2011 Trend = 0.65 Inches / Decade
Actual Precipitation
Average Precipitation
Trend
Inches
Millimeters
Year
NOAA's National Climatic Data Center

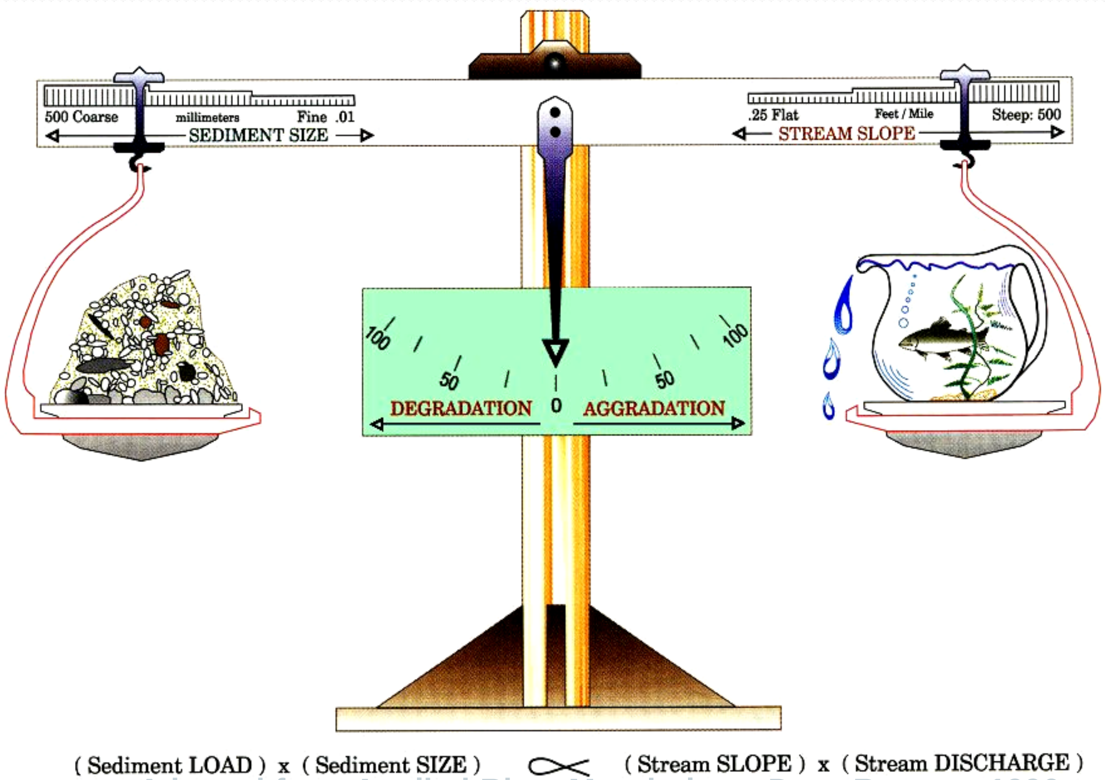
Streams Move More Than Water

- As water moves over the land it picks up sediment, forming the stream channel
- Streams create and maintain their shape and size themselves, a result of:
  - Volume of water
  - Amount of sediment
  - Type of sediment



Sediment Balance

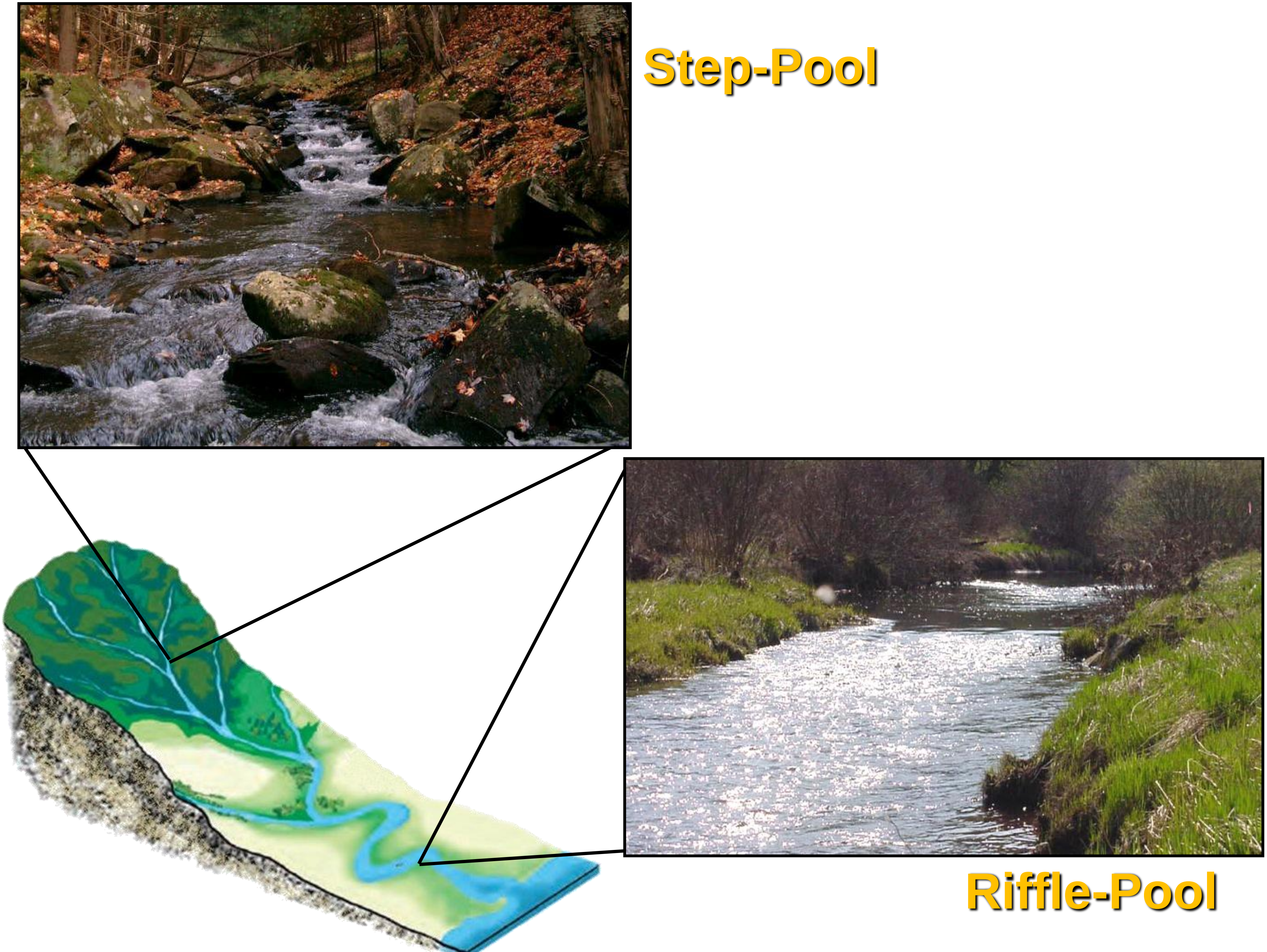
- Streams are said to be in equilibrium when the volume of water is enough to transport the available sediment without building up the channel (aggrading) or cutting down the channel (degrading).



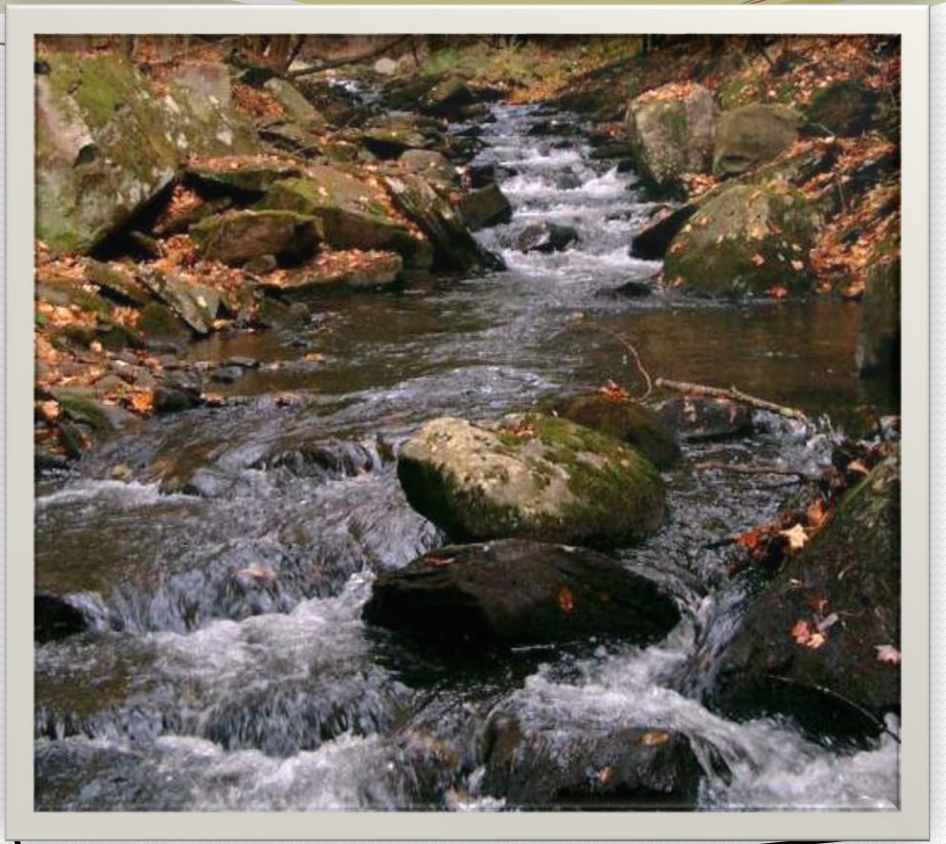
Adapted from Applied River Morphology, Dave Rosgen, 1996

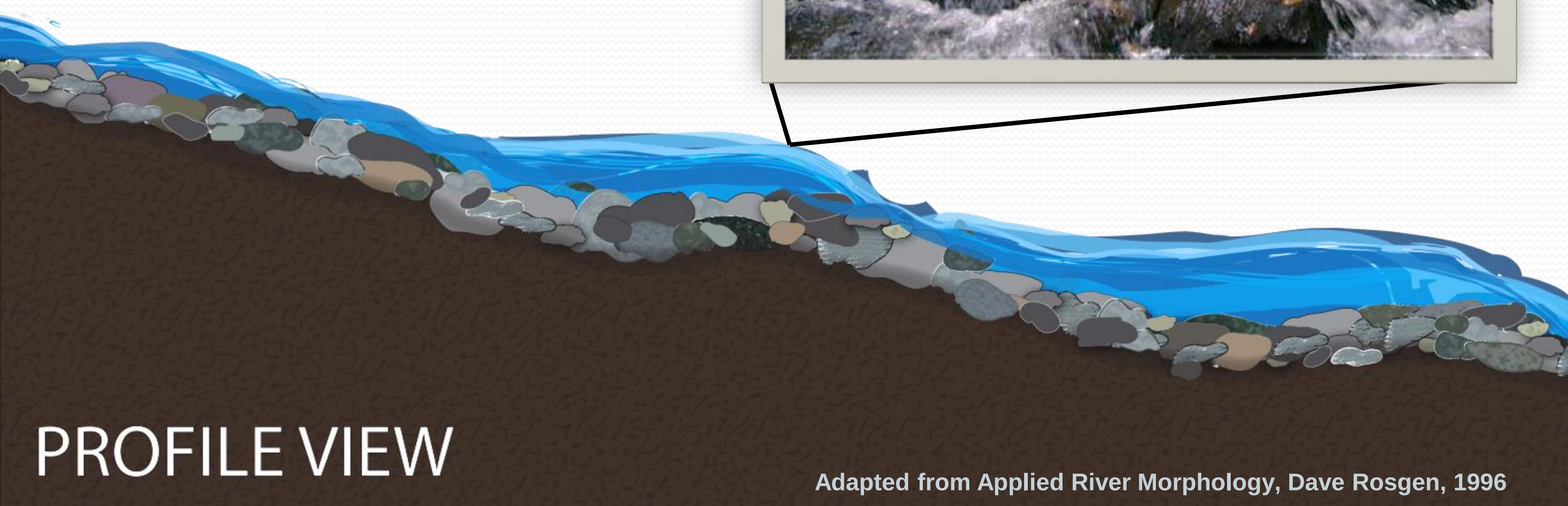
Two Main Stream Types

- **Step - Pool Sequence** - streams are usually found in the headwaters or on steep slopes
- **Riffle - Pool Sequence** - streams are usually found in the broad valleys and on flat slopes


Step-Pool
Riffle-Pool

Stream Type: Step - Pool





Adapted from Applied River Morphology, Dave Rosgen, 1996

Stream Type: Riffle - Pool

SECTION II

HOW A STREAM BECOMES UNSTABLE

&

SOURCES OF EXCESS SEDIMENT

A stream channel responds to any changes in those elements that have helped shape it over the centuries and thus impacts its stability and ability to transport both water and sediment

How do streams become unstable?

- Land use changes
- Dredging
- Channel straightening
- Berms
- Filling floodplain or channel
- Floodplain development
- Avulsions
- Large floods

Land Use

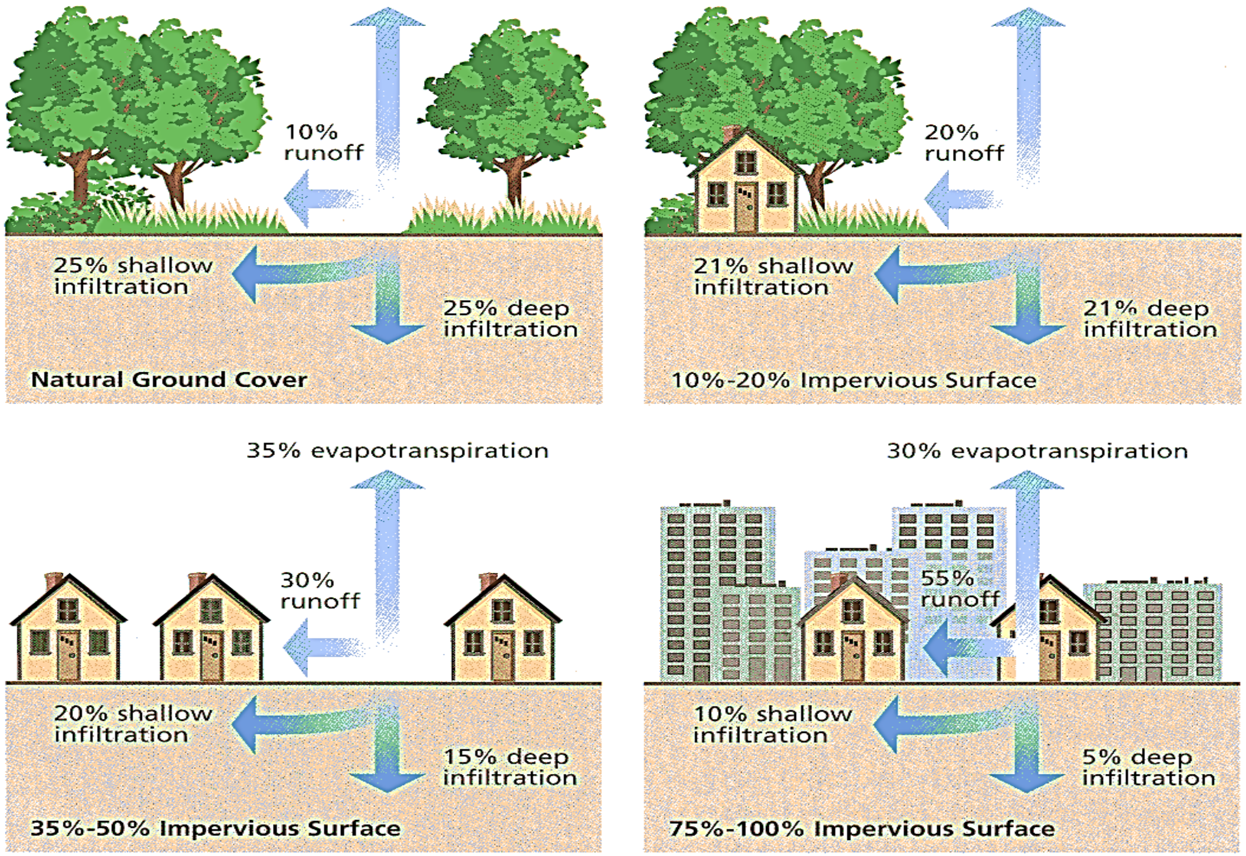
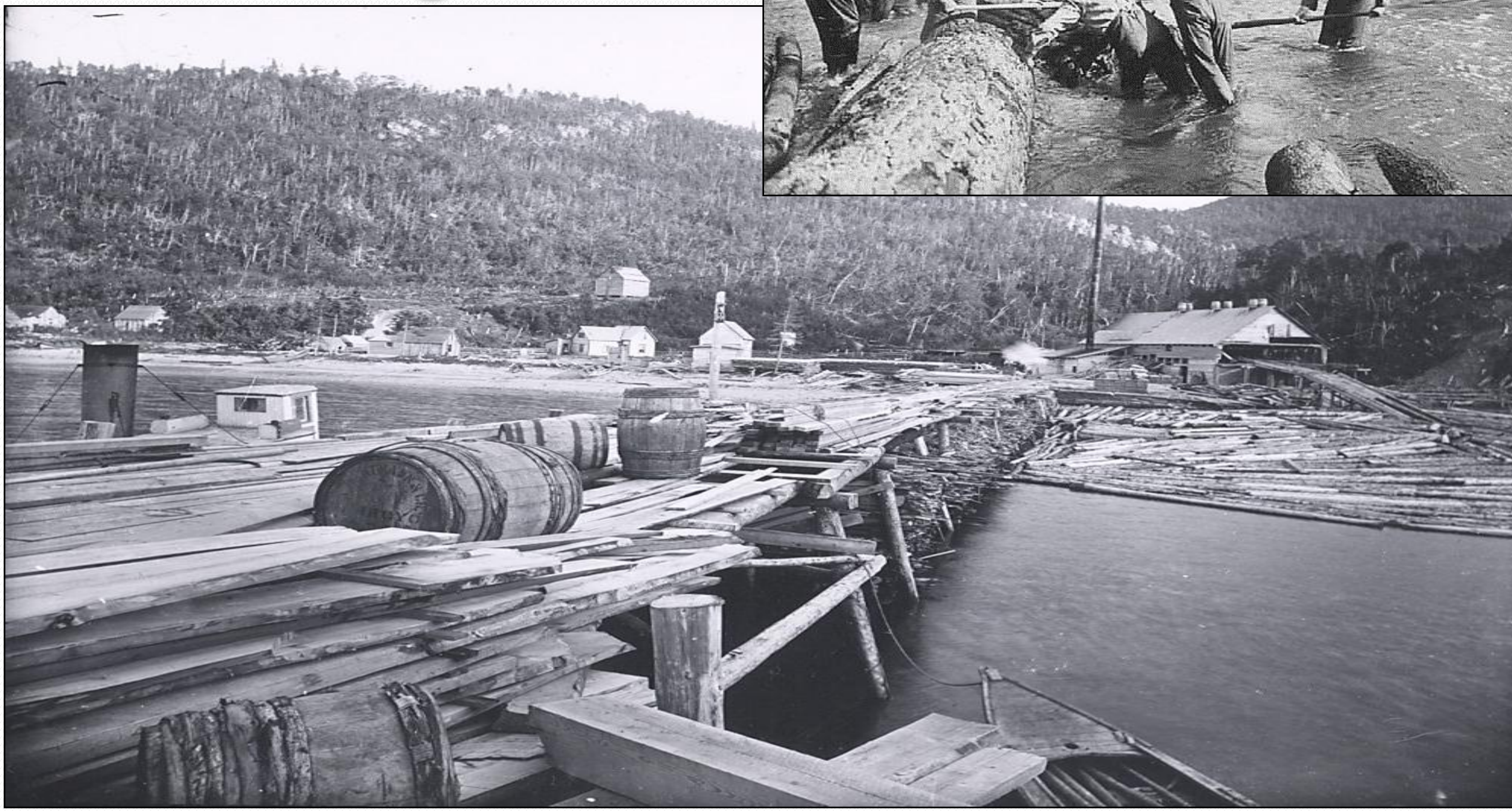


