EEP Project Closeout Summary

Project ID & Status

Project Name/Number:	Reedy Branch
EEP ID	301
County:	Alamance
Project Type:	Stream Restoration,
Current Status:	5 Years of Monitoring complete

Project Setting & Classifications

Basin:	Haw
Physiographic Region:	Piedmont
Ecoregion:	Carolina Slate Belt
USGS Hydro Unit:	03030002
NCDWQ Subbasin:	03-06-04
Thermal Regime:	Warm
Trout Water:	No
Designer:	Ecologic
Monitoring	SEPI Engineering (MY 2-5)

Project Timeline

Milestone	Date
Construction Completed	**November 2003**
Repair Work	**Fall 2004**
As-built survey	**February 2005**
Monitoring Year-1	**May 2005**
Repair Work	**May 2005**
Monitoring Year-2	**June 2006**
Monitoring Year-3	**November 2007**
Monitoring Year-4	**November 2008**
Monitoring Year-5	**November 2009**

Table 1. Project Restoration Components and Mitigation Assets

		Asset Data							
Drainage/Hydrology Component	**Restoration Component**	**Asset Map #**	**Approach**	**Level**	**Ratio Multip**	**Feet**	**SMU**	**Acres**	**WMU**
Reedy Branch	Reedy Branch	1	Priority II	Restoration	1.00	3125	3125	-	-

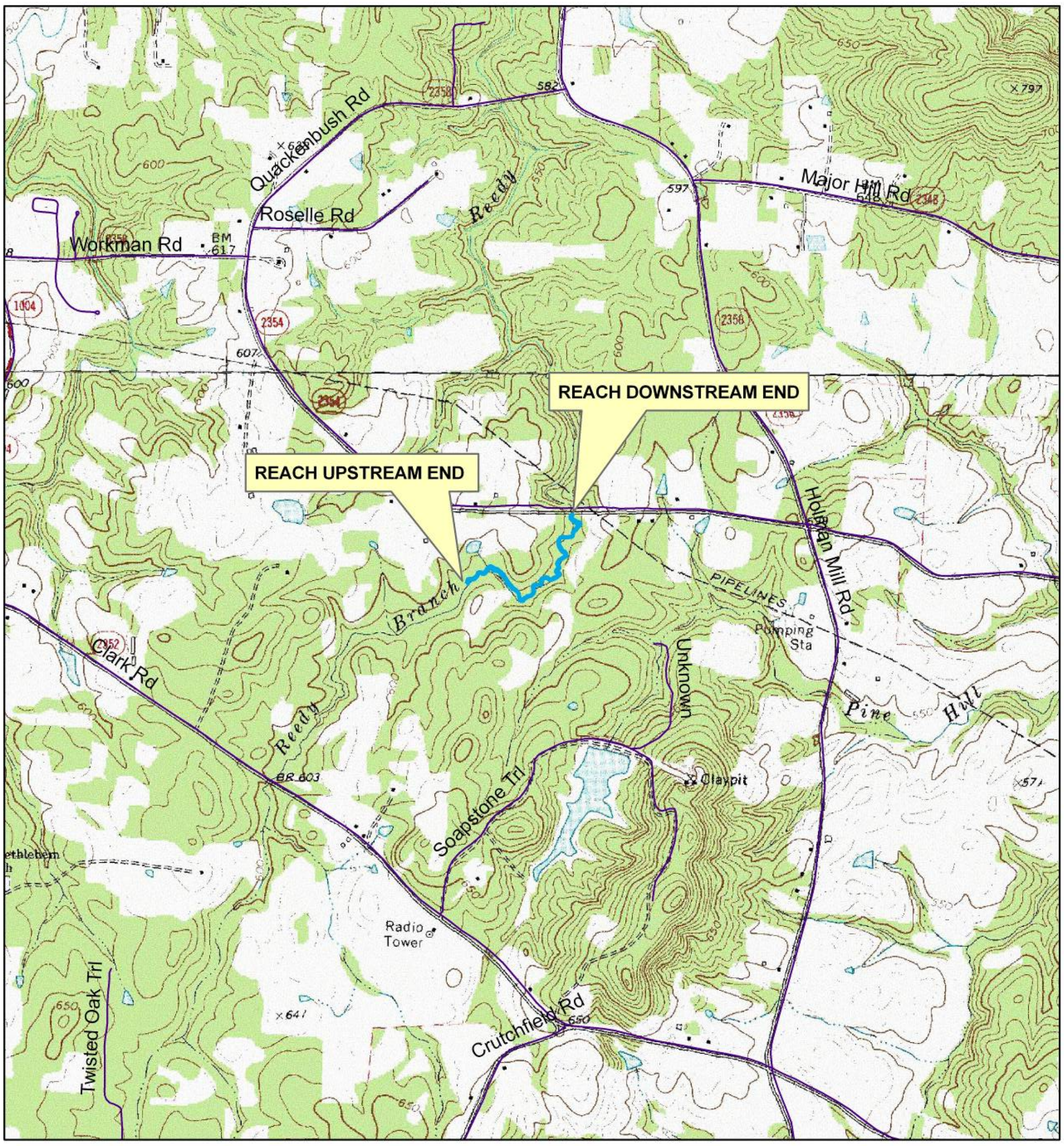
P1 = Priority I Restoration
P2 = Priority II Restoration
P3 = Priority III Restoration

