

South Carolina Middle Atlantic Coastal Plain, Ecoregion 63 Stream Morphology Results

In the South Carolina Middle Atlantic Coastal Plain, Ecoregion 63, geomorphic data were collected from 15 streams during January and February 2020 (Figure 1 and Table 1). The sites were all ungaged reference streams in forested watersheds with drainage areas ranging from 0.35 to 14.3 square miles. Several other streams were visited to evaluate their potential for inclusion in this study but were rejected due to local instability or other factors affecting their geomorphic conditions.

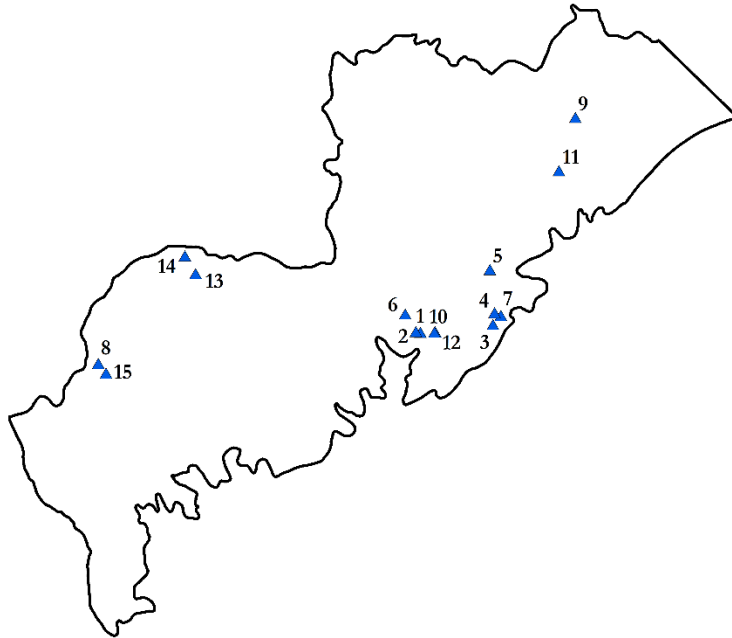


Figure 1. Reference Stream Sites in Ecoregion 63, South Carolina.

Table 1. Reference Stream Sites.

ID	Stream name	Source/Location	Latitude	Longitude	Drainage area (mile ²)
1	UT Nicholson Creek	Francis Marion NF	33.160604	-79.813020	0.35
2	UT Gough Creek	Francis Marion NF	33.162626	-79.831400	0.36
3	UT Cane Branch	Francis Marion NF	33.183908	-79.526605	0.57
4	Red Bluff Creek	Francis Marion NF	33.223015	-79.519964	0.58
5	UT Bond Swamp	Georgetown County	33.365872	-79.535571	0.59
6	UT Cane Gully Branch	Francis Marion NF	33.222307	-79.871977	1.27
7	Little Morgan Branch	Francis Marion NF	33.213300	-79.494886	1.31
8	Big Branch	Bamberg County	33.063887	-81.082283	2.03
9	Juniper Bay	SCDNR Fish Site	33.864485	-79.187739	2.09
10	Kutz Creek	Francis Marion NF	33.160895	-79.757817	2.45
11	Tyler Creek	SCDNR Fish Site	33.689045	-79.257043	2.78
12	Nicholson Creek	Francis Marion NF	33.162119	-79.754408	4.99
13	Buck Branch	Bowman Nature Park	33.360504	-80.698106	13.0
14	Cow Castle Creek	SCDNR Fish Site	33.419779	-80.740338	13.5
15	Savannah Creek	SCDNR Fish Site	33.031787	-81.051409	14.3

The reference streams in this ecoregion were selected through consultation with SCDNR and other local stream professionals, as well as extensive field reconnaissance. Reference reaches were identified generally based on the following criteria:

- Streams with drainage areas ranging between approximately 0.1 and 20 square miles
- Watersheds with stable land use and mostly forested over the past several decades
- Stream channels and floodplains in equilibrium with active bankfull stage indicators (i.e., bank height ratios near 1.0)
- Single-thread stream channels with freely-formed meander patterns in low-gradient valleys (less than 1% longitudinal slope)
- No valley restrictions throughout the reference reach or upstream/downstream that may influence channel form
- Healthy riparian forest buffers
- Accessible for data collection and protected for future access

Field measurements of stream geomorphological characteristics were collected to establish hydraulic geometry relationships following the methods outlined in the most current version of the North Carolina SQT Field User Manual¹. All stream assessments included collection of bankfull riffle dimension (cross-section) data. As conditions allowed, pattern data were collected for a subset of the reference sites.

¹ NC SQT https://stream-mechanics.com/wp-content/uploads/2017/09/Data-Collection-and-Analysis-Manual_NC-SQT-v3.0.pdf; currently under revision.

Data collected for all reference sites included:

- Rosgen stream type
- drainage area (DA)
- bankfull riffle cross-section area (A_{bkr})
- bankfull riffle width (W_{bkr}) and mean depth (d_{bkr}) for calculating width-to-depth ratio (WDR)
- width of floodprone area (W_{fpa}) for calculating entrenchment ratio (ER)
- maximum depth at top of bank and bankfull stage for calculating bank height ratio (BHR)
- channel water surface slope (S)
- sinuosity (k)
- median substrate size classification
- estimated Manning roughness coefficient (n)

The subset of reference sites with pattern data included collection of:

- meander wavelengths ($L_{meander}$)
- belt widths (W_{blt})
- radius of curvature of meander bends (R_c)

Profile data were not collected from streams within this ecoregion. In these low-slope, sand bed streams, riffle-pool sequences were not discernible. Rather, variations in bedform were generally due to tree roots, vegetation in the channel, woody debris, and accumulations of sand. This is typical of streams in coastal plain ecoregions. As a result, profile data (i.e., riffle slopes and lengths, pool lengths, and pool spacings) could not effectively be measured.

Large woody debris (LWD) information was collected in accordance with the most current version of the Application of the Large Woody Debris Index Field User Manual developed by Stream Mechanics and Ecosystem Planning & Restoration².

Field measurement results are presented in the appendix and in the tables and graphs below. Table 2 summarizes cross-section dimension geomorphic parameters used for Rosgen stream classification. Eight of the streams measured in Ecoregion 63 are C streams, while the remaining seven are E streams. Sand was the dominant bed material in all streams. Entrenchment ratios are very high. For all but two streams, the valleys were so wide that they precluded exact measurement; in these cases, entrenchment ratios are reported as >10.0. Width/depth ratios are highly variable, and range from 6.4 to 41.1. Despite the high width/depth ratios for the streams at the upper end of this range (e.g., Nicholson Creek and Kutz Creek), they are single-thread channels with defined streambeds and banks within the measured reach.

² Large Woody Debris Assessment https://stream-mechanics.com/wp-content/uploads/2017/12/LWDI-Manual_V1.pdf

Table 2. Morphology Dimensions.

