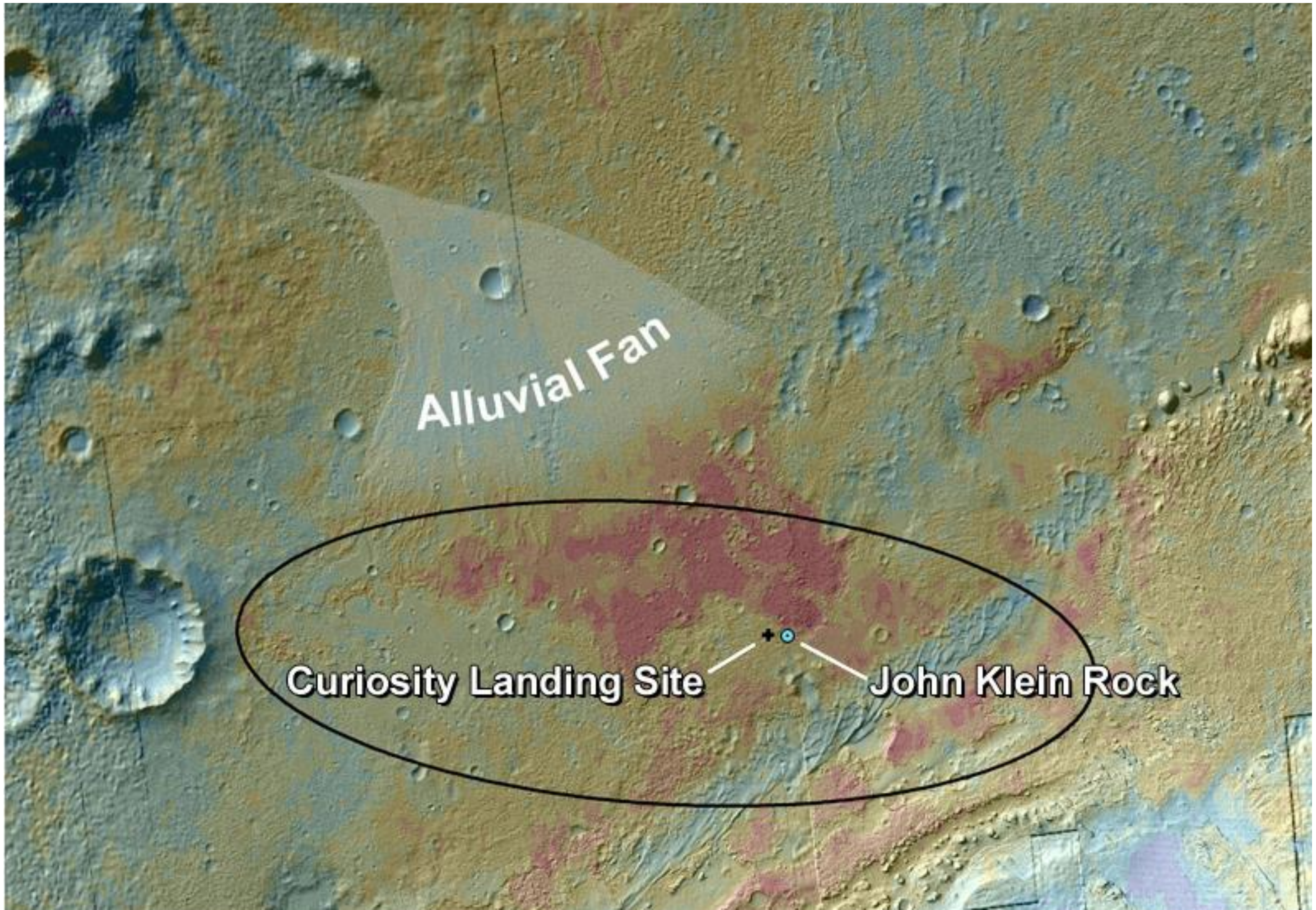
Urban Stream Restoration Implementation
Auburn, AL
March 13-14

Thank you sponsors and partners:

City of Auburn, Alabama Department of Transportation, Alabama Department of Environmental Management, Auburn University, Alabama Cooperative Extension System, Saugahatchee Watershed Management Project, Jennings, Environmental, Watershed Science, Inc., and North State Environmental, Inc.

Guess what NASA found on Mars?

"The patch of bedrock where Curiosity drilled for its first sample lies in an ancient network of stream channels descending from the rim of Gale Crater. The bedrock also is fine-grained mudstone and shows evidence of multiple periods of wet conditions, including nodules and veins."



Innovations in Urban Stream Restoration

Eve Brantley, PhD
Auburn University

Greg Jennings, PhD, PE
Jennings Environmental LLC

Innovations in Urban Stream Restoration

I. Urban Stream Ecosystem Challenges
II. Urban Stream Morphology
III. Tools for Stream Restoration: Morphology & Structures
IV. Permits for Stream Restoration
V. Vegetation for Stream Restoration
VI. Field Tour of Projects
VII. Urban Stream Case Studies
VIII. Demonstration Project - Auburn

I. Urban Stream Ecosystem Challenges

What are your CHALLENGES?

