

## BANKFULL REGIONAL CURVES FOR THE PIEDMONT REGION OF ALABAMA

Stream morphology data were collected at 21 Alabama Piedmont reference streams with drainage areas ranging from 0.2 to 242.1 km<sup>2</sup> (Table 1). Reference stream sites were selected based on the following criteria:

1. Channels were well-connected to alluvial floodplains with little evidence of incision (bank height ratios less than 1.2);
2. Channels had freely-formed meander patterns with alternating riffle and pool bedforms;
3. Streambanks and floodplains were well-vegetated with little evidence of erosion;
4. Upstream watersheds were rural with mostly forest and agricultural land uses;
5. Reference reaches were stable and unconfined for a longitudinal length of at least 20 times bankfull width.

Reference streams were surveyed using total station survey equipment to measure longitudinal profiles and riffle cross-sections. Streams were classified using the Rosgen stream classification system (Rosgen, 1996). The study included 10 C, 8 E, and 3 Bc Rosgen type streams based on the measured entrenchment ratios, width/depth ratios, and slopes listed in Table 1. The entrenchment ratios, calculated as the width of the floodprone area divided by the bankfull channel width, ranged from just over 1 for the narrow-valley Bc streams to greater than 5 for the alluvial E and C streams. Width/depth ratios, calculated as the bankfull riffle channel width divided by the mean riffle bankfull depth, ranged from less than 12 for the E streams to greater than 20 for the wide and shallow Bc and C streams. Reach channel slopes, measured using water surface elevation differences from the first riffle to the last riffle surveyed, ranged from as low as 0.001 m/m for the larger rivers to greater than 0.01 m/m for the smaller streams.

### Bankfull Channel Dimensions

The measured bankfull riffle cross-sectional areas ranged from 0.4 to 60 square meters (Table 1), with the relationship between cross-sectional area ( $A_{\text{bkf}}$ ) and drainage area (DA) shown in Figure 1. Similarly, the bankfull channel riffle widths ( $W_{\text{bkf}}$ ) and mean depths ( $d_{\text{bkf}}$ ) are shown in Figures 2 and 3 related to drainage area. To estimate bankfull discharge for each stream, the Manning equation was applied using estimates for roughness (Manning  $n$ ) based on the Cowan method (Table 2). The resulting bankfull discharge estimates are shown in relation to drainage area in Figure 4. The regression equations for the hydraulic geometry regional curves for the Piedmont of Alabama are summarized as follows:

$$A_{\text{bkf}} = 1.21 \text{ DA}^{0.653} \quad R^2 = 0.959$$

$$W_{\text{bkf}} = 3.96 \text{ DA}^{0.335} \quad R^2 = 0.944$$

$$d_{\text{bkf}} = 0.305 \text{ DA}^{0.319} \quad R^2 = 0.867$$

$$Q_{\text{bkf}} = 1.17 \text{ DA}^{0.757} \quad R^2 = 0.922$$

This set of regional curves for bankfull channel dimensions provides a tool for verifying bankfull stage in field surveys and for estimating dimensions in stream restoration projects in the Piedmont of Alabama.