R = Restoration
E = Wetland Enhancement
EI = Stream Enhancement I
EII = Stream Enhancemnt II
C = Wetland Creation
P = Preservation

SMU =Stream Mitigation Units
WMU = Wetland Mitigation Units
P/I/E = Perennial, Intermittent, Ephemeral

Asset Summary

Level	Ratio	Multip	Feet	SMU	Acres	WMU
R	1:1	1.00	3125	3125		
E	2:1					
EI	1.5:1					
EII	2:1					
C	3:1					
P	5:1					
			3125	**3125**	**0.00**	**0.00**



REEDY BRANCH
SITE VICINITY MAP

FIGURE 1
ALAMANCE COUNTY NC

Ecosystem Enhancement PROGRAM

Surveyed Stream Centerline (2008 Survey)

1,000 500 0 1,000 Feet

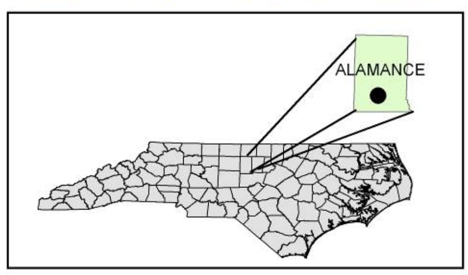


Figure 1. Project Site Map

Figure 2. Reedy Branch (EEP Project Number 301) Pre-existing Condition Photos

As-Built (2005)

Monitoring Year 5 (2009)

Cross Section #1. View upstream

Cross Section #1. View upstream within channel.

Photo Point #28 .

Photo Point #28

As-Built (2005)

Monitoring Year 5 (2009)

Cattle Crossing. View across channel from right bank.

Cattle Crossing. View across channel from right bank.

Photo Point #35.

Photo Point #35

Figure 3.   Reedy Branch (EEP Project Number 301) As-built comparison photos

Channel Stability

Dimension

The restored channel's dimension exhibited stability. It should be noted that only three cross sections (two riffles and one pool) were documented during the As-Built survey. Any comparison in this document of Monitoring Year 5 dimensional metrics to As-Built conditions were limited to these three As-Built cross sections (Cross Sections 1, 4, and 5). The additional three cross sections were added during Monitoring Year 2. There appeared to be adjustments in the form of channel incision at some riffle cross sections. Most notably, Cross Section 4 exhibited almost a 25% increase in cross sectional area since the As-Built year (see Figures 4 and 5). However, cross section 4 was the exception. Other riffle cross sections exhibited some incision and increase in cross sectional area as an initial adjustment during Monitoring Year 1 but then stabilized toward cross sectional areas at or below As-Built conditions by Monitoring Year 5 (see Table 2 and Figure 5). Regardless of these observations, healthy entrenchment ratios and width-depth ratios were maintained at all cross sections, indicating good floodplain access and sediment transport capacity. All riffle cross sections classified as a Rosgen C during Monitoring Year 5. The pool cross-sections maintained greater depths than the riffles, indicating the maintenance of distinct bedform features. These conditions indicate stability. The plots below describe or typify observed conditions and trends with regard to channel dimension.