Site	Drainage area (mile ²)	Channel slope (ft/ft)	Cross-section area (ft ²)	Bankfull width (ft)	Bankfull mean depth (ft)	Width/depth ratio	Entrenchment ratio	Rosgen Stream Class
1	0.35	0.0026	4.0	5.8	0.7	8.5	>10.0	E5
2	0.36	0.0027	4.8	9.6	0.5	18.8	5.5	C5
3	0.57	0.0007	6.5	6.7	1.0	7.0	>10.0	E5
4	0.58	0.0043	7.7	7.0	1.1	6.4	>10.0	E5
5	0.59	0.0027	3.3	7.0	0.5	14.7	>10.0	C5
6	1.27	0.0065	5.7	9.7	0.6	16.4	7.3	C5
7	1.31	0.0032	5.1	5.8	0.9	6.5	>10.0	E5
8	2.03	0.0019	16.9	14.2	1.2	12.0	>10.0	E5
9	2.09	0.0013	14.9	13.1	1.1	11.4	>10.0	E5
10	2.45	0.0017	12.8	20.9	0.6	34.3	>10.0	C5
11	2.78	0.0030	19.2	22.0	0.9	25.2	>10.0	C5
12	4.99	0.0013	46.9	43.9	1.1	41.1	>10.0	C5
13	13.0	0.0004	72.2	29.0	2.5	11.7	>10.0	E5
14	13.5	0.0005	73.2	34.1	2.1	15.9	>10.0	C5c-
15	14.3	0.0010	51.5	28.8	1.8	16.1	>10.0	C5c-

Table 3 summarizes estimated bankfull hydraulic parameters (velocity and discharge) for each stream based on the Manning equation. The Manning equation, in English units, is:

$$v = \frac{1.486 * (R^{2/3}) * (S^{1/2})}{n}$$

where v is average velocity (feet/second), R is the hydraulic radius (feet), S is average water surface slope (feet/feet), and n is a dimensionless coefficient describing channel roughness, known as Manning's n , which ranges from 0.033 to 0.150 for natural channels. The Cowan (1956) method was used to estimate the Manning's n values based on sediment size, irregularity within a cross-section, variation among cross-sections, obstructions, vegetation, and sinuosity. The bankfull discharge is estimated as the product of average velocity and riffle bankfull cross-section area.

For these streams, Manning's n values range from 0.045 to 0.075, which match expected values for natural alluvial streams in this ecoregion. Estimated bankfull average velocities for the study streams are generally around 1 foot per second, with a range of 0.5 to 1.5, with variations due to slope, cross-section dimensions, and channel roughness.

Table 3. Estimated Bankfull Hydraulic Parameters.

Site	Drainage area (mile ²)	Manning's n	Estimated Bankfull Velocity (ft/s)	Estimated Bankfull Discharge (cfs)
1	0.35	0.050	1.0	4.1
2	0.36	0.050	0.9	4.5
3	0.57	0.060	0.5	3.4
4	0.58	0.060	1.5	11
5	0.59	0.063	0.7	2.3
6	1.27	0.063	1.2	7.0
7	1.31	0.065	0.7	5.1
8	2.03	0.052	1.2	21
9	2.09	0.060	0.9	13
10	2.45	0.075	0.6	7.1
11	2.78	0.058	1.2	24
12	4.99	0.075	0.7	34
13	13.0	0.045	1.1	79
14	13.5	0.050	1.0	73
15	14.3	0.050	1.3	66

The graphs in Figures 2 through 5 show bankfull morphological parameters and estimated discharge related to watershed drainage area (i.e., regional curves). These graphs include data points measured in Ecoregion 63 of both South Carolina and North Carolina. North Carolina stream data points are shown for comparison only and should not be used for assessment or design in South Carolina. The North Carolina data represent seven streams, as published by Doll, et al. (2003). North Carolina data are not included in Figure 5 due to minor differences in the methodologies used to estimate bankfull discharge. Figures 2 through 5 also include best-fit regression lines for South Carolina stream data in addition to the regression equations and coefficients of determination.

Figures 2 through 4 demonstrate that measured bankfull cross-section area, width, and depth are often smaller in the South Carolina streams than in the assessed North Carolina streams. One reason for this result may be that many of the sites measured in South Carolina were in protected, forested watersheds with little or no impervious surface (e.g., Francis Marion National Forest). These undisturbed, forested watersheds tend to dampen peak flow responses to rainfall, producing equilibrium channels with little to no incision. The cross-section dimensions for South Carolina streams are validated by most streams having a bankfull elevation equal to the top of bank (i.e., Bank Height Ratio = 1.0).

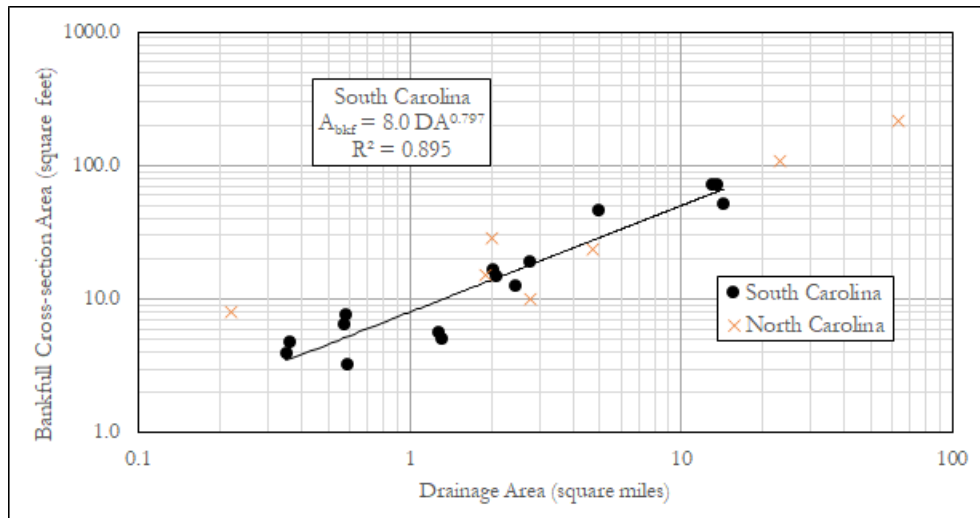


Figure 2. Bankfull riffle cross-section area related to drainage area for Ecoregion 63 streams with best-fit regression equations for South Carolina data. (Note: North Carolina stream data points are shown for comparison only and should not be used for assessment or design in South Carolina.)

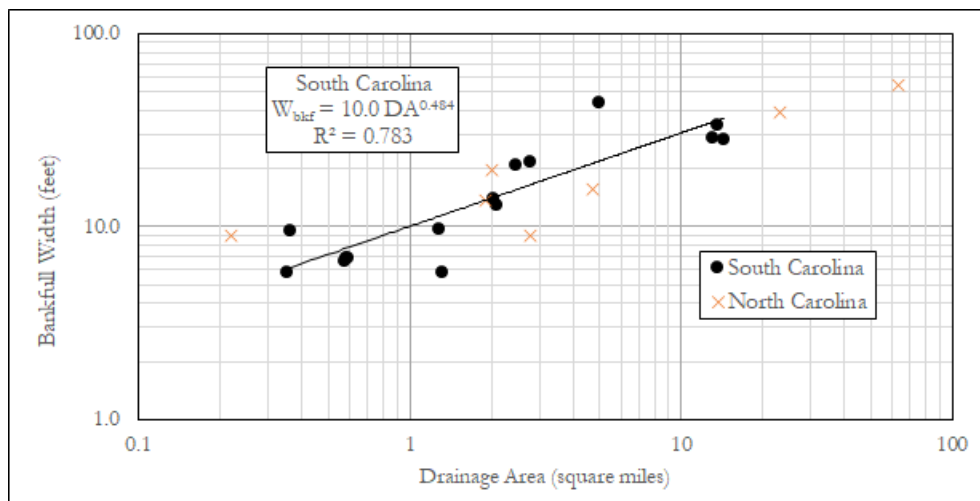


Figure 3. Bankfull riffle cross-section width related to drainage area for Ecoregion 63 streams with best-fit regression equations for South Carolina data. (Note: North Carolina stream data points are shown for comparison only and should not be used for assessment or design in South Carolina.)