Figure 3.21: Relationship between impervious cover and surface runoff. *Impervious cover in a watershed results in increased surface runoff. As little as 10 percent impervious cover in a watershed can result in stream degradation.*

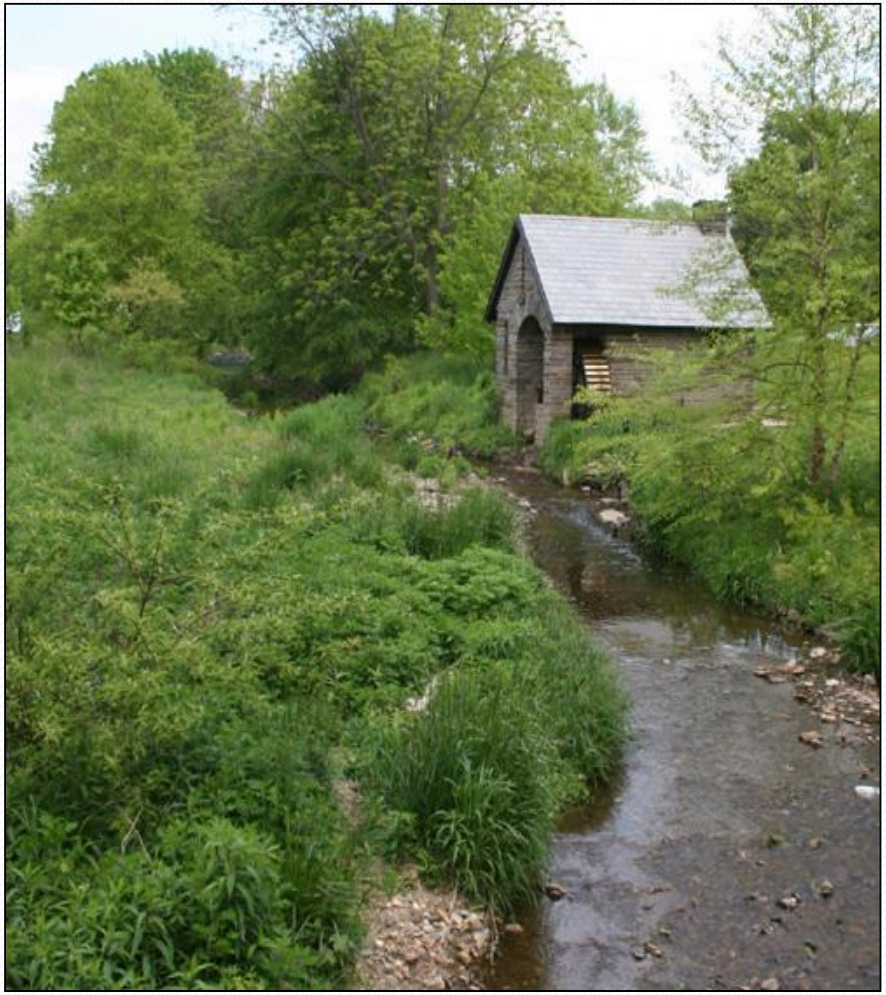
Traditional Travel Corridors

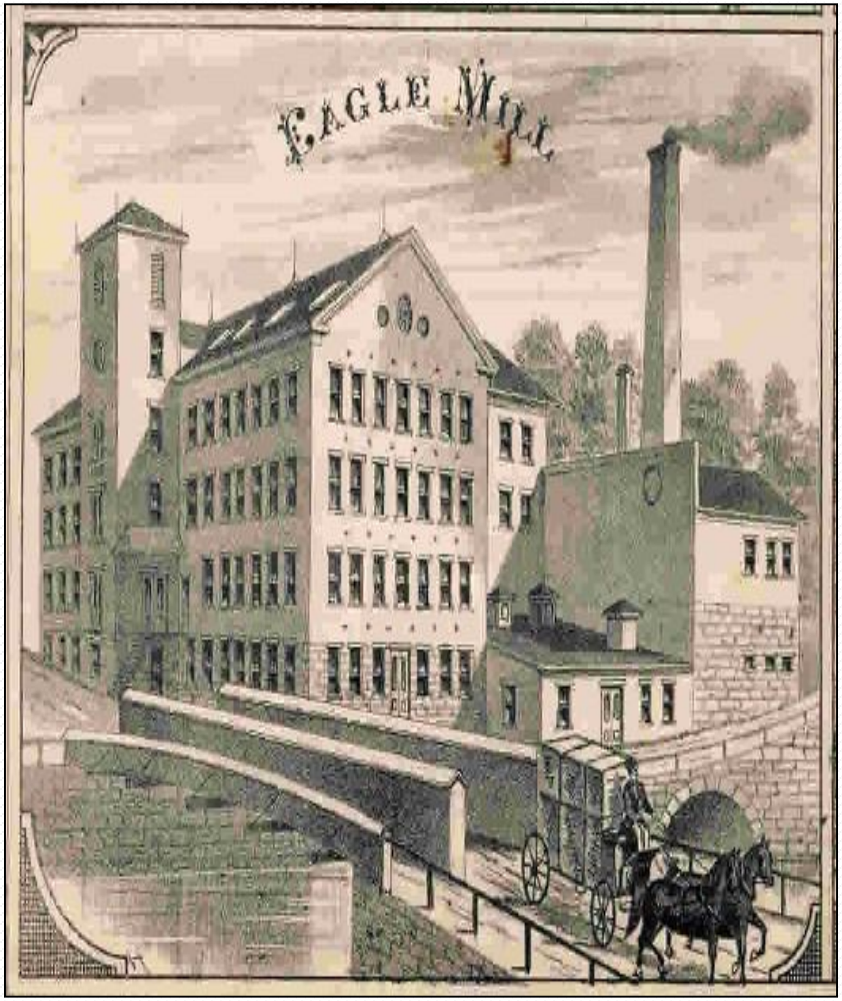
Timber and Agriculture

Transporting Logs



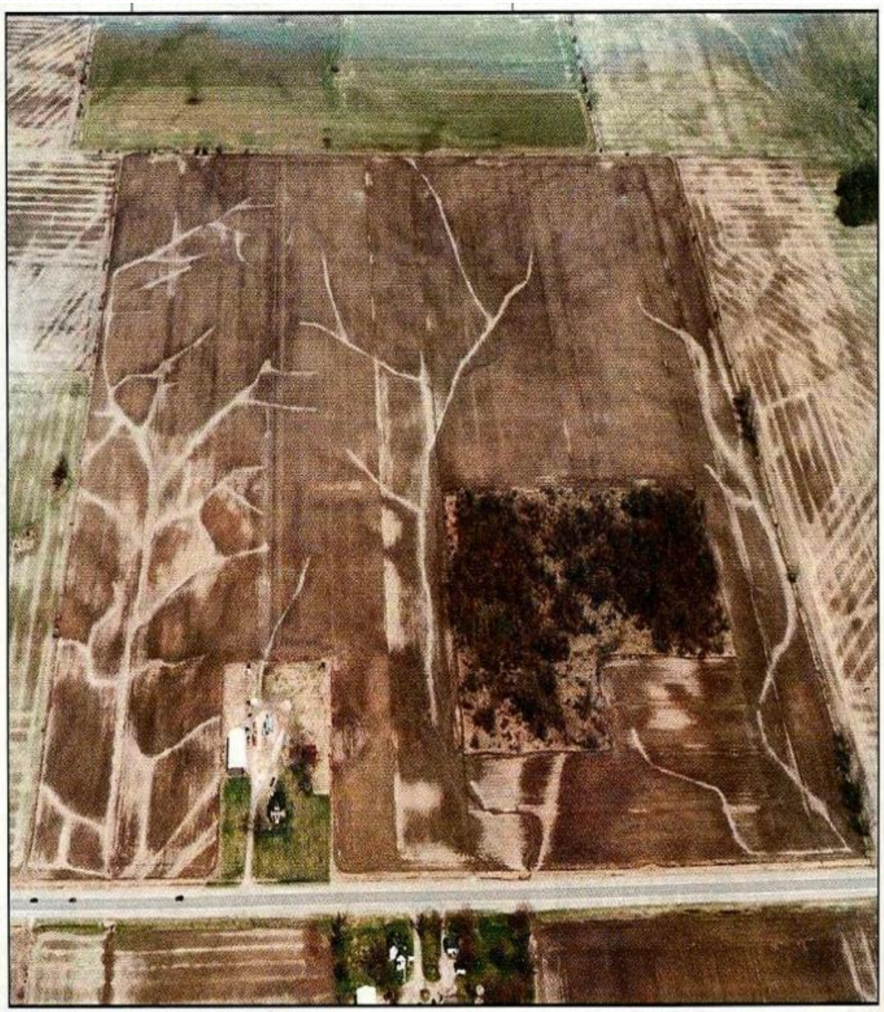
Mills Located on Streams



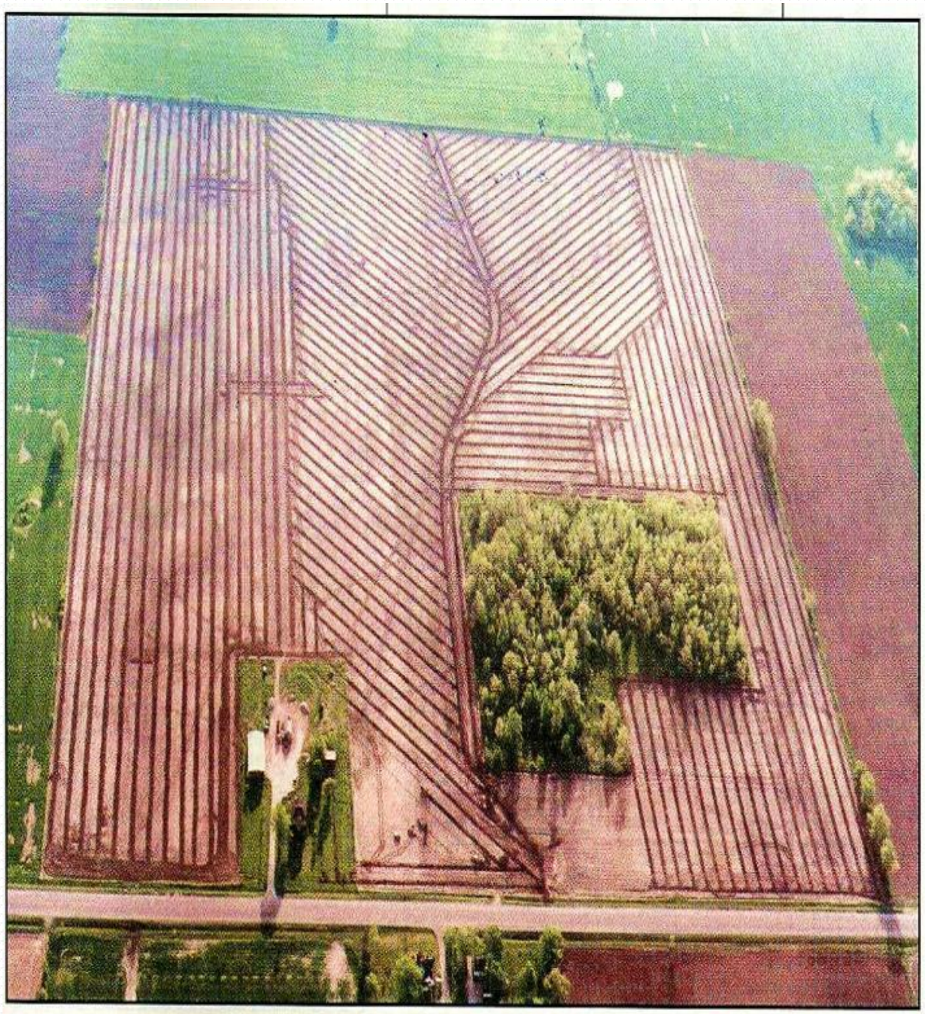


More Impervious Surfaces

Changing Drainage Patterns



Before field was drained on Jim Smith farm.



After tile lines were installed on Jim Smith farm.

