Stream Restoration Implementation

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https://www.youtube.com/user/RiverShared

Stream Ecosystem Restoration:

“activities that initiate or accelerate the recovery of ecosystem health, integrity, and sustainability”
(*SER, 2004*)

Standards for ecologically successful river restoration

Palmer et al., Journal of Applied Ecology, 2005, 42, 208–217

1. design of an ecological river restoration project should be based on a specified guiding image of a more dynamic, healthy river that could exist at the site
2. river's ecological condition must be measurably improved
3. river system must be more self-sustaining and resilient to external perturbations so that only minimal follow-up maintenance is needed
4. during the construction phase, no lasting harm should be inflicted on the ecosystem
5. both pre- and post-assessment must be completed and data made publicly available

Stream Restoration is a Systematic Process

1. Planning & Assessment
2. Engineering
3. Construction & Planting
4. Monitoring, Maintenance, Adjustments

Samford Univ Shades Creek

Daphne UT D'Olive Creek

Goals of Stream Restoration Projects

- Improve habitats & water quality
- Improve recreation & aesthetics
- Protect infrastructure & land value
- Educate citizens & decision-makers

Daphne UT D'Olive Creek

Samford Univ Shades Creek

Restoration Components

1. Channel morphology & floodplain connection
2. In-stream structures
3. Streambank stabilization
4. Vegetation
5. Stream crossings
6. Stormwater/watershed management
7. Monitoring & maintenance
8. Public access & education

1. Channel Morphology & Floodplain Connection

- Dimension (bankfull & flood flow)
- Pattern (meander)
- Profile (bed profile)
- Floodplain connection

2005 NCSU Rocky Branch 2006

2008 NCSU Rocky Branch

Reference Reaches:

Morphology design parameters serve as a “starting point”

Reference Reaches:

- Upstream/downstream
- Similar watersheds
- Databases
- Historical photos

Similar bed/bank materials; hydrology; sediment inflow; slope; valley

Reference Reaches:

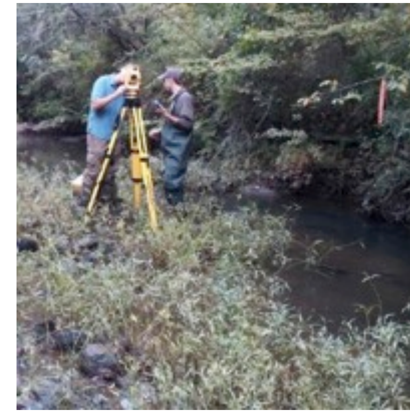
- Channels well-connected to alluvial floodplains with little evidence of incision (bank height ratios less than 1.2)
- Freely-formed meanders with alternating riffles and pools
- Streambanks and floodplains well-vegetated with no erosion
- Upstream watersheds mostly forest and agriculture
- Stable and unconfined for a length 20 times bankfull width

Low Bank Height and Natural Grade Control

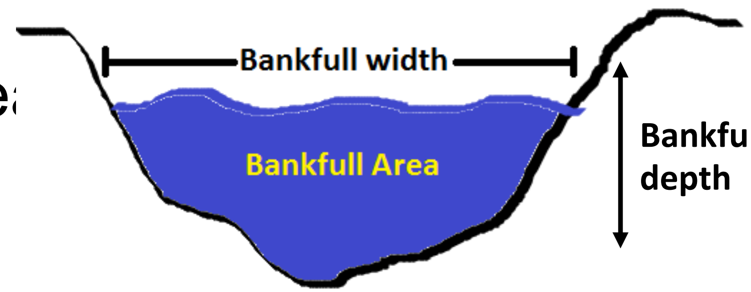
Bankfull Indicators:

Top of Bank, Point Bars, Lateral Benches

Regional curve development



- Total station surveys
- Quantify bedform morphology
  - Bankfull width, depth
  - Bankfull cross-sectional area
  - Bankfull discharge

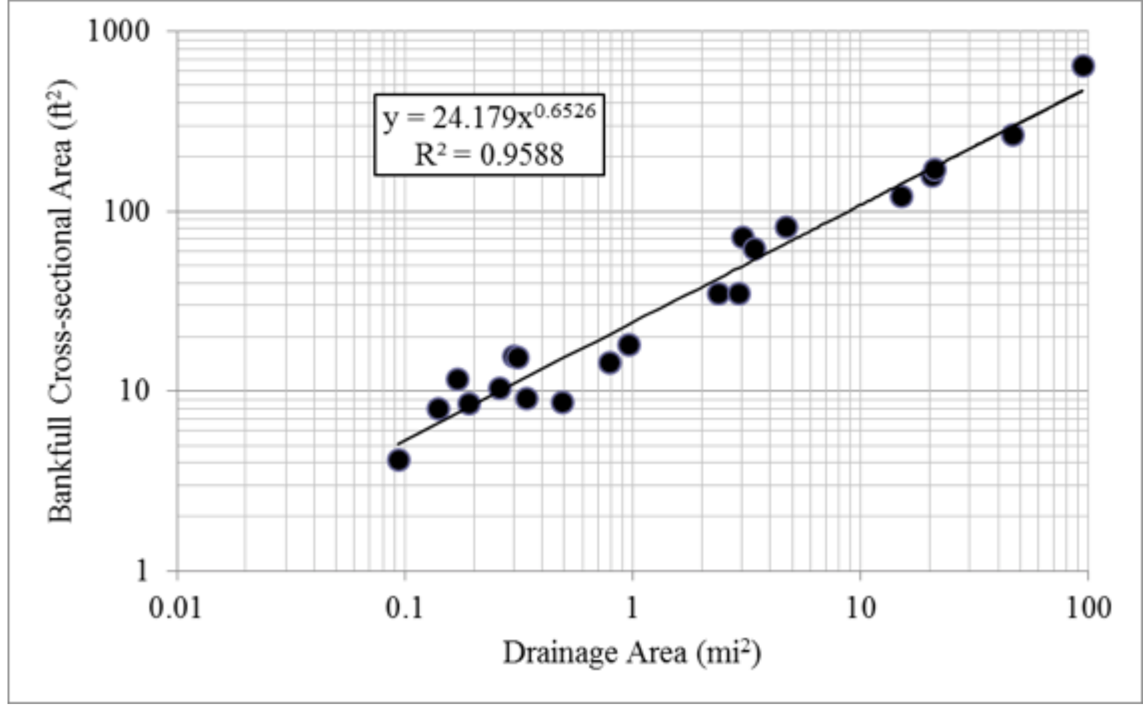


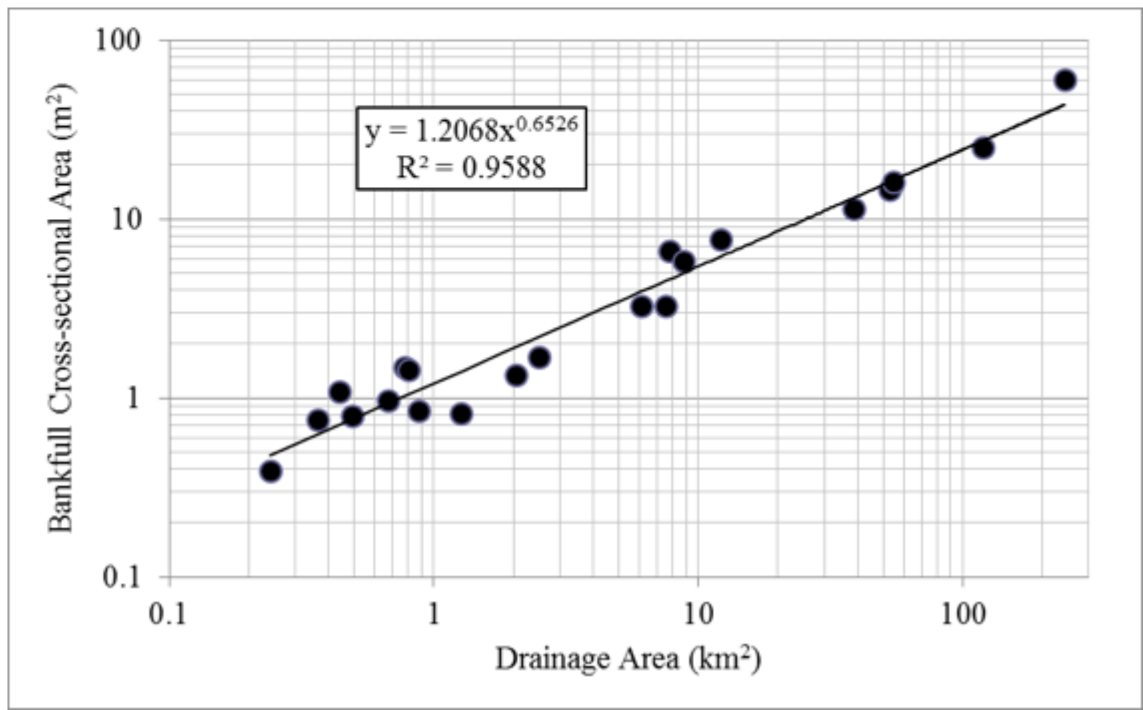
- Fit log-log plots with power functions
  - Geomorphology /drainage area
- Compare to other regional curves (PA, MD, VA, NC, GA)
  - Test for differences in slope (ANCOVA)

Regional Curve data sources: PA – White 2001; MD – McCandless and Everett 2002; VA – Lotspeich 2009; NC – Harman et al. 1999; GA – Pruitt 2001

Alabama Piedmont Regional Curves (21 reference streams)

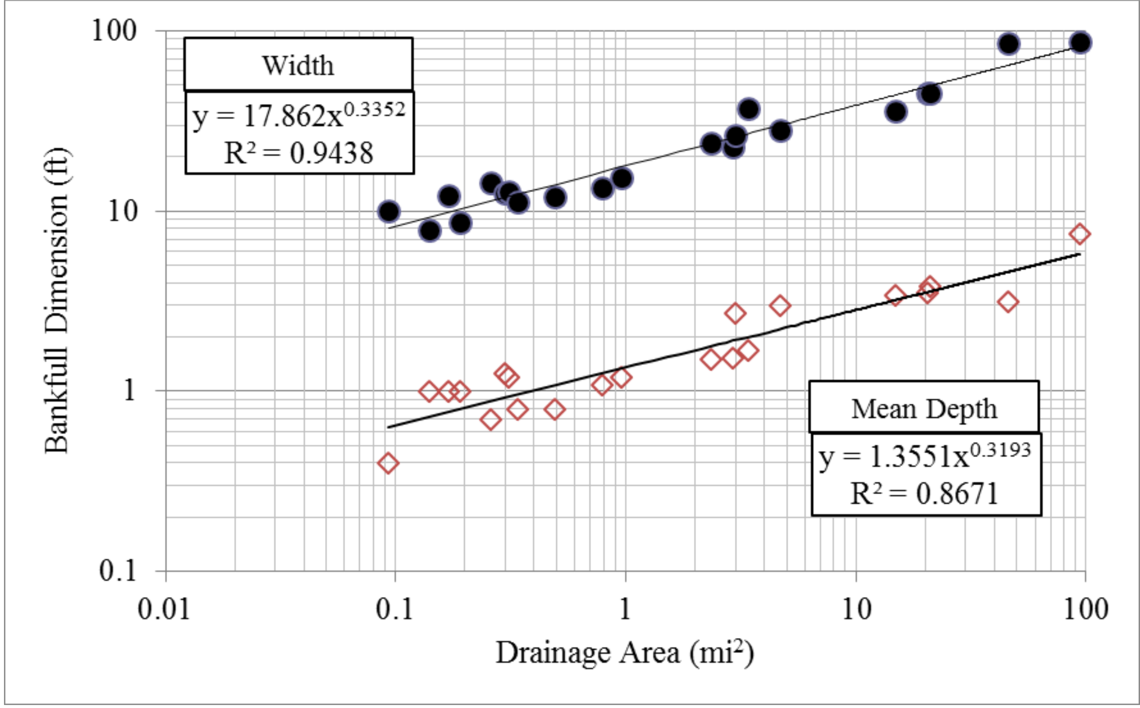
Bankfull Cross-sectional Area Related to Watershed Drainage Area

