CARBONTON DAM – DEEP RIVER WATERSHED RESTORATION SITE
2009 Annual Monitoring Report (Year 4)

Ecosystem Enhancement Program

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2009 Annual Monitoring Report (Year 4)

Chatham, Lee and Moore Counties, NC
NCEEP Project No. D-04012A
Design Firm: Milone and MacBroom, Inc.

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Ecosystem Enhancement PROGRAM

November 2009

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EXECUTIVE SUMMARY

Introduction

Dam removal projects performed pursuant to the guidance released by the North Carolina Dam Removal Task Force (DRTF) are required to quantitatively demonstrate chemical and biological improvements to restored in-channel ecosystems in order to achieve compensatory mitigation credit (DRTF 2001). The following monitoring report documents the latest efforts of Restoration Systems, LLC, on behalf of the N.C. Ecosystem Enhancement Program (NCEEP), to document changes in the study area of the Carbonton Dam removal project (Cape Fear Hydrologic Unit 03030003). The suite of ecological evaluations performed and described herein establishes new standards for mitigation monitoring. This standard is in keeping with the goal set forth by state and federal agencies to provide functional ecological gains to North Carolina watersheds through the efforts of the NCEEP and its contract partners.

The site of the former Carbonton Dam is approximately 9 miles west of Sanford, North Carolina at the juncture of Chatham, Lee, and Moore Counties, North Carolina (Figure 1, Appendix A). The on-site dam removal activities restored natural flow to approximately 126,673 linear feet of the Deep River and associated tributaries from the impounding impact of the dam. The limits of the former Site Impoundment have been identified as any stream reach of the Deep River or associated tributaries located above the former Carbonton Dam with a thalweg elevation less than 227.6 feet above mean sea level (MSL), prior to dam removal. Impacts to water quality within the former Site Impoundment (i.e., river and stream reaches formerly impounded by the dam) were manifested in the form of lower dissolved oxygen concentrations, higher temperatures, and increased sedimentation. The character of the aquatic communities within the former Site Impoundment shifted from a free-flowing (lotic) river system to an impounded (lentic) condition following construction of a dam at the site. Rare and endangered mussel and fish habitat, which depended on free-flowing lotic conditions, was absent or greatly diminished within areas of the Deep River impounded by the former dam. These affected stream reaches will be hereafter referred to as the former "Site Impoundment."

The dam was removed in a manner that minimized impacts to water resources both upstream and downstream of the dam site. Dam removal began with dewatering (lowering) of the Site Impoundment on October 15, 2005, followed by breaching on November 11, 2005. Demolition activities continued in stages until dam removal was completed on February 3, 2006.

Fourth-year monitoring activities began in April 2009. Monitoring is being performed for a minimum of five years, post dam removal--or until success criteria are achieved. Post removal monitoring data will be compared to baseline values collected in April-June 2005, Year-1 monitoring values collected in April-June 2006, Year-2 monitoring values collected in March-July 2007, and Year-3 monitoring values collected in March-September 2008.

Monitoring Plan

A monitoring plan was developed in accordance with the DRTF guidelines to evaluate the fulfillment of the project's primary success criteria, which include:

1) Re-colonization of rare and protected aquatic species, 2) improved water quality, and 3) an improved aquatic community. Reserve success criteria include: 1) downstream benefits below the dam, and 2) human values (scientific contributions and human recreation).

In order to evaluate project success for the above criteria, a monitoring network was deployed in 2005 throughout the former Site Impoundment, contributing waters, and reference areas both upstream and downstream of the former dam site (Figure 3, Appendix A). Within the established network, biological surveys were conducted to provide baseline (i.e., pre-dam removal) aquatic community data within the Site Impoundment, and will be monitored until 2010 to assess community changes following dam removal. Monitoring cross-section stations were also established to assess changes in bankfull channel geometry, channel substrate composition, and aquatic habitat. Water quality data within the former Site Impoundment and at a downstream reference area were obtained from North Carolina Division of Water Quality (NCDWQ) Ambient Monitoring Stations (AMS).

Fourth Year Monitoring Results

Water Quality

Ambient Monitoring Station (AMS) data indicate that dissolved oxygen concentrations within the former Site Impoundment continue to persist above the established threshold required to meet the success criteria (mean value is 4.71 mg/L higher than state standard). Additionally, water temperature has remained below the state standard during Year-4 monitoring. Fecal coliform within the former Site Impoundment was below the state standard of 200 colonies/100 ml for all but one sample during Year-4 monitoring. It should be noted that for the event that resulted in high fecal coliform measurements, reference data from the Ramseur station were not sampled on the same day. Additionally, a near 1-inch rain event occurred the day before the date of sampling for the Site Impoundment for both outlying data measurements. Therefore, it is expected that the reference station would have also shown a similar spike in fecal coliform data if they were available.

The Year-4 mean biotic index (used as a proxy for water quality) from formerly impounded stations is within one standard deviation of the reference mean, therefore meeting the established success criteria. Success was previously met for this mitigation goal during Year-1 monitoring (2006). The repeat success in the current monitoring year indicates that drought conditions were likely responsible for missing this goal in 2007 and 2008, and that improved water quality has persisted since dam removal.

Aquatic Community

The successful development of lotic conditions within the Deep River, and the resulting aquatic species colonization, has been documented through the recruitment of the Cape Fear shiner. Riffle/run/pool habitats have formed at varying intervals throughout the restored reaches, promoting lotic fish, freshwater mussel, and snail community recolonization.

Year-4 monitoring focused on continued documentation of fish diversity development, with a focus on the two major tributaries to the Deep River, McLendons Creek and Big Governors Creek. Habitat reconnaissance within McLendons Creek indicates a continued development of lotic conditions with noticeably less fine sediment in the channel substrate. Big Governors Creek exhibits slower development of riffle/run/pool habitats, and a heavy accumulation of woody debris may be slowing the progression towards lotic conditions. While Cape Fear shiner was not collected in either tributary, fish surveys resulted in a total of 19 other fish species and further re-establishment of lotic conditions. This improvement is supported by the increase in abundance (and diversity within Big Governors Creek) of darter species at both sites, as well as two new shiner species.

Benthic data from stations within the former Site Impoundment indicate that the mean values for total organisms, total taxa, and biotic index exceeded values from reference stations in 2009. While the mean number of EPT taxa within impounded stations did not exceed the reference station data, the difference in EPT richness is only two taxa, indicating a continued progression towards reference composition. The highest overall EPT richness (30 EPT taxa) occurred at a formerly impounded station (Station 1, Figure 3) located immediately upstream of the former dam.

The NCDWQ Habitat Assessment Field Data Sheet was completed at each station in order to evaluate the quality of in-stream habitat and to provide a comparable score that describes the available habitat. Compared to baseline conditions (2005), the mean total score of the formerly impounded stations quantitatively increased in Year-4 monitoring from 42.39 to 61.03, indicating improved aquatic habitat.

Rare and Protected Aquatic Species
Success criteria for rare and protected species were met through the recruitment of the Federally endangered Cape Fear shiner and five state-listed mussel species within the formerly impounded reaches of the Deep River. Year-2 fish monitoring resulted in a total of 41 specimens of the endangered Cape Fear shiner. These individuals were identified throughout the former Site Impoundment at eight of the sampling sites, while an additional six sites continue to develop favorable habitat for future colonization.

Fish surveys preformed within McLendons Creek and Big Governors Creek during Year-4 monitoring did not establish the presence of Cape Fear shiner. Mollusk sampling was not performed during Year-4 monitoring, but will be carried out in the final year of monitoring (2010) in order to further demonstrate a shift in mollusk communities from lentic to lotic character.

Reserve Success Criteria
Reserve success criteria have been achieved based on the implementation/refereed publication of scientific research related to the removal of Carbonton Dam, and the establishment of a public park at the location of the former dam. The Carbonton Dam removal project provided funding to the University of North Carolina at Chapel Hill to support original research by Adam Riggsbee, PhD and Jason Julian, PhD. Dr. Riggsbee has published three papers with one in revision from his dam removal research while Dr. Julian has published one paper pertaining to the restored reach of the Deep River.

Furthermore, a new public park has been established at the site of the former dam that consists of vehicle parking, picnicking sites, bank fishing, and improved access to the river for kayakers and canoeists. RS formally transferred the new park to the Deep River Park Association during a ceremony held on the grounds on November 22, 2008.

Summary
After the fourth year of monitoring since the removal of Carbonton Dam, mitigation success criteria has been met for all parameters, and successful restoration of lotic conditions has been demonstrated. Functional improvements have been documented in water quality, fish and mollusk abundance, benthic community, and sediment transport. Mitigation success has been demonstrated for the following criteria:

Re-introduction of rare and endangered aquatic species, water quality improvement with respect to dissolved oxygen concentrations and benthic biotic indices, improved aquatic community, scientific research, and public recreation. The following table summarizes the project success:

	Criterion	Parameter	Anticipated Change/Result	2009 Success
Primary success criteria:	Re-colonization of rare and protected aquatic species	Presence/absence of rare/protected individuals	Re-colonization within former Site Impoundment	Yes
		Rare/protected species habitat	Improvement/expansion	Yes
	Improved water quality	Benthic biotic indices	Decrease (= improve)	Yes
		AMS dissolved oxygen data	Increase within former Site Impoundment (must be ≥ 4.0 mg/L or consistent with reference station data)	Yes
	Improved aquatic community	Ephemeroptera, Plecoptera, and Trichoptera taxa, total number of benthic taxa	Increase (i.e., converge with reference station data)	Yes
		Fish, Mussel, and Snail community data	Demonstrated shifts in communities from lentic to lotic character	Yes
Reserve success criteria:	Downstream benefits below dam	Deep River bankfull channel within formerly eddie/scour pool areas below dam	Narrowing/increased stabilization of channel	Ongoing
	Scientific value	Published research	Successful completion	Yes
	Public recreation	Construction of planned on-Site park	Successful completion	Yes

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1.0 PROJECT BACKGROUND

1.1 Location and Setting

In order to provide stream restoration in the Cape Fear River Basin (Hydrologic Unit 03030003), Restoration Systems, LLC (RS) has removed the Carbonton Dam formerly located at the juncture of Chatham, Lee, and Moore Counties, North Carolina (Figures 1 and 2, Appendix A). The former Carbonton Dam was located on the Deep River approximately 9 miles west of Sanford, North Carolina, immediately downstream of the bridge crossing of NC 42 (35.5200N, -79.3485W). The Deep River is a 4^{th}-order river with a watershed upstream of the former dam location of approximately 1,000 square miles. For the purposes of this document, the 5.5-acre land parcel that supported the dam will be hereafter referred to as the "Site." All construction activities mentioned in this report occurred on-Site, unless specifically mentioned otherwise.

The on-Site construction activities restored the native flow regime to approximately 126,673 linear feet of the Deep River and associated tributaries from the impounding effects of the dam. These restored stream reaches will be hereafter referred to as the "Site Impoundment." The limits of the Site Impoundment have been identified as any stream reach of the Deep River or associated tributaries located above the former Carbonton Dam with a thalweg elevation less than 227.6 feet above mean sea level (MSL), prior to dam removal.

1.2 Restoration Structure and Objectives

The Site Impoundment formerly covered approximately 116 acres with water depths up to 25 feet and bank-to-bank impoundment widths from 150 to 260 feet. The former Site Impoundment was confined within the channel of the Deep River, and was characterized by steep banks with occasional areas of bank failure in locations where mature trees have been toppled by storms or flood flows. The lentic flow that characterized the Site Impoundment resulted in a stratified water column, where velocities were low near the surface, and stagnant at depths below the crest pool elevation.

Site restoration efforts consisted primarily of the physical removal of the Carbonton Dam. Construction activities associated with the removal of the dam were phased in order to minimize disturbance to aquatic resources upstream, downstream, and in the immediate vicinity of the Site. Furthermore, throughout the dam removal process, construction best management practices were utilized to prevent and minimize potential impacts to aquatic resources.

The demolition and removal of the Carbonton Dam is expected to generate at least 90,494 Stream Mitigation Units (SMUs) for use by the North Carolina Ecosystem Enhancement Program (NCEEP). The majority of the credits generated by this project will be validated by evaluating the ecological benefits that occur in the Deep River over the five-year, post-removal monitoring period. Bonus factors (reserve success criteria) include downstream benefits and human values such as recreation and scientific research. Table 1 presents the amount of SMU credits that are proposed for this project. The primary success criteria are being monitored in accordance with the North Carolina Dam Removal Task Force (DRTF) guidance. The mitigation ratios have also been derived from the DRTF guidance (DRTF 2004). The amount of restored channel was determined through methods described in Section 1.1.2 of the Restoration Plan (Restoration Systems 2005). The number of SMUs were determined by multiplying the amount of channel returned to lotic condition (linear feet) by the mitigation ratios. While up to 101,688 SMUs may be potentially created in accordance with the DRTF guidance, the project will only be evaluated for the amount of credit that is committed to NCEEP.

Table 1. Stream Mitigation Units (SMUs)[1] Generated by Removal of the Carbonton Dam			
Primary Success Criteria	**Channel Restored (feet)**	**Mitigation Ratio**	**SMU**
1) Water Quality 2) Improved Aquatic Community 3) Rare and Protected Aquatic Species	126,673 feet of free-flowing river and tributaries **under the crest pool**	0.7:1	88,671
Reserve Success Criteria	**Channel Restored (feet)**	**Mitigation Ratio**	**SMU**
Downstream Benefits Below the Dam	~ 500 feet below dam	0.7:1	350
Human Values 1) Human recreation 2) Scientific value	-----	10 percent bonus	12,667
		Total Potential SMUs	101,688
		Total Committed SMUs	**90,494**

[1] Primary success criteria will be monitored to verify and confirm positive changes to each functional criterion as outlined in this report and in the Dam Removal Guidance. Reserve criteria will be monitored for possible augmentation of the primary SMUs. If all primary criteria are successfully met, these reserve criteria should result in excess, unsold credits becoming available at the end of the monitoring period

1.3 Project History and Background

Table 2. Project Activities and Reporting History: Carbonton Dam Restoration Site			
Activity Report	Scheduled Completion	Data Collection Complete	Actual Completion or Delivery
Restoration Plan	July 2004	N/A	August 2005
Final Design	July 2004	N/A	August 2005
Construction	February 2006	N/A	February 2006
Temporary S&E mix applied to entire project area	February 2006	N/A	February 2006
Permanent seed mix applied to reach/segments	February 2006	N/A	February 2006
Installation of Trees and Shrubs	March 2006	N/A	March 2006
Mitigation Plan	January 2005	N/A	June 2006
Minor repairs made filling small washed out areas	N/A	N/A	N/A
Final Report	N/A	N/A	N/A
Year-1 Vegetation Monitoring	N/A	N/A	N/A
Year-1 Stream Monitoring	September 2006	July 2006	September 2006
Year-2 Stream Monitoring	September 2007	July 2007	November 2007
Year-3 Stream Monitoring	September 2008	October 2008	November 2008
Year-4 Stream Monitoring	September 2009	October 2009	November 2009

1.4 Project Mitigation Goals

The desired result of this project is ecological improvement within the former Site Impoundment through restoration of natural, lotic flow conditions.