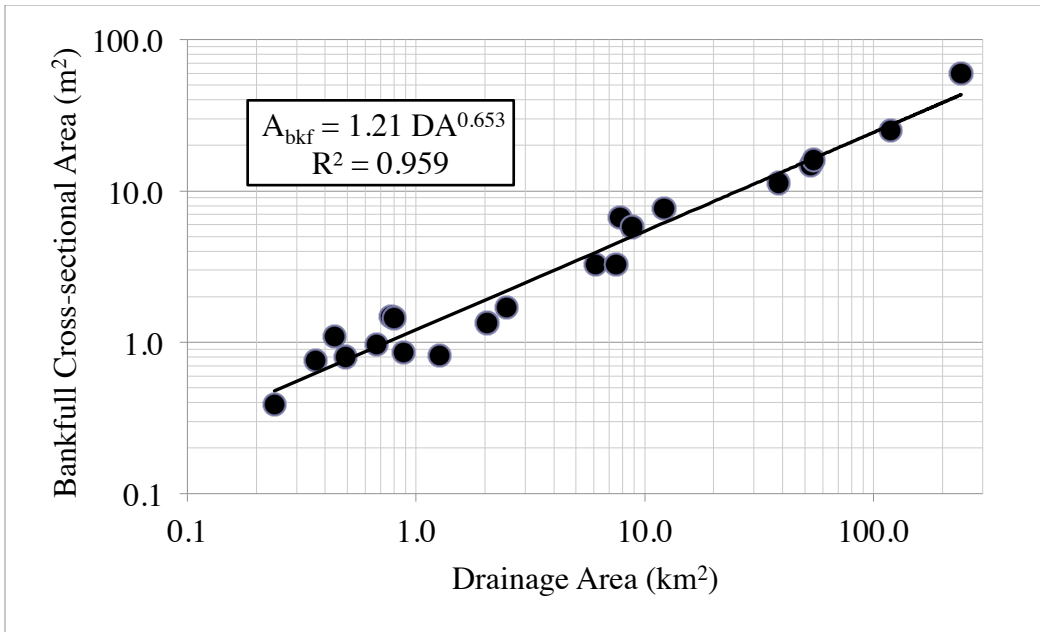


Figure 1. Bankfull Riffle Cross-Sectional Area Related to Drainage Area for 21 Alabama Piedmont Reference Streams.

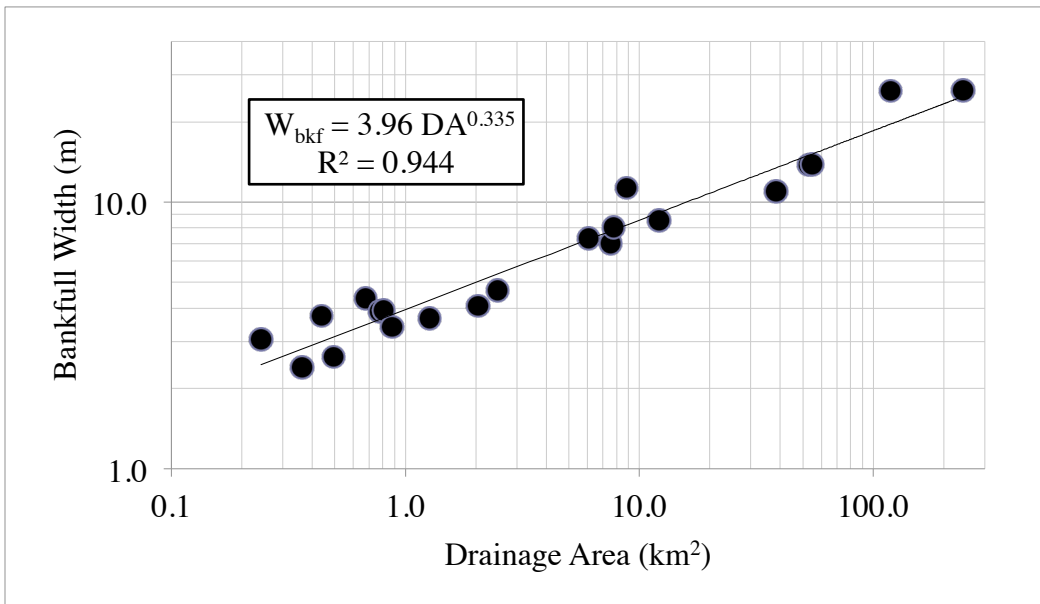


Figure 2. Bankfull Channel Riffle Width Related to Drainage Area for 21 Alabama Piedmont Reference Streams.

