

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

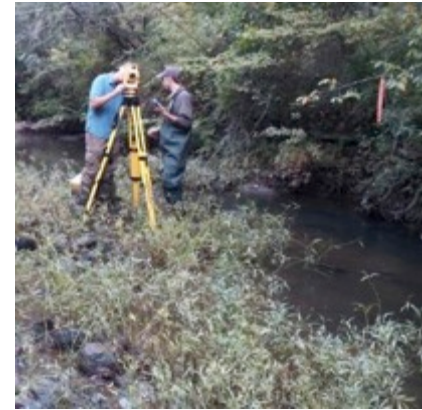


Bankfull Indicators:

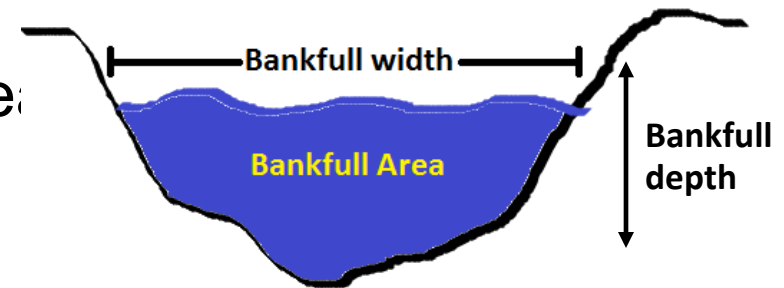
Top of Bank, Point Bars, Lateral Benches



Regional curve development



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

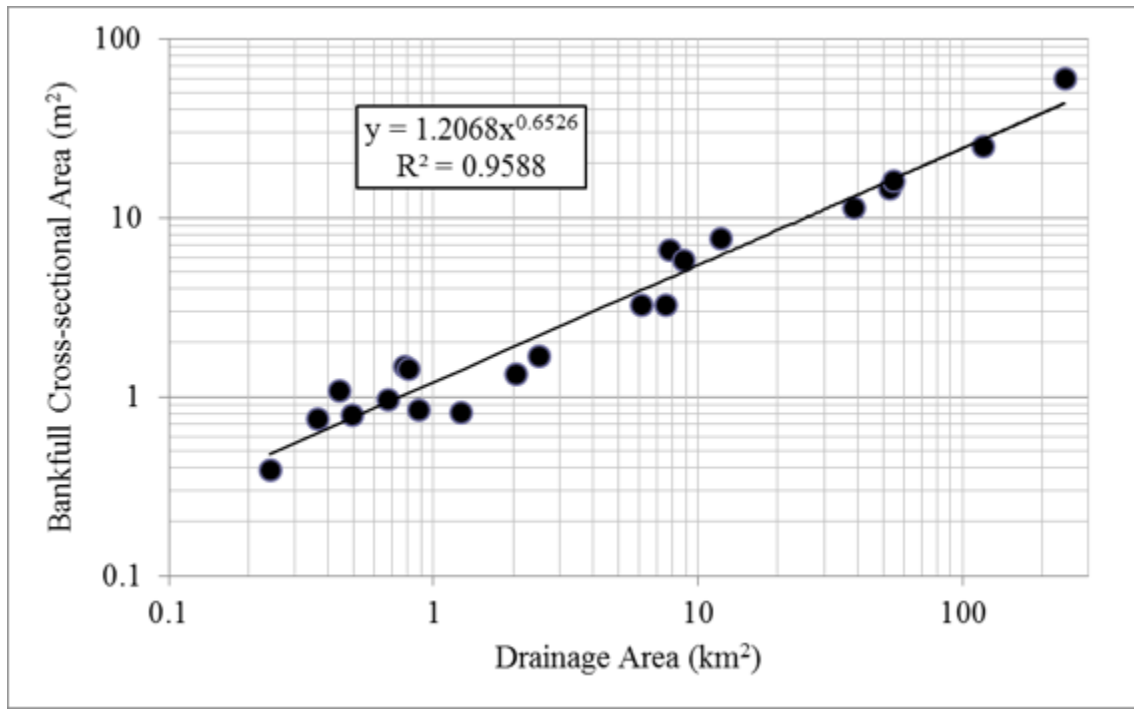
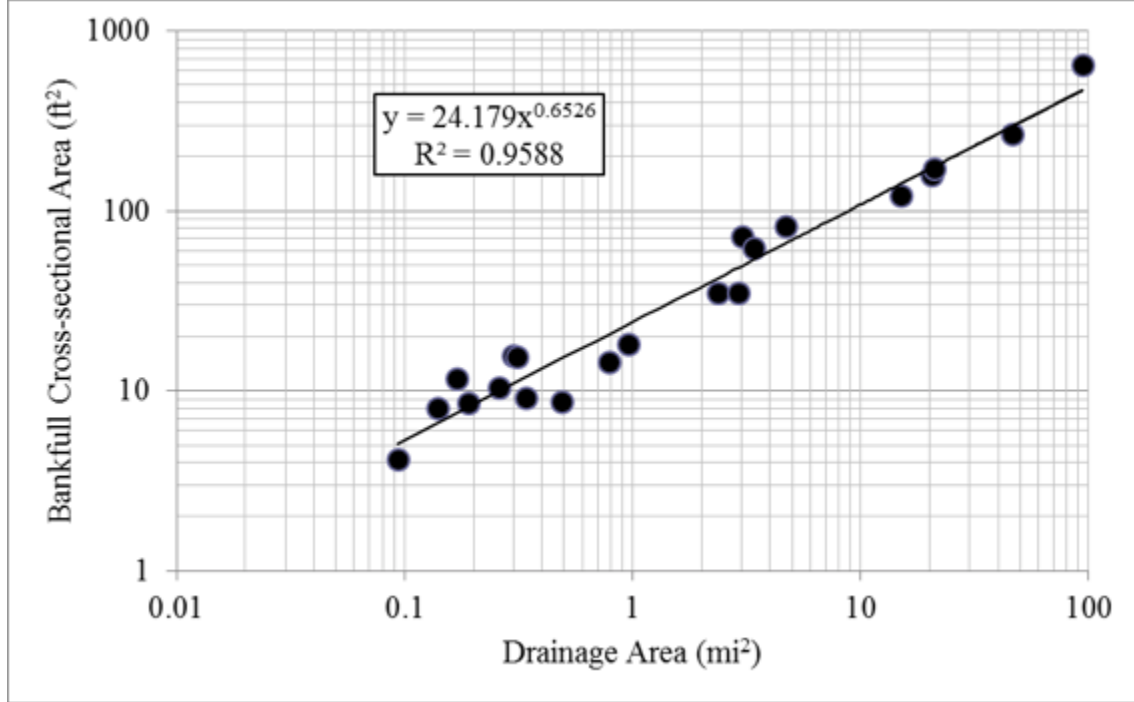


- Fit log-log plots with power functions
 - Geomorphology /drainage area
- Compare to other regional curves (PA, MD, VA, NC, GA)
 - Test for differences in slope (ANCOVA)

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

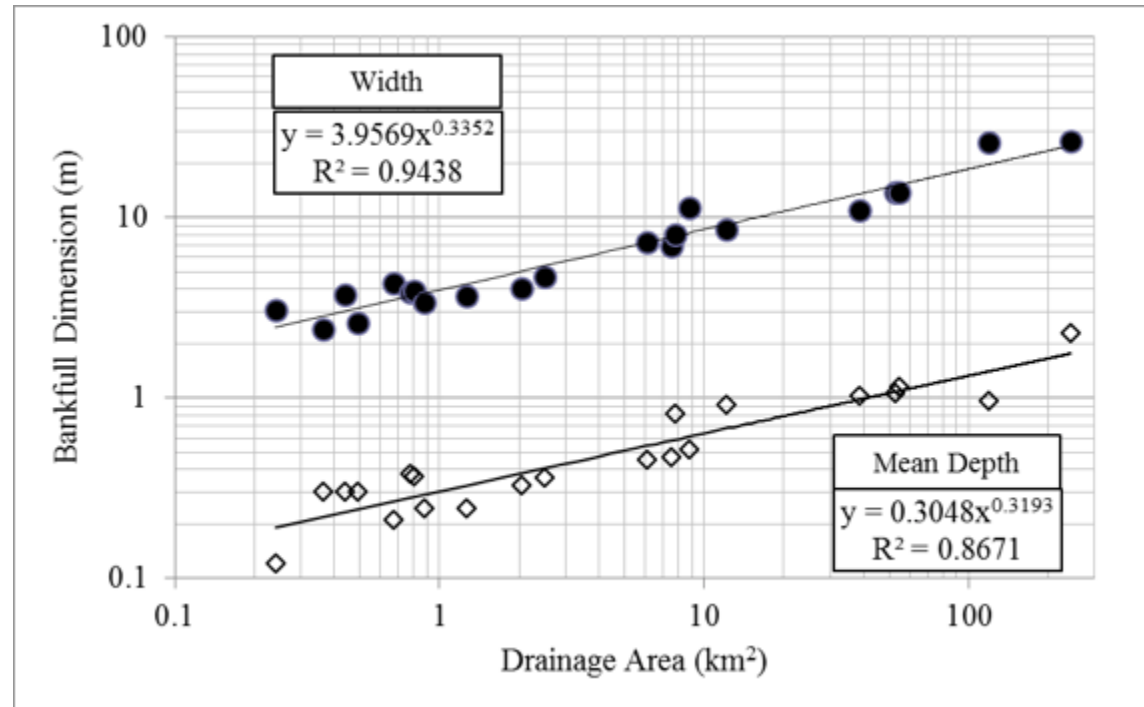
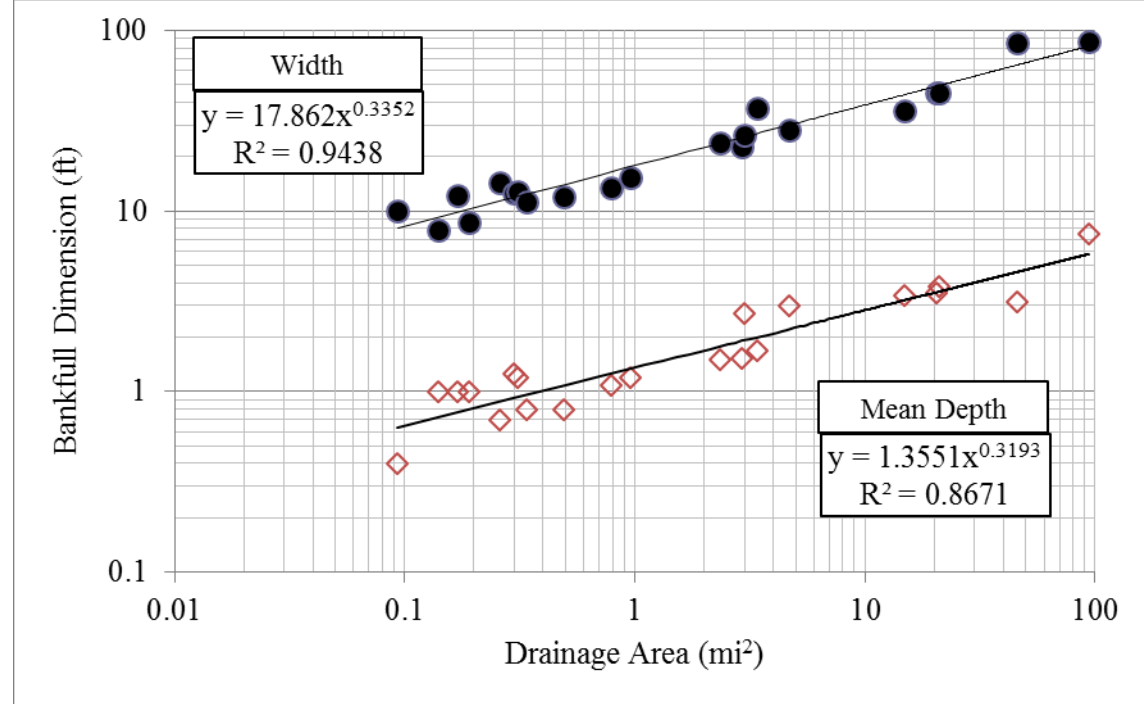
Alabama Piedmont Regional Curves (21 reference streams)