The specific goals of this project include:

- Restoration of approximately 126,673 linear feet of impounded Deep River and associated tributaries to natural, free-flowing riverine conditions.
- Restoration of previously inundated shallow water habitat for the Cape Fear shiner (*Notropis mekistocholas*), a federally endangered freshwater fish.
- Reduction or elimination of thermal stratification, which results in seasonal declines in dissolved oxygen concentrations below levels measured in reference reaches.
- Restoration of appropriate in-stream substrate.
- Restoration of upstream and downstream fish passage, and reconnection of currently disjunct populations of rare aquatic species of concern.
- Restoration of lotic mussel habitat.
- Improvement in the diversity and water quality tolerance metrics for benthic macroinvertebrate communities.
- Provide public recreational opportunities at the site of the former dam.
- Support independent academic research, resulting in peer-reviewed publications regarding the ecological consequences of large dam removal.

Table 3. Project Contacts: Carbonton Dam Restoration Site	
Designer Milone and MacBroom, Inc. (MMI)	307B Falls Street Greenville, SC 29601 (864) 271-9598
Construction Contractor Backwater Environmental, Inc.	P.O. Box 1654 Pittsboro, NC 27312 (919) 523-4375
Planting Contractor Carolina Silvics, Inc.	908 Indian Trail Road Edenton, NC 27932 (252) 482-8491
Seeding Contactor Backwater Environmental, Inc.	P.O. Box 1654 Pittsboro, NC 27312 (919) 523-4375
Seed Mix Sources Mellow Marsh Farm	1312 Woody Store Road Siler City, NC 27344 (919) 742-1200
Nursery Stock Suppliers Mellow Marsh Farm	1312 Woody Store Road Siler City, NC 27344 (919) 742-1200
Coastal Plain Conservation Nursery	3067 Conners Drive Edenton, NC 27932 (252) 482-5707
Taylor's Nursery	3705 New Bern Avenue Raleigh, NC 27610 (919) 231-6161
International Paper Nursery	5594 Highway 38 South Blenheim, SC 29516 (800) 222-1290
Ecological Monitors PBS&J (formerly EcoScience Corporation)	 1616 East Millbrook Road, Suite 310 Raleigh, NC 27609 (919 876-6888
The Catena Group (TCG)	410-B Millstone Drive Hillsborough, NC 27278 (919) 732-1300
Stream Monitoring POC	Matt Cusack
Vegetation Monitoring POC	N/A (project does not require vegetation monitoring)

Table 4. Project Background: Carbonton Dam Restoration Site	
Project County	Chatham, Lee, and Moore Counties NC
Drainage Area	Approximately 1000 square miles
Impervious cover estimate (%)	<10%
Stream Order	4^{th}-order
Physiographic Region	Piedmont
Ecoregion (Griffith and Omernik)	Triassic Basin
Rosgen (1994) Classification of As-built	N/A
Cowardin Classification	R2SB3/4
Reference Site ID	Deep River
Dominant Soil Types	N/A (stream restoration project only)
USGS HUC for Project and Reference	03030003
NCDWQ Sub-basin for Project and Reference	03-06-10
NCDWQ classification for Project and Reference	WS-IV HQW, WS-V HQW
Any portion of any project segment 303d listed?	No (NCDWQ 2006)
Reasons for 303d listing or stressor	
Any portion of any project segment upstream of a 303d listed segment?	Yes, Deep River, Sub-basin 03-06-11 (NCDWQ 2006)
Reasons for 303d listing or stressor	MS4 NPDES
Percent of project easement fenced	N/A

2.0 PROJECT MONITORING AND RESULTS

The monitoring results described herein document the Year-4 (2009) monitoring activities performed to determine the project's success in meeting the stated mitigation goals. Monitoring activities occurred at fifty-one (51) stations established prior to dam removal in 2005, as part of the monitoring deployment network (Figure 3, Appendix A). One (1) additional station was added during the first year of monitoring bringing the total number of stations to fifty-two (52). Pre-removal baseline data (2005), Year-1, Year-2, Year-3 and Year-4 monitoring data are compared to evaluate improvements in water quality, the aquatic community, rare and protected species, and human values within the former Site Impoundment.

2.1 WATER QUALITY

2.1.1 Biotic Indices

Benthic macroinvertebrates were sampled within the former Site Impoundment, as well as in the reference reaches both within the Deep River and its major tributaries. Stations were visited prior to dam removal (2005) and subsequently sampled in 2006, 2007, and 2008 at the same locations. Many of those stations were resampled during Year-4 monitoring, as well as 6 new sites (Stations 56-61, [Figure 3, Appendix A]) selected for their high quality benthic macroinvertebrate habitat, which closely resembles reference conditions. Reference stations that were selected prior to dam removal were targeted within areas of the Deep River that contained the greatest amount of benthic habitat. Stations within the former Site Impoundment were also selected prior to dam removal, but the amount of habitat that would develop after dam removal was unknown. As lotic conditions developed within the former Site Impoundment, it became clear that certain stations within the former Site Impoundment (Stations 3, 5, 8, and 10) would never provide the benthic habitat found at the reference stations. The new benthic sampling stations take the place of those previously sampled, including Stations 3, 5, 8, and 10.

After identification of collected macroinvertebrates, the North Carolina Tolerance Values or Hilsenhoff Tolerance Values were assigned to each of the collected species. These Tolerance Values range from zero (0) for organisms intolerant of organic wastes to 10 for organisms very tolerant of organic wastes. The biotic indices of each station sampled for benthic macroinvertebrates were tallied, and then summary data were generated for comparison between formerly impounded and reference stations. Success for this particular mitigation goal was achieved in Year-4 monitoring based on the established criteria that requires the mean biotic index of the impounded stations to be within one standard deviation of the mean biotic index of the reference stations. The mean biotic index from Year-4 monitoring in the formerly impounded stations (μ=5.94) is within one standard deviation of the reference station (μ=6.19). This success criteria was previously met during Year-1 monitoring (2006). The repeat success in the current monitoring year indicates that drought conditions may be responsible for missing this goal in 2007 and 2008, and that improved water quality has persisted since dam removal. Table 5 presents the summary data for benthic biotic indices of both formerly impounded and reference stations.

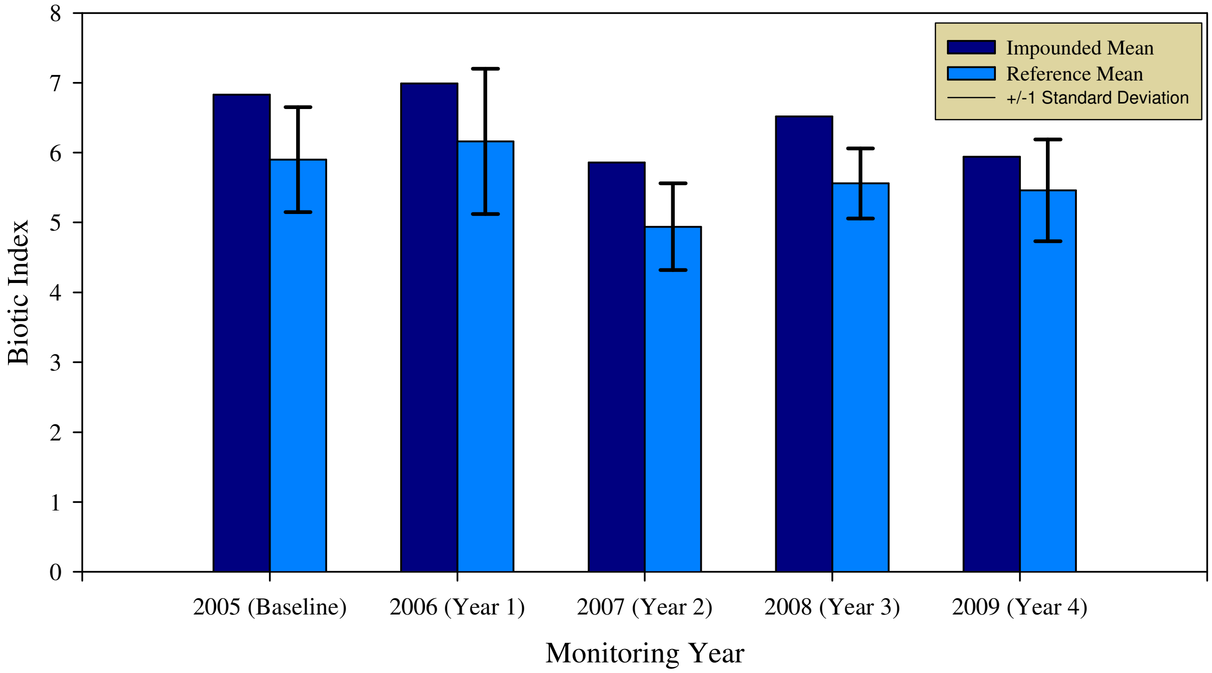
Table 5. Benthic Biotic Indices of Formerly Impounded and Reference Stations

	2005 (Baseline)		2006 (Year 1)		2007 (Year 2)	
	FORMERLY IMPOUNDED STATIONS	REFERENCE STATIONS	FORMERLY IMPOUNDED STATIONS	REFERENCE STATIONS	FORMERLY IMPOUNDED STATIONS	REFERENCE STATIONS
	Biotic Index	Biotic Index	Biotic Index	Biotic Index	Biotic Index	Biotic Index
High	7.97	6.91	8.58	7.62	8.52	5.71
Low	5.67	4.78	5.76	4.29	4.28	3.92
Mean	**6.83**	5.9	**6.99**	6.16	**5.86**	4.94
Median	6.79	5.99	6.72	6.02	5.3	5.02
Standard Deviation	0.83	0.75	0.95	1.04	1.52	0.62
Standard Deviation of Reference mean **(Success Criterion)**	**6.65**		**7.20**		**5.56**	

	2008 (Year 3)		2009 (Year 4)		2010 (Year 5)	
	FORMERLY IMPOUNDED STATIONS	REFERENCE STATIONS	FORMERLY IMPOUNDED STATIONS	REFERENCE STATIONS	FORMERLY IMPOUNDED STATIONS	REFERENCE STATIONS
	Biotic Index	Biotic Index	Biotic Index	Biotic Index	Biotic Index	Biotic Index
High	8.19	6.36	7.60	6.47		
Low	5.13	4.66	4.97	4.52		
Mean	**6.52**	5.56	**5.94**	5.46		
Median	6.40	5.60	5.63	5.60		
Standard Deviation	1.05	0.50	0.86	0.73		
Standard Deviation of Reference mean **(Success Criterion)**	**6.06**		**6.19**			

Graph 1 depicts the change in biotic indices from 2005 to present from both the formerly impounded and reference stations.

Graph 1. Mean Biotic Index of Formerly Impounded Stations vs. Reference Stations with Standard Deviation
Note: A lower index value is indicative of less tolerant species (= higher water quality)



2.1.2 Ambient Monitoring Station Network

Aside from the *in situ* sampling occurring at each monitoring station, physical water quality parameters are currently collected at an Ambient Monitoring Station (AMS) located within the former Site Impoundment at NC 42 (B5575000), immediately upstream of the former Carbonton Dam. A reference AMS is located on the Deep River at Ramseur, NC (B5070000). These data have been obtained from the North Carolina Division of Water Quality (NCDWQ), and data coverage exists on a monthly basis for at least the last 10 years. AMS data dating back five years prior to dam removal are used to provide a historical record of water quality for comparison to post-removal sampling. Due to time delay between collection date and public availability, the most recent AMS data available from NCDWQ is through April 6, 2009 at NC42, and through June 30, 2009 at Ramseur. Data collected by the AMS are not standard for all samples, but are always sampled at 0.1 meter depth and can include: water temperature (ºC), dissolved oxygen (mg/L), pH (field measured), conductance at 25ºC (µmhos/cm), turbidity (NTU), fecal coliform bacteria (number of colonies/100 milliliters), suspended residue (total suspended solids) (milligrams/Liter), ammonia as nitrogen (milligrams/Liter), total Kjeldahl nitrogen (milligrams/Liter), nitrite and nitrate as nitrogen (milligrams/Liter), total phosphorus (milligrams/Liter), and assorted metals. AMS data are used to evaluate physical water chemistry and associated parameters throughout the project's monitoring period. Water quality trends from AMS data are utilized in determining the project's overall success, using state standards established by NCDWQ's "Redbook".

2.1.2.1 Dissolved Oxygen

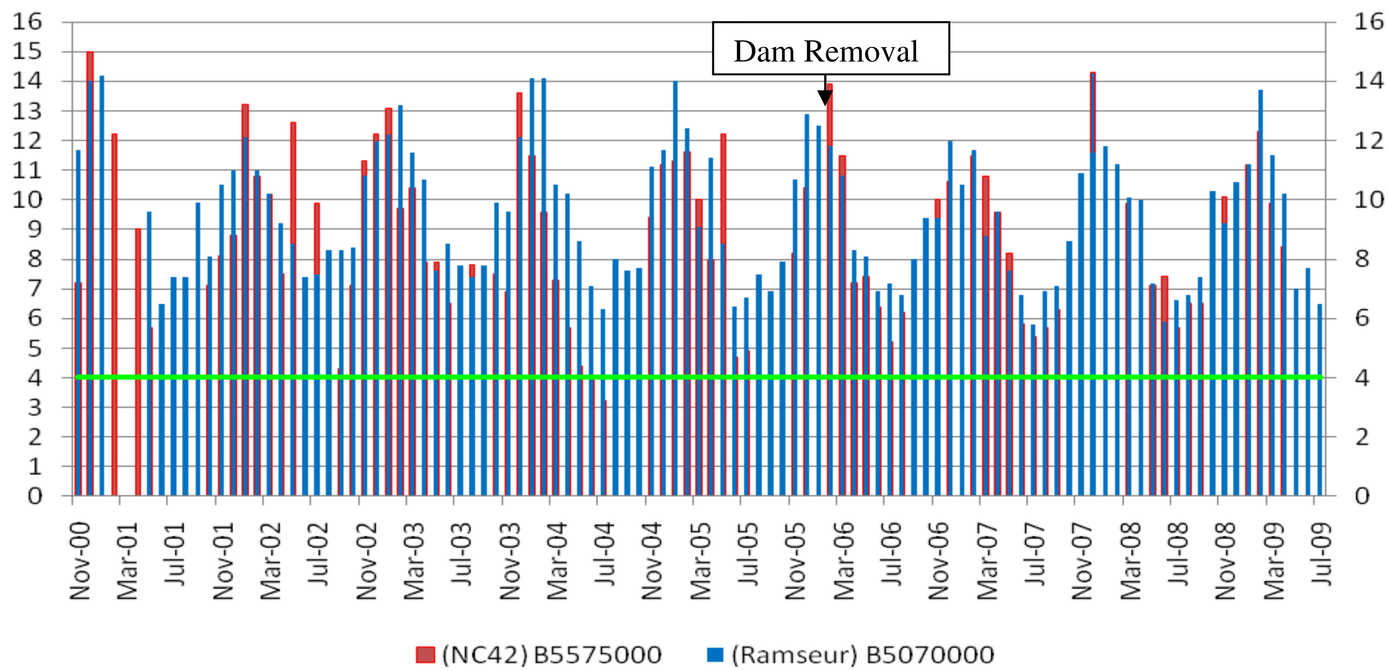
In order to achieve success, dissolved oxygen concentrations within the former Site Impoundment should not fall below the minimum NCDWQ standard for Class WS-IV waters (unless a similar failure is recorded at the reference station). The NCDWQ standard is an instantaneous value of no less than 4.0mg/L (daily average no less than 5.0 mg/L). Table 6 provides the minimum, maximum, and mean instantaneous values for dissolved oxygen recorded within the former Site Impoundment, as well as the number of samples that fell below the state standard for all monitoring years. Mean value for dissolved oxygen in Year-4 was 8.71 mg/L and exceeded the state standard for all samples.