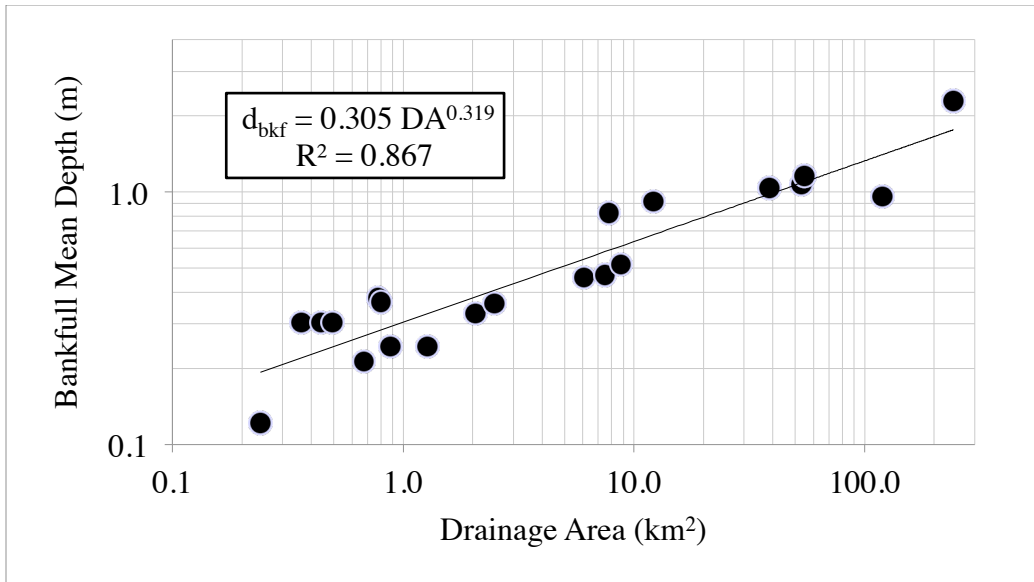


Figure 3. Bankfull Channel Riffle Mean Depth Related to Drainage Area for 21 Alabama Piedmont Reference Streams.

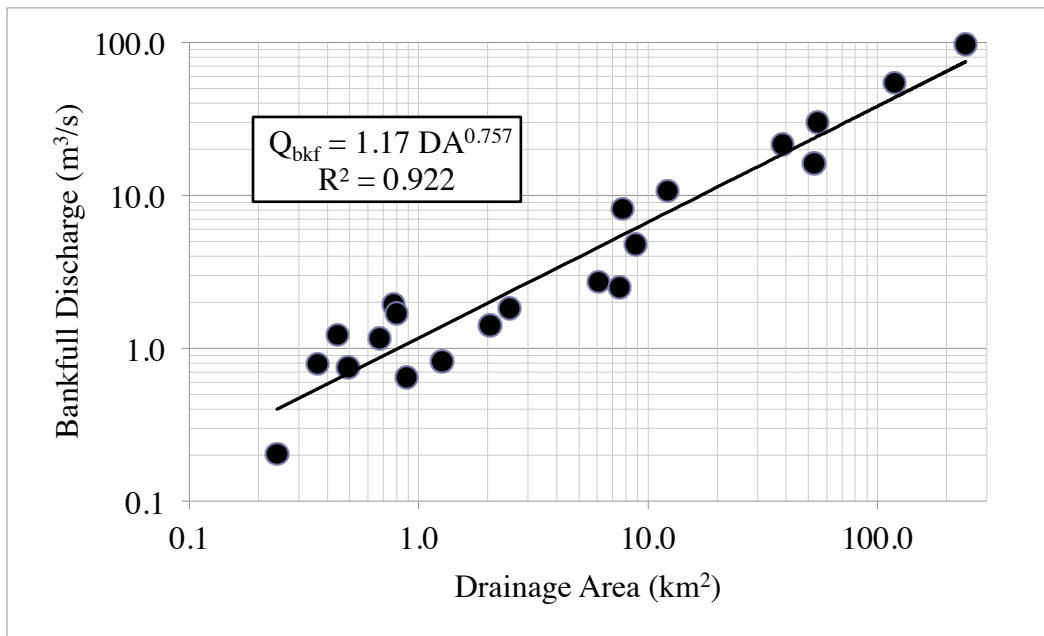


Figure 4. Estimated Bankfull Discharge Related to Drainage Area for 21 Alabama Piedmont Reference Streams.