Bankfull Cross-sectional Area Related to Watershed Drainage Area



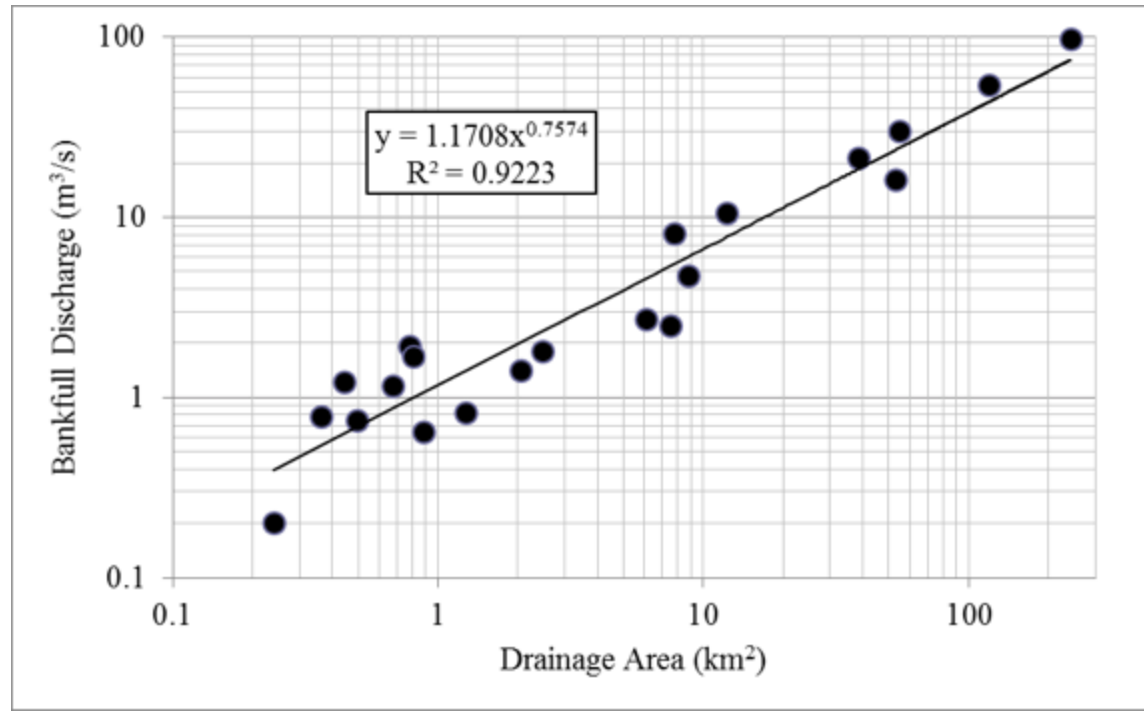
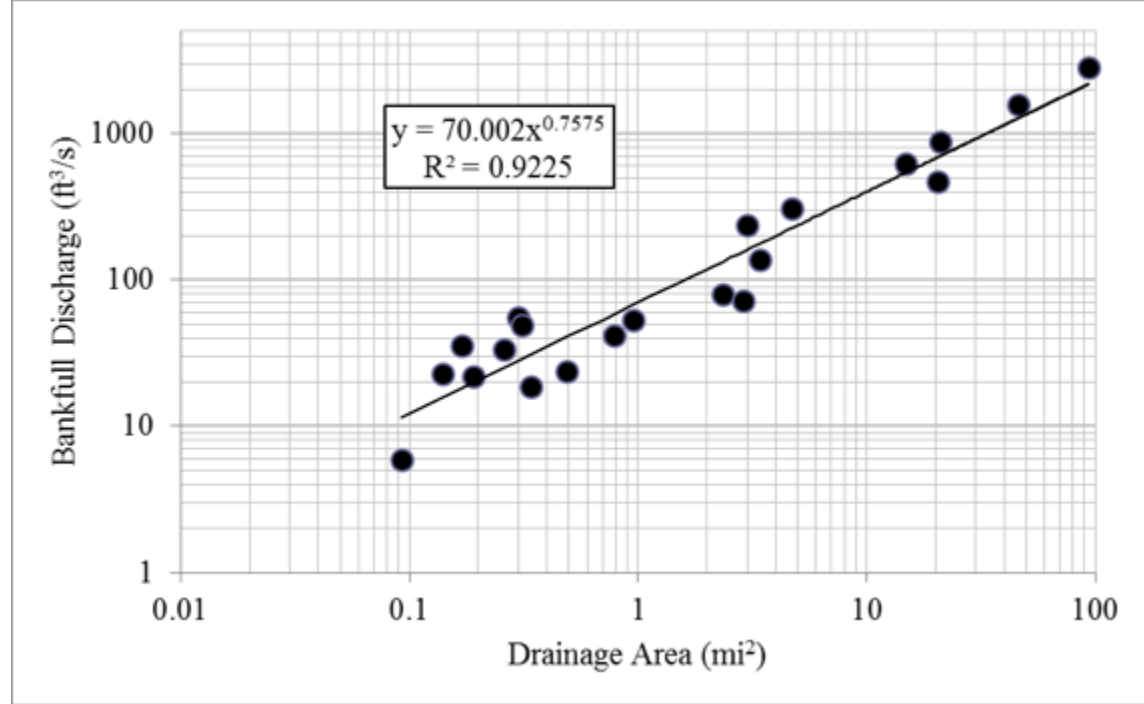
Alabama Piedmont Regional Curves (21 reference streams)

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

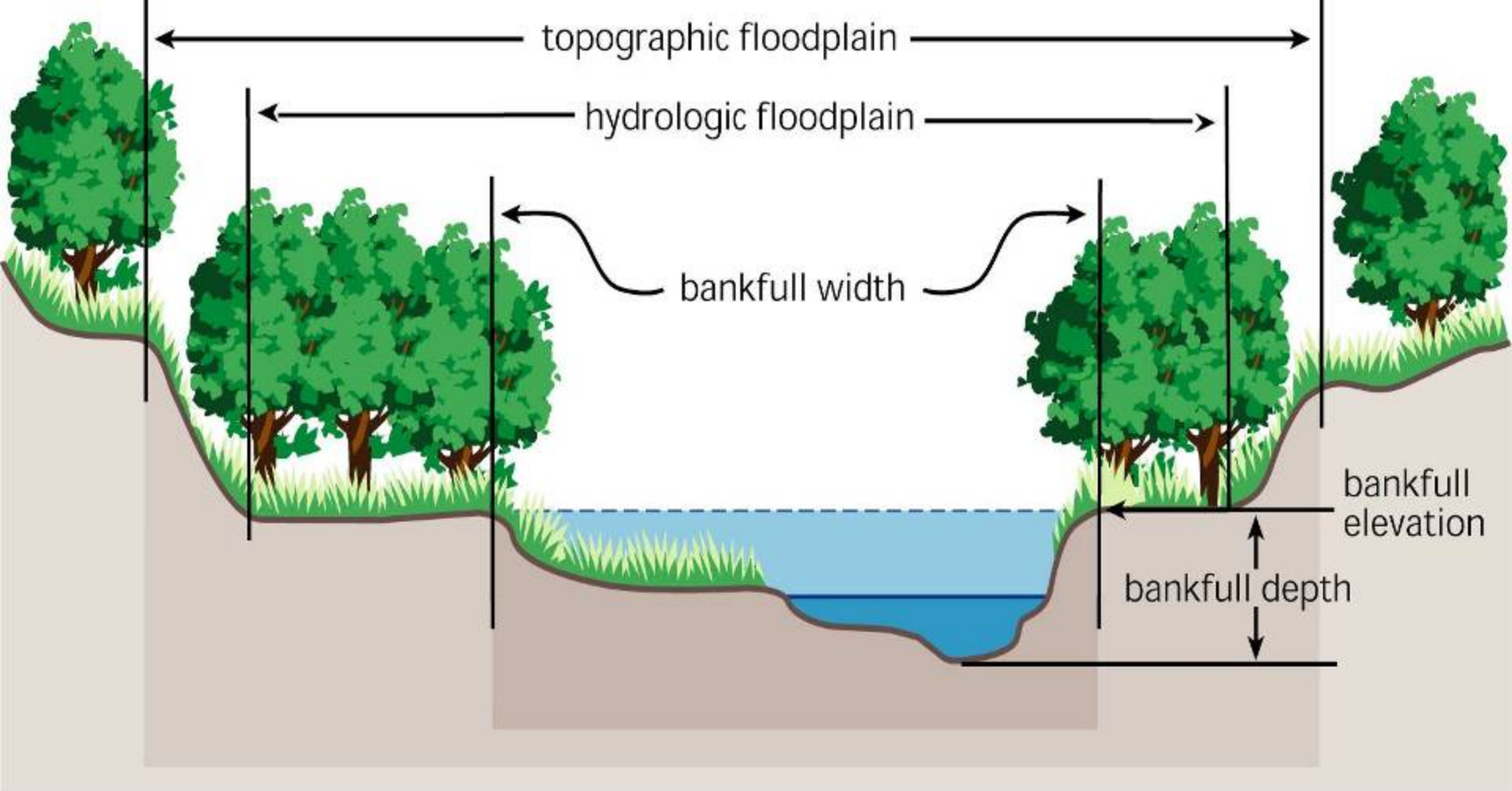


Completed Projects:

- 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

Priority 1:
lift channel

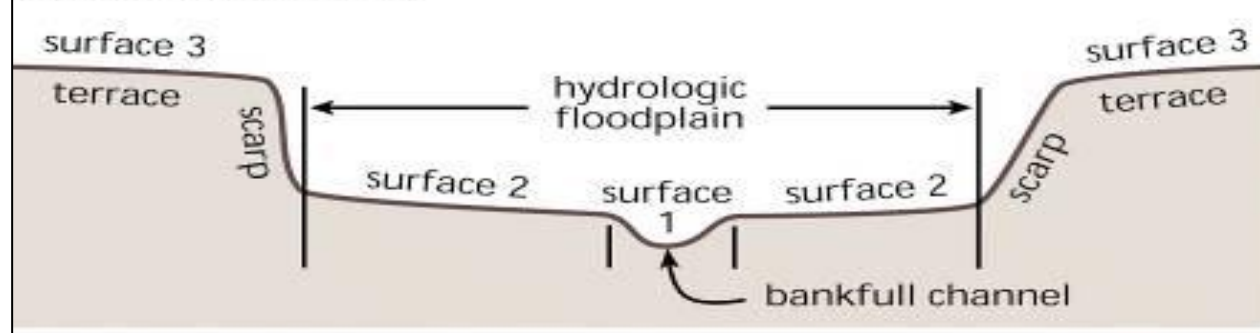


Incised Stream

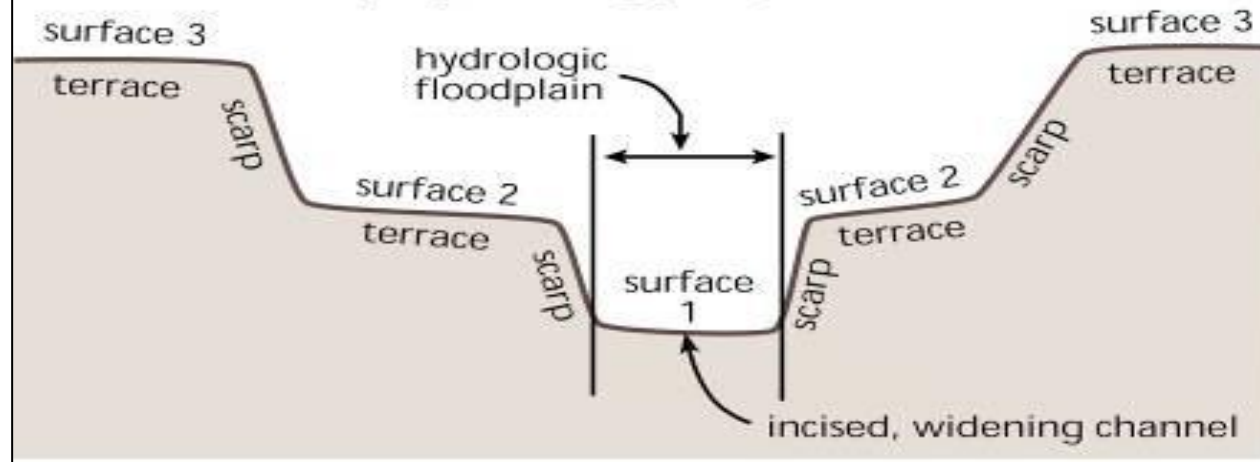


Priority 2 & 3:
lower floodplain

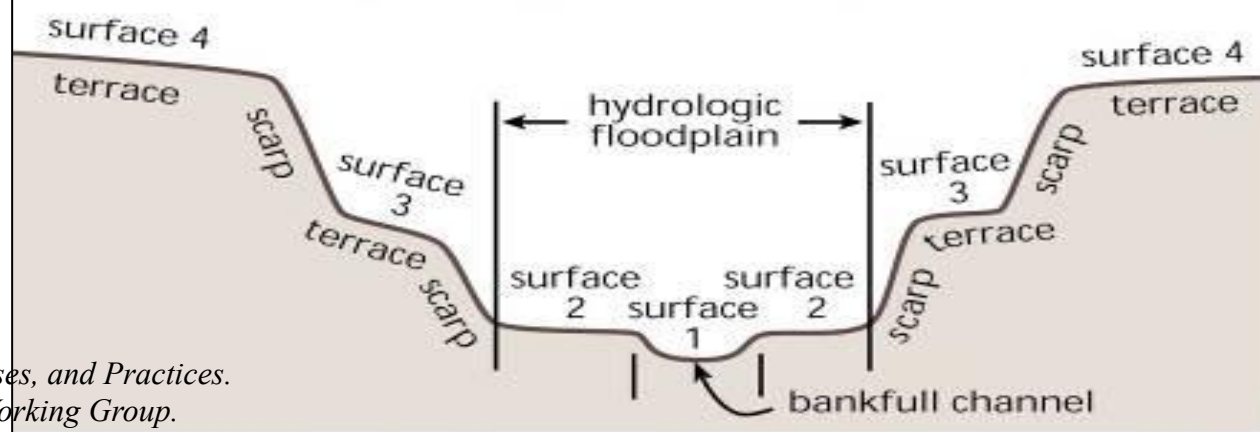
A. Nonincised Stream



B. Incised Stream (early widening phase)



C. Incised Stream (widening phase complete)



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:

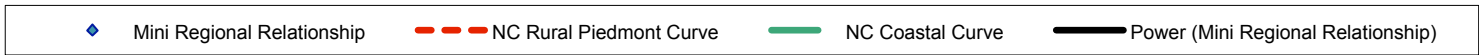
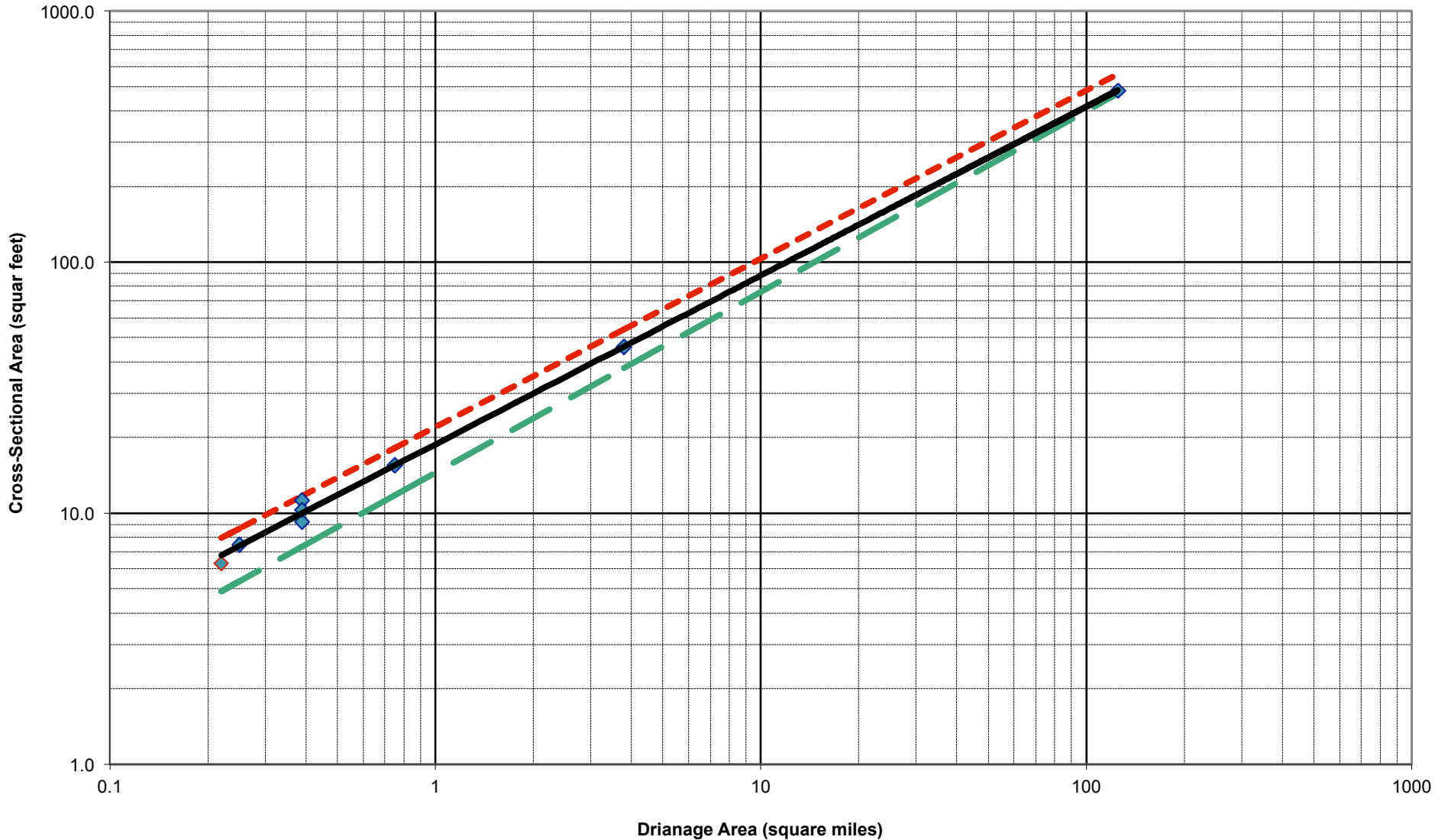
Morphological Table

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			Eva Creek - Tallapoosa 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_{mrf} (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_{mrf} (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, $[W_{mrf}/d_{mrf}]$	4.0	3.9	5.0	12.0	12.0	12.0	11.3	10.5	13.4	5.9	6.8	6.6
Riffle cross-section area, A_{mrf} (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_{maxr} (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, $[d_{maxr}/d_{mrf}]$	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_{mnp} (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, $[d_{mnp}/d_{mrf}]$	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_{mnp} (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, $[W_{mnp}/W_{mrf}]$	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_{mnp} (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, $[A_{mnp}/A_{mrf}]$	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_{maxnp} (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, $[d_{maxnp}/d_{mrf}]$	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, L.B.H. (ft)	2.1	2.7	2.3	1.0	1.1	1.2	1.6	1.6	1.7	2.1	2.1	2.1
Low bank height ratio, $[L.B.H./d_{mrf}]$	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	67.0	103.5	132.5	151	200	220	114	130	148
Entrenchment ratio, ER $[W_{fpa}/W_{mrf}]$	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, $v_{mrf} = Q/A$ (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_{bfr} (cfs)	20	20	20	20	20	20	35	35	35	30	30	35
Maunder 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
Maunder length ratio $[L_m/W_{mrf}]$	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, R_c (ft)	30.0	34.0	55.0	17.0	19.8	23.8	36.0	18.0	26.0	12.0	19.0	23.0
Radius of curvature ratio $[R_c/W_{mrf}]$	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_b (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
Maunder width ratio $[W_b/W_{mrf}]$	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 $[L_p/W_{mrf}]$				2.0	2.5	3.0	1.5	1.8	2.0	1.6	2.9	3.8
Pool-to-pool 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, $[p-p/W_{mrf}]$				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	0.0120	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
Stomosity, $k = SL/VL$ (F/F)	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_{mrf} (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, $[S_{mrf}/S]$	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, $[S_{run}/S]$										3.6	3.5	4.2
Pool slope, S_p (ft/ft)	0.0100	0.0100	0.0100	0.0090	0.0090	0.0090	0.0060	0.0065	0.0016	0.0090	0.0065	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
Slide slope, S_s (ft/ft)										0.0025	0.0012	0.0015
Slide slope ratio, $[S_s/S]$										0.1	0.2	0.3
Riffle length, L_{mrf} (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, $[L_{mrf}/W_{mrf}]$	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 Manning's 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
Manning's bankfull discharge, Q_{bfr} (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 (lbf/ft ²)	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

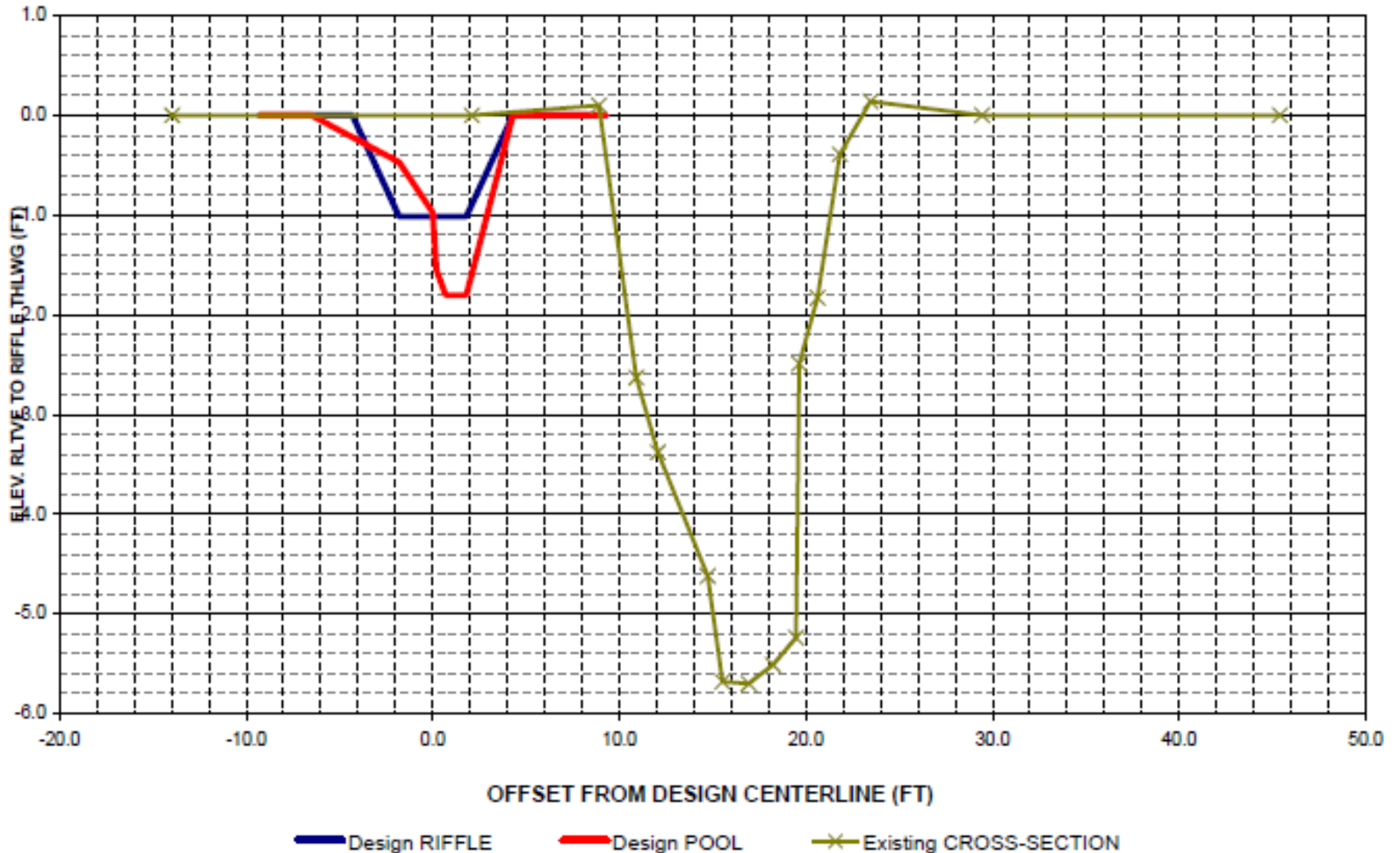
Concept NOT FOR DESIGN USE
Auburn Alabama and Tuskegee NF Mini-Regional Relationship
Prepared by DAB 11-29-07