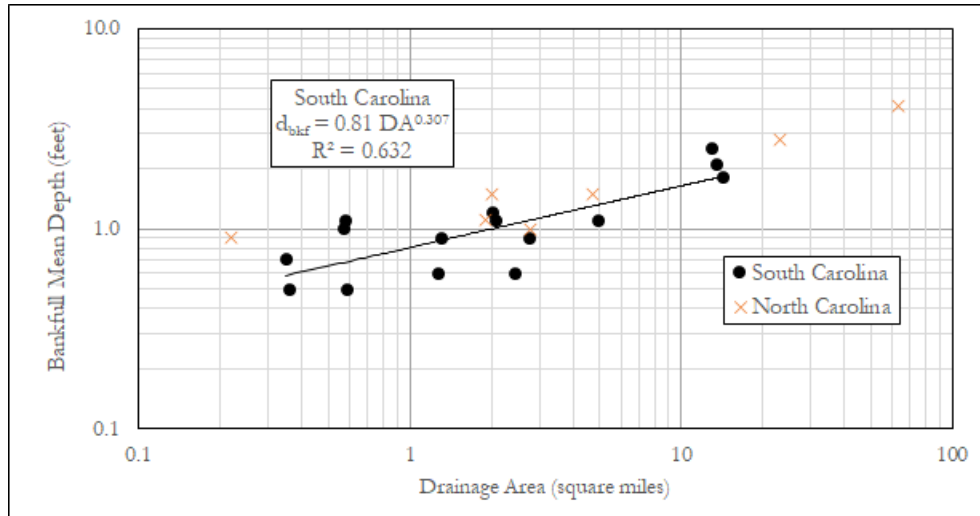


Figure 4. Bankfull riffle mean depth related to drainage area for Ecoregion 63 streams with best-fit regression equations for South Carolina data. (Note: North Carolina stream data points are shown for comparison only and should not be used for assessment or design in South Carolina.)

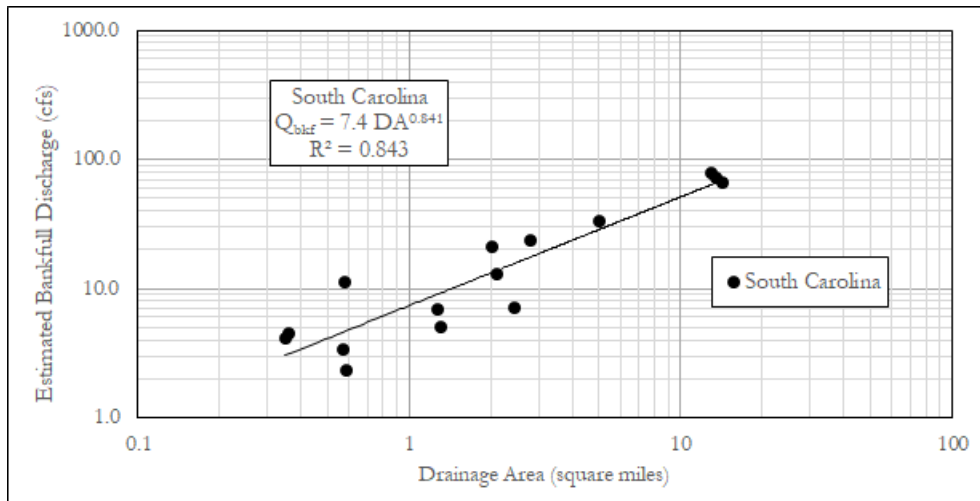


Figure 5. Estimated bankfull discharge related to drainage area for Ecoregion 63 streams.

Table 4 summarizes stream pattern data for the meandering reference streams with discernable planform parameters that could be assessed in the field. For each stream, the median pattern parameters and the median dimensionless ratios are listed. Median meander wavelength ratios range from 2.5 to 13.6, belt width ratios range from 1.3 to 8.1, and radius of curvature ratios range from 1.2 to 5.6.

Table 5 summarizes Large Woody Debris (LWD) assessments for each stream, including the numbers of LWD pieces, number of dams, and the LWD Index scores.

Table 4. Stream Morphology Pattern Parameters.

Site	Drainage area (mile ²)	Sinuosity (ft/ft)	Median meander wavelength [ratio to bankfull width] (ft [none])	Median belt width [ratio to bankfull width] (ft [none])	Median radius of curvature [ratio to bankfull width] (ft [none])
1	0.35	1.06	79 [13.6]	48 [8.1]	33 [5.6]
5	0.59	1.35	59 [8.4]	27 [3.8]	19 [2.7]
6	1.27	1.22	60 [6.2]	31 [3.2]	16 [1.7]
7	1.31	1.63	38 [6.6]	25 [4.3]	16 [2.7]
11	2.78	1.35	56 [2.5]	28 [1.3]	27 [1.2]
12	4.99	1.10	130 [3.0]	89 [2.0]	54 [1.2]

Table 5. Large Woody Debris Assessment Results.

Site	Number of Pieces	Number of Dams	Piece Score	Dam Score	LWDI
1	14	1	274	15	349
2	6	0	111	0	111
3	13	0	279	0	279
4	11	0	240	0	240
5	10	0	224	0	224
6	9	0	169	0	169
7	15	0	355	0	355
8	7	0	155	0	155
9	17	1	364	18	454
10	6	0	106	0	106
11	16	0	317	0	317
12	8	0	168	0	168
13	9	0	198	0	198
14	18	0	395	0	395
15	16	0	340	0	340

APPENDIX

ECOREGION 63, SOUTH CAROLINA

1. UT Nicholson Creek

Ecoregion 63, South Carolina

Latitude: 33.160604

Longitude: -79.813020

Drainage area: 0.35 square miles

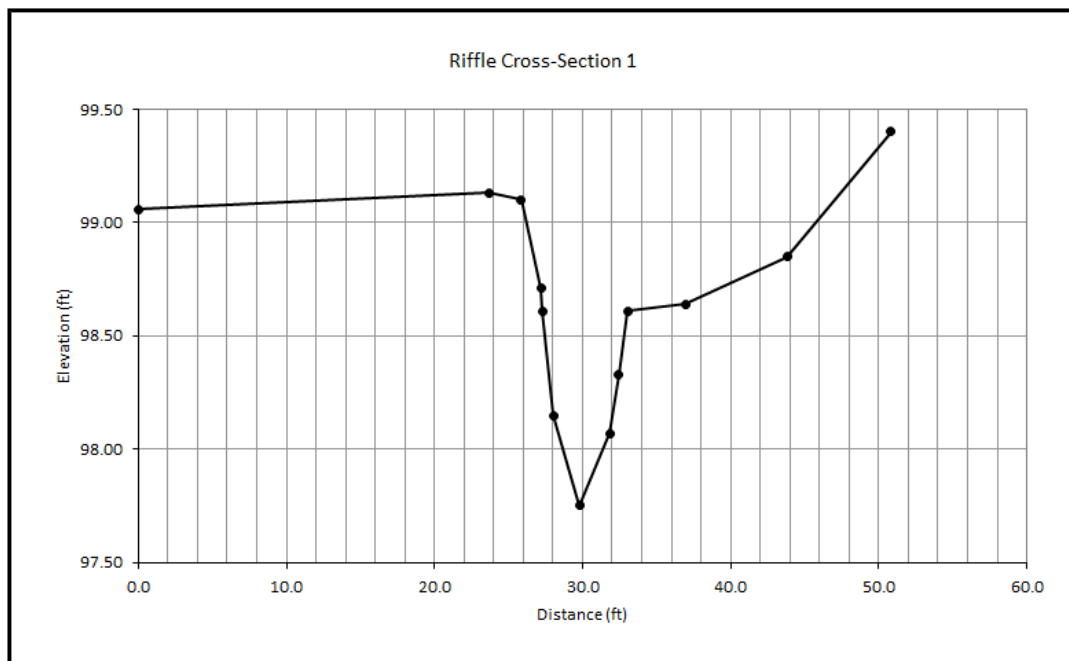
Median particle size: sand

Longitudinal slope: 0.0026 feet/foot

Stream classification: E5



Area (square feet) =	4.0
Width (feet) =	5.8
Mean depth =	0.7
Max depth =	1.0
Width/depth ratio =	8.5
Entrenchment ratio =	>10.0