### Bedform Dimensions

Table 3 lists measured dimensions and slopes for riffle and pool bedform features in the 15 smallest reference streams (up to 12.2 km<sup>2</sup> drainage area). The mean riffle and pool lengths listed in Table 3 represent the means of the measured longitudinal lengths of all the riffles and pools existing in each reference reach. These bedform lengths are shown in relation to drainage area in Figure 5. The regression lines are parallel for the two bedforms, with the pools being about twice as long as the riffles for this set

of reference streams. These same values are shown in relation to bankfull channel width in Figure 6. The power function exponents shown on these figures indicate the degree of non-linearity in these relationships. These graphs represent design tools that may be used to estimate ranges of bedform dimensions in restoration projects.

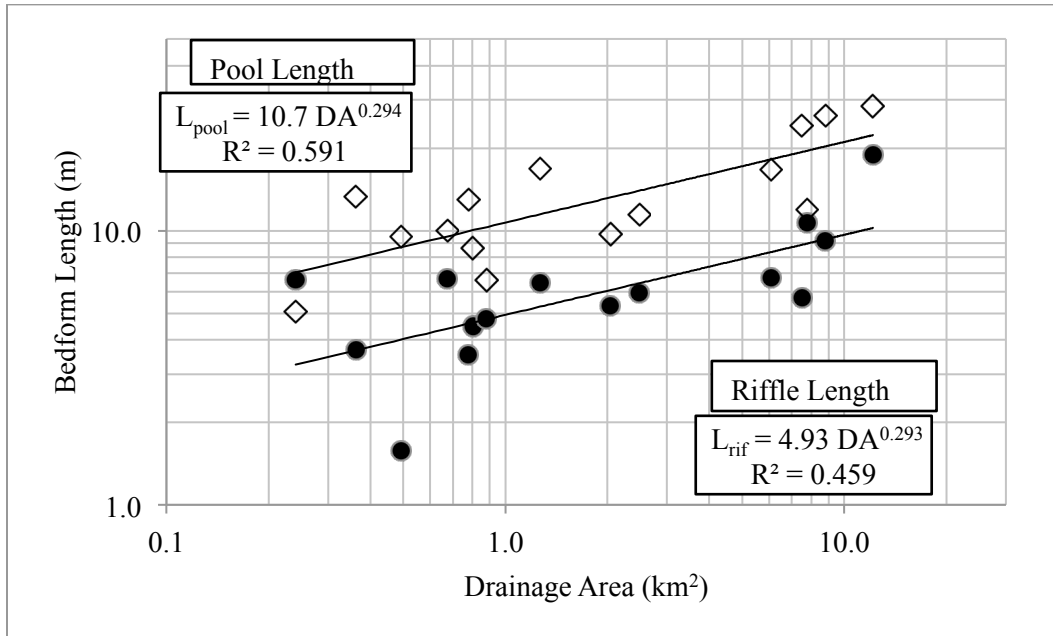


Figure 5. Riffle and Pool Length Related to Drainage Area for 15 Alabama Piedmont Reference Streams.

