Rethinking altered drainage systems: giving the river what it needs

Sarasota Bay Fisheries Forum – June 6, 2017

John Kiefer, PhD, PE, PWS
Amec Foster Wheeler, Environmental & Infrastructure, Inc.
john.kiefer@amecfw.com

1

What would you do if you had to build a stream from scratch?

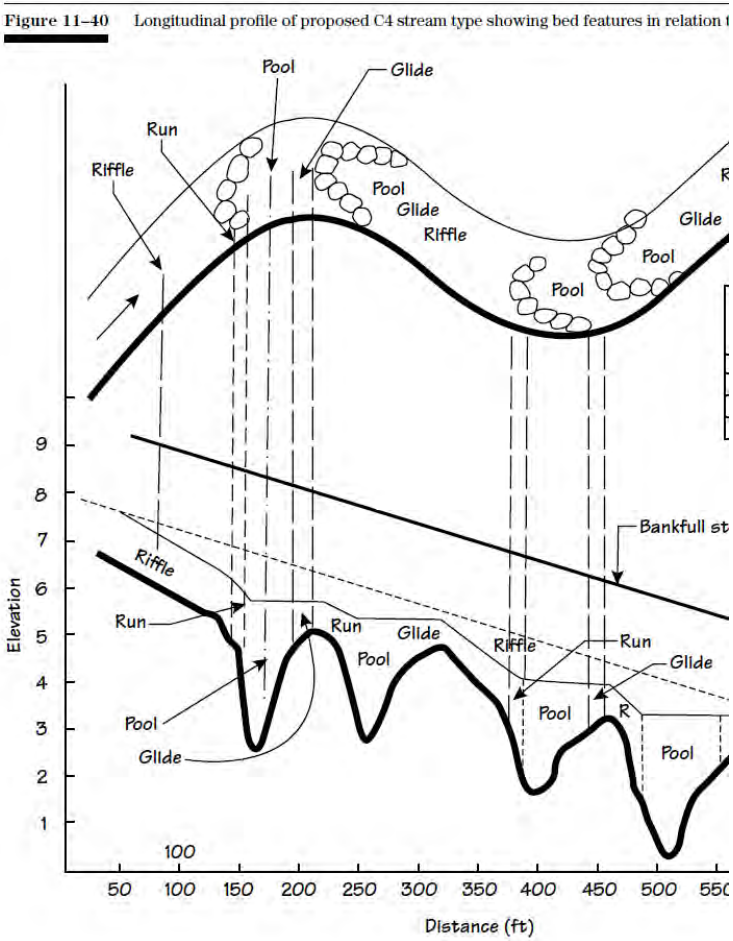
amec foster wheeler

amec foster wheeler

amec foster wheeler

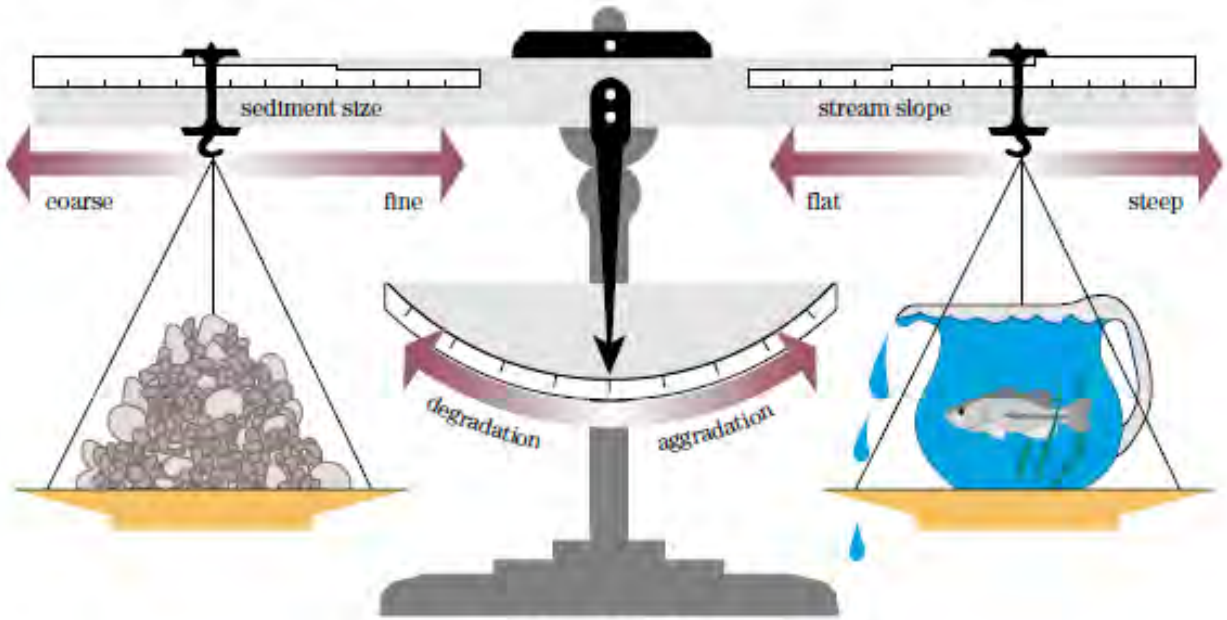
amec foster wheeler

Channels need to dance



Streams are conduits for water & sediment

Figure 13–2 Lane's balance as represented in Federal Interagency Stream Restoration Working Group (FISRWG) (1998)



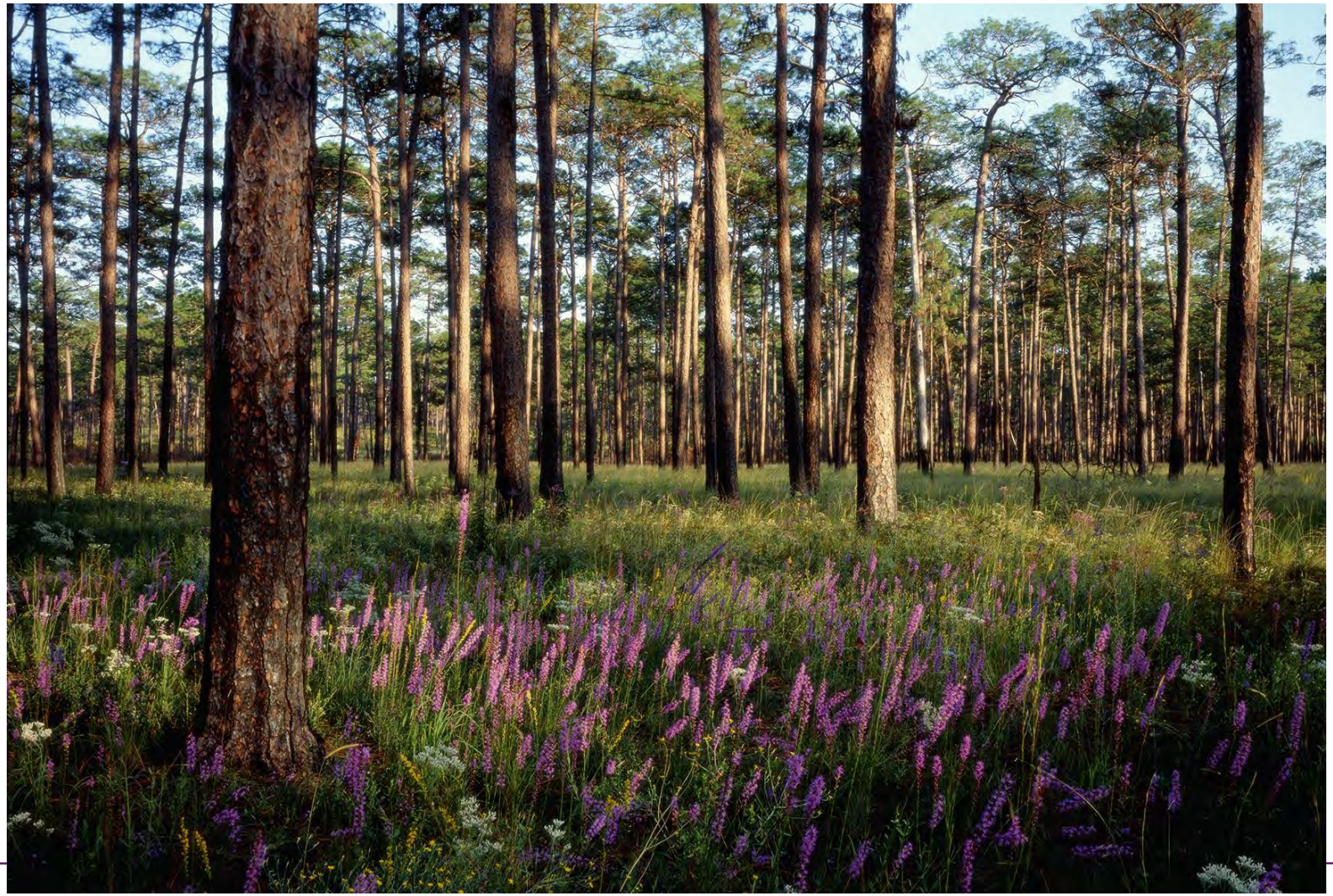
$$Q_s \bullet D_{50} \propto Q_w \bullet S$$

From Rosgen (1996), from Lane, Proceedings, 1955.
Published with the permission of American Society of Civil Engineers.

2

Some natural Florida stream types

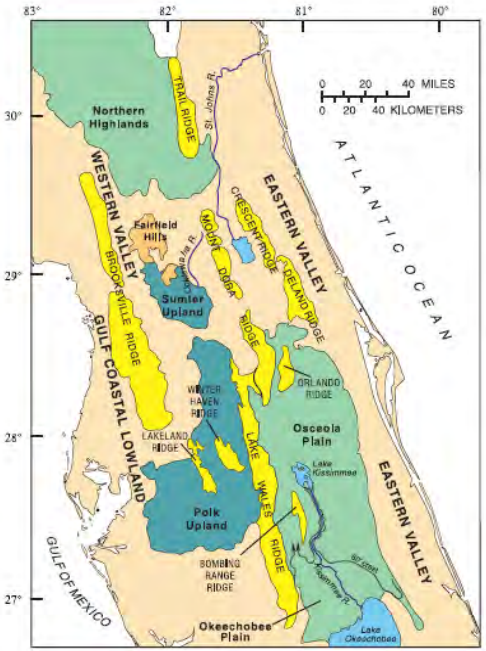
Flatwoods watersheds



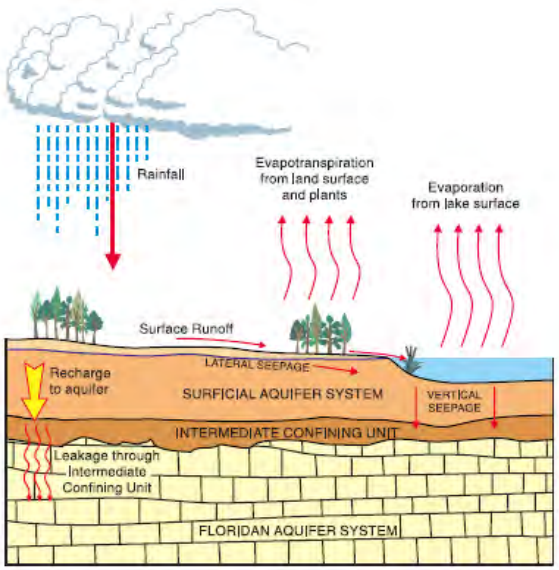
Highlands watersheds

Karst springsheds

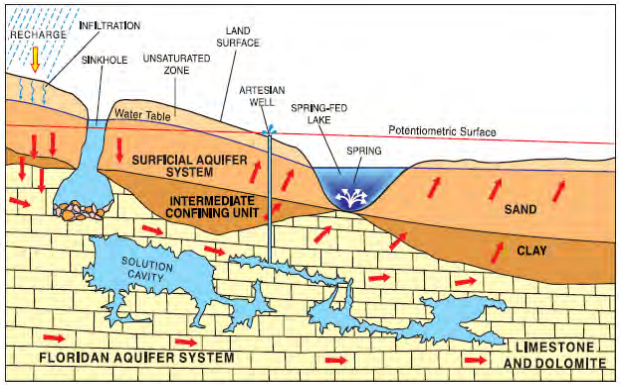
Natural reservoirs



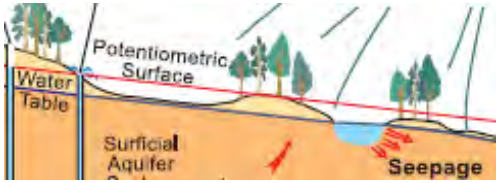
Flatwoods



Karst

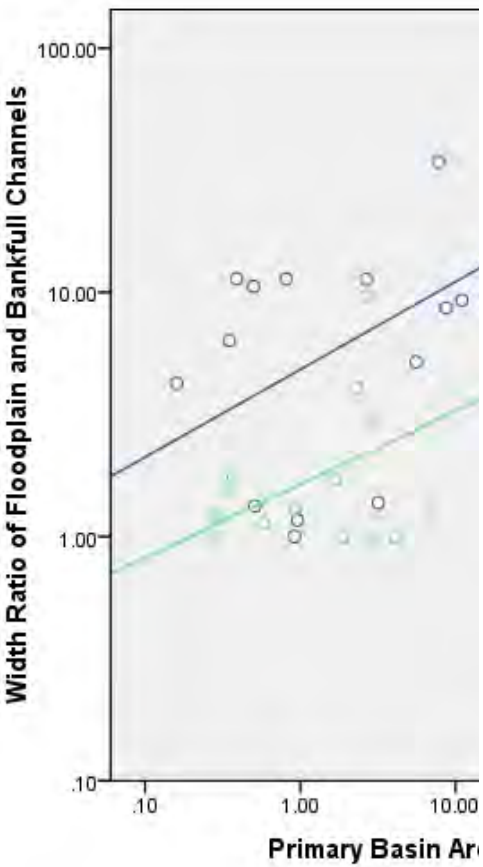


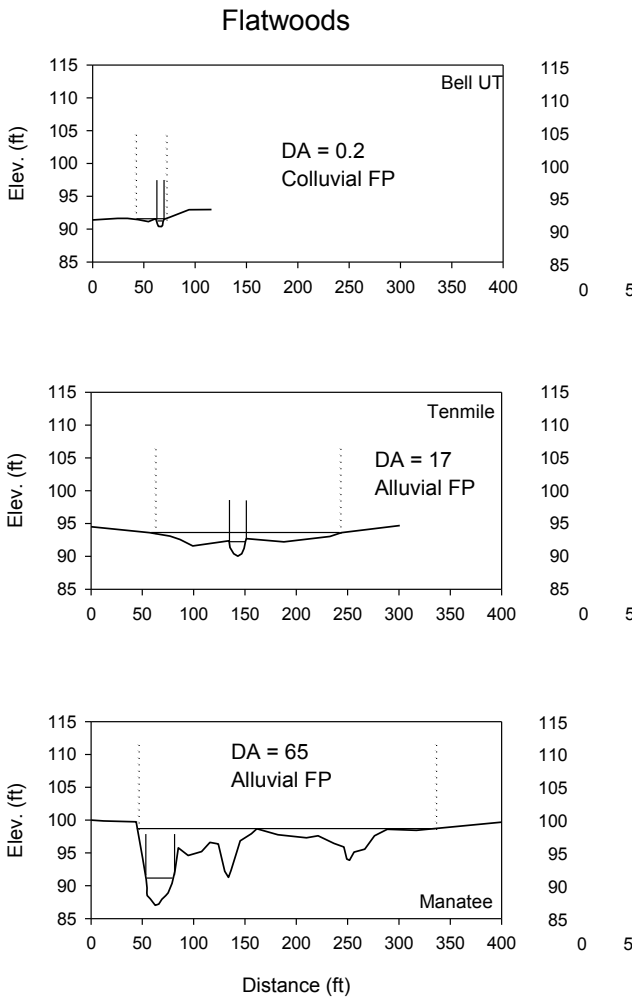
Highlands



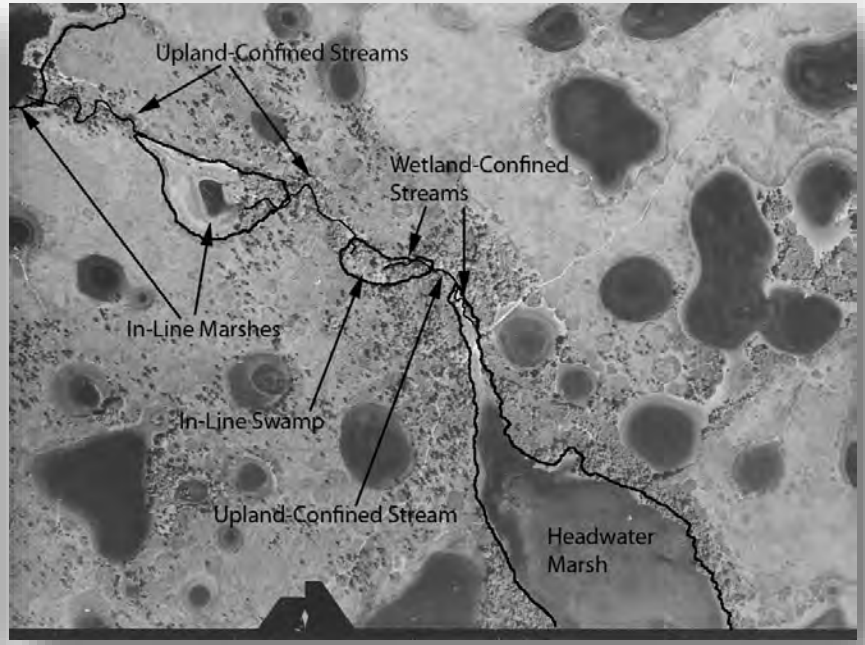
Diagrams from USGS Circular 1137 (1998)