2. UT Gough Creek Ecoregion 63, South Carolina

Latitude: 33.162626

Longitude: -79.831400

Drainage area: 0.36 square miles

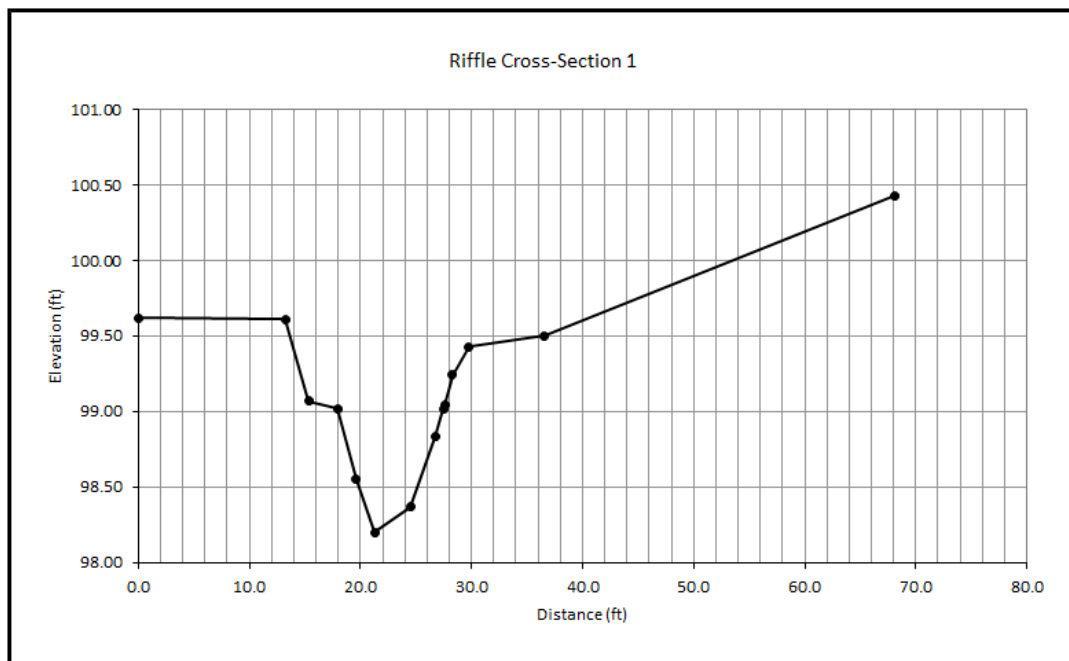
Median particle size: sand

Longitudinal slope: 0.0027 feet/foot

Stream classification: C5



Area (square feet) =	4.8
Width (feet) =	9.6
Mean depth =	0.5
Max depth =	0.8
Width/depth ratio =	18.8
Entrenchment ratio =	5.5



3. UT Cane Branch Ecoregion 63, South Carolina

Latitude: 33.183908

Longitude: -79.526605

Drainage area: 0.57 square miles

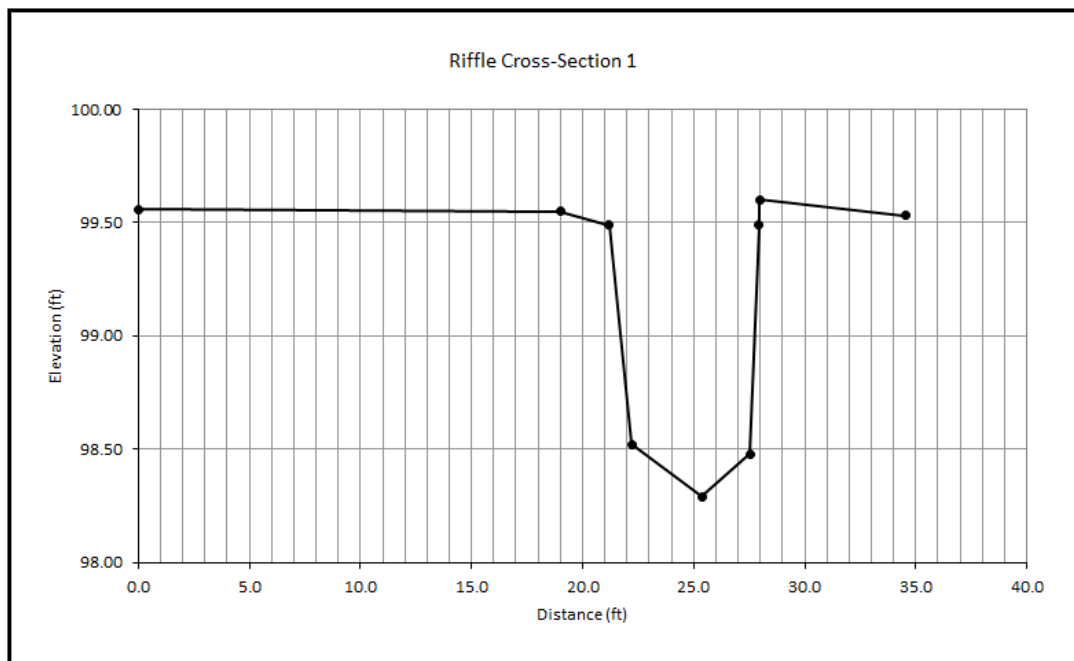
Median particle size: sand

Longitudinal slope: 0.0007 feet/foot

Stream classification: E5



Area (square feet) =	6.5
Width (feet) =	6.7
Mean depth =	1.0
Max depth =	1.2
Width/depth ratio =	7.0
Entrenchment ratio =	>10.0