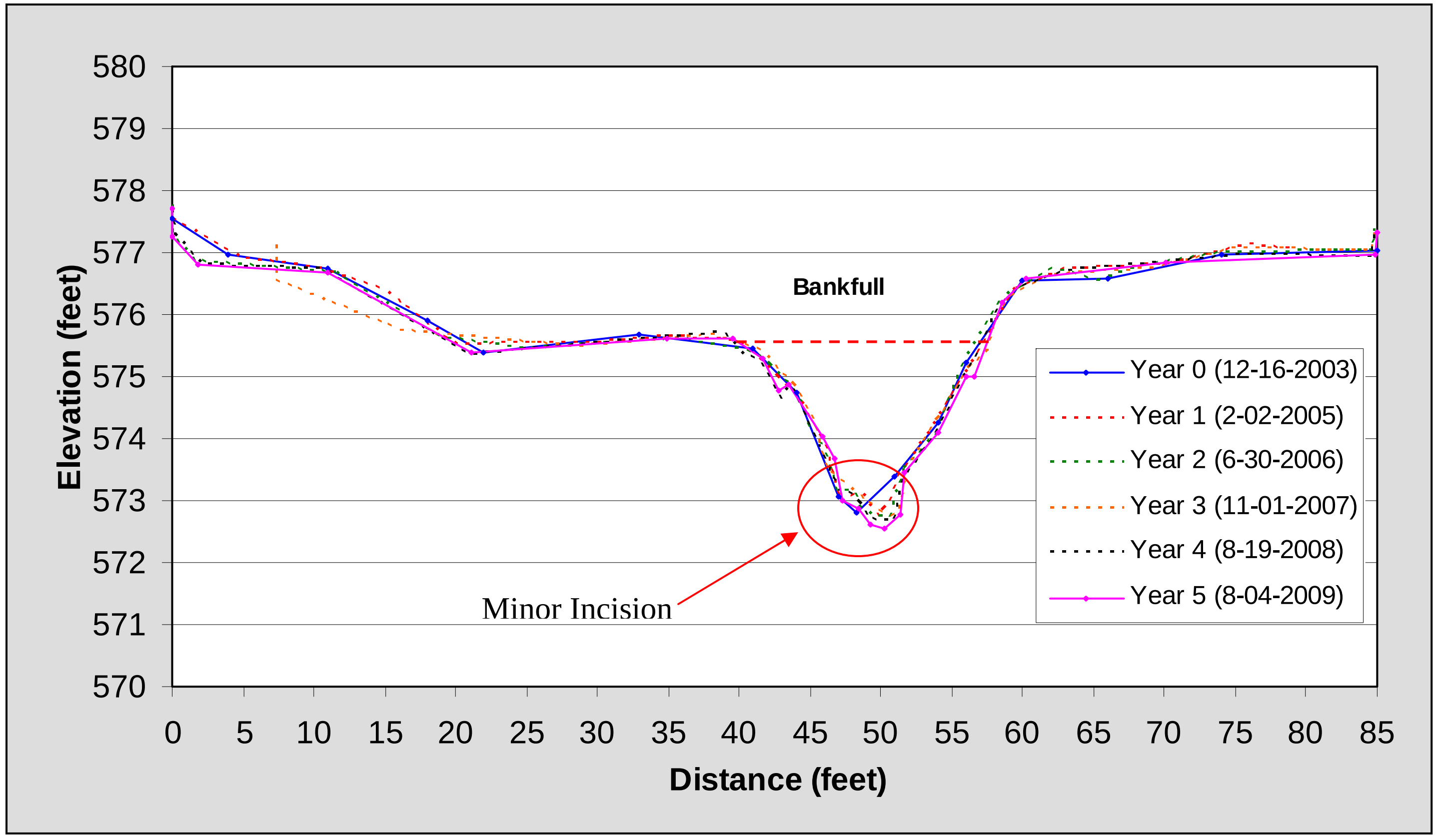
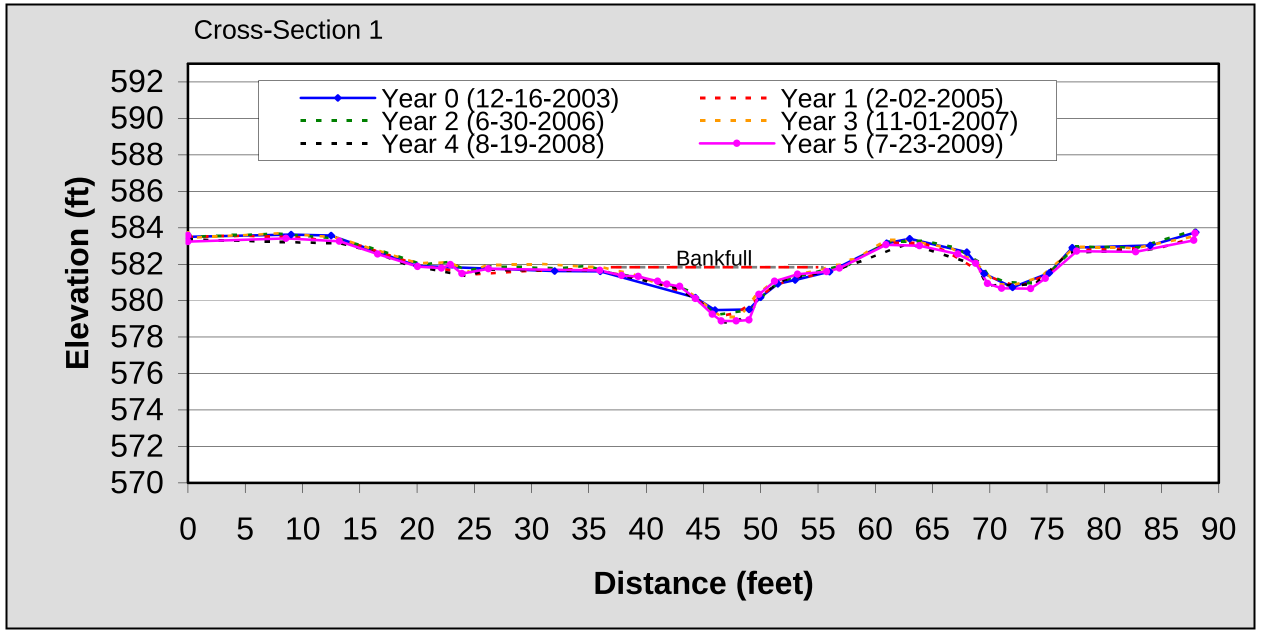


