Avoiding Geohazards in the Mid-Atlantic Highlands by Using "Natural Stream" Principles

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Photo: W. Gillespie

North Fork South Branch Potomac River, Hopeville, WV

“Natural Stream” Principles?

Fluvial Geomorphology Applied with Goal of Maintaining River & Stream Channels & Floodplains in Equilibrium.

Developed from Relatively Unimpaired Streams

“Packaged” by Dave Rosgen.[1]

Must Be Fine Tuned to Region’s flood meteorology, topography, geology, ecology, land-use, politics, & culture.

[1]Rosgen, D. L. 1996, Applied River Morphology, Wildland Hydrology, Pagosa Springs, Co.

<u>Why</u> Use Natural Stream Principles in Engineering & Construction?

1. Aesthetics
2. Ecosystem Support
3. Long-Term Cost Effectiveness
4. Reduce Flood Hazard
   - In Face of Increasing Flood Severity

Image from Will Harman, Michael Baker Corp.

Floodplain = Part of River

Photo: J.S. Kite

Mill Creek, Canaan Valley, W. Va

What is the "Work" of a Stream?

1. Water Delivery

Little Conemaugh River,
Johnstown, PA

Photo: J.S. Kite

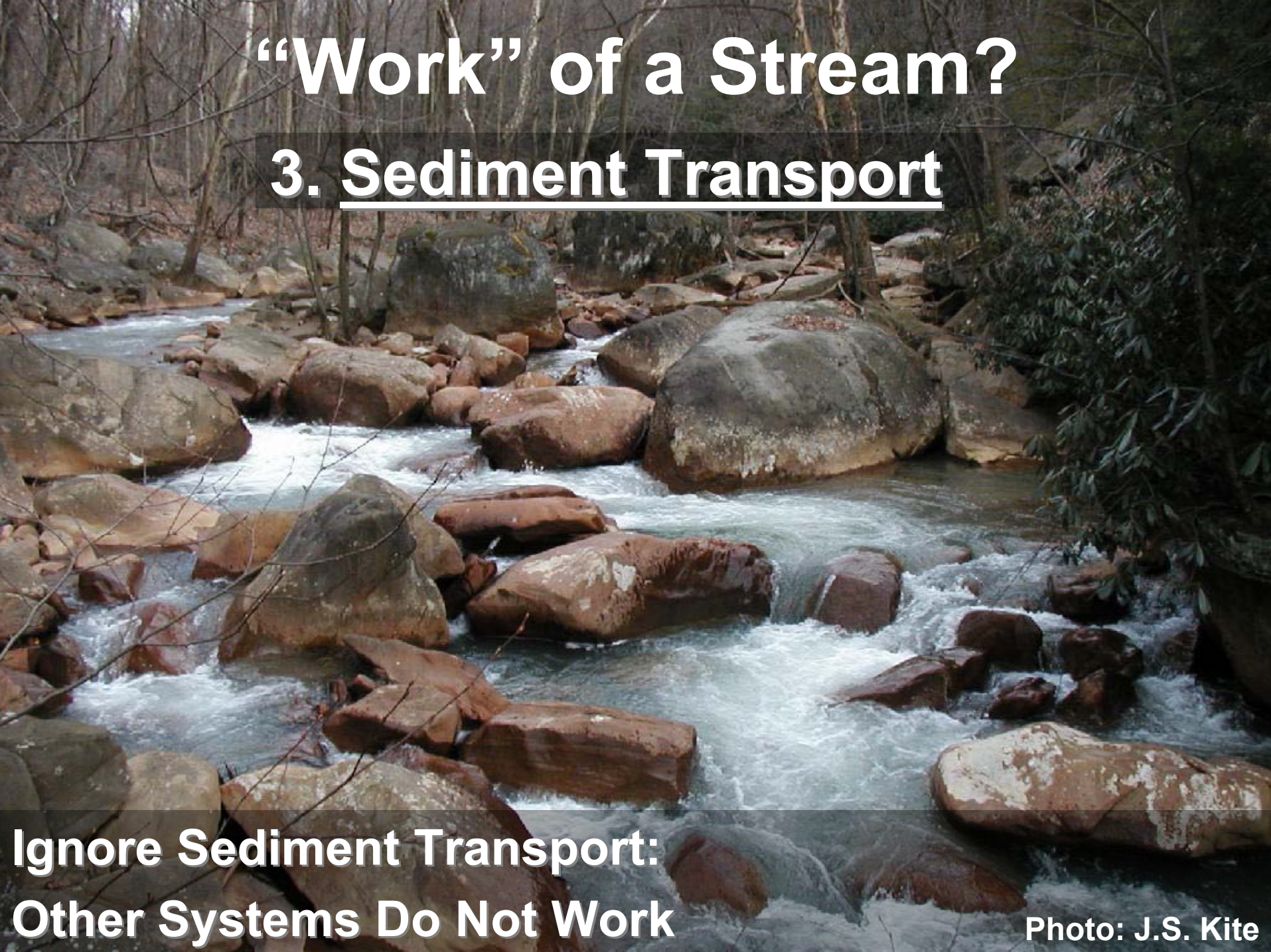
"Work" of a Stream?

2. Framework for Ecosystem Structure

Constructed Floodplain
Mitchell River Basin, NC
Michael Baker Corp

“Work” of a Stream?

3. Sediment Transport



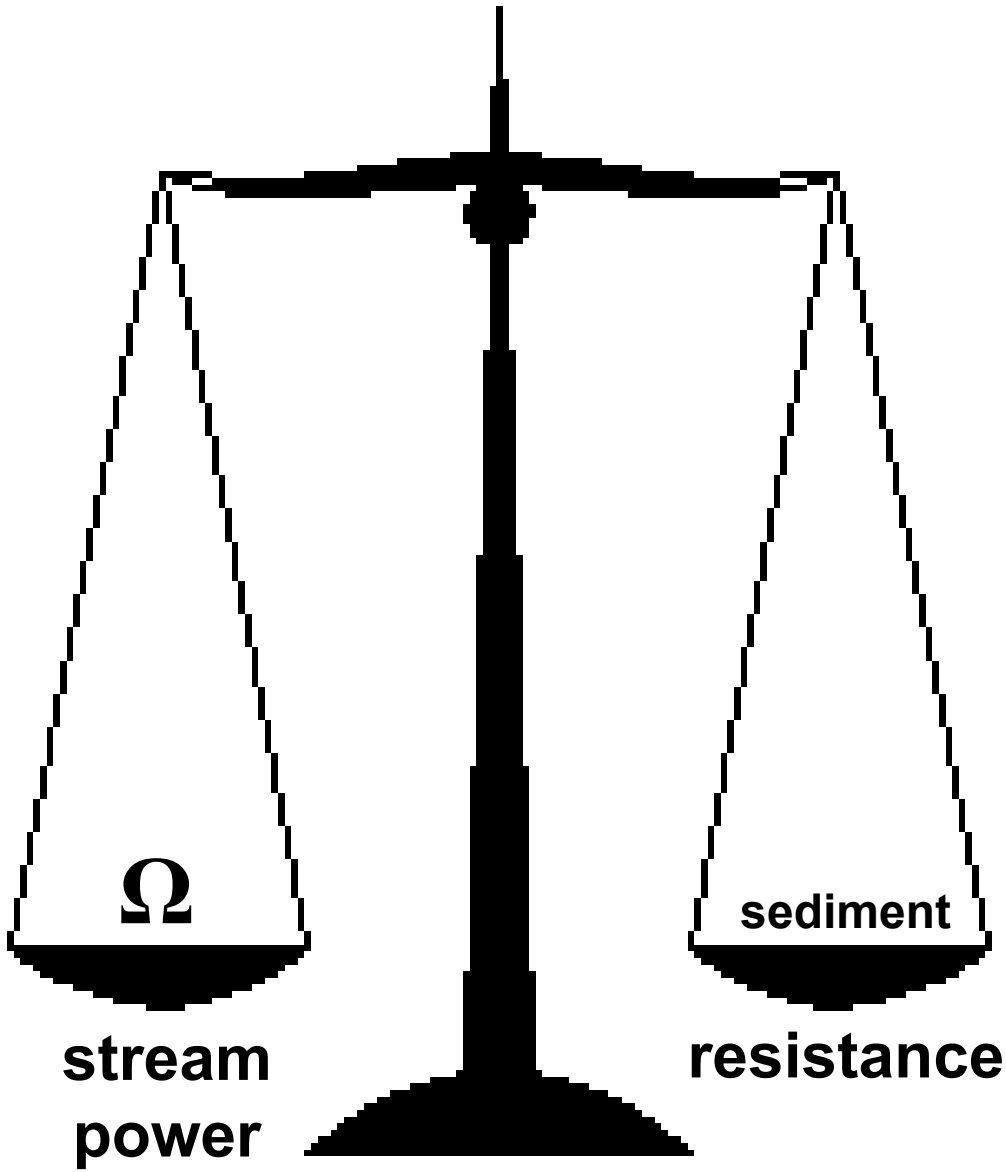
Ignore Sediment Transport:
Other Systems Do Not Work

Photo: J.S. Kite

“Grade”