Table 6. Dissolved Oxygen Summary Data

	Baseline	Year-1	Year-2	Year-3	Year-4
Minimum Value (mg/L)	1.10	7.20	5.20	5.40	5.70
Maximum Value (mg/L)	15.00	13.90	10.60	14.30	12.3
Mean Value (mg/L)	8.07	10.87	7.41	8.62	8.71
Number of Samples Below State Standard	6	0	0	0	0

Graph 2 below depicts the AMS dissolved oxygen concentrations measured at a 0.1 meter depth within the Site Impoundment (B5575000), and at the reference location (B5070000), from December 2000 through July 2009. Since the removal of Carbonton Dam, instantaneous dissolved oxygen concentrations within the former Site Impoundment have remained at or above 4.0 mg/L. It is expected that dissolved oxygen levels within the former impoundment will stay above the state standard as free-flowing conditions persist.

Graph 2. Recorded Dissolved Oxygen Concentrations in the Deep River
Note: Green line indicates state standard of 4.0mg/L



2.1.2.2 Temperature

In order to achieve success, the water temperature within the former Site Impoundment should not exceed the NCDWQ standard of 90 degrees Fahrenheit during the monitoring period. Table 7 provides the minimum, maximum, and mean values for water temperature recorded within the former Site Impoundment during all monitoring years, as well as the number of samples the recorded value exceeded the state standard.

Table 7. Water Temperature Summary Data

	Baseline	Year-1	Year-2	Year-3	Year-4
Minimum Value (deg F)	65.48	41.18	45.32	41.36	44.40
Maximum Value (deg F)	87.62	64.58	85.82	84.02	83.48
Mean Value (deg F)	63.26	52.76	67.57	63.99	62.86
Number of Samples Exceeding State Standard	0	0	0	0	0

Water temperature within the former Site Impoundment has remained below the state standard of 90 degrees Fahrenheit since dam removal on February 3, 2006.

2.1.2.3 Fecal Coliform

In order to achieve success, fecal coliform concentrations within the former Site Impoundment should not exceed an average daily count of 200/100 ml in any 30-day period. Table 8 shows the minimum, maximum, and mean values for fecal coliform recorded within the former Site Impoundment during all monitoring years, as well as the number of samples the recorded value exceeded the state standard.

Table 8. Fecal Coliform Summary Data

	Baseline	Year-1	Year-2	Year-3	Year-4
Minimum Value (count/100 ml)	3	22	26	14	8
Maximum Value (count/100ml	6300	47	160	5800	2500
Mean Value (count/100ml)	369.7	35.7	62.6	782.3	237.9
Number of Samples Exceeding State Standard	31	0	0	2	1

Fecal coliform within the former Site Impoundment exceeded the state standard of 200/100 ml once during Year-4 monitoring. With the exception of this single event, all other daily fecal coliform values recorded during Year-4 monitoring were significantly lower than the state standard (≤200/100 ml).

It should be noted that for the single event that resulted in high fecal coliform measurement (2500/100ml), reference data from the Ramseur station were not sampled on the same day. Additionally, a near 1-inch rain event occurred the day before the date of sampling for the Site Impoundment for the outlying data measurement. Therefore, it is expected that the reference station would have also shown a similar spike in fecal coliform data if had been collected on the same day.

2.2 AQUATIC COMMUNITIES

To determine success for the aquatic community's habitat criterion, the former Site Impoundment was monitored for baseline data and included benthic macroinvertebrates, fishes, mussels, and snails, as well as the quality of available microhabitats that developed. Benthos, fishes and mussel and snail sampling following dam removal will be used to demonstrate an increased abundance and quality of aquatic habitat within restored reaches of the Deep River and its tributaries.

2.2.1 Benthic Macroinvertebrates

The comparative metrics utilized for the success evaluation include the total number of organisms collected, the total taxa represented in the samples, the richness (diversity) of taxa from the Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) Orders (hereafter referred to as EPT taxa), and the biotic index of organic waste tolerance. Benthic macroinvertebrate data, located in Appendix B, are based on laboratory identifications of benthic macroinvertebrate taxa by Pennington and Associates, Inc. (P&A) of Cookeville, Tennessee. P&A is a NCDWQ-certified benthic identification laboratory.

Table 9 provides the baseline and Year-1 through Year-4 summary data for the benthic macroinvertebrate collections. The summary data shows that the mean values of total organisms, total taxa, EPT richness, and biotic index all improved at formerly impounded stations in Year-4 monitoring compared to last year. The mean values of total organisms, total taxa, and biotic index of impounded stations were also superior compared to reference values in 2009. While the EPT richness of the formerly impounded stations did not exceed reference values, the difference in EPT richness was only two taxa. The mean EPT richness of the impounded stations also shifted to within one standard deviation of the reference mean, indicating a continued progression towards reference composition. The highest overall EPT richness (30 EPT taxa) occurred at a formerly impounded station (Station 1, Figure 3) located immediately upstream of the former Carbonton Dam.

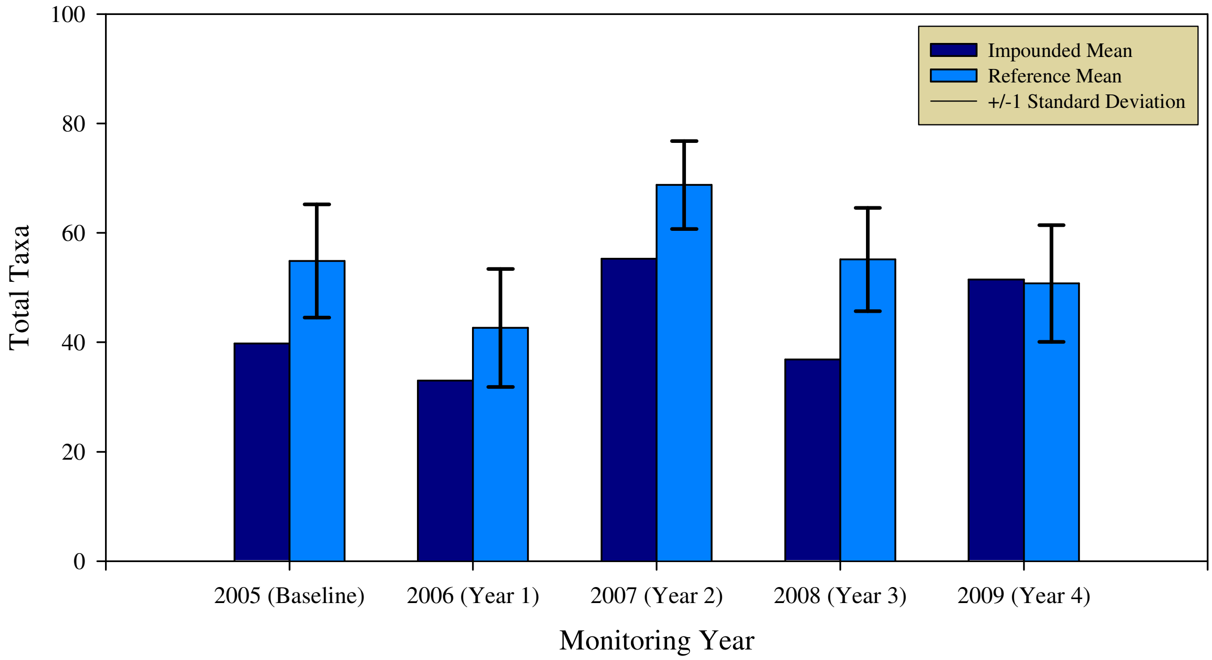
PBS&J scientist positions the kick net in a riffle of the Deep River

PBS&J staff collect benthic macroinvertebrates from the sample material

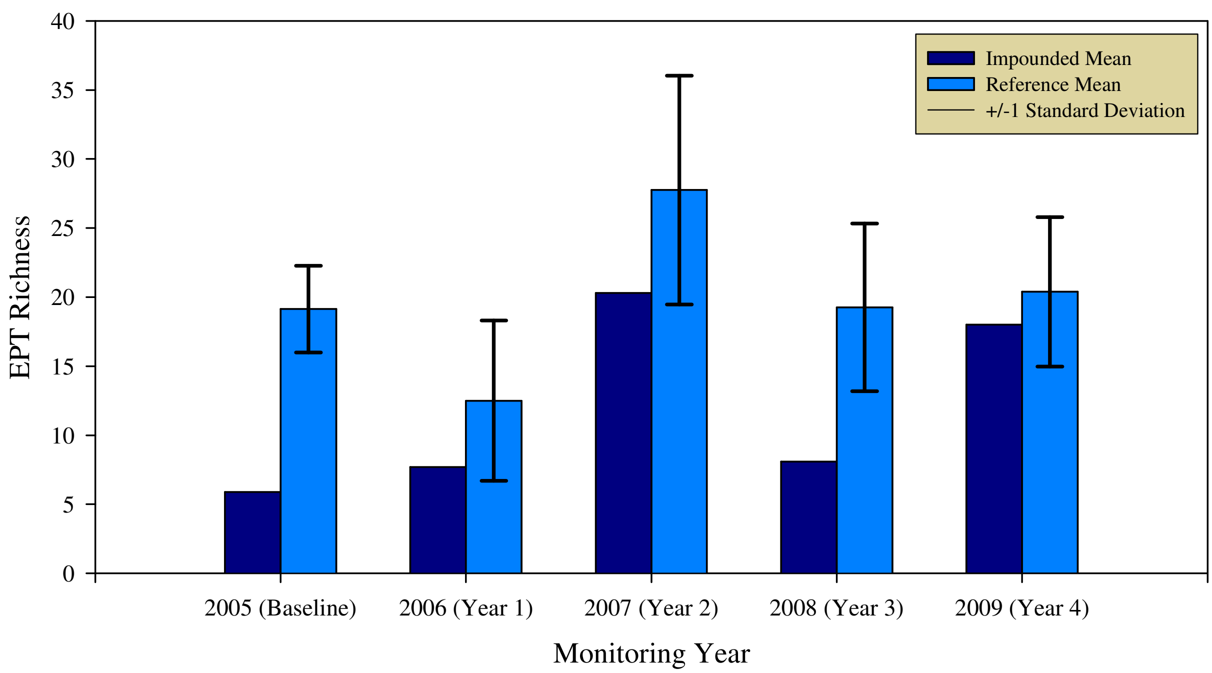
Table 9. Benthic Macroinvertebrate Summary Data								
2005	**Impounded Stations**				**Reference Stations**			
	Total Organisms	**Total Taxa**	**EPT Richness**	**Biotic Index**	**Total Organisms**	**Total Taxa**	**EPT Richness**	**Biotic Index**
High	403	62	10	7.97	1168	70	24	6.91
Low	97	18	1	5.67	237	41	14	4.78
Mean	223.33	39.78	5.89	6.83	549.75	54.88	19.13	5.90
Median	207.00	43.00	6.00	6.79	404.00	56.00	19.00	5.99
Standard Deviation	96.69	12.02	2.76	0.83	340.66	10.33	3.14	0.75
2006	**Impounded Stations**				**Reference Stations**			
	Total Organisms	**Total Taxa**	**EPT Richness**	**Biotic Index**	**Total Organisms**	**Total Taxa**	**EPT Richness**	**Biotic Index**
High	360	49	15	8.58	546	61	21	7.62
Low	55	17	0	5.76	89	33	5	4.29
Mean	177.50	33.00	7.70	6.99	220.63	42.63	12.50	6.16
Median	160.00	33.50	6.50	6.72	155.00	37.00	12.50	6.02
Standard Deviation	87.71	11.65	5.85	0.95	158.86	10.76	5.81	1.04
2007	**Impounded Stations**				**Reference Stations**			
	Total Organisms	**Total Taxa**	**EPT Richness**	**Biotic Index**	**Total Organisms**	**Total Taxa**	**EPT Richness**	**Biotic Index**
High	1168	83	36	8.52	1242	83	38	5.71
Low	117	31	1	4.28	506	59	14	3.92
Mean	466.40	55.30	20.30	5.86	849.63	68.75	27.75	4.94
Median	475.00	60.00	24.50	5.30	861.50	66.50	31.00	5.02
Standard Deviation	318.14	18.76	13.00	1.52	250.69	8.01	8.28	0.62
2008	**Impounded Stations**				**Reference Stations**			
	Total Organisms	**Total Taxa**	**EPT Richness**	**Biotic Index**	**Total Organisms**	**Total Taxa**	**EPT Richness**	**Biotic Index**
High	342	73	20	8.19	687	66	27	6.36
Low	21	16	1	5.13	246	41	10	4.66
Mean	160.80	36.90	8.10	6.52	384.25	55.13	19.25	5.56
Median	145.00	34.00	6.00	6.40	339.50	58.50	20.50	5.60
Standard Deviation	106.57	17.21	6.30	1.05	157.35	9.45	6.07	0.50
2009	**Impounded Stations**				**Reference Stations**			
	Total Organisms	**Total Taxa**	**EPT Richness**	**Biotic Index**	**Total Organisms**	**Total Taxa**	**EPT Richness**	**Biotic Index**
High	710	78	30	7.60	532	68	26	6.47
Low	152	29	2	4.97	200	34	11.00	4.52
Mean	399.67	51.50	18.00	5.94	354.13	50.75	20.38	5.46
Median	363.50	51.50	20.00	5.63	384.00	49.00	22.50	5.60
Standard Deviation	176.48	15.96	9.18	0.86	114.43	10.66	5.42	0.73

Graph 3 and Graph 4 depict the change in mean total taxa and mean EPT richness from 2005 to present from both the formerly impounded and reference stations.