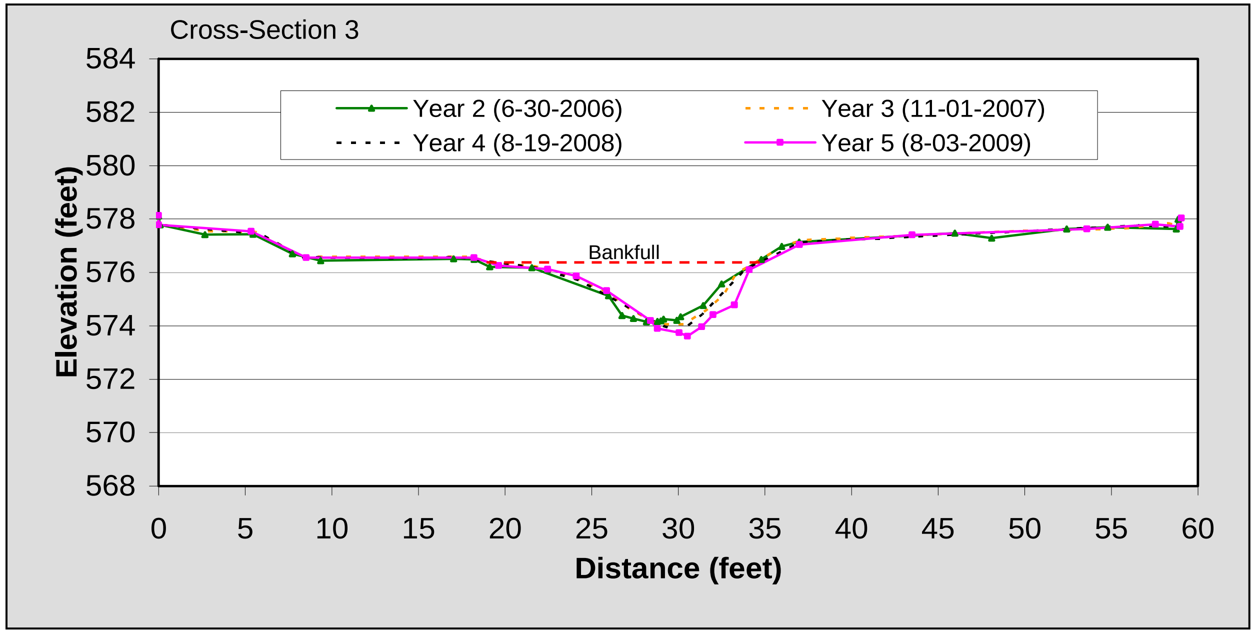
Table 2. Cross-Sectional Areas at Riffle Cross Sections

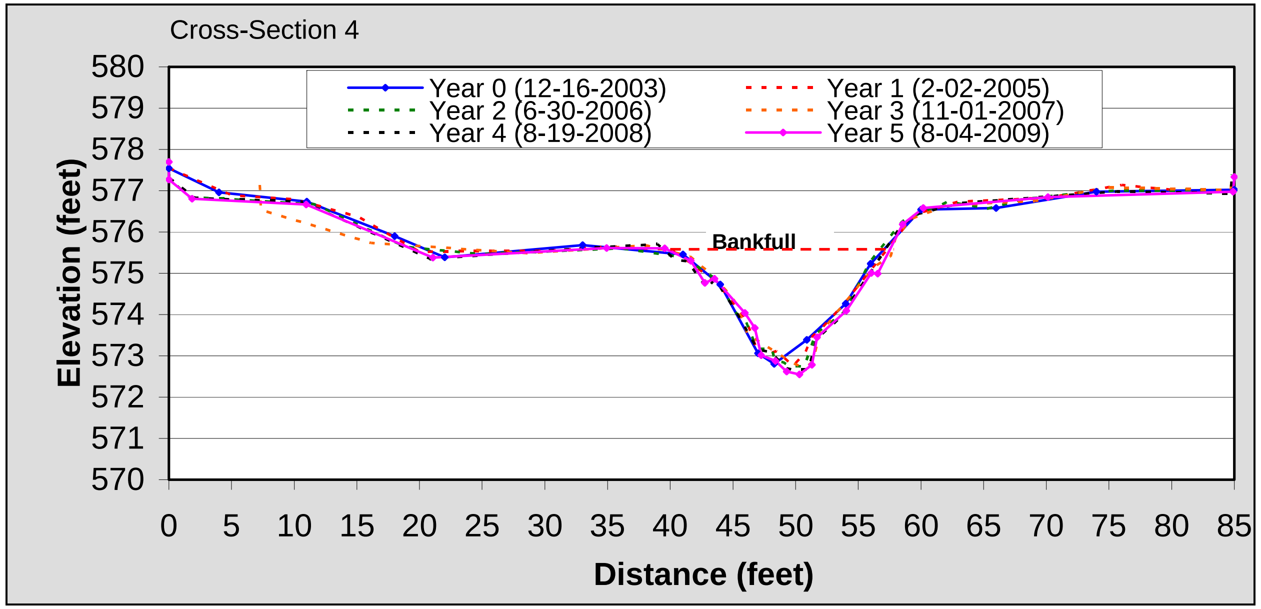
Riffle	MY0	MY1	MY2	MY3	MY4	MY5
XS-1	23.2	28.1	24.7	23.2	21.2	20.1
XS-3	NA	NA	18.5	18.0	18.8	20.6
XS-4	21.9	24.4	25.4	25.0	27.0	26.6
XS-6	NA	NA	31.2	27.9	29.6	28.3
Mean	22.6	26.3	25.0	23.5	24.1	23.9