Upland Development

Causes of Required Maintenance

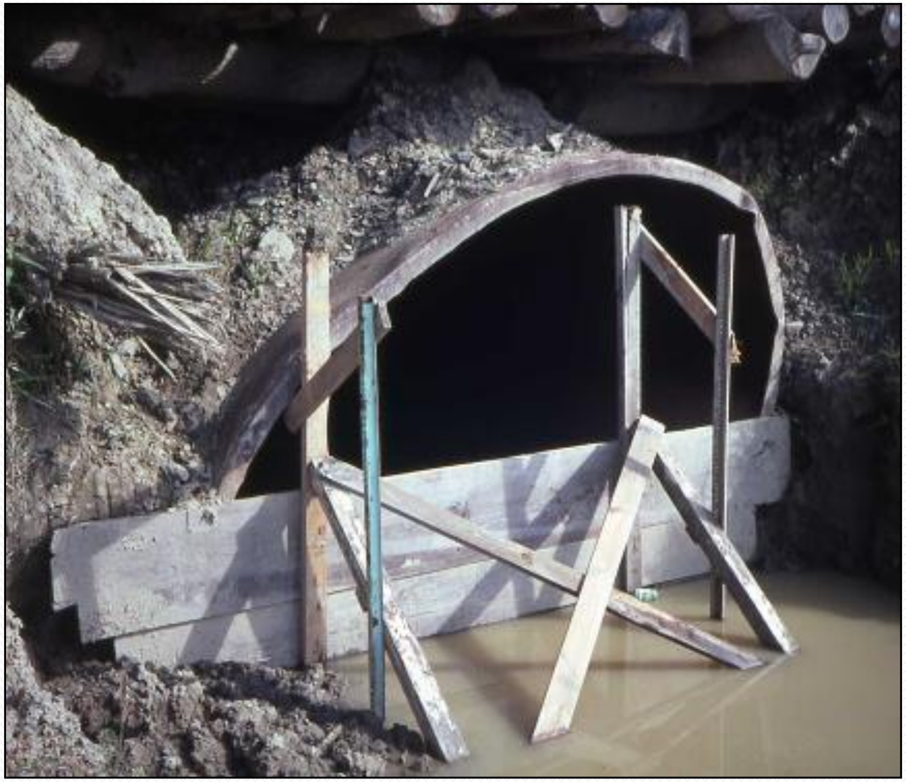
- **Flow Interruptions**
  - **Debris Jams, Ineffective Openings, Other Obstructions, etc.**
- Sediment Transport Interruptions
  - Excess Sediment Loading, Changes in Cross-Sectional Geometry, Significant Flood Event, etc.
- Changes in Hydrology
  - Land Cover Alterations, Time of Concentrations Routing, Significant Flood Event, etc.

Debris Jams

Ineffective Openings

Ineffective Openings

Other Obstructions



Causes of Required Maintenance

- Flow Interruptions
  - Debris Jams, Ineffective Openings, Other Obstructions, etc.
- **Sediment Transport Interruptions**
  - **Excess Sediment Loading, Changes in Cross-Sectional Geometry, Significant Flood Event, etc.**
- Changes in Hydrology
  - Land Cover Alterations, Time of Concentrations Routing, Significant Flood Event, etc.

Excess Sediment Loading

Excess Sediment Loading

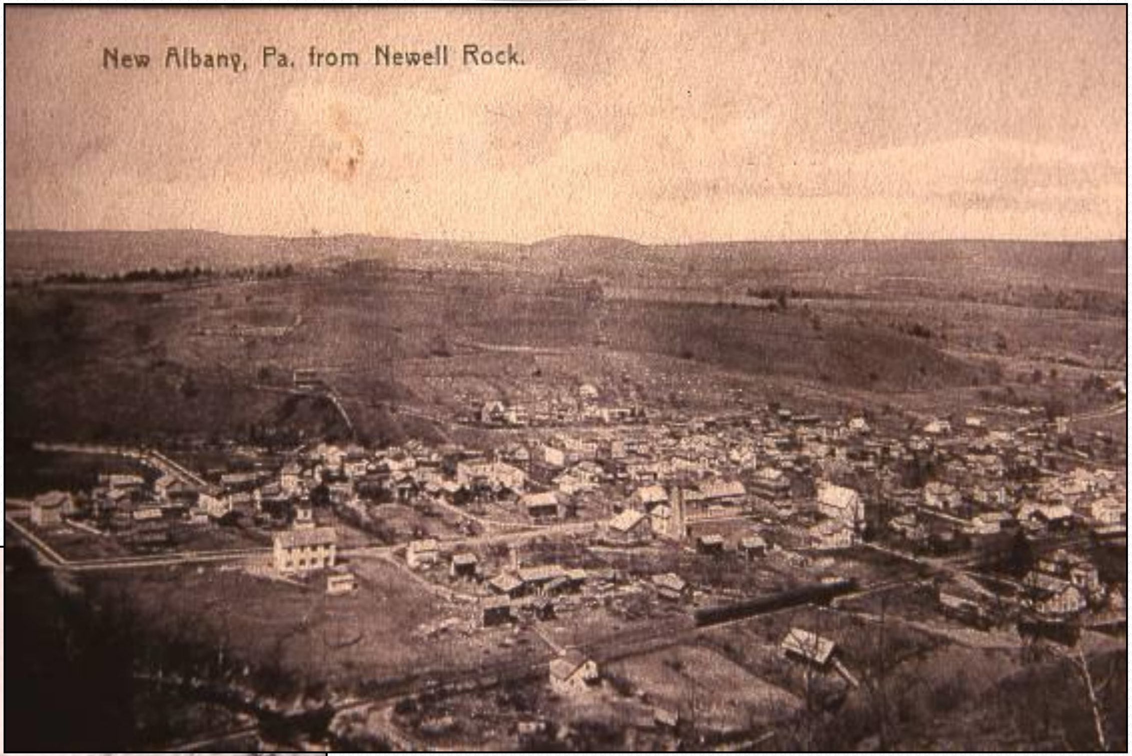
Excess Sediment Loading

Significant Flood Event

Causes of Required Maintenance

- Flow Interruptions
  - Debris Jams, Ineffective Openings, Other Obstructions, etc.
- Sediment Transport Interruptions
  - Excess Sediment Loading, Changes in Cross-Sectional Geometry, Significant Flood Event, etc.
- **Changes in Hydrology**
  - **Land Cover Alterations, Time of Concentrations Routing, Significant Flood Event, etc.**

Land Cover Alterations



Time of Concentration Alterations

Adverse Environmental Effects of Improper Maintenance!

- Introduction of Additional Sediment
- Elimination of Floodplain Access
- Entrenchment and Incision of the Channel
- Destabilization of Stream Corridor
- Removal of Stabilizing Vegetation
- Destruction of Aquatic and Terrestrial Ecosystems
- Limitation or Removal of Fish Passage
- Impacts on Infrastructure
- Threatened Life and Safety

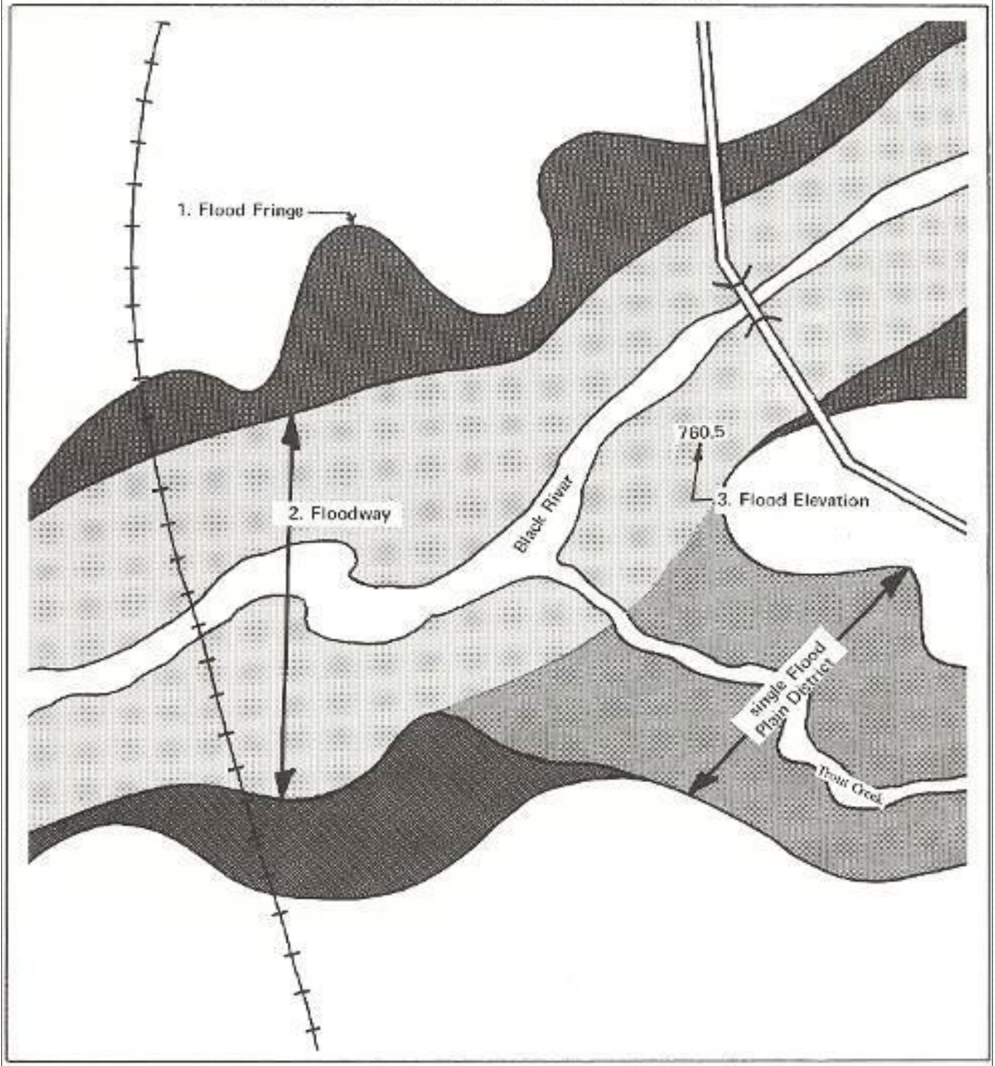
Lateral

Encroachment

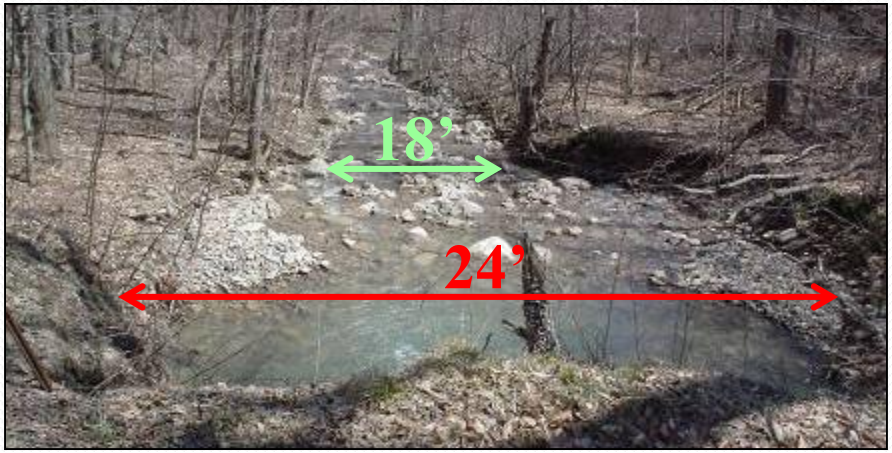
Lateral Encroachment

Transverse Encroachment

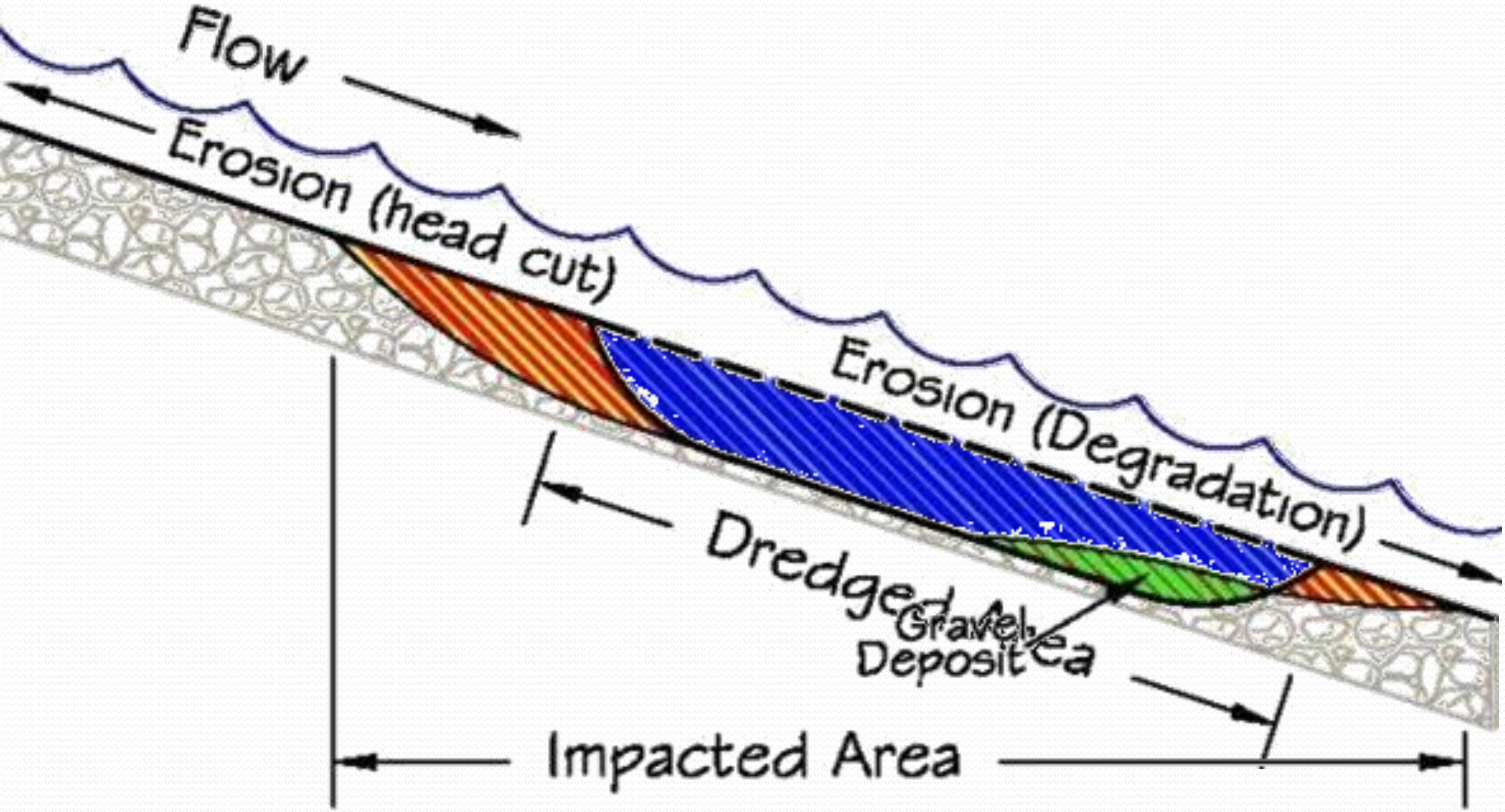
Figure 1. Example III, Three Flood Plain Districts.