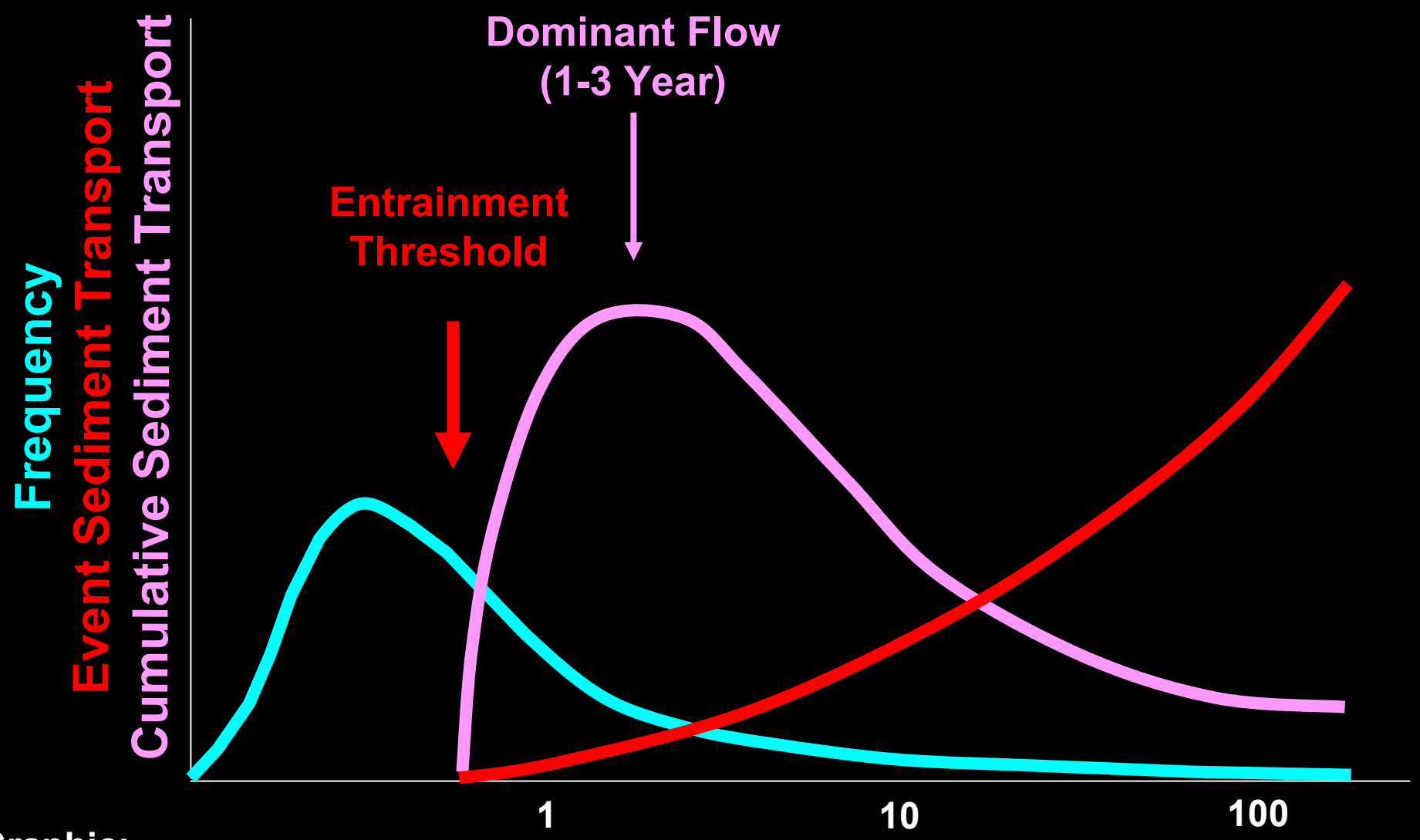
Delicate Balance

between sediment supply & system’s ability to transport sediment



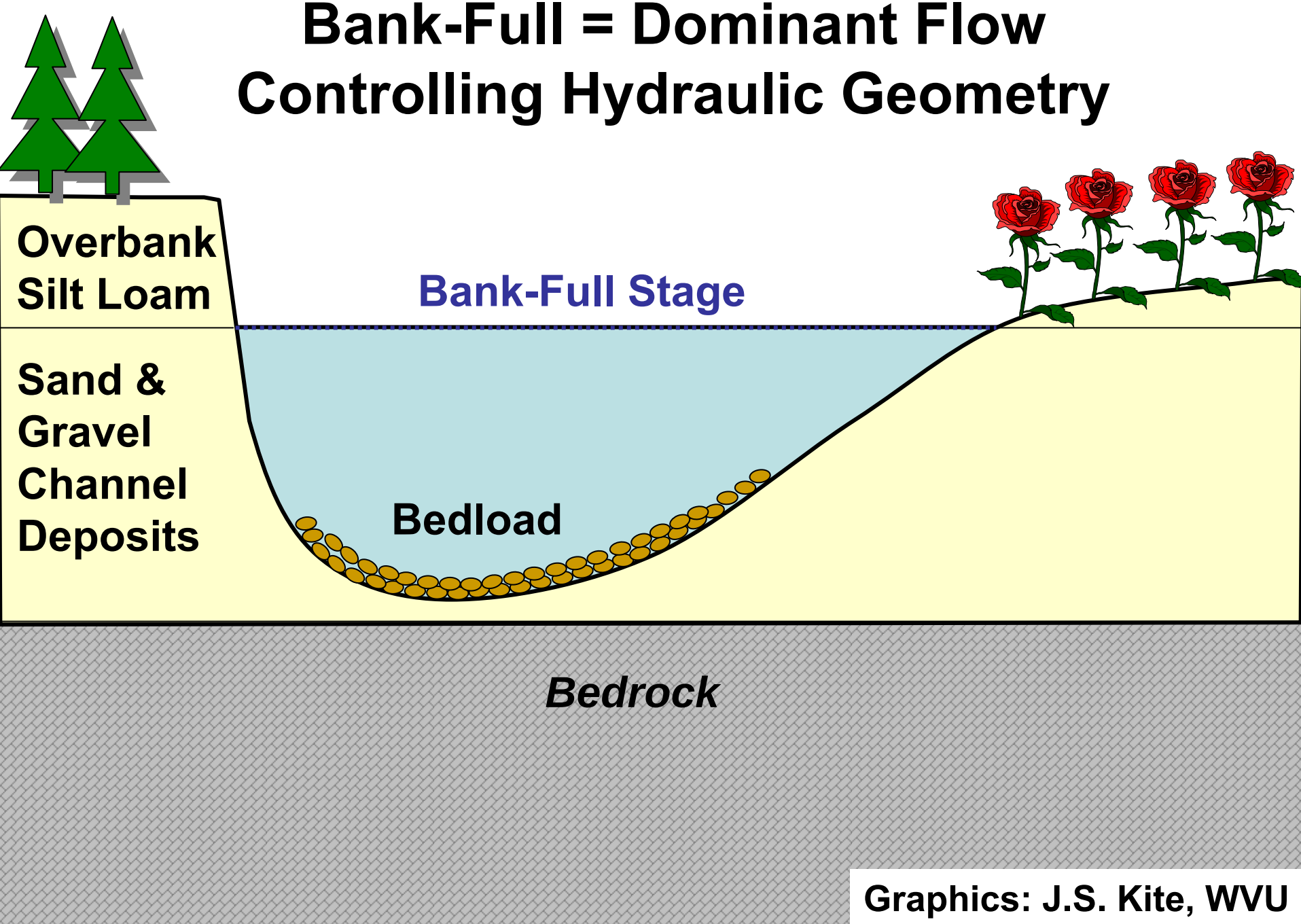
J.S. Kite

Wolman-Miller Dominant Flow Hypothesis



Graphic:
S. Kite, WVU

Bank-Full = Dominant Flow Controlling Hydraulic Geometry



Graphics: J.S. Kite, WVU

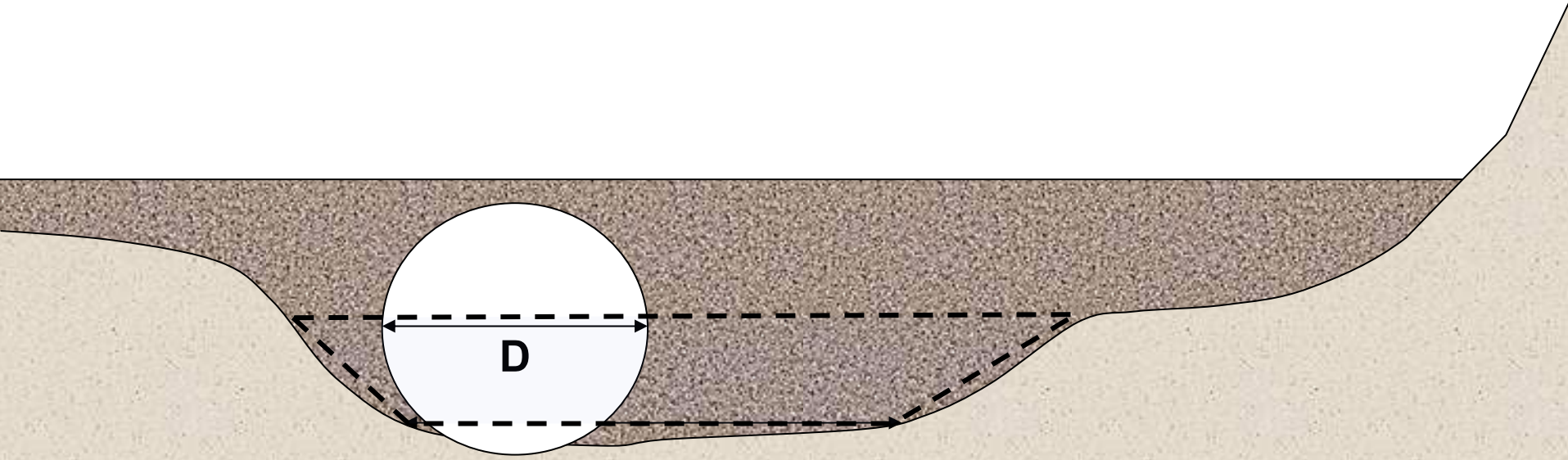
Road Crossings

Conventional Culverts May Be Migration Barriers & Block Sediment Transport

Photo: J.S. Kite

Culvert Area - Bankfull Channel Area Ratio

Addresses Culvert's Ability to Pass "Floods"

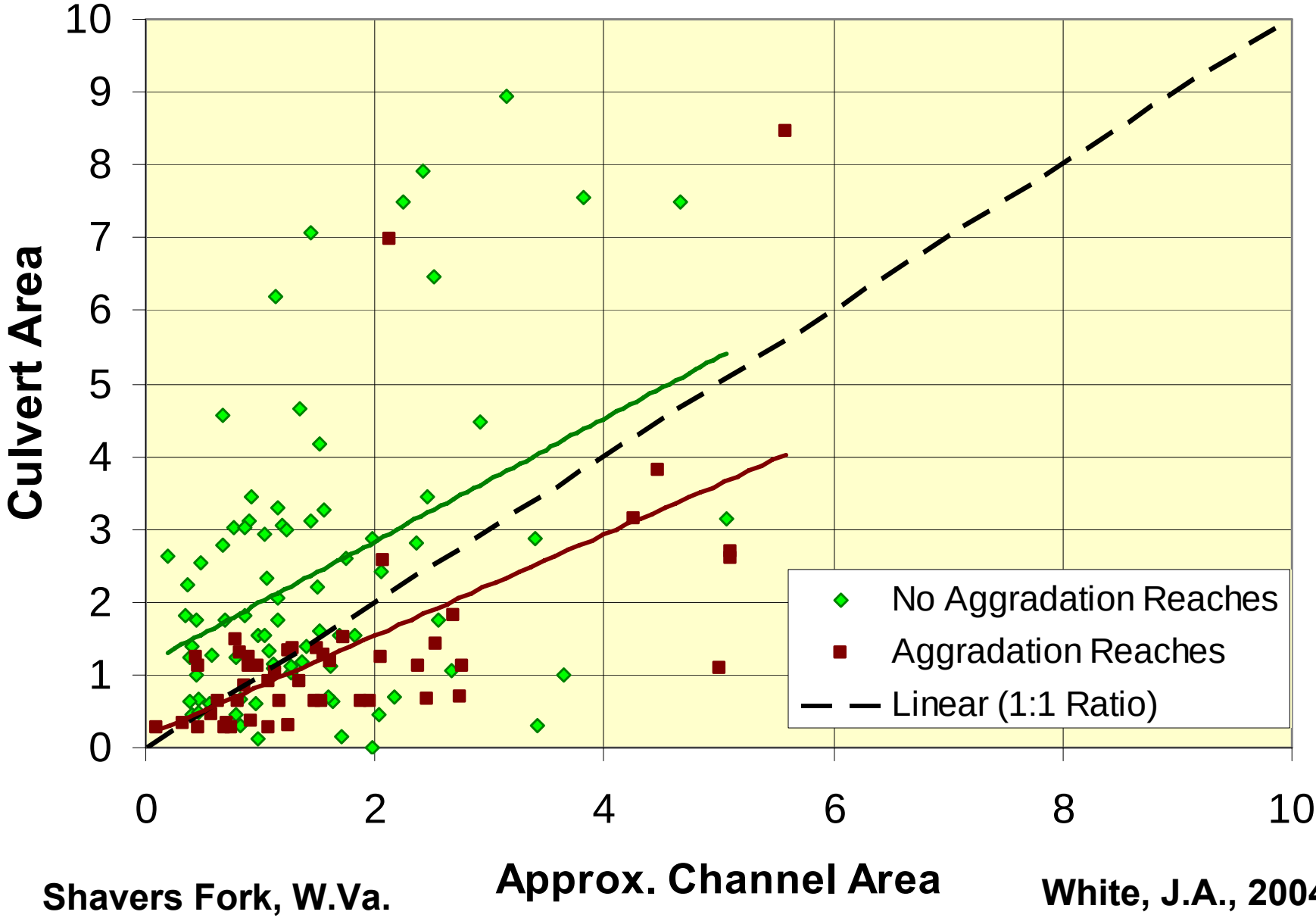


Culvert Area - Bankfull Channel Area Ratio =

$$\text{Area}_{\text{Culvert}} / \text{Area}_{\text{Bankfull Channel}}$$

Graphics: J.S. Kite, WVU

Channel Area vs. Culvert Area: Non-aggrading and Aggrading Reaches



Shavers Fork, W.Va.

White, J.A., 2004, MS

Arch Culvert

Photo:
J.S. Kite

Image from Will Harman, Michael Baker Corp.