Graph 3. Mean Total Taxa of Impounded Stations vs. Reference Stations with Standard Deviation



Graph 4. Mean EPT Richness of Impounded Stations vs. Reference Stations with Standard Deviation



2.2.2 Fishes

Success criteria was previously met in 2007 when survey collections demonstrated that riffle adapted species had colonized in newly restored habitats that were formerly impounded. A total of 34 fish species were collected at the fifteen fish monitoring sites. Additionally, at least ten of the sampling sites contained emerging fish communities that emulate reference conditions found beyond the former impoundment. Overall, a greater number of fish species were documented throughout the former impoundment during Year-2 monitoring relative to baseline and Year-1 surveys.

Fish surveys were conducted during Year-4 monitoring to further document the development of fish diversity, with an emphasis on the potential presence of Cape Fear shiner in two major tributaries to the Deep River, McLendons Creek and Big Governors Creek. A total of 19 fish species were collected at two surveyed sites (one site on each tributary) [Figure 3]. While the Cape Fear shiner was not collected at either site, Year-4 surveys demonstrate further re-establishment of lotic conditions and many lotic adapted species within the former impoundment. Collections within McLendons Creek include two new shiner species (whitemouth shiner and spottail shiner) and a greater abundance of Piedmont darter and tessellated darter, both indicative of improved lotic habitat. Within Big Governors Creek, the increased number of native shiner species and a greater abundance of tessellated darter, as well as the addition of Piedmont darter, may also be indicative of improving lotic habitat. The survey results of Year-4 collections are provided in Tables 10 and 11, and the complete report from The Catena Group (TCG) is located in Appendix C.

Table 10. Fish Survey Results: McLendons Creek

Scientific Name	Common Name	Relative Abundance
Aphredoderus sayanus	pirate perch	Rare
Erimyzon oblongus	creek chubsucker	Rare
Etheostoma olmstedi	tessellated darter	Very Abundant
Gambusia holbrookii	eastern mosquitofish	Common
Hybognathus regius	eastern silvery minnow	Uncommon
Lepomis auritus	redbreast sunfish	Very Abundant
Lepomis macrochirus	bluegill	Uncommon
Luxilus albeolus	white shiner	Rare
Micropterus salmoides	largemouth bass	Rare
Nocomis leptocephalus	bluehead chub	Common
Notropis alborus	whitemouth shiner	Rare
Notropis altipinnis	highfin shiner	Rare
Notropis hudsonius	spottail shiner	Rare
Notropis petersoni	coastal shiner	Uncommon
Notropis scepticus	sandbar shiner	Uncommon
Percina crassa	Piedmont darter	Very Abundant

Table 11. Fish Survey Results: Big Governors Creek		
Scientific Name	**Common Name**	**Relative Abundance**
Aphredoderus sayanus	pirate perch	Uncommon
Cyprinella analostana	satinfin shiner	Common
Centrarchus macropterus	flier	Rare
Etheostoma olmstedi	tessellated darter	Common
Gambusia holbrookii	eastern mosquitofish	Abundant
Lepomis auritus	redbreast sunfish	Abundant
Lepomis macrochirus	bluegill	Uncommon
Luxilus albeolus	white shiner	Rare
Notemigonus crysoleucas	golden shiner	Common
Nocomis leptocephalus	bluehead chub	Rare
Notropis petersoni	coastal shiner	Common
Percina crassa	Piedmont darter	Rare

2.2.3 Mollusks

Success criteria was previously met in 2008 when mollusk collections indicated a recruitment of freshwater mussel species in riffle-adapted habitats (primarily in the upper reach or the Site Impoundment). Because these fauna are slow colonizers due to their dependence on host fish species, Year-3 monitoring (2008) comprised the first year for mollusk sampling after dam removal. When comparing the mussel fauna observed during the pre-removal surveys with the Year-3 surveys, it was evident that the fauna had transitioned from one composed of habitat generalists and lentic-adapted species, to one composed of habitat generalists and lotic-adapted species. A total of eleven freshwater mussel species, three aquatic snail species, and one freshwater clam species were found within newly formed riffle habitats in the former impounded reach.

Mollusk sampling was not performed during Year-4 monitoring, but will be carried out in the final year of monitoring (2010) in order to further demonstrate a shift in mollusk communities from lentic to lotic character.

2.2.4 Habitat Assessment

Habitat assessment data were collected at all monitoring stations to evaluate the potential for changing aquatic habitats to support changes in community populations. The NCDWQ Habitat Assessment Field Data Sheet was completed at each station in order to evaluate the quality and character of the sampled habitat niches and to provide a comparable score that describes the available habitat. Table 12 presents the NCDWQ Habitat Assessment Field Data Sheet scores from baseline (2005) through Year-4 monitoring. The categories including channel modification, light penetration, and riparian vegetative zone width typically did not change in the span of a single monitoring year. Other categories including in-stream habitat, bottom substrate, and bank stability showed improvement within formerly impounded stations. Compared to baseline data (2005), the mean total score of the formerly impounded stations quantitatively increased in Year-4 monitoring from 42.39 to 61.26. The mean total score for reference stations increased 1.61 points since baseline conditions. Success evaluation is defined as a perceived progression of the former Site Impoundment habitat values toward those of the lotic reference stations. During Year-4 monitoring, the mean total score for stations in the former Site Impoundment increased

Table 12: NCDWQ Habitat Assessment Form Scores

	Station	Channel Modification	Instream Habitat	Bottom Substrate	Pools	Riffles	Bank Stability	Light Penetration	Riparian Zone	TOTAL SCORE 2005	Station	Channel Modification	Instream Habitat	Bottom Substrate	Pools	Riffles	Bank Stability	Light Penetration	Riparian Zone	TOTAL SCORE 2006	Station	Channel Modification	Instream Habitat	Bottom Substrate	Pools	Riffles	Bank Stability	Light Penetration	Riparian Zone	TOTAL SCORE 2007
FORMERLY IMPOUNDED STATIONS	**1**	4	7	1	0	0	9	0	7	**28**	**1**	4	16	12	10	14	12	0	7	**75**	**1**	4	10	12	8	14	11	0	7	**66**
	2	4	11	1	0	0	12	0	10	**38**	**2**	4	10	3	4	7	12	0	10	**50**	**2**	4	18	1	10	0	12	0	10	**55**
	3	5	12	3	0	0	14	2	9	**45**	**3**	5	11	3	8	0	13	2	9	**51**	**3**	5	14	8	0	0	11	2	9	**49**
	4	4	14	1	0	0	14	2	10	**45**	**4**	4	16	1	8	0	8	2	10	**49**	**4**	4	15	14	10	0	14	2	10	**69**
	5	4	12	1	0	0	14	2	10	**43**	**5**	4	12	6	8	12	14	2	10	**68**	**5**	4	19	11	10	14	14	2	10	**84**
	6	4	10	1	0	0	12	0	10	**37**	**6**	4	11	3	8	0	10	0	10	**46**	**6**	4	15	12	0	0	12	0	10	**53**
	7	4	10	1	0	0	12	0	9	**36**	**7**	4	6	8	8	0	9	0	9	**44**	**7**	4	16	11	8	0	14	0	9	**62**
	8	4	12	8	0	0	14	2	7	**47**	**8**	4	10	6	4	7	12	2	7	**52**	**8**	4	16	15	10	14	13	2	7	**81**
	9	4	10	1	0	0	14	2	8	**39**	**9**	4	16	3	8	0	8	2	8	**49**	**9**	4	15	3	10	0	14	2	8	**56**
	10	5	16	12	0	0	14	2	10	**59**	**10**	5	10	11	4	3	12	2	10	**57**	**10**	5	16	15	10	14	11	2	10	**83**
	11	4	14	12	0	0	11	2	10	**53**	**11**	4	20	1	0	7	10	2	10	**54**	**11**	4	16	2	6	10	13	2	10	**63**
	20	4	7	1	0	0	6	0	10	**28**	**20**	4	10	1	8	0	9	0	10	**42**	**20**	4	11	1	8	0	14	0	10	**48**
	21	5	6	1	0	0	4	0	2	**18**	**21**	5	7	1	8	0	5	0	2	**28**	**21**	5	14	1	8	0	9	7	6	**50**
	22	5	5	1	0	0	4	0	8	**23**	**22**	5	9	1	8	0	10	0	8	**41**	**22**	5	10	1	0	0	14	0	8	**38**
	23	5	9	1	0	0	5	2	8	**30**	**23**	5	9	1	3	12	11	2	8	**51**	**23**	5	6	1	10	14	14	2	8	**60**
	24	4	11	1	0	0	10	7	4	**37**	**24**	4	7	1	3	7	12	7	4	**45**	**24**	4	17	1	0	0	14	7	4	**47**
	27	5	9	1	0	0	12	10	10	**47**	**27**	5	12	8	4	16	10	10	10	**75**	**27**	5	16	12	10	14	12	10	10	**89**
	29	5	5	1	0	0	12	10	10	**43**	**29**	5	15	1	8	0	10	10	10	**59**	**29**	5	9	1	0	0	12	10	10	**47**
	30	5	13	1	0	0	14	10	10	**53**	**30**	5	11	1	8	0	12	10	10	**57**	**30**	5	11	1	0	0	10	10	10	**47**
	31	5	10	1	0	0	12	10	10	**48**	**31**	5	11	1	8	0	10	10	10	**55**	**31**	5	10	1	0	0	10	10	10	**46**
	32	4	5	1	0	0	10	8	10	**38**	**32**	4	10	1	7	7	12	8	10	**59**	**32**	4	10	1	0	0	12	8	10	**45**
	34	4	11	1	0	0	14	10	10	**50**	**34**	4	0	1	8	0	14	10	10	**47**	**34**	4	0	0	0	0	12	10	10	**36**
	36	4	6	1	0	0	4	8	8	**31**	**36**	4	10	1	8	0	11	8	8	**50**	**36**	4	9	1	0	0	12	8	8	**42**
	38	5	19	1	0	0	5	10	10	**50**	**38**	5	12	1	8	0	12	10	10	**58**	**38**	5	15	1	0	0	12	10	10	**53**
	40	2	16	1	0	0	14	8	10	**51**	**40**	2	10	1	8	0	6	8	10	**45**	**40**	2	10	1	0	0	12	8	10	**43**
	41	5	6	1	0	0	12	8	10	**42**	**41**	5	15	1	8	7	12	8	10	**66**	**41**	5	10	1	8	0	12	8	10	**54**
	42	5	11	1	0	0	12	10	10	**49**	**42**	5	10	1	8	0	12	10	10	**56**	**42**	5	14	1	8	0	12	10	10	**60**
	43	5	6	1	0	0	10	10	10	**42**	**43**	5	11	1	8	0	12	10	10	**57**	**43**	5	14	1	8	0	12	10	10	**60**
	47	5	11	6	0	0	14	10	10	**56**	**47**	5	14	11	10	14	13	10	10	**87**	**47**	5	14	11	6	14	12	10	10	**82**
	48	5	11	1	0	0	12	7	10	**46**	**48**	5	14	1	3	0	12	7	10	**52**	**48**	5	14	1	10	10	12	7	10	**69**
	49	5	11	1	0	0	12	7	10	**46**	**49**	5	16	2	6	3	12	7	10	**61**	**49**	5	9	11	8	0	12	7	10	**62**
	50	4	15	3	0	0	12	7	10	**51**	**50**	4	11	1	4	3	12	7	10	**52**	**50**	4	10	3	3	0	12	10	10	**52**
	51	5	12	1	0	0	12	10	10	**50**	**51**	5	6	1	8	0	12	10	10	**52**	**51**	5	9	1	8	0	12	10	10	**55**
	55	Station not established in 2005								N/A	**55**	5	18	11	4	12	12	7	8	**77**	**55**	5	20	8	10	14	14	7	8	**86**
	MEAN	**4.5**	**10.4**	**2.2**	**0.0**	**0.0**	**11.0**	**5.3**	**9.1**	**42.39**	**MEAN**	**4.5**	**11.4**	**3.2**	**6.6**	**3.9**	**11.0**	**5.4**	**9.1**	**54.91**	**MEAN**	**4.5**	**12.7**	**4.9**	**5.5**	**3.9**	**12.3**	**5.7**	**9.2**	**58.59**
REFERENCE STATIONS	**12**	4	20	12	6	7	14	2	10	**75**	**12**	4	15	12	4	12	12	2	10	**71**	**12**	4	16	12	6	14	12	2	10	**76**
	14	2	14	3	4	10	4	2	0	**39**	**14**	4	11	8	4	12	12	2	0	**53**	**14**	4	19	12	6	16	10	2	0	**69**
	15	4	11	8	8	0	10	7	10	**58**	**15**	4	12	14	10	0	14	7	10	**71**	**15**	4	15	11	10	0	13	7	10	**70**
	16	4	11	12	8	0	12	2	10	**59**	**16**	4	6	4	8	0	12	2	10	**46**	**16**	4	10	11	10	0	14	2	10	**61**
	17	4	11	2	4	3	12	2	10	**48**	**17**	4	15	1	8	0	14	2	10	**54**	**17**	4	5	4	0	0	12	2	10	**37**
	18	4	11	8	6	3	10	7	6	**55**	**18**	4	7	11	8	0	12	7	6	**55**	**18**	4	11	14	8	10	12	7	6	**72**
	19	4	16	11	6	0	12	2	10	**61**	**19**	4	12	11	9	0	14	2	10	**62**	**19**	4	14	12	10	0	14	2	10	**66**
	25	5	8	1	8	0	12	10	10	**54**	**25**	5	14	2	8	0	10	10	10	**59**	**25**	5	18	1	0	0	14	10	10	**58**
	26	5	10	1	8	0	14	10	10	**58**	**26**	5	9	1	8	0	7	10	10	**50**	**26**	5	0	1	0	0	6	10	10	**32**
	33	5	6	8	8	16	13	10	10	**76**	**33**	5	12	8	6	7	12	10	10	**70**	**33**	5	0	4	0	0	14	10	10	**43**
	35	4	5	1	4	0	10	8	10	**42**	**35**	4	9	1	2	0	12	8	10	**46**	**35**	4	13	1	8	0	5	8	10	**49**
	37	5	16	1	3	7	14	10	9	**65**	**37**	5	11	1	8	0	14	10	9	**58**	**37**	5	14	1	0	7	14	10	9	**60**
	39	5	11	3	6	0	12	7	9	**53**	**39**	5	14	1	8	0	14	7	9	**58**	**39**	5	11	1	0	10	12	7	9	**55**
	44	4	16	2	8	3	13	7	10	**63**	**44**	4	20	8	8	3	12	7	10	**72**	**44**	4	16	4	10	10	12	7	10	**73**
	45	4	15	6	6	0	12	8	10	**61**	**45**	4	16	11	10	7	13	8	10	**79**	**45**	4	19	12	8	7	12	8	10	**80**
	52	4	20	15	6	7	14	0	10	**76**	**52**	4	11	12	4	16	12	0	10	**69**	**52**	4	15	12	10	16	13	0	10	**80**
	53	4	20	11	4	14	12	2	9	**76**	**53**	4	15	12	4	12	12	2	9	**70**	**53**	4	19	12	6	14	10	2	10	**77**
	54	5	6	1	8	0	13	10	10	**53**	**54**	5	0	1	8	0	10	10	10	**44**	**54**	5	0	1	0	0	10	10	10	**36**
	MEAN	**4.2**	**12.6**	**5.9**	**6.2**	**3.9**	**11.8**	**5.9**	**9.1**	**59.56**	**MEAN**	**4.3**	**11.6**	**6.6**	**6.9**	**3.8**	**12.1**	**5.9**	**9.1**	**60.39**	**MEAN**	**4.3**	**11.9**	**7.0**	**5.1**	**5.8**	**11.6**	**5.9**	**9.1**	**60.78**