Transverse Encroachment



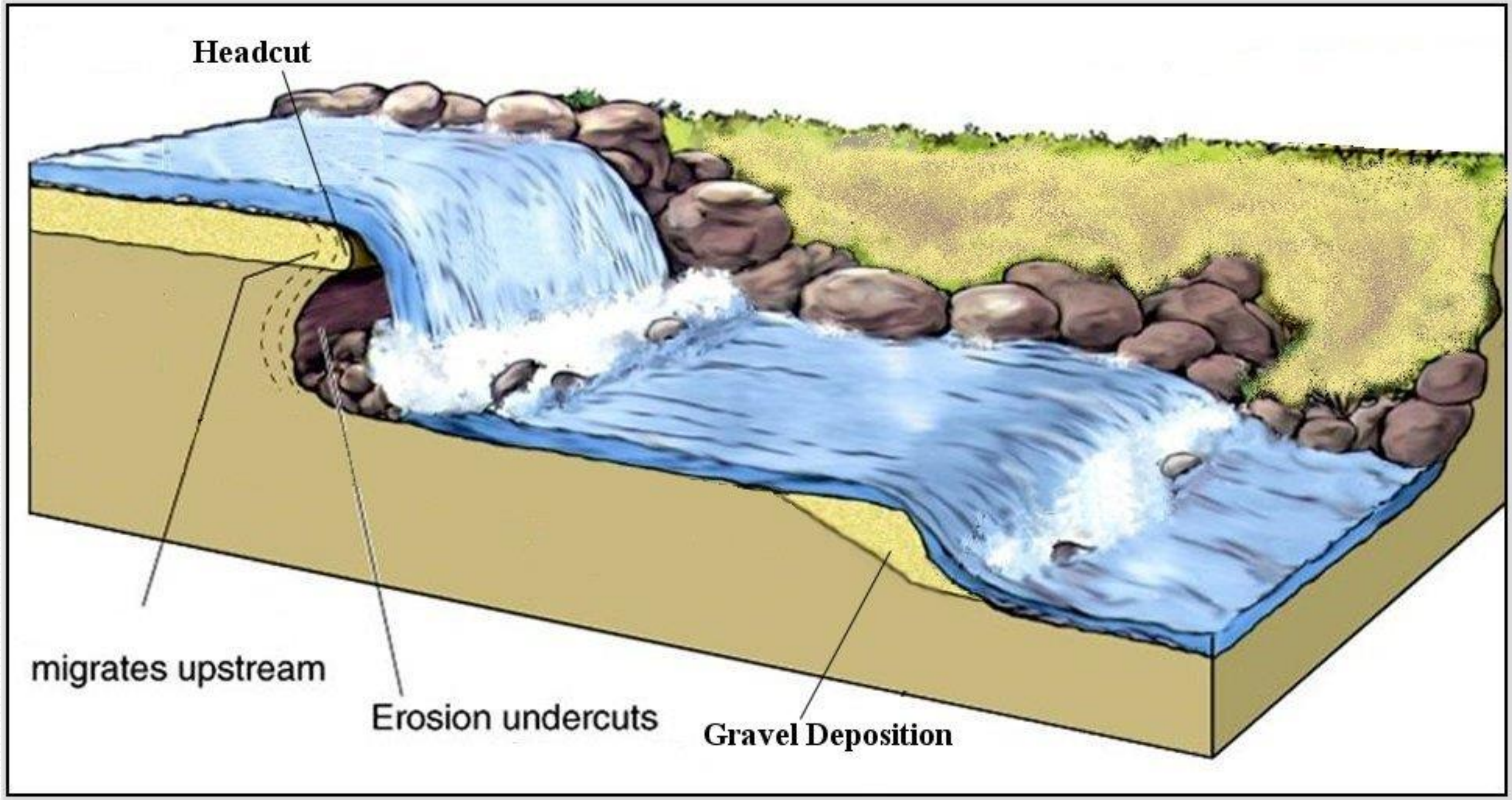
Dredging



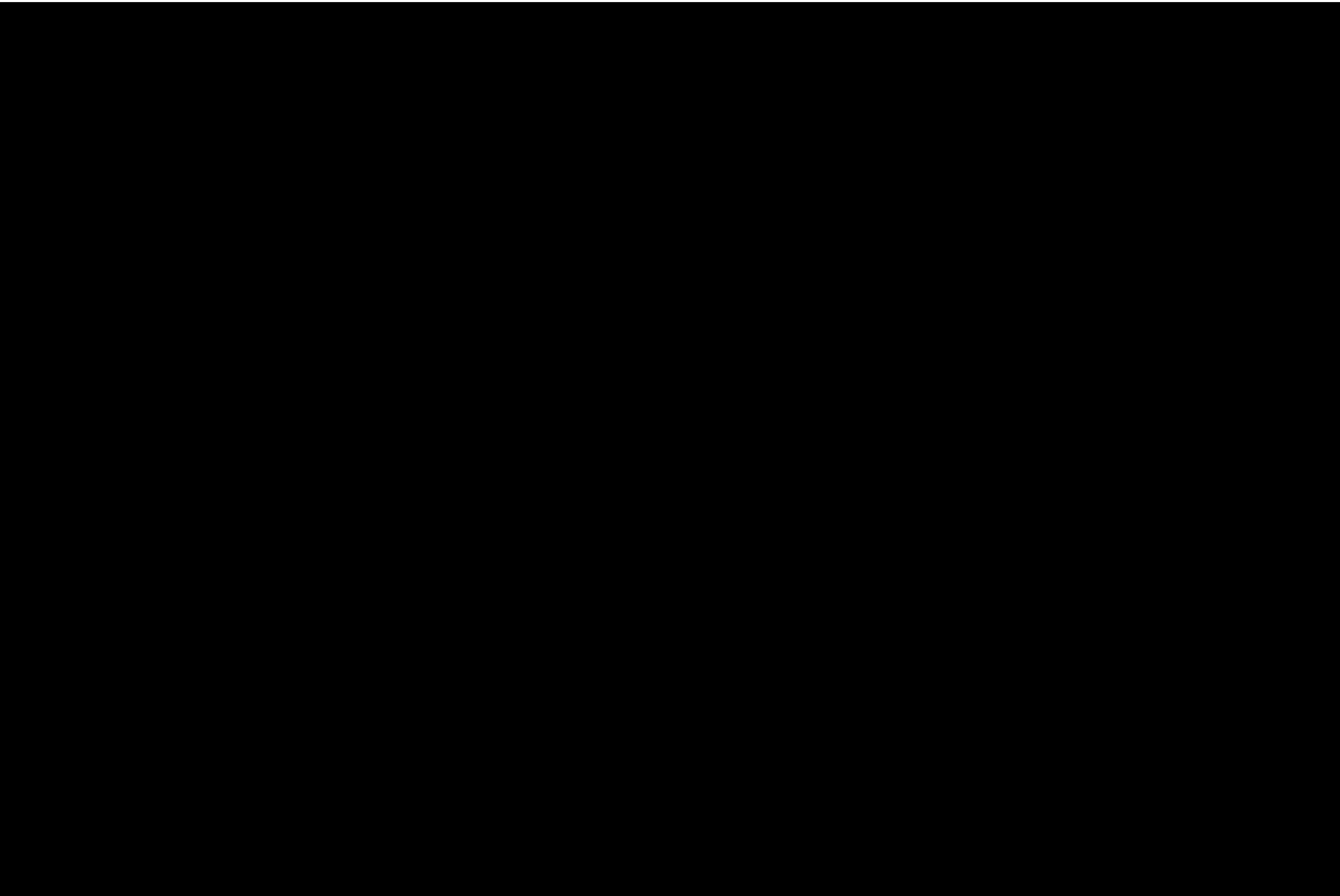
After R. Hey, 2003

Headcut Definition

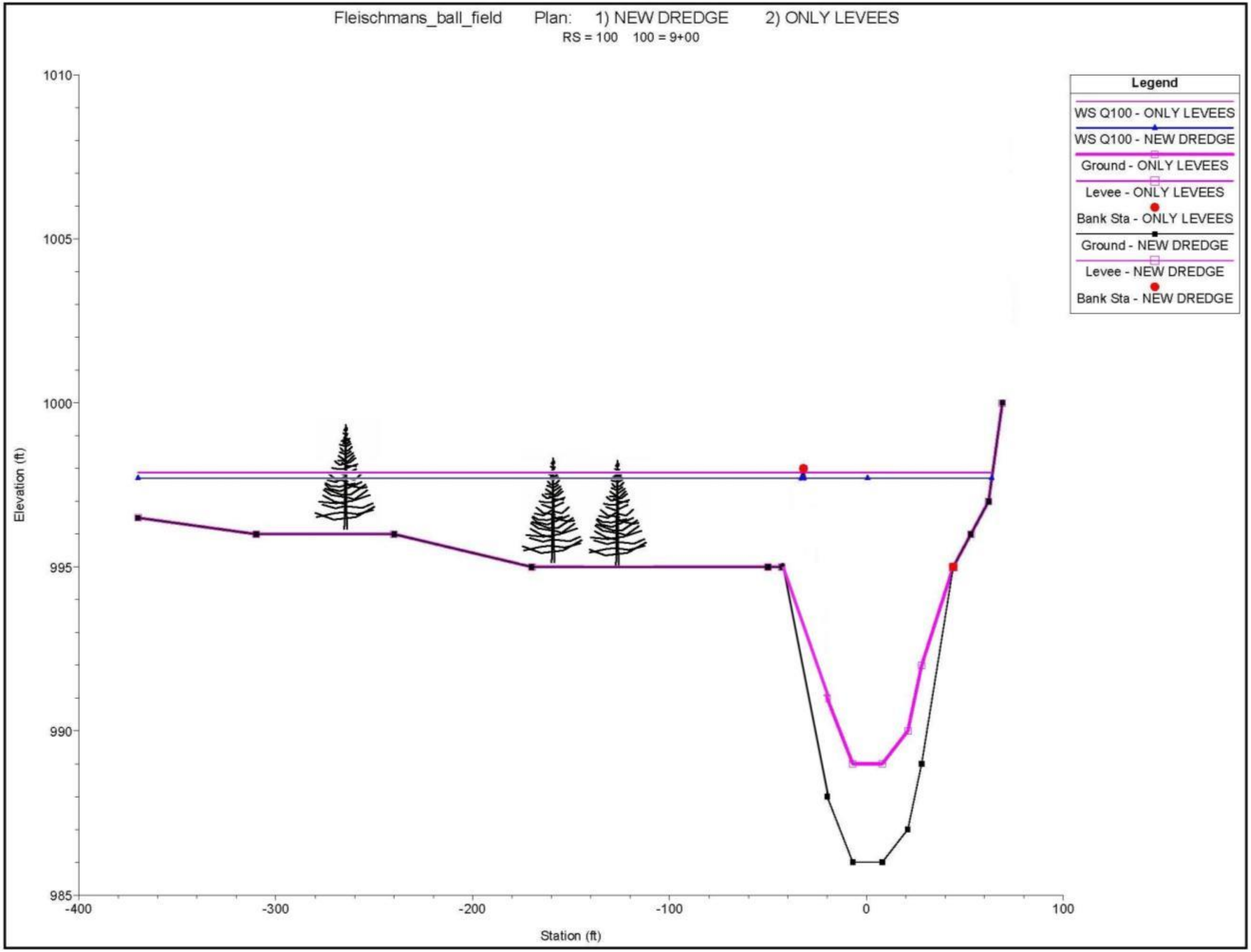
- Instability that progress ***upstream*** and ***downstream*** from a local disturbance.



Another Example of Dredging



Does Dredging help flooding?

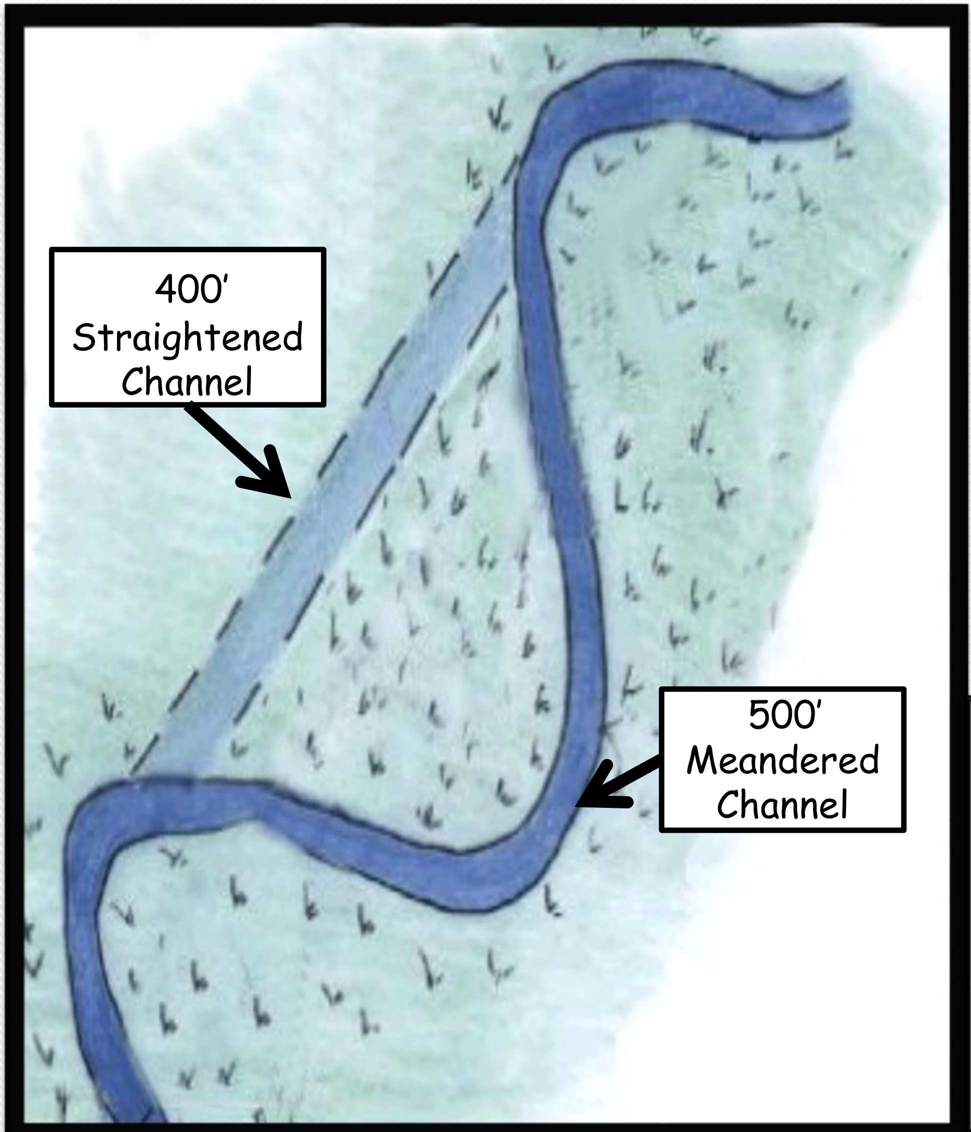



KOMATSU
PC300LC

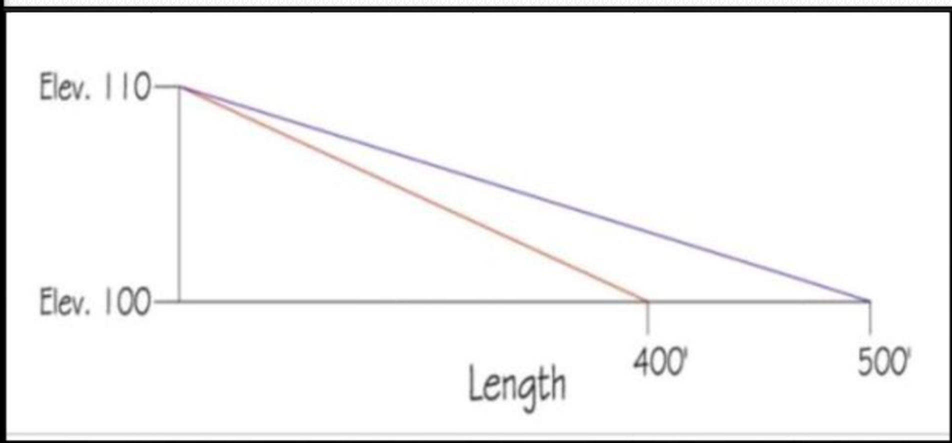

Steep riffle
Erosion
Channel is too wide
Gravel Deposition

Berms

Channel Straightening



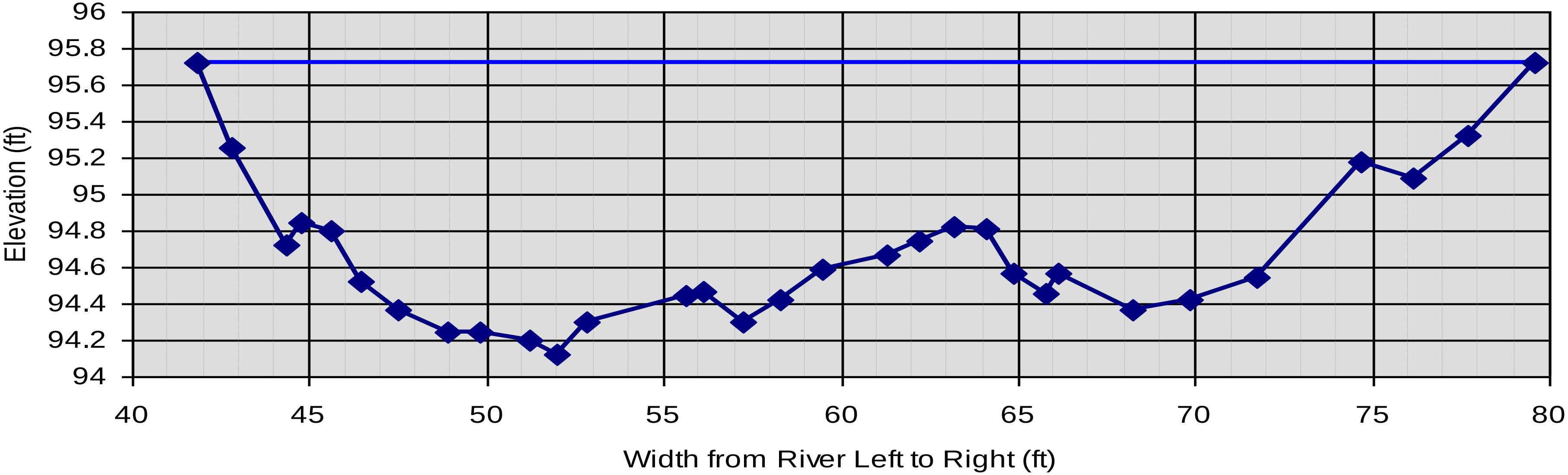
- Shorter distance means a steeper slope
- A steeper slope increases velocity
- A steeper slope increases erosion on the streambank and bed