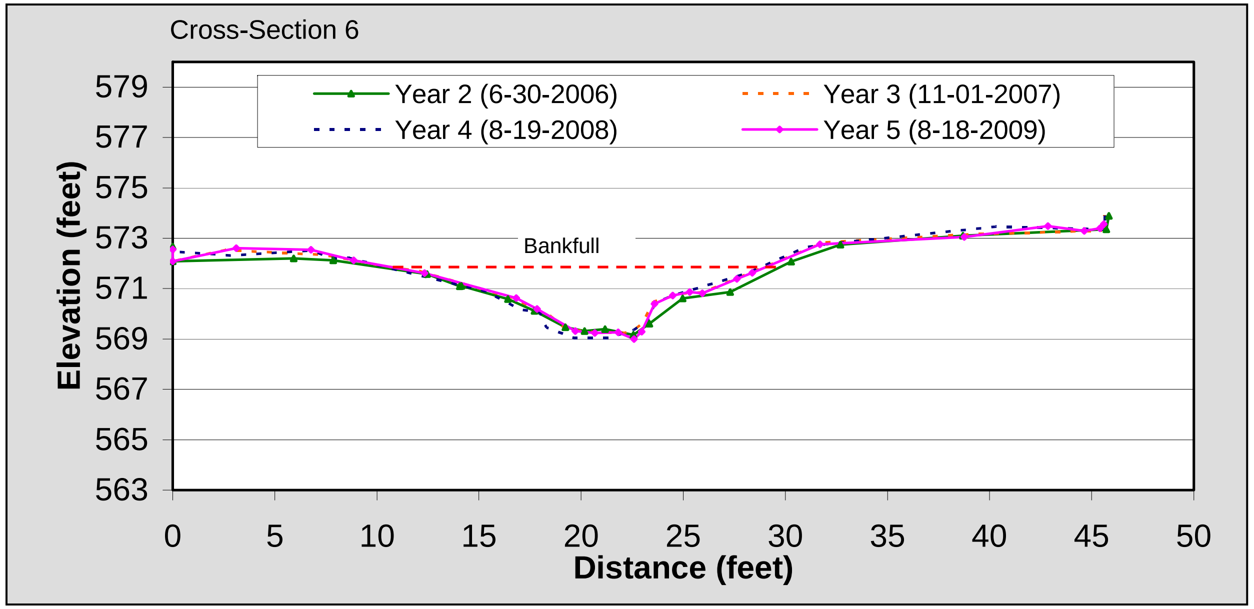
Figure 4. Riffle cross-section (XS-4) typifying minor incision observed at some riffles. Photo is view facing downstream of cross section 4 vicinity on August 4, 2009