- Hydrology – too much water
- Pollutants – upstream and on-site
- Vegetation – wrong plants, wrong place
- Physical Constraints
- Conflicting Opinions
- Other?

What is a Stream?

… a body of water with a current, confined within a bed and streambanks

Synonyms: bayou, beck, branch, brook, burn, creek, crick, kill, lick, rill, river, rivulet, run, slough, syke

A stream is:

- conduit in the water cycle
- critical habitat
- connected to a watershed

Stream Ecosystems

- Channel (bed & banks)
- Floodplain
- Water & Sediment
- Plants & Animals

Stream Functions & Services

1. Transport water
2. Transport sediment
3. Habitat (aquatic & terrestrial)
4. Recreation & aesthetics
5. Safe Water Supply

What Makes a Stream Healthy?
(Physical, Biological, Chemical)

1. Bed stability & diversity
2. Sediment transport balance
3. In-stream habitat & flow diversity
4. Bank stability (native plant roots)
5. Riparian buffer (streamside forest)
6. Active floodplain
7. Healthy watershed

Healthy Stream 1. Bed Stability & Diversity

- Appropriate size sediments to resist incision
- Open interstitial spaces to support habitats
- Riffle/Pool sequences in alluvial streams
- Step/Pool sequences in high-gradient streams

Riffles

- Steep slope
- High velocity & shear stress
- Large substrate
- High porosity & groundwater exchange

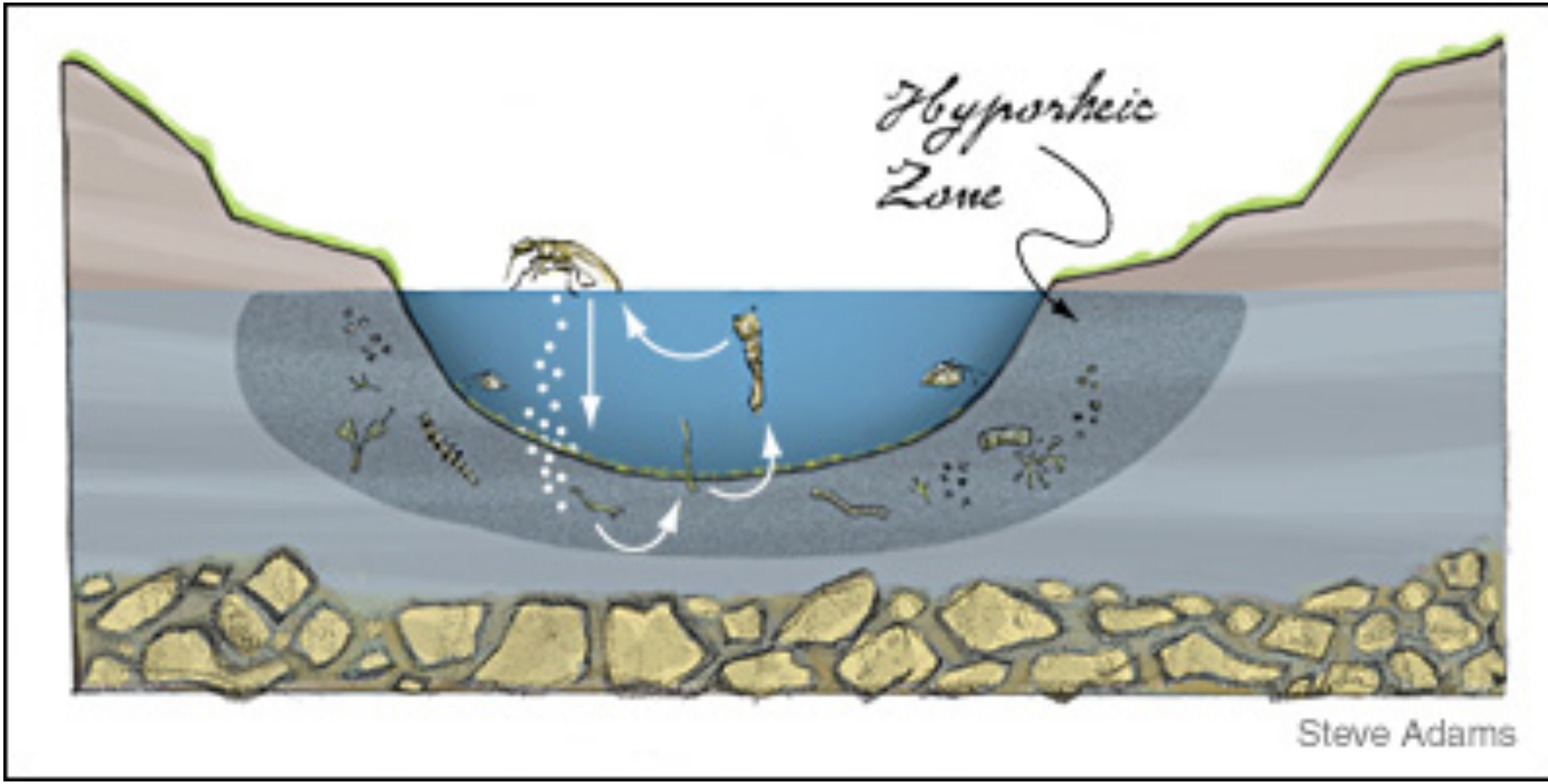
Pools

- Flat slope
- Low velocity & shear stress
- Small substrate
- Scour during high flow