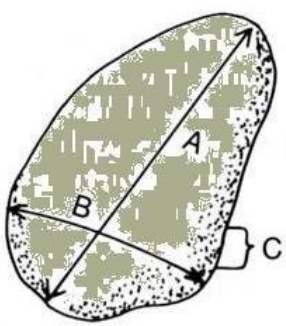
Stream Channel Straightening


MAY 25 2004

ORIGINAL X-SECTION



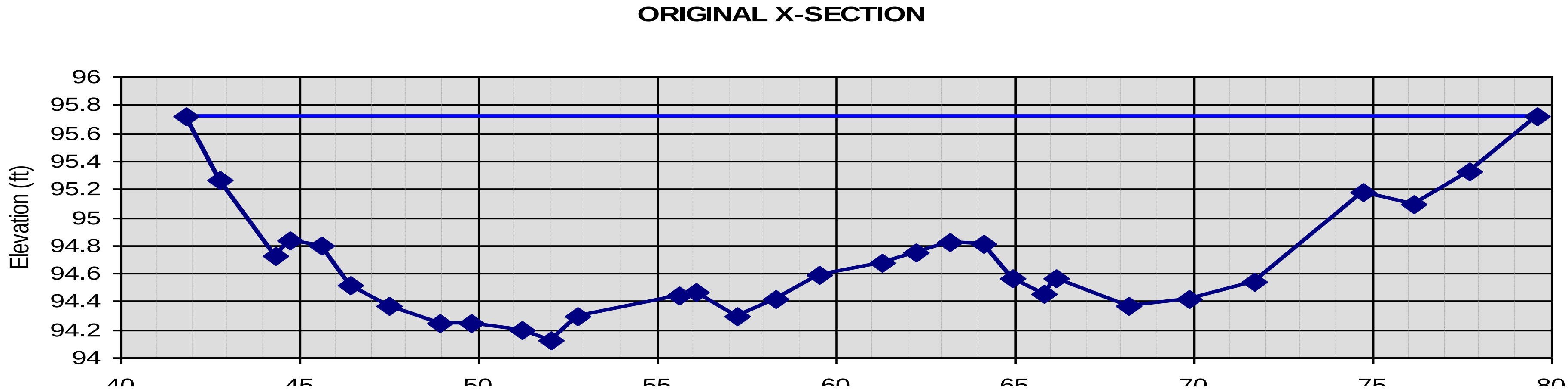
ORIGINAL VALUES PRIOR TO STREAM ALTERATIONS											
SLOPE	MEAN DEPTH	HYDRAULIC RADIUS	WIDTH	X-SECTIONAL AREA	MAX DEPTH	VELOCITY	DISCHARGE	SHEAR STRESS	SHEAR VELOCITY	UNIT STREAM POWER	THRESHOLD GRAIN SIZE (mm)
1.0	1.1	1.0	37.8	40.0	1.6	4.4	175.0	0.65	0.58	2.89	41.1

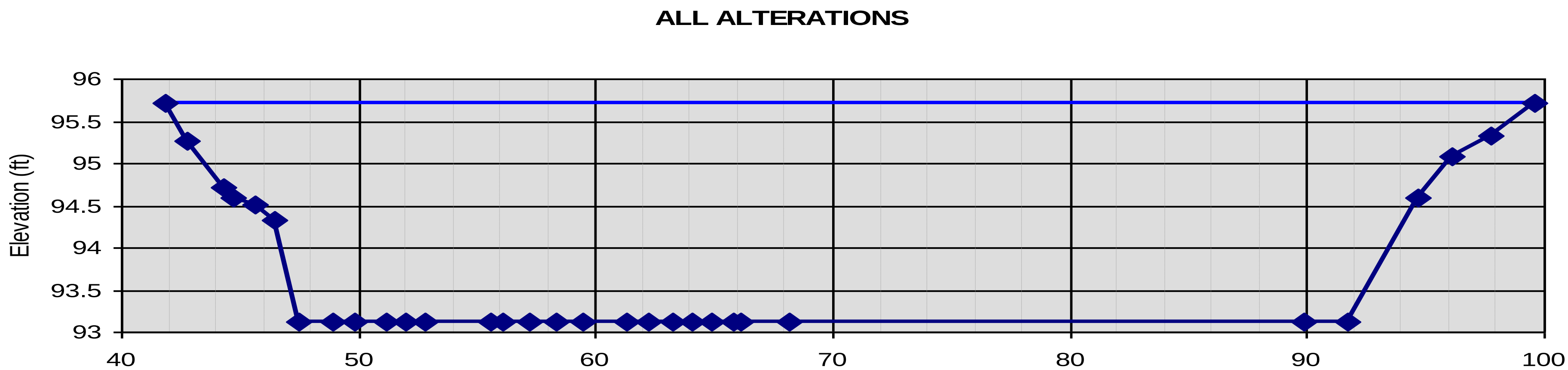


A = LONGEST AXIS (LENGTH)

B = INTERMEDIATE AXIS (WIDTH)

C = SHORTEST AXIS (THICKNESS)





CHANGES TO WIDTH, DEPTH AND SLOPE

SLOPE	MEAN DEPTH	HYDRAULIC RADIUS	WIDTH	X-SECTIONAL AREA	MAX DEPTH	VELOCITY	DISCHARGE	SHEAR STRESS	SHEAR VELOCITY	UNIT STREAM POWER	THRESHOLD GRAIN SIZE (mm)
1.0	1.1	1.0	37.8	40.0	1.6	4.4	175.0	0.65	0.58	2.89	41.1
1.5	2.2	2.2	57.8	128.9	2.6	8.7	1127.8	2.04	1.03	18.26	292.0
0.05	2.2	2.2	57.8	128.9	2.6	1.6	205.9	0.07	0.19	0.11	4.7

Destabilization of Stream Corridor

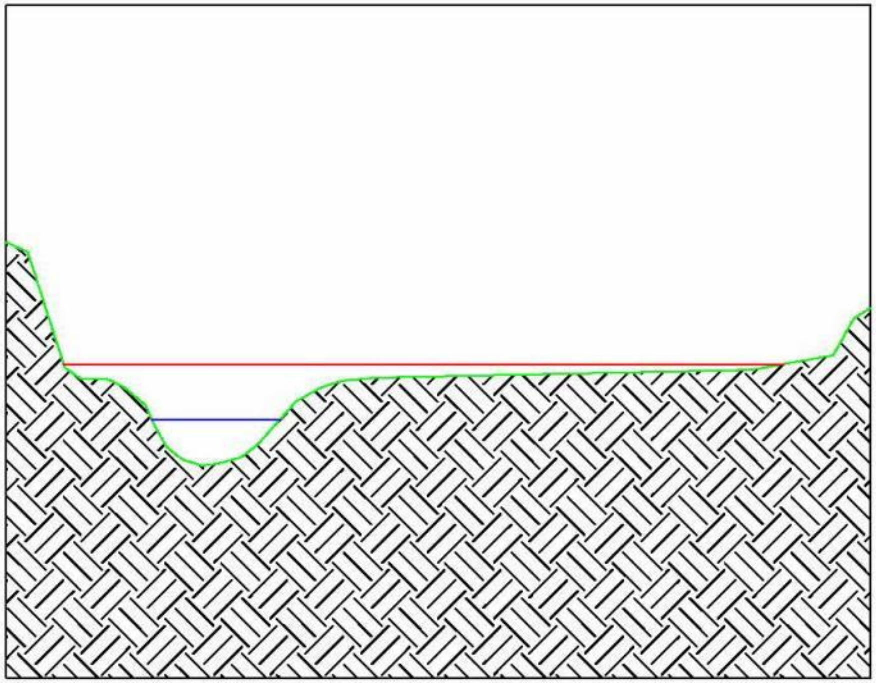
Erosion – Mass failures

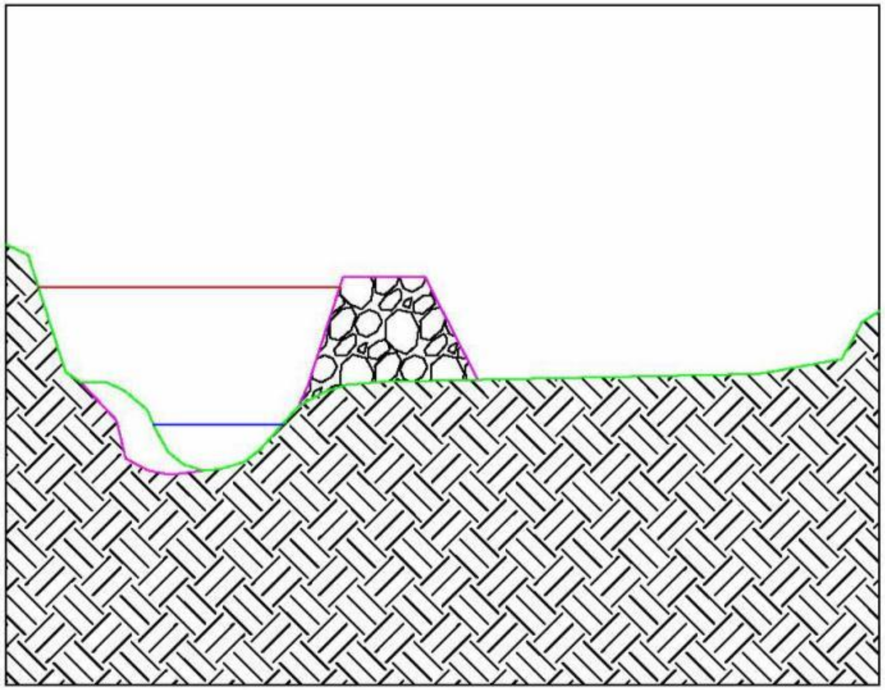
Erosion – Lateral Migration

Impaired Floodplains

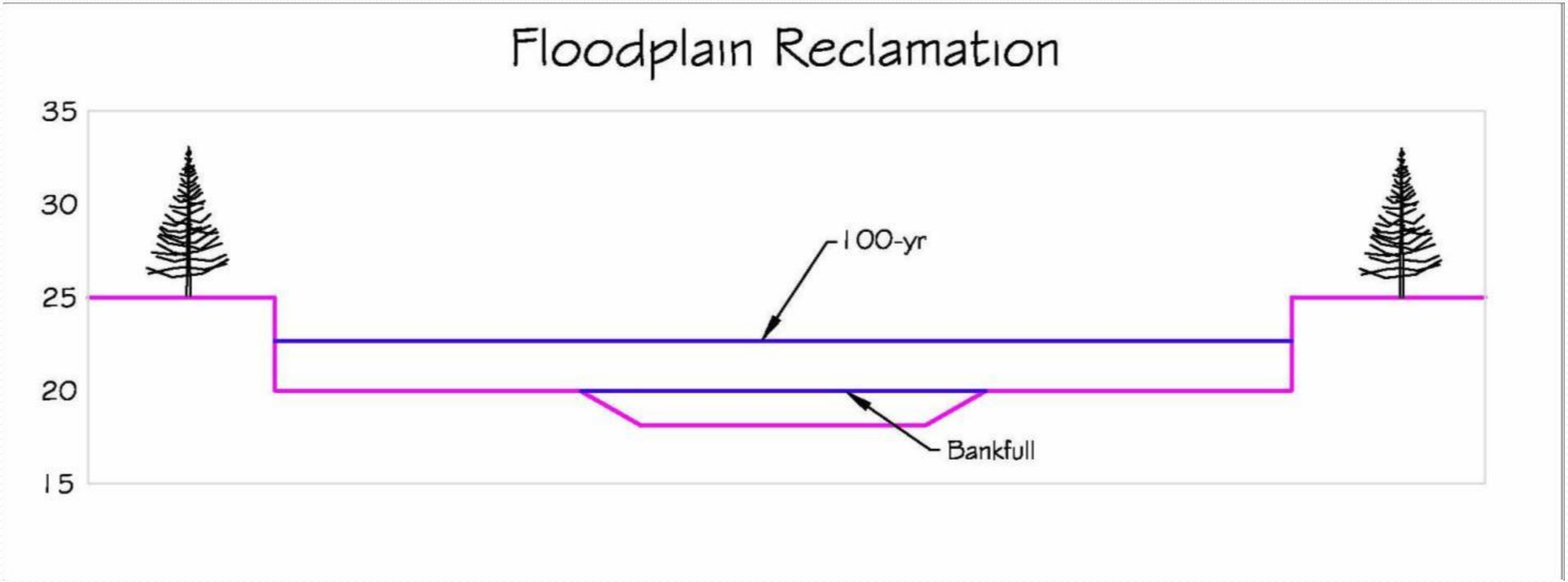
Berms Definition

An earthen embankment or wall, usually built to provide protection or a result of side casting during stream channel dredging





Channel Modifications

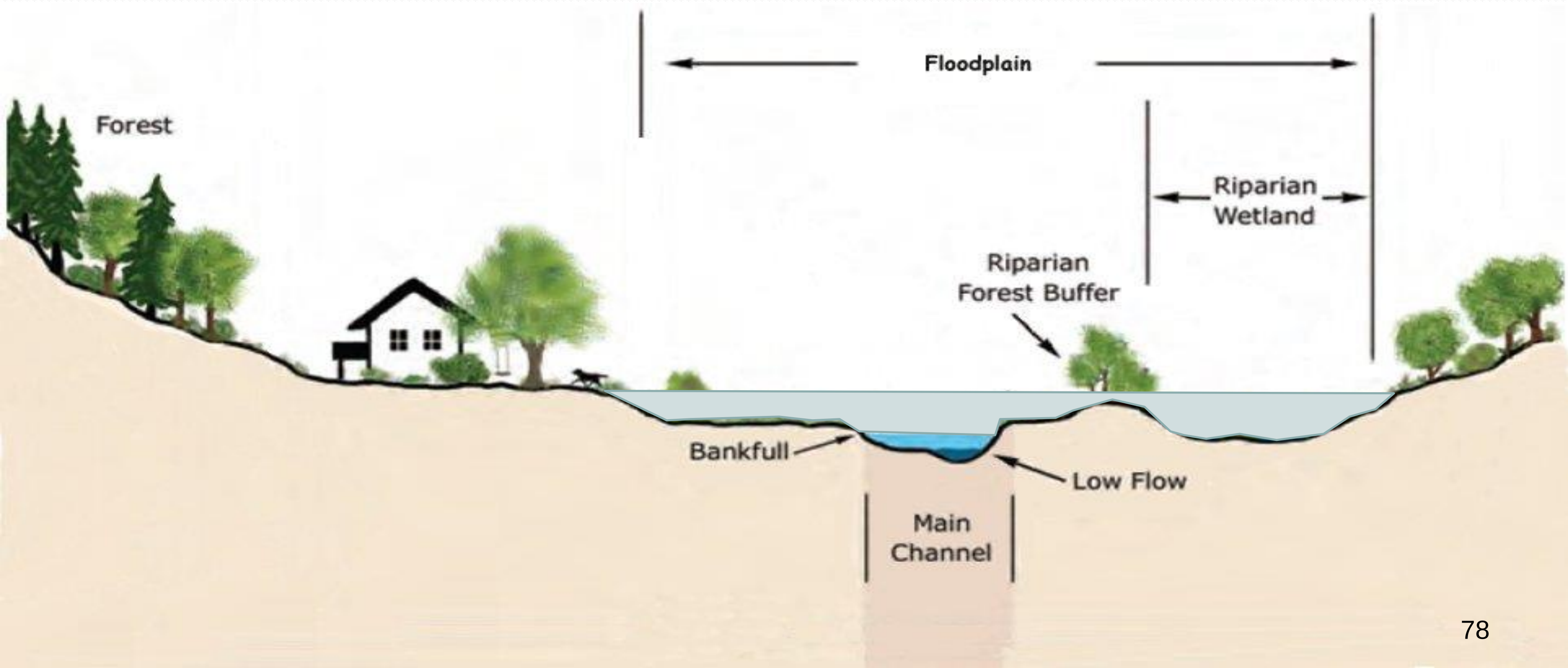


When the channel is disconnected from the floodplain…

- Velocity and energy of Stream increases
- Erosion increases
- More damage to infrastructure from debris
- The flood stage is higher