Prefab Concrete Box Culverts ≈ Bridge
Constructed Floodplain
Constructed Channel
Constructed Floodplain
Image from Will Harman, Michael Baker Corp.

Bank Erosion Hazard

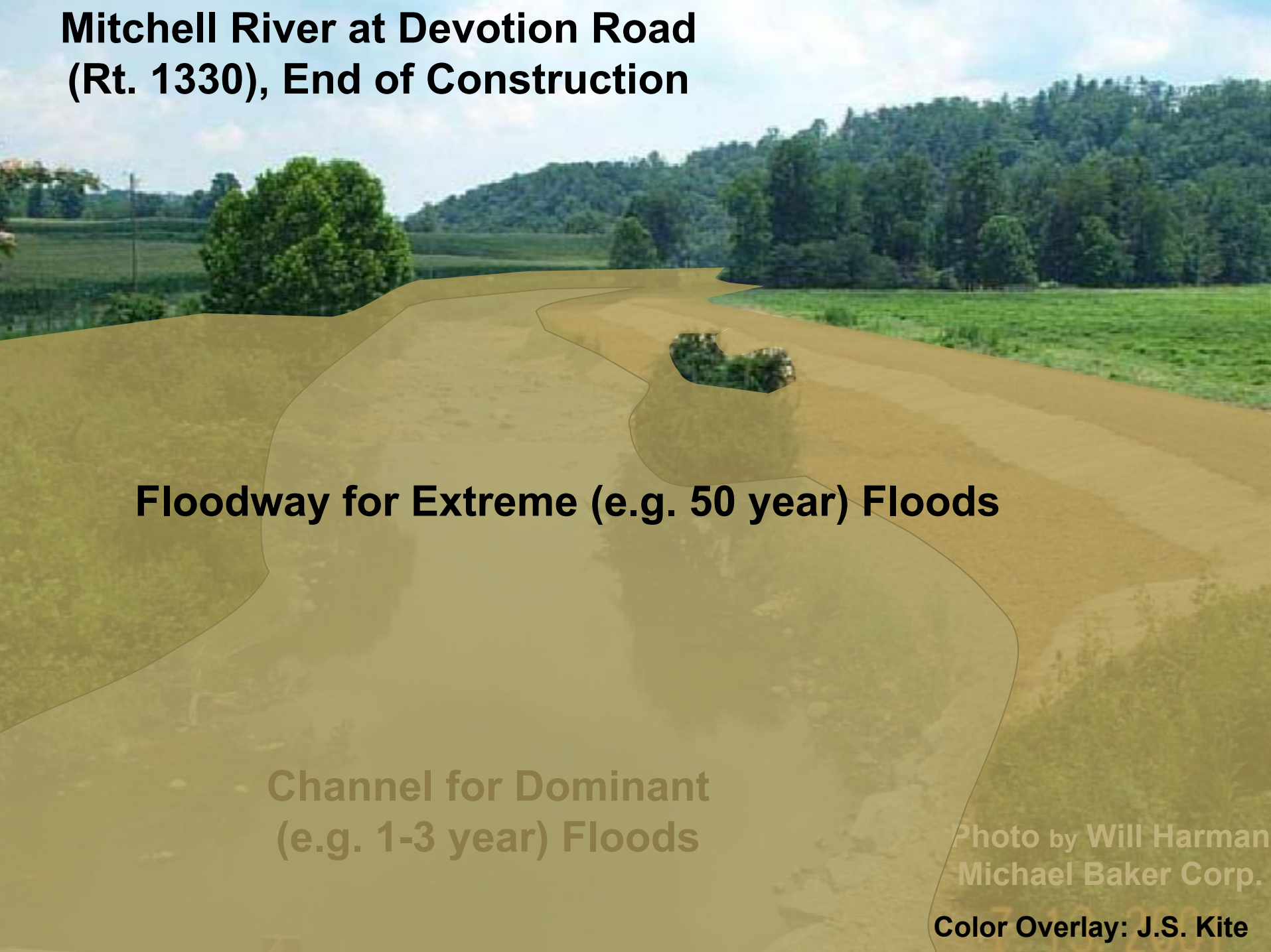
Mitchell River Basin, NC

Michael Baker Corp. Photo

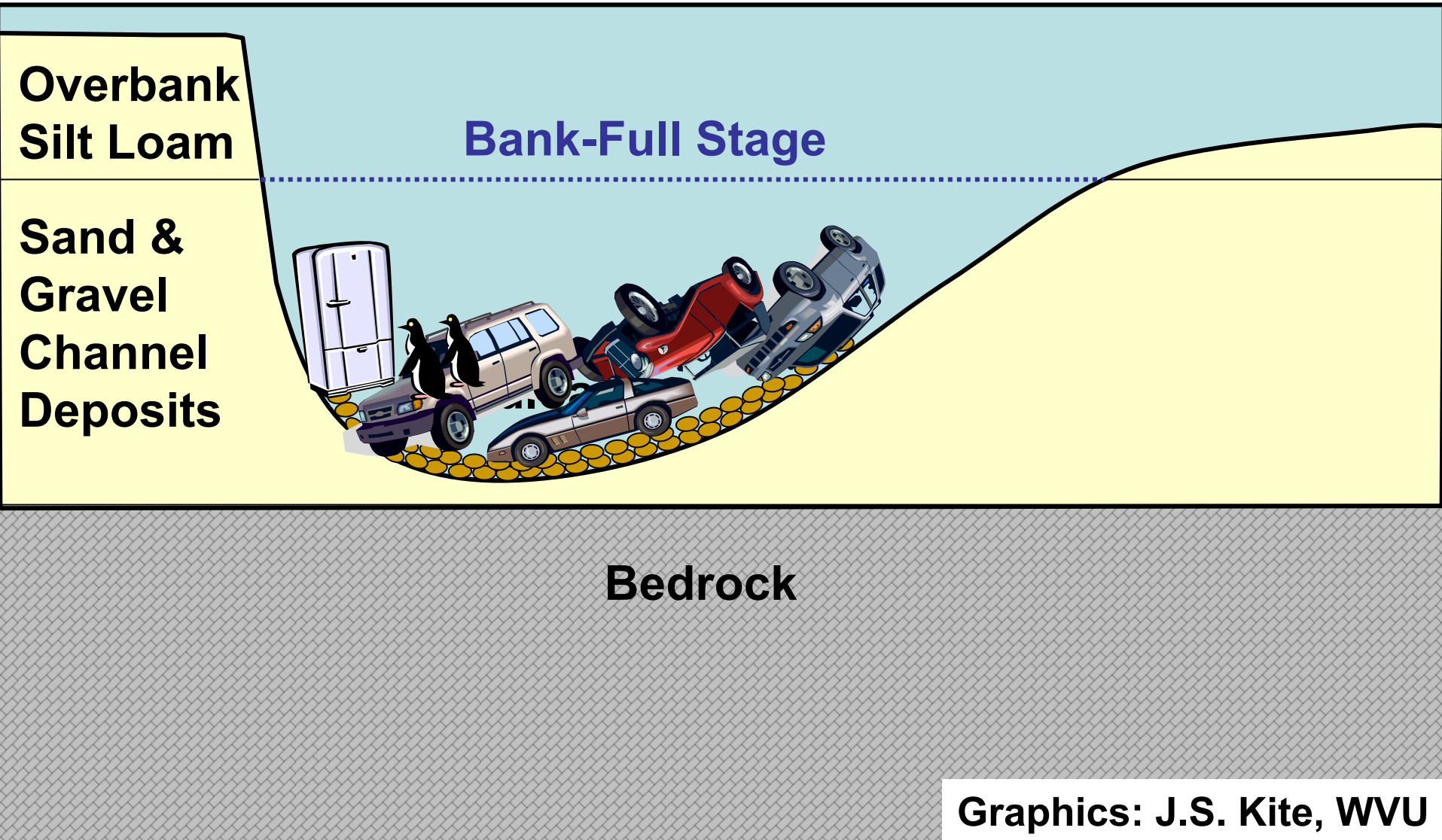

Natural Stream Design May Rely on Structures (e.g. Cross Veins)
Flow Directed to Mid-Channel to Reduce Bank Shear Stress
Constructed Reach
WVU Stream Design Workshop,
Mitchell River Basin, NC
Photo: J.S. Kite

Good “Design” Must Address Dominant (1-3 Year) Flow, Not Just Big (10-200 Year) Floods

Constructed Channel Reach
WVU Stream Design Workshop,
Mitchell River Basin, North Carolina
J.S. Kite, WVU

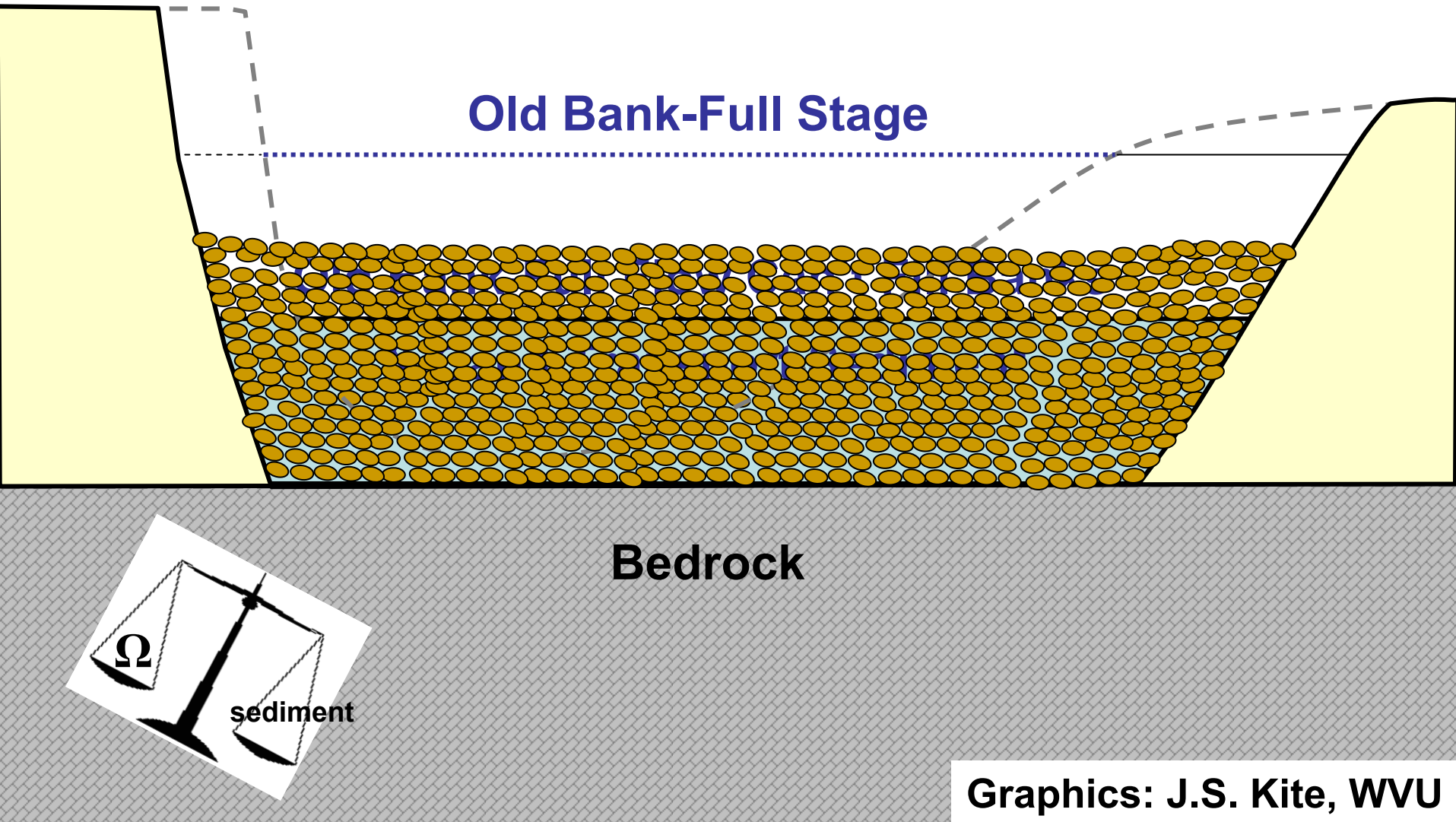

Mitchell River at Devotion Road
(Rt. 1330), End of Construction
Floodway for Extreme (e.g. 50 year) Floods
Channel for Dominant
(e.g. 1-3 year) Floods
Photo by Will Harman
Michael Baker Corp.
Color Overlay: J.S. Kite