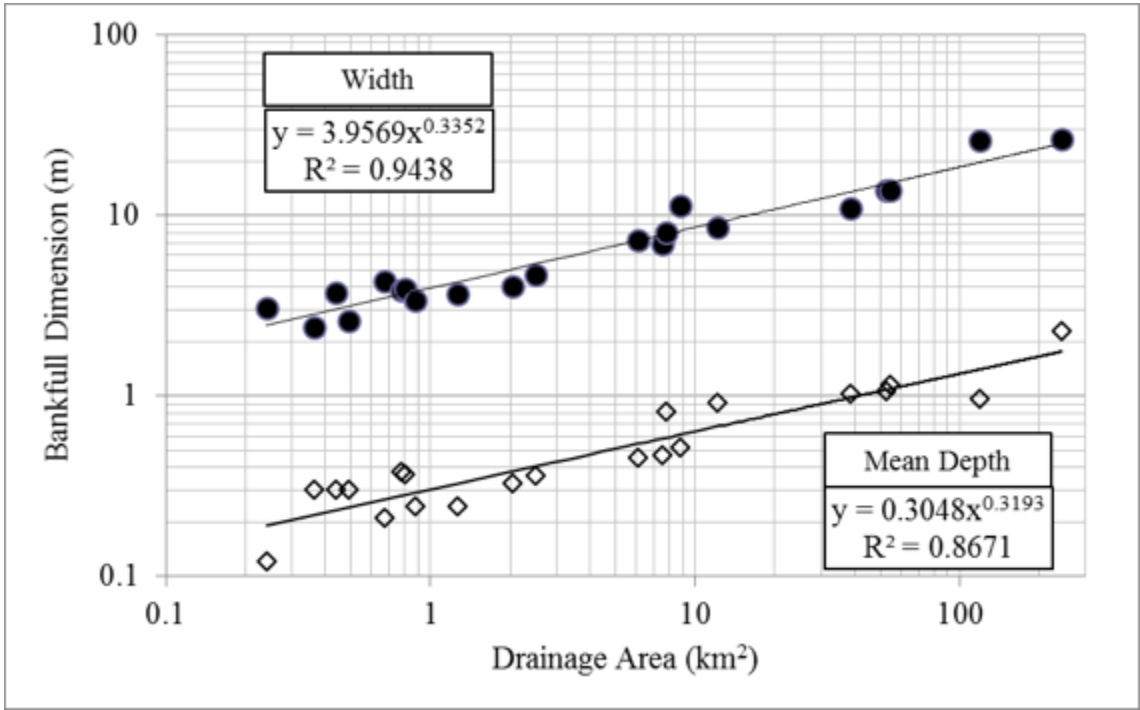




Alabama Piedmont Regional Curves (21 reference streams)

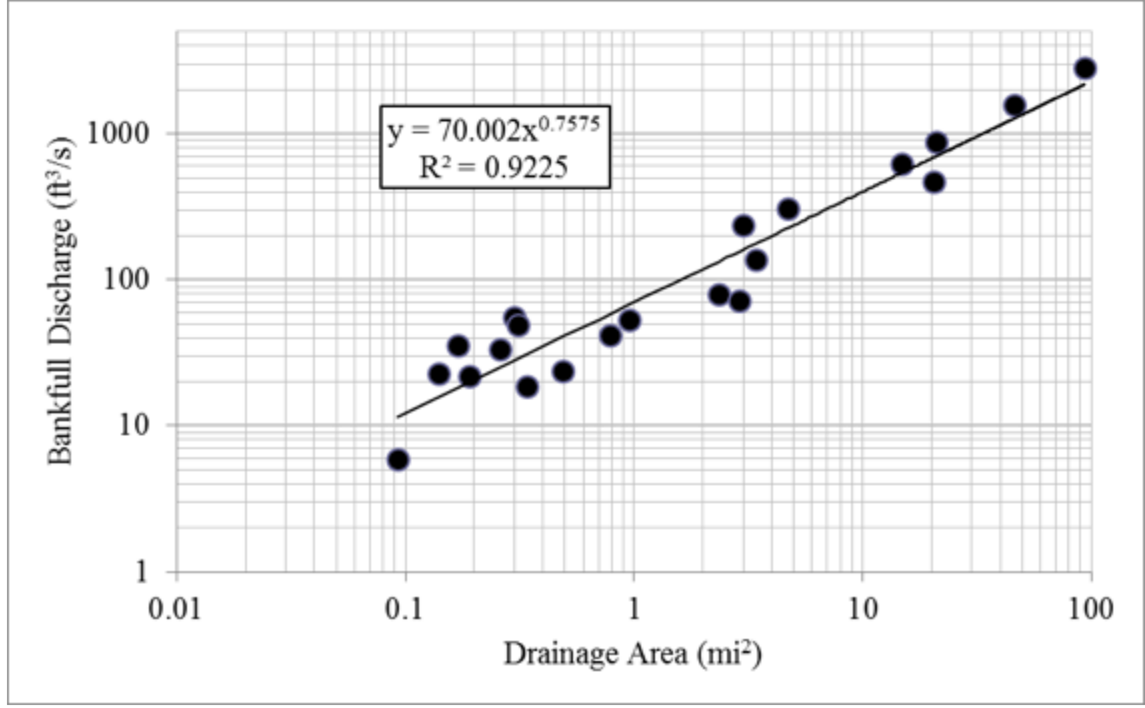
Bankfull Width and Mean Depth Related to Watershed Drainage Area

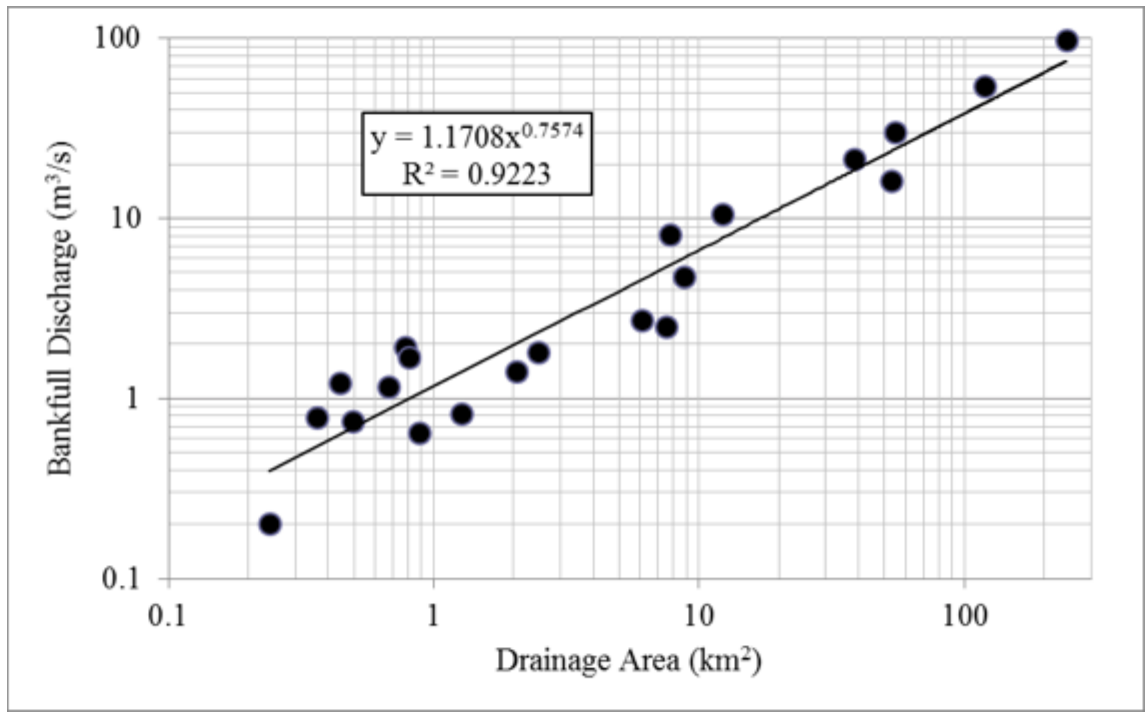




Alabama Piedmont Regional Curves (21 reference streams)

Bankfull Discharge (estimated) Related to Watershed Drainage Area

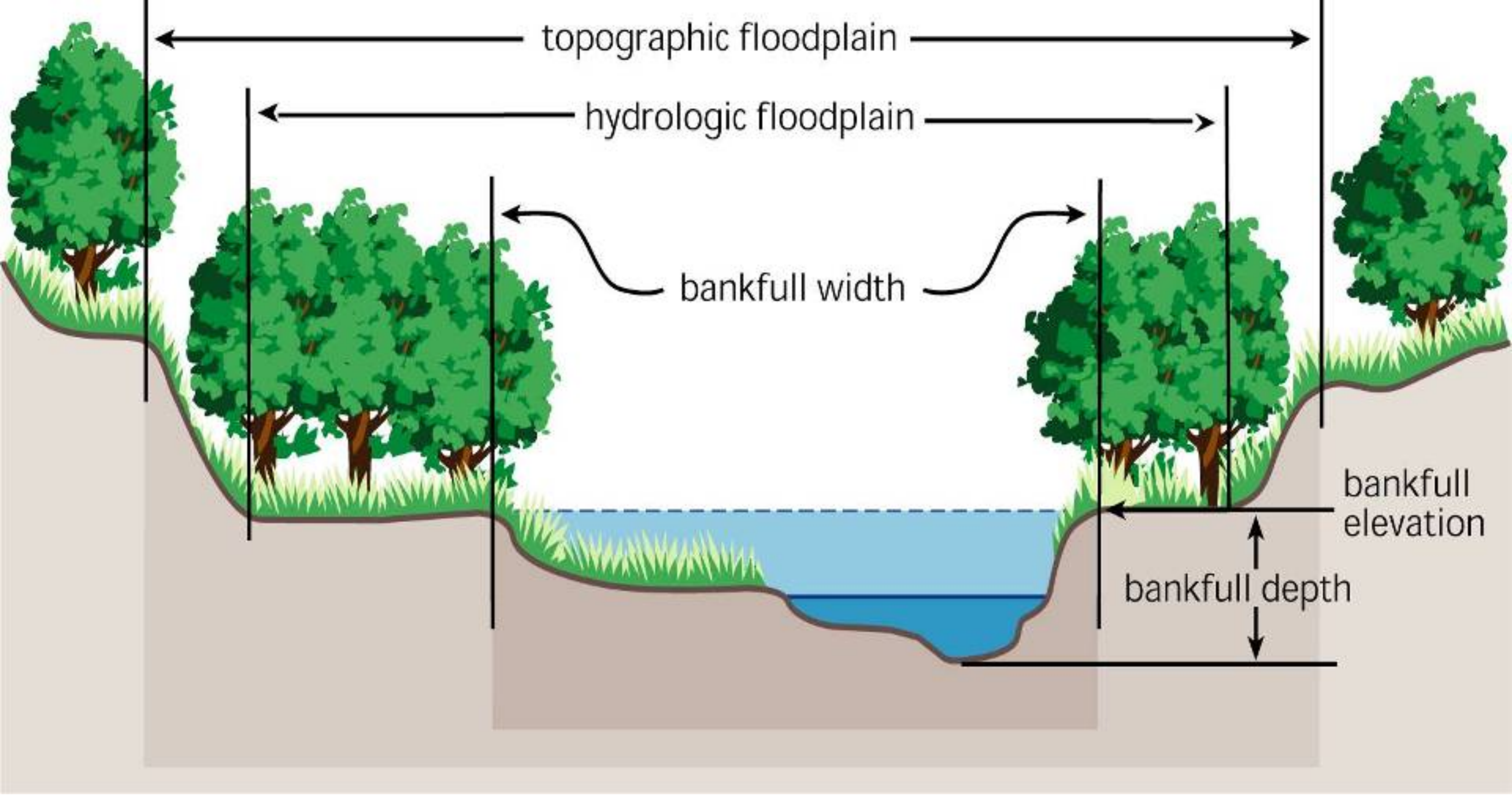




Completed Projects:

- Upstream/downstream
- Similar watersheds
- Successes & Failures

Auburn Town Creek Park (5 years later)