Bigger watershed = bigger & more complex channels





Streams of the flatwoods



Streams of the flatwoods

Streams of the flatwoods

Streams of the highlands

3

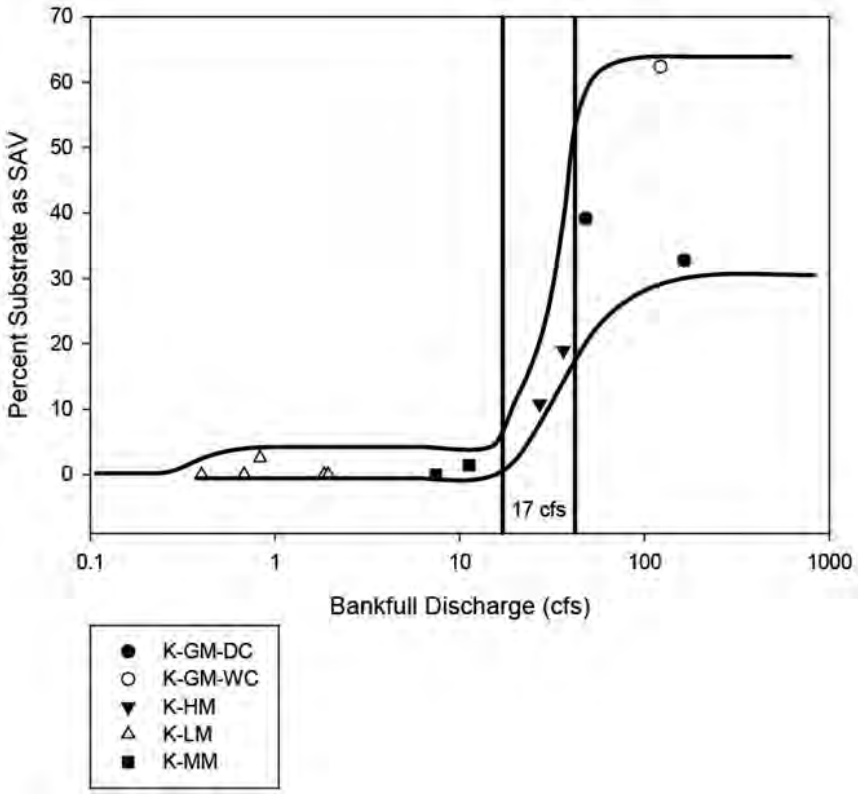
Does all this really matter?

Of course it does!

- **Only if you care about all of the following:**
  - Succeeding
  - Erosion and stability
  - Water quality
  - Salinity gradients
  - Flood hazards
  - Climate change resiliency
  - Riparian wetlands
  - Birds
  - Aquatic fauna
  - Not wasting money
  - Self-sustaining
  - Fishing

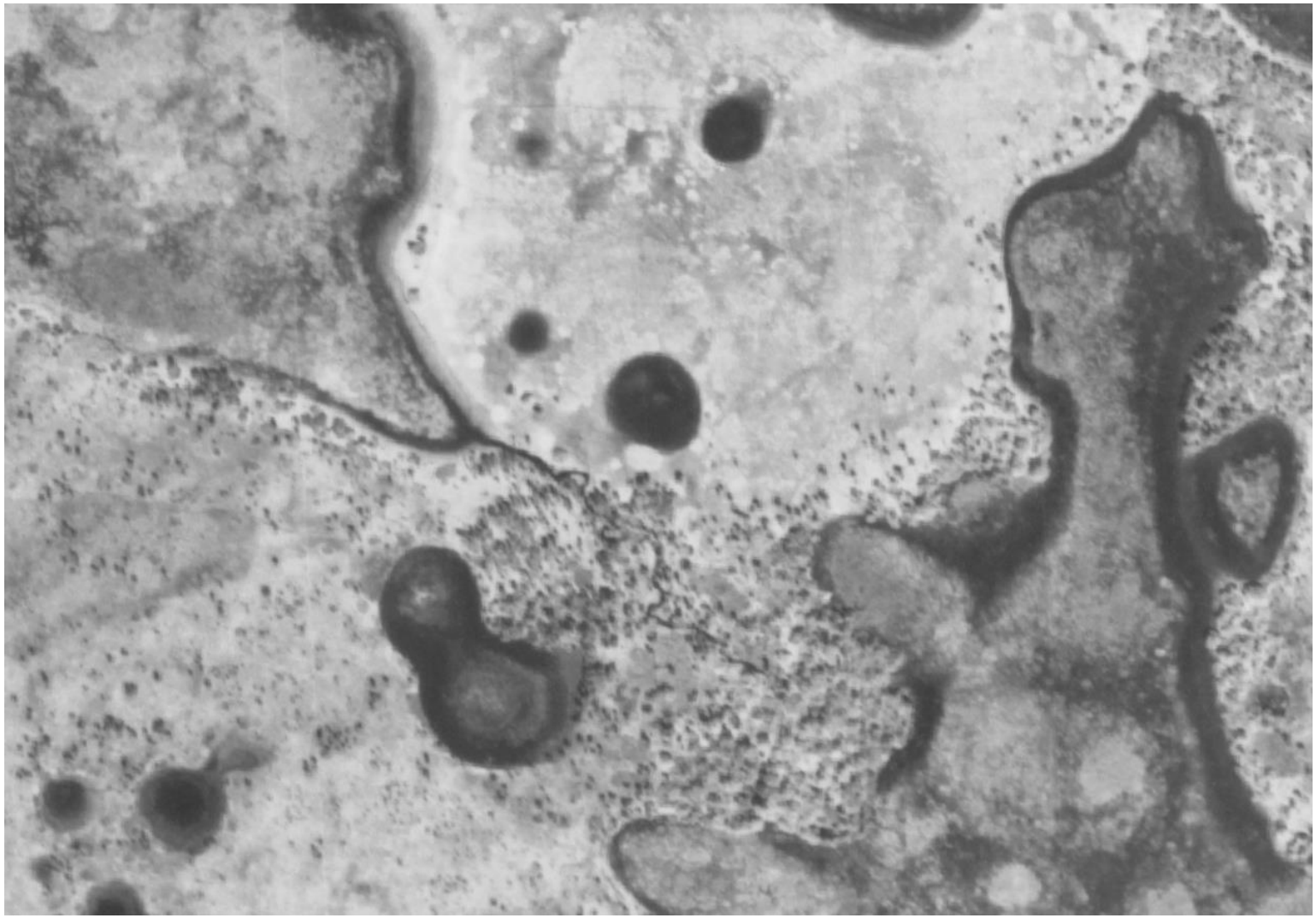
Why classify streams?

- **Figure out what can be established in any given part of a watershed**
- **Develop proper expectations for what kinds of channel and floodplain habitats are supportable**
- **Know what to monitor**



Forensic stream sleuthing

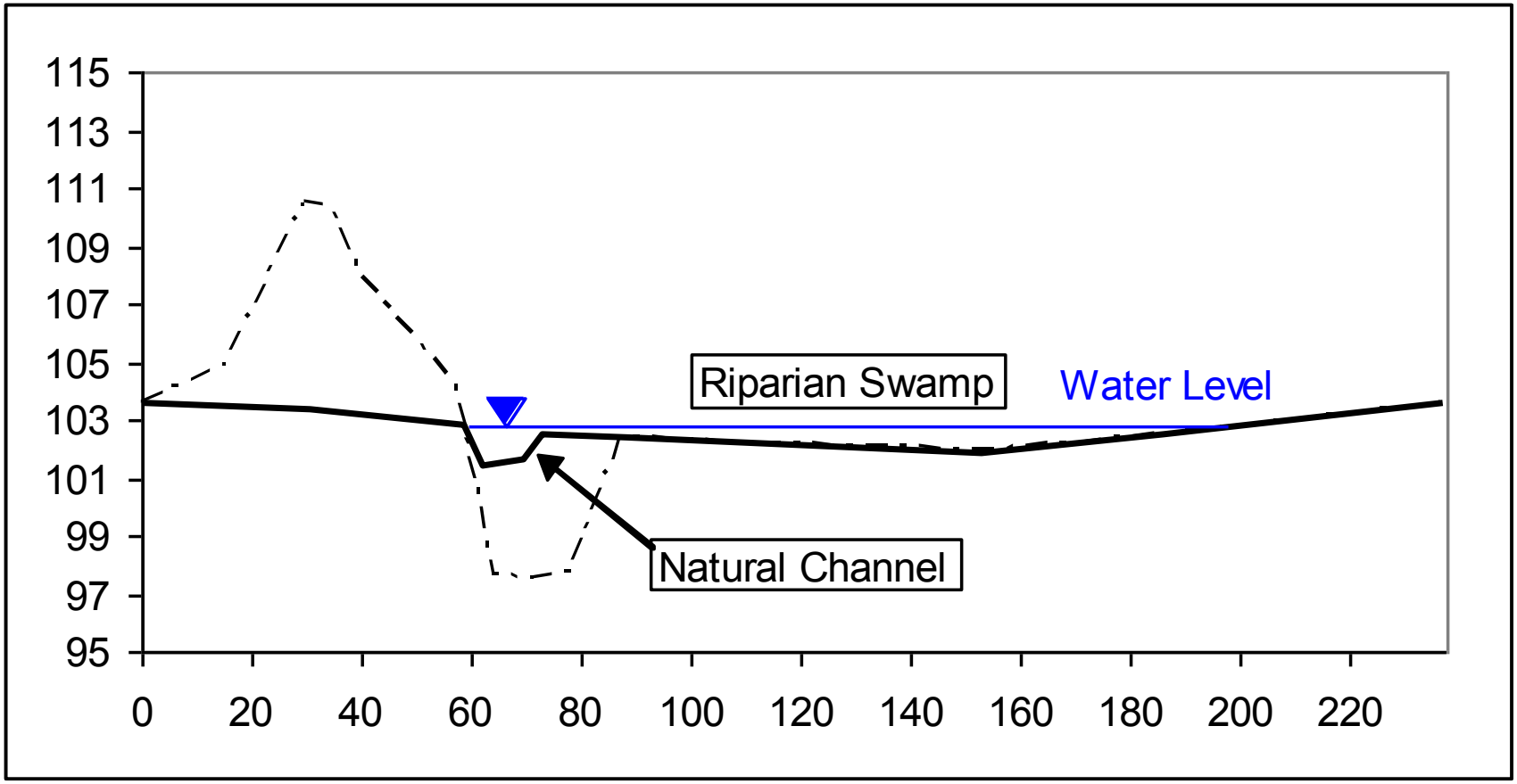
Forensic stream sleuthing

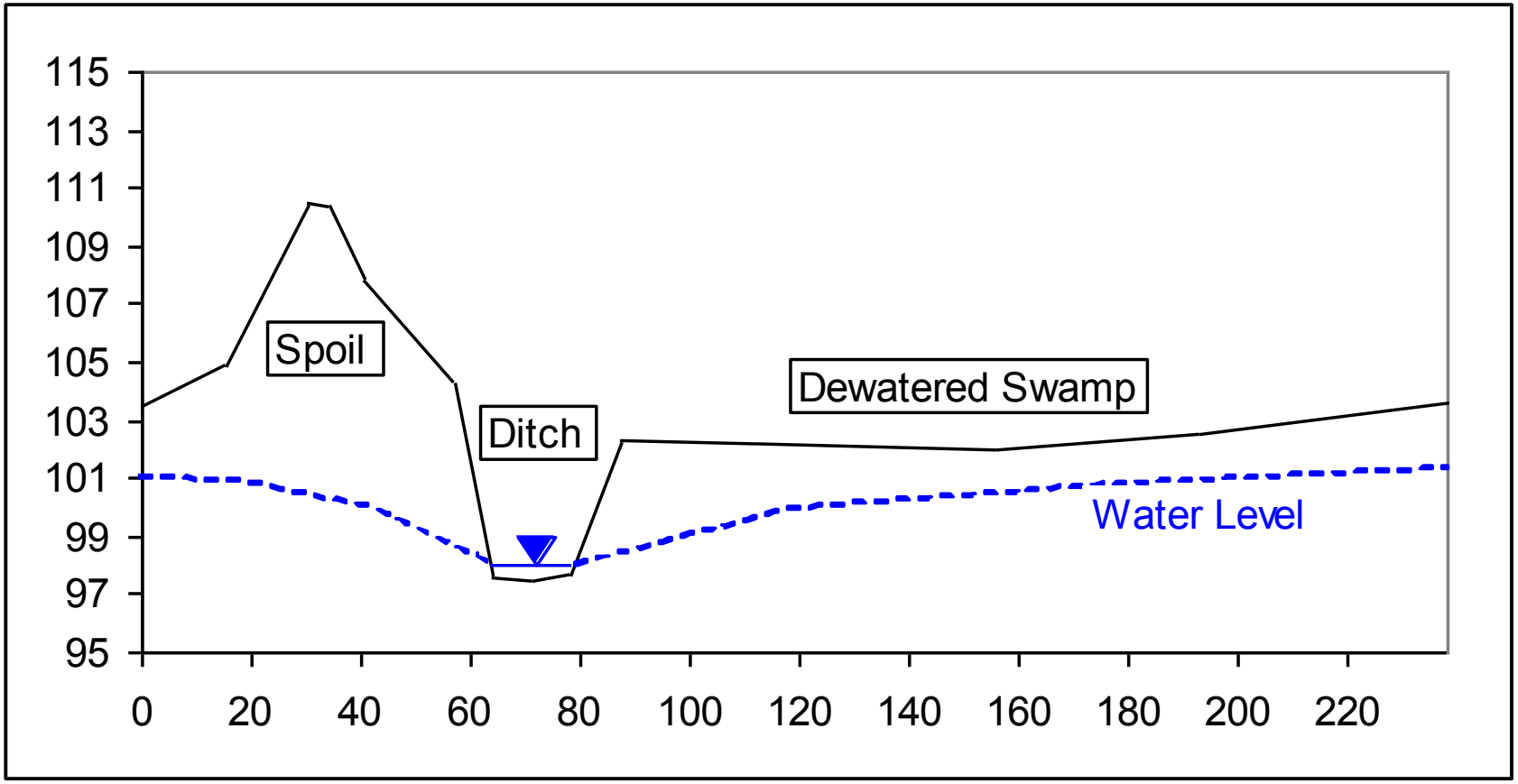


4

Some ways that trapezoidal ditches mess things up.