4. Red Bluff Creek Ecoregion 63, South Carolina

Latitude: 33.223015

Longitude: -79.519964

Drainage area: 0.58 square miles

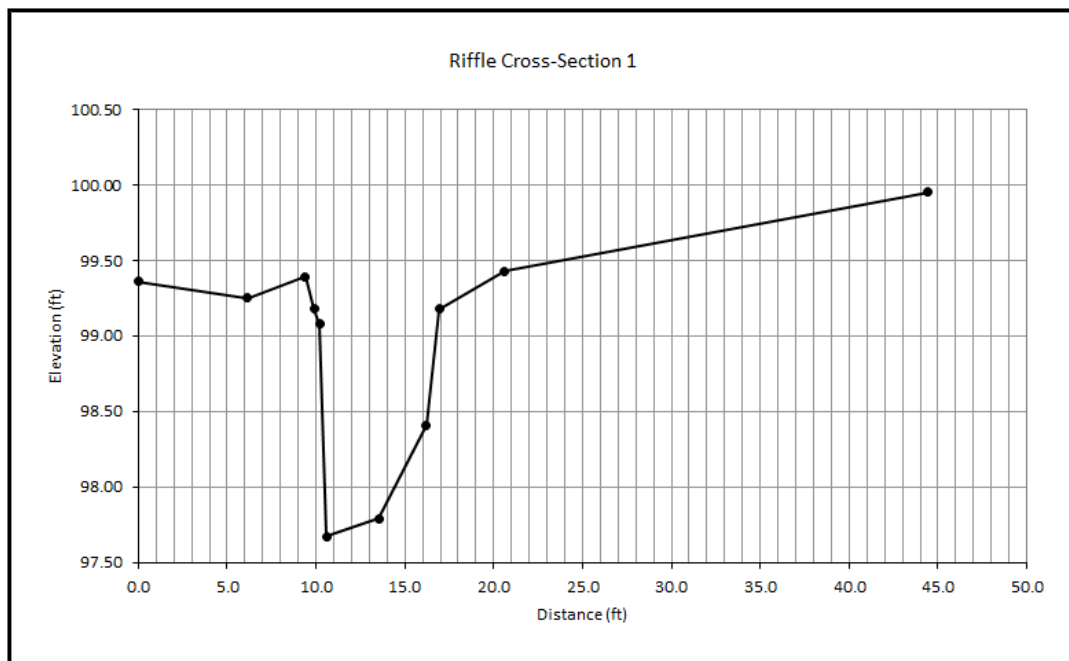
Median particle size: sand

Longitudinal slope: 0.0043 feet/foot

Stream classification: E5



Area (square feet) =	7.7
Width (feet) =	7.0
Mean depth =	1.1
Max depth =	1.5
Width/depth ratio =	6.4
Entrenchment ratio =	>10.0



5. UT Bond Swamp Ecoregion 63, South Carolina

Latitude: 33.365872

Longitude: -79.535571

Drainage area: 0.59 square miles

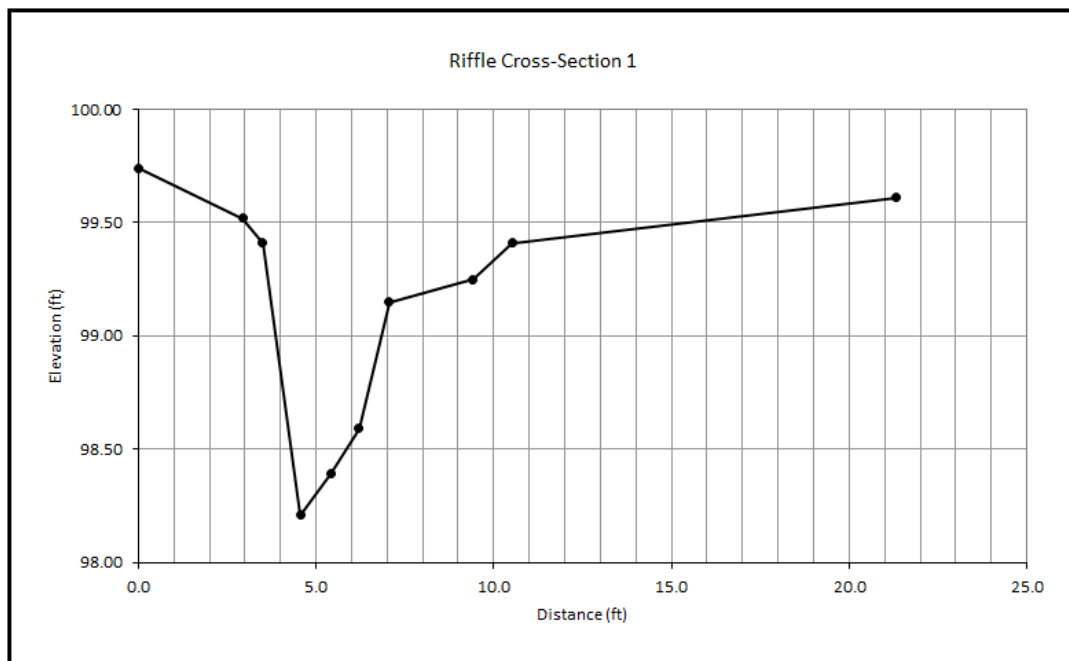
Median particle size: sand

Longitudinal slope: 0.0027 feet/foot

Stream classification: C5



Area (square feet) =	3.3
Width (feet) =	7.0
Mean depth =	0.5
Max depth =	1.2
Width/depth ratio =	14.7
Entrenchment ratio =	>10.0



6. UT Cane Gully Branch Ecoregion 63, South Carolina

Latitude: 33.222307

Longitude: -79.871977

Drainage area: 1.27 square miles

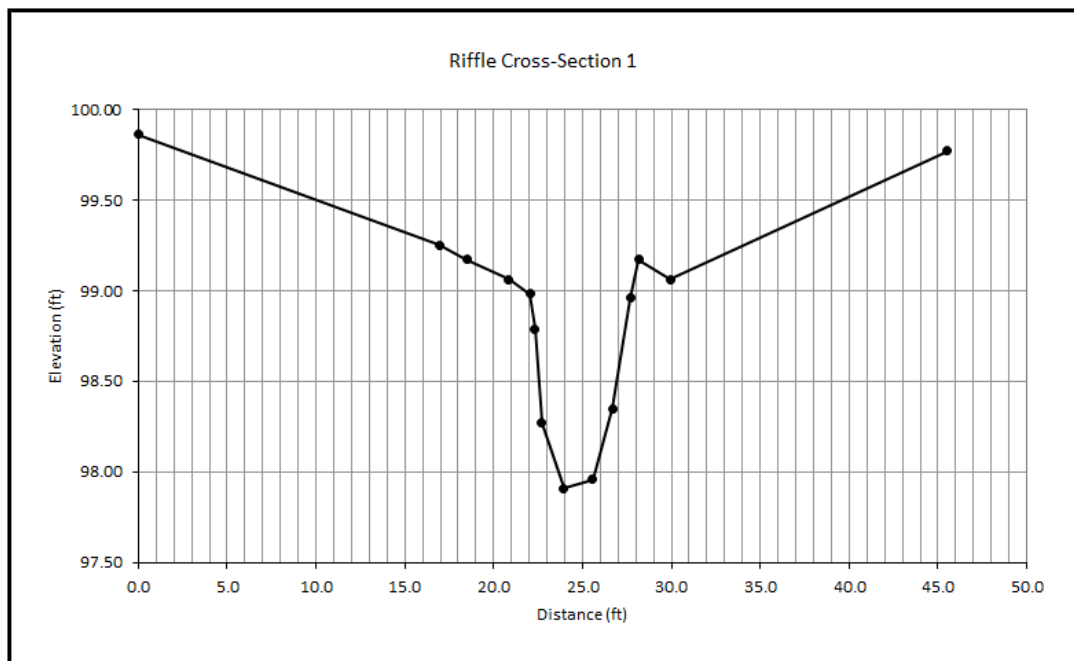
Median particle size: sand

Longitudinal slope: 0.0065 feet/foot

Stream classification: C5



Area (square feet) =	5.7
Width (feet) =	9.7
Mean depth =	0.6
Max depth =	1.3
Width/depth ratio =	16.4
Entrenchment ratio =	7.3