Problems: Bed Stability & Diversity

- Headcutting and excess scour
- Embedded gravels sealing off hyporheic connections
- Plane bed – filling of pools
- Armoring

Hyporheic Connections



That is, a stream is not a pipe …

dnr.state.mn.us

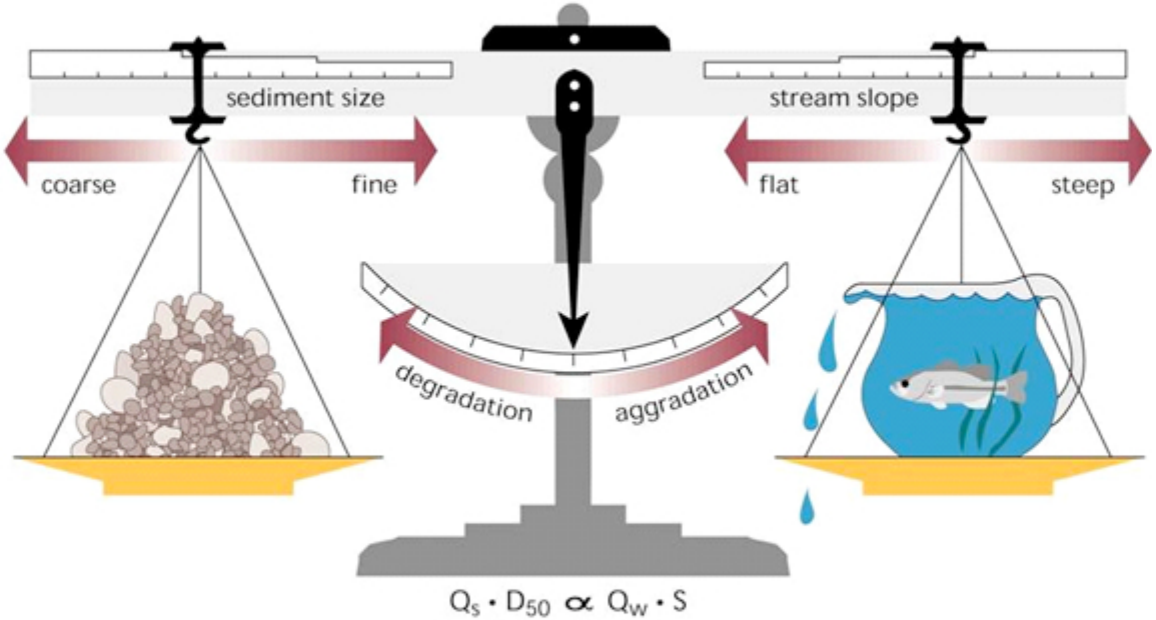
Problems: Bed Stability & Diversity

- Headcutting and excess scour
- Embedded gravels sealing off hyporheic connections
- Plane bed – filling of pools
- Armoring

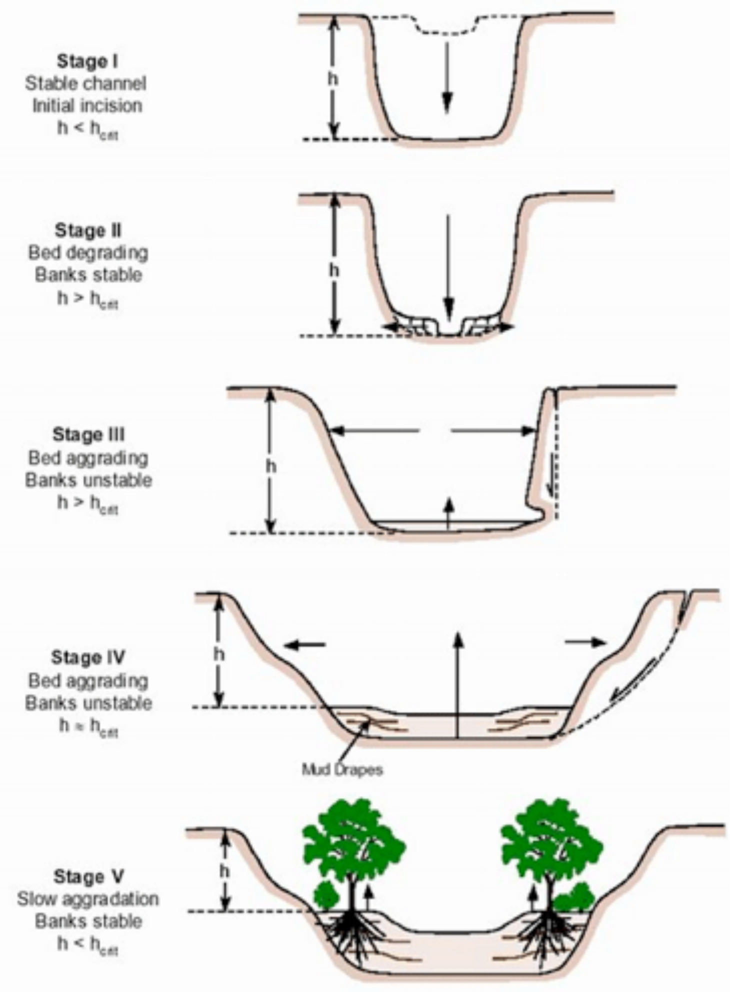
Healthy Stream 2. Sediment Transport Balance