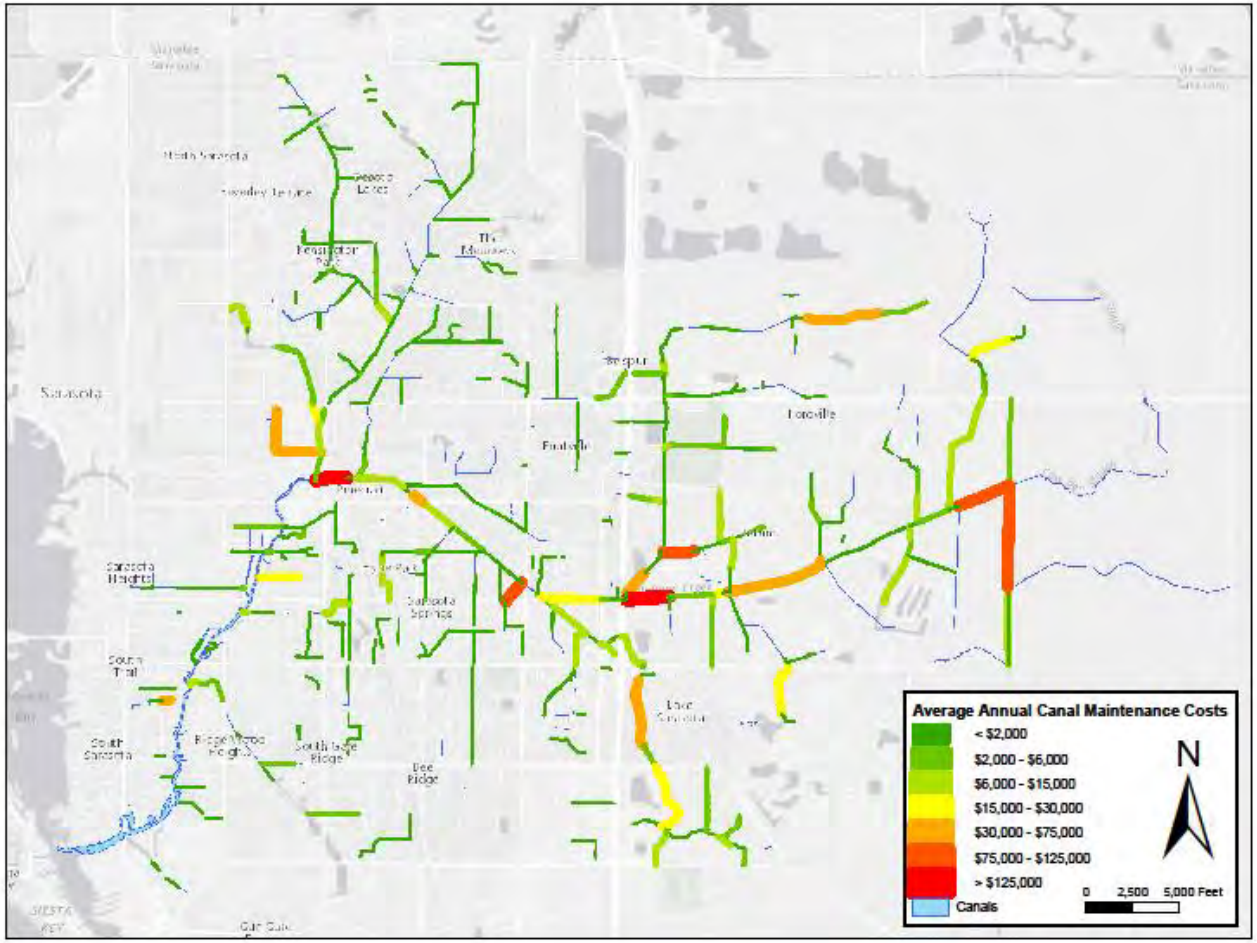
The ever-present trapezoidal ditch




115
113
111
109
107
105
103
101
99
97
95
0
20
40
60
80
100
120
140
160
180
200
220
Spoil
Ditch
Dewatered Swamp
Water Level

amec foster wheeler

amec foster wheeler


Average Annual Canal Maintenance Costs
< $2,000
$2,000 - $6,000
$6,000 - $15,000
$15,000 - $30,000
$30,000 - $75,000
$75,000 - $125,000
> $125,000
Canals
N
0 2,500 5,000 Feet


Leading edge of sediment plume
moving downstream


Stable
Unstable
Scalloped Gravity Failures
Toe Scour


Shallow Plane Failures
Stable Toe

5

What happens when development follows?

Urban Stream Syndrome

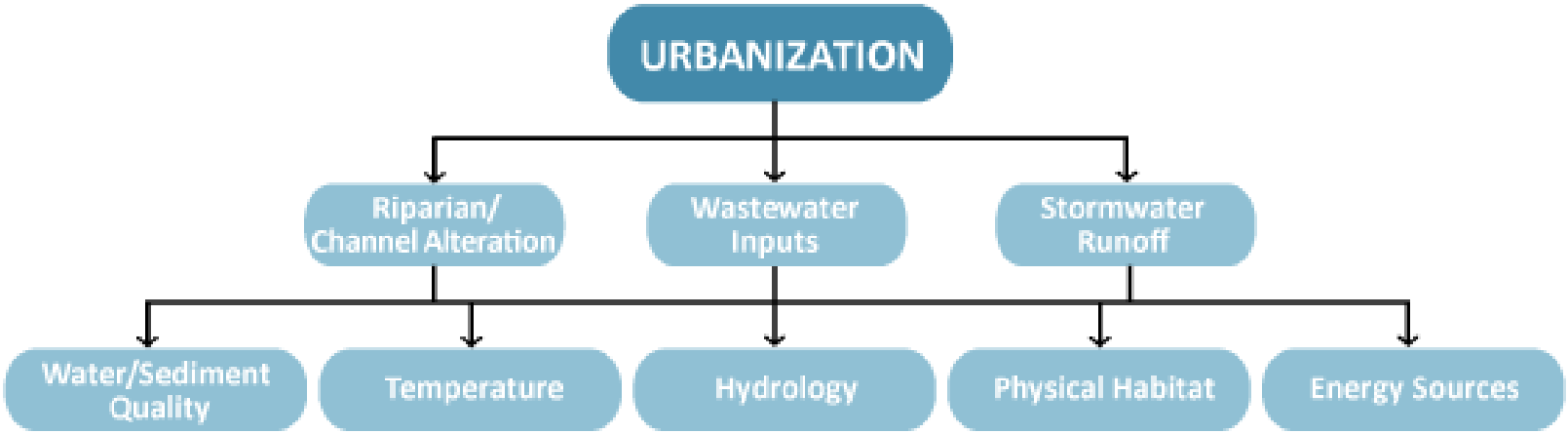
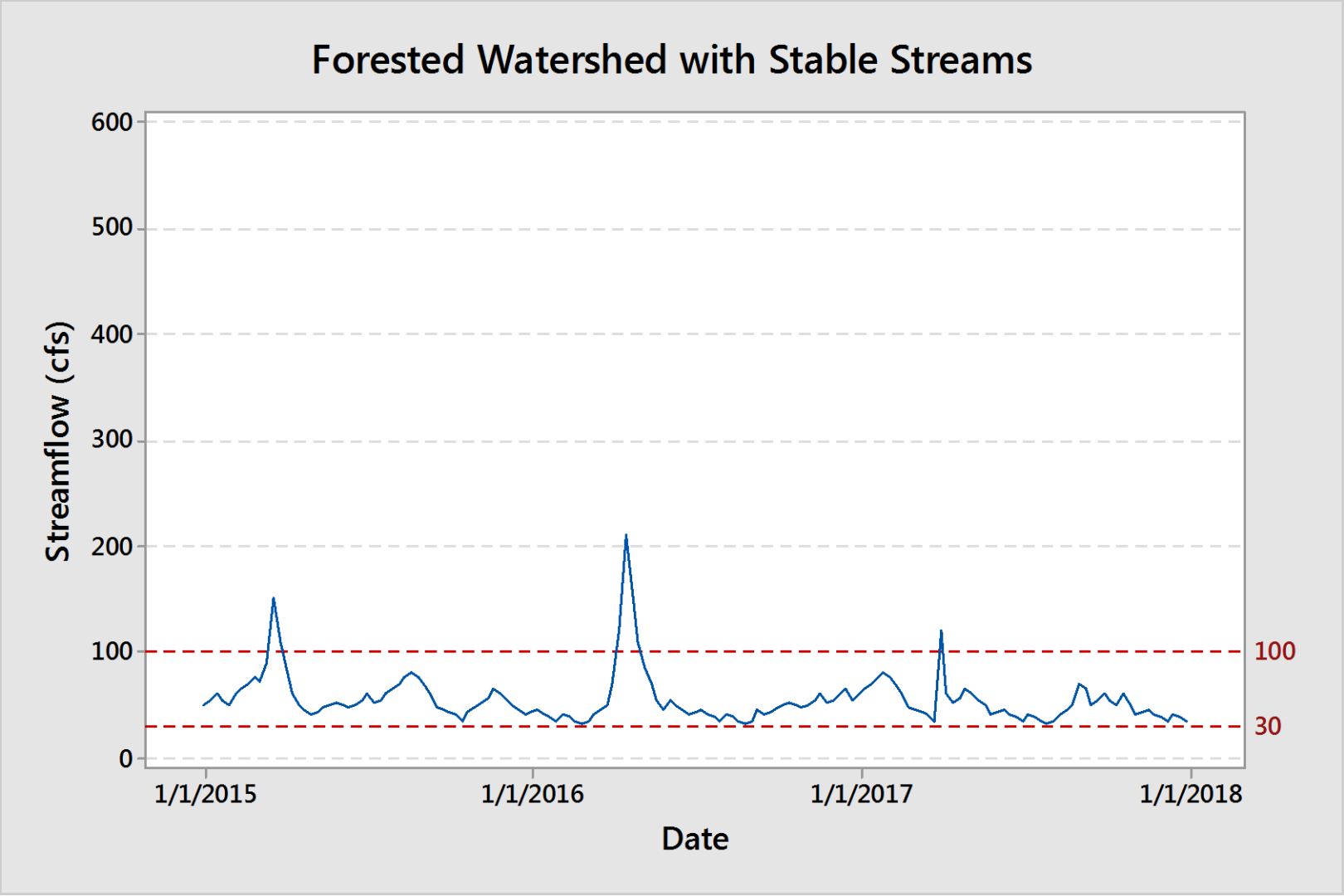
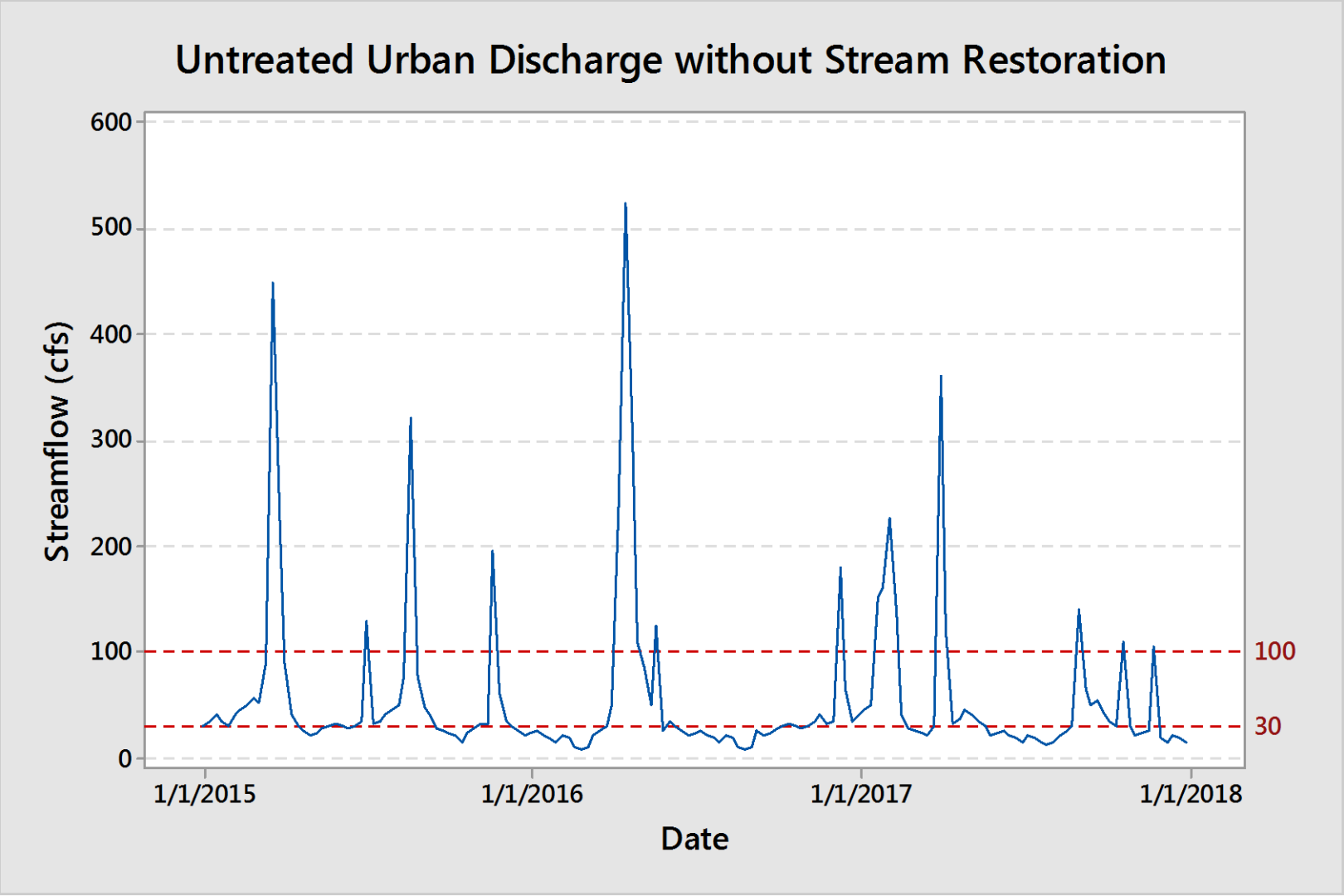


Image from US EPA

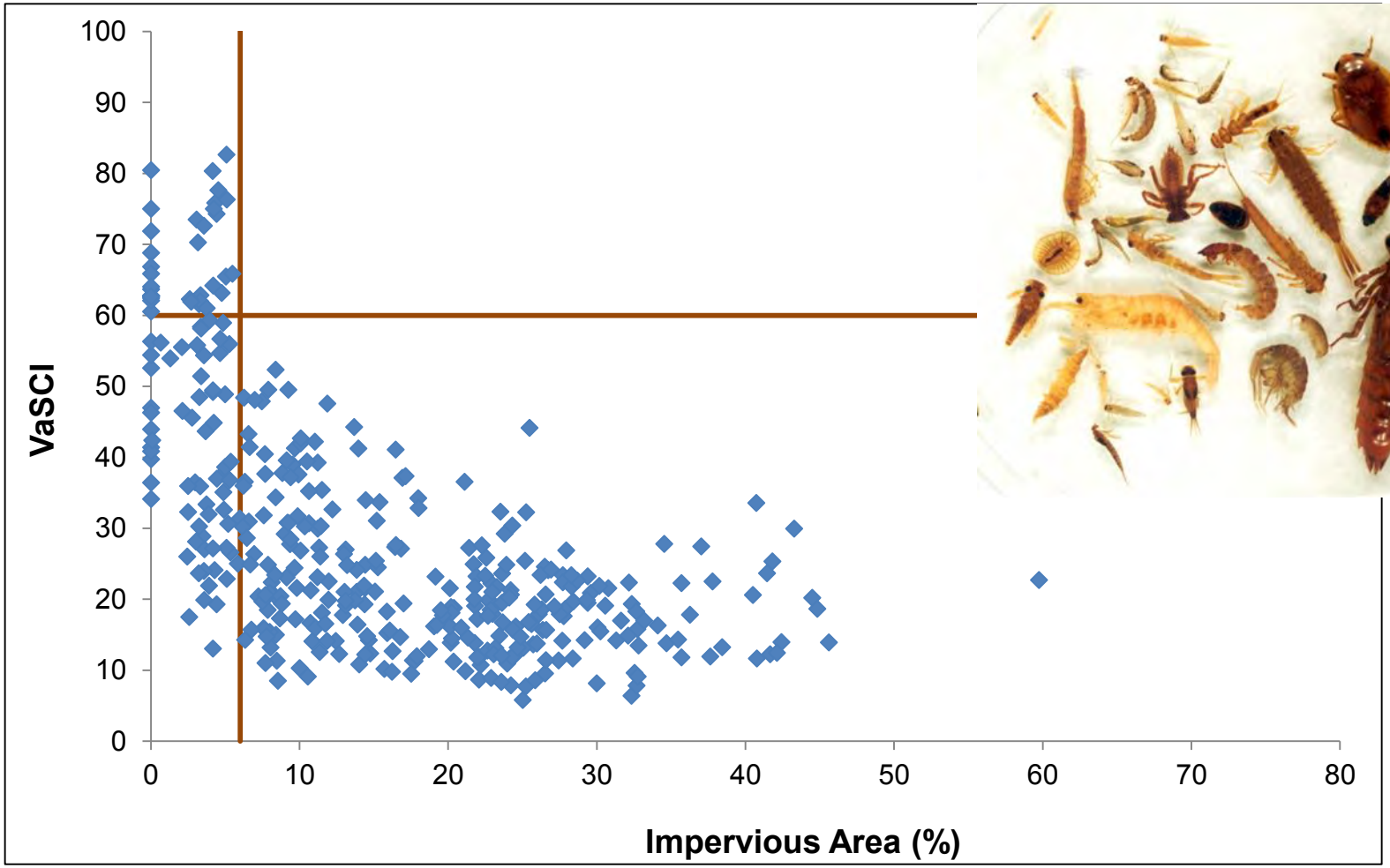


- 3 BkFl events
- 7 weeks cumulative exceedance
- 3 eight-month spells
- 0 weeks cumulative baseflow non-exceedance