7. Little Morgan Branch Ecoregion 63, South Carolina

Latitude: 33.213300

Longitude: -79.494886

Drainage area: 1.31 square miles

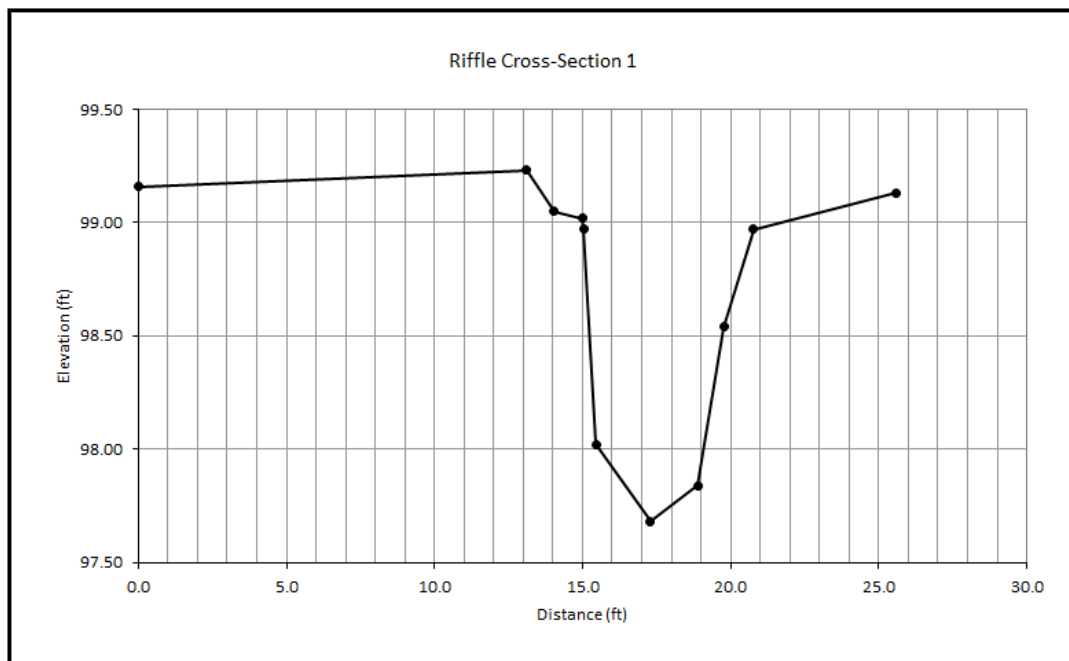
Median particle size: sand

Longitudinal slope: 0.0032 feet/foot

Stream classification: E5



Area (square feet) =	5.1
Width (feet) =	5.8
Mean depth =	0.9
Max depth =	1.3
Width/depth ratio =	6.5
Entrenchment ratio =	>10.0



8. Big Branch Ecoregion 63, South Carolina

Latitude: 33.063887

Longitude: -81.082283

Drainage area: 2.03 square miles

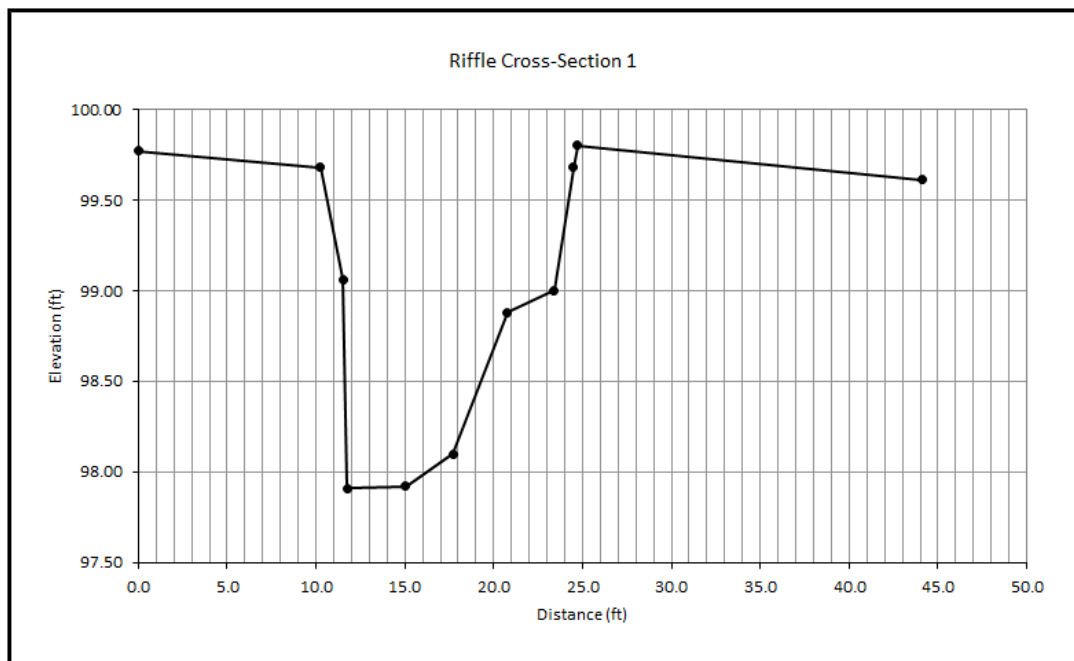
Median particle size: sand

Longitudinal slope: 0.0019 feet/foot

Stream classification: E5



Area (square feet) =	16.9
Width (feet) =	14.2
Mean depth =	1.2
Max depth =	1.8
Width/depth ratio =	12.0
Entrenchment ratio =	>10.0



9. Juniper Bay Ecoregion 63, South Carolina

Latitude: 33.864485

Longitude: -79.187739

Drainage area: 2.09 square miles

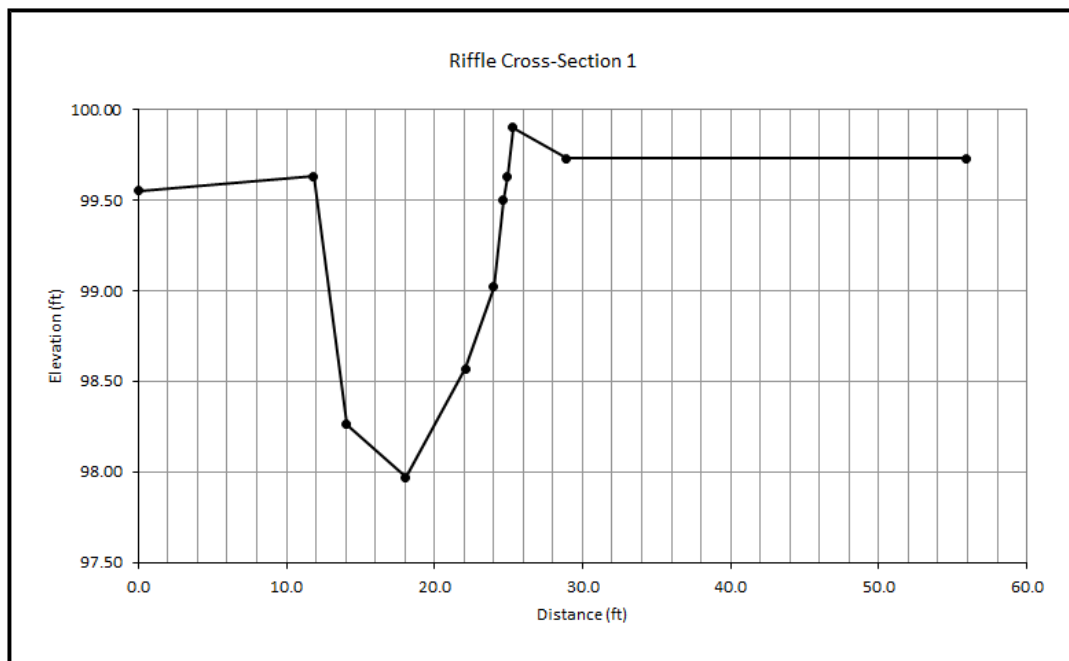
Median particle size: sand

Longitudinal slope: 0.0013 feet/foot

Stream classification: E5



Area (square feet) =	14.9
Width (feet) =	13.1
Mean depth =	1.1
Max depth =	1.7
Width/depth ratio =	11.4
Entrenchment ratio =	>10.0