Common Flood Mitigation Error – Over-Widening of Channel



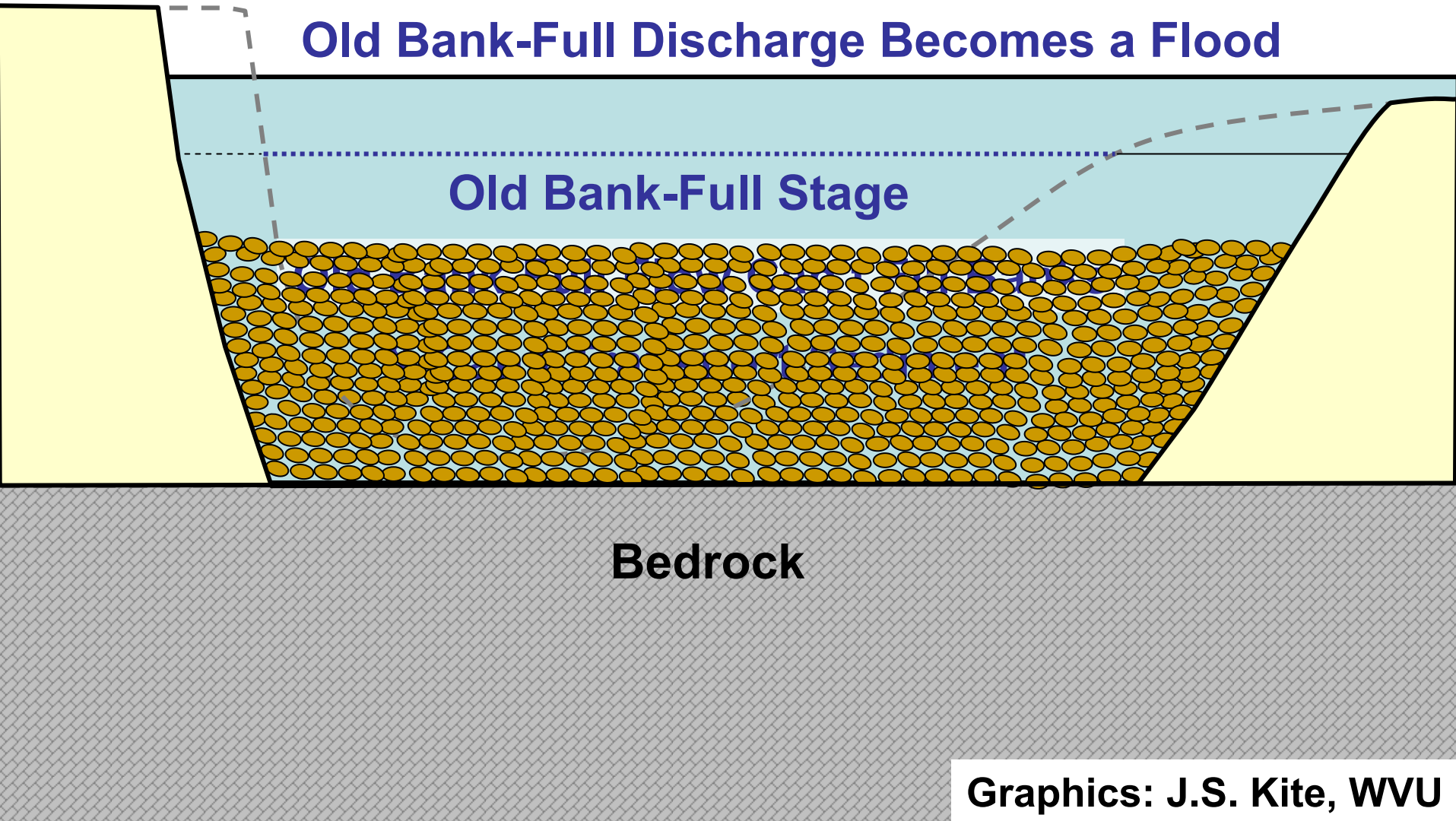
Graphics: J.S. Kite, WVU

Common Flood Mitigation Error – Over-Widening of Channel



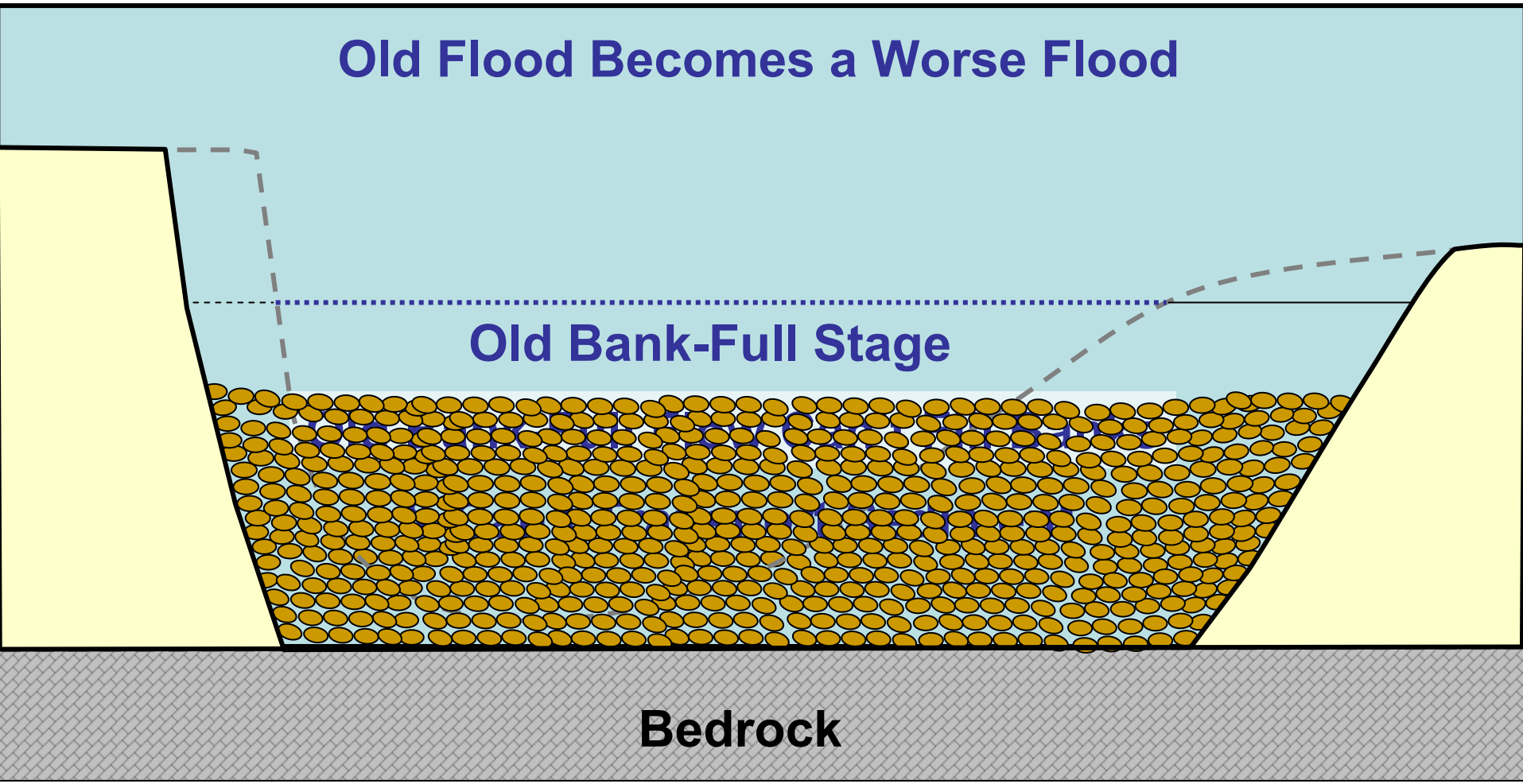
Graphics: J.S. Kite, WVU

Common Flood Mitigation Error – Over-Widening of Channel



Graphics: J.S. Kite, WVU

Common Flood Mitigation Error –



No Matter What the Mayor Says!

Don't Over-Widen Channels after a Flood.

Re-Construct Bank-Full Channel Dimensions for Sediment Transport

J.S. Kite, WVU

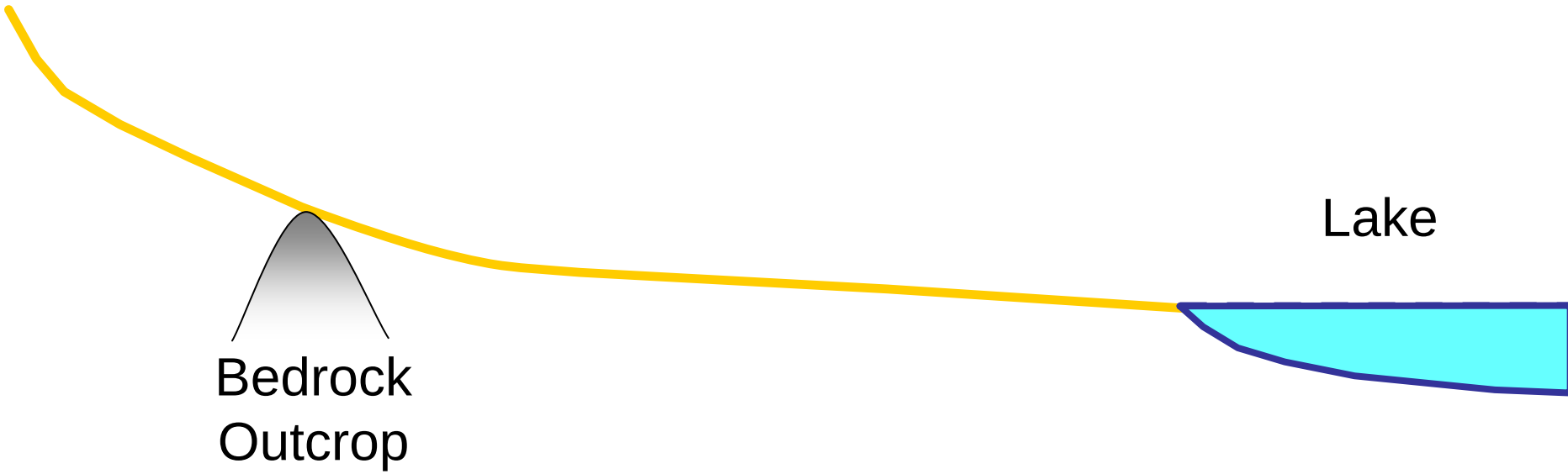
Base Level & Profile Equilibrium

Base Level = Lowest elevation to which a stream can erode (*e.g.* Sea Level, Lake, Falls, Downstream Reach, *etc*.)