- 12 BkFl events
- 20 weeks cumulative exceedance
- 0 eight-month spells
- 69 weeks cumulative baseflow non-exceedance

Urban Stream Syndrome



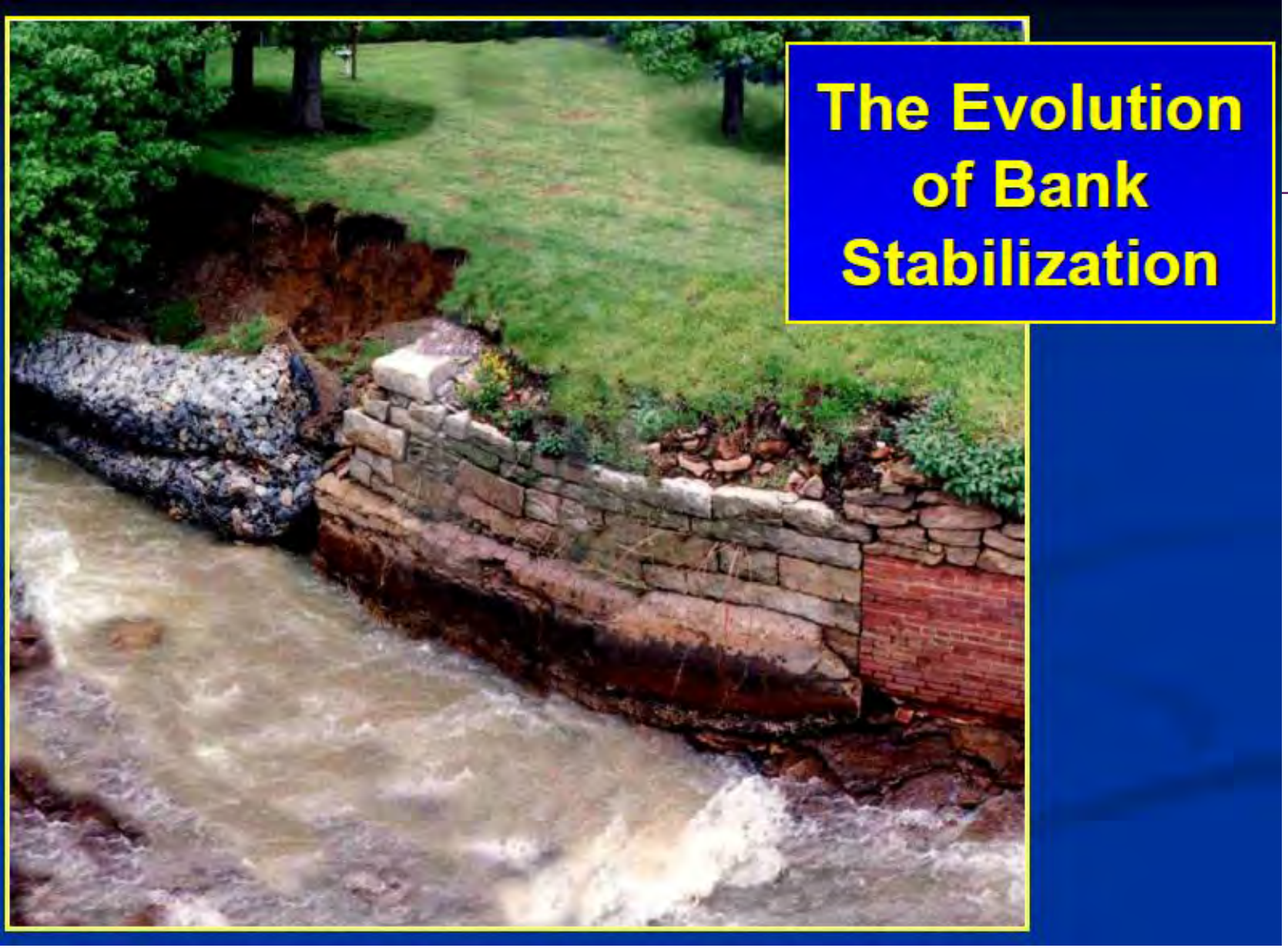


Image Credit: Dave Rosgen

Traditional, over-wide “gabion” F4 stream type channel requiring annual sediment dredging

Image Credit: Dave Rosgen

Benchmark Creek Gabions
(self-propelling, time-release bedload capsules)

Image Credit: Dave Rosgen

Benchmark Creek — 10 years later

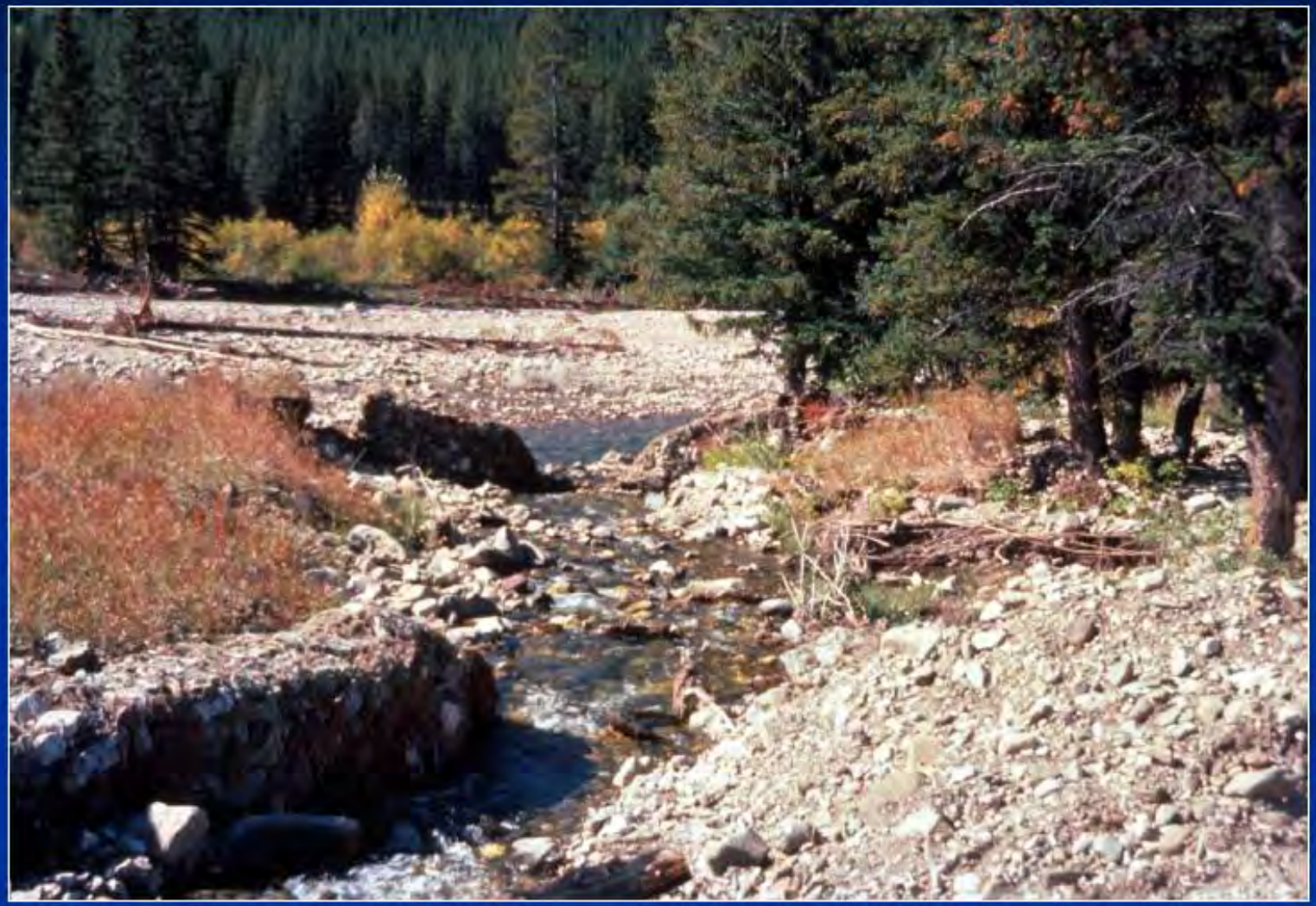


Image Credit: Dave Rosgen

…Would you fish this?
Spring Creek "Restoration"

Image Credit: Dave Rosgen

6

Please tell me there is a better way!

OK

- **Our job is to give the stream what it needs – Dave Rosgen, PhD**

- **"You cannot beat a river into submission. You have to surrender to its current and use its power as your own." – The Ancient One**

- from the movie Doctor Strange, 2016 (Marvel and Disney Studios)

Image Credit: Dave Rosgen

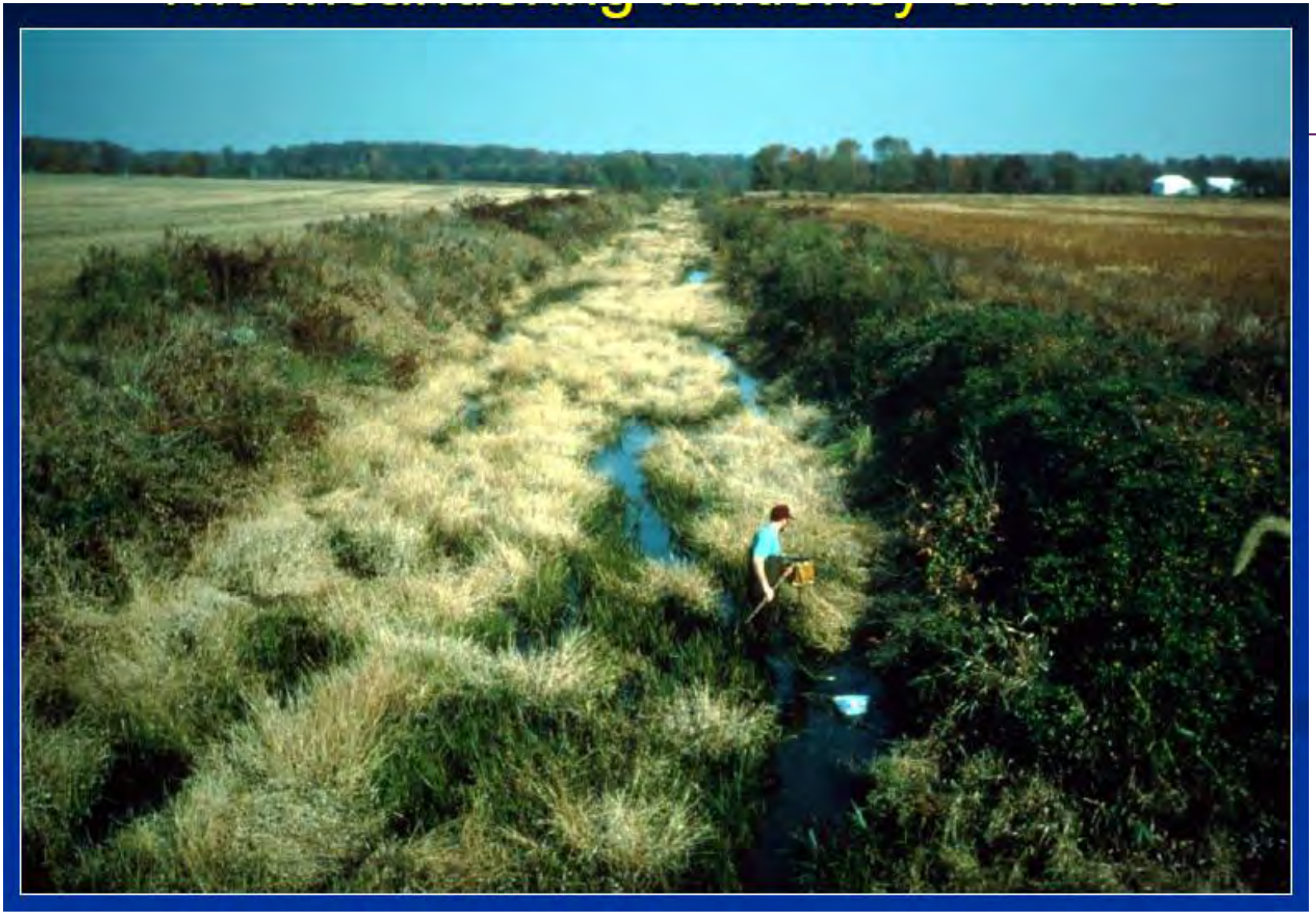
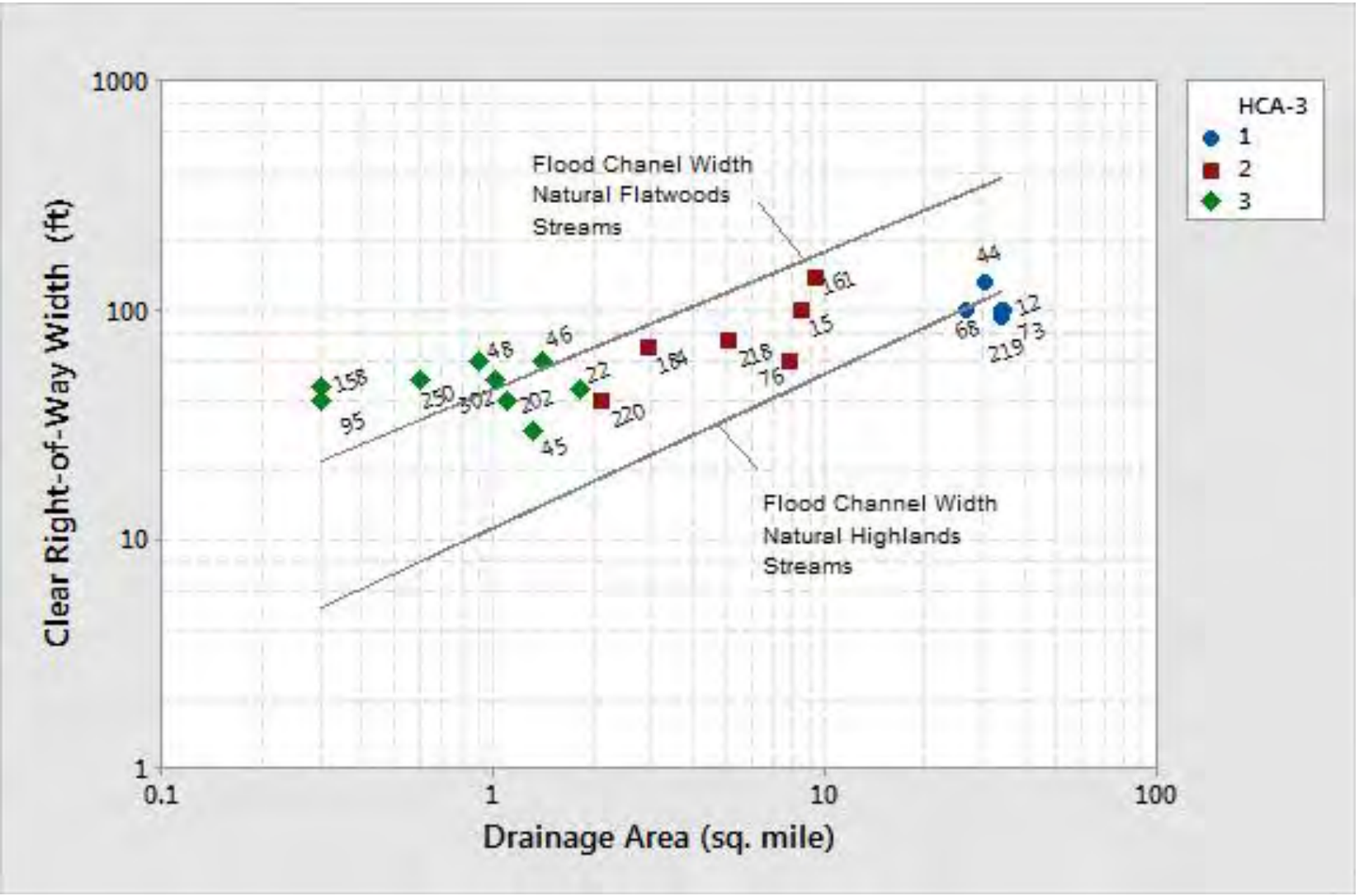
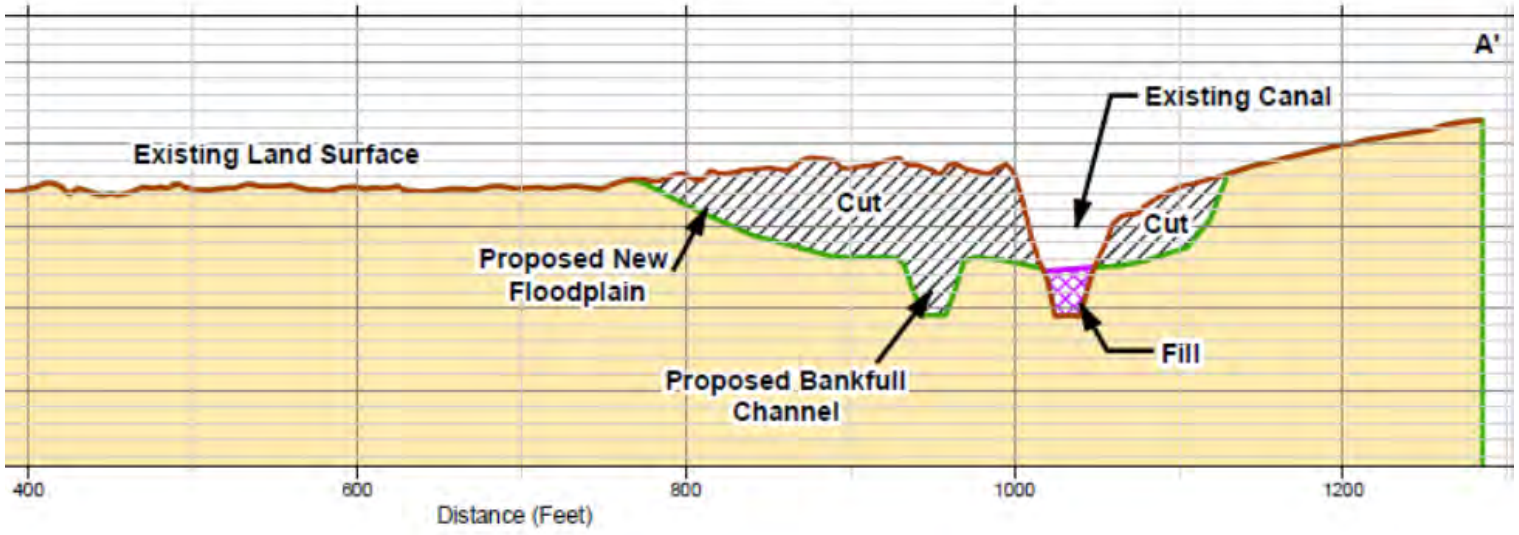
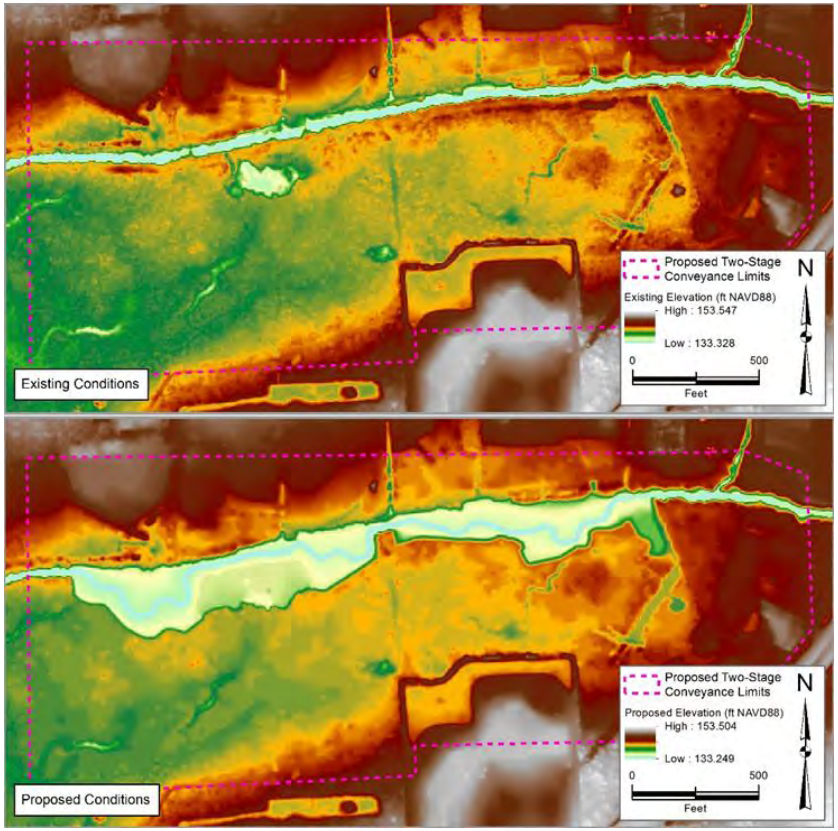