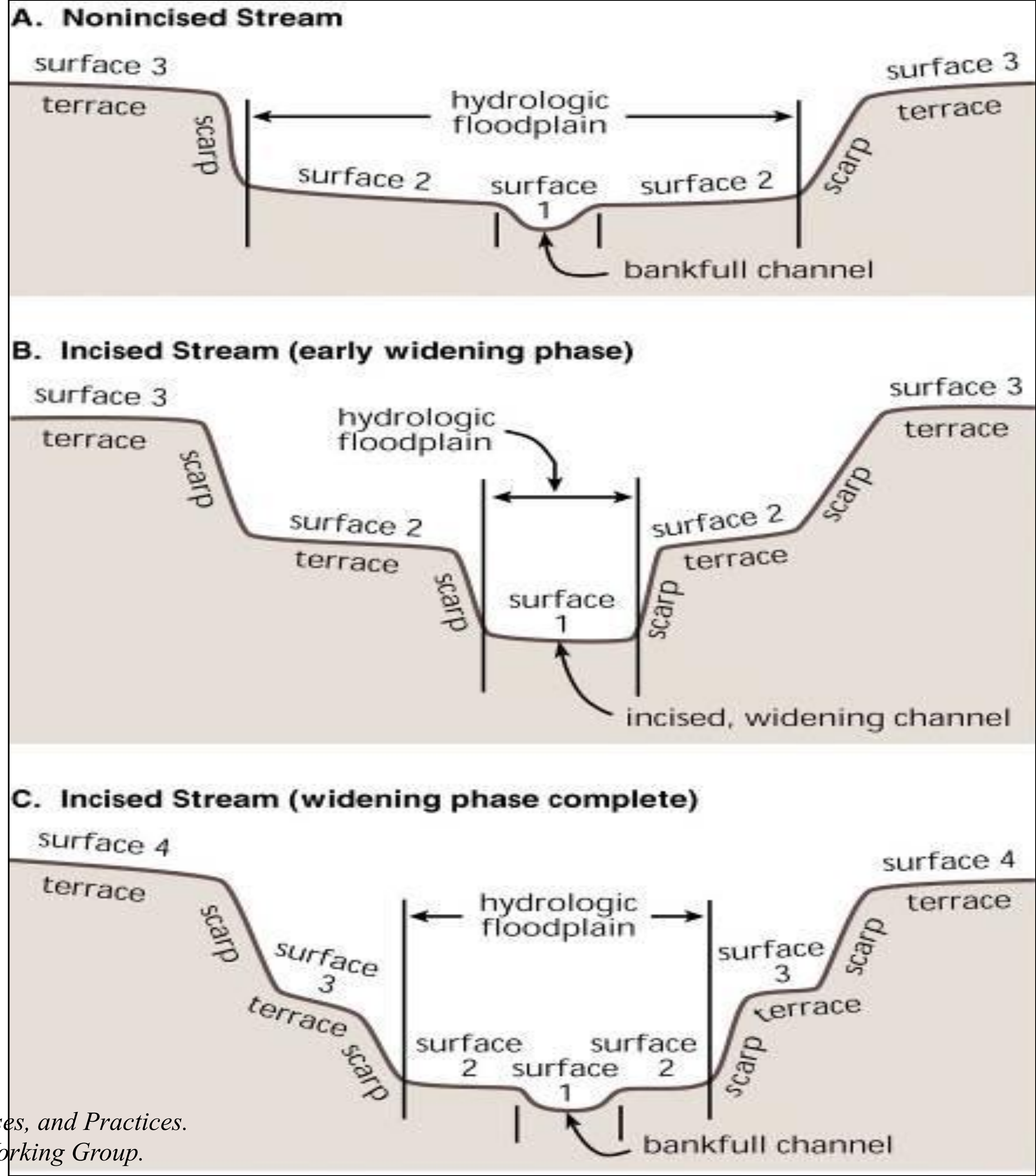
Bankfull Stage: Water fills the active channel and begins to spread onto the floodplain

Stream Corridor Restoration: Principles, Processes, and Practices. 1998. Federal Interagency Stream Restoration Working Group.

Priority 1:
lift channel

Incised Stream

Priority 2 & 3:
lower floodplain



Stream Corridor Restoration: Principles, Processes, and Practices. 1998. Federal Interagency Stream Restoration Working Group.

Priority 1: Reconnect Floodplain

Replace incised channel with shallow channel raised to existing floodplain elevation

ER = 18   W/d = 12
K = 1.4   S = 0.008

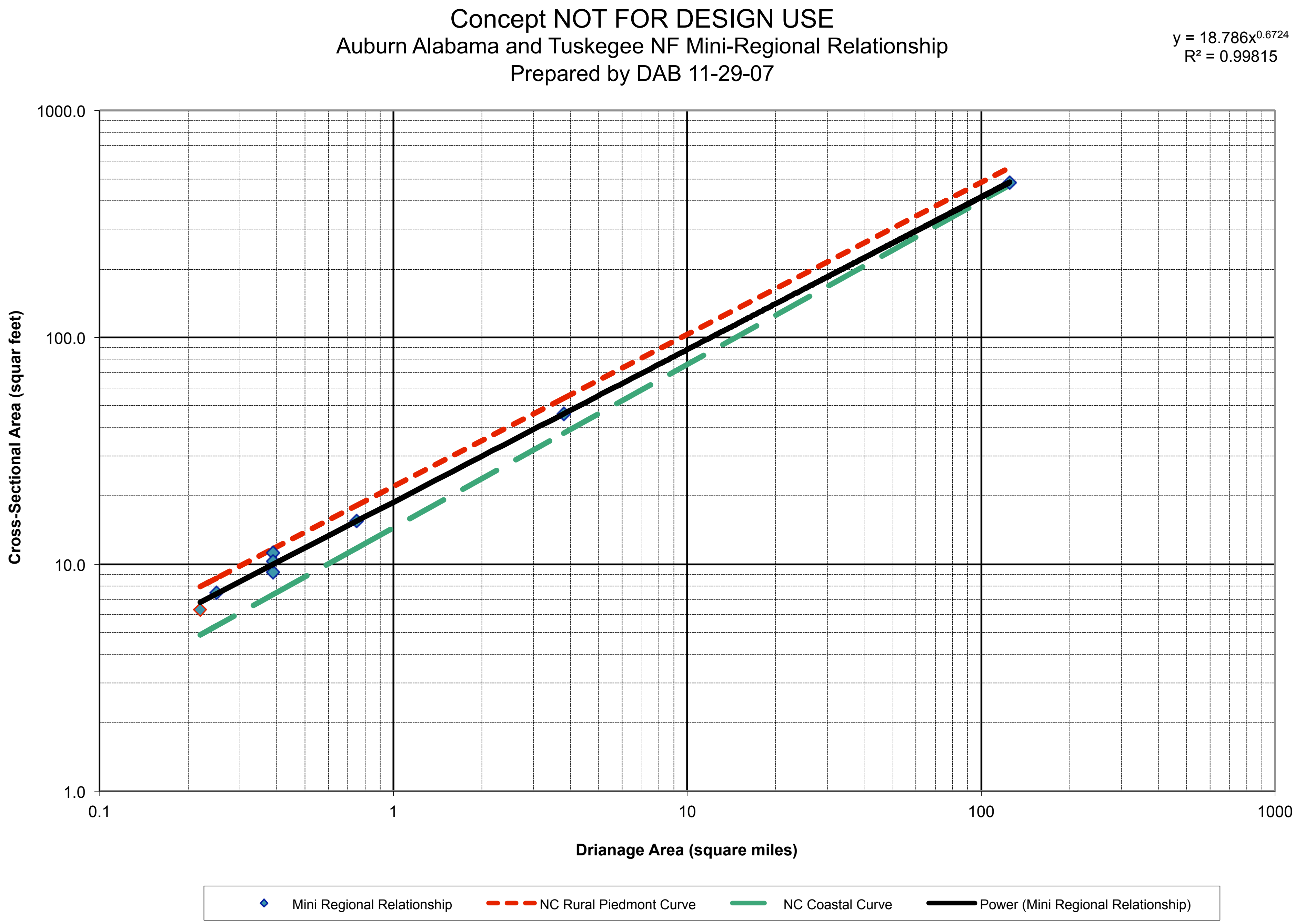
2006   Town Creek Tributary   2007

Engineering Design:

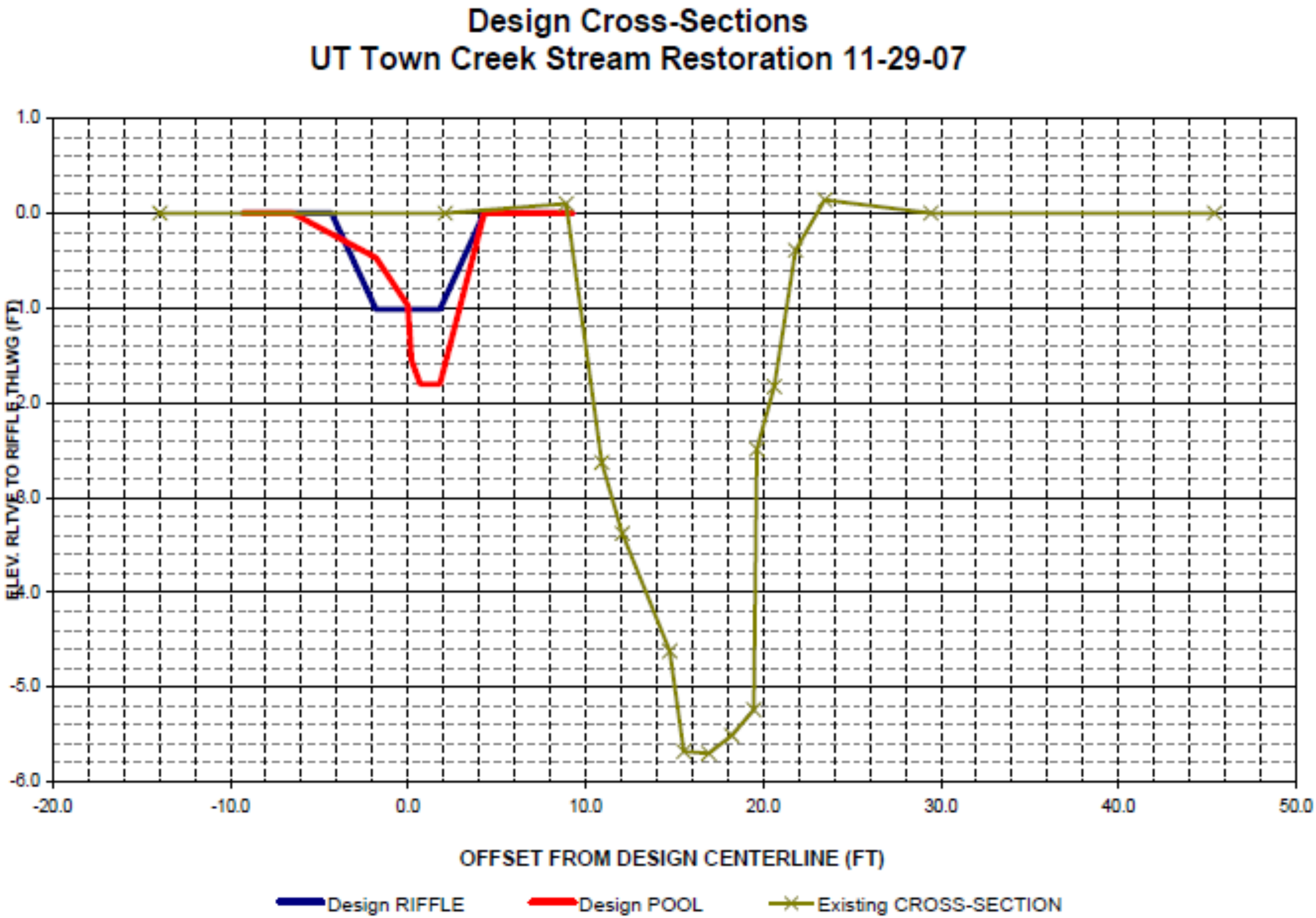
Morphological Table

David Bidelspach, PE, Stantec

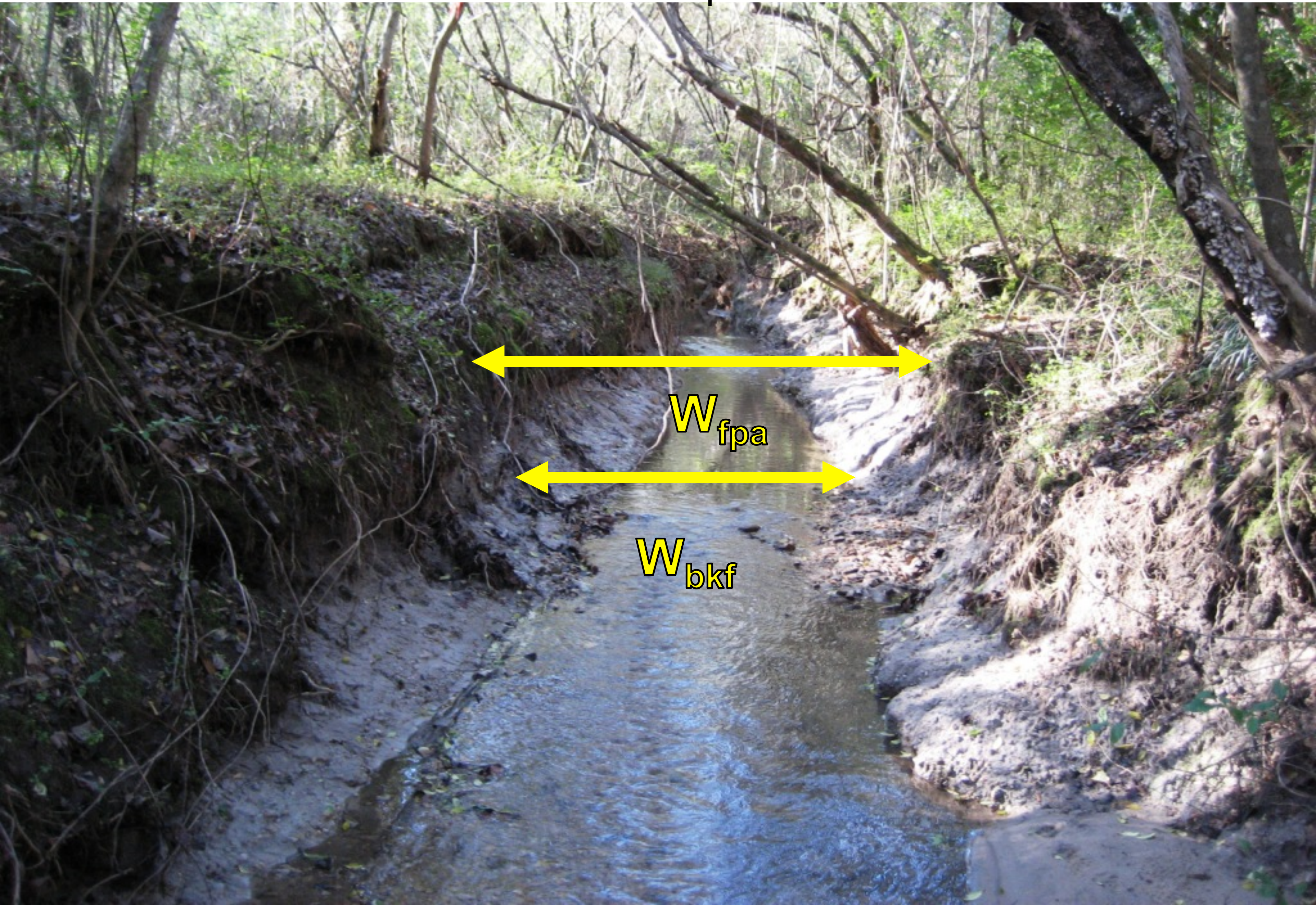
Parameter	Existing Stream			Design Stream			Reference Stream 1			Reference Stream 2		
	Min	Median	Max	Min	Median	Max	Min	Median	Max	Min	Median	Max
Stream name	Privet Creek - Auburn AL			Privet Creek - Auburn AL			Eve Crick - Tuskegee AL			Sals Branch - Raleigh NC		
Stream type	G5c			E4			E5			E4		
Drainage area, DA (sq mi)	0.22			0.22			0.39			0.20		
Mean riffle depth, d_{bkf} (ft)	1.3	1.3	1.5	0.7	0.7	0.7	0.9	1.0	0.9	1.3	1.2	1.3
Riffle width, W_{bkf} (ft)	5.1	5.2	7.5	8.5	8.6	8.8	10.1	10.4	12.3	7.4	8.3	8.5
Width-to-depth ratio, $[W_{bkf}/d_{bkf}]$	4.0	3.9	5.0	12.0	12.0	12.0	11.1	10.5	13.4	5.9	6.8	6.6
Riffle cross-section area, A_{bkf} (sq ft)	6.5	7.0	11.3	6.0	6.2	6.5	9.2	10.3	11.3	9.3	10.2	11.0
Max riffle depth, d_{mbkf} (ft)	1.6	1.7	2.2	1.0	1.1	1.2	1.5	1.6	1.7	1.8	1.9	1.9
Max riffle depth ratio, $[d_{mbkf}/d_{bkf}]$	1.2	1.3	1.5	1.4	1.5	1.6	1.6	1.6	1.9	1.4	1.5	1.5
Mean pool depth, d_{bkfp} (ft)	1.5	1.5	1.5	1.4	1.7	2.1	2.2	2.4	2.6	2.4	2.7	3.5
Mean pool depth ratio, $[d_{bkfp}/d_{bkf}]$	1.2	1.1	1.0	2.0	2.4	2.8	2.4	2.4	2.8	1.9	2.2	2.7
Pool width, W_{bkfp} (ft)	6.5	6.5	6.5	10.6	10.8	11.0	10.5	10.5	10.5	11.0	14.0	15.0
Pool width ratio, $[W_{bkfp}/W_{bkf}]$	1.3	1.3	0.9	1.3	1.3	1.3	1.0	1.0	0.9	1.5	1.7	1.8
Pool cross-section area, A_{bkfp} (sq ft)	9.0	9.0	9.0	7.2	8.7	10.4	12.5	12.5	12.5	11.7	15.9	18.2
Pool area ratio, $[A_{bkfp}/A_{bkf}]$	1.4	1.3	0.8	1.2	1.4	1.6	1.4	1.2	1.1	1.3	1.6	1.7
Max pool depth, d_{mbkfp} (ft)	1.6	1.6	1.6	1.4	1.4	1.5	2.3	2.3	2.3	2.5	2.9	3.0
Max pool depth ratio, $[d_{mbkfp}/d_{bkf}]$	1.3	1.2	1.1	2.0	2.0	2.0	2.5	2.3	2.5	2.0	2.4	2.3
Low bank height, LBH (ft)	2.1	5.7	5.3	1.0	1.1	1.2	1.6	1.6	1.7	2.1	2.1	2.1
Low bank height ratio, $[LBH/d_{mbkf}]$	1.3	3.4	2.4	1.0	1.0	1.0	1.1	1.0	1.0	1.2	1.1	1.1
Width flood-prone area, W_{fpa} (ft)	50	7	12	67.9	103.5	132.5	151	210	220	114	130	148
Entrenchment ratio, ER $[W_{fpa}/W_{bkf}]$	9.7	1.4	1.5	8.0	12.0	15.0	15.0	20.2	17.9	15.4	15.7	17.4
Point bar slope (ft/ft)	0.25	0.50	0.50	0.10	0.12	0.15	0.15	0.15	0.20	0.15	0.18	0.20
Bankfull mean velocity, u_{bkf} = Q/A (ft/s)	3.1	2.9	1.8	3.3	3.2	3.1	3.8	3.4	3.1	3.2	2.9	3.2
Bankfull discharge, Q_{bkf} (cfs)	20	20	20	20	20	20	35	35	35	30	30	35
Meander length, L_m (ft)	105.0	121.0	133.0	59.4	77.6	97.1	28.0	35.0	42.0	47.0	60.0	89.0
Meander length ratio $[L_m/W_{bkf}]$	20.6	23.3	17.7	7.0	9.0	11.0	2.8	3.4	3.4	6.4	7.2	10.5
Radius of curvature, Rc (ft)	30.0	34.0	55.0	17.0	19.8	23.8	16.0	18.0	26.0	12.0	19.0	23.0
Radius of curvature ratio $[Rc/W_{bkf}]$	5.9	6.5	7.3	2.0	2.3	2.7	1.6	1.7	2.1	1.6	2.3	2.7
Belt width, W_{blt} (ft)	35.0	56.0	68.0	25.5	43.1	53.0	19.0	24.0	35.0	25.0	48.0	69.0
Meander width ratio $[W_{blt}/W_{bkf}]$	6.9	10.8	9.1	3.0	5.0	6.0	1.9	2.3	2.8	3.4	5.8	8.1
Pool length, L_p (ft)				17.0	21.6	26.5	15.0	19.0	24.0	12.0	24.0	32.0
Pool length ratio $[L_p/W_{bkf}]$				2.0	2.5	3.0	1.5	1.8	2.0	1.6	2.9	3.8
Pool-to-poo spacing, p-p (ft)				33.9	38.8	44.2	22.0	26.0	28.0	29.0	44.0	57.0
Pool-to-pool spacing ratio, $[p\text{-}p/W_{bkf}]$				4.0	4.5	5.0	2.2	2.5	2.3	3.9	5.3	6.7
Stream length, SL (ft)	1090.0	1090.0	1090.0	1200.0	1200.0	1200.0	205.0	205.0	205.0	245.0	268.0	290.0
Valley length, VL (ft)	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	160.0	160.0	160.0	151.0	183.0	168.0
Valley slope, VS (ft/ft)	0.0130	0.0130	0.0130	0.0130	0.0130	0.0130	0.0104	0.0104	0.0104	0.0110	0.0130	0.0150
Average water surface slope, S (ft/ft)	0.0119	0.0119	0.0119	0.0100	0.0100	0.0100	0.0077	0.0077	0.0077	0.0050	0.0060	0.0060
Sinuosity, k = SL/VL (ft/ft)	1.09	1.09	1.09	1.20	1.20	1.20	1.28	1.28	1.28	1.62	1.46	1.73
Riffle slope, S_{rif} (ft/ft)	0.0150	0.0150	0.0150	0.0150	0.0170	0.0225	0.0090	0.0170	0.0240	0.0080	0.0150	0.0200
Riffle slope ratio, $[S_{rif}/S]$	1.3	1.3	1.3	1.5	1.7	2.3	1.2	2.2	3.1	1.6	2.5	3.3
Run slope, S_{run} (ft/ft)										0.0180	0.0210	0.0250
Run slope ratio, $[S_{rif}/S]$										3.6	3.5	4.2
Pool slope, S_p (ft/ft)	0.0100	0.0100	0.0100	0.0000	0.0000	0.0000	0.0000	0.0005	0.0016	0.0000	0.0005	0.0013
Pool slope ratio, $[S_p/S]$	0.8	0.8	0.8	0.0	0.0	0.0	0.0	0.1	0.2	0.0	0.1	0.2
Glide slope, S_g (ft/ft)										0.0005	0.0012	0.0015
Glide slope ratio, $[S_g/S]$										0.1	0.2	0.3
Riffle length, L_{rif} (ft)	11.0	11.0	11.0	11.0	15.1	17.7	7.0	9.0	14.0	6.0	11.0	23.0
Riffle length ratio, $[L_{rif}/W_{bkf}]$	2.2	2.1	1.5	1.3	1.8	2.0	0.7	0.9	1.1	0.8	1.3	2.7
Bankfull wetted perimeter, WP (ft)	7.6	7.9	10.5	9.9	10.1	10.3	11.9	12.4	14.1	9.9	10.8	11.1
Bankfull hydraulic radius, R (ft)	0.8	0.9	1.1	0.6	0.6	0.6	0.8	0.8	0.8	0.9	0.9	1.0
Bankfull Mannings n (estimate)	0.045	0.045	0.045	0.045	0.045	0.045	0.035	0.035	0.035	0.035	0.035	0.035
Mannings bankfull discharge, Q_{bkf} (cfs)	21.1	23.4	42.9	14.2	14.9	15.8	28.9	34.0	36.4	26.8	32.5	36.1
Bankfull shear stress (tau)	0.63	0.66	0.80	0.38	0.38	0.39	0.37	0.40	0.38	0.29	0.35	0.37
Shields - diameter mobilized (mm)	35	40	60	22	22	22	21	22	22	18	20	21
D_{50} (mm)	1	1	1	2	2	2	2	2	2	4	6	12
D_{84} (mm)	8	32	45	12	12	12	8	8	8	32	34	32

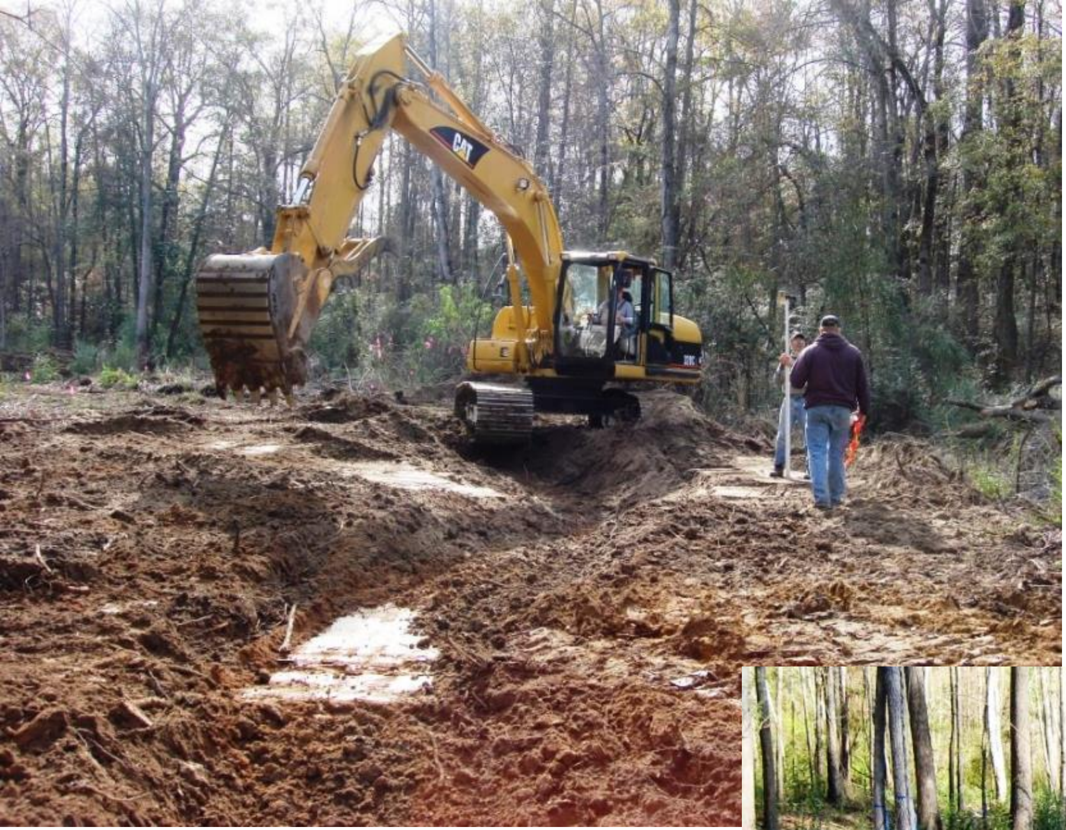

Concept NOT FOR DESIGN USE
Auburn Alabama and Tuskegee NF Mini-Regional Relationship
Prepared by DAB 11-29-07
y = 18.786x^0.6724
R² = 0.99815
1000.0
100.0
10.0
1.0
Cross-Sectional Area (squar feet)
0.1
1
10
100
1000
Drianage Area (square miles)
Mini Regional Relationship
NC Rural Piedmont Curve
NC Coastal Curve
Power (Mini Regional Relationship)