Image Source: http://www.rustycans.com/OhioFalls.jpeg

Stream Adjustments to <u>Lower</u> Base Level

- **<u>Equilibrium</u> - Concave Profile**



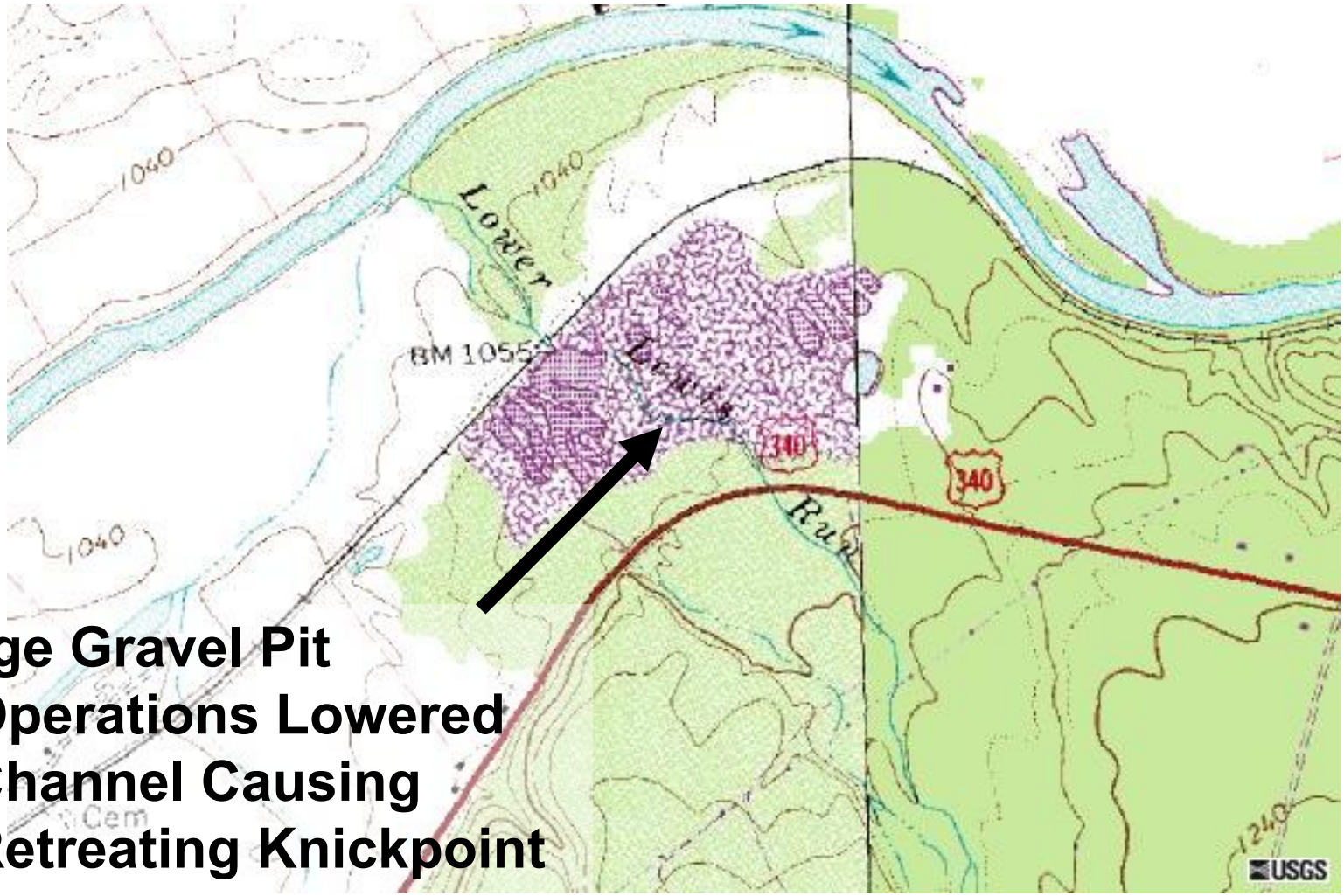
Graphics: J.S. Kite, WVU

Stream Adjustments to <u>Lower</u> Base Level

- <u>Incision</u> to Adjust Profile

Graphics: J.S. Kite, WVU

Lewis Run, Rockingham County, VA



Large Gravel Pit Operations Lowered Channel Causing Retreating Knickpoint

1987 Topo Map: TerraServer-USGS

Graphics: J.S. Kite, WVU

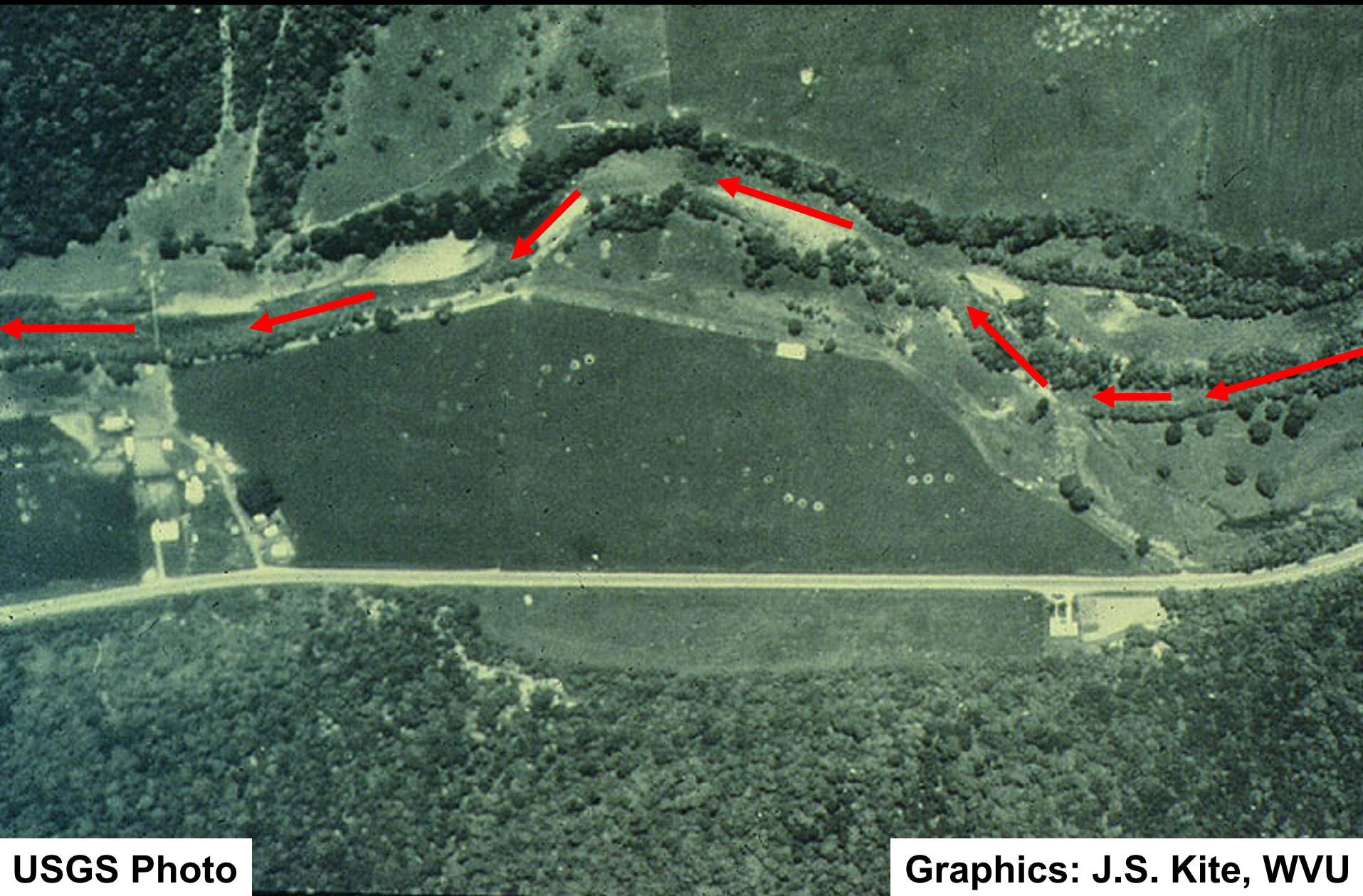
Lewis Creek, Rockingham Co., Va., 10 Nov 1985

Key to Reducing Flood Damage: Bank Stability

Anthony Creek, Greenbrier Co., W.Va.

Photo: J.S. Kite

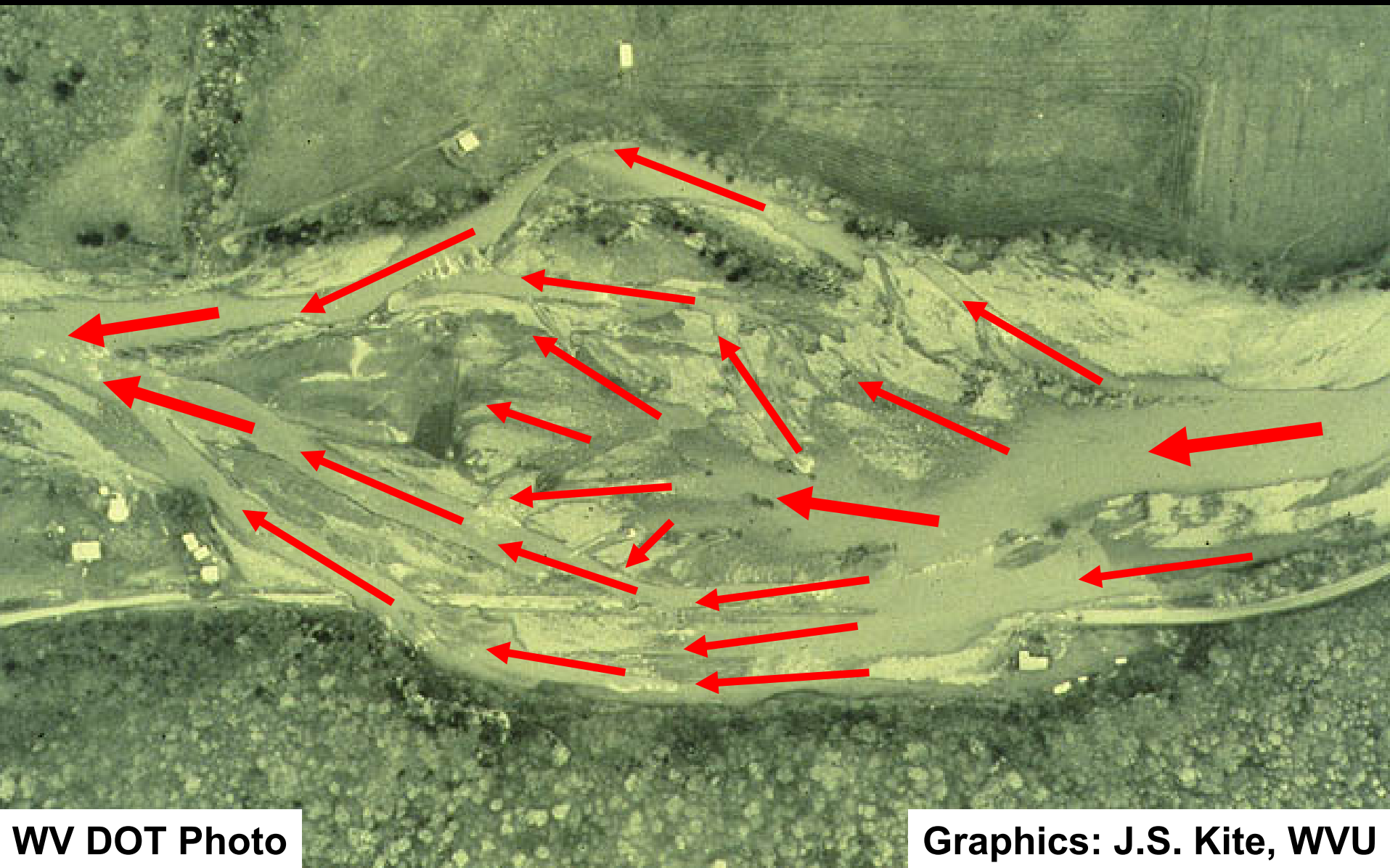
W.Va. Rt. 28/55, Near Champe Rocks: Before 1985 Flood