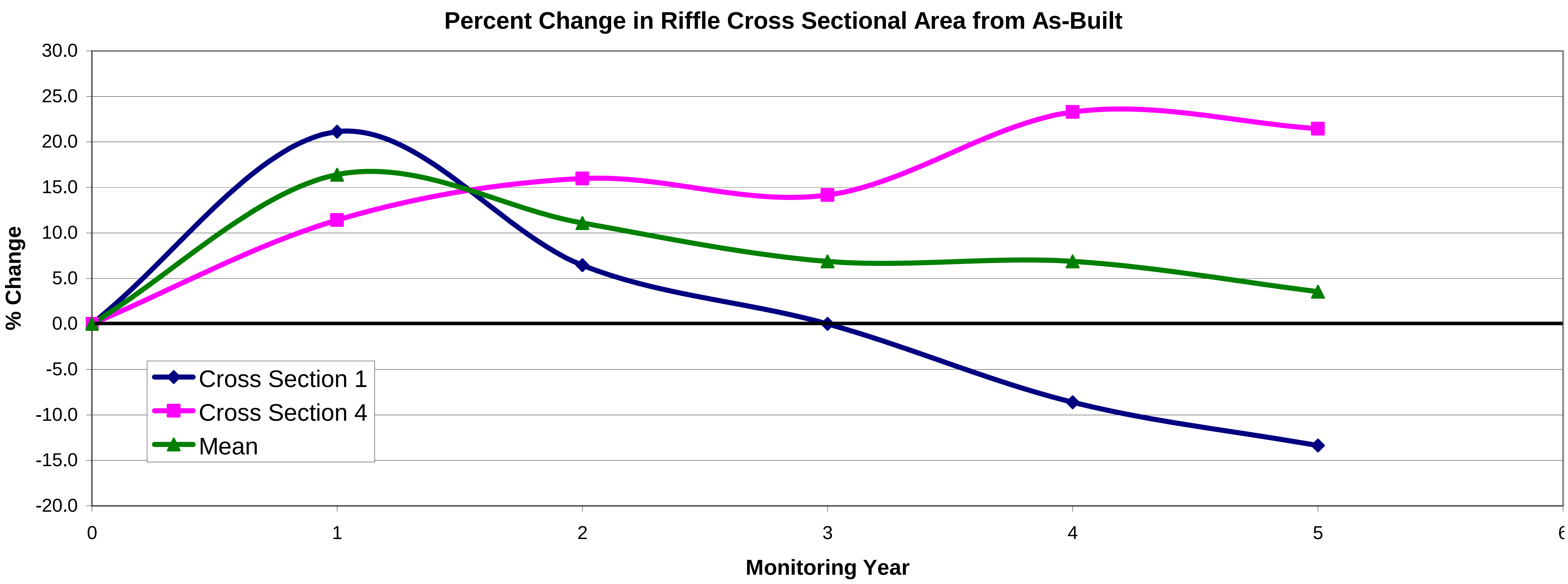
Annual Riffle Cross-Section Overlays











<u>Figure 5</u>. <u>Percent change from As-built cross-sectional area</u>

The production of this type of figure is but one method to assess channel stability. In order for the reach dimension to be considered stable, the change in the cross-sectional area should not be unidirectional, and the amplitude in the variation should not increase over the 5-year monitoring period. A stream's channel dimension may exhibit an initial adjustment before a stable variation pattern can be observed around some new point of equilibrium. This is often due to the fact that there is necessarily some level of uncertainty in any stream design, and the vegetation often takes 2-3 years to exert significant influence on the channel. The above plot includes the percent change relative to the as-built for each of the 4 project riffle cross-sections. The mean is also included. This projects' mean riffle cross-sectional area generally demonstrated a healthy pattern of variability. After an initial moderate increase in area during Monitoring Year 1, the area generally decreased toward As-Built conditions by Monitoring Year 3. This adjustment was followed by less variation in the final monitoring years, indicating the channel dimension likely reached a stable equilibrium. The observed pattern indicated that the intended floodplain access was provided and maintained. Maintenance of a mean entrenchment ratio of greater than 3.75 over the four riffle cross-sections supported this observation.

Profile

The reach demonstrated some vertical adjustment during Monitoring Years 1 – 3 in the form of aggradation in riffles, followed by stabilization of these areas in the final Monitoring Years. During Monitoring Year 2, 244 lf (8%) of the monitoring reach was noted to be affected by aggradation. During Monitoring Year 3, 293 lf (9%) of the monitoring reach had noted aggradation. However, riffle aggradation areas were probably normal post-construction channel adjustments in the form of the riffles narrowing to a stable dimension. That assessment was based on the trend observed during the final two Monitoring Years of aggradation clearing within the thalweg. By the final Monitoring Year, only one area (17 lf) of aggradation was found within a riffle, affecting 1% of the channel bed. No channel downcutting was documented during the five year monitoring period. The Monitoring Year 5 measured profile indicated that the project reach was vertically stable overall when compared to the project baseline. The figure below provides a sample of the surveyed profile. Bedform slope and spacing distributions naturally varied from year to year, but distinct riffle-pool bedform distributions were maintained, providing diversity in the bedform.