Engineering Design: David Bidelspach, PE, Stantec



Entrenchment Ratio = W_{fpa} / W_{bkf} = 15/12 = 1.2

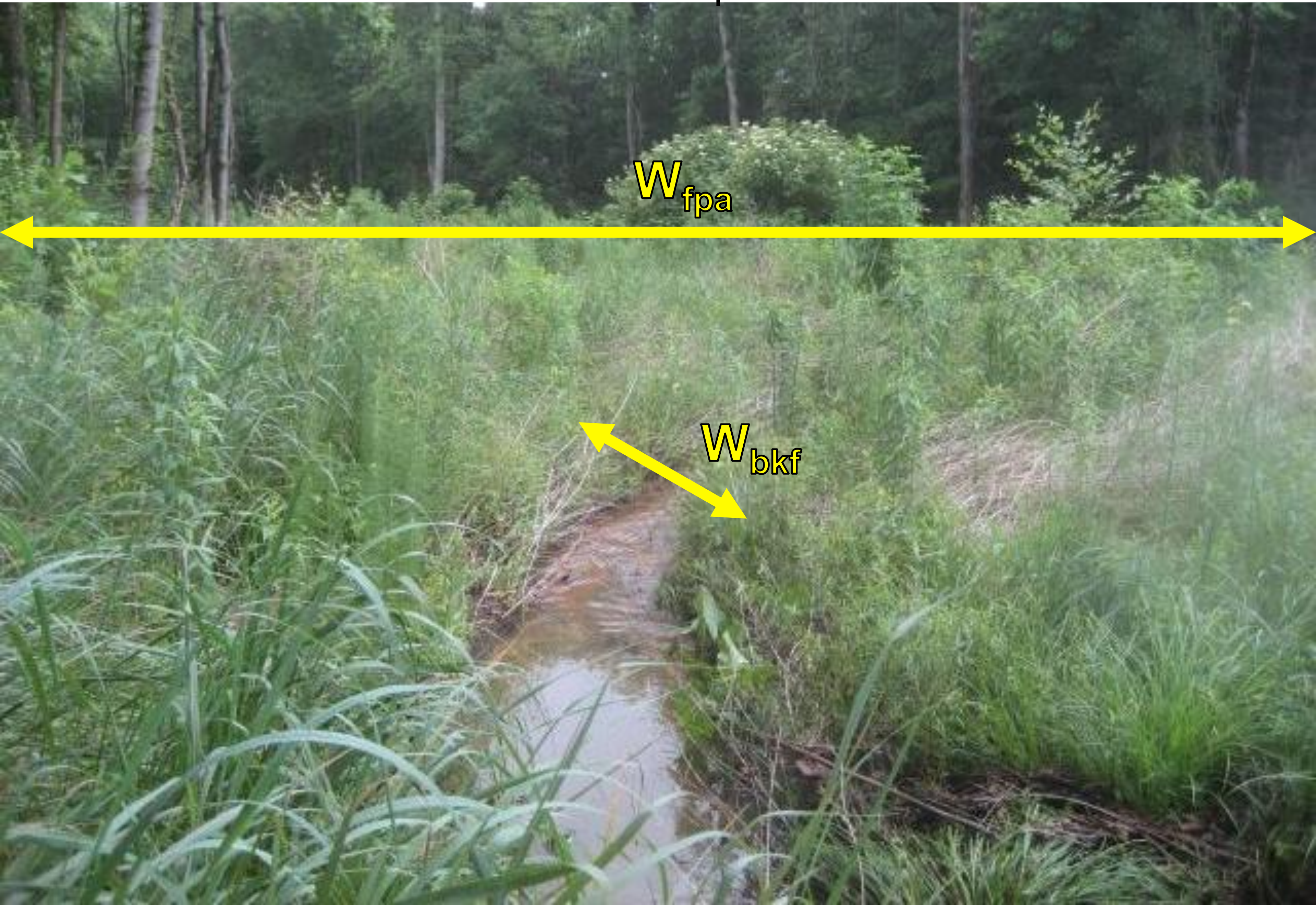




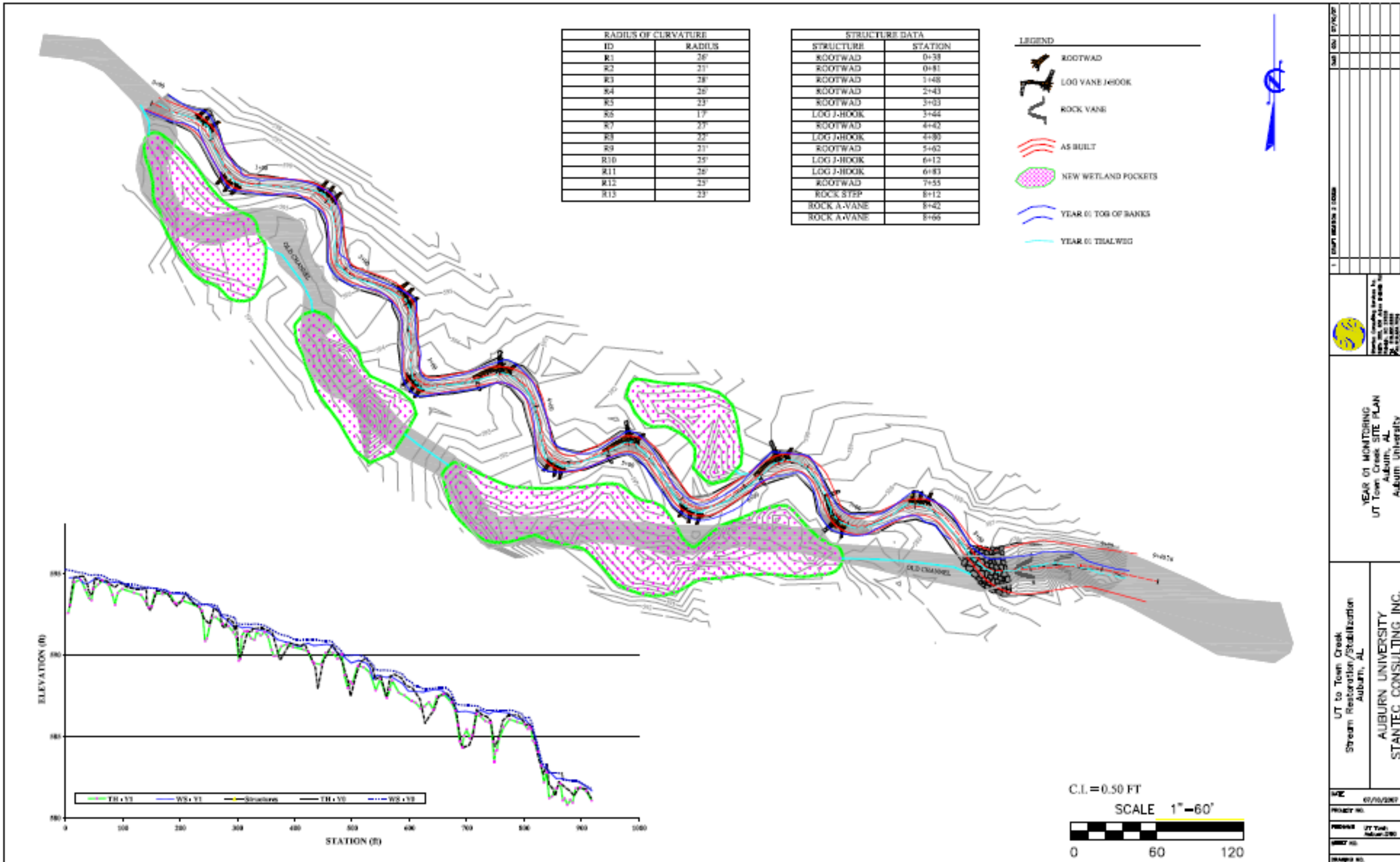
Construction:

January, 2008

Entrenchment Ratio = W_{fpa} / W_{bkf} = 120/8 = 15



As-Built Survey



RADIUS OF CURVATURE	
ID	RADIUS
R1	26'
R2	21'
R3	28'
R4	26'
R5	23'
R6	17'
R7	27'
R8	22'
R9	21'
R10	25'
R11	26'
R12	25'
R13	23'

STRUCTURE DATA	
STRUCTURE	STATION
ROOTWAD	0+38
ROOTWAD	0+81
ROOTWAD	1+48
ROOTWAD	2+43
ROOTWAD	3+03
LOG J-HOOK	3+44
ROOTWAD	4+42
LOG J-HOOK	4+80
ROOTWAD	5+62
LOG J-HOOK	6+12
LOG J-HOOK	6+83
ROOTWAD	7+55
ROCK STEP	8+12
ROCK A-VANE	8+42
ROCK A-VANE	8+66

5 years after construction

5 years after construction

Channel Evolution: *Vegetation Effects*

- Width-to-depth ratio will decrease
- Banks will steepen

As-built:

A_{bkf} = 4.5 sq ft

W_{bkf} / d_{bkf} = 7.6 / 0.6 = 13

Bank Angles: 3:1

5 Years Later:

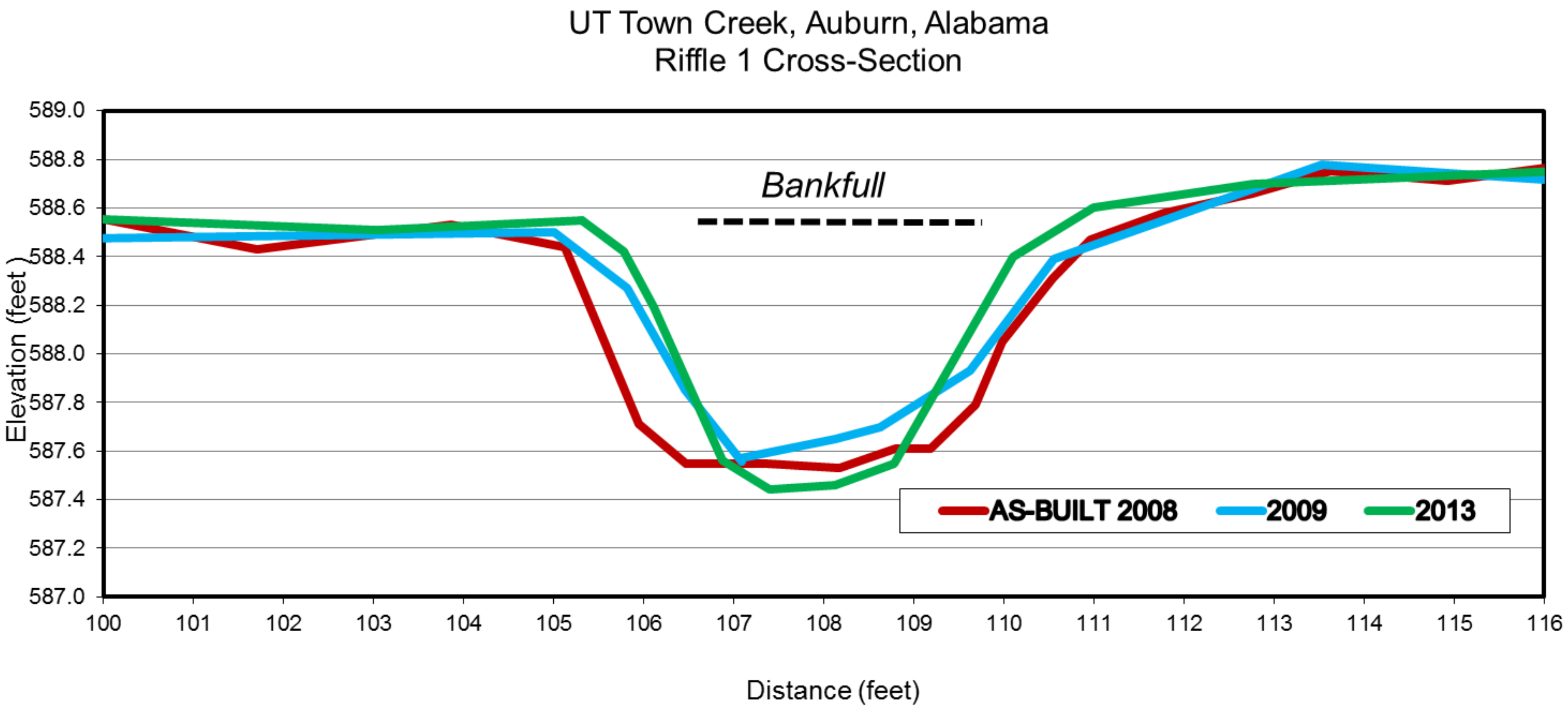
A_{bkf} = 3.8 sq ft

W_{bkf} / d_{bkf} = 5.4 / 0.7 = 8

Bank Angles: Near Vertical

Channel Evolution: *Vegetation Effects*

- Width-to-depth ratio will decrease
- Banks will steepen



Priority 1: Raise channel to existing valley and construct new meandering channel