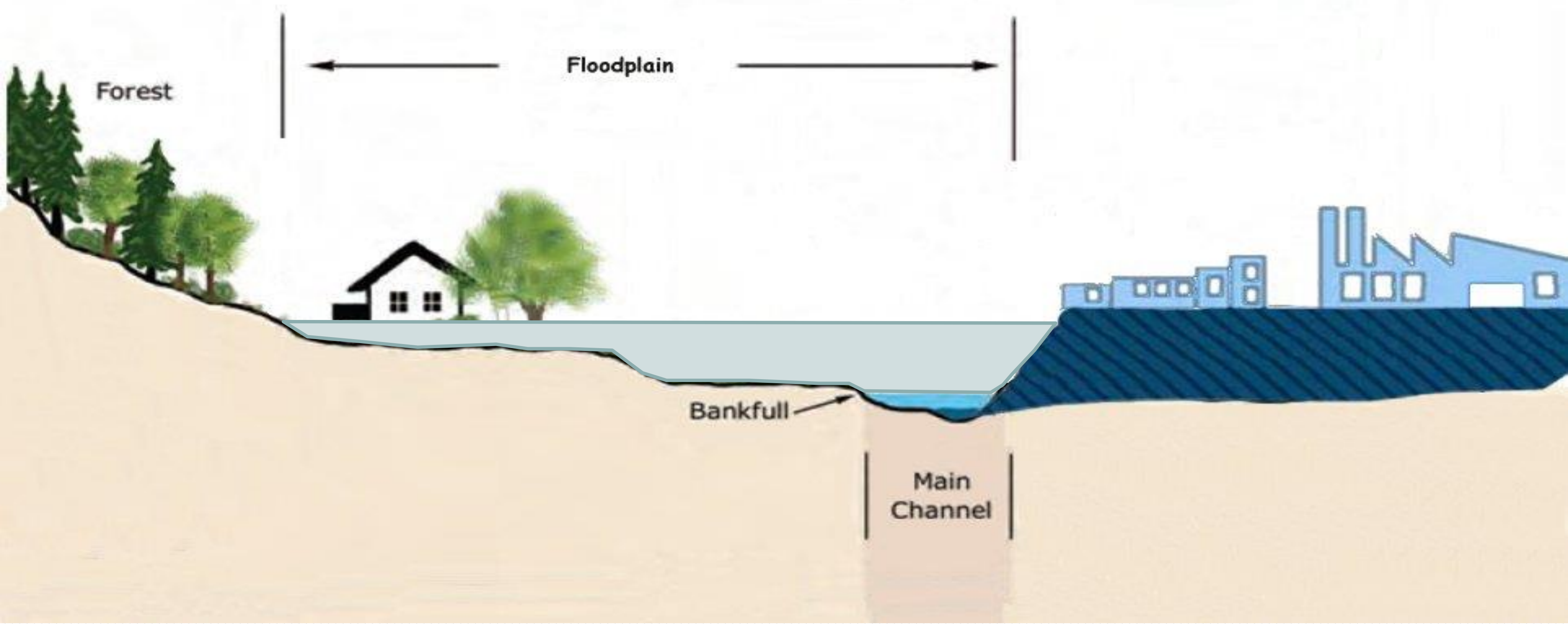
Floodplain

The floodplain is part of the river during storm conditions



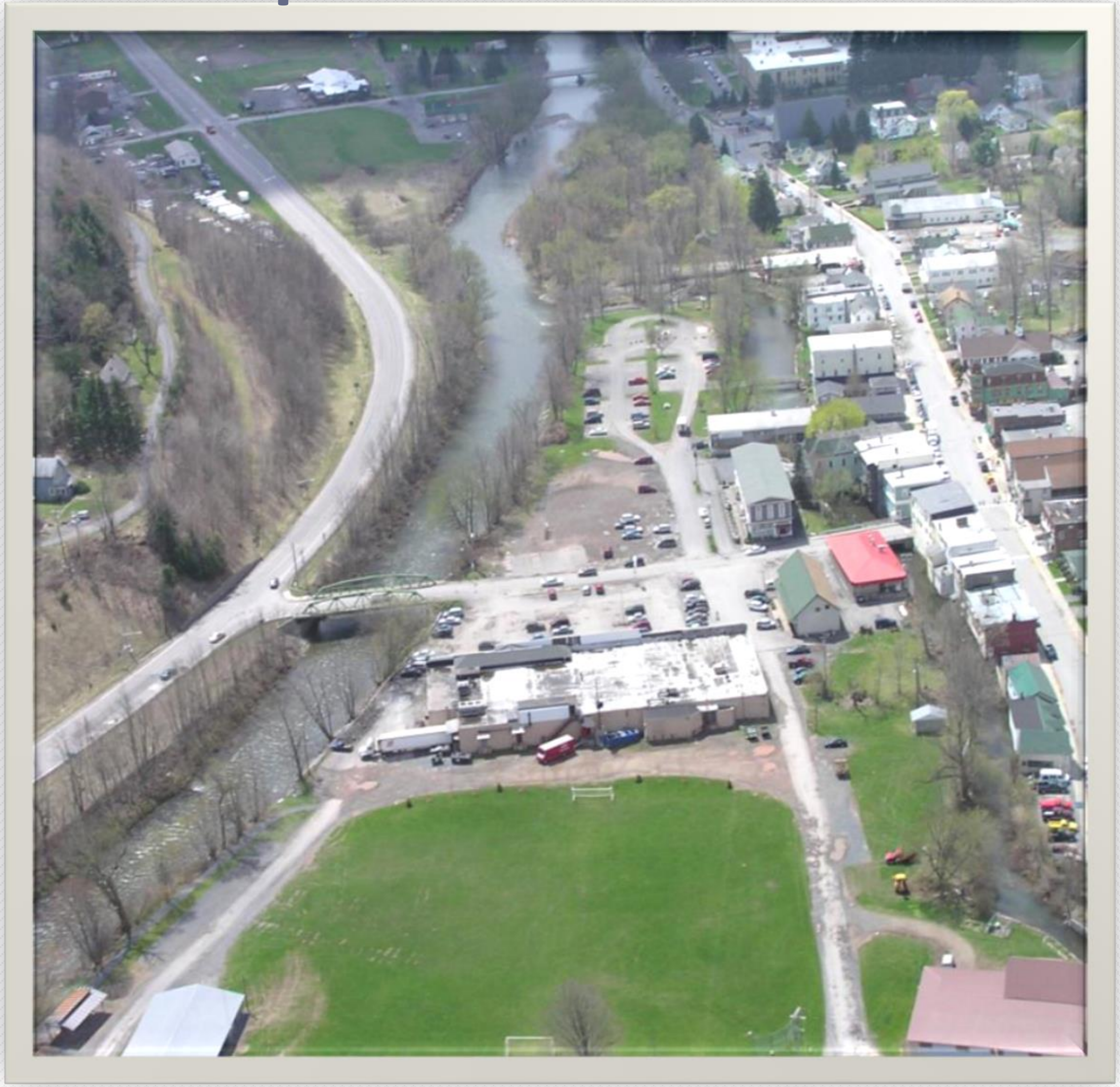
Today's Floodplains are not necessarily Tomorrow's floodplain

If large areas of the floodplain are filled, then there will be an increase in the land area needed to store flood waters. This means your home, farm, or business may be impacted.



Floodplain Development

- Buildings
- Bridge approaches
- Roads
- Parking lots
- Etc.



When the floodplain is developed…

- More threat to life and property
- Velocity and energy increases
- Erosion increases
- More damage to infrastructure
- The flood stage downstream is higher
- Higher cost of flood damage
- Increased flood insurance

Floodplain development can lead to significant stream issues including erosion & infrastructure damage


08/28/2011


RESTAURANT


Flood water level

Unstable Channels

General Channel Responses to Instabilities

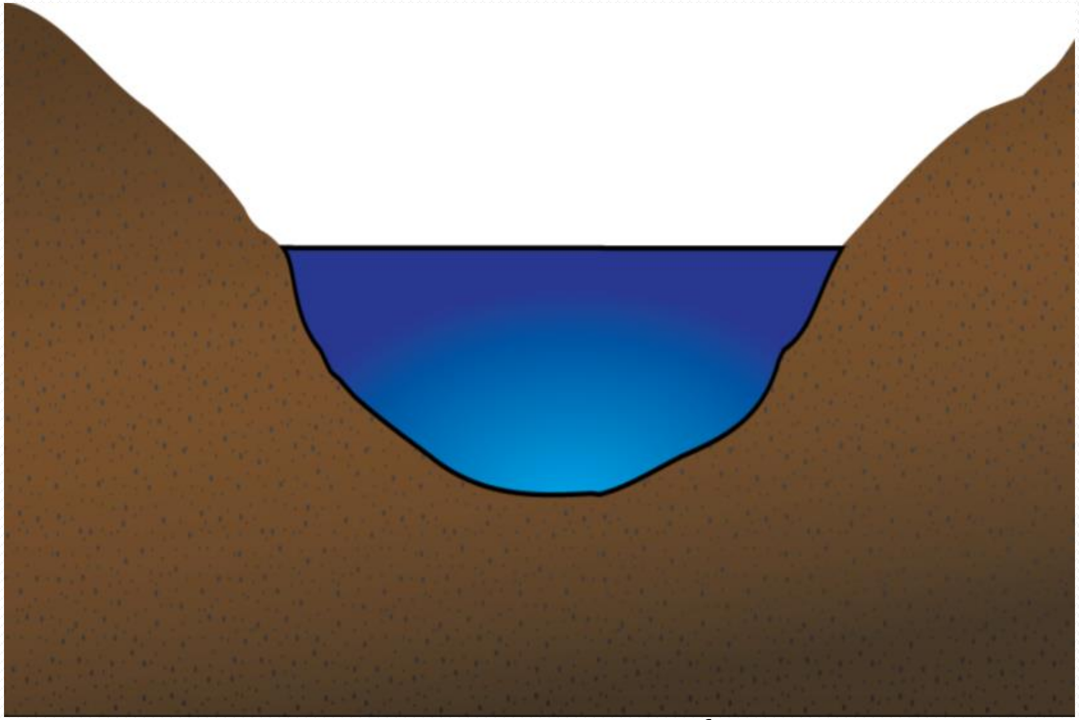
- Instability progresses **downstream** when there is a change in local sediment supply
  - **Increased supply** (landslide or gravel rich tributary) results in deposition downstream
  - **Decreased supply** (as from a dam or concrete or heavy stone lined channel) results in downstream erosion

General Channel Responses to Instabilities

- Instability progresses **upstream** when there is a change in local channel form
  - **An incised channel** (dredged or severely down-cut) results in bed erosion upstream
    - Usually in the form of a head-cut
  - **An aggraded channel** (as from a dam or overly wide) will result in deposition upstream

Incised or Entrenched Channels

- Streams that cannot access their floodplain at the bankfull flow are said to be incised or entrenched
- Incised streams display high velocities & erosive forces during floods
- Incised streams are almost always unstable



After Rosgen 1996

Avulsions Definition

- Avulsions are where the stream is no longer in its original channel
- Is it …
  - A threat to water quality ?
  - A threat to property?
  - A better alignment?
- Is it possible to work with this new alignment?

Avulsions

- Do NOT work if there is no immediate danger to property or necessary infrastructure
- *Notify the municipality and SWCD that there is an avulsion*

Avulsions

- Do work if property or infrastructure is in danger
- Ask for assistance from County SWCD or USC
- If the repair must be made immediately
  - Bring the “new” bank up to the same elevation as the existing ground
  - Armor with large rocks if any are available
  - Notify County SWCD or USC of the repair immediately
- *This repair will be temporary and will require careful monitoring*

Platte Kill avulsion 2009

Platte Kill avulsion 2011

SECTION III

UPPER SUSQUEHANNA COALITION

EMERGENCY STREAM INTERVENTION

&

STREAM MAINTENANCE PROTOCOL TRAINING OVERVIEW

FLOOD RESPONSE

Flood Response

- Immediate Priority Items
- High Priority Items
- Assessment
- Repair
- Documentation and Further Needs

Immediate Priority

- *Immediate priority items are those facilities and infrastructure which need to be repaired and/or kept open in order that further recovery may be allowed to continue, or to prevent immediate loss of human life*

Immediate Priority Items

- During or right after a flood some things must be done, including, but not necessarily limited to:
  - Opening clogged bridges
  - Opening closed roads
  - Keeping important installations functioning:
    - Power Plants
    - Fire Stations
    - Rescue Centers
    - Hospitals
    - Water Wells & Systems
    - Sewage Treatment Plants & Systems

Flood Repair

"Emergencies" – obvious problems

- Bridges plugged
- Roads severely damaged/closed
- Buildings (especially inhabited buildings) endangered

High Priority Items

- High priority items are those items that are necessary for the first part of the cleanup process
- This course concentrates on getting channels back into some acceptable condition
  - Open clogged channels
  - Put avulsed channels back in place
  - Stabilize actively eroding streambanks
  - Stabilize (even if only temporarily) landslides
  - *Return the channel to a condition such that the natural processes of streams can begin to return it to its natural state*

Assess the Stream Channels

- To decide where to work and where not to work
- To decide where to work first
- To identify the equipment and work force that will be required
- To identify reaches that require technical assistance

Where to Work – Channel Problems

- Actively eroding high banks
  - Eroding bank is heading toward infrastructure or homes
  - High sediment load from eroding bank
  - Another “small flood” would “blow out” the bank
- Channel blocks
- Debris at culverts
- Undermined revetments
- Impaired channel capacity

Actively eroding high banks

Channel Block

Debris at a Culverts

Undermined Revetment

- Revetment may become undermined due to:
  - Improper installation depth
  - Stream downcutting

Impaired Channel Capacity

Where Not to Work

- The channel dimensions are ok, or there has been little damage
- Banks are stable
- The channel bottom is imbricated
  - The gravel is "shingled" and is difficult to move
  - Moving the gravel around loosens it and erosion at the reach and deposition downstream

Would you work here?

- Single channel
- Meanders
- Floodplain

Would you work here?

- Single channel
- Some meander
- Stable banks

Understanding Imbrication

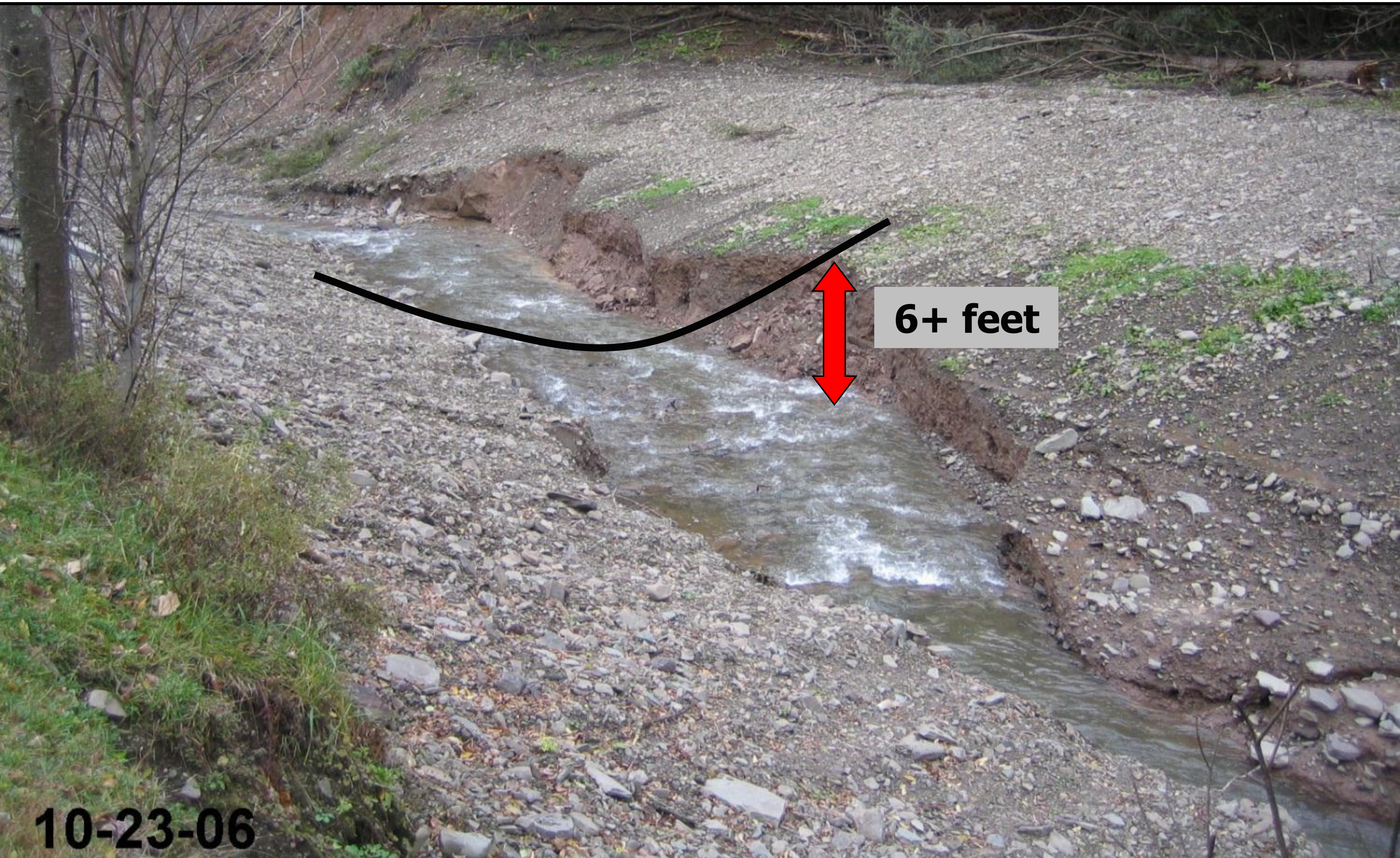
- As storm flows subside bed material overlap and become wedged together like shingles
- Caused by water velocity
- Materials are less mobile

Is this what you would do here?