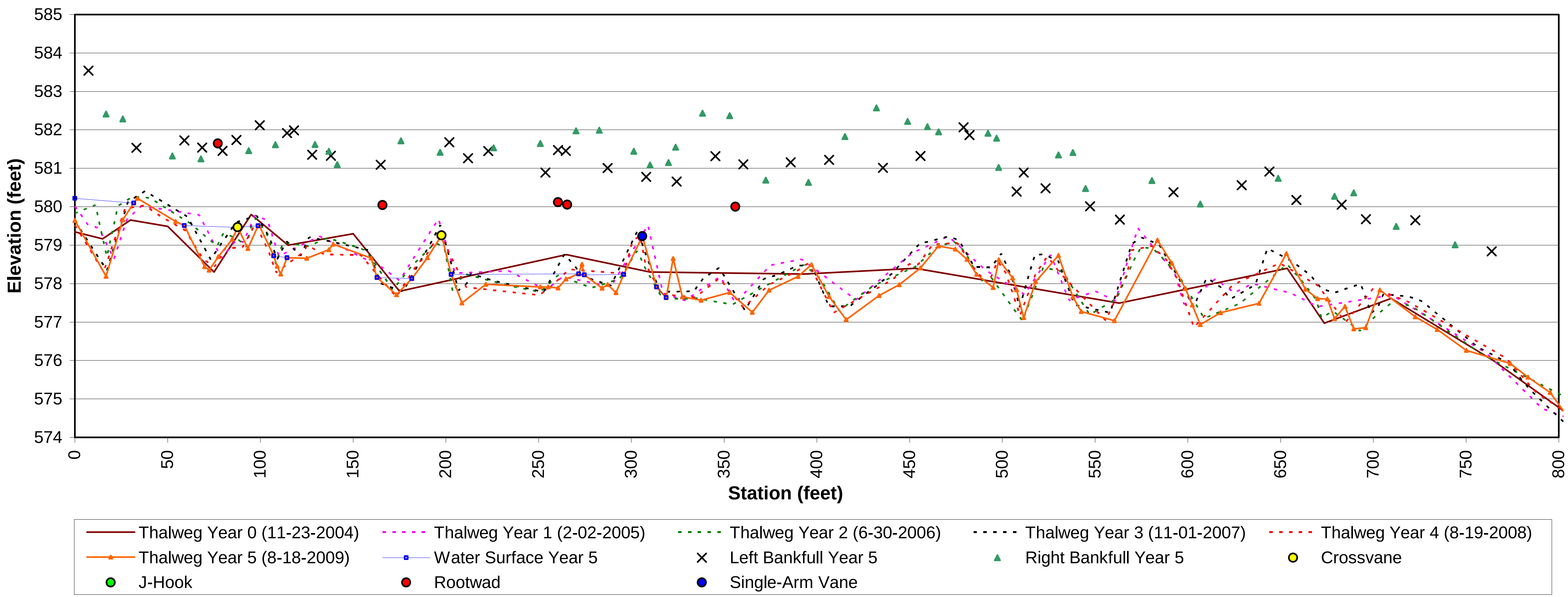


Figure 6. Longitudinal Profile Segment (Station 0+00 to 8+00). Note: The As-Built (MY-0) datum was of a different standard (coarser) than subsequent surveys.

Substrate

The substrate data was variable and indicated sediments were being moved by the system, but were not always deposited in bedforms that were typical for the observed substrate size class distributions. The restoration plan indicated that the material in the existing channel was primarily gravel, and the restored channel bed should maintain a bimodal gravel and bedrock substrate distribution (i.e., Rosgen stream type C4/1 design goal). Overall, while there were fluctuations in the substrate size distributions, the distributions indicated that the restored channel had sand and silt as the main components of the bed substrate. This trend probably was not a result of poor design, but a result of the channel drying during at least the last three monitoring years. All pebble counts in these final Monitoring Years were performed in a dry channel where fine sediments settled out in riffles as flow levels receded. During dry periods, grass grew and took over in parts of the channel, and soil development started to occur. Many of the riffle pebble counts were performed in a grass-covered channel where the grass roots appeared to facilitate the retention of silts and fine sediments. Pebble counts would probably indicate a condition much closer to the design intent if pebble counts were performed while the channel had surface flow and was allowed to flush these fines out of the riffles.

Cross Section 1 – Riffle: Monitoring Year 5 - Coarse sand (d50) to Medium gravel (d84). Significant fining occurred in Monitoring Year 4 with coarsening in Monitoring Year 5.

Cross Section 3 – Riffle: Monitoring Year 5 - Silt (d50) to Very Coarse Sand (d84). Significant fining occurred in Monitoring Year 4 with coarsening in Monitoring Year 5. Had high percentage of silt in Monitoring Year 5.

Cross Section 4 – Riffle: Monitoring Year 5 - Silt (d50) to Medium Gravel (d84). Significant fining occurred in Monitoring Years 1 – 3, coarsening in Monitoring Year 5, and significant silt fining again in Monitoring Year 5. Had high percentage of silt in Monitoring Year 5.

Cross Section 6 – Riffle: Monitoring Year 5 - Coarse Sand (d50) to Very Coarse gravel (d84). Coarsening occurred during Monitoring Years 2 – 3, and significant fining occurred during Monitoring Years 4 and 5. Had high percentage of silt in Monitoring Year 5.

Table 3. Project Bedform Substrate Means (Monitoring Years 1 – 5)

Mean (All Monitoring)	**D50**	**D84**	**Mean (All Monitoring)**	**D50**	**D84**
Cross Section 1 - Riffle	0.66	11.83	**Cross Section 2 - Pool**	0.33	1.66
Cross Section 3 - Riffle	0.07	0.38	**Cross Section 5 - Pool**	0.89	9.82
Cross Section 4 - Riffle	0.72	10.29			
Cross Section 6 - Riffle	1.39	32.25			

Status of Engineered Structures

Grade control structures were comprised of rock single-arm vanes, rock cross vanes, rock j-hooks, and rootwads. There are 23 rock structures and 30 rootwads along the project. Of all rock structures, only two cross vanes were noted to have severe problems during Monitoring Year 5. The cross vane at Station 30+00 (2,000 feet downstream of start of project reach) had the bulk of water flowing under and around a large rock on the left arm of the structure. The second severe structure problem was with the cross vane located at Station 33+20 (2,320 feet downstream of start of project reach) where significant back arm scour of the right structure arm was noted, and some rocks appear to have dislodged, leaving exposed matting. Otherwise, there were two cross vanes and a rock single-arm vane that had some minor piping, and a rootwad with some minor scour around the structure footing, but none of these problems were of severe concern. According to visual surveys, 95% of grade-control structures and 98% of rootwads were documented to be performing in a stable condition during the final monitoring year. The channel grade was maintained throughout monitoring, and the majority of structures were providing the intended function.

Vegetation

The final planted seedling density across all vegetation plots was 436 stems per acre, meeting the Monitoring Year 5 stem density goal of 260 stems/acre. Planted stem densities were limited to a level below the final Monitoring Year 5 goal of 260 stems per acre in 5 of the 12 plots. However, it should be noted that a multitude of native volunteer stems were counted in all plots. With the inclusion of these volunteers in density calculations, all plots passed the Monitoring Year 5 stem density goal of 260 stems per acre. Many overstory trees were left immediately adjacent to project planting areas during the Reedy Branch restoration. These trees are likely the source of many of the volunteer stems, and possibly a contributor to the limited survival of planted stems due to a high amount of shading along the project.