- Minor erosion & deposition in balance long-term
- Alluvial bars and benches
- Upstream sources under control
- Sufficient stream power to avoid aggradation

Streams convey water and sediment



Lane's Balance *(Lane, 1955)*



Channel Evolution Model *(Schumm, 1984)*

Problems: Sediment Transport Balance

- Excess stream power – eroding bed
- Insufficient stream power – aggradation
- Upstream sources inundating system

Healthy Stream 3.

In-stream Habitat & Flow Diversity

Macrohabitats: riffles, runs, pools, glides, steps, side channels, scour holes

Microhabitats: roots, leaf packs, wood, rocks, plants, hyporheic zone

Problems: In-stream Habitats

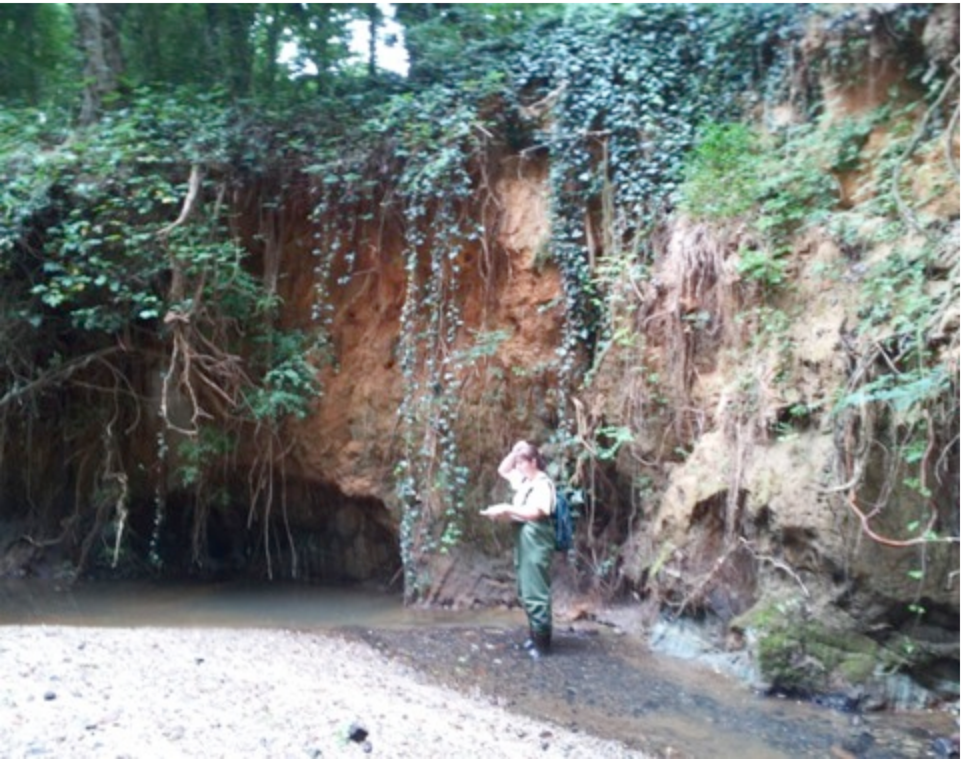
- Uniform flow – lack of diversity
- Lack of wood, leaves, roots, natural organics
- Human interventions
- Water quality impairments – DO, nutrients, toxics

Healthy Stream 4. Bank Stability

- Dense native plant roots
- Low banks with low stress

Problems: Bank Stability

- Loss of vegetation
- High, steep banks – channelization
- Armoring, invasive plants



Healthy Stream 5. Riparian Buffer (Streamside Forest)

- Diverse native plants with multiple layers
- Food and shade

Problems: Riparian Buffer

- Mowers and moo’ers
- Invasive plants
- Armoring and impervious surfaces

Healthy Stream 6. Active Floodplain

- Regular (every year) flooding to relieve stress
- Riparian forested wetlands
- Stormwater retention & treatment


Problems: Active Floodplain

- Channel incision
- Straightening, channelizing, levies
- Floodplain fill and encroachment