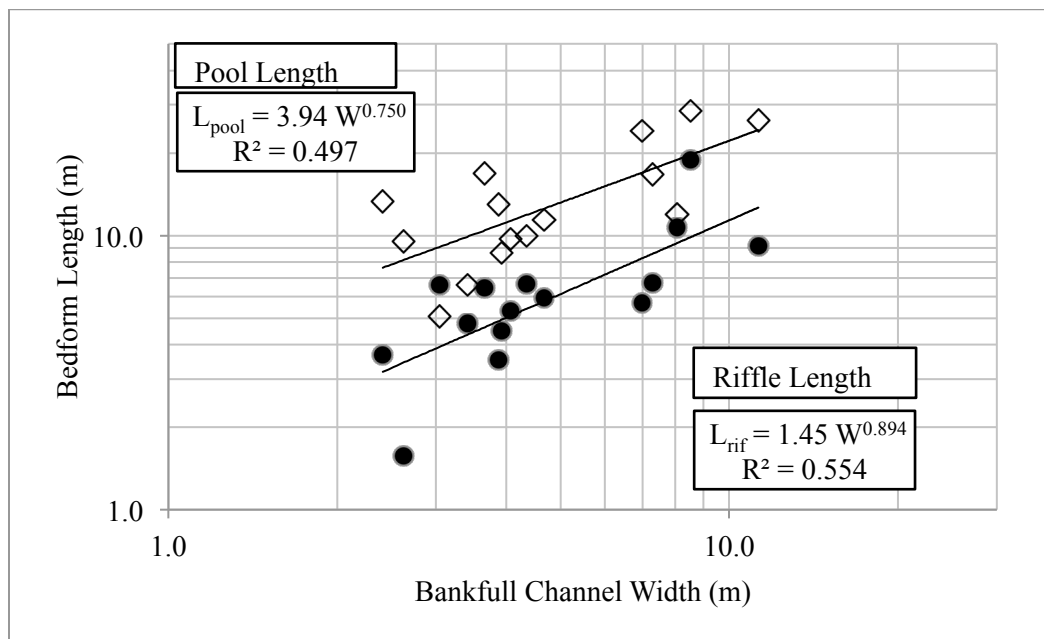


Figure 6. Riffle and Pool Length Related to Bankfull Channel Riffle Width for 15 Alabama Piedmont Reference Streams.

Table 3 lists the ratios of riffle and pool length to bankfull width for each stream. Riffle length ratios range from 0.6 to 2.2, with a median of 1.3. Pool length ratios range from 1.5 to 5.5, with a median of 2.4. The variability in these ratios is not related to drainage area. Table 3 also lists the proportion of each reach that contains riffles. Values range from 0.14 to 0.60, with a median of 0.34. This result indicates that a typical reference stream in this region contains about one-third riffles and two-thirds pools. The variability in these proportions is not related to drainage area.

Table 3 also lists the mean spacing of pools found in each reference stream and also the ratios of pool spacing to bankfull channel width. Values of pool spacing ratio range from 1.4 to 6.3, with a median of 3.5. The variability in these ratios not related to drainage area. Pool spacing values are shown in relation to bankfull channel width in Figure 7.

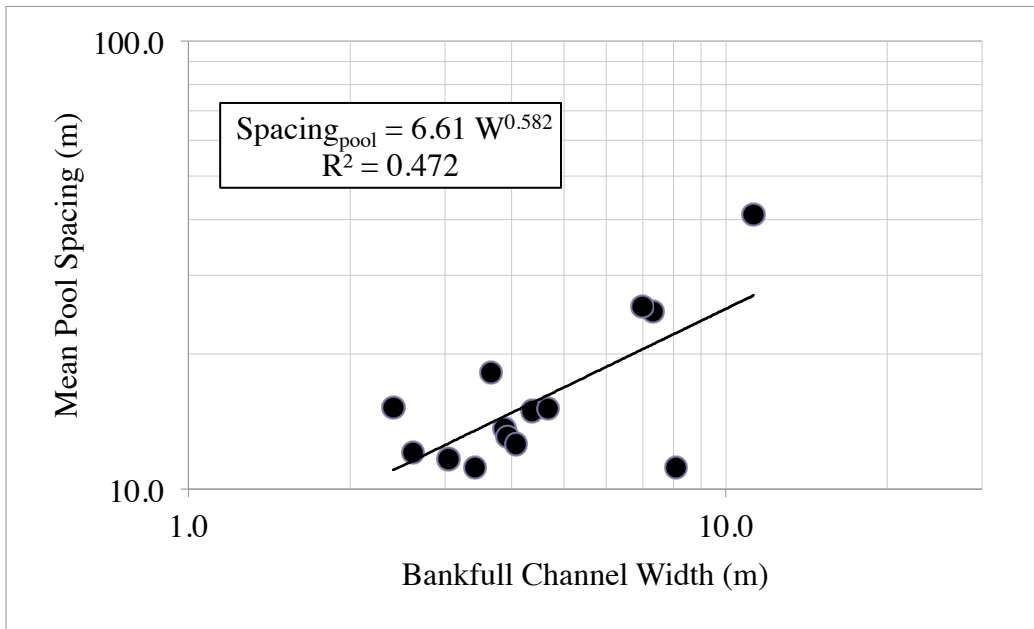


Figure 7. Mean Pool Spacing Related to Bankfull Channel Riffle Width for 21 Alabama Piedmont Reference Streams.