Image Credit: Dave Rosgen

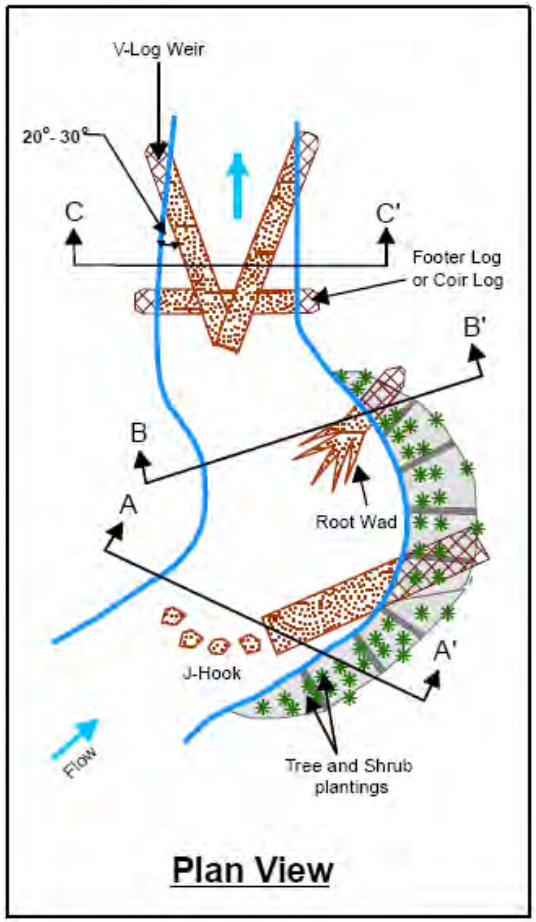

Clear Right-of-Way Width (ft)
1000
100
10
1
0.1
1
10
100
Drainage Area (sq. mile)
Flood Chanel Width
Natural Flatwoods
Streams
Flood Channel Width
Natural Highlands
Streams
HCA-3
1
2
3
158
95
250
48
302
46
202
45
22
220
184
161
15
218
76
44
68
12
73
219

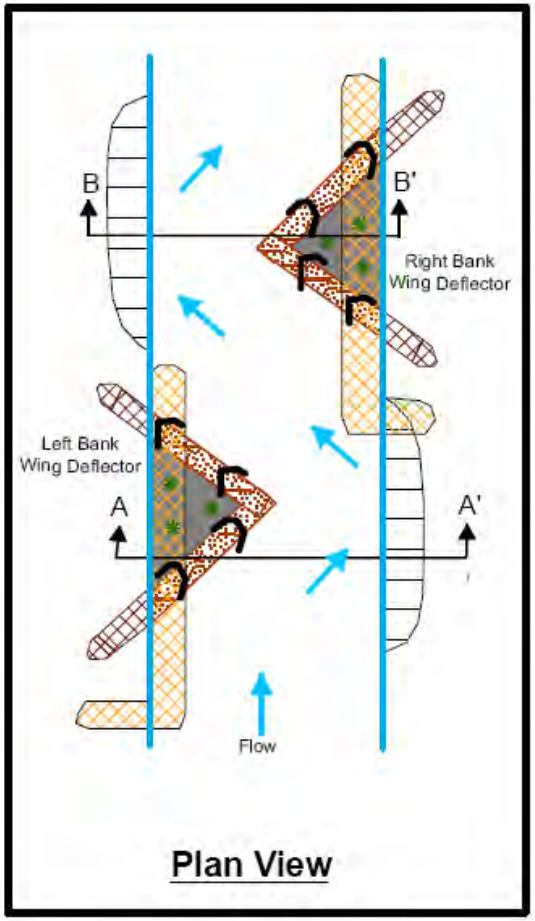

A'
Existing Canal
Existing Land Surface
Cut
Cut
Proposed New
Floodplain
Fill
Proposed Bankfull
Channel
400
600
800
1000
1200
Distance (Feet)


Existing Conditions
Proposed Two-Stage
Conveyance Limits
Existing Elevation (ft NAVD88)
High : 153.547
Low : 133.328
0
500
Feet
N
Proposed Conditions
Proposed Two-Stage
Conveyance Limits
Proposed Elevation (ft NAVD88)
High : 153.504
Low : 133.249
0
500
Feet
N

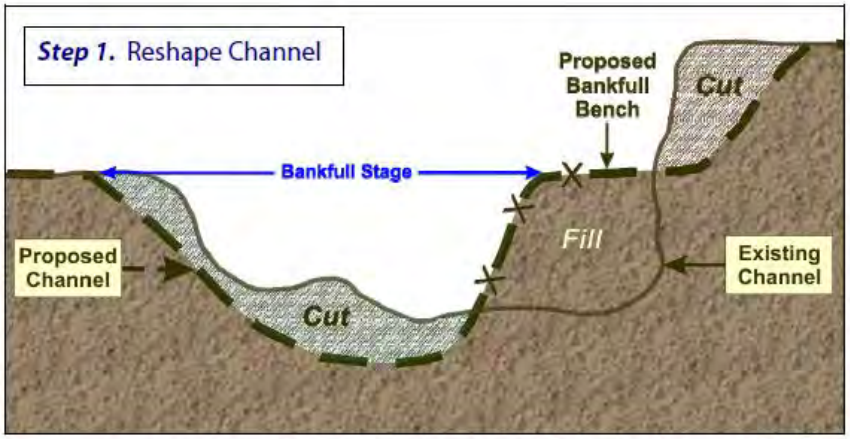
Natural Channel Design

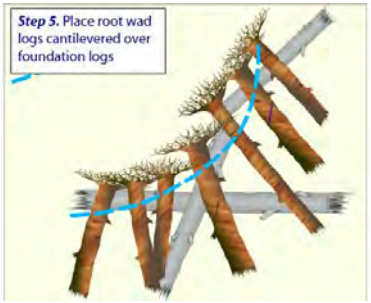
- **Designing channels that fit their watersheds**
  - Bankfull dimensions
- **Large woody debris (LWD) structures redirect energy, provide habitat, and enhance water quality**
  - Rootwads
  - V-log weirs
  - Wing deflectors
  - J-hooks

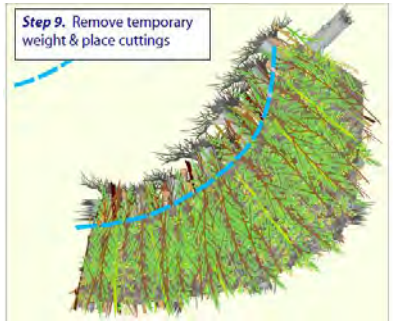




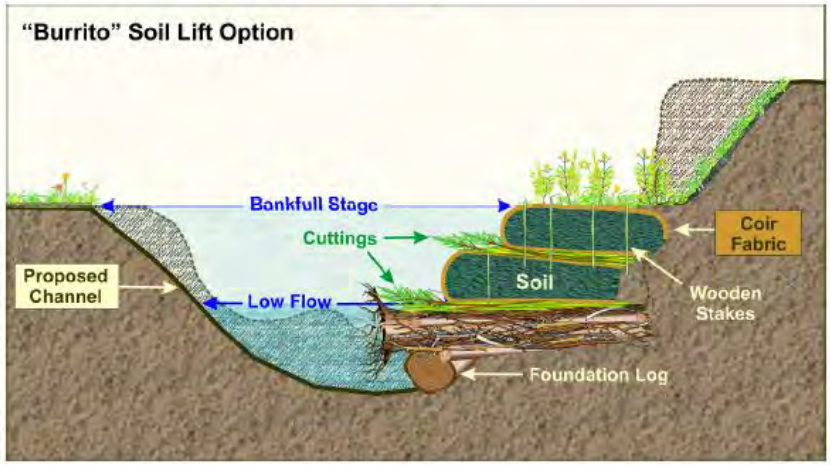
Toe Wood Structure





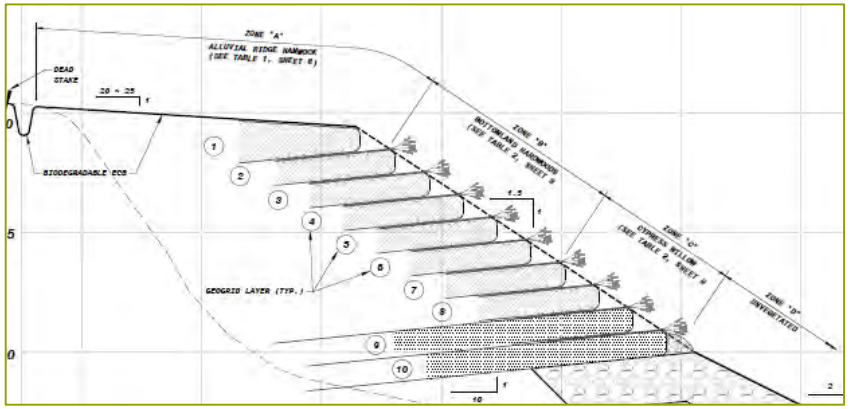


Step 11 – Option 3. Install "burrito" soil lifts and layers of cuttings between soil lifts up to the bankfull stage



Vegetation Reinforced Soil Slope (VRSS)

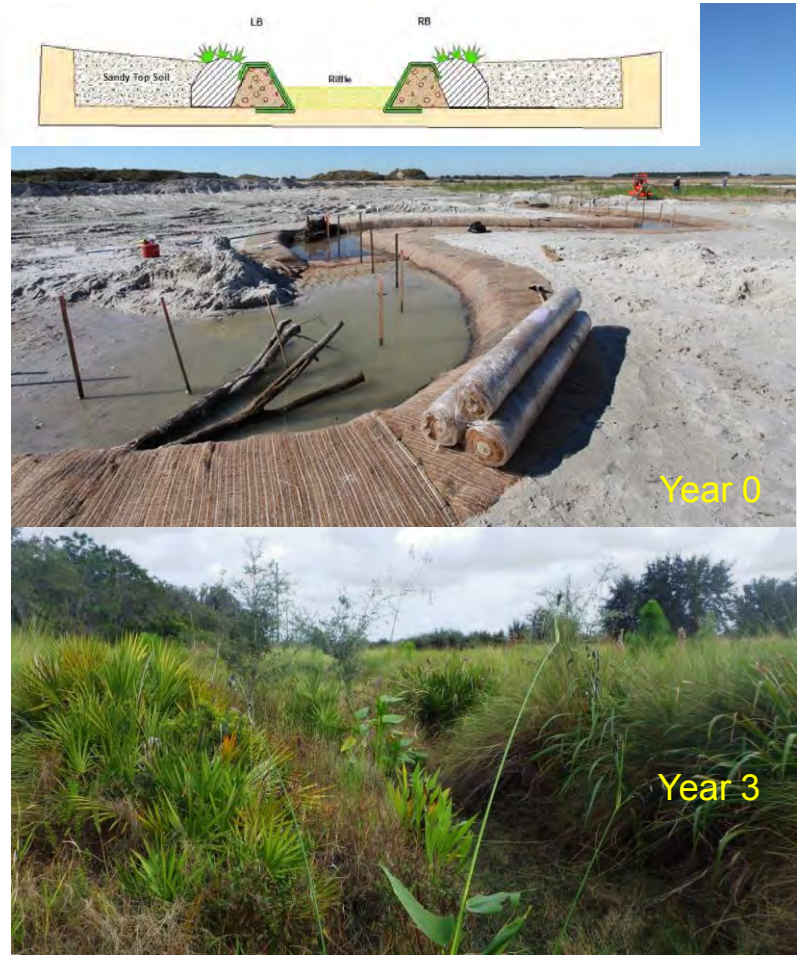
- **Stabilizes banks by wrapping layers of soil**
- **Plant between the layers, roots bind layers**
- **Living shoreline**
  - ecological benefits
  - aesthetically pleasing
- **Similar level of service to rip rap with lower costs**