Table 12 (Cont.): NCDWQ Habitat Assessment Form Scores

	Station	Channel Modification	Instream Habitat	Bottom Substrate	Pools	Riffles	Bank Stability	Light Penetration	Riparian Zone	TOTAL SCORE 2008	Station	Channel Modification	Instream Habitat	Bottom Substrate	Pools	Riffles	Bank Stability	Light Penetration	Riparian Zone	TOTAL SCORE 2009	Station	Channel Modification	Instream Habitat	Bottom Substrate	Pools	Riffles	Bank Stability	Light Penetration	Riparian Zone	TOTAL SCORE 2010
FORMERLY IMPOUNDED STATIONS	**1**	4	12	8	8	14	12	0	7	**65**	**1**	4	12	12	8	14	12	0	7	**69**	**1**									
	2	4	14	1	10	0	14	0	10	**53**	**2**	4	20	4	0	0	14	0	10	**52**	**2**									
	3	5	15	8	0	0	9	2	9	**48**	**3**	5	15	12	0	0	10	2	9	**53**	**3**									
	4	4	15	12	10	0	14	2	10	**67**	**4**	4	16	12	8	3	14	2	10	**69**	**4**									
	5	4	19	15	10	14	13	2	10	**87**	**5**	4	19	15	10	14	13	2	10	**87**	**5**									
	6	4	15	12	0	0	12	0	10	**53**	**6**	4	15	12	0	0	12	0	10	**53**	**6**									
	7	4	15	11	8	0	14	0	9	**61**	**7**	4	11	12	8	0	14	0	9	**58**	**7**									
	8	4	20	15	10	14	13	2	7	**85**	**8**	4	20	15	10	14	13	2	7	**85**	**8**									
	9	4	15	8	10	0	14	2	8	**61**	**9**	4	15	8	10	0	14	2	8	**61**	**9**									
	10	5	19	15	10	14	14	2	10	**89**	**10**	5	19	15	10	14	14	2	10	**89**	**10**									
	11	4	10	1	8	7	14	2	10	**56**	**11**	4	10	1	8	7	14	2	10	**56**	**11**									
	20	4	10	3	10	0	14	10	10	**61**	**20**	4	10	3	10	0	14	10	10	**61**	**20**									
	21	5	10	1	10	0	14	7	6	**53**	**21**	5	10	1	10	0	14	7	6	**53**	**21**									
	22	5	13	3	10	0	14	0	8	**53**	**22**	5	13	3	10	0	14	0	8	**53**	**22**									
	23	5	17	1	4	0	14	2	8	**51**	**23**	5	13	1	4	0	14	2	8	**47**	**23**									
	24	4	9	1	0	0	12	7	4	**37**	**24**	4	9	1	0	0	12	7	4	**37**	**24**									
	27	5	16	3	6	3	12	10	10	**65**	**27**	5	15	1	6	3	10	10	10	**60**	**27**									
	29	5	9	1	0	0	12	10	10	**47**	**29**	5	9	1	0	0	14	10	10	**49**	**29**									
	30	5	16	3	0	0	10	10	10	**54**	**30**	5	15	1	8	3	12	10	10	**64**	**30**									
	31	5	14	3	0	0	12	10	10	**54**	**31**	5	10	1	8	3	6	10	10	**53**	**31**									
	32	4	5	1	0	0	10	8	10	**38**	**32**	4	5	1	0	0	10	8	10	**38**	**32**									
	34	4	1	0	0	10	10	10	10	**45**	**34**	4	18	3	0	0	14	10	10	**59**	**34**									
	36	4	5	1	0	0	6	8	8	**32**	**36**	4	5	1	0	6	8	8	8	**40**	**36**									
	38	5	14	1	0	0	13	10	10	**53**	**38**	5	16	1	0	0	12	10	10	**54**	**38**									
	40	2	15	1	0	0	14	8	10	**50**	**40**	2	15	1	4	0	12	8	10	**52**	**40**									
	41	5	10	1	10	10	13	8	10	**67**	**41**	5	14	1	10	12	14	8	10	**74**	**41**									
	42	5	10	1	4	14	14	10	10	**68**	**42**	5	10	1	10	7	14	10	10	**67**	**42**									
	43	5	9	1	10	3	12	10	10	**60**	**43**	5	14	1	10	7	14	10	10	**71**	**43**									
	47	5	15	3	6	14	12	10	10	**75**	**47**	5	15	4	4	14	12	10	10	**74**	**47**									
	48	5	14	1	10	10	13	7	10	**70**	**48**	5	15	2	10	10	11	7	10	**70**	**48**									
	49	5	15	4	8	0	11	7	10	**60**	**49**	5	16	4	8	0	11	7	10	**61**	**49**									
	50	4	14	3	0	12	12	10	10	**65**	**50**	4	15	1	0	10	12	10	10	**62**	**50**									
	51	5	10	1	8	0	12	10	10	**56**	**51**	5	14	1	8	0	12	10	10	**60**	**51**									
	55	5	20	8	10	14	14	7	8	**86**	**55**	5	20	14	10	14	14	7	8	**92**	**55**									
	MEAN	**4.5**	**12.9**	**4.5**	**5.6**	**4.5**	**12.4**	**6.0**	**9.2**	**59.56**	**MEAN**	**4.5**	**13.8**	**4.9**	**5.9**	**4.6**	**12.5**	**6.0**	**9.2**	**61.26**	**MEAN**									
REFERENCE STATIONS	**12**	4	20	15	6	7	14	2	10	**78**	**12**	4	20	15	6	7	14	2	10	**78**	**12**									
	14	4	16	15	6	16	11	2	0	**70**	**14**	4	16	15	6	16	11	2	0	**70**	**14**									
	15	4	11	8	8	0	10	7	10	**58**	**15**	4	11	8	8	0	10	7	10	**58**	**15**									
	16	4	11	11	10	0	14	2	10	**62**	**16**	4	12	11	10	0	14	2	10	**63**	**16**									
	17	4	11	8	4	0	12	2	10	**51**	**17**	4	11	4	4	0	12	2	10	**47**	**17**									
	18	4	11	14	8	10	5	7	6	**65**	**18**	4	11	14	8	10	8	7	6	**68**	**18**									
	19	4	16	11	10	0	14	2	10	**67**	**19**	4	15	15	10	0	14	2	10	**70**	**19**									
	25	5	5	1	8	0	14	10	10	**53**	**25**	5	6	1	8	0	14	10	10	**54**	**25**									
	26	5	0	1	0	0	6	10	10	**32**	**26**	5	0	1	0	0	14	10	10	**40**	**26**									
	33	5	5	4	0	0	14	10	10	**48**	**33**	5	10	1	0	0	14	10	10	**50**	**33**									
	35	4	5	1	8	0	14	8	10	**50**	**35**	4	6	1	8	0	13	8	10	**50**	**35**									
	37	5	10	1	0	7	14	10	9	**56**	**37**	5	10	1	0	0	14	10	9	**49**	**37**									
	39	5	15	1	0	10	12	7	9	**59**	**39**	5	14	1	0	10	14	7	9	**60**	**39**									
	44	4	14	4	10	10	12	7	10	**71**	**44**	4	15	3	10	=	12	7	10	**61**	**44**									
	45	4	16	6	10	12	12	8	10	**78**	**45**	4	16	6	10	12	12	8	10	**78**	**45**									
	52	4	16	12	10	16	16	0	10	**84**	**52**	4	16	12	10	16	14	0	10	**82**	**52**									
	53	4	20	15	10	7	10	2	10	**78**	**53**	4	20	15	10	7	10	2	10	**78**	**53**									
	54	5	0	1	0	0	14	10	10	**40**	**54**	5	5	1	0	0	14	10	10	**45**	**54**									
	MEAN	**4.3**	**11.2**	**7.2**	**6.0**	**5.3**	**12.1**	**5.9**	**9.1**	**61.11**	**MEAN**	**4.3**	**11.9**	**6.9**	**6.0**	**4.6**	**12.7**	**5.9**	**9.1**	**61.17**	**MEAN**									

1.03 percent compared to last year. The mean total score for stations in the former Site Impoundment also exceeded the Year-4 mean total score of the reference stations by 0.09.

2.2.4.1 Sediment Class Size Distribution

Sediment grain size distribution was analyzed at 38 monitoring stations in 2008 (24 formerly impounded, 14 reference). At each of the 38 stations, 100-count pebble counts were performed consistent with the Wolman method (Wolman 1954). Mean values for D16, D50, and D84 at formerly impounded stations remained within the same size class indices, indicating limited change in substrate during Year-4 sampling. The medium grain size (D50) for impounded stations sampled in 2009 is 7.05 mm coarser than dam pre-removal substrate (2005). The D16 and D84 size class indices also coarsened within formerly impounded stations following dam removal. Reference stations showed only minor changes in sediment size class following dam removal. Table 13 provides baseline, Year-1through Year-4 sediment grain size distributions attained by pebble count method for both reference and formerly impounded stations.

Sediment grain size classes (Wolman 1954):	
Particle Size	**Size Class**
<2 mm	Sand/silt
2-8 mm	Fine gravel
8-16 mm	Medium gravel
16-32 mm	Coarse gravel
32-64 mm	Very coarse gravel
64-128 mm	Small cobble
128-256 mm	Large cobble
>256 mm	Boulder

Table 13. Sediment Class Size Distribution

	Station	Baseline (2005)			Year 1 (2006)			Year 2 (2007)			Year 3 (2008)			Year 4 (2009)			Year 5 (2010)		
		d16	d50	d84	d16	d50	d84	d16	d50	d84	d16	d50	d84	d16	d50	d84	d16	d50	d84
FORMERLY IMPOUNDED	3	<2 mm	<2 mm	<2 mm	<2 mm	2-8 mm	>256 mm	<2 mm	64-128 mm	>256 mm	<2 mm	128-256 mm	>256 mm	<2 mm	64-128 mm	>256 mm			
	4	<2 mm	<2 mm	<2 mm	2-8 mm	8-16 mm	16-32 mm	<2 mm	2-8 mm	16-32 mm	<2 mm	2-8 mm	16-32 mm	<2 mm	8-16 mm	64-128 mm			
	6	16-32 mm	16-32 mm	16-32 mm	2-8 mm	2-8 mm	2-8 mm	<2 mm	8-16 mm	>256 mm	2-8 mm	16-32 mm	16-32 mm	<2 mm	<2 mm	128-256 mm			
	8	<2 mm	<2 mm	<2 mm	<2 mm	8-16 mm	16-32 mm	<2 mm	32-64 mm	16-32 mm	<2 mm	16-32 mm	>256 mm	<2 mm	16-32 mm	64-128 mm			
	10	2-8 mm	8-16 mm	16-32 mm	<2 mm	2-8 mm	32-64 mm	16-32 mm	32-64 mm	>256 mm	16-32 mm	32-64 mm	>256 mm	16-32 mm	64-128 mm	>256 mm			
	22	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm			
	23	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm			
	24	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm			
	27	<2 mm	<2 mm	<2 mm	<2 mm	2-8 mm	8-16 mm	<2 mm	2-8 mm	8-16 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	4-8 mm			
	29	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm			
	30	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	2-8 mm	<2 mm	<2 mm	<2 mm			
	31	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm			
	32	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm			
	34	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm			
	36	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm			
	38	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm			
	41	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm			
	42	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	2-8 mm	<2 mm	<2 mm	2-8 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm			
	43	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm			
	47	<2 mm	<2 mm	16-32 mm	<2 mm	8-16 mm	16-32 mm	<2 mm	2-8 mm	16-32 mm	<2 mm	2-8 mm	16-32 mm	<2 mm	8-16 mm	16-32 mm			
	49	<2 mm	<2 mm	<2 mm	2-8 mm	2-8 mm	2-8 mm	<2 mm	8-16 mm	16-32 mm	<2 mm	8-16 mm	16-32 mm	<2 mm	<2 mm	16-32 mm			
	50	<2 mm	<2 mm	16-32 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	8-16 mm	<2 mm	8-16 mm	8-16 mm	<2 mm	<2 mm	<2 mm			
	51	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	2-8 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm			
	55	Cross-section not established in 2005			2-8 mm	8-16 mm	16-32 mm	2-8 mm	16-32 mm	32-64 mm	<2 mm	16-32 mm	32-64 mm	2-8 mm	16-32 mm	32-64 mm			
REFERENCE	12	8-16 mm	16-32 mm	>256 mm	2-8 mm	8-16 mm	64-128 mm	2-8 mm	16-32 mm	128-256 mm	2-8 mm	16-32 mm	128-256 mm	2-8 mm	16-32 mm	128-256 mm			
	14	<2 mm	64-128 mm	>256 mm	<2 mm	2-8 mm	128-256 mm	<2 mm	8-16 mm	32-64 mm	<2 mm	8-16 mm	128-256 mm	<2 mm	16-32 mm	128-256 mm			
	16	<2 mm	2-8 mm	32-64 mm	2-8 mm	16-32 mm	32-64 mm	<2 mm	16-32 mm	64-128 mm	2-8 mm	32-64 mm	64-128 mm	2-8 mm	16-32 mm	128-256 mm			
	18	<2 mm	32-64 mm	32-64 mm	8-16 mm	32-64 mm	64-128 mm	8-16 mm	32-64 mm	64-128 mm	8-16 mm	32-64 mm	64-128 mm	2-8 mm	16-32 mm	64-128 mm			
	19	2-8 mm	32-64 mm	32-64 mm	<2 mm	<2 mm	32-64 mm	<2 mm	16-32 mm	64-128 mm	<2 mm	2-8 mm	32-64 mm	<2 mm	8-16 mm	16-32 mm			
	25	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm			
	26	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm			
	33	<2 mm	2-8 mm	16-32 mm	<2 mm	2-8 mm	8-16 mm	<2 mm	2-8 mm	8-16 mm	<2 mm	2-8 mm	8-16 mm	<2 mm	<2 mm	2-8 mm			
	35	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm			
	39	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm			
	44	<2 mm	8-16 mm	16-32 mm	<2 mm	<2 mm	8-16 mm	<2 mm	2-8 mm	16-32 mm	<2 mm	<2 mm	16-32 mm	<2 mm	<2 mm	8-16 mm			
	45	<2 mm	8-16 mm	64-128 mm	<2 mm	<2 mm	16-32 mm	<2 mm	2-8 mm	32-64 mm	<2 mm	2-8 mm	16-32 mm	<2 mm	<2 mm	32-64 mm			
	52	8-16 mm	32-64 mm	64-128 mm	2-8 mm	8-16 mm	128-256 mm	2-8 mm	16-32 mm	64-128 mm	<2 mm	32-64 mm	64-128 mm	<2 mm	16-32 mm	64-128 mm			
	54	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm			

2.2.4.2 Channel Cross-sections

Cross-sectional surveys of channel geometry were performed at all 52 monitoring stations during 2009. Thirty-four (34) permanent cross-sections were revisited throughout the former Site Impoundment and on tributaries where functional restoration is expected to occur. Eighteen (18) permanent cross-sections were revisited on reference reaches above and below the former Site Impoundment. Cross-section locations are displayed on Figure 3 (Appendix A). All monitoring years' cross-sectional surveys are displayed on Figures 4A-4D (Appendix A). Table 14 provides bankfull channel geometry including bankfull cross-sectional area (Abkf), bankfull width (Wbkf), maximum bankfull depth (Dmax), mean bankfull depth (Dbkf), and width-to-depth ratio (width/depth).