USGS Photo

Graphics: J.S. Kite, WVU

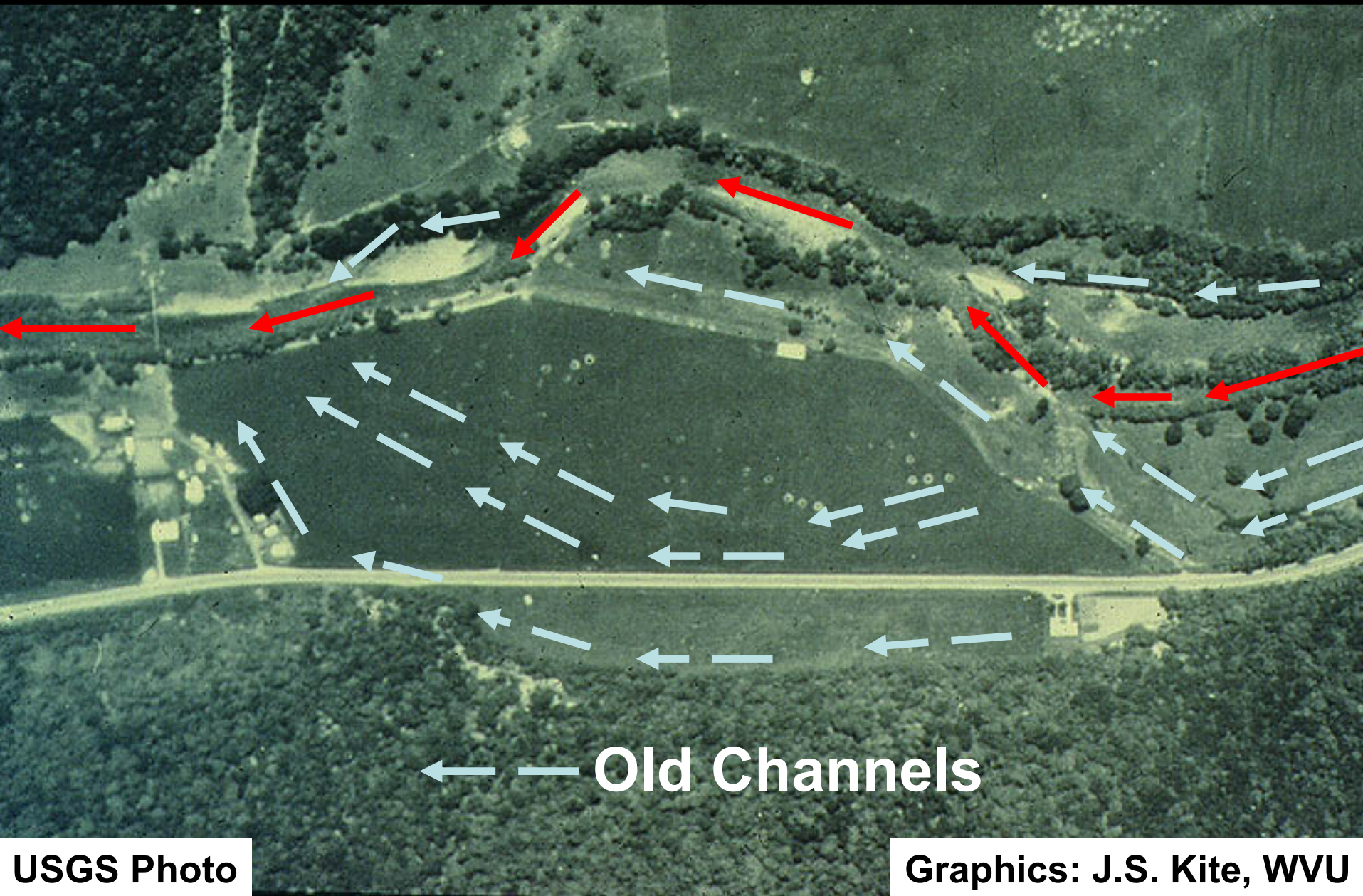
W.Va. Rt. 28/55, Near Champe Rocks: After 1985 Flood



WV DOT Photo

Graphics: J.S. Kite, WVU

W.Va. Rt. 28/55, Near Champe Rocks: Before 1985 Flood



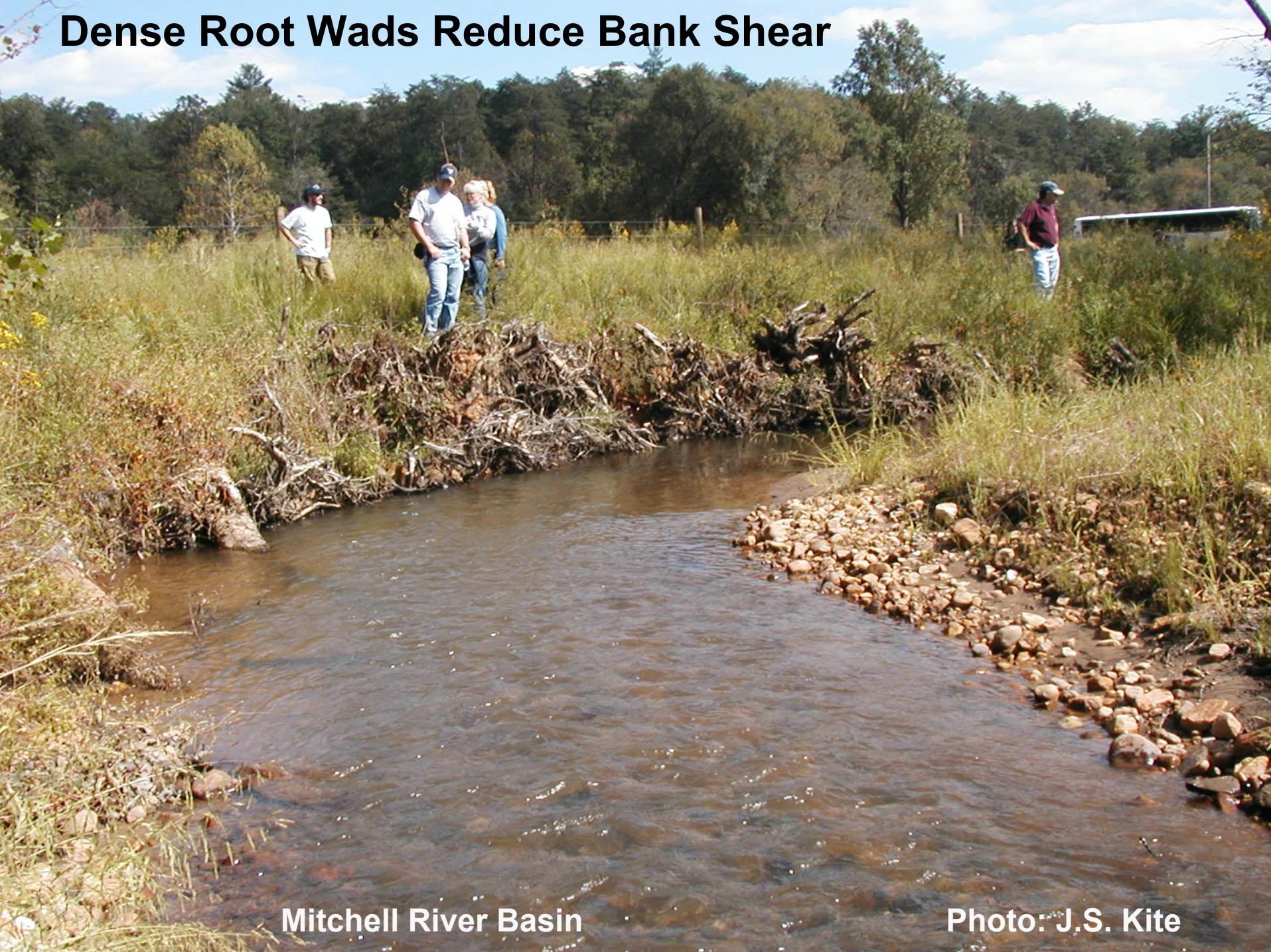
USGS Photo

Graphics: J.S. Kite, WVU


Vegetation = Nature's
Bank Protection
Image from Will Harman,
Michael Baker Corp.


Photo by Will Harman,
Michael Baker Corp.