$y = 18.786x^{0.6724}$
 $R^2 = 0.99815$

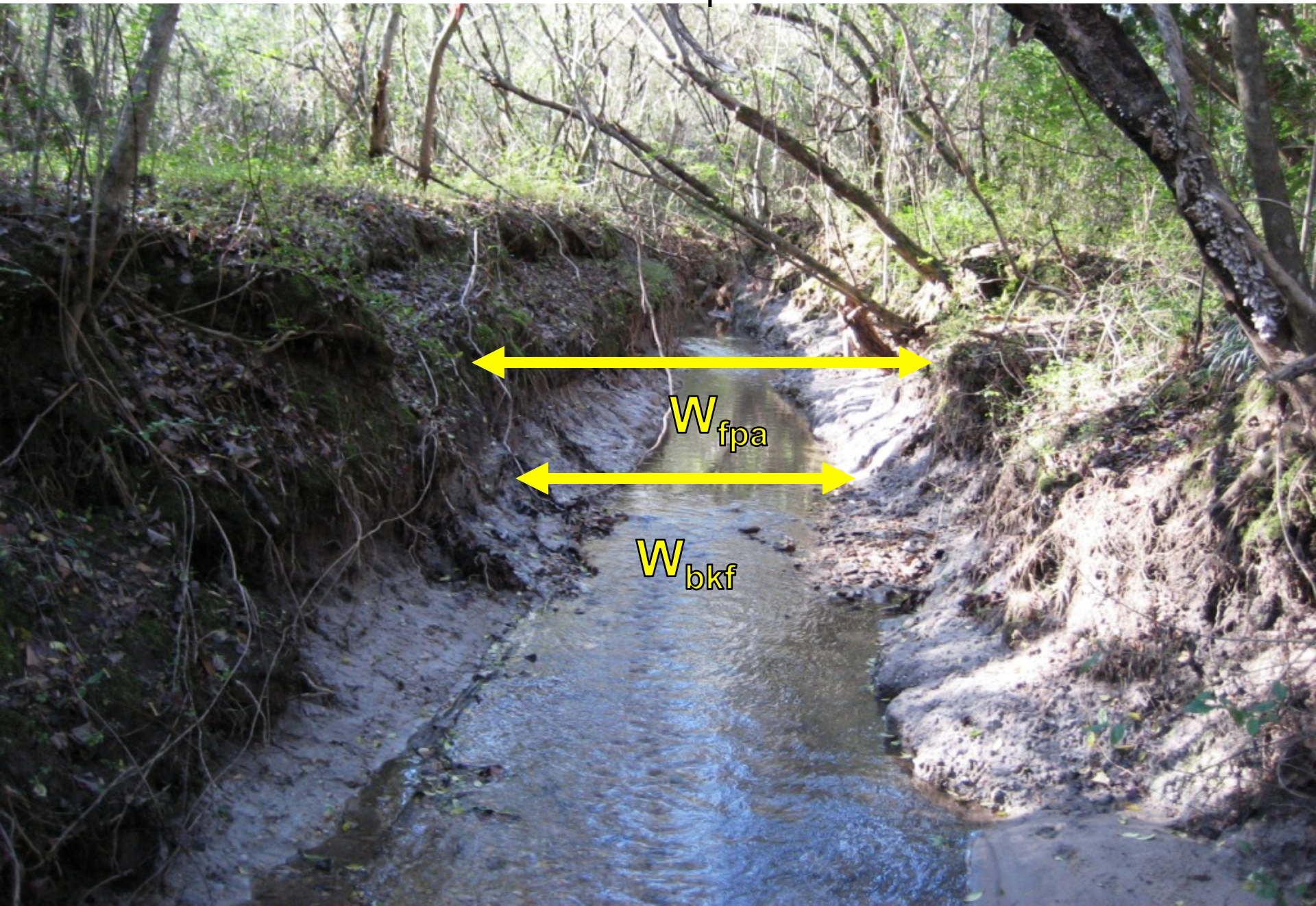


Engineering Design: David Bidelspach, PE, Stantec

Design Cross-Sections UT Town Creek Stream Restoration 11-29-07



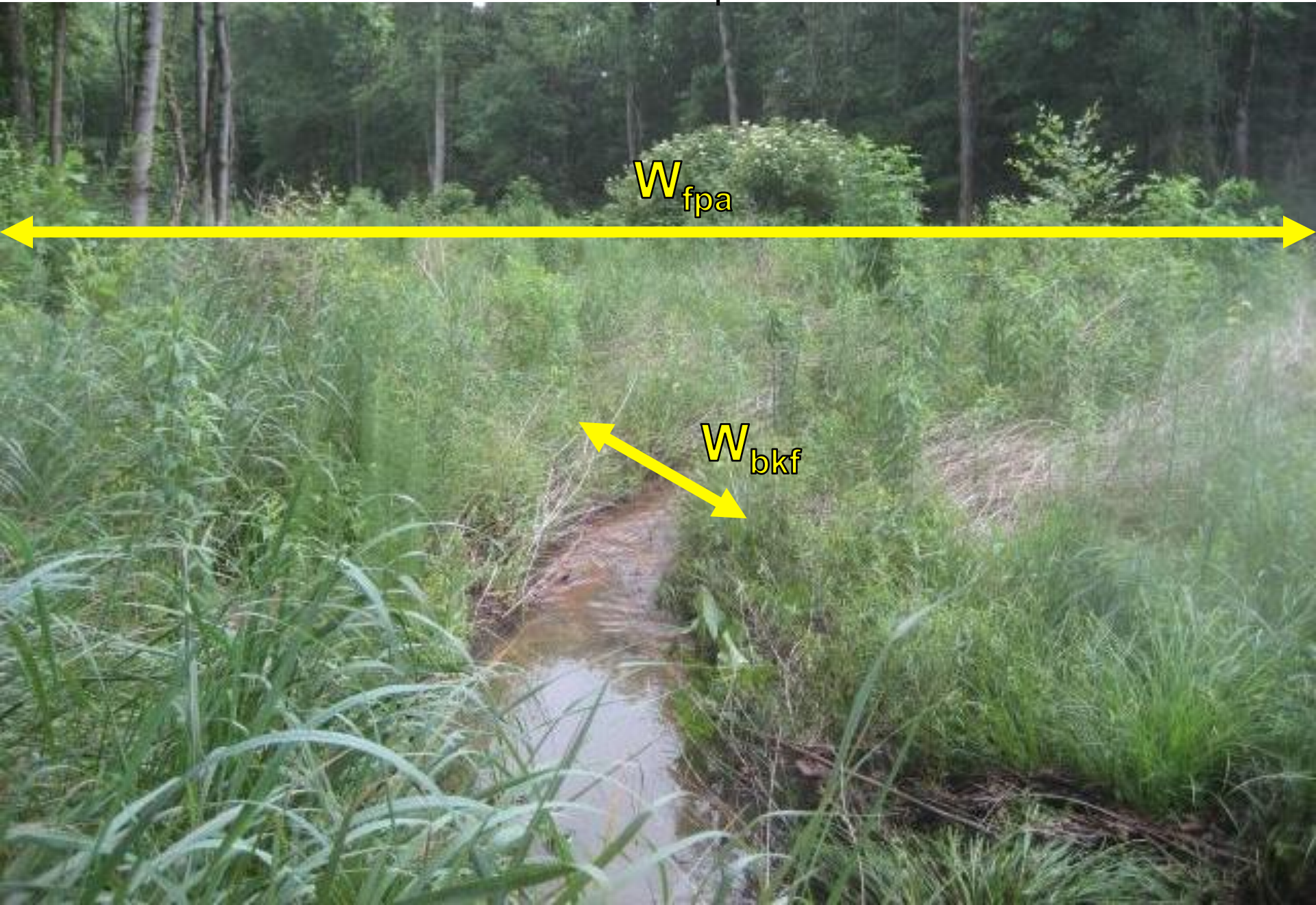
$$\text{Entrenchment Ratio} = W_{\text{fpa}} / W_{\text{bkf}} = 15/12 = 1.2$$