In general, bankfull channel parameters were largely unchanged compared to conditions assessed during previous monitoring years. Limited scouring and erosion of bank material was detected at formerly impounded stations, with an associated, minor change in bankfull areas. The Deep River channel is geomorphically stable, and any erosion is episodic and localized. Station 55 was established following dam removal and therefore no baseline (2005) bankfull channel geometry data are available for this station. Other stations for which pins were not found, and subsequently replaced, are noted on Figures 4A-4D. Hence, the discrepancies in cross-sectional dimensions and bankfull channel geometry between years at the locations where new pins were installed.

PBS&J staff prepares to perform a Total Station cross-sectional survey of the Deep River at Station 15.

Table 14. Cross-section Bankfull Channel Geometry

	Station	2005 (Baseline)					2006 (Year-1)					2007 (Year-2)					2008 (Year-3)					2009 (Year-4)					Station
		Abkf (ft)	Wbkf (ft)	Dmax (ft)	Dbkf (ft)	width: depth	Abkf (ft)	Wbkf (ft)	Dmax (ft)	Dbkf (ft)	width: depth	Abkf (ft)	Wbkf (ft)	Dmax (ft)	Dbkf (ft)	width: depth	Abkf (ft)	Wbkf (ft)	Dmax (ft)	Dbkf (ft)	width: depth	Abkf (ft)	Wbkf (ft)	Dmax (ft)	Dbkf (ft)	width: depth	
Formerly Impounded Stations	1	4707.0	235.2	27.2	20.0	11.8	4702.7	235.0	27.7	20.0	11.8	4884.9	235.2	28.5	20.8	11.3	5094.7	239.1	27.5	21.3	11.2	4960.0	239.1	30.0	20.7	11.5	1
	2	3837.0	196.3	28.0	19.6	10.0	3771.9	196.0	27.0	19.2	10.2	3883.0	201.7	27.1	19.3	10.5	3800.6	201.8	26.8	18.8	10.7	3728.4	195.7	26.7	19.1	10.3	2
	3	2849.0	166.2	23.9	17.1	9.7	2897.2	158.8	24.3	18.2	8.7	2964.5	159.2	24.7	18.6	8.6	2947.3	160.4	24.7	18.4	8.7	2910.6	158.7	24.2	18.3	8.7	3
	4	4229.1	185.2	29.9	22.8	8.1	3632.1	193.7	24.4	18.8	10.3	3457.1	191.9	23.4	18.0	10.6	3608.8	193.1	24.3	18.7	10.3	3612.2	191.6	24.1	18.8	10.2	4
	5	2783.1	174.6	23.7	15.9	11.0	2792.5	165.8	23.2	16.8	9.9	2860.5	169.0	23.7	16.9	10.0	2932.8	169.8	23.8	17.3	9.8	3032.1	169.0	23.7	17.9	9.4	5
	6	3362.5	188.2	22.8	17.9	10.5	3450.9	187.7	22.8	18.4	10.2	3487.0	189.2	23.4	18.4	10.3	3435.9	192.7	23.1	17.8	10.8	3275.7	188.1	22.2	17.4	10.8	6
	7	2443.2	149.8	19.0	16.3	9.2	2869.7	173.8	20.4	16.5	10.5	2897.3	193.8	20.4	15.0	13.0	2947.8	193.0	20.6	15.3	12.6	2940.7	193.6	20.5	15.2	12.7	7
	8	3098.8	181.6	24.1	17.1	10.6	3341.5	185.2	28.6	18.0	10.3	3434.9	184.9	25.4	18.6	10.0	3506.3	190.3	26.2	18.4	10.3	3321.5	183.3	25.2	18.1	10.1	8
	9	2064.0	172.5	15.0	12.0	14.4	2108.0	173.5	15.0	12.2	14.2	2094.4	176.6	14.9	11.9	14.9	2076.5	176.5	14.8	11.8	15.0	2092.6	175.5	14.9	11.9	14.7	9
	10	2221.5	199.0	18.0	11.2	17.8	2423.6	195.9	18.6	12.4	15.8	2353.2	199.9	18.9	11.8	17.0	2414.3	198.7	18.9	12.1	16.4	2520.1	196.4	18.5	12.8	15.3	10
	11	3591.3	199.5	24.3	18.0	11.1	3720.9	199.3	24.6	18.7	10.7	3706.3	198.9	24.8	18.6	10.7	3714.1	199.3	25.0	18.6	10.7	3751.6	199.0	25.1	18.9	10.6	11
	20	72.2	42.9	3.6	1.7	25.2	86.2	44.1	4.4	2.0	22.1	108.9	45.5	4.2	2.4	19.0	105.0	44.7	5.3	2.4	19.0	134.5	70.1	5.2	1.9	36.6	20
	21	149.6	57.9	3.6	2.6	22.3	187.8	77.9	4.4	2.4	32.5	199.1	64.8	4.8	3.1	21.1	161.7	63.2	5.0	2.6	24.7	218.2	64.9	5.4	3.4	19.3	21
	22	148.9	49.1	4.8	3.0	16.4	184.1	56.8	5.8	3.2	17.8	195.5	52.1	5.9	3.8	13.9	159.6	50.2	5.9	3.2	15.8	275.8	74.2	6.7	3.7	20.0	22
	23	76.6	30.2	4.7	2.5	12.1	104.8	34.5	5.7	3.0	11.5	116.7	38.8	6.7	3.0	12.9	141.7	40.2	8.0	3.5	11.4	163.5	45.6	3.6	3.6	12.7	23
	24	65.6	39.6	2.9	1.7	23.3	54.4	37.1	2.4	1.5	24.7	41.4	31.2	2.1	1.3	23.5	54.9	32.3	3.3	1.7	19.0	80.9	39.6	3.9	2.0	19.4	24
	27	62.3	24.9	3.9	2.5	10.0	73.4	28.6	4.5	2.6	11.0	81.8	28.78	5.7	2.8	10.1	78.4	28.34	6.4	2.8	10.2	86.4	30.14	5.9	2.9	10.5	27
	29	43.2	13.5	4.8	2.5	5.4	64.2	16.6	6.2	10.4	1.6	66.3	16.46	6.4	4.0	4.1	53.7	14.69	6.5	3.7	4.0	53.8	14.42	5.5	3.7	3.9	29
	30	153.2	22.1	8.8	6.9	3.2	115.5	29.5	6.5	3.9	7.6	113.5	30.68	6.5	3.7	8.3	85.6	28.38	5.6	3.0	9.4	88.3	21.2	5.8	4.2	5.1	30
	31	141.2	29.3	6.5	4.8	6.1	147.3	28.9	6.9	5.1	5.7	160.6	29.75	7.9	5.4	5.5	167.8	28.9	8.9	5.8	5.0	171.3	28.47	9.1	6.0	4.7	31
	32	72.1	15.5	7.5	4.6	3.4	75.7	15.9	8.0	4.8	3.3	78.5	15.87	8.6	4.9	3.2	84.3	16.97	9.2	5.0	3.4	79.4	16.14	9.1	4.9	3.3	32
	34	37.1	18.7	4.1	2.0	9.4	39.8	18.7	4.2	2.1	8.9	35.0	18.14	3.8	1.9	9.4	46.9	20.34	4.9	2.3	8.8	44.7	19.83	4.4	2.3	8.8	34
	36	111.3	21.5	9.2	5.2	4.1	111.6	21.1	9.3	5.3	4.0	110.6	21.56	9.7	5.1	4.2	113.1	21.45	9.8	5.3	4.1	115.4	21.97	10.0	5.3	4.2	36
	38	269.7	43.2	8.6	6.2	7.0	256.3	40.7	8.0	32.0	1.3	254.1	40.91	7.9	6.2	6.6	282.7	41.25	8.5	6.9	6.0	314.3	43.1	9.6	7.3	5.9	38
	40	329.2	53.3	8.2	6.2	8.6	431.2	53.3	10.6	8.1	6.6	461.1	54.78	11.4	8.4	6.5	445.9	54.01	11.4	8.3	6.5	457.3	53.66	11.5	8.5	6.3	40
	41	429.9	50.3	11.4	8.6	5.9	521.8	48.2	13.4	10.8	4.5	419.4	51.4	10.9	8.2	6.3	411.1	50.16	10.7	8.2	6.1	427.8	50.8	11.8	8.4	6.0	41
	42	139.4	30.9	6.0	4.5	6.9	156.9	32.1	7.0	4.9	6.6	167.7	30.2	7.4	5.6	5.4	143.5	30.22	7.2	4.7	6.4	123.7	31.53	7.8	3.9	8.0	42
	43	155.9	29.4	6.7	5.3	5.6	176.8	31.1	7.4	5.7	5.5	187.0	32.67	8.0	5.7	5.7	180.2	31.48	7.8	5.7	5.5	187.4	32.39	8.0	5.8	5.6	43
	47	318.5	60.5	7.8	5.3	11.4	312.7	56.3	8.0	5.6	10.1	320.7	60.6	8.1	5.3	11.4	315.7	60.1	8.1	5.3	11.4	339.3	60.9	8.5	5.6	10.9	47
	48	695.0	72.9	13.8	9.5	7.7	630.8	69.5	13.4	9.1	7.6	674.5	70.4	12.8	9.6	7.3	680.1	72.2	13.5	9.4	7.7	673.3	73.6	13.2	9.2	8.0	48
	49	550.4	59.7	13.7	9.2	6.5	380.5	59.1	10.1	6.5	9.1	406.8	54.5	12.0	7.5	7.3	398.7	59.5	10.4	6.7	8.9	331.6	48.2	9.1	6.9	7.0	49
	50	378.9	59.8	7.7	6.3	9.5	388.6	59.2	8.7	6.6	9.0	381.5	58.1	8.1	6.6	8.9	380.0	58.1	8.2	6.5	8.9	400.4	58.6	8.3	6.8	8.6	50
	51	209.5	39.9	10.8	5.3	7.5	203.9	35.6	10.7	5.7	6.2	211.2	38.0	10.8	5.6	6.8	226.1	38.4	11.2	5.9	6.5	216.0	36.6	11.1	5.9	6.2	51
	55	N/A	N/A	N/A	N/A	N/A	3357.6	228.4	18.0	14.7	15.5	3428.4	236.0	18.7	14.5	16.3	3425.4	235.4	18.6	14.5	16.2	3483.2	229.5	18.6	15.2	15.1	55
Reference Stations	12	3054.7	212.8	17.4	14.4	14.8	3029.3	213.0	17.5	14.2	15.0	3065.6	213.3	17.6	14.4	14.8	2925.4	212.03	17.5	13.8	15.4	2872.9	209.54	17.1	13.7	15.3	12
	14	6111.5	393.8	22.6	15.5	25.4	5924.9	402.6	21.6	14.7	27.4	6458.5	454.5	21.2	14.2	32.0	5948.3	452.6	21.5	13.1	34.4	5983.5	444.8	21.4	13.5	33.1	14
	15	3241.5	187.2	23.7	17.3	10.8	3583.2	200.0	24.9	17.9	11.2	3668.1	202.6	25.7	18.1	11.2	3655.7	207.2	25.4	17.6	11.7	3530.4	201.3	25.0	17.5	11.5	15
	16	2370.1	176.7	16.3	13.4	13.2	2382.1	173.3	16.6	13.7	12.7	2526.5	187.2	17.3	13.5	13.9	2506.1	185.9	17.4	13.5	13.8	2541.9	186.2	12.2	13.7	13.6	16
	17	2864.3	193.5	24.7	20.0	9.7	3466.6	201.9	22.7	17.2	11.7	3561.8	202.4	24.0	17.6	11.5	3530.3	202.3	23.3	17.5	11.6	3483.0	200.4	23.0	17.4	11.5	17
	18	1722.0	181.5	12.3	9.5	19.1	1697.3	174.5	12.2	9.7	18.0	1756.4	174.6	12.7	10.1	17.4	1795.2	174.8	12.8	10.3	17.0	1751.2	173.2	12.5	10.1	17.1	18
	19	2647.0	167.9	21.1	15.8	10.6	2581.6	167.6	20.6	15.4	10.9	2662.1	166.9	21.1	15.9	10.5	2677.0	166.6	21.1	16.1	10.4	2665.1	167.9	21.1	15.9	10.6	19
	25	22.7	19.9	2.3	1.1	18.1	24.4	20.7	2.3	10.6	2.0	24.6	20.7	2.3	1.2	17.4	28.3	22	2.4	1.3	17.1	27.1	22.05	2.3	1.2	17.9	25
	26	5.9	13.1	0.9	0.5	26.2	5.9	12.7	0.8	0.5	25.4	11.1	17.59	1.9	0.6	27.8	7.8	15.72	1.0	0.5	31.7	10.0	16.36	1.2	0.6	26.7	26
	33	9.6	7.0	2.2	1.4	5.0	15.4	9.8	3.0	1.6	6.1	25.9	20.13	3.7	1.3	15.6	25.4	20.03	3.8	1.3	15.8	27.8	19.67	3.8	1.4	13.9	33
	35	93.2	28.1	6.3	3.3	8.5	102.8	26.9	6.3	3.8	7.1	101.3	28.99	7.8	3.5	8.3	105.0	30.52	7.6	3.4	8.9	104.2	29.02	7.9	3.6	8.1	35
	37	6.2	11.3	1.0	0.6	18.8	6.0	9.5	1.1	0.6	15.8	7.3	11.04	1.4	0.7	16.7	8.5	10.97	1.4	0.8	14.2	9.6	14.37	1.3	0.7	21.6	37
	39	287.6	42.0	9.3	6.9	6.1	272.5	40.4	8.7	6.8	5.9	283.7	41.23	9.1	6.9	6.0	287.7	40.92	9.2	7.0	5.8	274.9	39.76	9.0	6.9	5.8	39
	44	310.3	49.7	8.1	6.2	8.0	332.3	51.9	8.4	6.4	8.1	360.5	52.3	8.7	6.9	7.6	359.6	52.9	8.6	6.8	7.8	319.3	53.7	7.8	5.9	9.0	44
	45	289.3	59.8	8.9	4.8	12.5	293.7	56.0	9.0	5.2	10.8	306.9	57.4	8.7	5.3	10.7	315.5	57.5	9.1	5.5	10.5	320.1	66.1	8.8	4.8	13.7	45
	52	2909.8	228.1	16.0	12.8	17.8	2798.1	220.9	15.6	12.7	17.4	2825.7	220.9	15.6	12.8	17.3	2910.9	220.9	15.1	13.2	16.8	2837.1	220.8	15.2	12.8	17.2	52
	53	2146.7	165.6	20.4	13.0	12.7	1882.9	160.7	19.3	11.7	13.7	2134.4	165.0	19.8	12.9	12.8	2142.2	164.5	23.5	13.0	12.6	1632.4	170.1	13.1	9.6	17.7	53
	54	17.7	10.7	2.7	1.7	6.3	14.6	9.4	2.4	1.6	5.9	17.4	10.9	2.7	1.6	6.8	19.7	12.1	3.1	1.6	7.4	19.8	12.3	2.8	1.6	7.6	54

*New cross-section pins established in 2006.