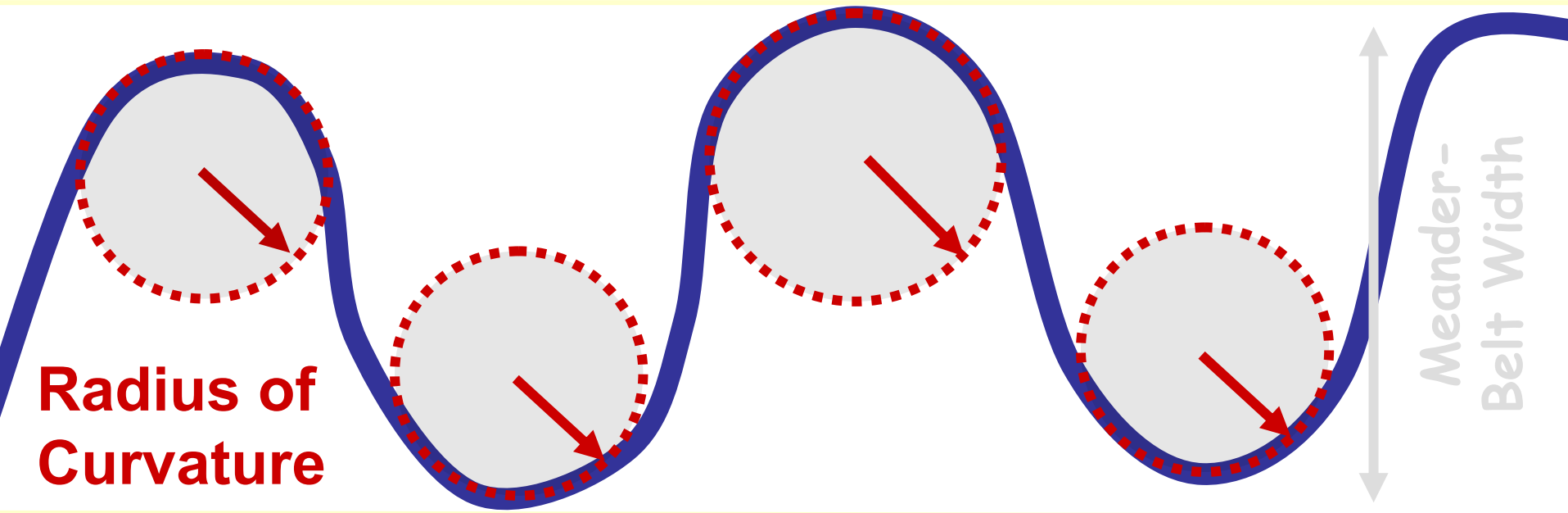
Dense Root Wads Reduce Bank Shear



Hydraulic Geometry in Plan View

Sinuosity = P =
River Distance Along Thalweg /
Straight-Line Distance

Sinuosity	Rosgen Class
1.0 - 1.2	Low
1.2 - 1.5	Moderate
1.5 +	High



λ = Meander Wavelength

Graphics:
J.S. Kite, WVU

North Fork South Branch Potomac River, Hopeville: Before

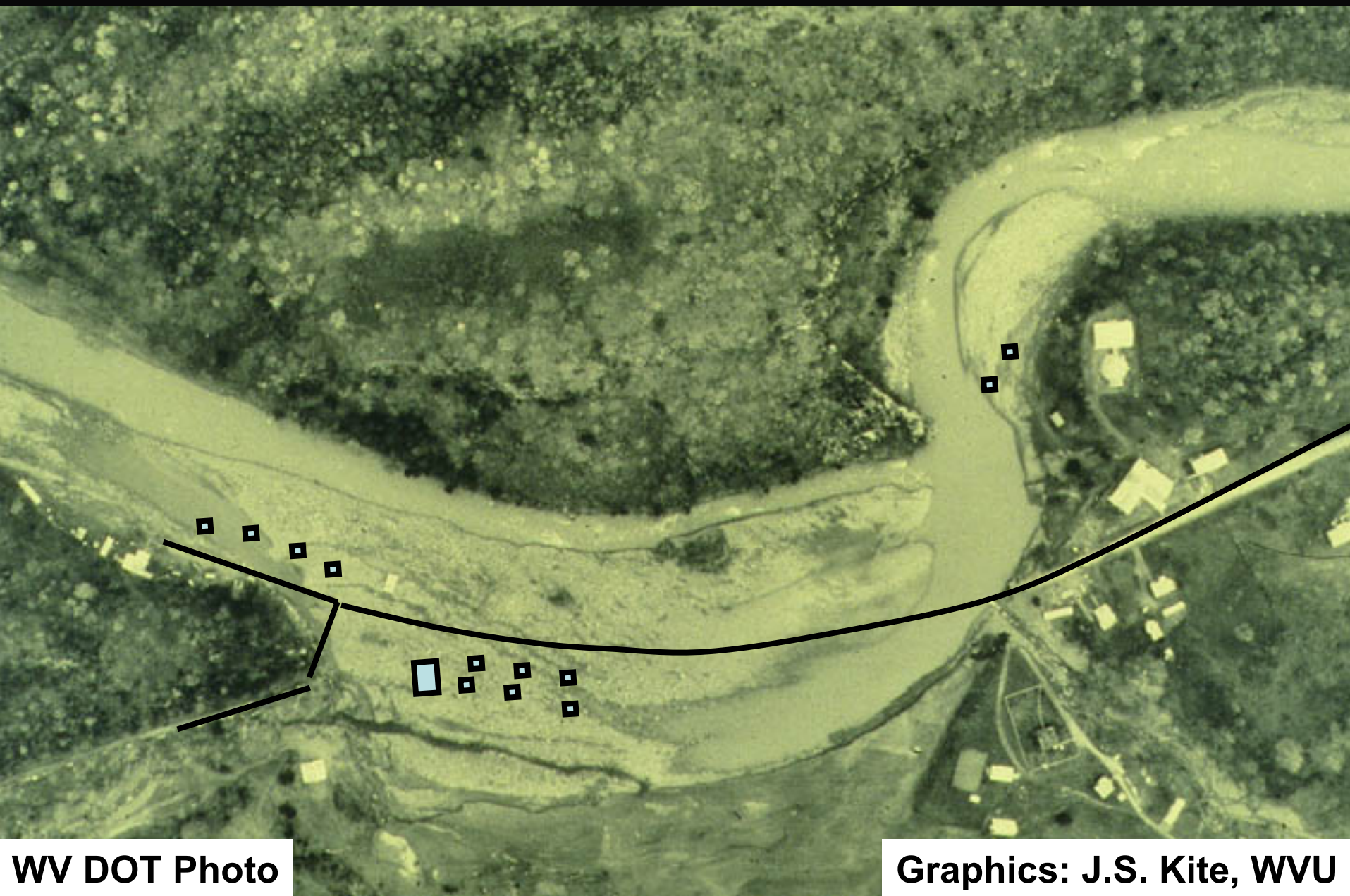
USGS Photo

North Fork South Branch Potomac River, Hopeville Anticline

North Fork South Branch Potomac River, Hopeville: After

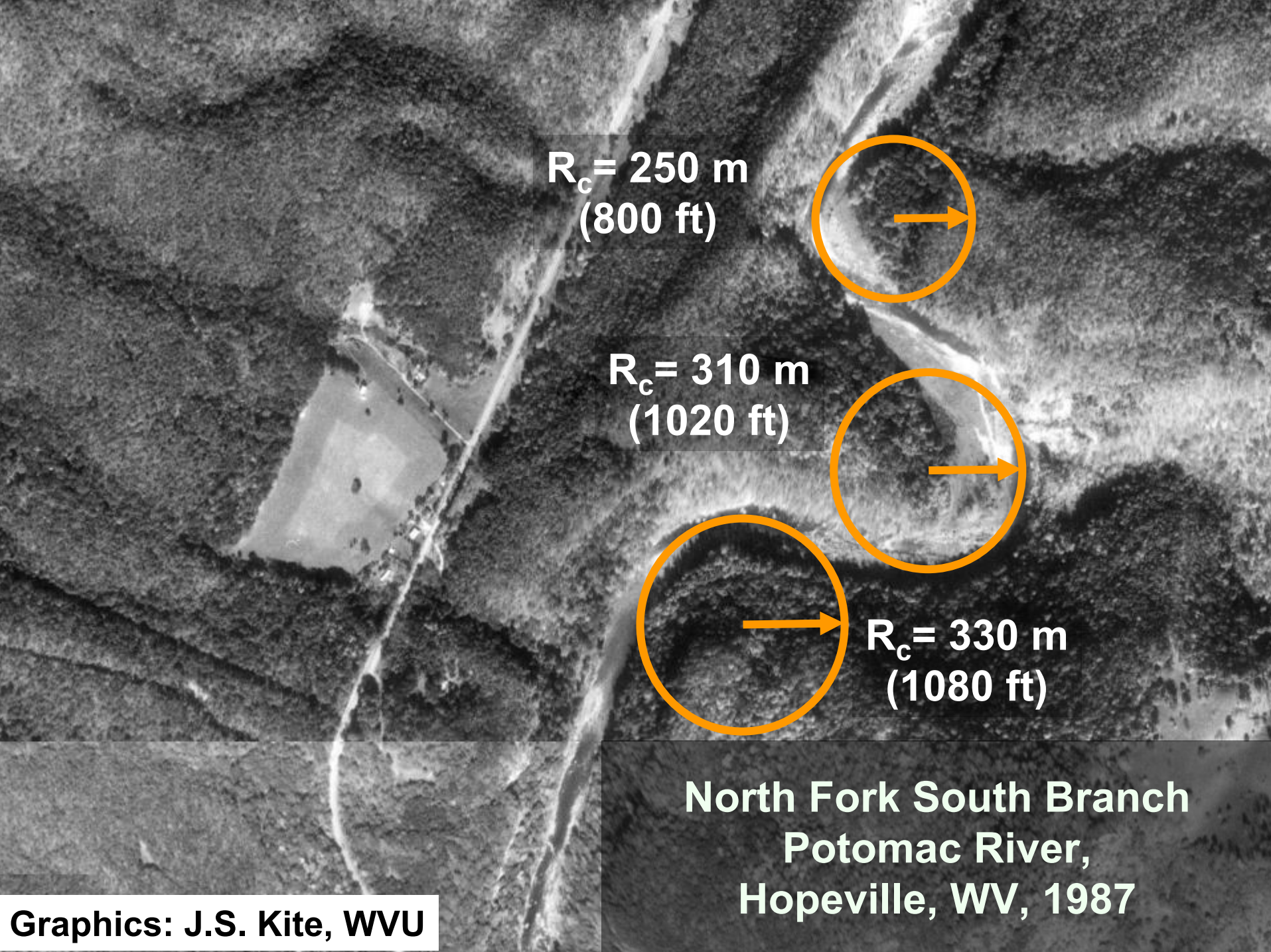
WV DOT Photo

North Fork South Branch Potomac River, Hopeville: After



WV DOT Photo

Graphics: J.S. Kite, WVU



Graphics: J.S. Kite, WVU

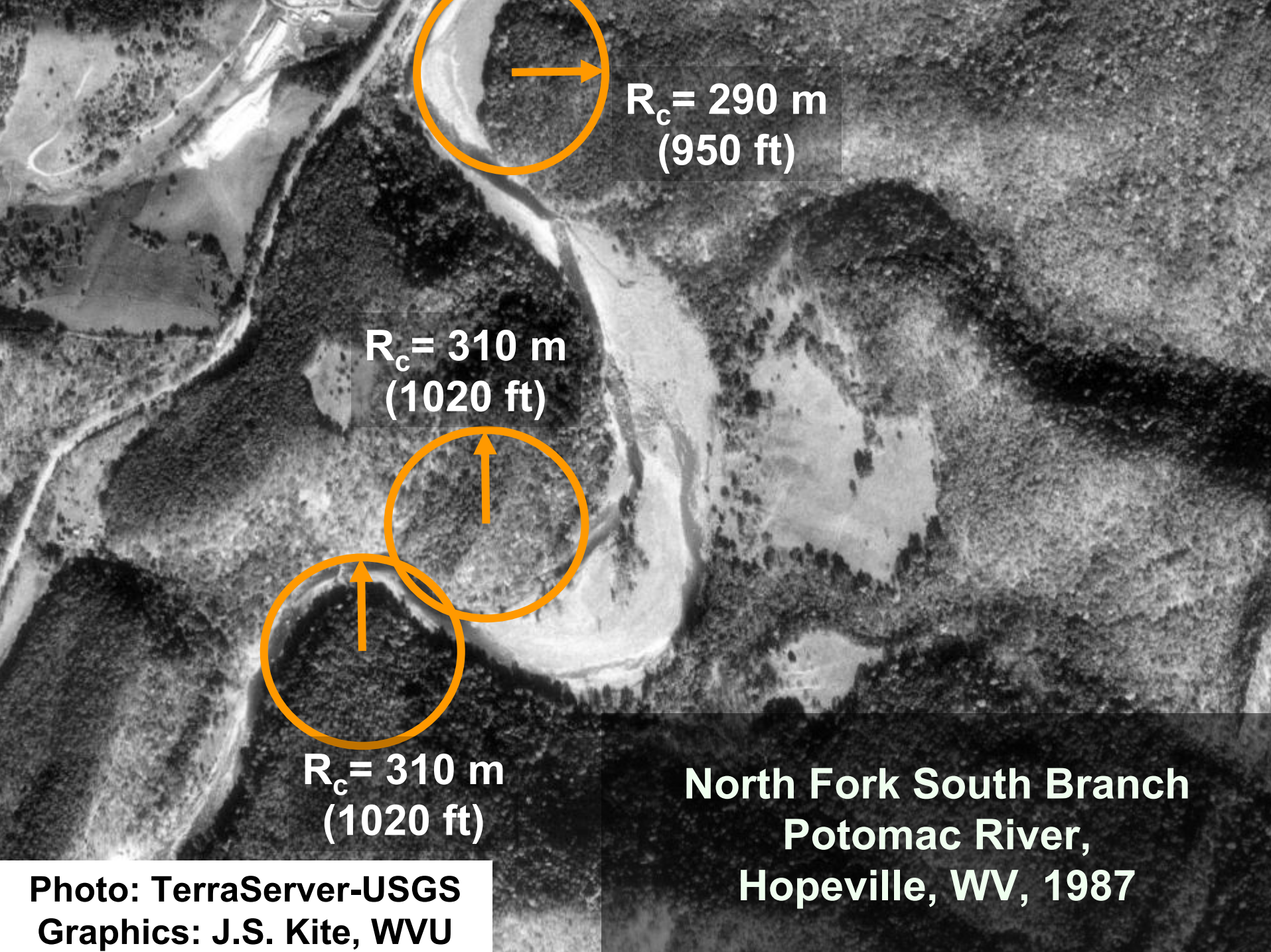
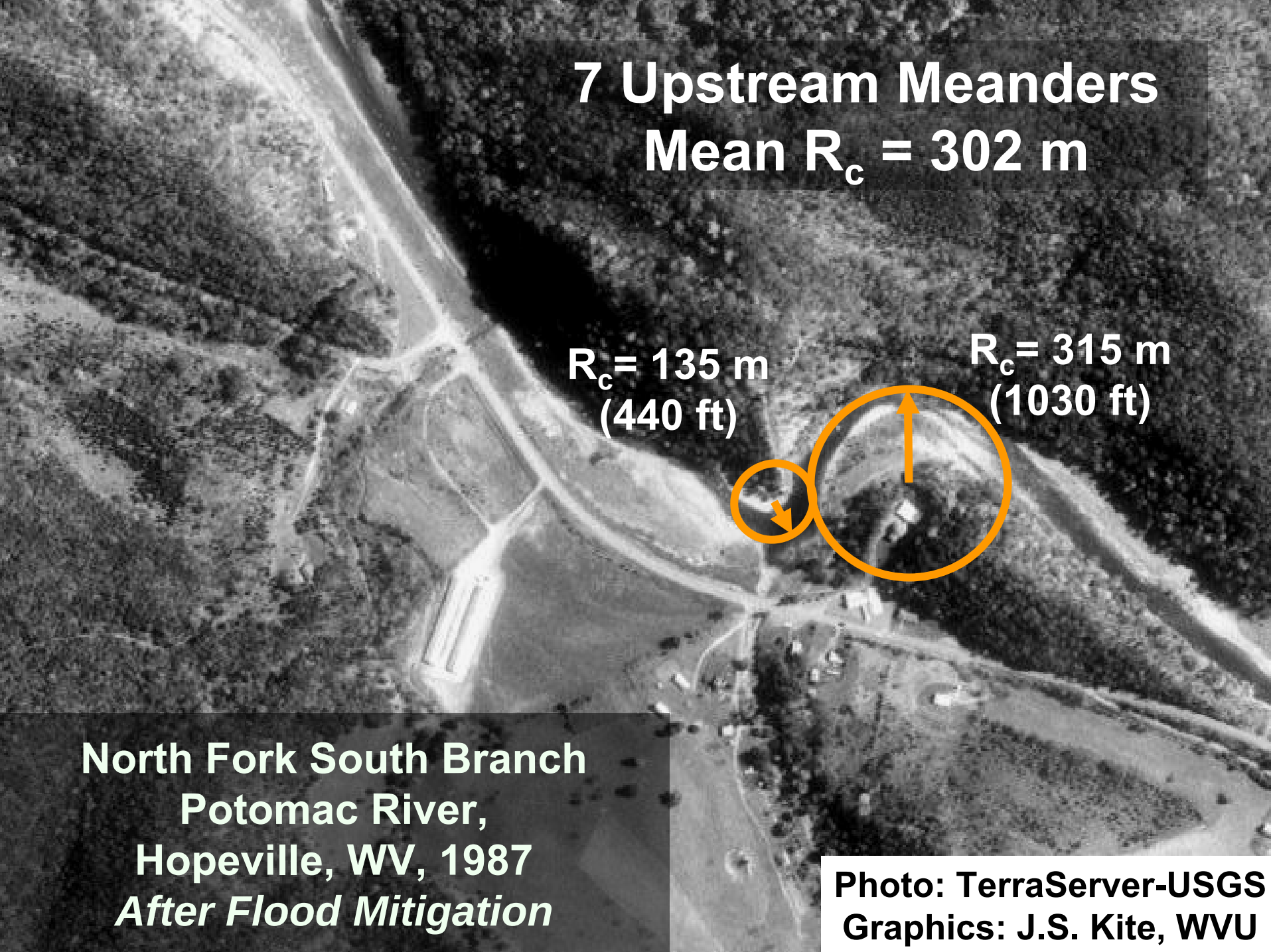
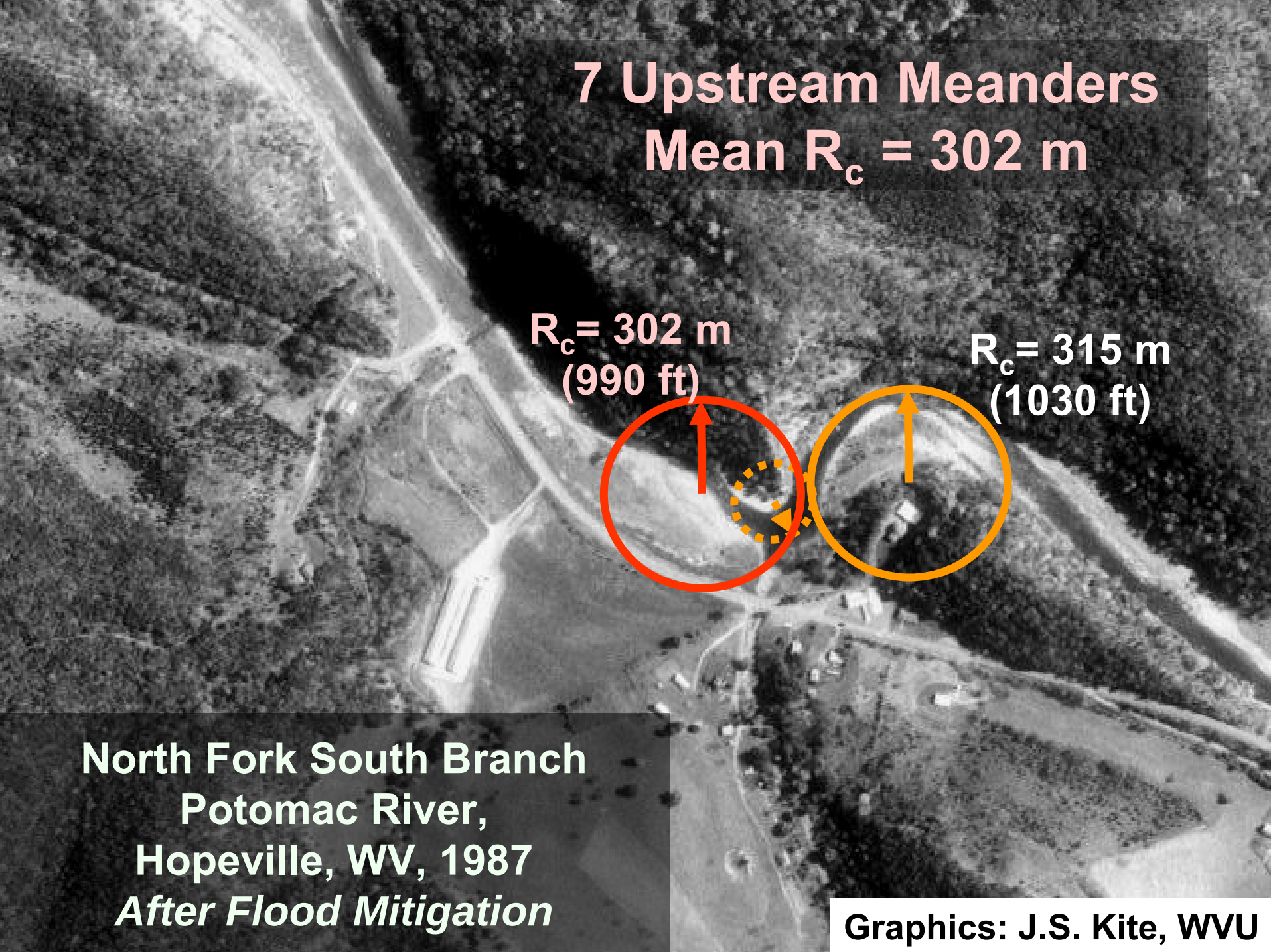


Photo: TerraServer-USGS
Graphics: J.S. Kite, WVU


7 Upstream Meanders