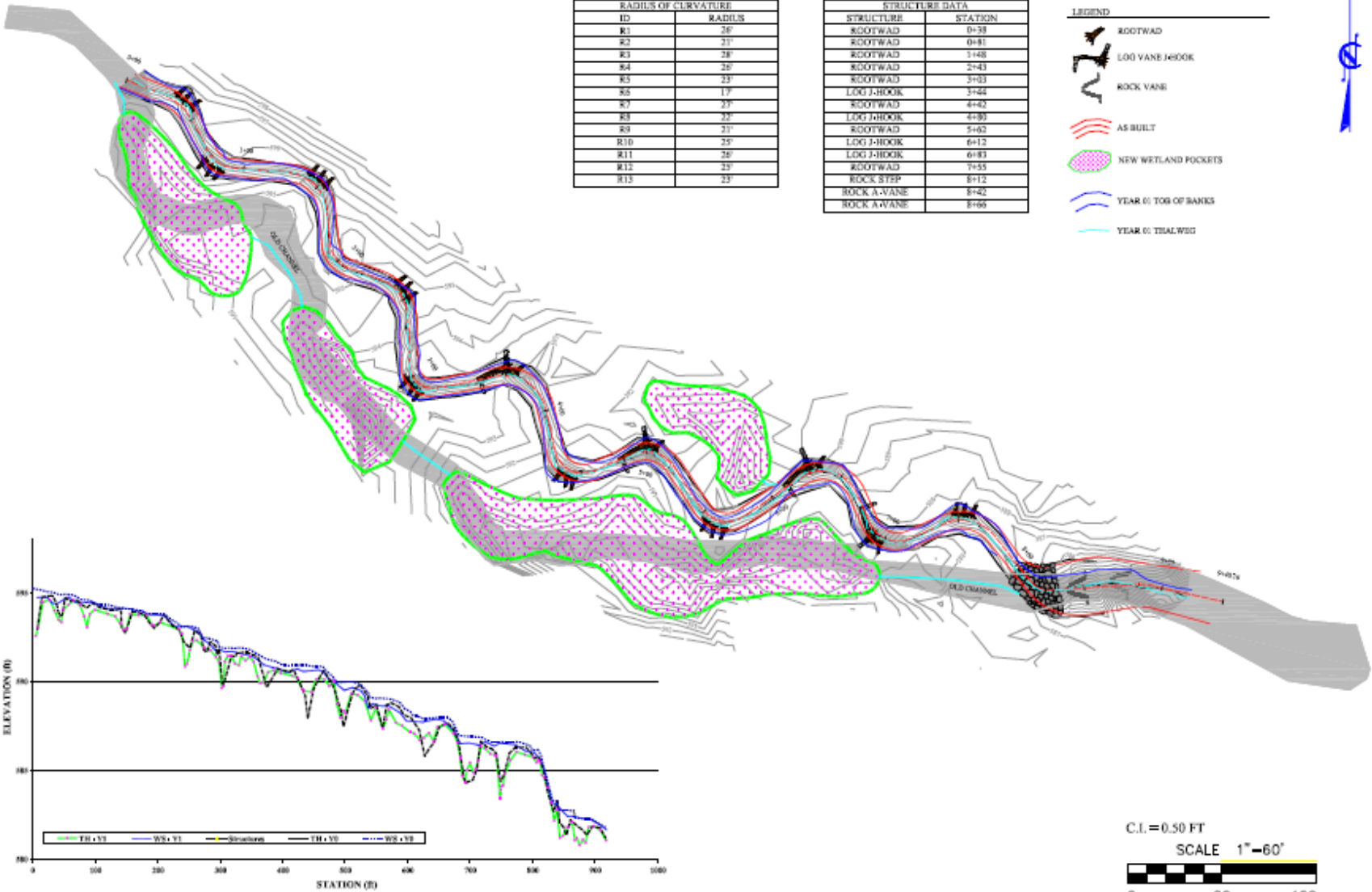
Construction: January, 2008



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



As-Built Survey



DATE	07/26/2017
PROJECT NO.	
PROJECT	UT to Town Creek Stream Restoration/ Stabilization Auburn, AL
DRAWN BY	
CHECKED BY	
DATE	
SCALE	
PROJECT NO.	
PROJECT	UT to Town Creek Stream Restoration/ Stabilization Auburn, AL
DRAWN BY	
CHECKED BY	
DATE	
SCALE	

UT to Town Creek Stream Restoration/ Stabilization Auburn, AL

AUBURN UNIVERSITY

STANTEC CONSULTING INC.

YEAR 01 MONITORING UT Town Creek SITE PLAN Auburn, AL Auburn University

5 years after
construction



5 years after
construction



Channel Evolution: *Vegetation Effects*

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

As-built:

$$A_{\text{bkf}} = 4.5 \text{ sq ft}$$

$$W_{\text{bkf}} / d_{\text{bkf}} = 7.6 / 0.6 = 13$$

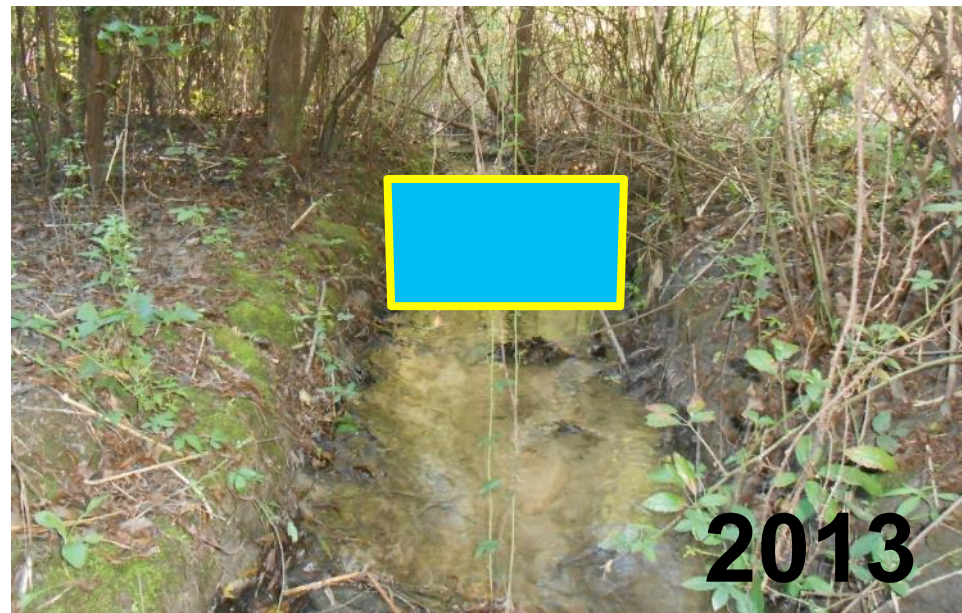
Bank Angles: 3:1

5 Years Later:

$$A_{\text{bkf}} = 3.8 \text{ sq ft}$$

$$W_{\text{bkf}} / d_{\text{bkf}} = 5.4 / 0.7 = 8$$

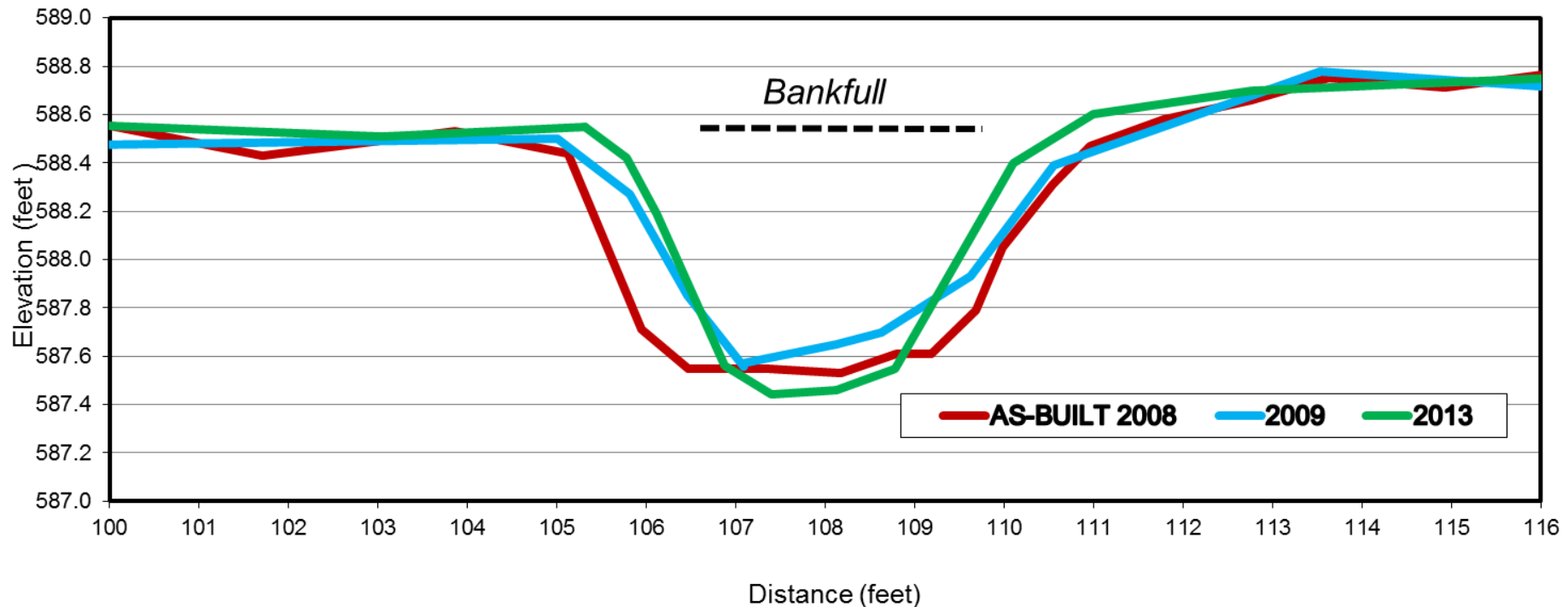
Bank Angles: Near Vertical



Channel Evolution: *Vegetation Effects*

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

UT Town Creek, Auburn, Alabama
Riffle 1 Cross-Section



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



2008

Purlear Creek

2009

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



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



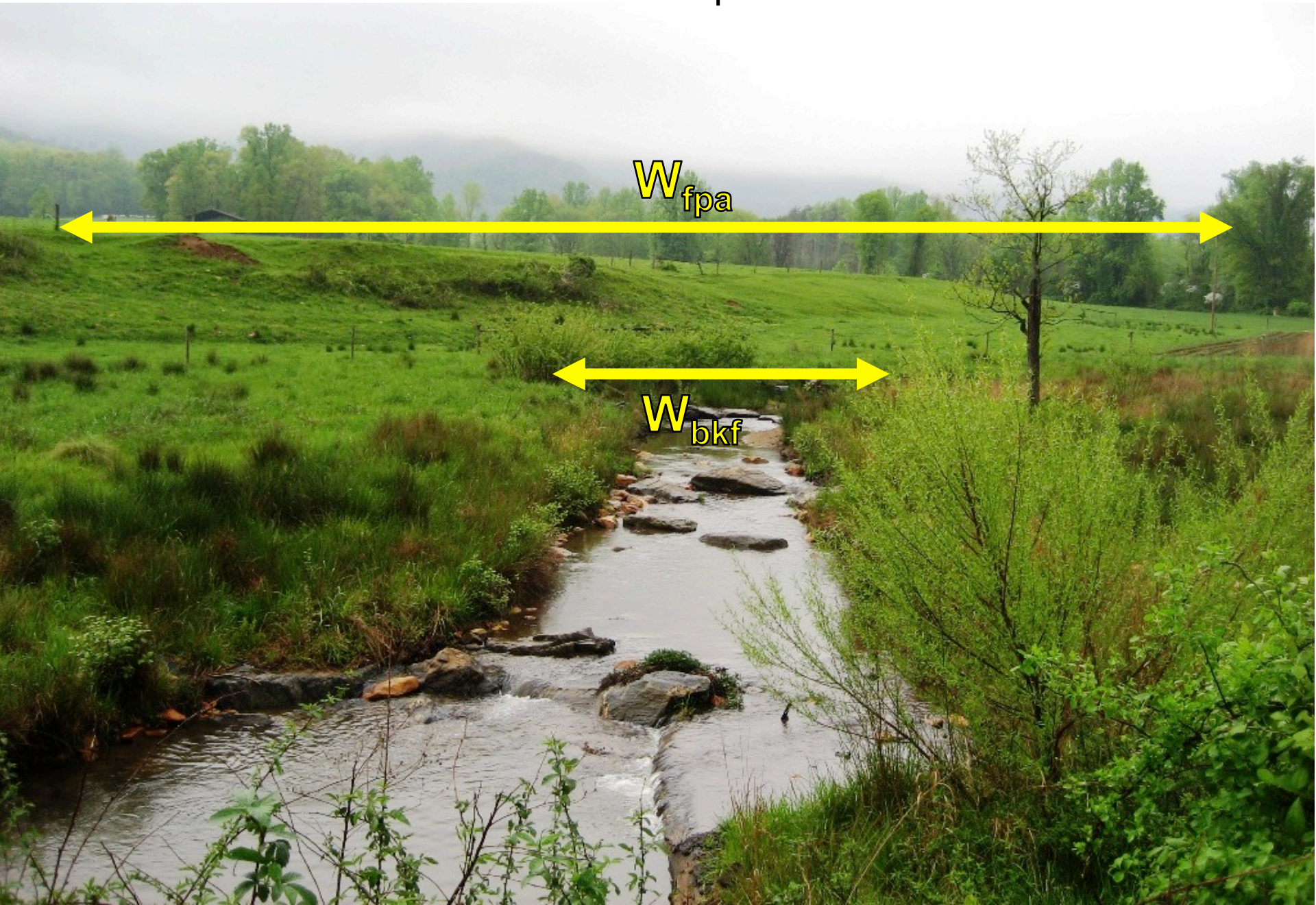
2005

South Fork Mitchell River

2006

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

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



Priority 2: Excavate lower floodplain and construct new meandering channel



2007

Cary Walnut Creek Tributary

2014

Photo Credit: David Bidelspach, Stantec, Inc.