### Bedform Slopes

Table 3 lists the mean measured riffle slopes and ratios of riffle slope to overall reach slope for the 15 smallest reference streams. The values of riffle slope ratios range from 1.7 to 7.0, with a median of 3.2. The measured riffle slopes and overall reach slopes are shown in relation to drainage area in Figure 8. The regression lines are parallel for the two slopes, with the riffle slopes being about three times the reach slopes for this set of reference streams. These graphs represent design tools that may be used to estimate ranges of bedform dimensions in restoration projects. Designers should carefully consider the natural variability demonstrated in these datasets.

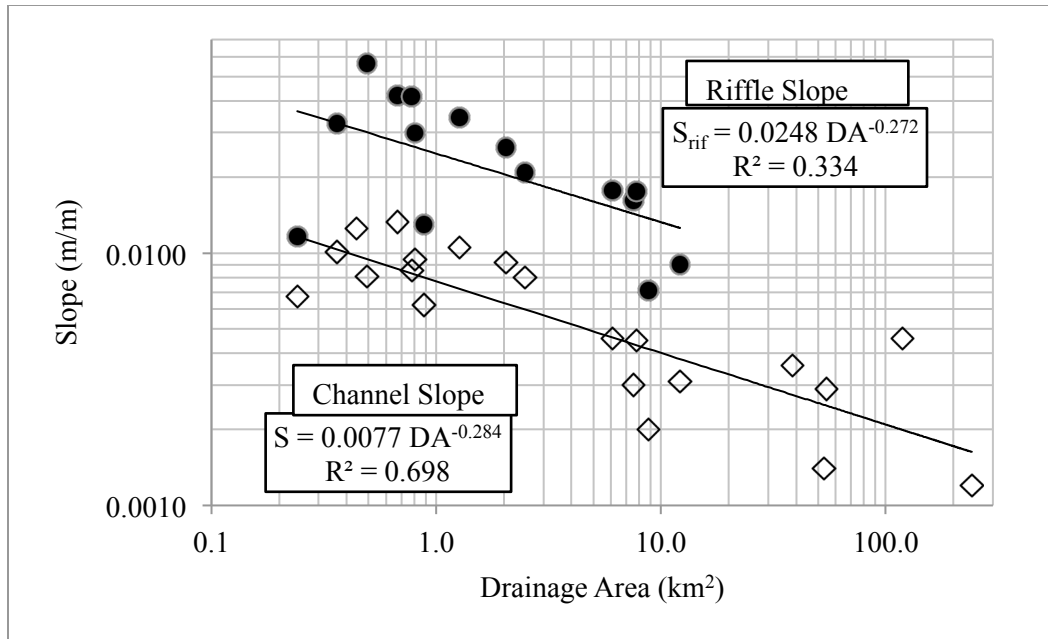


Figure 8. Reach Channel Slope and Mean Riffle Slope Related to Drainage Area for 21 Alabama Piedmont Reference Streams.

Table 1. Stream Morphology Dimensions for Alabama Piedmont Reference Streams.