2.2.4.3 Photography and Videography

Photography and videography were conducted during Year-4 monitoring to assess qualitative changes in channel cross-sections and in-stream habitat. Monitoring pictures and videos of all stations have been included on a digital video disc (DVD) in Appendix E.

2.3 RARE AND PROTECTED SPECIES

Success criteria for rare and protected species were met through the recruitment of the Federally endangered Cape Fear shiner and five state-listed mussel species within the former Site Impoundment. Fish surveys in 2007 documented the Cape Fear shiner at eight sampling sites throughout the Deep River, with a total of 41 individuals collected. Furthermore, areas of favorable habitat for the Cape Fear shiner were observed at many other locations. Mollusk surveys in 2008 documented several mussel species of conservation interest associated with lotic condition, including five state-listed species: yellow lampmussel (*Lampsilis cariosa*), creeper (*Strophitus undulatus*), triangle floater (*Alasmidonta undulata*), eastern creekshell (*Villosa delumbis*), and the notched rainbow (*Villosa constricta*). The presence of notched rainbow is especially significant because this species is extremely rare throughout the Deep River watershed. Four collected mussel species (triangle floater, yellow lampmussel, creeper and eastern creekshell) were targeted rare species identified in the pre-removal report.

Fish surveys performed within McLendons Creek and Big Governors Creek during Year-4 monitoring did not establish the presence of Cape Fear shiner within the tributaries to the Deep River. While no individuals of Cape Fear shiner were collected outside the river mainstem, lotic habitat conditions and riffle-adapted species continue to establish in both tributaries. While it is possible that the Cape Fear shiner will use these new riffle habitats as they develop further, it is unclear how long that recruitment process will take. Lotic habitats have been slower to form within these tributaries, possibly as a result of persistent drought conditions in previous years, and the heavy accumulation of large woody debris (which has contributed to low/slow flowing conditions).

2.4 RESERVE CRITERIA

2.4.1 Public Recreation

RS formally transferred Carbonton Park with an endowment to the Deep River Park Association during a ceremony on November 22, 2008. The completed park consists of vehicle parking, picnicking sites, bank fishing, and improved access to the river for kayakers and canoeists.

The amount of credit to be derived from the successful implementation of the park has not yet been determined. Under exceptional circumstances, if all primary criteria are successfully met, these reserve criteria should result in excess, unsold credits becoming available at the end of the monitoring period.

2.4.2 Scientific Research

The former Site Impoundment was subject to original research by Adam Riggsbee, PhD and Jason Julian, PhD—alumni of the University of North Carolina at Chapel Hill (UNC). RS provided UNC with unrestricted funding to support basic research efforts. To date, Julian has published two papers related to his dissertation, which investigated the environmental processes controlling benthic light availability and the resulting controls on primary and secondary productivity (Julian et. al. 2008a and 2008b). The research may be beneficial in measuring the positive impacts to biological productivity that occurs from lowering the water levels after dam removal to facilitate light penetration to the riverbed. Additional research by Riggsbee investigated the role of sediment suspensions (resulting from dam removal and bankfull discharges) on nutrient and organic matter availability within the water column (Riggsbee et al. 2007 and Riggsbee et al., 2008). Dr. Riggsbee has published three papers with an additional manuscript in revision that originated during his dissertation research (Riggsbee et.al. 2007, Riggsbee et al., 2008 and Doyle et al. 2008), while Dr. Julian has published two papers (Julian et.al. 2008a and Julian et al., 2008b) pertaining to the restored reach of the Deep River. Drs. Riggsbee and Julian have also given numerous oral presentations at professional conferences regarding their research.

The amount of credit to be derived from the support of this research by RS has not yet been determined. Under exceptional circumstances, if all primary criteria are successfully met, these reserve criteria should result in excess, unsold credits becoming available at the end of the monitoring period.

2.5 SUMMARY

After the fourth year of monitoring since the removal of Carbonton Dam, mitigation success criteria has been met for all parameters, and successful restoration of lotic conditions has been demonstrated. Functional improvements have been documented in water quality, fish and mollusk abundance, benthic community, and sediment transport. Mitigation success has been demonstrated for the following criteria: re-introduction of rare and endangered aquatic species, water quality improvement with respect to dissolved oxygen concentrations and benthic biotic indices, improved aquatic community, scientific research, and public recreation. The final year of monitoring in 2010 will aim to further document overall restoration of lotic conditions with an emphasis on the mollusk community and the colonization of Cape Fear shiner in tributaries of the Deep River. Continued monitoring will also further document the convergence of benthic taxa to reference data, and improvements in water quality and aquatic habitat. Table 15 summarizes the project success in meeting primary and reserve mitigation criteria.

Table 15. Mitigation Success Criteria Summary				
	Criterion	**Parameter**	**Anticipated Change/Result**	**2009 Success**
Primary success criteria:	Re-colonization of rare and protected aquatic species	Presence/absence of rare/protected individuals	Re-colonization within the former Site Impoundment	Yes
		Rare/protected species habitat	Improvement/expansion	Yes
	Improved water quality	Benthic biotic indices	Decrease (= improve)	Yes
		AMS dissolved oxygen data	Increase within former Site Impoundment (must be ≥ 4.0 mg/L or consistent with reference station data)	Yes
	Improved aquatic community	Ephemeroptera, Plecoptera, and Trichoptera taxa, total number of benthic taxa	Increase (i.e., converge with reference station data)	Yes
		Fish, Mussel, and Snail community data	Demonstrated shifts in communities from lentic to lotic character	Yes
Reserve success criteria:	Downstream benefits below dam	Deep River bankfull channel within formerly eddie/scour pool areas below dam	Narrowing/increased stabilization of channel	Ongoing
	Scientific value	Published research	Successful completion	Yes
	Public recreation	Construction of planned on-Site park	Successful completion	Yes

3.0 REFERENCES

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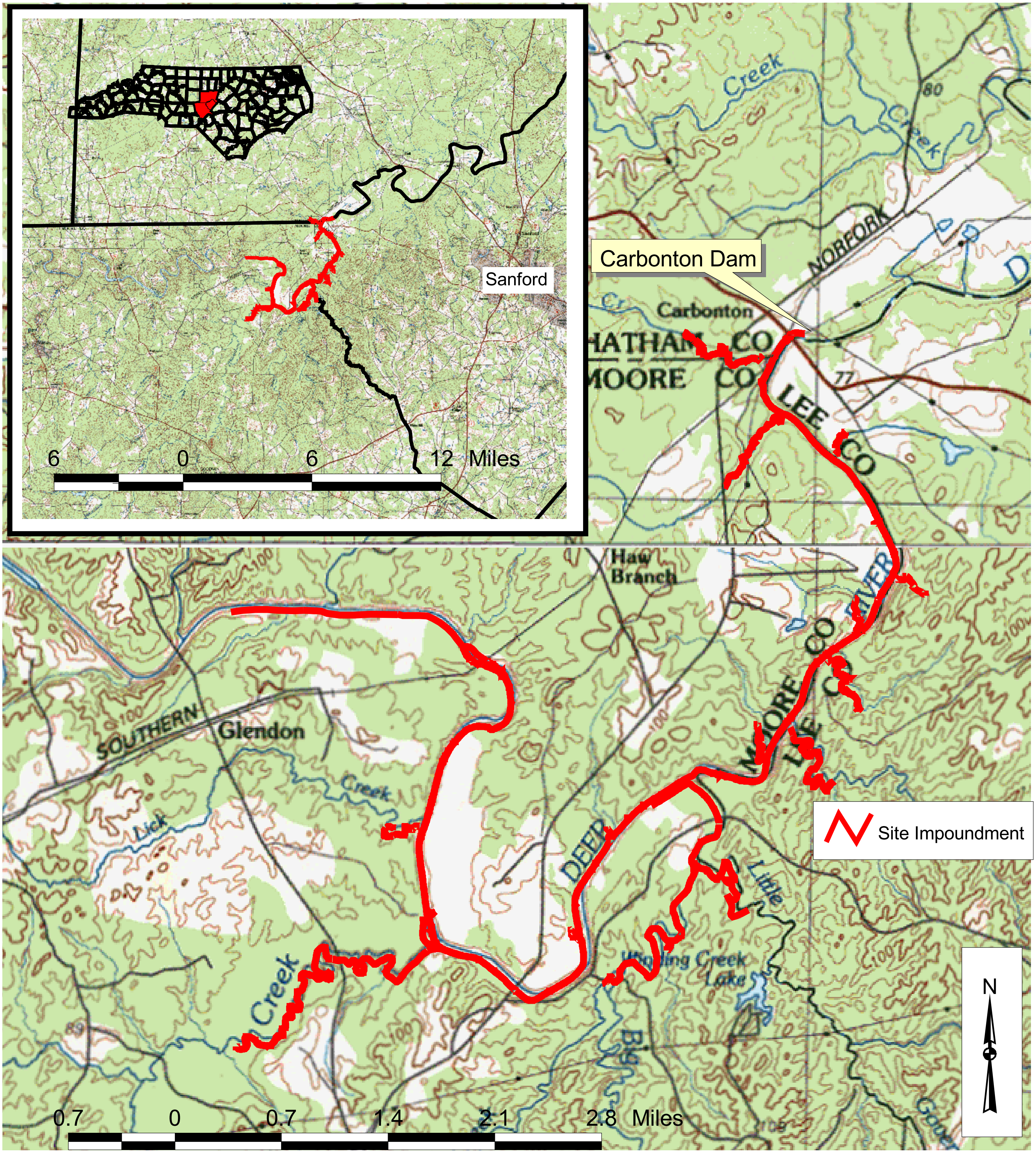
APPENDIX A: FIGURES



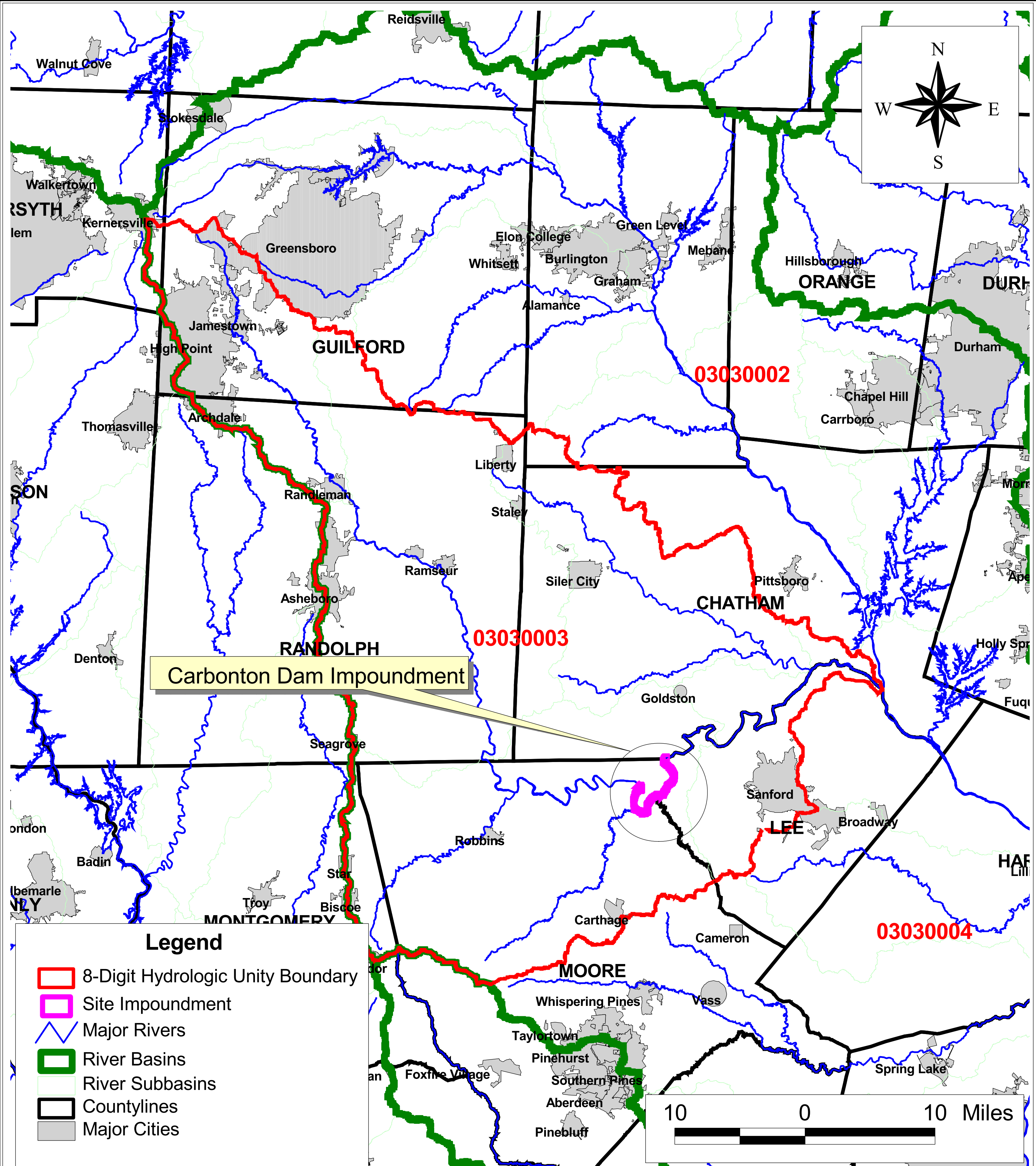
Site Location

Deep River- Carbonton Dam
Restoration Site

Lee, Chatham, and Moore
Counties, North Carolina

RESTORATION SYSTEMS, LLC
Natural Resources Restoration & Conservation

FIGURE	Drawn By: MTC	Date: SEP 2006
1	Chkd By: APS	Project No: 06-288.03
	SCALE: AS SHOWN	