10. Kutz Creek Ecoregion 63, South Carolina

Latitude: 33.160895

Longitude: -79.757817

Drainage area: 2.45 square miles

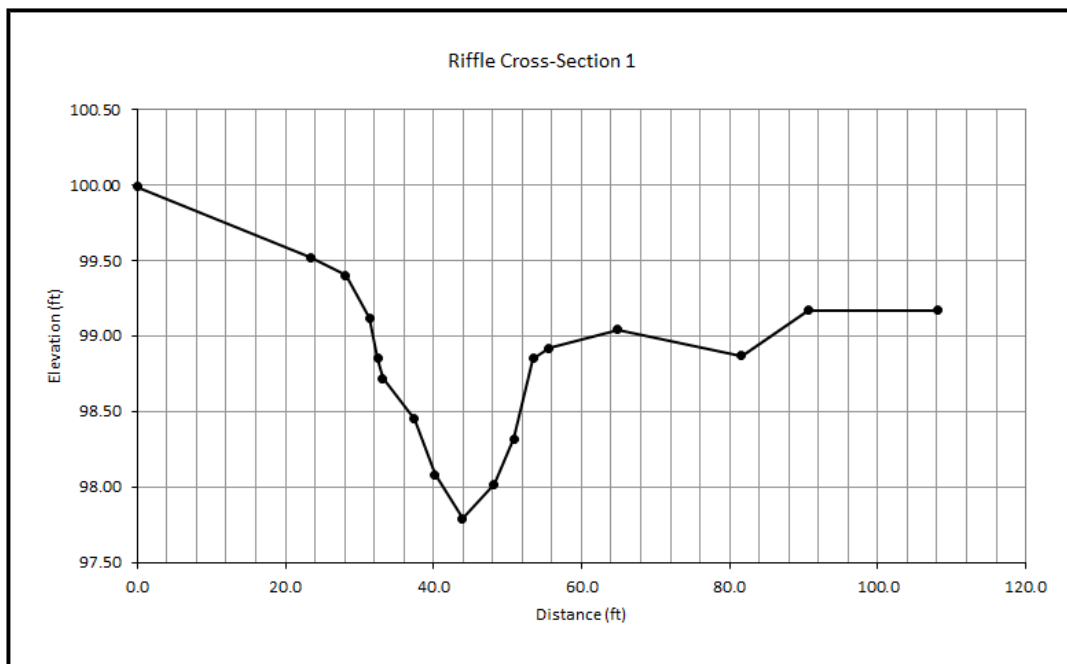
Median particle size: sand

Longitudinal slope: 0.0017 feet/foot

Stream classification: C5



Area (square feet) =	12.8
Width (feet) =	20.9
Mean depth =	0.6
Max depth =	1.1
Width/depth ratio =	34.3
Entrenchment ratio =	>10.0



11. Tyler Creek Ecoregion 63, South Carolina

Latitude: 33.689045

Longitude: -79.257043

Drainage area: 2.78 square miles

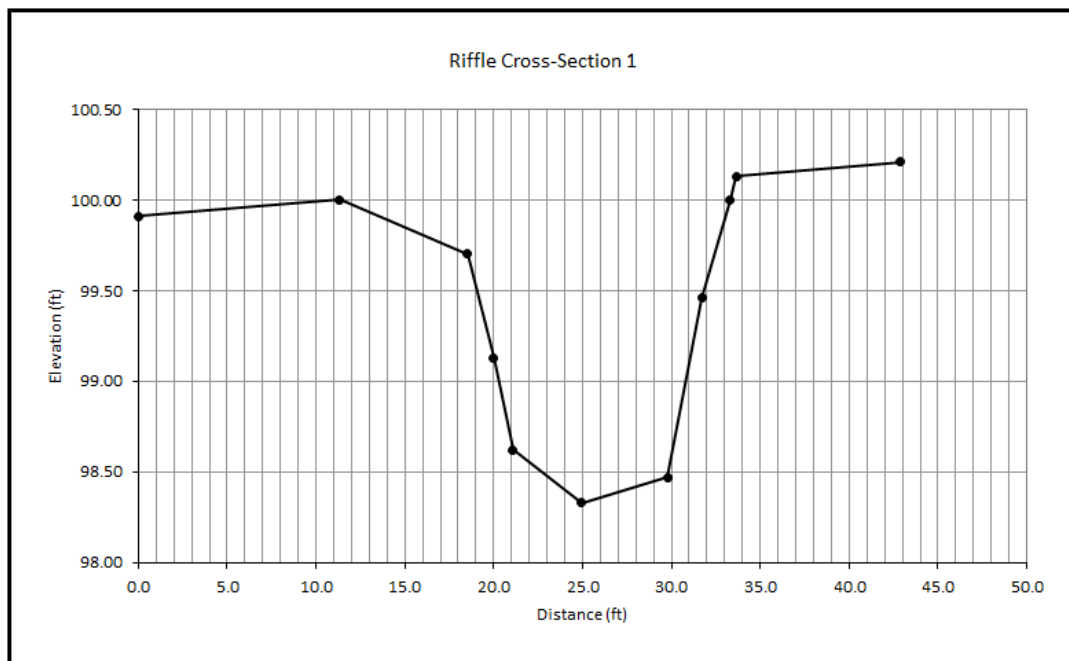
Median particle size: sand

Longitudinal slope: 0.0030 feet/foot

Stream classification: C5



Area (square feet) =	19.2
Width (feet) =	22.0
Mean depth =	0.9
Max depth =	1.7
Width/depth ratio =	25.2
Entrenchment ratio =	>10.0