Site Location	Drainage Area (km <sup>2</sup> )	Reach Slope (m/m)	Bankfull Cross-sectional Area (m <sup>2</sup> )	Bankfull Width (m)	Bankfull Mean Depth (m)	Width to Mean Depth Ratio (m/m)	Flood-prone Width (m)	Entrenchment Ratio (m/m)	Rosgen Stream Classification
UT Chewacla Creek, CCC Causeway	0.2	0.0067	0.4	3.0	0.1	25.0	13.0	4.3	C
UT Moores Mill Creek, Chewacla Park	0.4	0.0101	0.8	2.4	0.3	7.9	8.0	3.3	E
UT Coon Creek, Upstream Footpath	0.4	0.0125	1.1	3.7	0.3	12.3	33.0	8.8	C
UT Spring Entiachopco Creek, Pate Road	0.5	0.0081	0.8	2.6	0.3	8.6	20.0	7.6	E
UT Coon Creek, Waterfall Path	0.7	0.0133	1.0	4.4	0.2	20.4	18.0	4.1	C
Clarar's Creek	0.8	0.0085	1.5	3.9	0.4	10.2	10.7	2.8	E
Patterson Creek, Timbergut Upstream	0.8	0.0094	1.4	3.9	0.4	10.8	23.0	5.8	E
UT Ropes Creek, East	0.9	0.0062	0.9	3.4	0.2	14.0	50.0	14.6	C
UT Entiachopca Creek, Loombean Spring SR 49	1.3	0.0105	0.8	3.7	0.2	15.0	35.0	9.6	C
UT Wesobulga Creek, Spivey Road	2.0	0.0092	1.3	4.1	0.3	12.4	35.0	8.6	C
UT Emuckfaw Creek, East Zana Germany Ferry Road	2.5	0.0080	1.7	4.7	0.4	12.9	8.4	1.8	Bc
UT Entiachopco Creek, Fuller Road Pile Creek	6.1	0.0046	3.3	7.3	0.5	16.0	50.0	6.8	C

UT Entiahopco Creek, Osburn Creek CR 35 Tallapoosa	7.5	0.0030	3.3	7.0	0.5	14.9	60.0	8.6	C
Ropes Creek, CR 66	7.8	0.0045	6.7	8.1	0.8	9.8	86.0	10.6	E
Coon Creek, Upstream of Tributaries	8.8	0.0020	5.8	11.3	0.5	21.8	30.0	2.7	C
Jones Creek, Valley Grove Road	12.2	0.0031	7.7	8.5	0.9	9.3	47.0	5.5	E
Little Hillabee Creek, Upstream Bridge and Trib	38.6	0.0036	11.4	11.0	1.0	10.6	80.0	7.3	E
Chactafaula Creek, US Macon CR 54 Crossing	53.1	0.0014	14.7	13.8	1.1	12.9	43.0	3.1	C
Little Hillabee Creek, Millerville	54.6	0.0029	16.1	13.8	1.2	11.9	52.0	3.8	E
Chewacla Creek	118.9	0.0046	25.1	26.2	1.0	27.3	33.2	1.3	Bc
Entiahopco Creek, Pate Road	242.1	0.0012	60.0	26.4	2.3	11.5	48.0	1.8	Bc



Table 2. Bankfull Discharge Estimations for Alabama Piedmont Reference Streams.

Site Location	Drainage Area (km <sup>2</sup> )	Reach Slope (m/m)	Bankfull Cross-sectional Area (m <sup>2</sup> )	Manning n	Hydraulic Radius (m)	Bankfull Mean Velocity (m/s)	Bankfull Discharge (m <sup>3</sup> /s)
UT Chewacla Creek, CCC Causeway	0.2	0.0067	0.4	0.046	0.1	0.5	0.2
UT Moores Mill Creek, Chewacla Park	0.4	0.0101	0.8	0.046	0.3	0.9	0.8
UT Coon Creek, Upstream Footpath	0.4	0.0125	1.1	0.048	0.3	1.0	1.2
UT Spring Entiachopco Creek, Pate Road	0.5	0.0081	0.8	0.046	0.3	0.8	0.7
UT Coon Creek, Waterfall Path	0.7	0.0133	1.0	0.040	0.2	1.0	1.2
Clarar's Creek	0.8	0.0085	1.5	0.040	0.3	1.1	1.9
Patterson Creek, Timbergut Upstream	0.8	0.0094	1.4	0.046	0.3	1.0	1.7
UT Ropes Creek, East	0.9	0.0062	0.9	0.046	0.2	0.7	0.6
UT Entiachopca Creek, Loombean Spring SR 49	1.3	0.0105	0.8	0.042	0.2	0.9	0.8
UT Wesobulga Creek, Spivey Road	2.0	0.0092	1.3	0.047	0.3	0.9	1.4
UT Emuckfaw Creek, East Zana Germany Ferry Road	2.5	0.0080	1.7	0.046	0.3	0.9	1.8
UT Entiachopco Creek, Fuller Road Pile Creek	6.1	0.0046	3.3	0.053	0.4	0.7	2.7