2008 Purlear Creek 2009

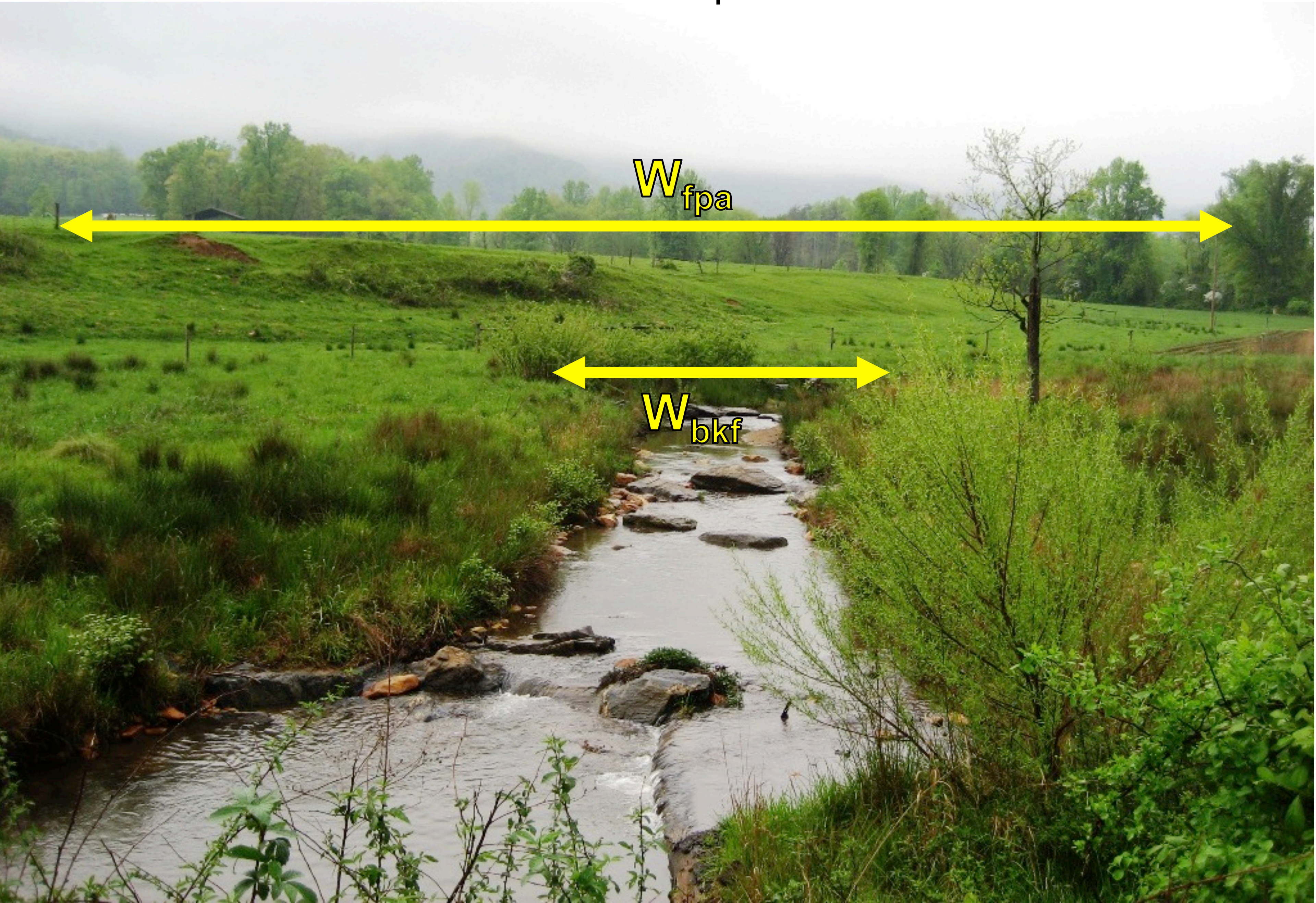
Entrenchment Ratio = W_{fpa} / W_{bkf} = 120/12 = 10

Priority 1: Raise channel to existing valley and construct new meandering channel

2005 South Fork Mitchell River 2006

Photo Credits: Darrell Westmoreland, North State Environmental, Inc.

Entrenchment Ratio = W_{fpa} / W_{bkf} = 120/20 = 6



Priority 2: Excavate lower floodplain and construct new meandering channel

2007 Cary Walnut Creek Tributary 2014

Photo Credit: David Bidelspach, Stantec, Inc.

Entrenchment Ratio = W_{fpa} / W_{bkf} = 120/15 = 8

Priority 2: Excavate lower floodplain and construct new meandering channel

2004 NCSU Rocky Branch 2005

2006

NCSU Rocky
Branch

2006

Entrenchment Ratio = W_{fpa} / W_{bkf} = 65/16 = 4

2013 NCSU Rocky Branch

2013 NCSU Rocky Branch

Montgomery White Slough (2009)

Project Mgmt: Auburn Univ

Funding: ADEM, EPA 319

Design: GMC, Jennings

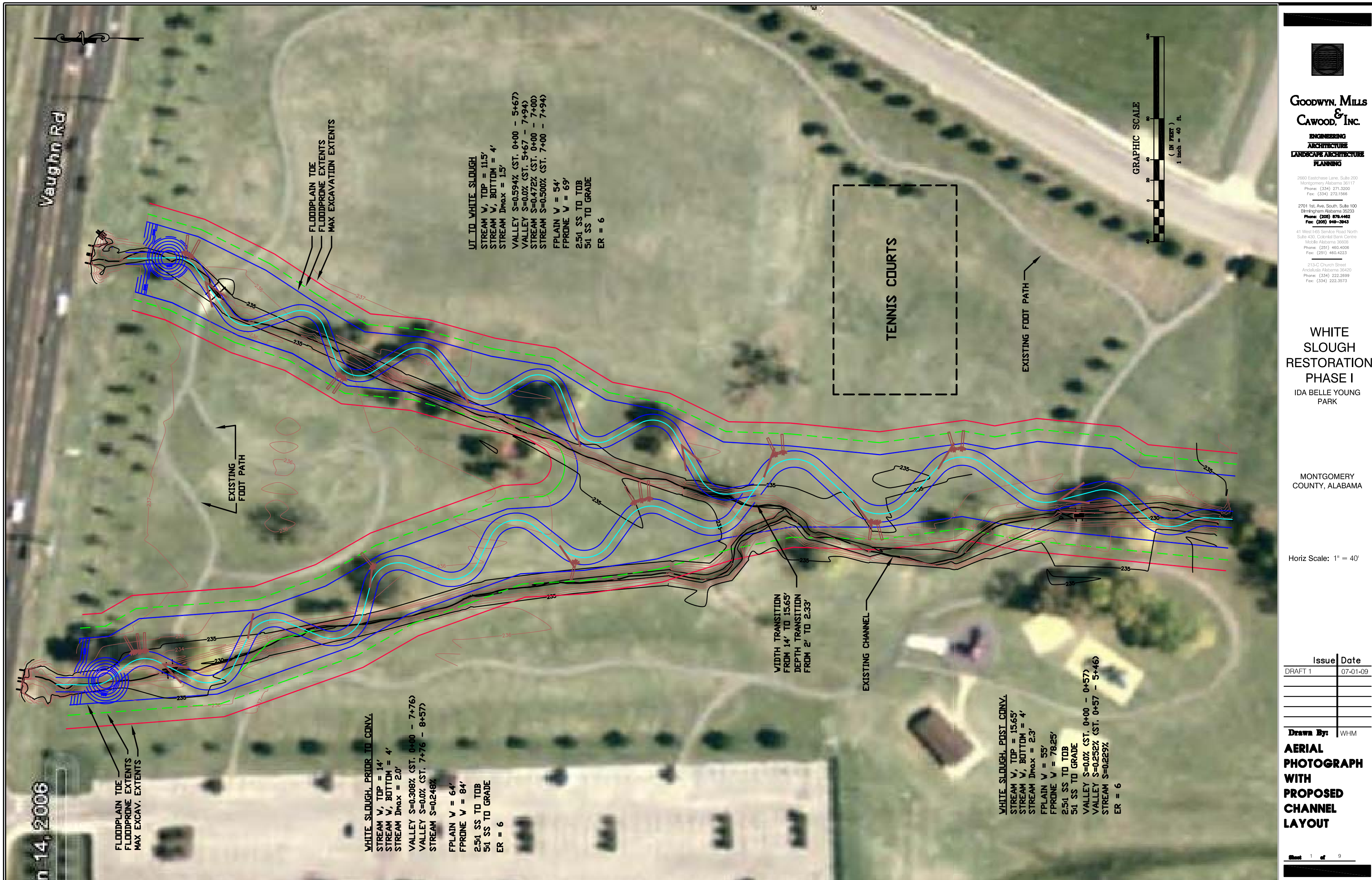
Construction: GMC

Vegetation: GMC, Auburn Univ

2008

2010

Engineering Design: William McLemore, PE, GMC



Priority 2: Reconnect Floodplain

Excavate wide floodplain and meander channel at a lower elevation

ER = 6
W/d = 11
K = 1.4
S = 0.003

2008 White Slough 2010

Entrenchment Ratio = W_{fpa} / W_{bkf} = 84/14 = 6

Priority 2: Reconnect Floodplain

Priority 2: Reconnect Floodplain

Priority 2: Excavate lower floodplain and construct new meandering channel

2008 Trib to Saugatchee Creek 2008

Entrenchment Ratio = W_{fpa} / W_{bkf} = 75/15 = 5

In-Stream Structures

- Boulders and logs sized to resist washout
- Vanes oriented to provide bank protection & maintain position
- Footers, splash rocks, backer logs, sills, chinking, geotextiles, backfilling to maintain structure stability
- Drops/steps support aquatic organism passage & structure stability

Functions: *Flow Direction & Revetment*

- Streambank protection
- Grade control
- Sediment transport
- Habitat enhancement (pools, aeration, cover)

Vanes (Boulder or Log)

- Oriented upstream at 20-30 degrees from bank tangent
- Sloping up from channel invert at 3-5 % arm toward bank
- May control grade using J-hook (< 0.5 ft drop)
- May need footers, sills, geotextile to avoid piping/washout