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



Priority 2: Excavate lower floodplain and construct new meandering channel



2004

NCSU Rocky Branch

2005



2006

NCSU Rocky
Branch

2006



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





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

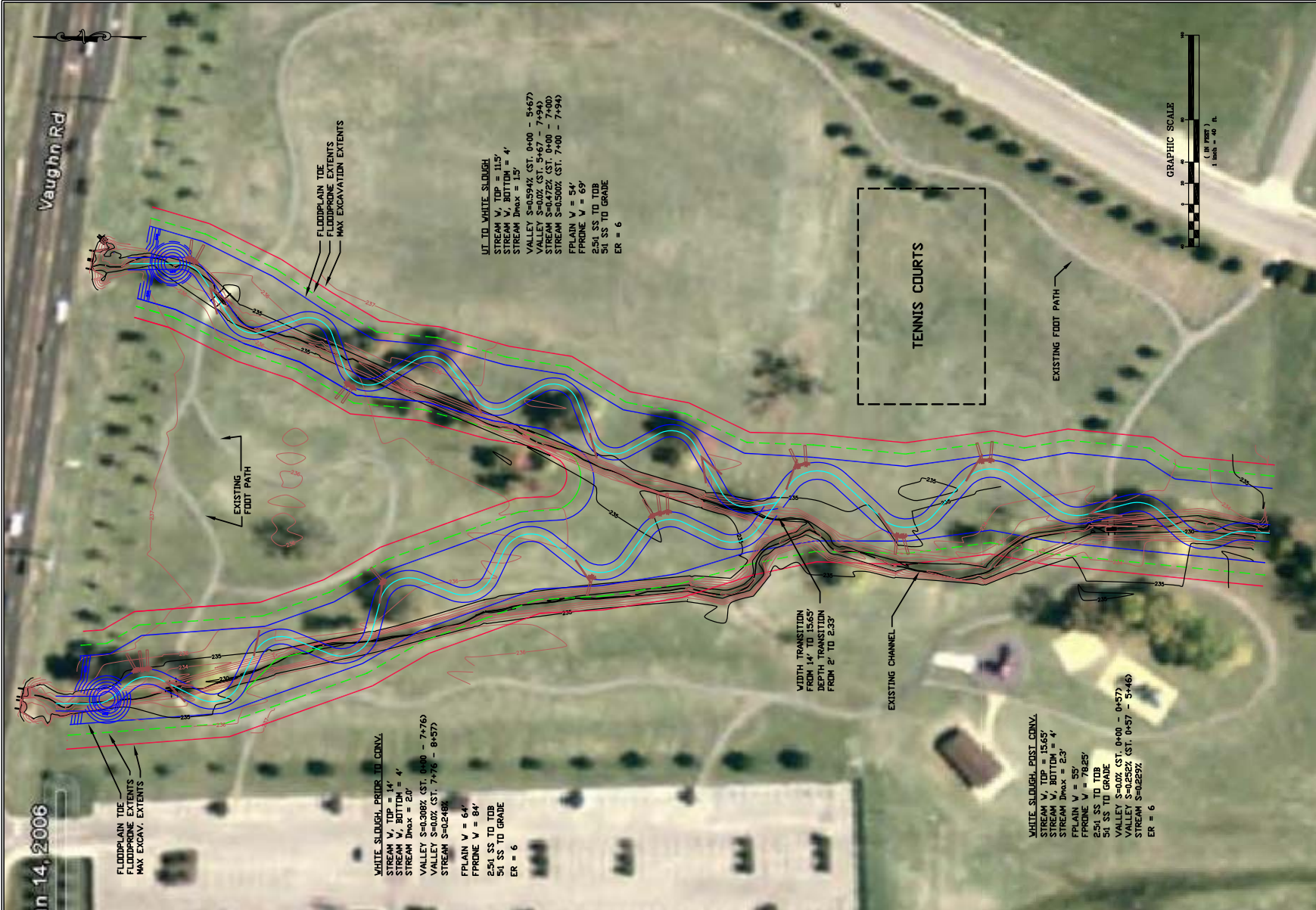
Vegetation: GMC, Auburn Univ

2008



2010

Engineering Design: William McLemore, PE, GMC



Goodwyn Mills & Caswood, Inc.
 MONTGOMERY ARCHITECTURE LANDSCAPE ARCHITECTURE PLANNING

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 Marietta, Georgia 30067
 Phone: (770) 271-3200
 Fax: (770) 272-2464

2700 Peachtree Street, N.E. #100
 Atlanta, Georgia 30329
 Phone: (404) 961-4400
 Fax: (404) 961-4400

41 Wood Dale, S.W. 3rd Street, North
 36th Street, W. 8th Street, Corner
 36th Street, W. 8th Street, Corner
 Phone: (251) 465-4000
 Fax: (251) 465-4000

WHITE SLOUGH RESTORATION PHASE I
 IDA BELLE YOUNG PARK

MONTGOMERY COUNTY, ALABAMA

Horiz Scale: 1" = 40'

Issue	Date
DRAFT 1	07-01-09

Drawn By: WMM

AERIAL PHOTOGRAPH WITH PROPOSED CHANNEL LAYOUT

Sheet 1 of 2

Priority 2: Reconnect Floodplain

Excavate wide floodplain and meander channel at a lower elevation

$$ER = 6$$

$$W/d = 11$$

$$K = 1.4$$

$$S = 0.003$$

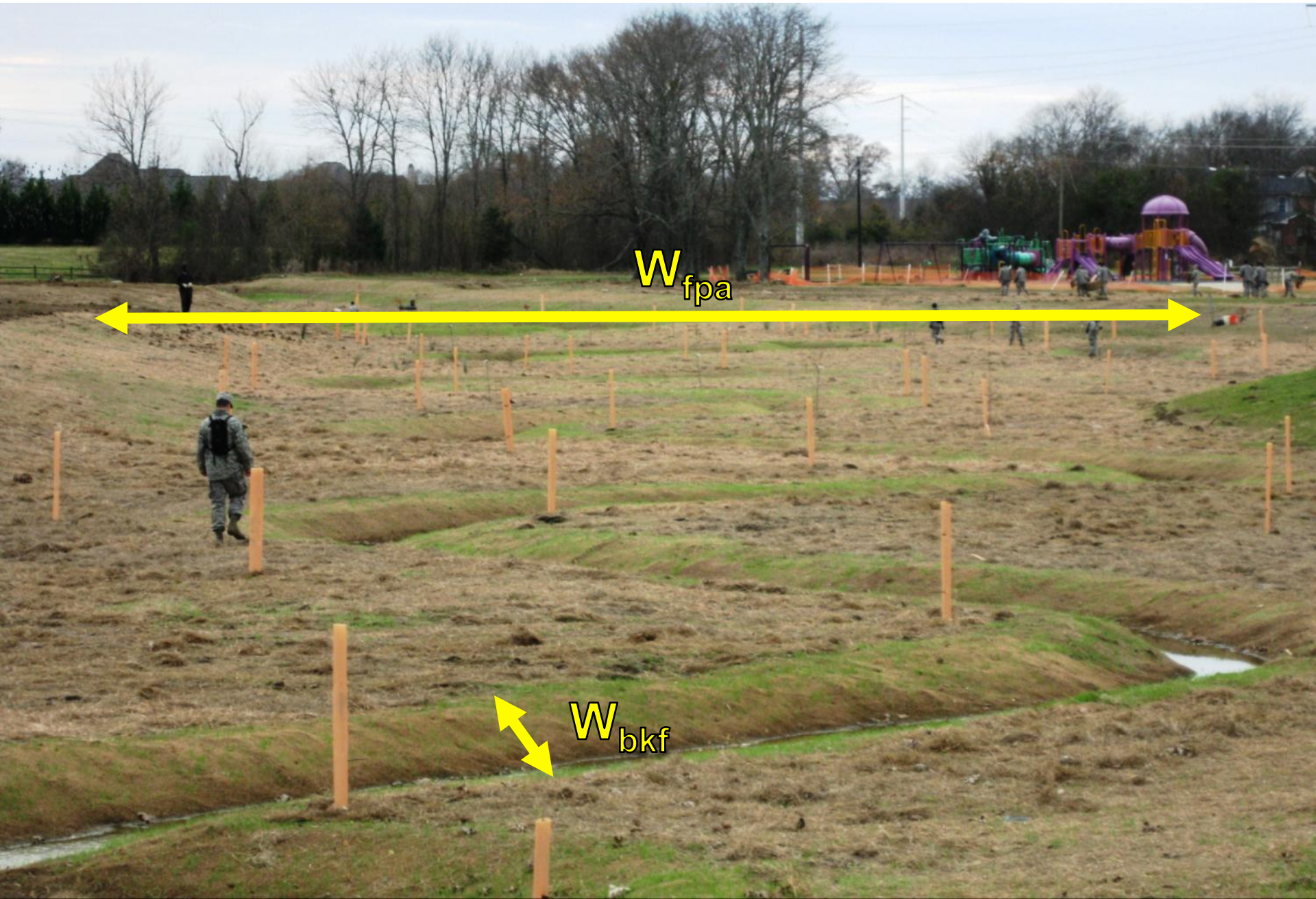


2008

White Slough

2010

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



Priority 2: Reconnect Floodplain



Priority 2: Reconnect Floodplain



Priority 2: Excavate lower floodplain and construct new meandering channel



2008

Trib to Saugatchee Creek

2008

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



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



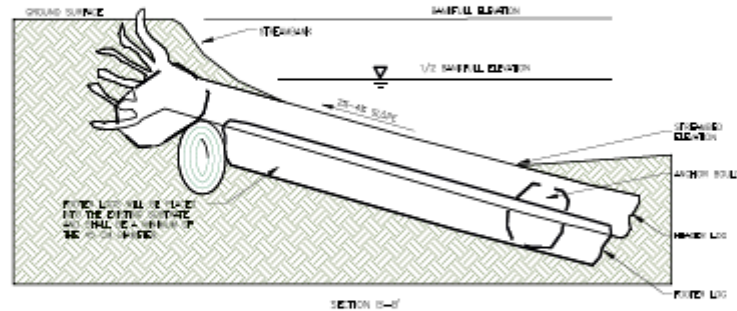
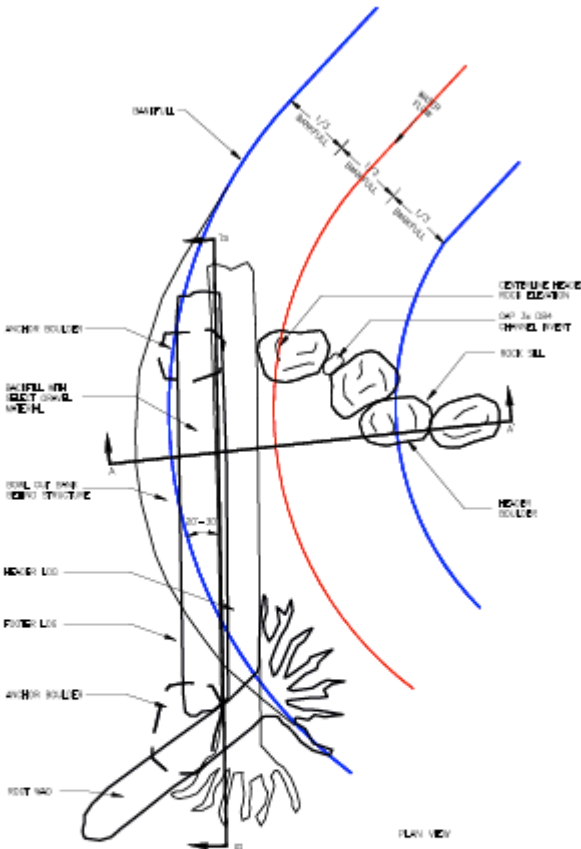
Chinking Boulders to Prevent Piping