Mean R_c = 302 m
R_c= 135 m
(440 ft)
R_c= 315 m
(1030 ft)
North Fork South Branch
Potomac River,
Hopeville, WV, 1987
After Flood Mitigation
Photo: TerraServer-USGS
Graphics: J.S. Kite, WVU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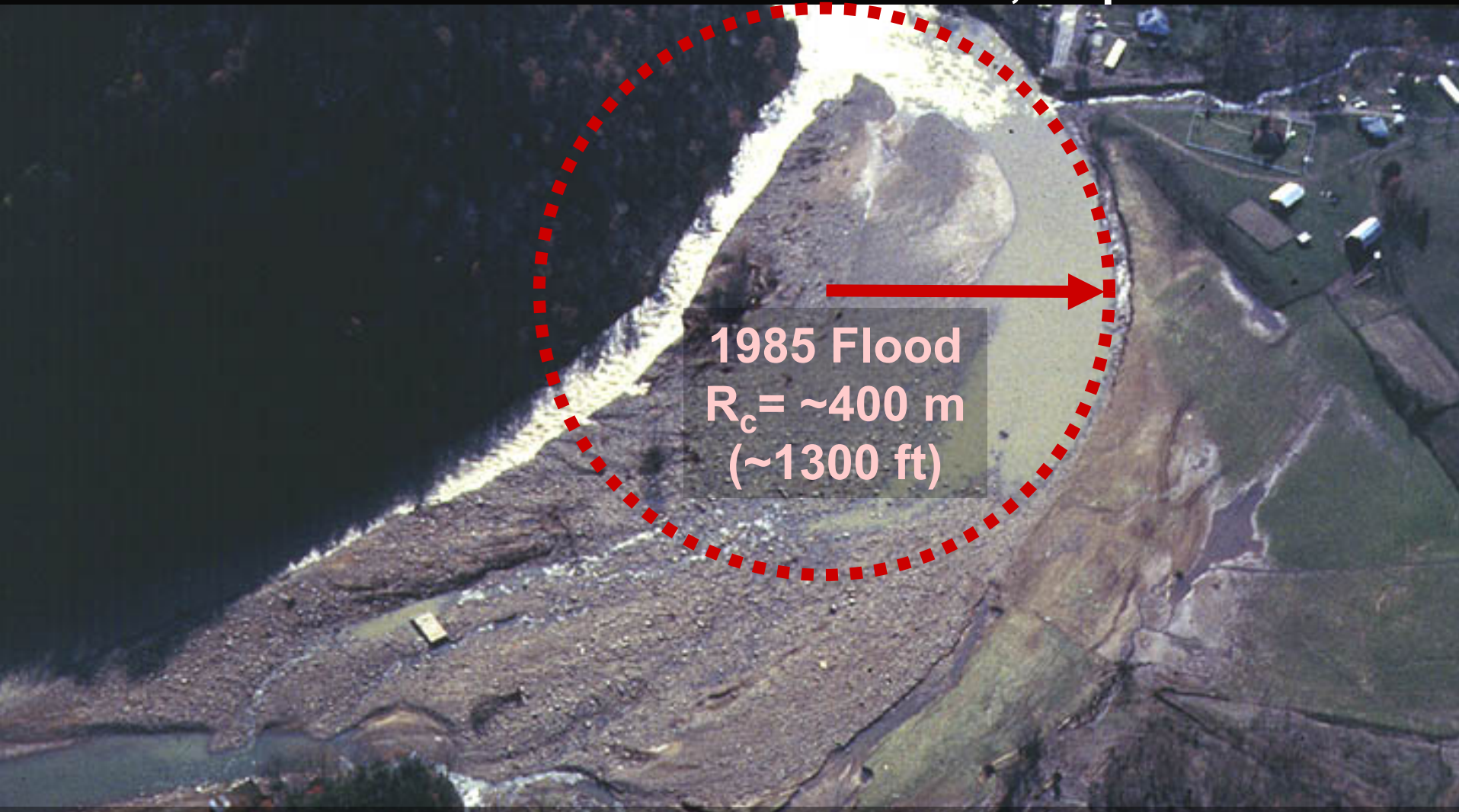
Potomac River,
Hopeville, WV, 1987
After Flood Mitigation
Graphics: J.S. Kite, WVU

North Fork South Branch Potomac River, Hopeville 1985



When 'Rules of the River' are not respected, adverse channel adjustments often result."

(Luna Leopold, 1994)

Photo: W. Gillespie

Graphics: J.S. Kite

National Interactive Forum on Geomorphic Reclamation

"Putting a New Face on Mining Reclamation"

September 12-14, 2006
Farmington Civic Center
Farmington, New Mexico

Sponsored by
the Office of Surface Mining, Western Region,
and OSM's National Technical Training Program

www.ott.wrcc.osmre.gov/forums/Geomorphic%20Reclamation/nifgr.htm