Boulder Vanes

- Single-arm
- J-hook
- Cross-vane

20-30 degrees

3-5 % arm slopes

Runaway Truck Ramp

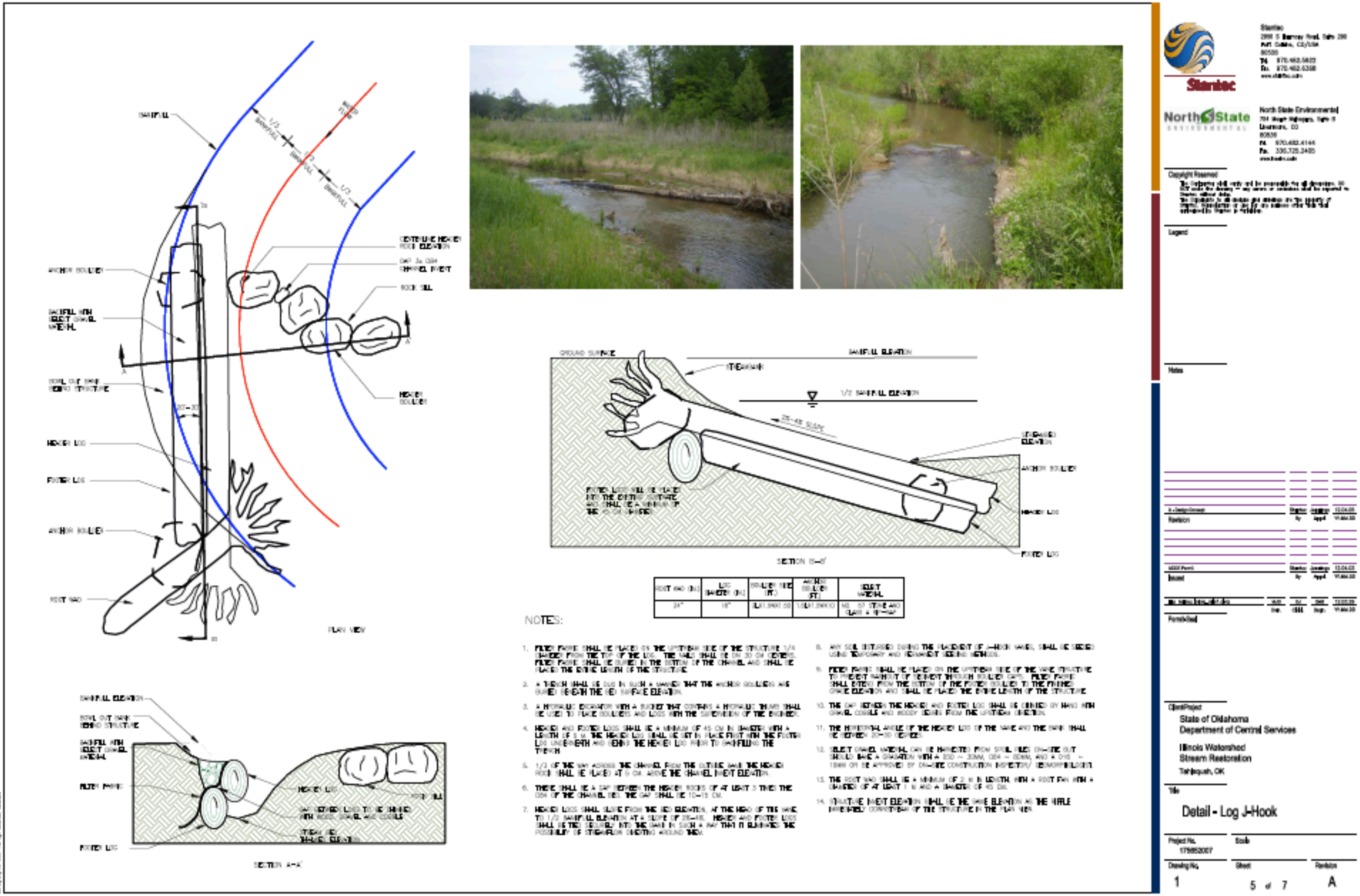
Boulder J-Hook Vane: *Scour Pool*

Boulder J-Hook Vane

Chinking Boulders to Prevent Piping

Geotextile Curtain to Prevent Piping

Log J-hook Vanes for flow direction & habitat



Multiple Log Vanes

Saugahatchee Creek

2007

2008

Multiple Log Vanes

Saugahatchee Creek

2009 January

2009 July

Multiple Log Vanes: Saugahatchee Creek

Log Vanes (with Toe Wood downstream)

- Auburn NE Sewer
- Redirect flow to allow natural vegetation to stabilize bank

Log Vanes (with Toe Wood downstream)

- 2-4 % arm slopes
- 20-25 degree arm angles
- Sealed with woven geotextile & backer logs

Log Vane (with J-Hook)

Log J-Hook Vane

Log J-Hook Vane

Log J-Hook Vane: Flow direction, bank protection, habitat

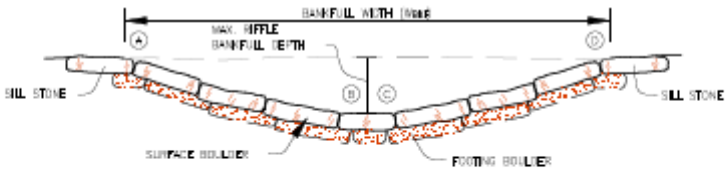
Arm slope = 1.2 / 30 = 4%; Arm angle = 25 degrees

Storm Flow: Flow direction + Bank protection

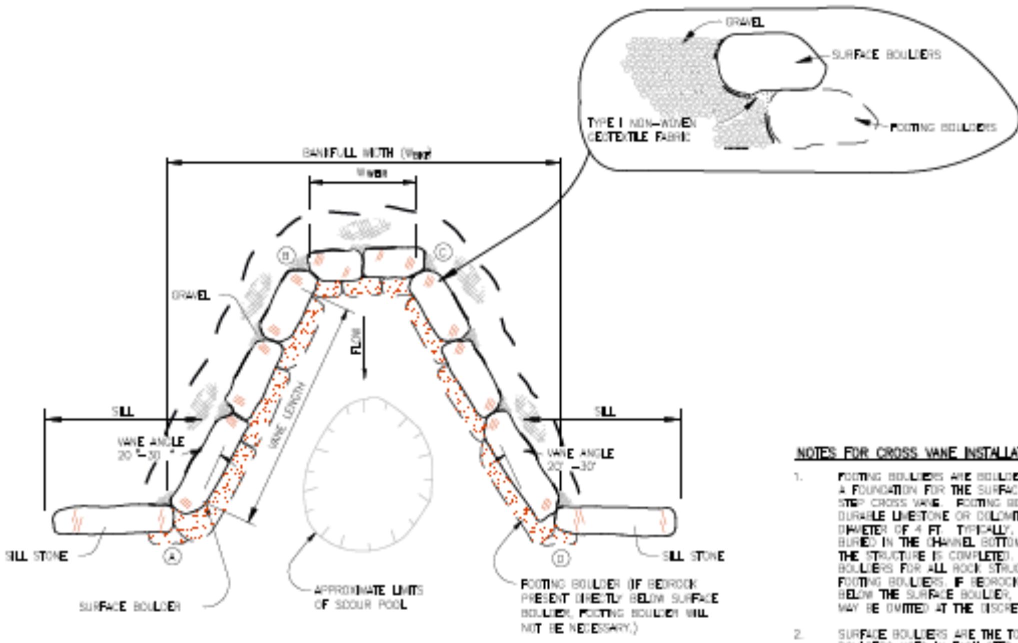
Boulder Cross Vane

- Direct flow in new channel alignment
- Grade control and scour pool
- Footer boulders & geotextile

Cross Vanes for flow direction & grade control



CROSS VANE TYPICAL CROSS-SECTION



CROSS-VANE PLAN VIEW

CROSS VANE LONGITUDINAL PROFILE

NOTES FOR CROSS VANE INSTALLATION:

1. FOOTING BOULDERS ARE BOULDERS PLACED TO PROVIDE A FOUNDATION FOR THE SURFACE BOULDERS IN EACH STEP CROSS VANE. FOOTING BOULDERS SHALL BE DURABLE LIMESTONE OR DOLOMITE WITH A MINIMUM DIAMETER OF 4 FT. TYPICALLY, FOOTING BOULDERS ARE BURIED IN THE CHANNEL BOTTOM AND NOT SEEN WHEN THE STRUCTURE IS COMPLETED. ALL SURFACE BOULDERS FOR ALL ROCK STRUCTURES REQUIRE FOOTING BOULDERS. IF BEDROCK IS PRESENT DIRECTLY BELOW THE SURFACE BOULDER, THE FOOTING BOULDER MAY BE OMITTED AT THE DISCRETION OF FWSM.

2. SURFACE BOULDERS ARE THE TOP MOST COURSE OF BOULDERS USED IN EACH STEP CROSS VANE. ALL SURFACE BOULDERS CAN BE SEEN PROTRUDING FROM THE WATER SURFACE DURING EXTREMELY LOW FLOWS. SURFACE BOULDERS SHALL BE DURABLE LIMESTONE OR DOLOMITE WITH A MINIMUM DIAMETER OF 4 FT.

3. THE VANE LENGTH IS THE STRAIGHT LINE PORTION OF CROSS VANE STRUCTURES MEASURED FROM THE STREAM BANK AT BANKFULL ELEVATION TO THE CHANNEL BED.

4. THE VANE ANGLE IS THE SMALLEST ANGLE MEASURED BETWEEN A VANE AND A LINE TANGENT TO BANKFULL ELEVATION AT THE POINT WHERE THE VANE INTERSECTS THE BANK.

5. CONSTRUCT STEP CROSS VANE STRUCTURES BY FIRST SHAPING THE BANK TO THE GRADES SPECIFIED. NEXT EXCAVATE ENOUGH BED MATERIAL TO PLACE THE BOULDERS, GEOTEXTILE FABRIC AND GRAVEL OVERLAY. ONCE THE INVERTS HAVE BEEN ESTABLISHED THE REMAINDER OF THE FOOTING AND SURFACE BOULDERS SHALL BE PLACED, MINIMIZING VOIDS. PLACE GEOTEXTILE FILTER FABRIC AT THE UPSTREAM FACE OF THE STRUCTURE AS SHOWN AND BACKFILL (OVERLAY) WITH GRAVEL. FILL THE VOIDS ON THE UPSTREAM SIDE OF SURFACE BOULDERS WITH GRAVEL. DO NOT LEAVE EXPOSED GEOTEXTILE FABRIC AND TRIM EXPOSED GEOTEXTILE FABRIC. ONCE STRUCTURE IS INSTALLED, EXCAVATE SCOUR POOL AND PLACE GRAVEL SUBSTRATE AS REQUIRED. RE-DRESSING OF CHANNEL AND BANKFULL BENCH/FLOODPLAIN WILL LIKELY BE REQUIRED FOLLOWING INSTALLATION OF IN-STREAM STRUCTURES AND SHALL BE CONSIDERED INCIDENTAL TO CONSTRUCTION.

6. THE SURFACE OF CROSS, J-HOOK AND LOG VANES SHALL BE FINISHED TO A SMOOTH AND COMPACT SURFACE IN ACCORDANCE WITH THE LINES, GRADES AND CROSS-SECTIONS OR ELEVATIONS SHOWN ON THE DRAWINGS. THE DEGREE OF FINISH FOR INVERT ELEVATIONS SHALL BE WITHIN .1 ft OF THE GRADES AND ELEVATIONS INDICATED PROVIDED ANY HEIGHT DOES NOT EXCEED 2 INCHES. ALL GAPS OR VOIDS SHALL BE PLUGGED WITH ROCK TO FORM A TIGHT-FITTING SEAL.

7. CONTRACTOR SHALL USE AN EXCAVATOR WITH A HYDRAULIC THUMB TO CONSTRUCT HYDRAULIC STRUCTURES.

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Notes

Revision

Issued

File Name

Permit-Seal

Client/Project
State of Oklahoma
Department of Central Services
Illinois Watershed
Stream Restoration
Tahlequah, OK