UT Entiahopco Creek, Osburn Creek CR 35 Tallapoosa	7.5	0.0030	3.3	0.048	0.4	0.7	2.5
Ropes Creek, CR 66	7.8	0.0045	6.7	0.052	0.7	1.1	8.1
Coon Creek, Upstream of Tributaries	8.8	0.0020	5.8	0.040	0.5	0.7	4.7
Jones Creek, Valley Grove Road	12.2	0.0031	7.7	0.040	0.8	1.2	10.7
Little Hillabee Creek, Upstream Bridge and Trib	38.6	0.0036	11.4	0.035	0.9	1.6	21.6
Chactafaula Creek, US Macon CR 54 Crossing	53.1	0.0014	14.7	0.039	1.0	1.0	16.3
Little Hillabee Creek, Millerville	54.6	0.0029	16.1	0.035	1.1	1.6	30.0
Chewacla Creek	118.9	0.0046	25.1	0.035	1.0	1.9	54.7
Entiahopco Creek, Pate Road	242.1	0.0012	60.0	0.040	2.1	1.4	97.7

Table 3. Stream Morphology Bedform Measurements for Alabama Piedmont Reference Streams.

Site Location	Drainage Area (km <sup>2</sup> )	Mean Riffle Length (m)	Riffle Length to Bankfull Width Ratio (m/m)	Mean Pool Length (m)	Pool Length to Bankfull Width Ratio (m/m)	Riffle Length to Proportion of Reach Length (m/m)	Mean Pool Spacing (m)	Pool Spacing to Bankfull Width Ratio (m/m)	Mean Riffle Slope (m/m)	Riffle Slope to Reach Slope Ratio
UT Chewacla Creek, CCC Causeway	0.2	6.6	2.2	5.1	1.7	0.60	11.7	3.5	0.0116	1.7
UT Moores Mill Creek, Chewacla Park	0.4	3.7	1.5	13.4	5.5	0.25	15.2	6.3	0.0325	3.2
UT Spring Entachopco Creek, Pate Road	0.5	1.6	0.6	9.5	3.6	0.14	12.1	4.6	0.0564	7.0
UT Coon Creek, Waterfall Path	0.7	6.7	1.5	10.0	2.3	0.40	15.0	3.4	0.0419	3.1
Clarar's Creek	0.8	3.5	0.9	13.0	3.3	0.27	13.6	3.5	0.0416	4.9
Patterson Creek, Timbergut Upstream	0.8	4.5	1.1	8.6	2.2	0.34	13.1	3.3	0.0300	3.2
UT Ropes Creek, East	0.9	4.8	1.4	6.6	1.9	0.42	11.2	3.3	0.0129	2.1
UT Entachopca Creek, Loombean Spring SR 49	1.3	6.5	1.8	16.8	4.6	0.34	18.2	5.0	0.0343	3.3
UT Wesobulga Creek, Spivey Road	2.0	5.3	1.3	9.7	2.4	0.41	12.6	3.1	0.0261	2.8
UT Emuckfaw Creek, East Zana Germany Ferry Road	2.5	5.9	1.3	11.4	2.4	0.34	15.1	3.2	0.0208	2.6

UT Entiachopco Creek, Fuller Road Pile Creek	6.1	6.7	0.9	16.7	2.3	0.29	24.9	3.4	0.0177	3.8
UT Entiachopco Creek, Osburn Creek CR 35 Tallapoosa	7.5	5.7	0.8	24.1	3.5	0.24	25.6	3.7	0.0162	5.4
Ropes Creek, CR 66	7.8	10.7	1.3	11.9	1.5	0.55	11.2	1.4	0.0175	3.9
Coon Creek, Upstream of Tributaries	8.8	9.1	0.8	26.2	2.3	0.26	41.0	3.6	0.0071	3.5
Jones Creek, Valley Grove Road	12.2	18.9	2.2	28.4	2.6	0.57			0.0090	2.9