04/19/2017


2017

Soil bioengineering stabilization – growth pattern



- **Soil bioengineering**
- **Natural channel design**

Water Quality Benefits - Chesapeake Bay TMDL Stream Restoration Protocols

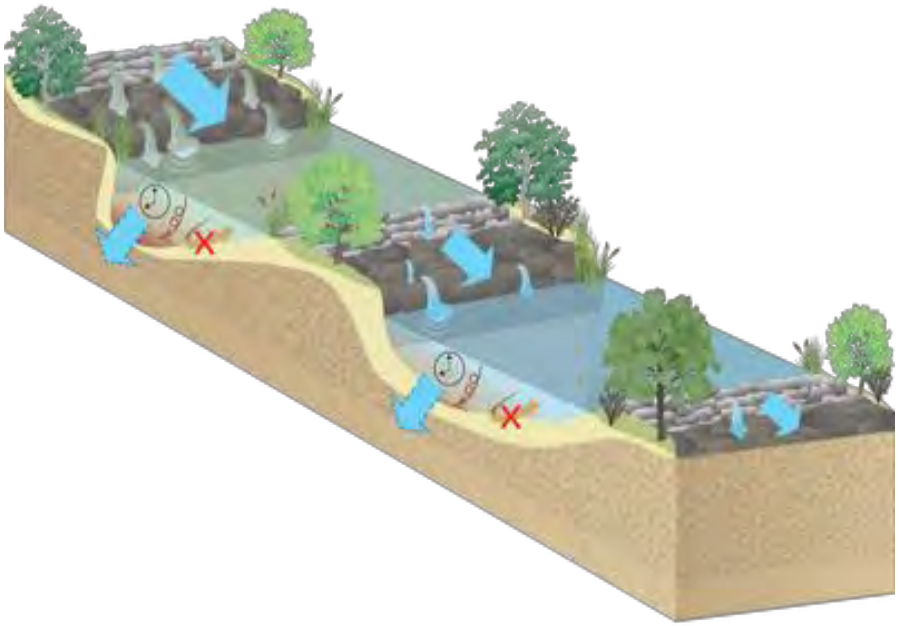
- **P1: Bank stabilization during storm flow**
- **P2: Hyporheic exchange during baseflow**
- **P3: Floodplain reconnection (including wet RSC)**
- **P4: Dry RSC – Provides add-on reductions downstream of untreated impervious surface**

- **Determined to be among the lowest cost options for TP, TN, and TSS reduction in Virginia.**
- **Protocols are additive**
- **Renewable in 5-year increments**

Regenerative Stormwater Conveyance (RSC)

- **Series of pools, weir structures, and underlying sand to treat and convey stormwater**
- **Low impact development**
- **Can be applied to incised channels**

Regenerative stormwater conveyance systems (RSC)



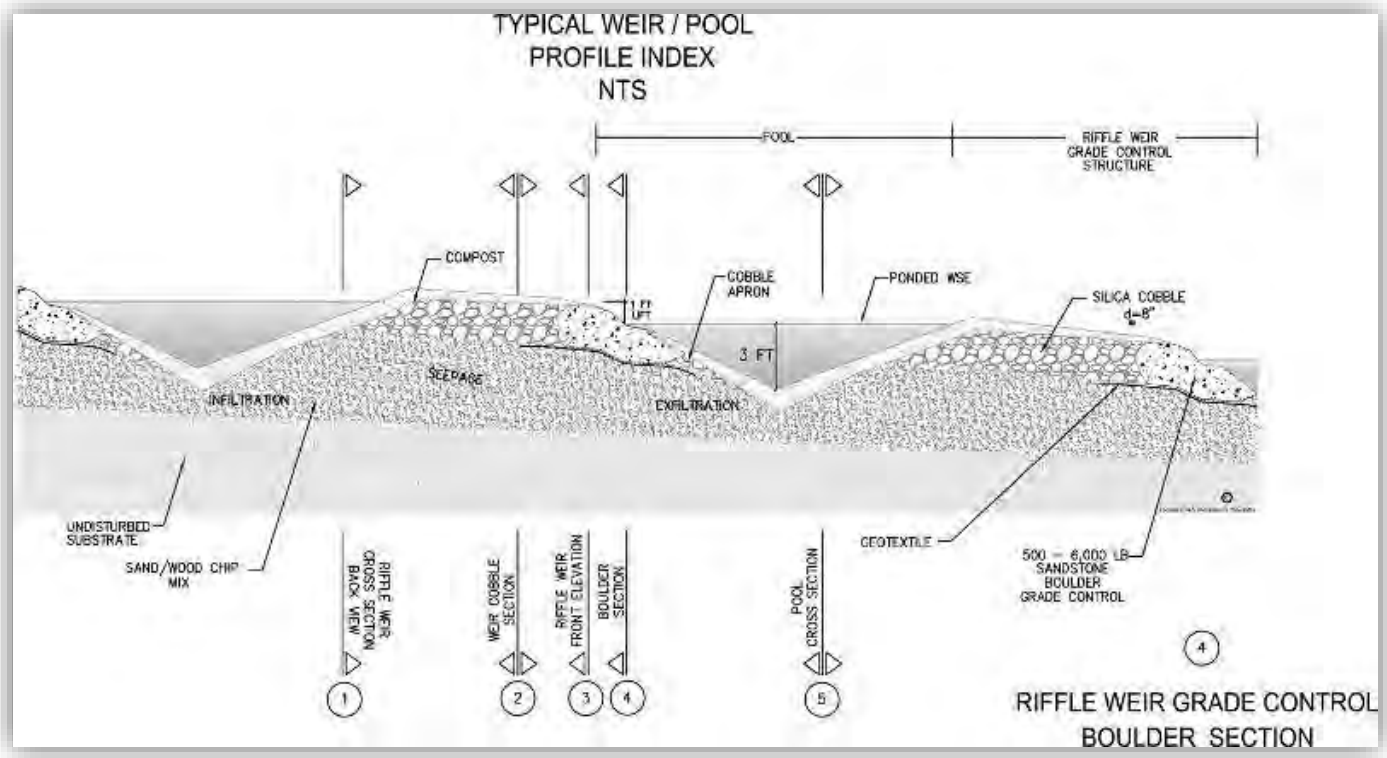
Reducing water quantity

The structure of this system is effective at reducing stormwater volume, thereby preventing streambed erosion and increasing groundwater recharge.

Improving water quality

With a reduced flow, stormwater is retained for a longer period, enabling pollutants, nutrients, and sediment to settle and be biologically transformed.

Regenerative Stormwater Conveyance



http://www.foresthillsconnection.com/site2/wp-content/upLoadImage2012/filtration-pool.jpg

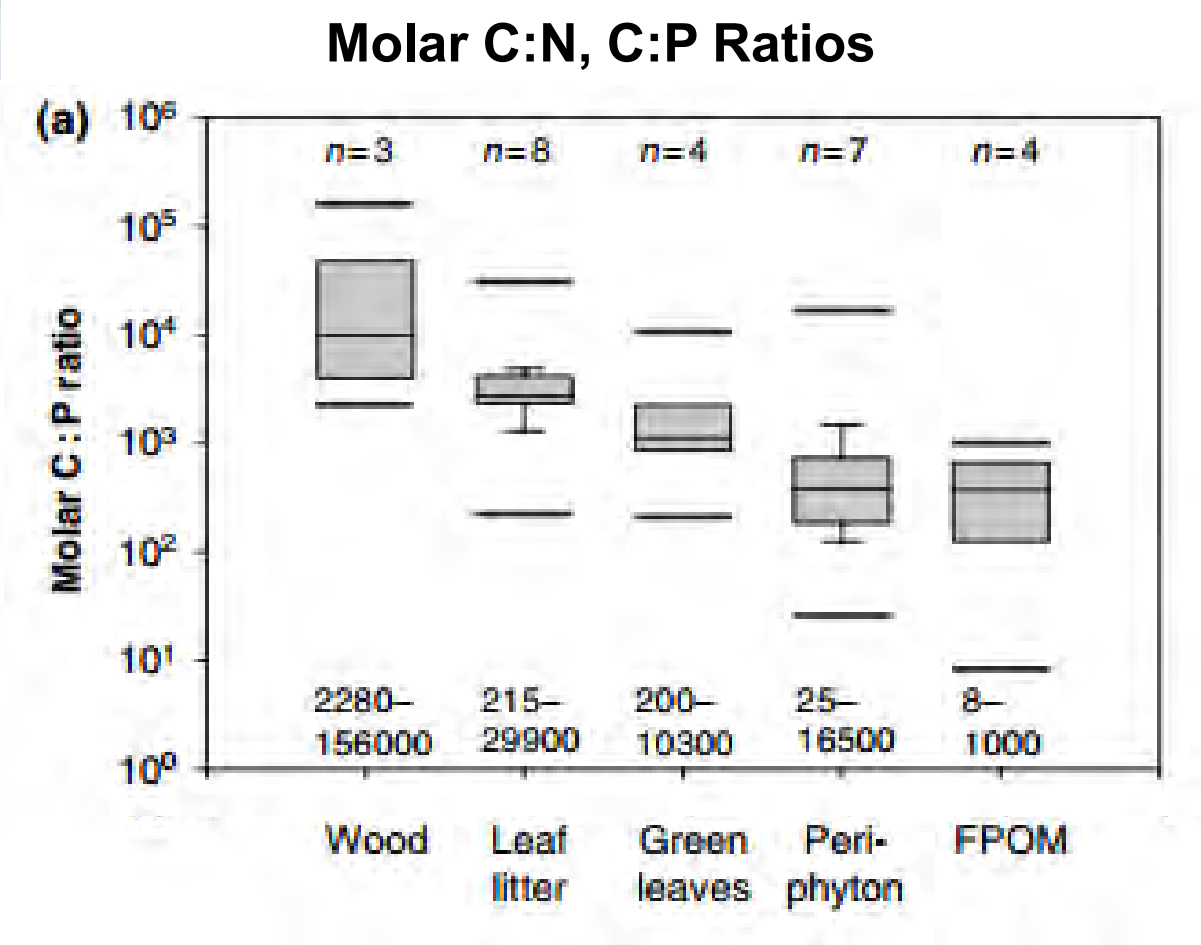
Ecological Stoichiometry

Benthic Resource Elemental Composition

Terrestrially-derived: wood, leaf litter, green leaves

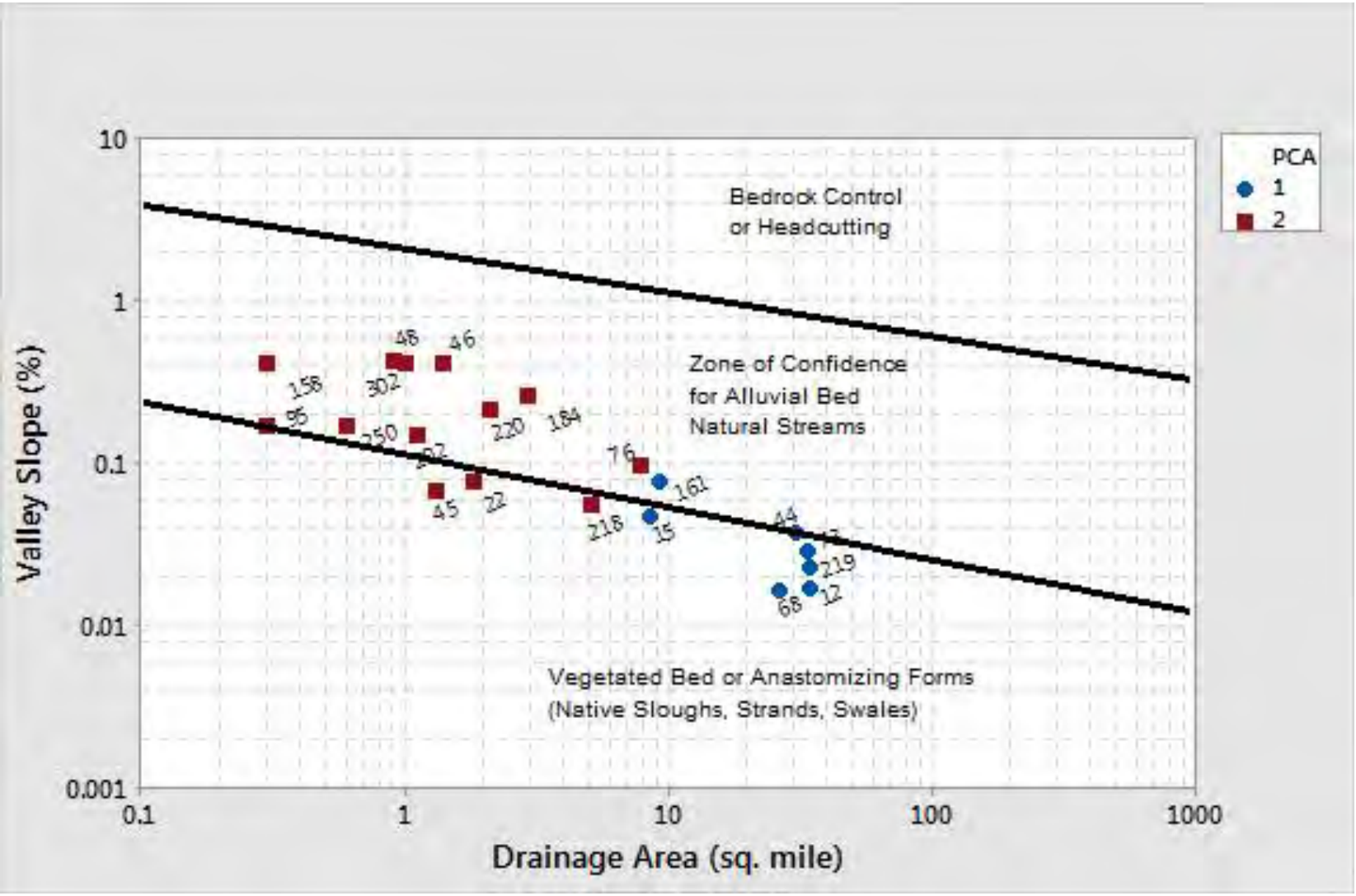
Aquatic origin: periphyton, aquatic plants