Table 4. Project Stem Counts

Planted Stem Density (stems per Acre) by Plot														
			Plots											
MY	**CY**	**Avg**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Y0*	2004*	**N/A**	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Y1*	2005*	**N/A**	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Y2	2006	**926**	1,466	868	1,864	934	861	663	671	454	1,045	875	458	942
Y3	2007	**556**	1,340	744	1,419	447	533	290	210	124	669	239	250	409
Y4	2008	**477**	1,340	537	1,378	366	369	248	168	124	376	239	166	409
Y5	2009	**436**	1,340	372	1,378	325	287	166	168	165	376	199	166	287

*The Monitoring Year 1 final report indicated that planting was performed only two months prior to the monitoring work, so no vegetation monitoring was performed. Therefore, no baseline stem count data are available from the As-Built or first monitoring year.

Figure 7. Debris caught in cattle fencing above bankfull elevation on October 13, 2008.

Overbank Events

There have been 3 separate over-bank flow events that were documented by crest gauge readings. These observations were made on August 8, 2006; January 11, 2007; and January 15, 2009. At least one over-bank event occurred sometime between August 27 and September 7, 2008. This event was confirmed through observation of significant wrack lines, new cattle fencing damage, and large amounts of debris caught in cattle fencing above bankfull elevation on October 13, 2008. To confirm this observation, the NOAA NCDC Graham 2 ENE, NC substation (ID 313555) reported a 6.58 inch rain event that occurred on August 27-28, 2008, and a 2.35 inch event that occurred on September 6-7, 2008. In addition to these observations, there were three 1.5+ inch rain events noted over the monitoring period. The monitoring success criterion of two separate bankfull events in separate years was met.

Project Goals, Outcomes and Conclusions:

The above is a summary of documentation from the Reedy Branch restoration plan, mitigation plan, and monitoring reports, which should be consulted if additional detail is necessary. Reedy Branch was a typical stream within this and surrounding watersheds, exhibiting instability and degradation in response to current and historical land use practices. Reedy Branch is a tributary of Cane Creek in the Cape Fear River Basin. The project site is located off of Quakenbush Road near Snow Camp, NC. Cattle pasture and chicken production make up the farming practices on the farm surrounding the restoration site. The restored stream is enclosed in a moderately dense wooded area and contains large bedrock outcrops as well other sporadic occurrences of bedrock throughout the reach. The site is located in the Carolina Slate Belt, known for shallow soils and high run-off during storm events resulting in very "flashy" flows, and streams that are unable to sustain flow during base-flow periods (Weaver and Pope 2001; Weaver and Fine 2003). This summer drying trend was confirmed during Monitoring Years 3 through 5. The goals and objectives of this project were as follows:

- Improve water quality by reducing the sediment load generated by eroding banks and by restoring a riparian buffer
- Reestablish stable channel dimension, pattern, and profile
- Restore a functioning floodplain
- Enhance aquatic and terrestrial habitat in the stream corridor
- Provide at least one stable cattle crossing across the main channel.

Livestock were excluded from the entire project, except where two cattle crossings were installed as part of the restoration. Both cattle crossings were noted to have severe fencing damage as a result of flooding in the past. Both crossings experienced damaged fencing, dislodged fence posts, and scour of the gravel path. Both of these crossings will be repaired in 2010. As noted in the Project Timeline table on page 1 of this report, warranty repair work was performed on the project in May of 2005 (Monitoring Year 1). There were three problems that were repaired. The first was a small area of run-on erosion down-slope from one of the construction access areas. The second area was a cross vane that was leaking. The last repair area was a section of cattle crossing fence that was pulled down during a storm flow event. The landowner repaired this fencing at his own expense, with help from the local County Extension Office.

The restored Reedy Branch stream reach exhibited geomorphologic stability (including minimal bank erosion or other instabilities), maintained floodplain access, and was surrounded by a diverse riparian buffer that provides significant stream shading. According to visual surveys, 99% of the banks along the project were performing in a stable condition (i.e., no bank erosion) during the final monitoring year. Visual surveys also revealed that 90% of riffles and 89% of pools are performing in a stable condition during the final monitoring year. The restored pattern, dimension, and profile have maintained distinct bedforms and have yielded improved quality distribution of in-stream habitat. Currently, the major habitat limitation with this project is the trend that the reach goes dry during the summer, limiting the diversity of aquatic organisms that are able to inhabit the reach.

Collectively, the characteristics of the projects' assets and their measured performance yielded the ratios listed in Table 1. EEP considers the project to be functioning well with a trajectory such that the sites potential functional uplift has or will be realized. EEP seeks regulatory closure on the assets detailed in Table 1.

References

Weaver, J.C., and B.F. Pope. 2001. Low-Flow Characteristics and Discharge Profiles for Selected Streams in the Cape Fear River Basin, North Carolina, through 1998. USGS Water Resource Investigations Report 01-4094: 1-140.
Weaver, J.C., and J.M. Fine. 2003. Low-Flow Characteristics and Profiles for the Rocky River in the Yadkin-Pee Dee River Basin, North Carolina, through 2002. USGS Water Resource Investigations Report 03-4147: 1-50.