Geotextile Curtain to Prevent Piping



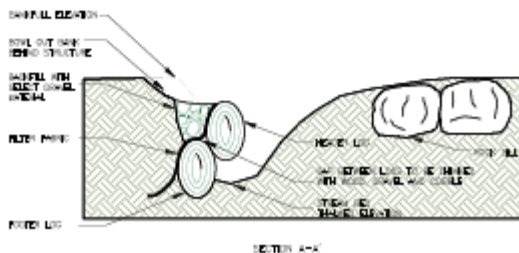
Log J-hook Vanes for flow direction & habitat



ROOT WAD (IN)	LOG (INCHES DIA)	HOOKED LOG (FT)	ANCHOR BOLTS (FT)	SELECT GRAVEL
24"	18"	1.5 TO 2.0	1.5 TO 2.0	NO. 30 STONE AND CLEAR # 57

NOTES:

1. POINT LOG SHALL BE PLACED ON THE UPPER SURFACE OF THE STRUCTURE 1/4" BELOW FROM THE TOP OF THE LOG. THE HOLE SHALL BE 1/4" TO 3/4" DIA. CENTER POINT LOG SHALL BE SQUARE IN THE BOTTOM OF THE CHANNEL AND SHALL BE FLAT ON THE EXISTING BOTTOM OF THE STRUCTURE.
2. A TRUSS SHALL BE USED IN SUCH A MANNER THAT THE HOOKED LOGS ARE SUPPORTED WITHIN THE 1% SURFACE ELEVATION.
3. A HORIZONTAL EQUATOR WITH A SURFACE THAT CONTAINS A HORIZONTAL TRUSS SHALL BE USED TO FLAKE LOGS AND LOGS WITH THE SUBMERGED END OF THE EQUATOR.
4. HOOKED AND POINT LOGS SHALL BE A MINIMUM OF 45 CM IN DIAMETER WITH A LENGTH OF 3 M. THE HOOKED LOG SHALL BE SET IN PLACE FIRST WITH THE POINT LOG UNDERNEATH AND HOOKED LOGS SHALL BE SET TO OVERFLOW THE TRUSS.
5. 1/3 OF THE WAY ACROSS THE CHANNEL FROM THE EXISTING CHANNEL CENTERLINE SHALL BE LINED AT A 20% ABOVE THE CHANNEL CENTERLINE.
6. THERE SHALL BE A 2% SLOPE TOWARD THE HOOKED LOGS IF AT LEAST 3 TIMES THE LENGTH OF THE CHANNEL. THE SLOPE SHALL BE 10:1 TO 5:1.
7. HOOKED LOGS SHALL BE PLACED FROM THE 1% ELEVATION AT THE HEAD OF THE WAD TO 1/3 SPILLWAY ELEVATION AT A SLOPE OF 20:1. HOOKED AND POINT LOGS SHALL BE TIED TOGETHER INTO THE WAD IN SUCH A MANNER THAT IT MINIMIZES THE POSSIBILITY OF UP-DRAW (SLUICING) AROUND THEM.
8. ANY SOIL DISTURBED DURING THE INSTALLATION OF J-HOOK VANES SHALL BE COVERED USING TEMPORARY AND PERMANENT EROSION MEASURES.
9. POINT LOGS SHALL BE PLACED ON THE UPPER SURFACE OF THE WAD STRUCTURE TO PREVENT SPILLAGE OF POINT LOGS FROM CHANNELS. POINT LOGS SHALL EXTEND FROM THE BOTTOM OF THE POINT LOGS TO THE EXISTING CHANNEL CENTERLINE AND SHALL BE PLACED THE ENTIRE LENGTH OF THE STRUCTURE.
10. THE END BENEATH THE HOOKED AND POINT LOG SHALL BE CENTERED BY HAND WITH CHANNEL CENTERLINE AND SHOULD BE 20 CM FROM THE UPPER SURFACE.
11. THE HORIZONTAL ANGLE OF THE HOOKED LOG OF THE WAD AND THE OVER SHALL BE 20-70 DEGREE.
12. SELECT GRAVEL INFILL CAN BE IMPORTED FROM SPILL FILL OR WAD BUT SHALL BE AT LEAST 1" DIA. WITH A 20% TO 30% OF 3/4" DIA. AND A MAXIMUM OF 45 CM.
13. THE ROOT WAD SHALL BE A MINIMUM OF 2 M IN LENGTH WITH A ROOT PAN WITH A DIAMETER OF AT LEAST 1 M AND A LENGTH OF 45 CM.
14. STRUCTURE ELEVATION SHALL BE THE SAME ELEVATION AS THE RIVER CHANNEL CENTERLINE OF THE STRUCTURE IN THE PLAN VIEW.



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Legend:

Notes:

Item	Description	Quantity	Unit	Material
1	Point Log	1	Log	18" Dia x 20' Long
2	Hooked Log	2	Log	18" Dia x 20' Long
3	Anchor Bolt	2	1/2" Dia x 24" Long	
4	Root Wad	1	Wad	2' Dia x 4' Long
5	Spillway Infill	1	Cu Yd	30" Dia x 20' Long
6	Gravel	1	Cu Yd	30" Dia x 20' Long

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

Project No.	Scale	
17062007		
Drawing No.	Sheet	Revision



Multiple Log Vanes

Saugahatchee Creek

2007



2008



Multiple Log
Vanes

Saugahatchee
Creek

2009 January



2009 July

07.14.2009

Photo Credit: Dan Ballard, Town of Auburn

Multiple Log Vanes: Saugahatchee Creek



2012 April

Photo Credit: Dan Ballard, Town of Auburn

Log Vanes (with Toe Wood downstream)

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



***March
2013***

Log Vanes (with Toe Wood downstream)

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



July
2013

Log Vane (with J-Hook)



October
2013

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



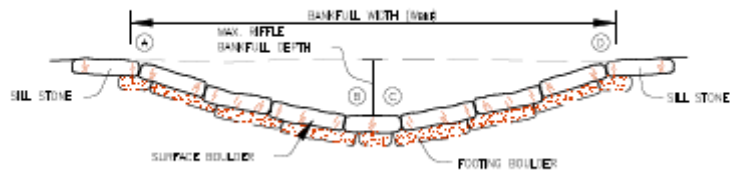
2012/07/08

Boulder Cross Vane

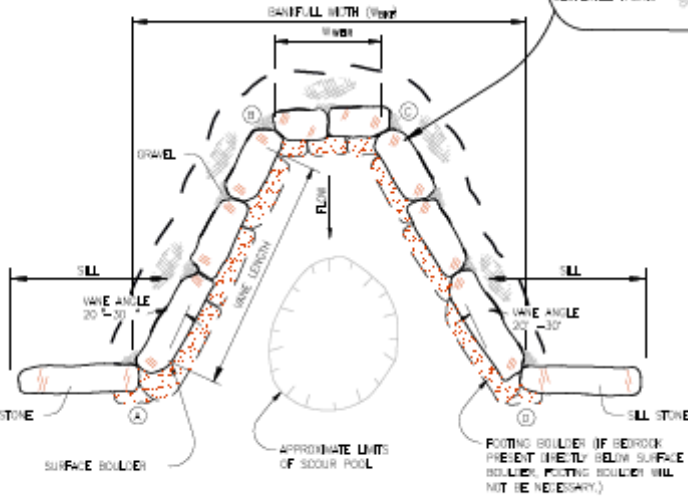
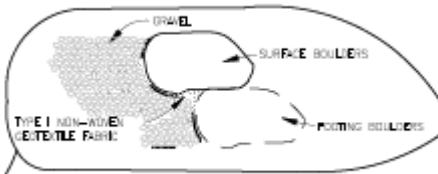
- Direct flow in new channel alignment
- Grade control and scour pool
- Footer boulders & geotextile



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 BOLLIER ARE BOLLIER PLACED TO PROVIDE A FOUNDATION FOR THE SURFACE BOLLIER IN EACH STEP CROSS VANE. FOOTING BOLLIER SHALL BE DURABLE LIME-STONE OR DOLOMITE WITH A MINIMUM DIAMETER OF 4 FT. TYPICALLY, FOOTING BOLLIER ARE BURIED IN THE CHANNEL BOTTOM AND NOT SEEN WHEN THE STRUCTURE IS COMPLETED. ALL SURFACE BOLLIER FOR ALL ROCK STRUCTURES REQUIRE FOOTING BOLLIER. IF BEDROCK IS PRESENT SHORTLY BELOW THE SURFACE BOLLIER, THE FOOTING BOLLIER MAY BE OMITTED AT THE DISCRETION OF PM/SA.
2. SURFACE BOLLIER ARE THE TOP MOST COURSE OF BOLLIER USED IN EACH STEP CROSS VANE. ALL SURFACE BOLLIER CAN BE SEEN PROTRUDING FROM THE WATER SURFACE DURING EXTREMELY LOW FLOWS. SURFACE BOLLIER SHALL BE DURABLE LIME-STONE OR DOLOMITE WITH A MINIMUM DIAMETER OF 4 FT.
3. THE VANE LENGTH IS THE STRAIGHT LINE PORTION OF CROSS VANE STRUCTURE, 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 SHARPEN THE BANK TO THE GRADES SPECIFIED. NEXT EXCAVATE ENOUGH BED MATERIAL TO PLACE THE BOLLIER, GEOTEXTILE FABRIC AND GRAVEL OVERLAY. ONCE THE HEIGHT HAS BEEN ESTABLISHED, THE REMAINDER OF THE FOOTING AND SURFACE BOLLIER SHALL BE PLACED, MINORING VOIDS. PLACE GEOTEXTILE FABRIC AT THE UPSTREAM FACE OF THE STRUCTURE AS SHOWN AND BANKFULL (OVERLAY) WITH GRAVEL. FILL THE VOIDS ON THE UPSTREAM SIDE OF SURFACE BOLLIER WITH GRAVEL. DO NOT LEAVE EXPOSED GEOTEXTILE FABRIC AND THEN EXPOSED GEOTEXTILE FABRIC. ONCE STRUCTURE IS INSTALLED, EXCAVATE SCOUR POOL AND PLACE GRAVEL SUBSTRATE AS REQUIRED. RE-WEDGING OF CHANNEL AND BANKFULL BEHIND FLOODPLAIN WILL LIKELY BE REQUIRED FOLLOWING INSTALLATION OF IN-STREAM STRUCTURE AND SHALL BE CONSIDERED INCIDENTAL TO CONSTRUCTION.
6. THE SURFACE OF CROSS-VANES 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 LEANING 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 JOINTS SHALL BE FILLED 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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Legend

Note

Code	Description	Quantity	Unit	Value
1	Excavation	1000	cu yd	1000.00
2	Gravel	500	cu yd	500.00
3	Concrete	100	cu yd	100.00
4	Reinforcing Steel	1000	lb	1000.00
5	Formwork	1000	sq ft	1000.00
6	Geotextile Fabric	1000	sq ft	1000.00
7	Surface Boulders	1000	cu yd	1000.00
8	Footing Boulders	1000	cu yd	1000.00
9	Sill Stone	1000	cu yd	1000.00
10	Other	1000	cu yd	1000.00
Total				10000.00