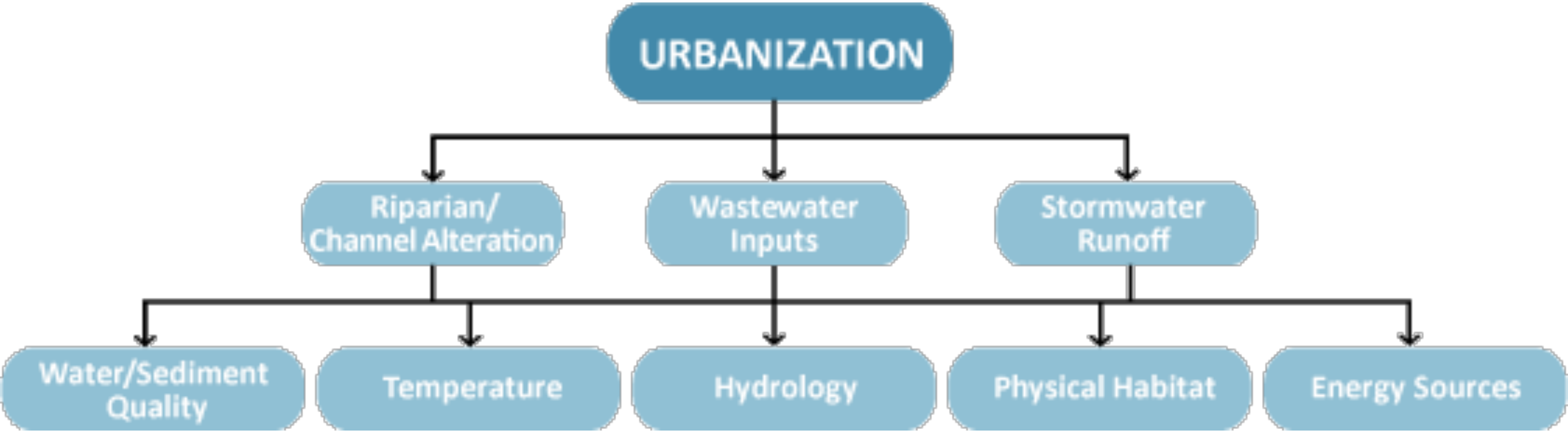
Healthy Stream 7. Healthy Watershed

- Stormwater management
- Wastewater management
- Upstream sediment control
- Watershed management

Problems: Healthy Watershed

- Stormwater energy and volume
- Point and nonpoint source pollution
- Erosion and sediment
- Stream neglect

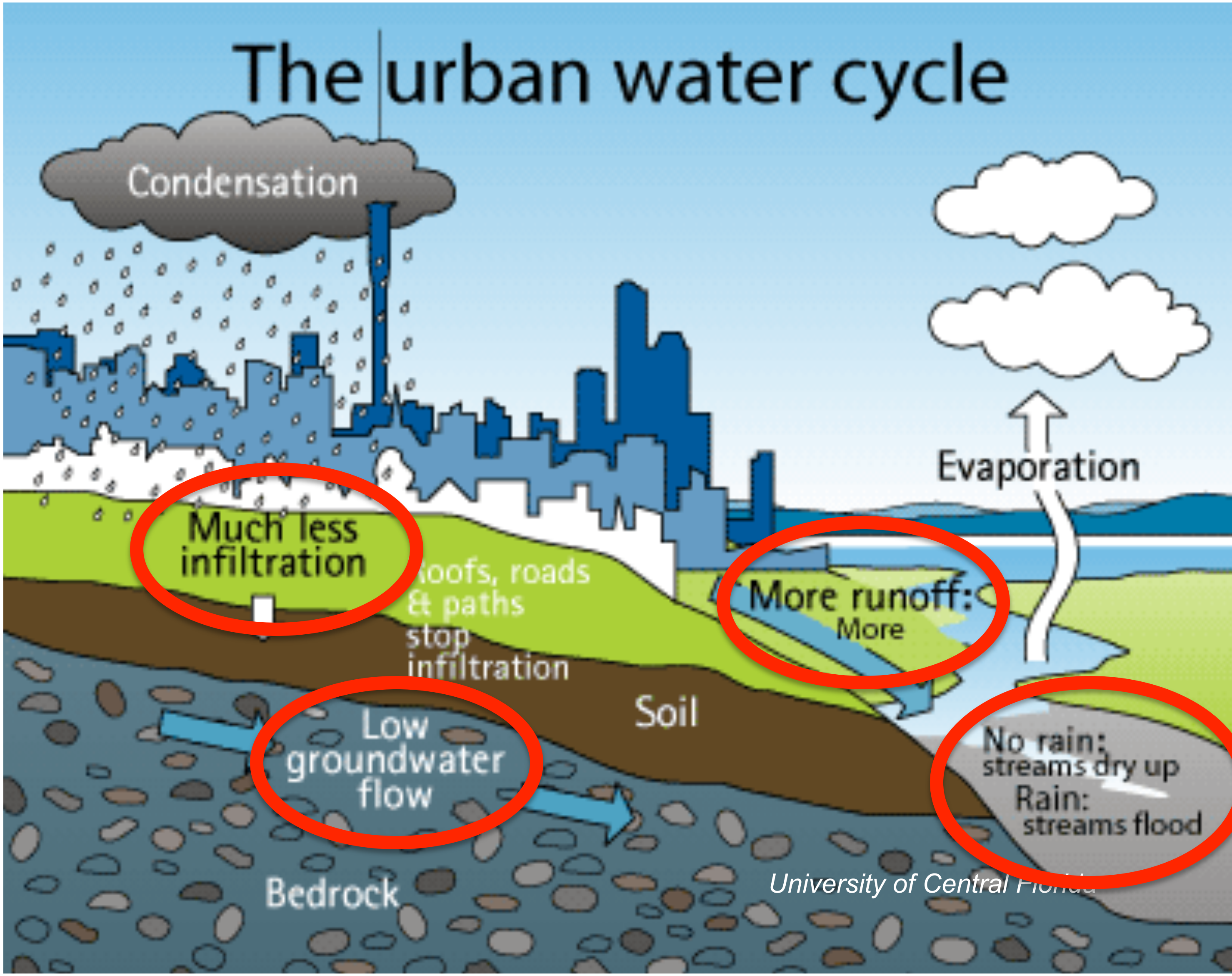
Effects of Urbanization on Streams (US EPA)