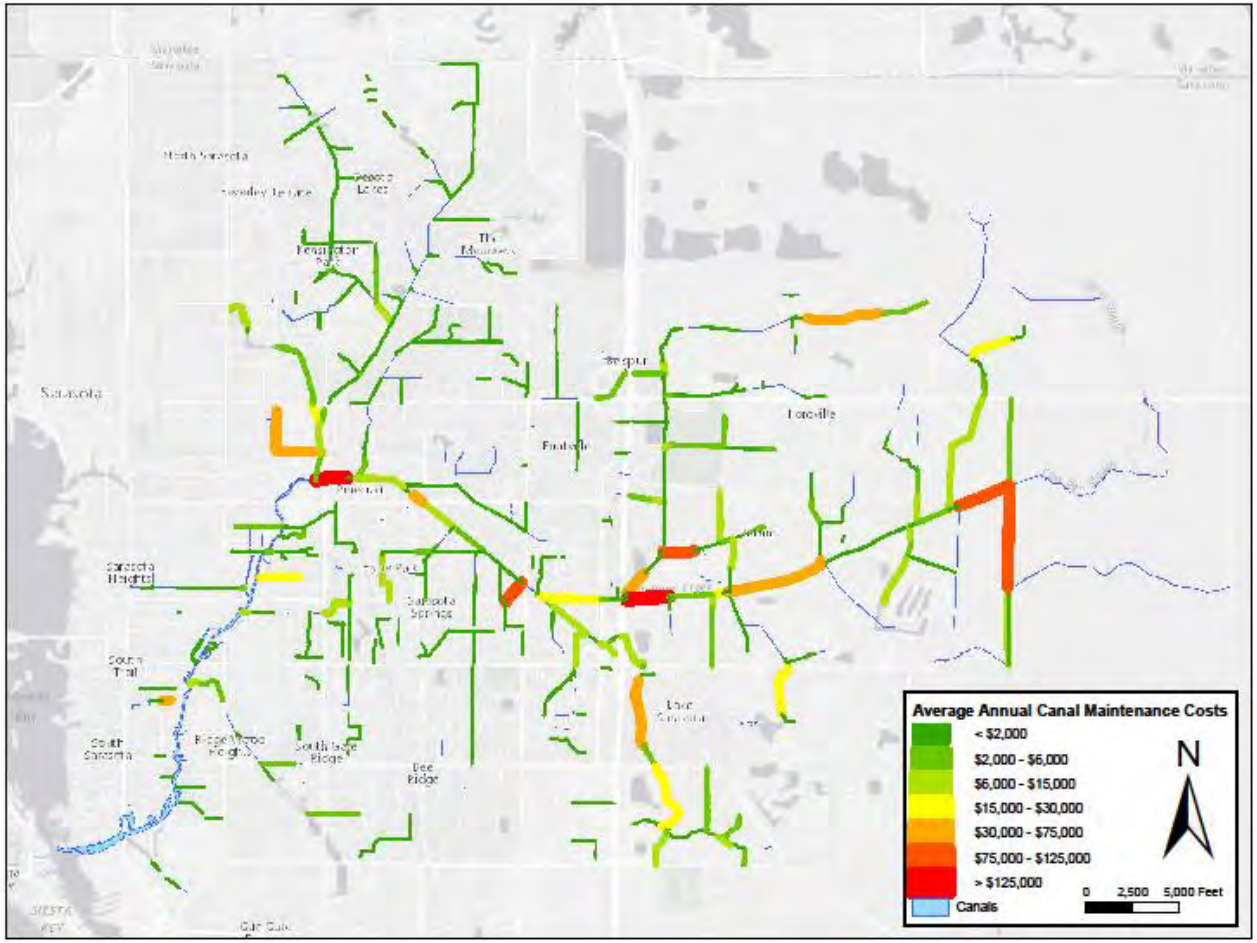
- Closest to requirements of bacteria



Source: Cross et al. 2005

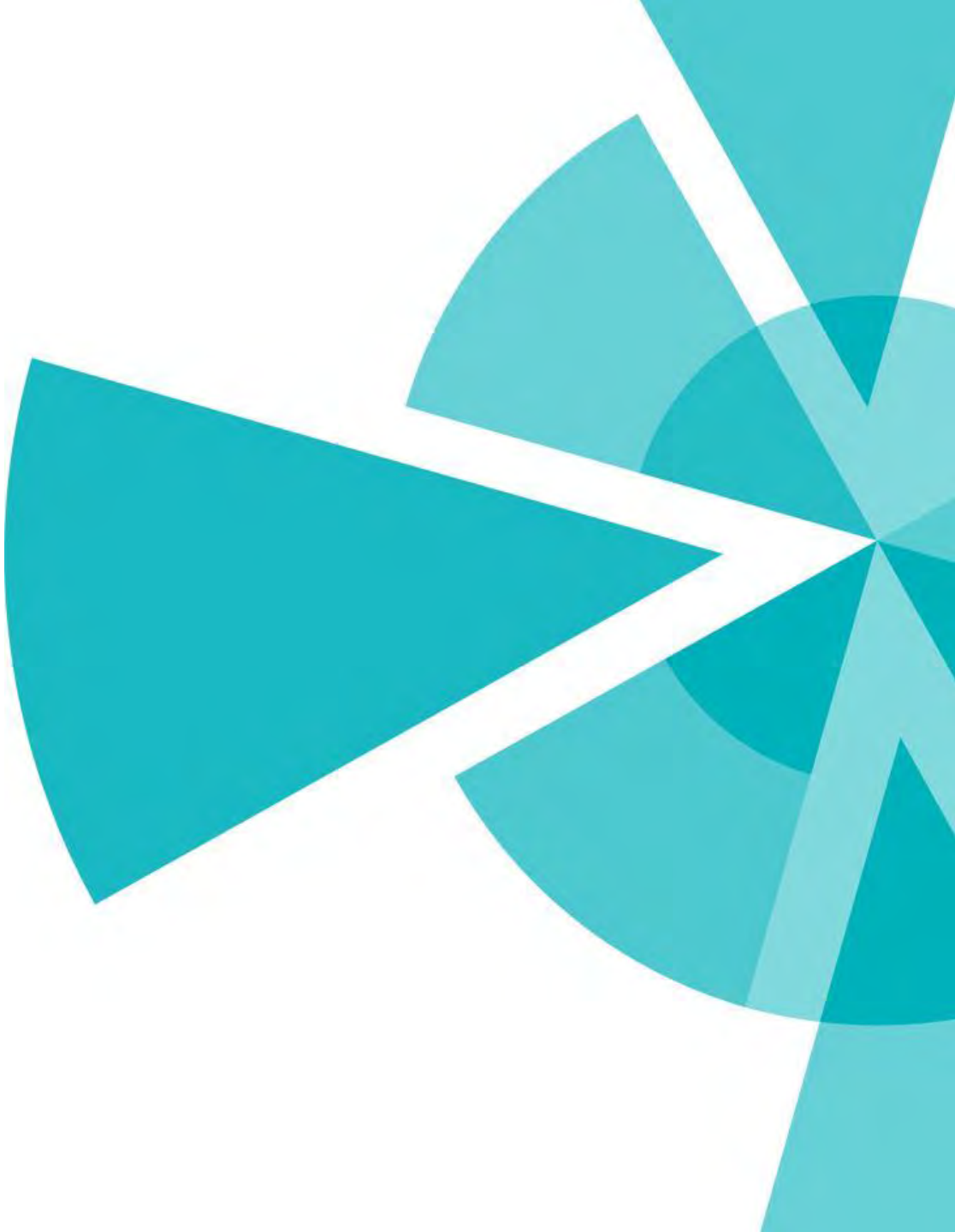
Valley foci for sedimentation


Bedrock Control
or Headcutting
Zone of Confidence
for Alluvial Bed
Natural Streams
Vegetated Bed or Anastomizing Forms
(Native Sloughs, Strands, Swales)
PCA
1
2
Valley Slope (%)
Drainage Area (sq. mile)
10
1
0.1
0.01
0.001
0.1
1
10
100
1000
48
46
158
302
95
250
220
184
76
161
45
22
218
15
44
219
68
12


Average Annual Canal Maintenance Costs
< $2,000
$2,000 - $6,000
$6,000 - $15,000
$15,000 - $30,000
$30,000 - $75,000
$75,000 - $125,000
> $125,000
Canals
N
0 2,500 5,000 Feet

7

Some lessons learned



Standard Applied Science & Engineering

amec foster wheeler

Recommendations of the Expert Panel to Define Removal Rates for Individual Stream Restoration Projects

Joe Berg, Josh Burch, Deb Cappuccitti, Solange Filoso, Lisa Fraley-McNeal, Dave Goerman, Natalie Hardman, Sujay Kaushal, Dan Medina, Matt Meyers, Bob Kerr, Steve Stewart, Bettina Sullivan, Robert Walter and Julie Winters

Accepted by Urban Stormwater Work Group (USWG): **February 19, 2013**
Approved by Watershed Technical Work Group (WTWG): **April 5, 2013**
Final Approval by Water Quality Goal Implementation Team (WQGIT): **May 13, 2013**
Test-Drive Revisions Approved by the USWG : **January 17, 2014**
Test-Drive Revisions Approved by the WTWG: August 28, 2014
Test-Drive Revisions Approved by the WQGIT: September 8, 2014

Prepared by:
Tom Schueler, Chesapeake Stormwater Network
and
Bill Stack, Center for Watershed Protection

United States Department of Agriculture

Natural Resources Conservation Service

Part 654
National Engineering Handbook

Stream Restoration Design

(210-VI-NEH, August 2007)

Vegetated Reinforced Soil Slope Streambank Erosion Control

emip

By Robbin B. Sotir[1] and J. Craig Fischenich[2]

May 2003

Complexity	Environmental Value	Cost
Low Moderate High	Low Moderate High	Low Moderate High

OVERVIEW

The vegetated reinforced soil slope (VRSS) soil bioengineering system is an earthen structure made from living, rootable, live-cut, woody plant material branches, bare root, tubling or container plant stock in conjunction with rock, geosynthetics, geogrids, and/or geocomposites (Figure 1). The VRSS system is useful for the immediate repair or prevention of deeper failures providing a structurally sound system with soil reinforcement, drainage and erosion control typically on steepened slope sites where space is limited. In the VRSS system, the living cut branches and plants are expected to grow (performing additional soil reinforcement functions via the roots and surface protection via the top growth).

Live vegetation in the VRSS is typically installed from just above the baseflow elevation and up the face of the reconstructed streambank, acting principally to protect the bank through immediate mechanical soil reinforcement and confinement, drainage, and, in the toe area, with rock. The VRSS system extends below the depth of scour, typically with rock. Rock is useful in improving infiltration and supporting the riparian zone. The internal systems such as rock, live cut branches, geosynthetics, geogrids, and geocomposites can also be configured to act as drains that redirect and/or collect internal bank seepage and transport the water to the stream via a rock toe. (Figures 2-7).

Figure 1. Illustrations of VRSS system frontal configurations

Figure 2. Constructing a VRSS structure rock toe protection and slope drainage

[1] President; Robbin B. Sotir & Associates, Inc., 434 West Cobb Parkway, Marietta, GA 30064
[2] USAE Research and Development Center, Environmental Laboratory, 3909 Halls Ferry Rd., Vicksburg, MS 39180

ERDC TN-EMRRP-SR-30 1

Publication No. 03-154-253

PENINSULAR FLORIDA STREAM SYSTEMS: GUIDANCE FOR THEIR CLASSIFICATION AND RESTORATION

FINAL REPORT

Prepared by

AMEC ENVIRONMENT AND INFRASTRUCTURE, INC.
Lakeland, FL

UNIVERSITY OF FLORIDA
Gainesville, FL

and

UNIVERSITY OF SOUTH FLORIDA
Tampa, FL

under a grant sponsored by

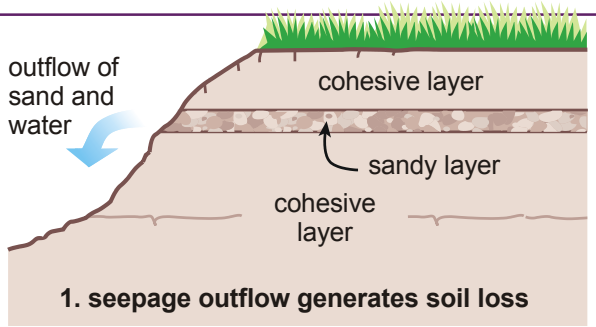
FIPR Florida Industrial and Phosphate Research Institute

June 2015

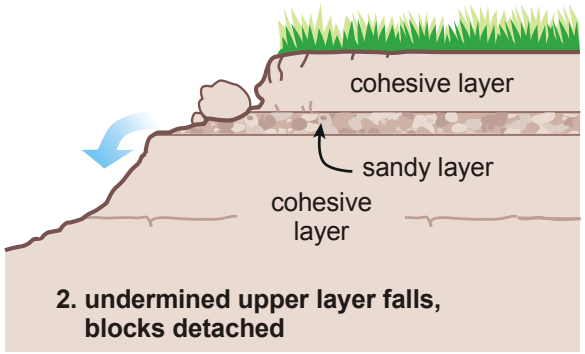
Ground Water as an Erosive Force

Excessive sapping can be induced by degradation

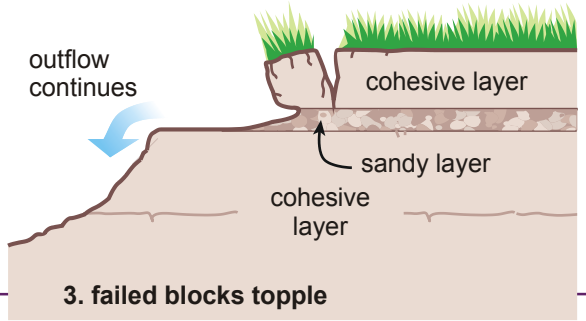
Particularly sensitive in sand-and-gravel aquifer region



1. seepage outflow generates soil loss



2. undermined upper layer falls, blocks detached



3. failed blocks topple

Ground Water is a Key Ingredient

Effects of Desnagging for Flood Management (Alligator Creek)

- **Snags and bank vegetation removed to improve channel capacity and reduce floods**
- **Assumes channel is non-deformable**
- **Results**
  - Eroding and collapsing banks
  - Trees fall in and replace those removed
  - Habitat smothering
  - Sediment clogged culverts (displaced flooding)

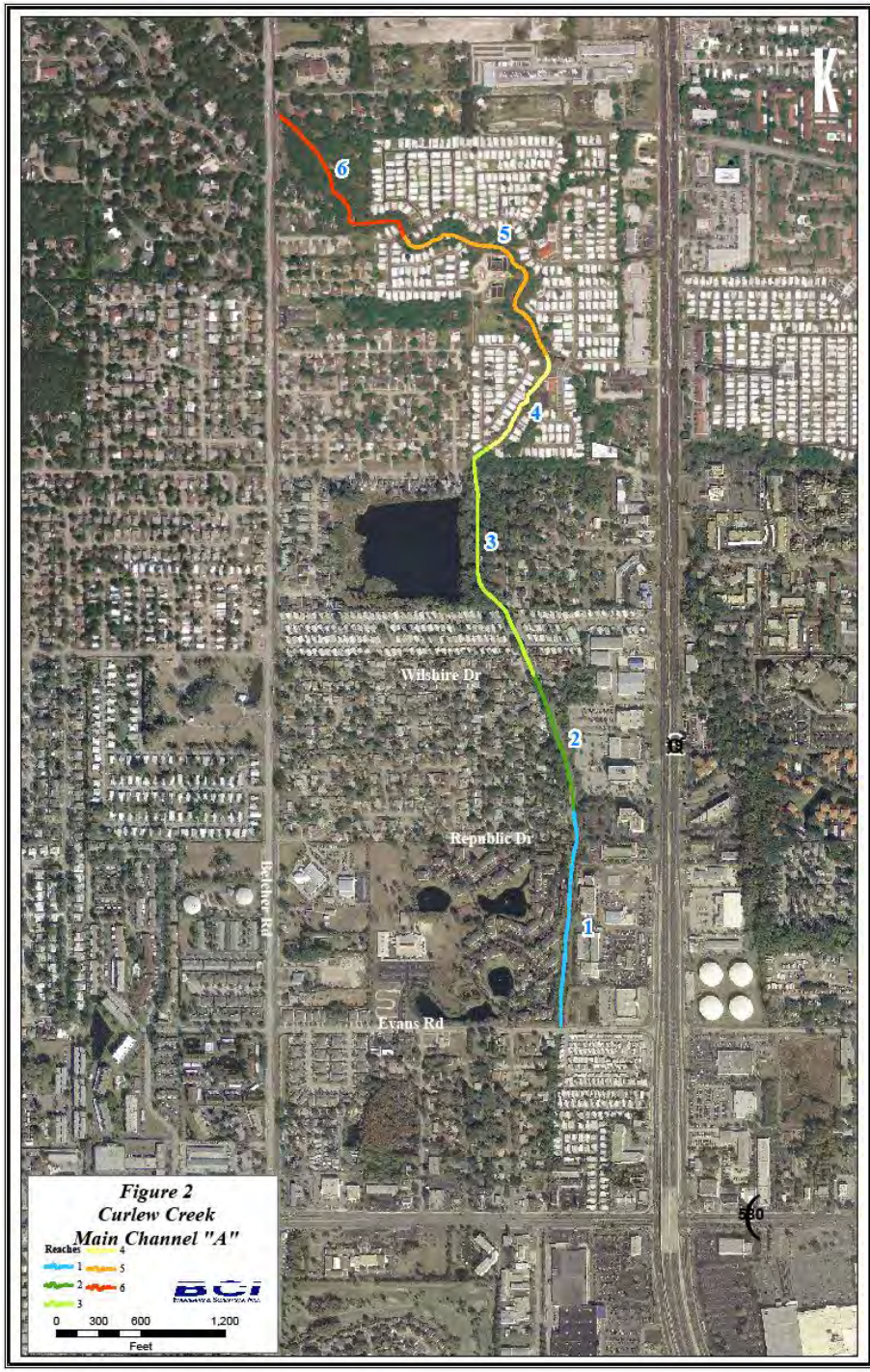
Upstream and downstream threats (e.g. not all erosion is local) (Curlew Creek)

Local erosion easily fixed using soil bioengineering techniques, right?