3-06-08

This downstream adjustment created a head-cut upstream…

This slope was actively migrating as the stream continued to lower its bed to adjust its profile. This increased potential risk to those downstream.



Post-Flood Work

- Improper post-flood work can negatively affect:
  - Stream function
  - Stream stability
  - Aquatic habitat
  - Water quality
  - Local resources
- Improper post-flood work can add costs to future repair

Post-Flood Problem Itemization Sheet

- This is located in **Appendix A** in Training Manual
- It lists problems commonly found after a flood
- Use a sheet for each stream reach
- Check off problems; add any notes/sketches that are necessary
- Customize the sheet to suit your needs
- Photos should be taken during the assessment

Post-Flood Problem Itemization Sheet

- The advantages to using the sheet are:
  - Identify the location, number & types of problems on each reach
  - Identify the most severely impacted reaches (keep in mind that some streams or reaches may not be impacted at all)
  - Prioritize work on the most severely impacted reaches
  - Determine manpower & equipment needs
  - Revision of priorities may be required throughout assessment period

Post-Flood Problem Itemization Sheet

- The sheets can serve as a record:
  - That can document work done for state or federal reimbursement
  - This document can be attached to a permit application as additional information
  - To document work done under an emergency permit

Immediate Post Flood Emergency Stream Intervention
Problem Itemization Sheet

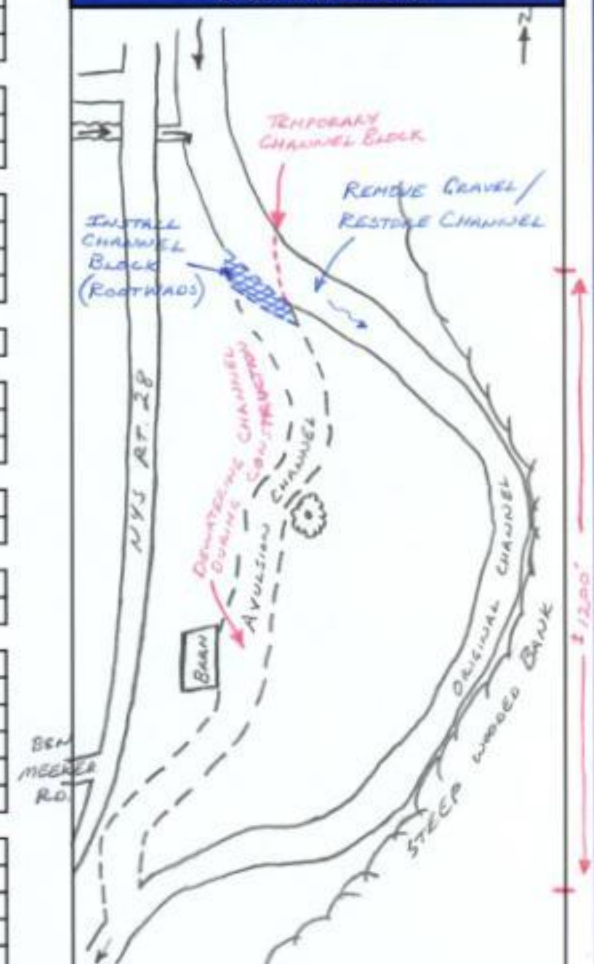
Date: 3/16/09 Time: 2:30 PM

Crew: JOEL + GALE

Stream	PLATTE KILL
Reach	

		YES	NO
Debris Jam at Bridge/Culvert			✓
	Bridge / Culvert		
	Location		
Scour at Bridge/Culvert			✓
	Footings exposed		
	Undermining		
Mass Failure			✓
	Estimated height (avg)		
	Estimated length (avg)		
	Number of failures		
Debris/Log/Gravel Jams		✓	
Avulsion		✓	
	Estimated length	1200'	
	Estimated width	40'	
Scouring/ Down Cutting			
	Estimated depth		
Head Cut			
	Estimated depth		
Gravel Deposits		✓	
	Location - center	✓	
	left side		
	right side		
	Estimated height	3'	
	Estimated length	75'	
Eroded Banks			
	Left bank		
	Right bank		
	Estimated height		
	Estimated length		

Sketch or Comments



Further Documentation

- Recommended documentation during construction:
  - Before & After photos
  - Description of the work
    - Date
    - Time
    - Equipment
    - Material
    - Labor Force

Further Documentation

- Post Construction Review
  - Was the work performed satisfactorily & completely, and meet the needs identified on the Post-Flood Problem Itemization Sheet?
- Contact SWCD, USC or NYCDEC for assistance with:
  - Vegetation
  - Structures
  - Long Term Monitoring

Channel Sizing

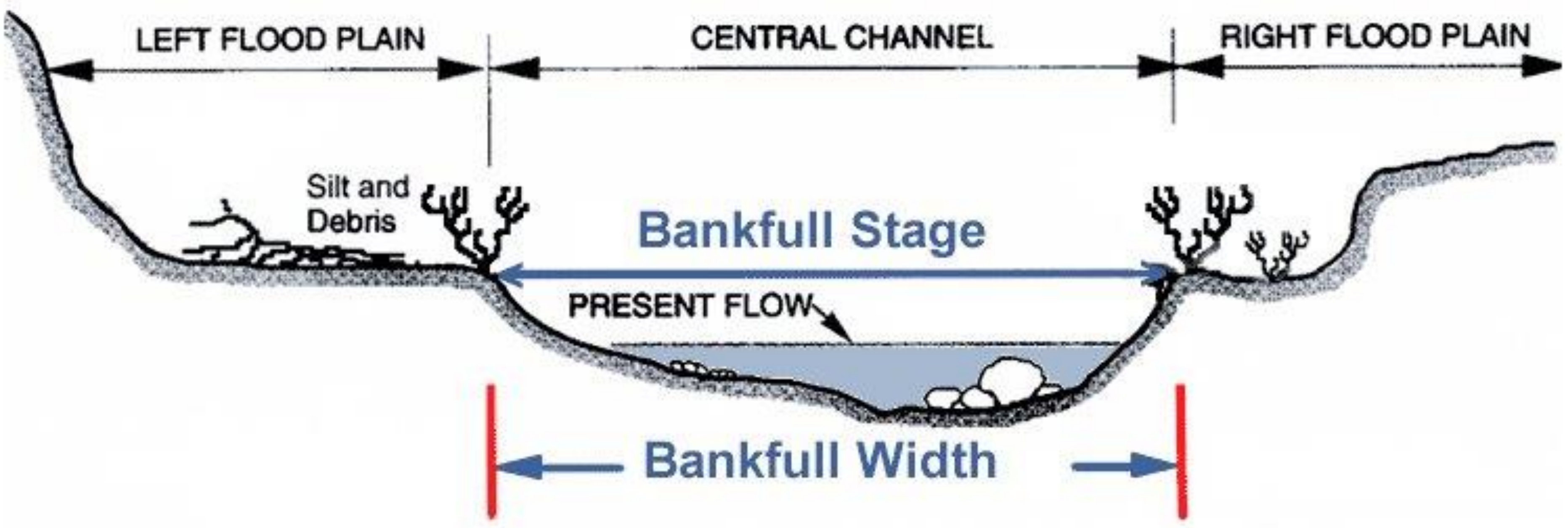
Bankfull Flow

- Bankfull flow is the channel forming discharge

"The bankfull stage corresponds to the discharge at which the channel maintenance is most effective, that is, the discharge at which moving sediment, forming or removing bars, forming or changing bends and meanders, and generally doing the work that results in the average morphologic characteristics of the channel."

Dunne and Leopold, 1978

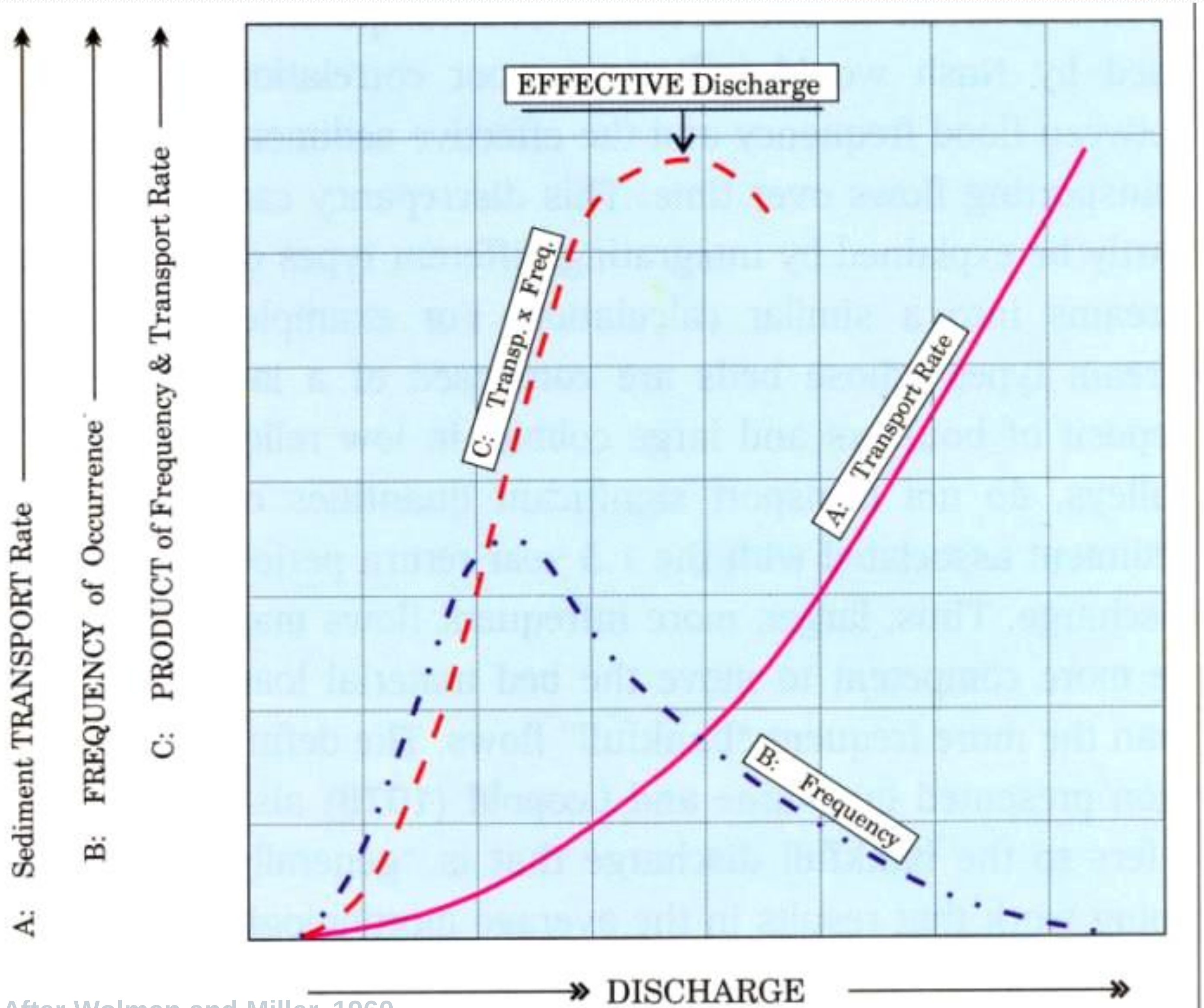
Bankfull Flow



Adapted from Newbury & Gaboury, 1993

Effective Discharge

How the stream is created and maintained



After Wolman and Miller, 1960

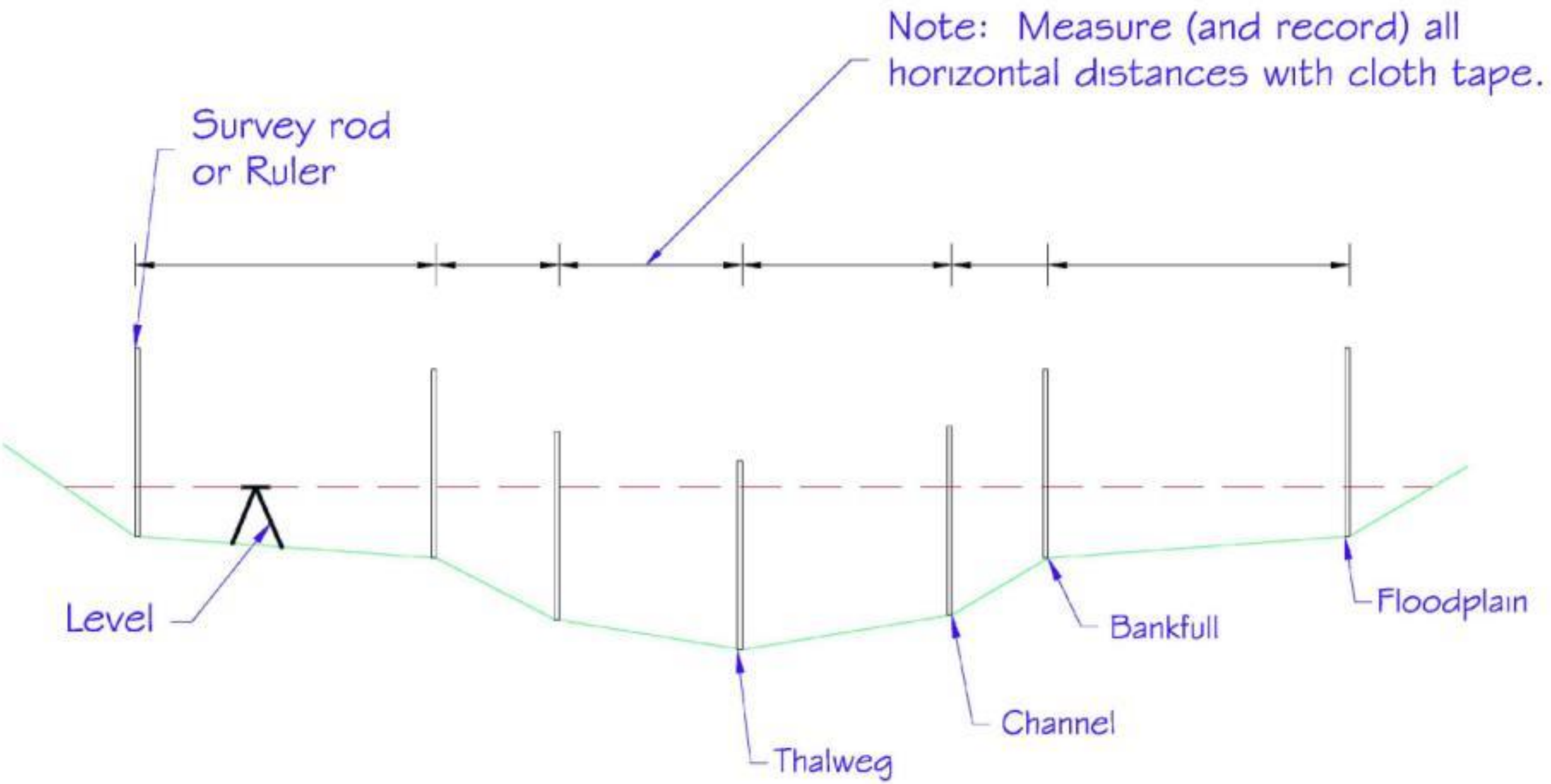
Channel Forming Discharge

- Channel forming discharge, effective discharge, & bankfull all have the same meaning
- The channel forming discharge is approximately equal to the 1.5 year storm
- The regional curves that give information about the size of the channel are based on the bankfull or channel forming discharge