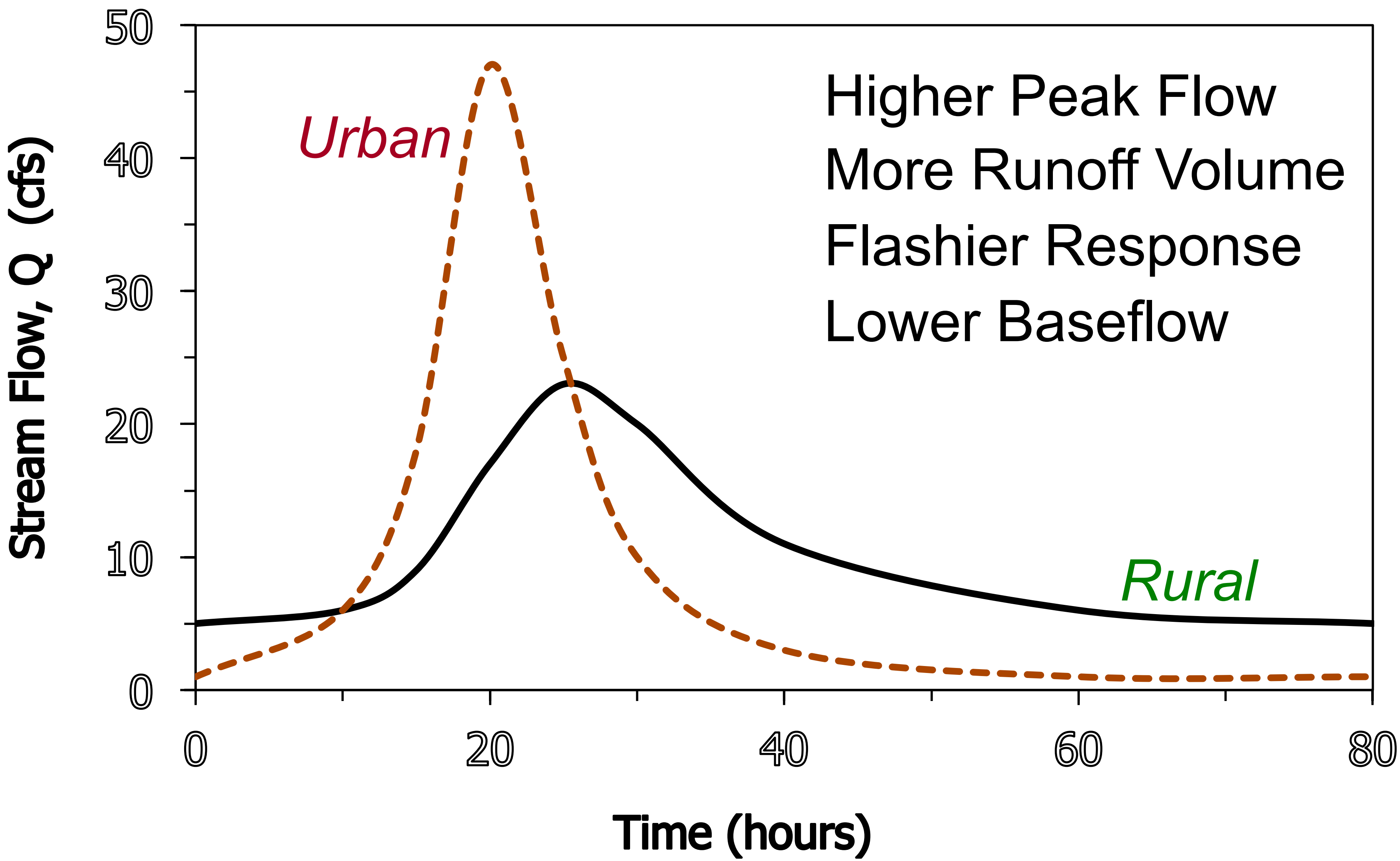
Urban Stream Syndrome (*USS*)