Upstream and downstream threats (e.g. not all erosion is local)

Need to recognize too much water and sediment from upstream can kill a project

Not stabilizing a downstream headcut can undermine a project

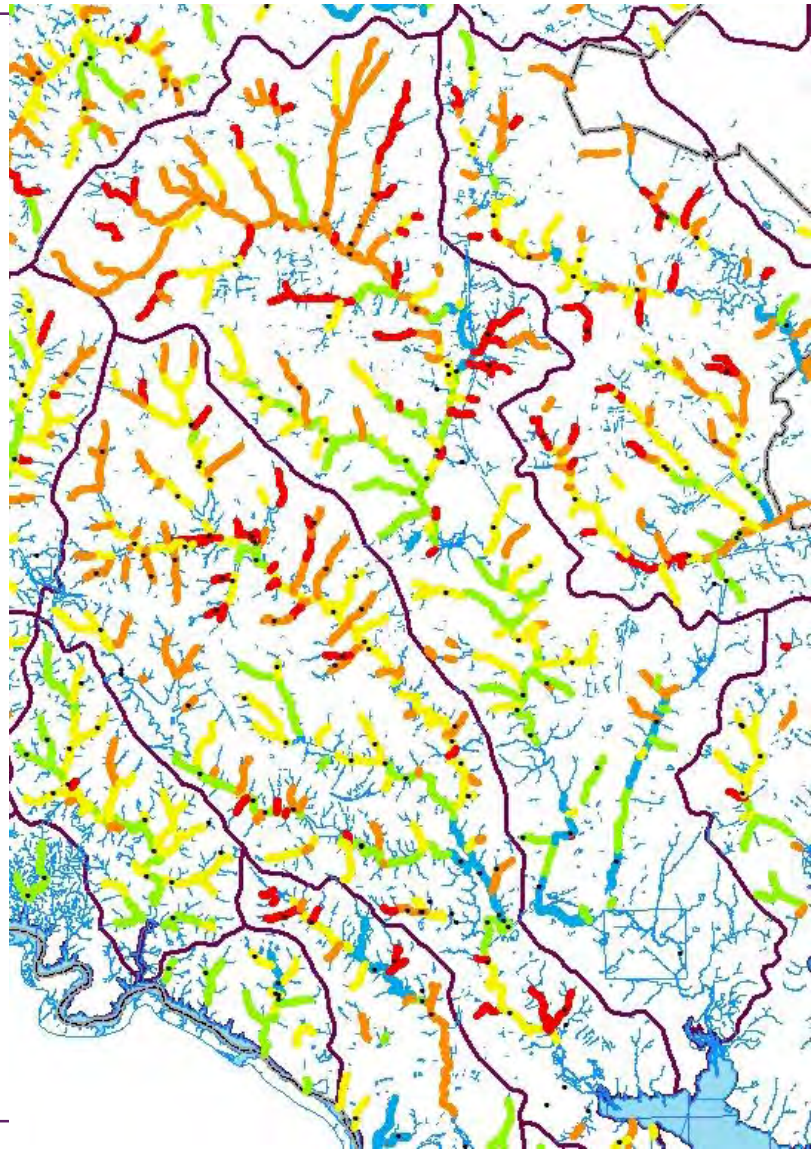


Match scale of solution to the problem

Watershed Approach

- Mapped fish and macroinvertebrate fauna from existing data
- Mapped habitat indices, CEM, watershed variables (DA, %impervious surface)
- Prioritizing watershed restoration in basins where it is possible and where urbanization has not yet ruined the streams
- Prioritizing stream restoration where watershed conditions are not readily changed and immense channel changes occured
- Construction sequence is based on 1) working to protect the few remaining good areas, 2) working in areas likely to cause offsite effects before working on areas receiving such effects

Working with state DEQ to establish a sediment TMDL and IBI suitable for the urban setting



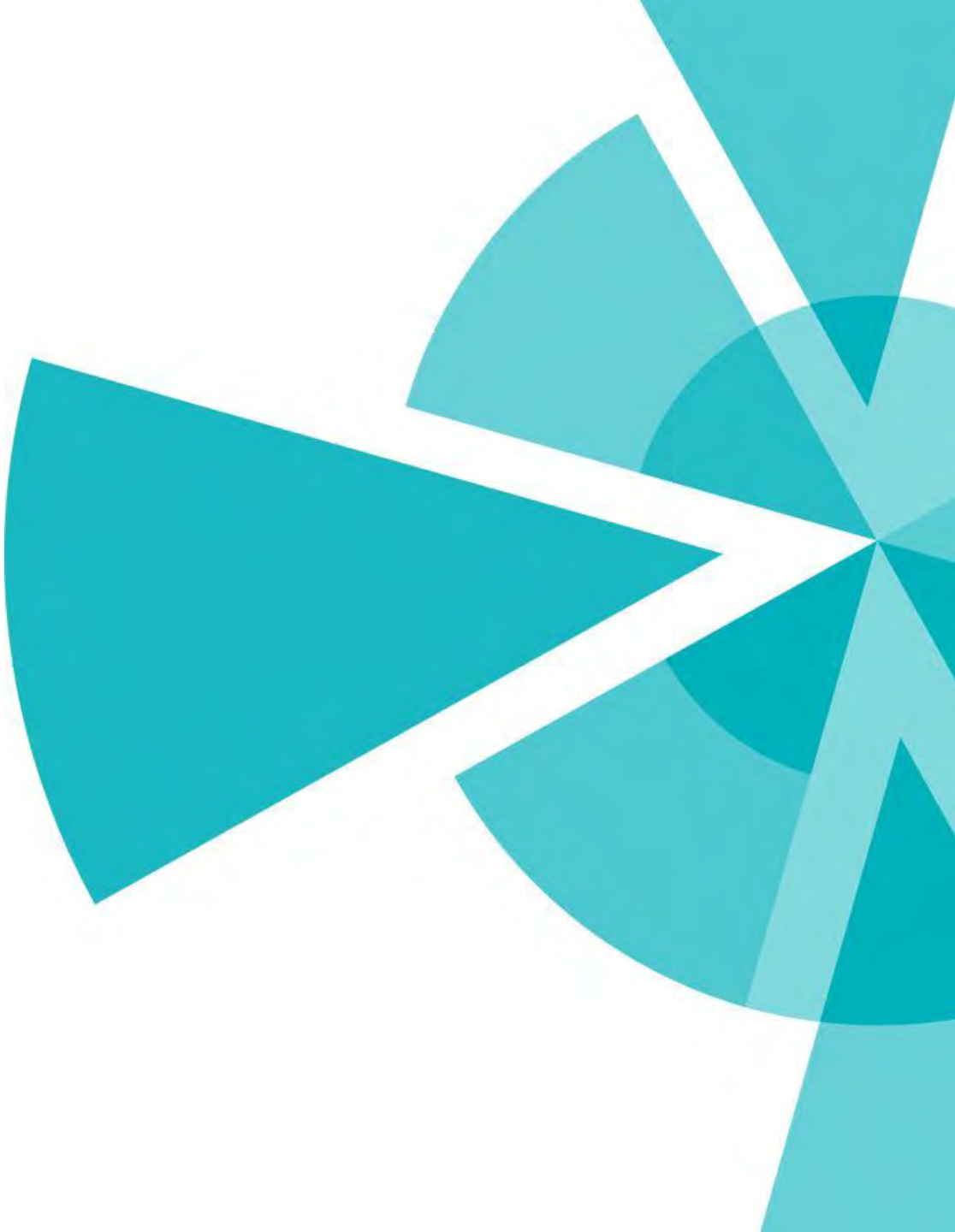
Summary – Designing with nature…

Which is better? These sites have similar hydraulic capacity and tractive force resistance.

- Beyond a great natural aesthetic
- Designed to adjust, not resist - adds climate resiliency
- Is set up to succeed
- Hedges against unintended consequences
- Usually is functionally multiple
- Sometimes reduces capital cost
- Typically reduces O&M cost

8

Some paths forward…



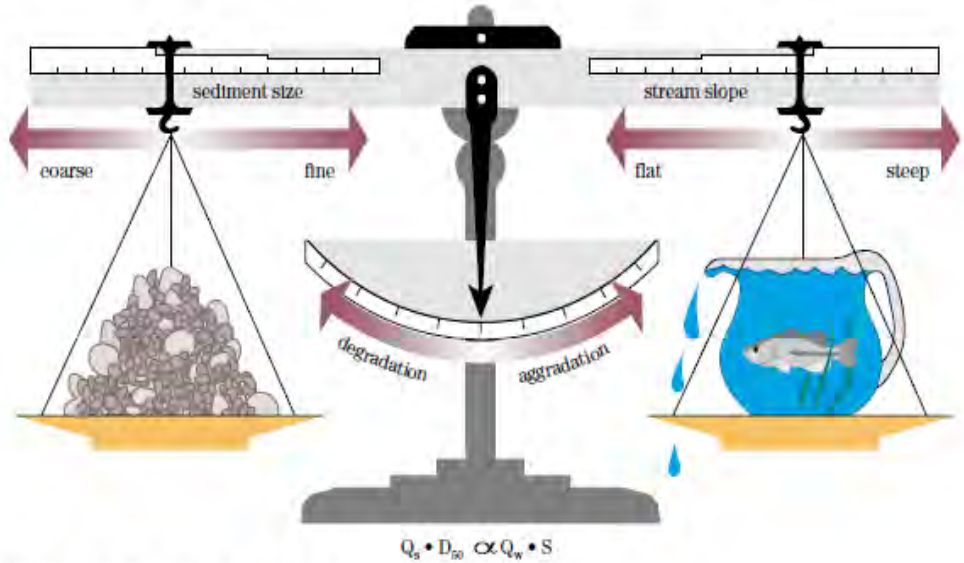
Stream Losses

- **75% of Florida's low- to mid-order streams are likely to be physically altered or impaired**
- **Net losses of headwater streams continue without in-kind mitigation**

Natural Streams are Multi-Tasking Conduits

- Water
- Sediment
- Organic debris
- Fish
- Solutes

Figure 13–2 Lane's balance as represented in Federal Interagency Stream Restoration Working Group (FISRWG) (1998)



From Rosgen (1996), from Lane, Proceedings, 1955.
Published with the permission of American Society of Civil Engineers.

Multimodal river corridors

- **Pedestrian Access and Redevelopment Corridor (PARC)**
  - 1.2 mile trapezoidal ditch to become riverine corridor
  - 5600 LF excavated high flow bench
  - 3200 LF constructed low flow channel
  - 6000 LF greenway trails
  - 3 pedestrian bridges
  - Concrete RR bridge to replace existing timber bridge
  - 1400 LF cable-suspended pedestrian bridge
  - $45M est. construction cost

PARC Design Components

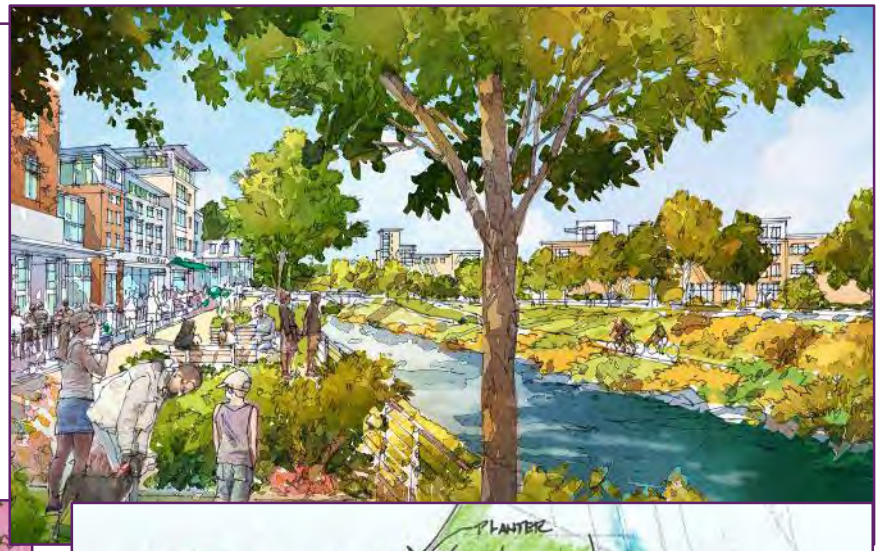
Excavated high flow bench

- Flood Control
- Facilitate Greenway Trails and Riverwalk Atmosphere

PARC Design Components

Greenway Parks and Trails

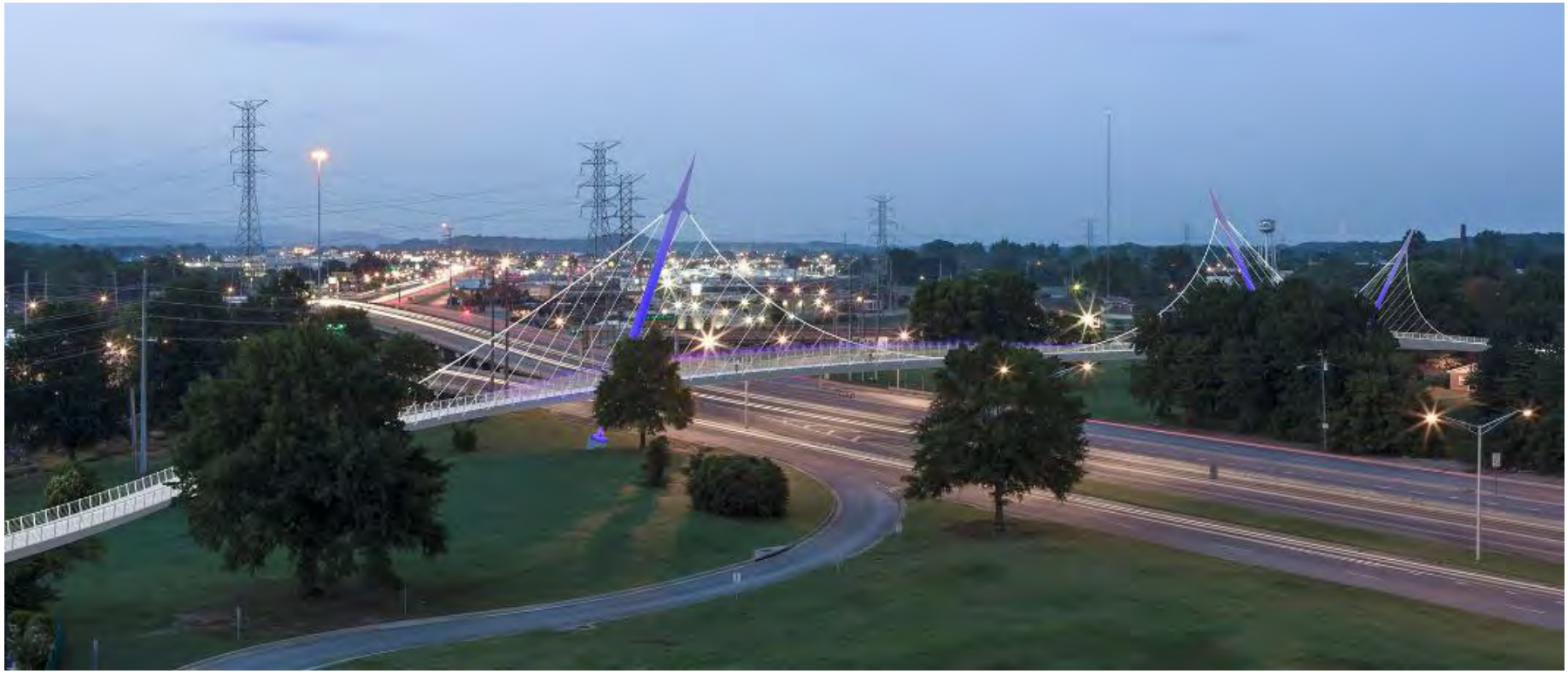
- 6,000 LF of greenway trails
- 2,000 LF promenade
- Waterfront amphitheater



PARC Design Components

Cable-Suspended Pedestrian Bridge

- 1,400 LF elevated bridge designed by Rosales + Partners
- 3 cable-suspended spans



Focus on just the stream

- **Project ideas do not have to come from big government or major corporate programs**
- **Ask your government to contemplate stream restoration as a stormwater management tool**
  - Support capital improvement projects featuring stream restoration
- **Stream mitigation as a driver**
  - Ask the USACE to start enforcing the 2008 Mitigation Rule's requirement for in-kind stream restoration in Florida
  - Support FDEP's efforts to promulgate a stream UMAM
- **Look for stream-specific grants from EPA and other federal partners**
- **Secure dedicated funding. Some Australian jurisdictions take competitive plans across a watershed and fund those ranked best each year**
  - Plans can come from any competent entity
  - HOA, local government, individual landowners

Q&A