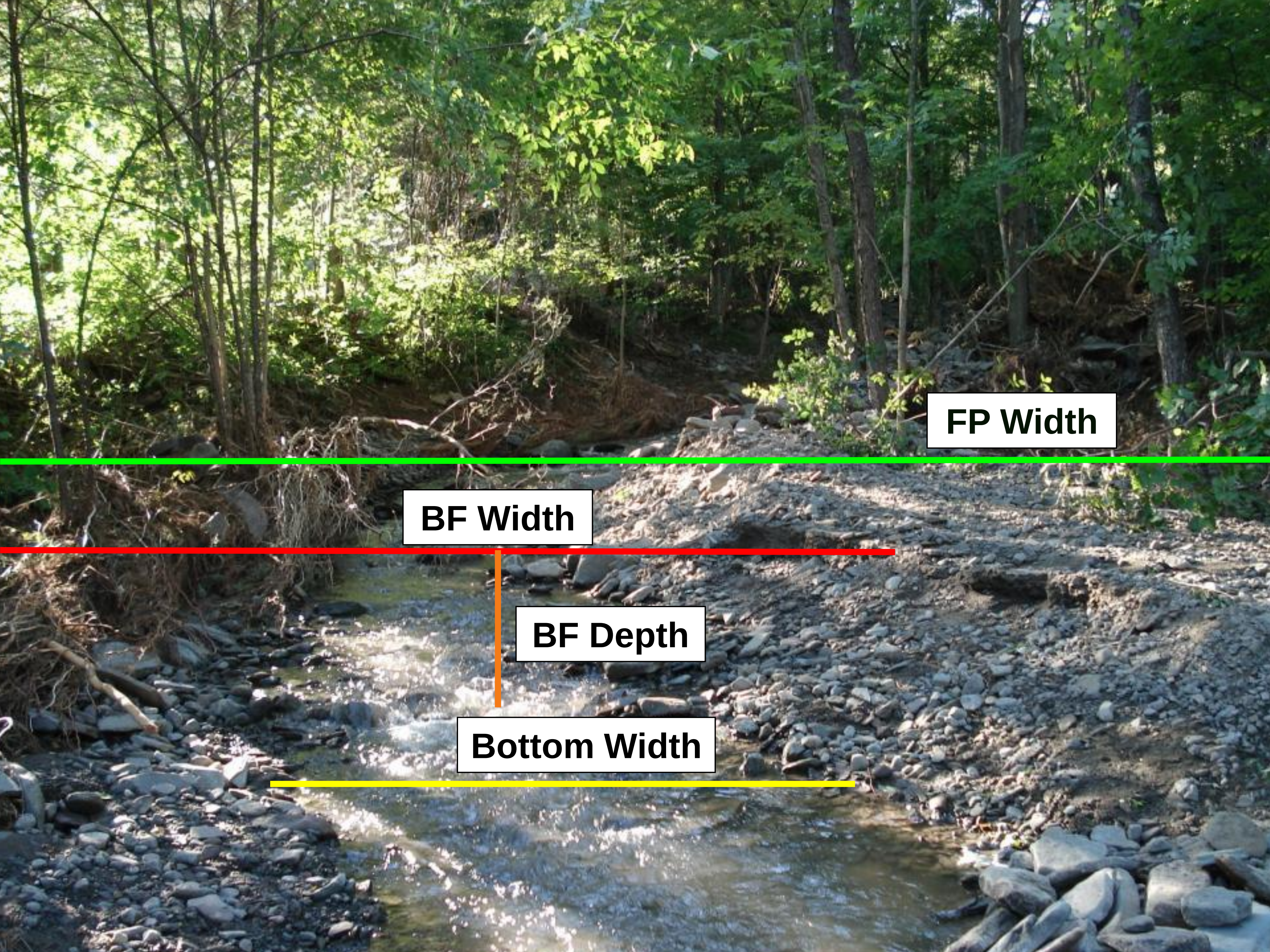
Using an Existing Stable Reach

- Use of the tables may not be required
- A relatively undamaged reach may exist either upstream or downstream
- Measure the undamaged reach & duplicate it in the damaged reach (draw a sketch)
  - Bankfull width and depth, floodplain width, bottom width, meander curve radius, and stream slope
- Call SWCD or USC for assistance

Using an Existing Stable Reach



Points to measure on a stable riffle cross section

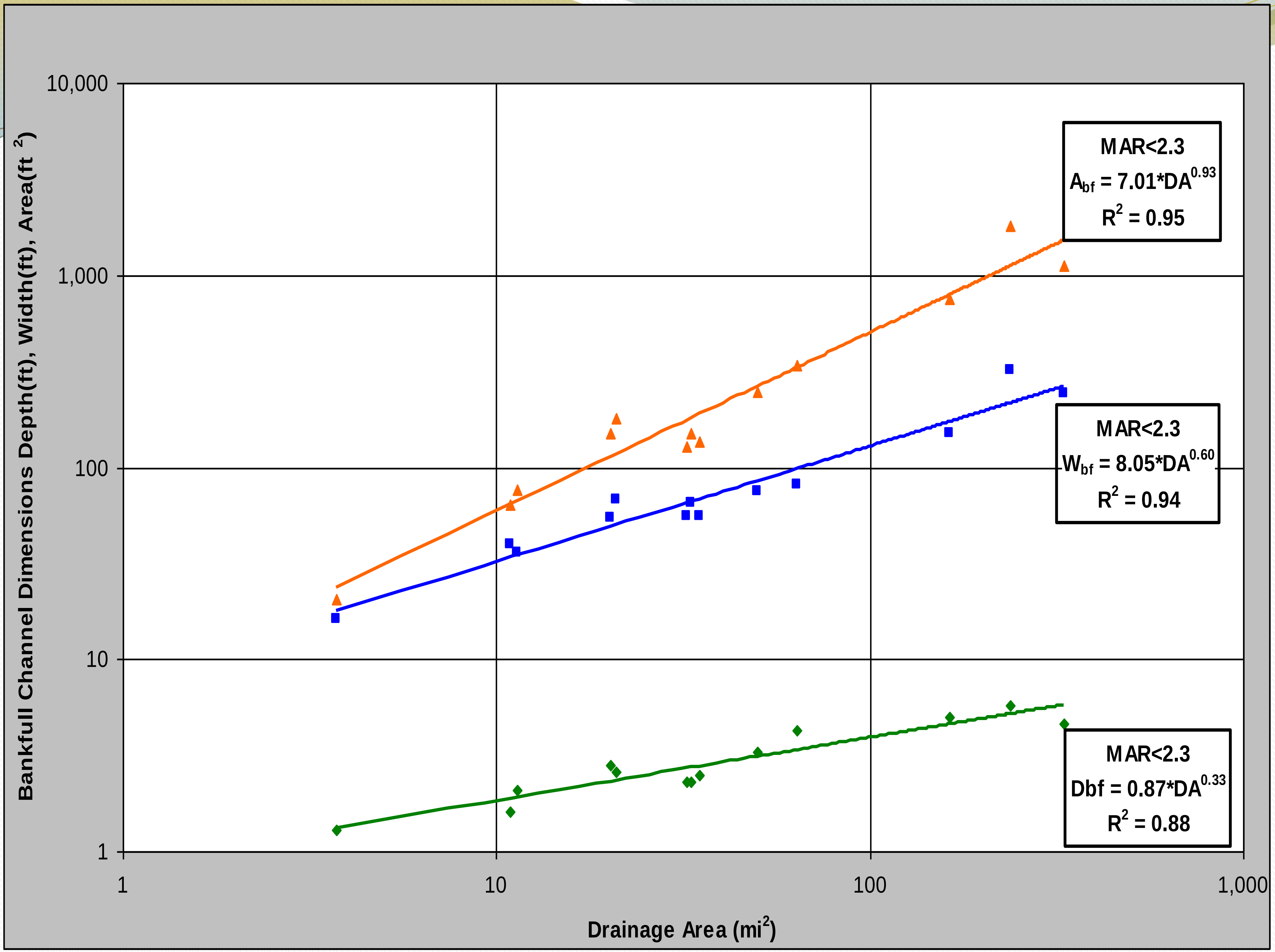


FP Width
BF Width
BF Depth
Bottom Width


Meander radius & slope

Regional Curves / Stream Stats

- Based on data collected by USC, NYCDEC & USGS gage station
- Information given is based on Drainage Area
- Represents the size & cross section of natural streams in this region
- Dimensions given – Bankfull Dimensions
  - Cross sectional area
  - Bankfull top width
  - Average bankfull depth (mean depth)



Bankfull Channel Dimensions Depth(ft), Width(ft), Area(ft 2)
10,000
1,000
100
10
1
1
10
100
1,000
Drainage Area (mi2)
MAR<2.3
Abf = 7.01*DA0.93
R2 = 0.95
MAR<2.3
Wbf = 8.05*DA0.60
R2 = 0.94
MAR<2.3
Dbf = 0.87*DA0.33
R2 = 0.88

Regional Curves

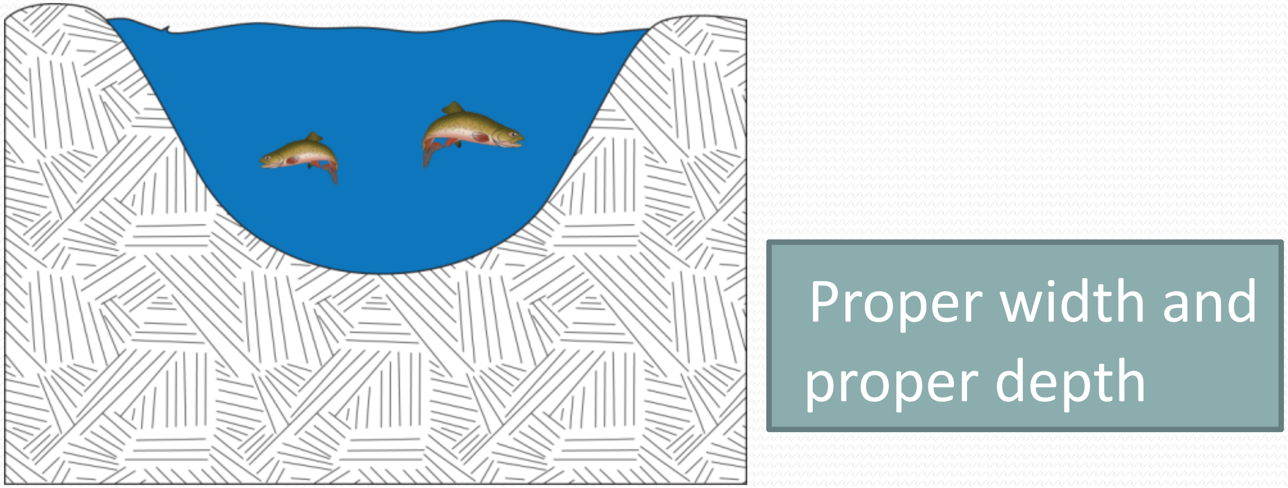
- After a flood the channel dimensions have often been changed – **too big** or **too small**
- Sometimes it is difficult to determine the original size of the stream
- Use the Regional Curves/Stream Stats to get reasonable bankfull dimensions

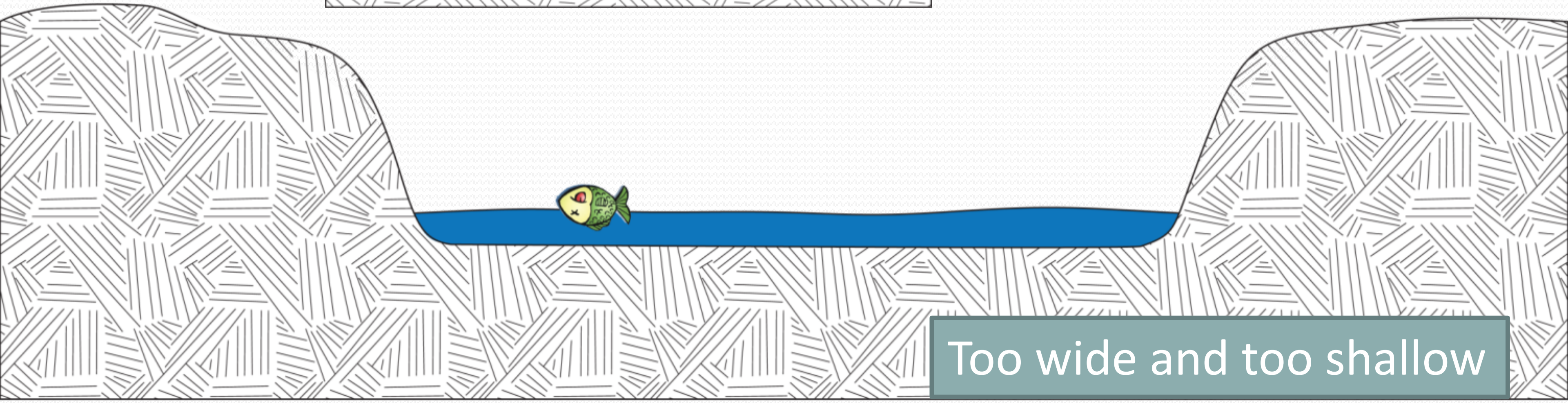
Regional Curves

- Proper width and depth are important
- For hydraulics
  - Sized to carry the bankfull flow
  - Moves the proper size and amount of sediment
  - Avoids erosion
  - Avoids deposition
- For the environment

Regional Curves

- Channel dimensions and aquatic habitat



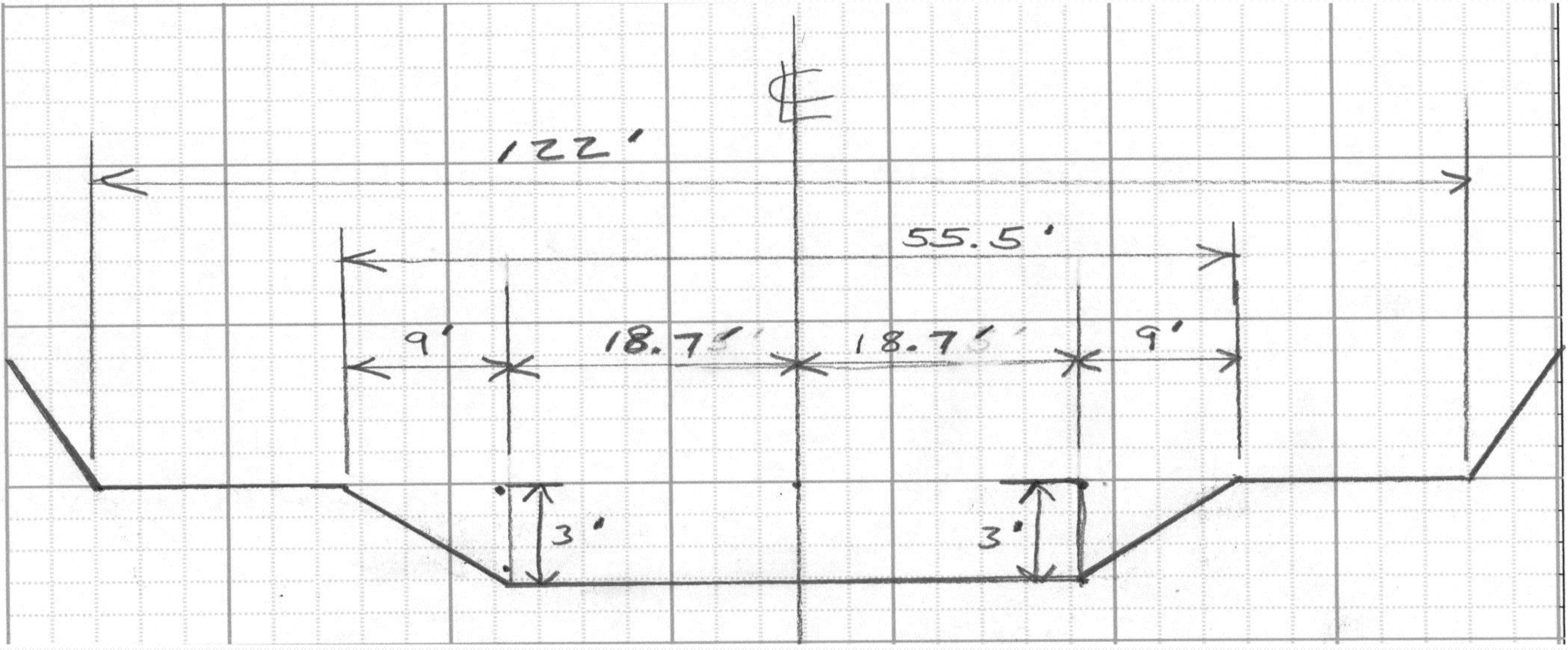


Classroom Sessions

- Develop an understanding of what elements impact on stream stability – “morphology”
- Learn what appropriate information and action is needed for a proposed worksite
- Develop ability to identify location of work site and related drainage area
- Learn to utilize the Stream Stats database
- Learn to develop the appropriate stream dimensions for the work site – construction dimensions

Classroom Product Example

- It is highly recommended that you prepare a sketch of the proposed cross section to use during stake out & construction



Field Exercises

- How to collect field data for reference reaches as alternative to Stream Stats
- Project survey and layout
- Construction methods
- Final site stabilization
- Site monitoring
- Long term stabilization methods

Lessons Taught

- Where to dig & Not dig
- Vegetative Strategies
- Stable Stream Dimensions for watershed location & stream type

- ***NOT ENGINEERING BUT HOW TO USE SIMPLE COMMON SENSE TOOLS***

Appropriate Channel Design Structures

- These structures are made of rocks or logs
  - Rip Rap
  - Barbs
  - Cross vanes
  - Straight vanes
  - J-hooks
  - Step-pools
  - Etc.

- If you think you need to install one or more of these contact SWCD or USC for assistance

Straight Vane

J-Hook

USC EMERGENCY STREAM INTERVENTION & STREAM MAINTENANCE TRAINING

- 3 Sessions planned for 2013
  - Steuben / Chemung Region
  - Tioga / Broome Region
  - Chenango / Otsego Region
- Applications available
- Limited Scholarships for County & Town Representatives

Questions?