12. Nicholson Creek Ecoregion 63, South Carolina

Latitude: 33.162119

Longitude: -79.754408

Drainage area: 4.99 square miles

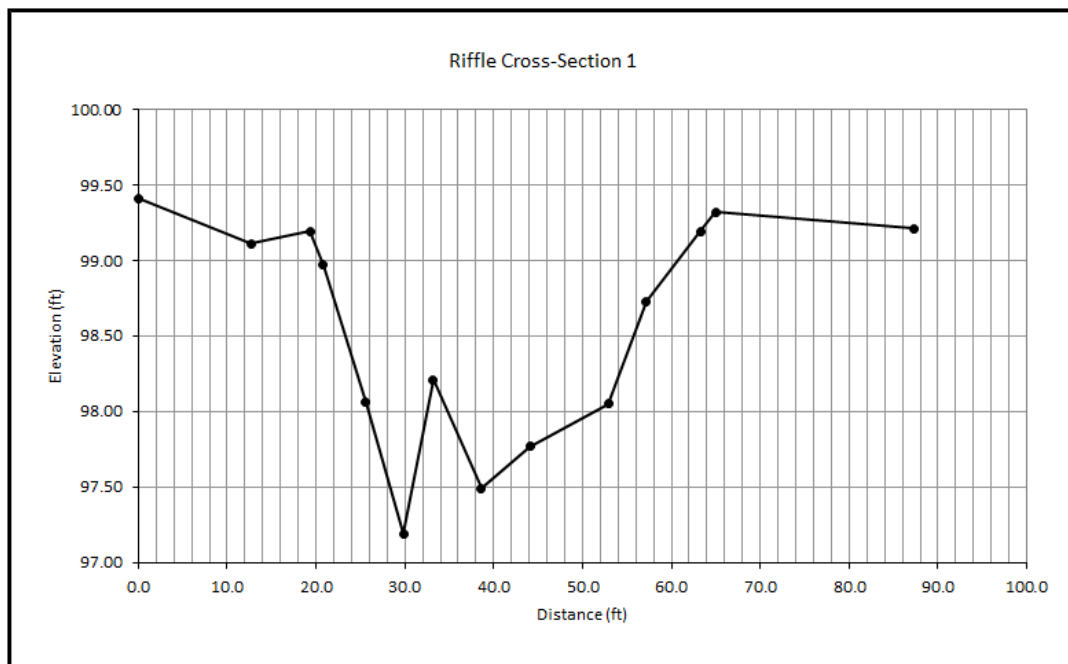
Median particle size: sand

Longitudinal slope: 0.0013 feet/foot

Stream classification: C5



Area (square feet) =	46.9
Width (feet) =	43.9
Mean depth =	1.1
Max depth =	2.0
Width/depth ratio =	41.1
Entrenchment ratio =	>10.0



13. Buck Branch

Ecoregion 63, South Carolina

Latitude: 33.360504

Longitude: -80.698106

Drainage area: 13.0 square miles

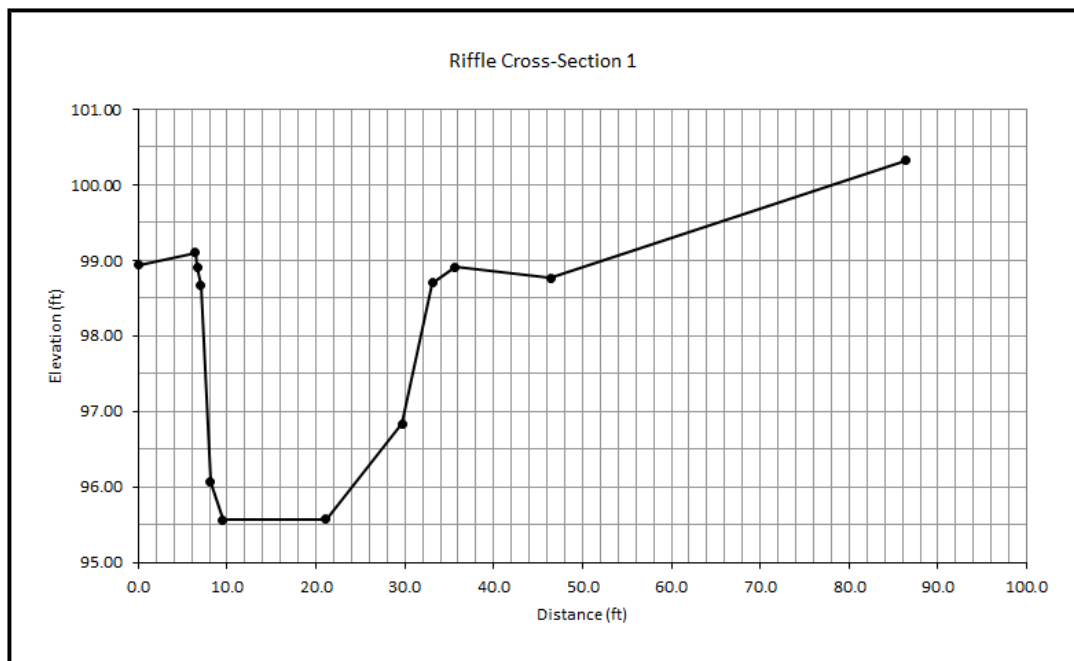
Median particle size: sand

Longitudinal slope: 0.0004 feet/foot

Stream classification: E5



Area (square feet) =	72.2
Width (feet) =	29.0
Mean depth =	2.5
Max depth =	3.3
Width/depth ratio =	11.7
Entrenchment ratio =	>10.0



14. Cow Castle Creek Ecoregion 63, South Carolina

Latitude: 33.419779

Longitude: -80.740338

Drainage area: 13.5 square miles

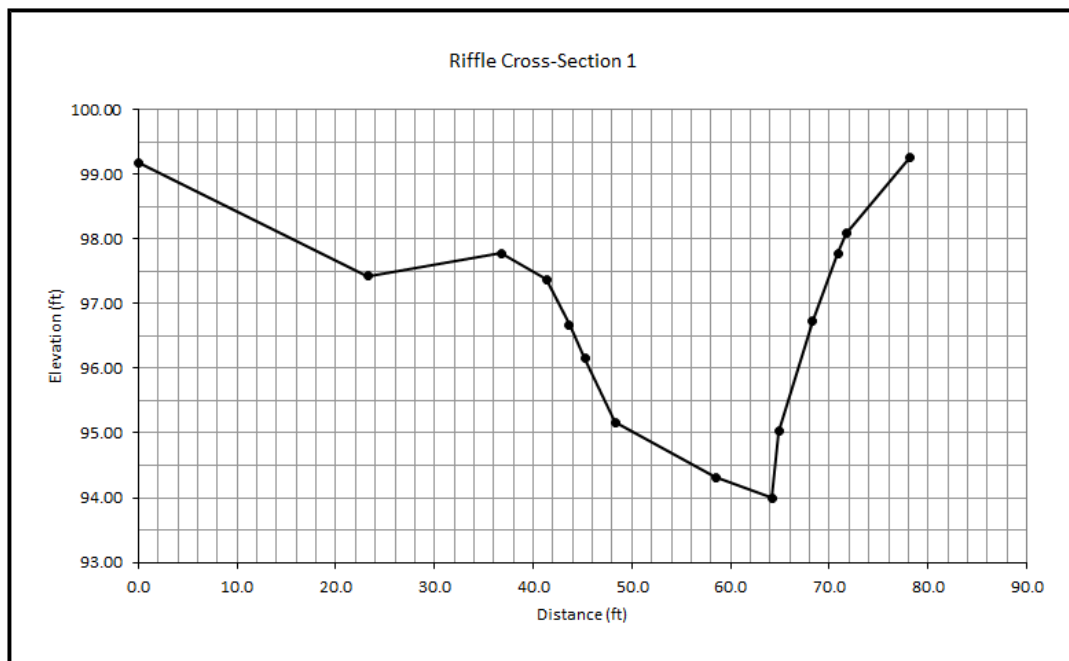
Median particle size: sand

Longitudinal slope: 0.0005 feet/foot

Stream classification: C5c-



Area (square feet) =	73.2
Width (feet) =	34.1
Mean depth =	2.1
Max depth =	3.8
Width/depth ratio =	15.9
Entrenchment ratio =	>10.0



15. Savannah Creek Ecoregion 63, South Carolina

Latitude: 33.031787

Longitude: -81.051409

Drainage area: 14.3 square miles

Median particle size: sand

Longitudinal slope: 0.0010 feet/foot

Stream classification: C5c-



Area (square feet) =	51.5
Width (feet) =	28.8
Mean depth =	1.8
Max depth =	2.6
Width/depth ratio =	16.1
Entrenchment ratio =	>10.0