Title
Detail - Toe Wood Sod Mats

Project No. 175952007

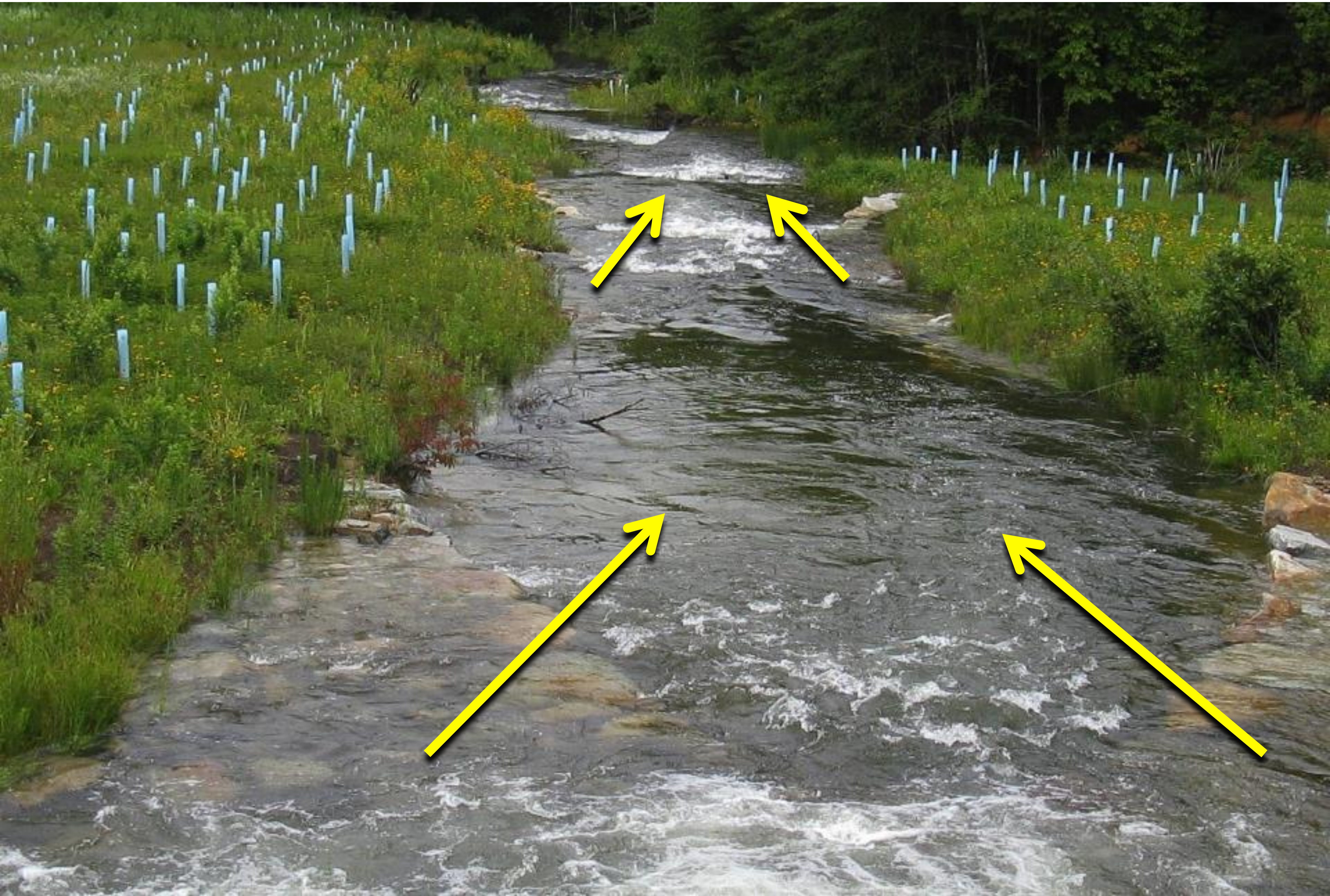
Scale

Drawing No. 1

Sheet 7 of 7

Revision A

Boulder Cross Vanes: *Grade Control*



Double-Drop Boulder Cross Vane

Double-Drop Offset Boulder Cross Vane

Double-Drop Offset Boulder Cross Vane

Photo Credit: CAWACO RC&D

<u>Cross-Vane (Double-Drop):</u> Grade control, flow direction, scour

Arm slope = 2.5 / 50 = 5%; Arm angles = 25 degrees

Max drop over each step = 0.5 ft

Riffle Morphology: Bankfull Width = 25 ft; Depth = 2.2 ft

Floodprone Width = 55 ft

Entrenchment Ratio, ER = 55/25 = 2.2

Cross Vane (logs embedded)

Cross Vane (logs embedded)

Offset Boulder Cross Vane at a Bridge

Boulder W-Vane

Boulder W-Vane

Constructed Riffle

Constructed Riffle (Rock & Roll)

Constructed Riffle (Rock & Roll)

Constructed Riffle with Embedded Wood

- Undercut bed 2 ft and backfill with gravel, cobble, boulders, wood
- Cut thalweg 0.5 ft deep

Constructed Riffle with Embedded Wood

Riffle with Embedded Logs

Riffle with Log Rollers

1st Order Streambed Transplant

Substrate transfer from old channel to new channel

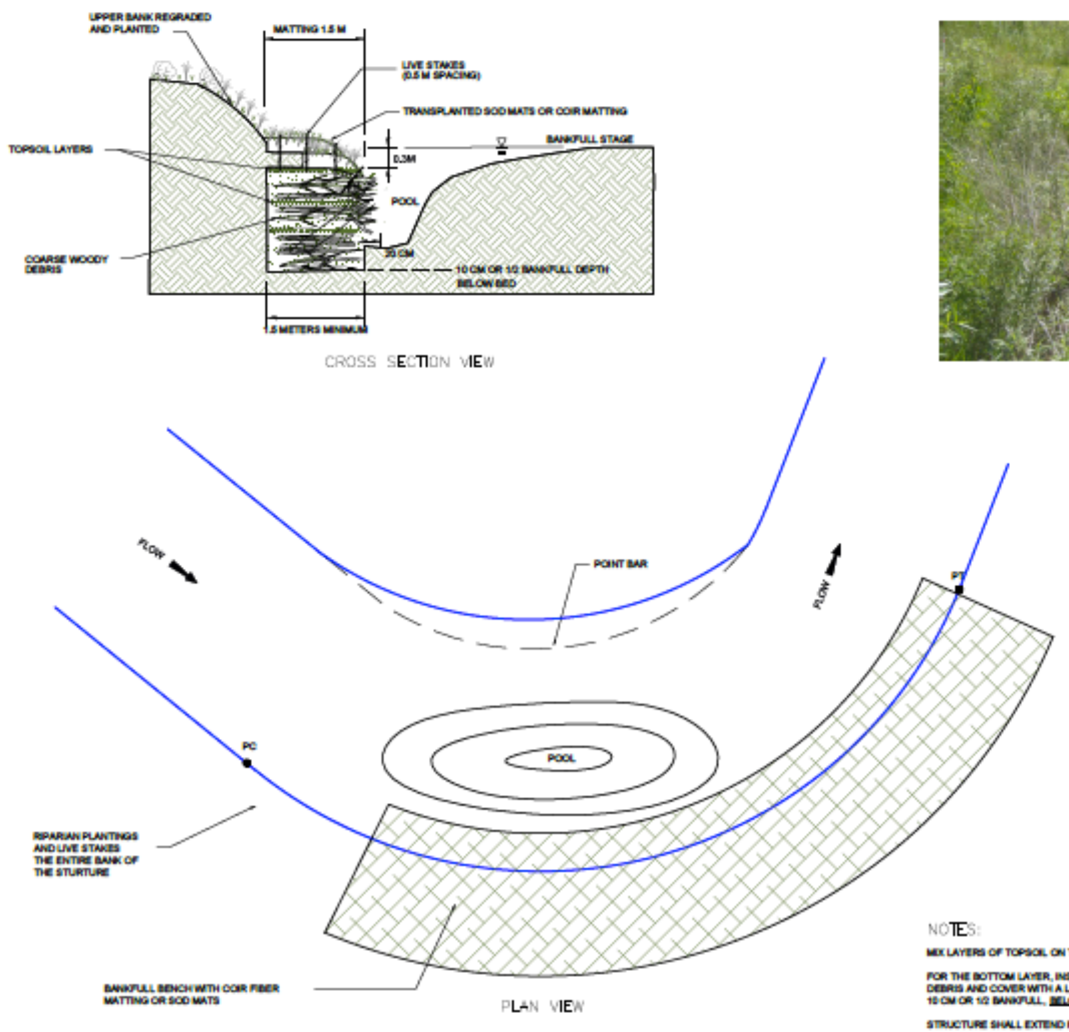
1st Order Streambed Transplant: *5 Yrs Later*

Step-Pool + Cross Vane: *Terminus Priority 1*

Toe Wood Revetment

- Layers of logs and brush under water in pools
- Live cuttings above water (silky dogwood, elderberry)
- Matting, seed, transplanted alders on top

Toe Wood for bank protection, roughness, habitat



NOTES:

MIX LAYERS OF TOPSOIL ON TOP OF COARSE WOODY DEBRIS.

FOR THE BOTTOM LAYER, INSTALL LIVE STAKES ON TOP OF COARSE WOODY DEBRIS AND COVER WITH A LAYER OF TOPSOIL. THIS SHALL BE AT A DEPTH OF 10 CM OR 1/2 BANKFULL, BELOW THE BOTTOM OF THE BED.

STRUCTURE SHALL EXTEND FROM PC+1 TO PC HORIZONTAL LOCATION.

WOODY DEBRIS SHALL NOT EXTEND INTO THE CHANNEL MORE THAN 20 CM.

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Notes

Client/Project
State of Oklahoma
Department of Central Services
Illinois Watershed
Stream Restoration
Tahlequah, OK

Title
Detail - Toe Wood Sod Mats

Project No. 175652007

Scale

Drawing No. 1

Sheet 6 of 7

Revision A

Toe Wood for bank protection, roughness, habitat

Successful Structures

- Properly designed and located
- Low profile
- Constructed to withstand stress
- Excellent vegetation

Streambank Stabilization

- Temporary matting
- Bioengineering

Temporary Matting

- Biodegradable (coir, jute, excelsior)
- Seed and straw UNDER mat
- Keep matting relaxed
- Key in at top
- Stakes: wood or biodegradable plastic

Stream Crossings

- Aquatic organism passage
- Minimize geomorphic impacts
- Pass flood flows

Offset Boulder Cross Vane at a Bridge

Case Study: Parkerson Mill Creek, Auburn, AL
(Northeast Sewer Project, 2013)

Channel realignment

Toe wood revetment

Native plants

Boulder and log vanes

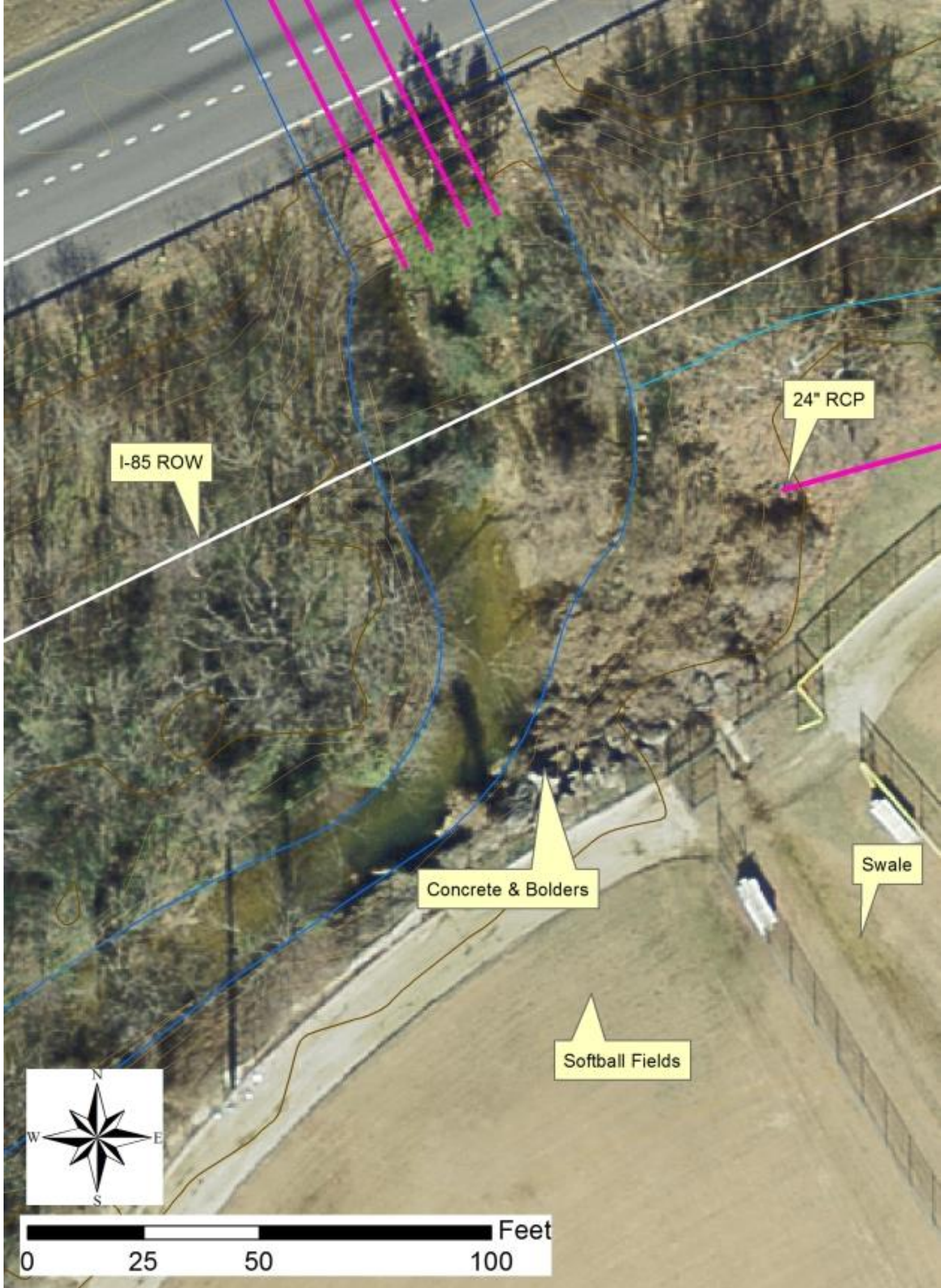
Coir matting

Case Study:

Parkerson Mill Creek, Auburn, AL

Softball Complex downstream of I-85, 2014

- Channel realignment
- Boulder and log vanes
- Toe wood revetment
- Coir matting
- Native plants



Problems:

- Sharp turn downstream of culvert to accommodate recreation
- Sediment accumulation in channel downstream of culvert forcing flow toward banks
- Failing bank armor
- Lack of native plants


April 7, 2014

April 8, 2014
(after flood)

Stream Restoration Implementation

Greg Jennings, PhD, PE
jenningsenv@gmail.com

https://www.youtube.com/user/RiverShared