Rethinking altered drainage systems: giving the river what it needs

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

From Rosgen (1996), from Lane, Proceedings, 1955. Published with the permission of American Society of Civil Engineers.
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
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
Some ways that trapezoidal ditches mess things up.
The ever-present trapezoidal ditch

![Graph showing water levels in Natural Channel and Riparian Swamp]
Leading edge of sediment plume moving downstream
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

![Diagram showing a scatter plot between VaSCI and Impervious Area (%)]
The Evolution of Bank Stabilization

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”
Please tell me there is a better way!
• 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)
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 1. Reshape Channel**

**Step 11 - Option 3.** Install “burrito” soil lifts and layers of cuttings between soil lifts up to the bankfull stage

**“Burrito” Soil Lift Option**

**Step 5.** Place root wad logs cantilevered over foundation logs

**Step 6.** Add temporary counterweight to submerge logs

**Step 7.** Remove temporary weight & place cuttings

**Step 8.** Place backfill over cuttings

**Step 9.** Secure sod mats with live staking

**Step 10.** Remove temporary weight and place woody transplants from front to back 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
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

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

Ecological Stoichiometry

**Benthic Resource Elemental Composition**

Terrestrially-derived: wood, leaf litter, green leaves

Aquatic origin: periphyton, aquatic plants

- Closest to requirements of bacteria

**Molar C:N, C:P Ratios**

Source: Cross et al. 2005
Valley foci for sedimentation
Some lessons learned
Vegetated Reinforced Soil Slope  
Streambank Erosion Control

By Robbin B. Side and J. Craig Fishelich

May 2003

OVERVIEW
The vegetated reinforced soil slope (VRSS) and riprap engineering system is an earthen structure made from log, sodbale, vegetative, woody plant material, bioengineered soil mix, riprap, and or container plant stock in combination with rock, geotextiles, and geocomposites. The VRSS system is similar in function and design to a Siltbank System (ABE, 1994).

The VRSS system is useful for the prevention, repair, or protection of deeper failures providing a structurally sound system with soil reinforcement, drainage, and erosion control typically on steepened slope areas where slopes are limited. The VRSS system provides for the construction of cut banks and may be adapted to fit a variety of environmental conditions. The VRSS system is adaptable to a variety of soils, slope angles, and vegetation types.

Live vegetation in the VRSS is typically instreamed just above the baseflow elevation and up the face of the structure. This system is carefully constructed to protect the banks through immediate reinforcement via re-vegetation and confinement, drainage, and, in the toe area, with rock. The VRSS system prevents the loss of stream bank material through the supporting of riprap and the installation of low-flow, overtopping drainage devices. The streambank is thus protected against erosion and the system is designed to restore its function in the waterway.

Figure 1. Illustrations of VRSS system frontal configurations

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

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Part 654
National Engineering Handbook

Stream Restoration Design

Peninsular Florida Stream Systems: Guidance for Their Classification and Restoration

Final Report

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Ground Water as an Erosive Force

Excessive sapping can be induced by degradation
Particularly sensitive in sand-and-gravel aquifer region
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 occurred
- 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
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
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
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