- Response to watershed changes
- Loss of natural functions & values
- Causes problems locally & downstream
- Requires systematic assessment & treatment

Urban Disturbances to Hydrologic Cycle



Hydrograph Changes Due to Urbanization



Runoff: *more*

Infiltration: *less*

Flooding: *more*

Baseflow: *less*

Symptoms of USS

- Erosion & incision
- Water quality decline
- Habitat loss
- Ecosystem degradation
- Flooding
- Land loss
- Infrastructure damage
- Recreation impaired
- Aesthetics impaired
- Economic loss

Urban Stream: Incision & bank erosion

Constraints: Utilities, Road, Bridges, Culverts

Causes of USS

- Watershed impervious
- Channelization
- Impoundments
- Diversions
- Floodplain filling
- Pollution discharges
- Sedimentation
- Stormwater runoff
- Utilities & culverts
- Buffer loss
- *Neglect & Ignorance*

What is the Ecological Response?

- In-stream
- Riparian

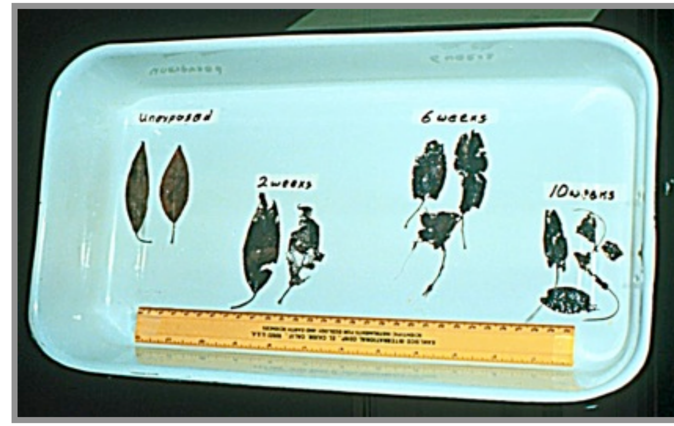

Pool
Riffle
Leaf Pack
Undercut Banks
Woody Debris

Urban Stream Syndrome

Benthic Macroinvertebrates

Functional Feeding Groups

- Shredders -commonly found in leaf packs
- Collectors – filter organic matter from water column
- Grazers – feeds on periphyton attached to rocks, large woody debris
- Predators – feed on other organisms



Bioindicators

- Aquatic macroinvertebrates are used to assess the relative health of a stream system and its watershed
  - relatively immobile -they will ‘take a hit’ with water pollution
  - are easy to capture, relatively abundant and easy to distinguish
  - have diverse communities with varying levels of tolerance to pollution

Pollution Tolerance Levels

- Highly sensitive to pollution or stream habitat alteration

Pollution Tolerance Levels

- Wide range of tolerance to pollution or stream habitat alteration

Pollution Tolerance Levels

- Generally tolerant of pollution or stream habitat alteration


Riparian Vegetation

Invasive, Nonnative Plants

- Tallow tree
- Japanese climbing fern
- Stilt grass (Microstegium)
- Wisteria
- Chinese privet
- Cogon grass

Streams = Conveyor Belts

Active Floodplain

Floodplain Functions

- Nutrient & Pollutant Processing
- Floodwater Storage
- Sediment Storage
- Channel Stability
- Habitat