Client/Project

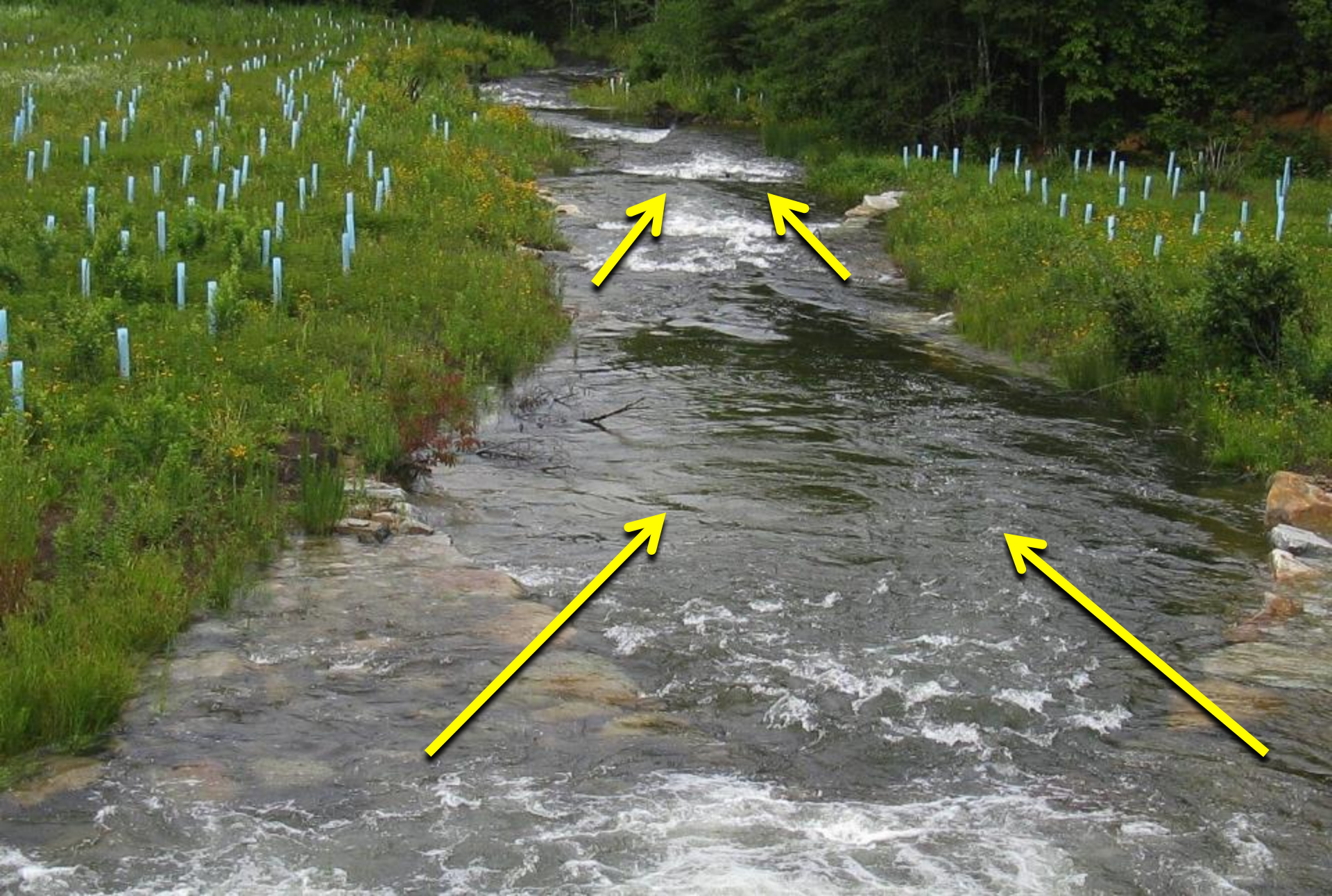
State of Oklahoma
Department of Central Services
Illinois Watershed
Stream Restoration
Tulare, OK

Title

Detail - Toe Wood Sod Mats

Project No.	Scale	
17062007		
Drawing No.	Sheet	Revision
1	7 of 7	A

Boulder Cross Vanes: *Grade Control*



Double-Drop Boulder Cross Vane



Double-Drop Offset Boulder Cross Vane



Double-Drop Offset Boulder Cross Vane



01.05.2009

Photo Credit: CAWACO RC&D

Cross-Vane (Double-Drop): 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*

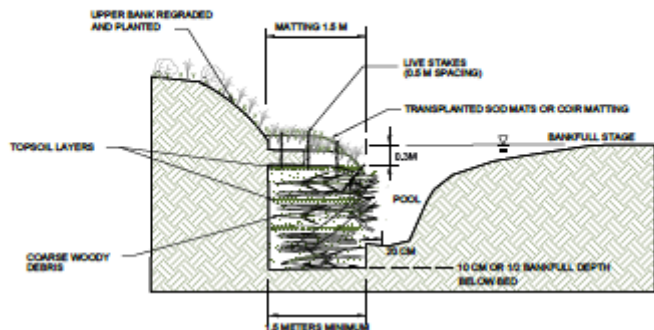


Toe Wood Revetment

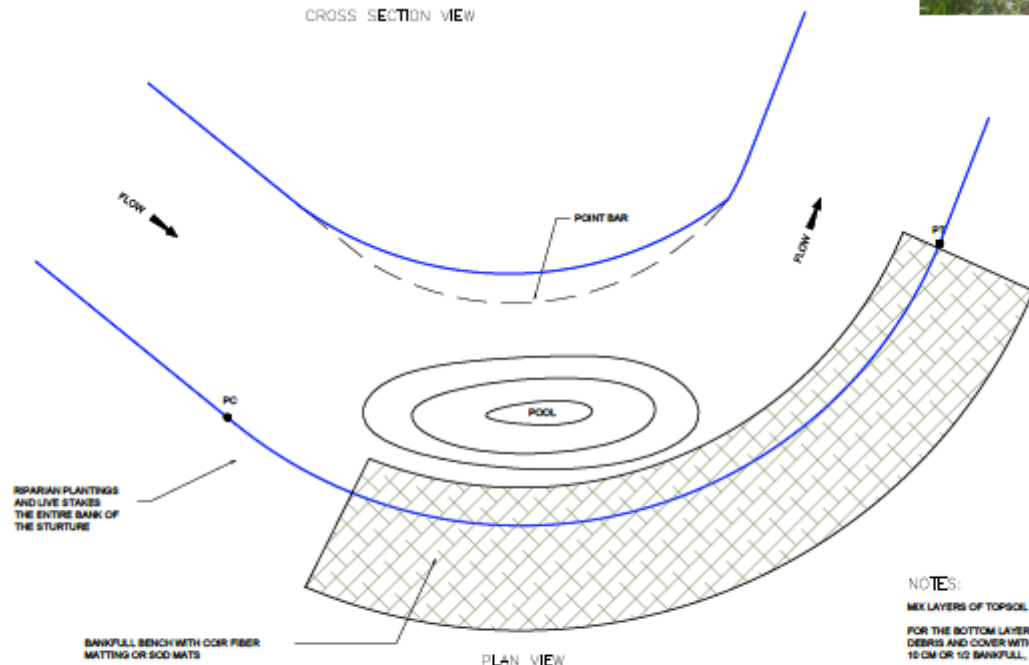
- Layers of logs and brush under water in pools
- Live cuttings above water (silky dogwood, elderberry)
- Matting, seed, transplanted alders on top



Toe Wood for bank protection, roughness, habitat



CROSS SECTION VIEW



PLAN VIEW



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 10 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 30 CM.



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Legend

Notes

Rev	Description	By	Check	Date
1	Issue for Construction	APP	APP	11/04/09
2	Revised	APP	APP	11/04/09
3	Issue for Construction	APP	APP	11/04/09
4	Issue for Construction	APP	APP	11/04/09
5	Issue for Construction	APP	APP	11/04/09
6	Issue for Construction	APP	APP	11/04/09
7	Issue for Construction	APP	APP	11/04/09
8	Issue for Construction	APP	APP	11/04/09
9	Issue for Construction	APP	APP	11/04/09
10	Issue for Construction	APP	APP	11/04/09

Client/Project

State of Oklahoma
Department of Central Services
Illinois Watershed
Stream Restoration
Tulsa, OK

Title

Detail - Toe Wood Sod Mats

Project No.	Scale	
175952007		
Drawing No.	Sheet	Revision
1	6	7

1

6 of 7

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



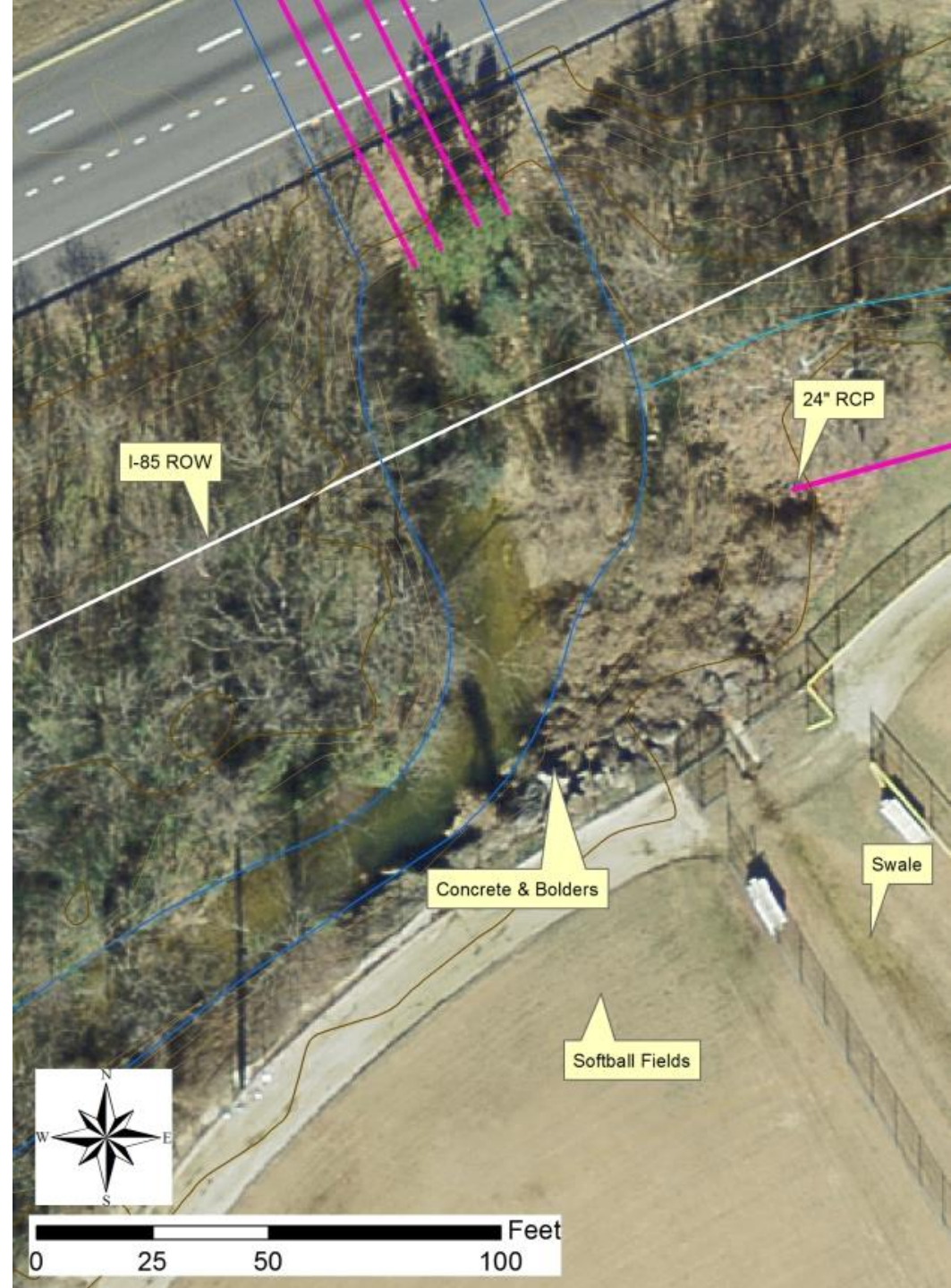


Case Study:

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>