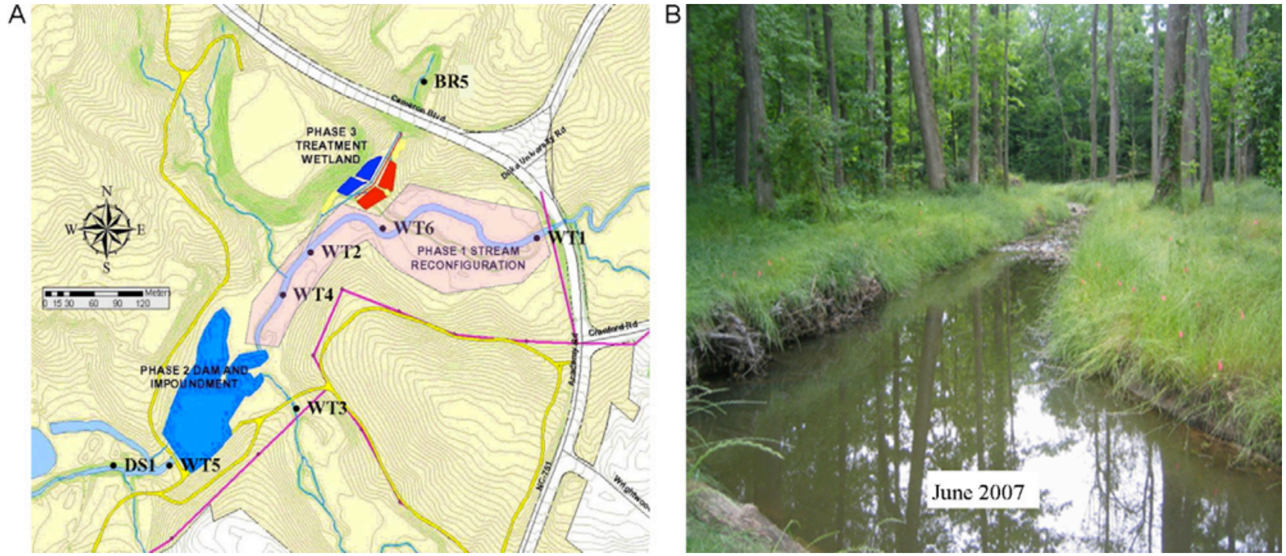



Floodplains as BMPs?

- Southern forested wetlands - documented pollutant transformation
- P sediment deposition: 1.6 to 36.0 kg ha-1 yr-1
- P adsorption: 130 to 199 kg ha-1 yr-1
- Denitrification of NO3-N: 0.5 to 350 kg ha-1 yr-1

Walbridge, M.R. and B.G. Lockaby. 1994. Effects of forest management on biogeochemical functions in southern forested wetlands. Wetlands (14)1 pp 10-17.

Duke, NC

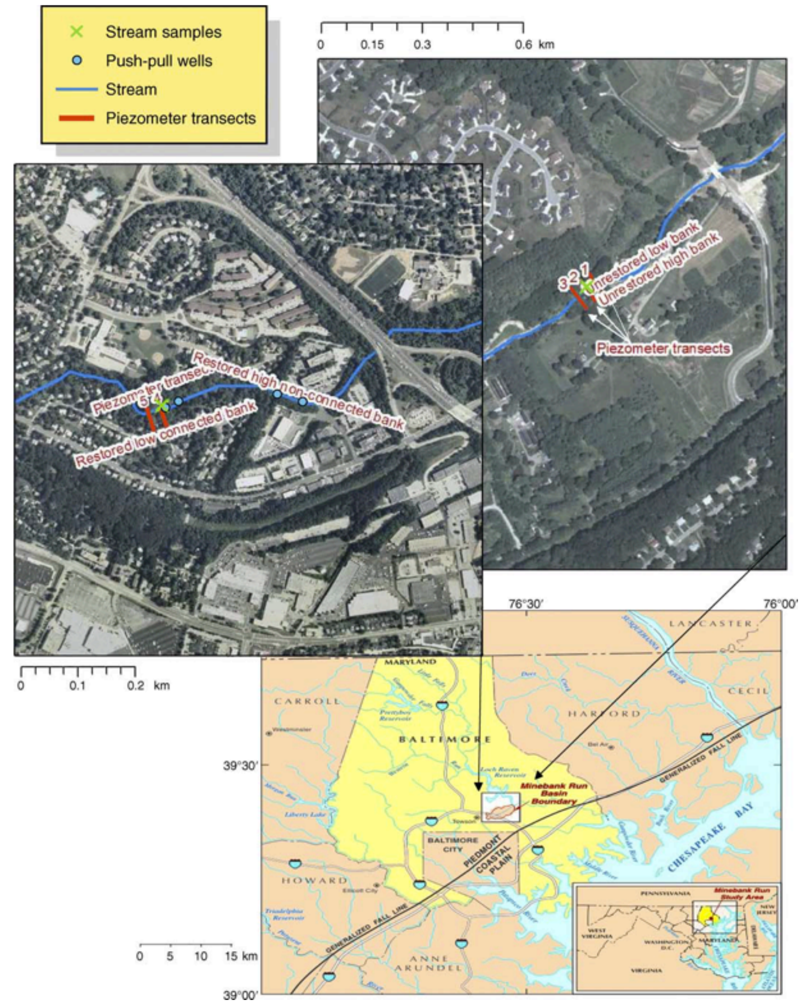


- $(NO_2^- + NO_3^-)$ –N loads reduced by 64%
- P loads were reduced by 28%
- 600m stream / floodplain restoration, 1.6 ha storm water reservoir/ wetland complex & 0.5 ha surface flow treatment wetland
- Richardson, C.J., N. Flanagan, M.Ho, and J.Pahl, Integrated stream and wetland restoration: A watershed approach to improved water quality on the landscape, Ecological Engineering, vol. 37 (2011), pp. 25-39.

Baltimore, MD

- Riparian areas with low, hydrologically ‘‘connected’’ streambanks designed to promote flooding & dissipation of erosive force for storm water management had substantially higher rates of denitrification than restored high ‘‘nonconnected’’ banks and both unrestored low and high banks

  Kaushal SS, Groffman PM, Mayer PM, Striz E, Gold AJ. 2008. Effects of stream restoration on denitrification in an urbanizing watershed. Ecological Applications, 18(3), pp. 789–804.



Next …

- Details on morphology, constraints, solutions

Later …

- Details on vegetation, local field case studies