Hydrologic Units

EcoScience Corporation
Raleigh, North Carolina

Deep River-Carbonton Dam Restoration Site

Chatham, Lee, and Moore Counties, North Carolina

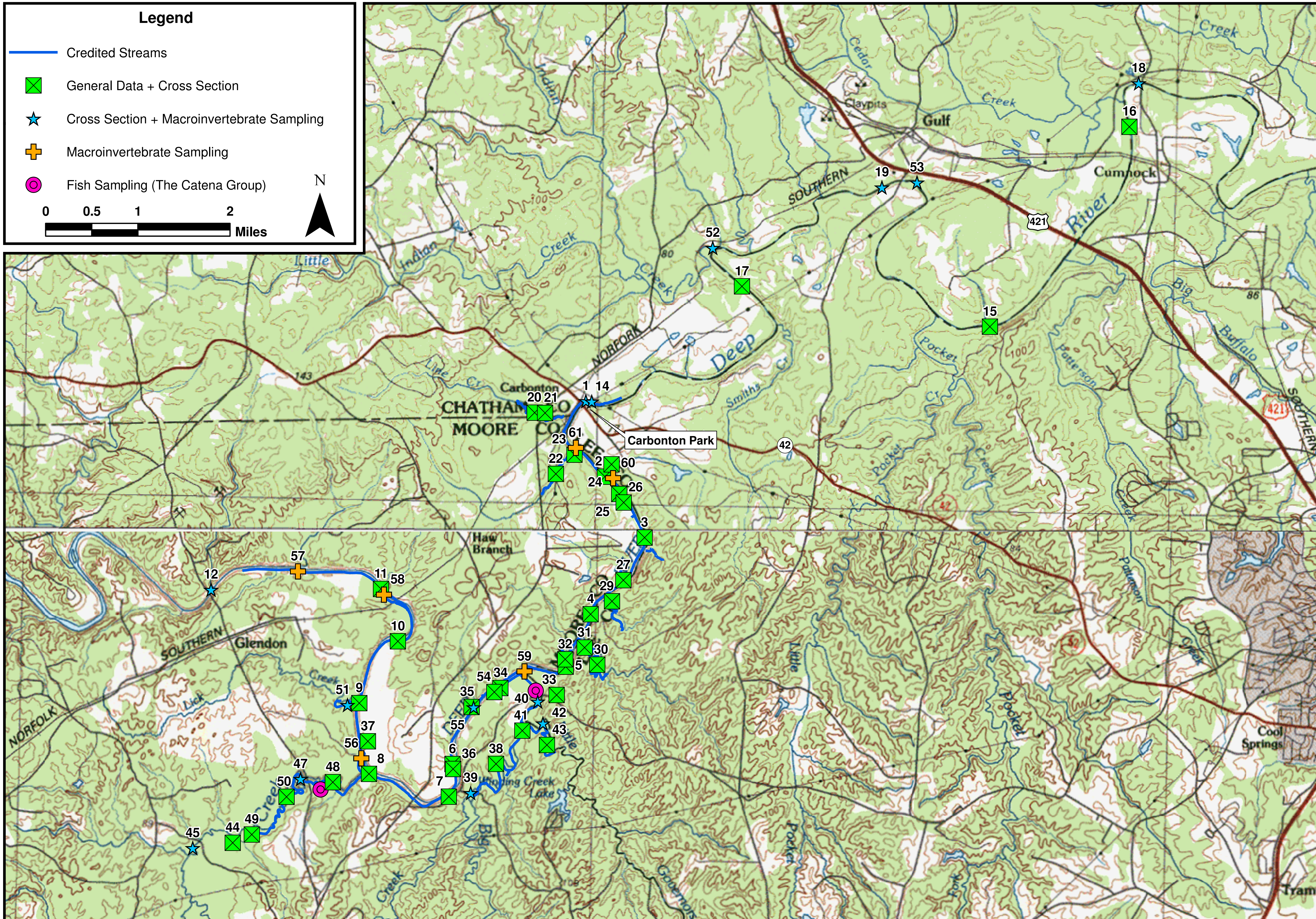
Drawn By: MTC

Chkd By: GRM

Date: SEP 2006

Project: 06-288

FIGURE 2



PBS&J

RESTORATION SYSTEMS, LLC
Natural Resources Restoration & Conservation

Client:

Ecosystem Enhancement PROGRAM

Project:

CARBONTON DAM-DEEP RIVER WATERSHED RESTORATION SITE

Chatham, Lee and Moore Counties, North Carolina

Title:

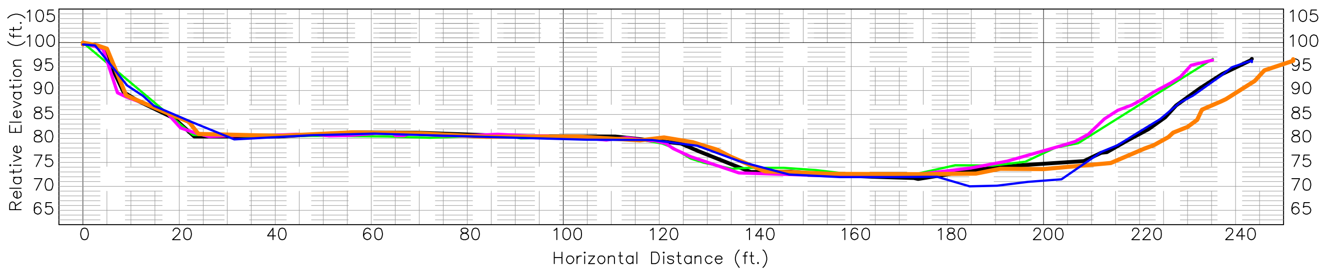
MONITORING STATION LOCATIONS

Dwn By: MCG	Ckd By: MTC
Date: Oct 2009	Scale: As Shown

Project No.: 100007916

FIGURE 3

STATION 1



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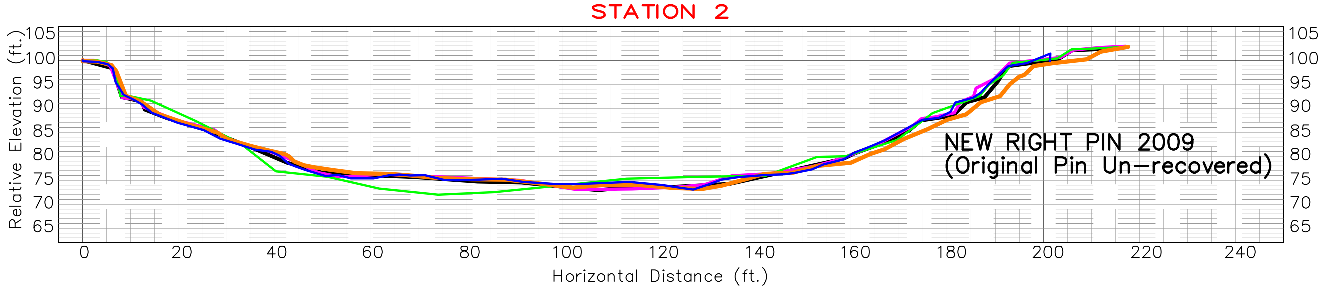

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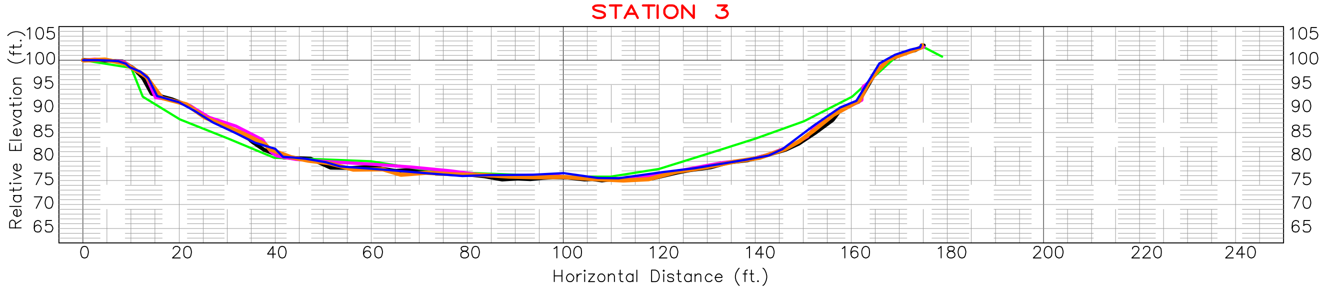

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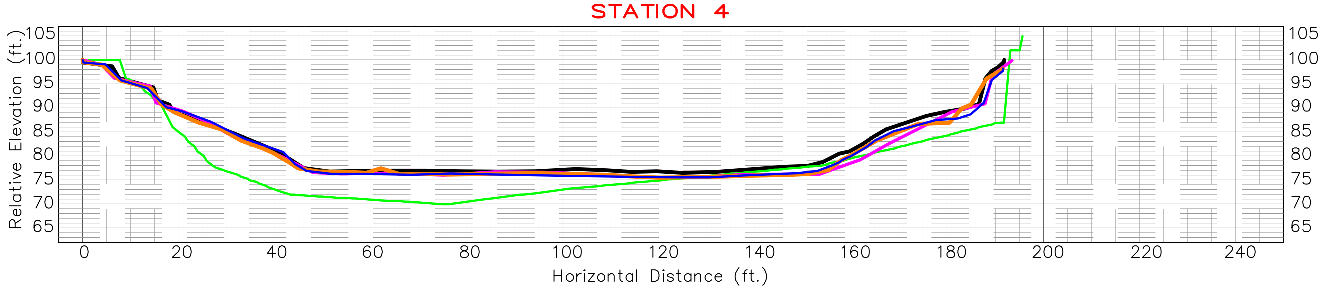

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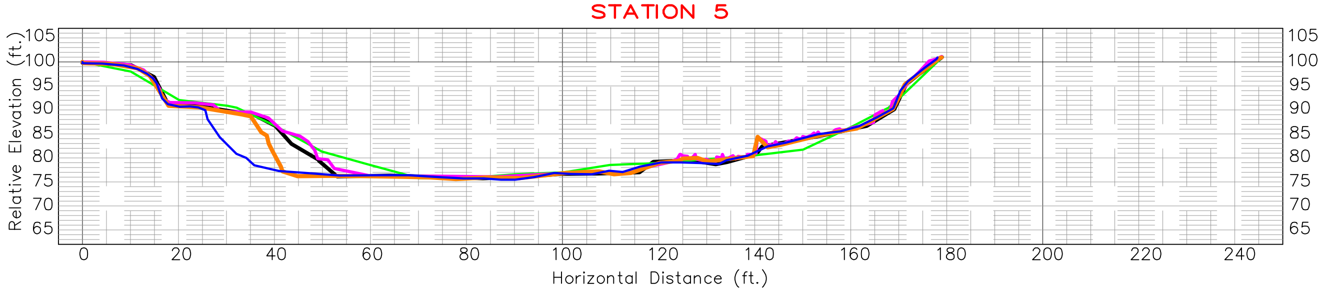

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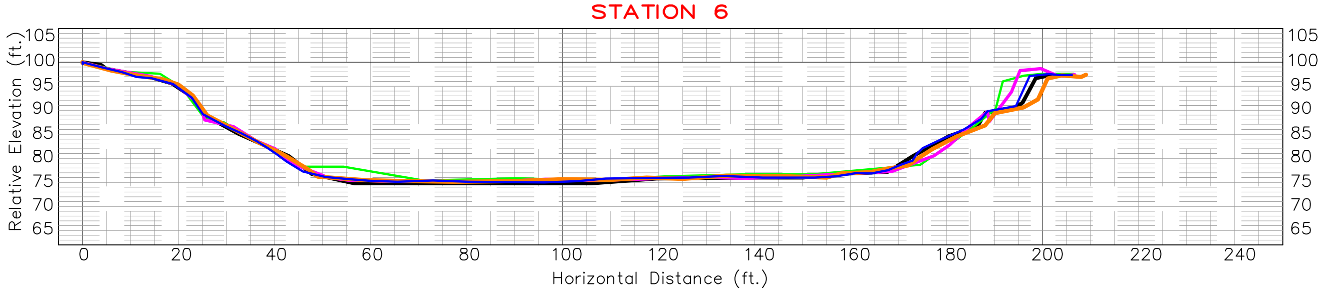

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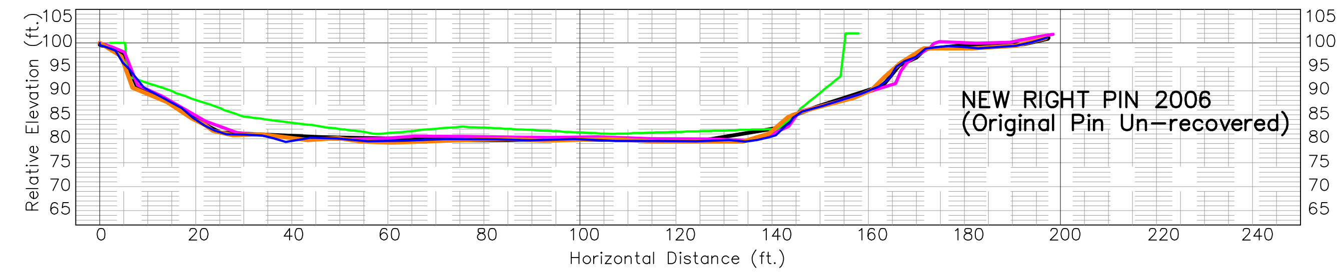

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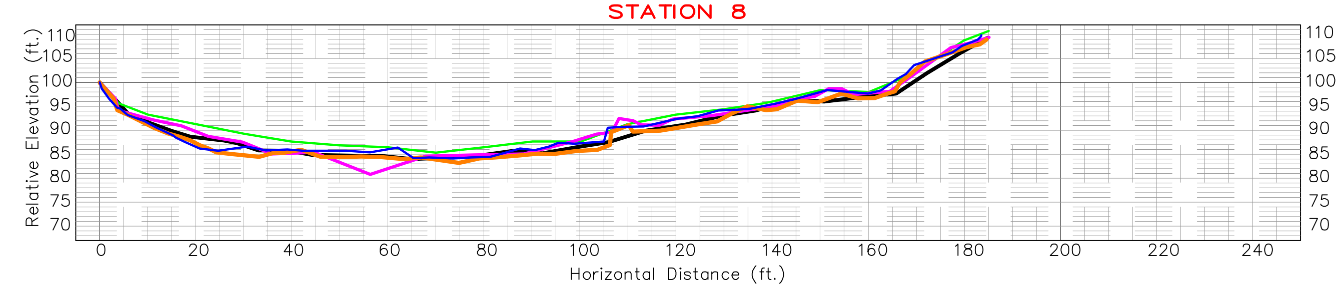

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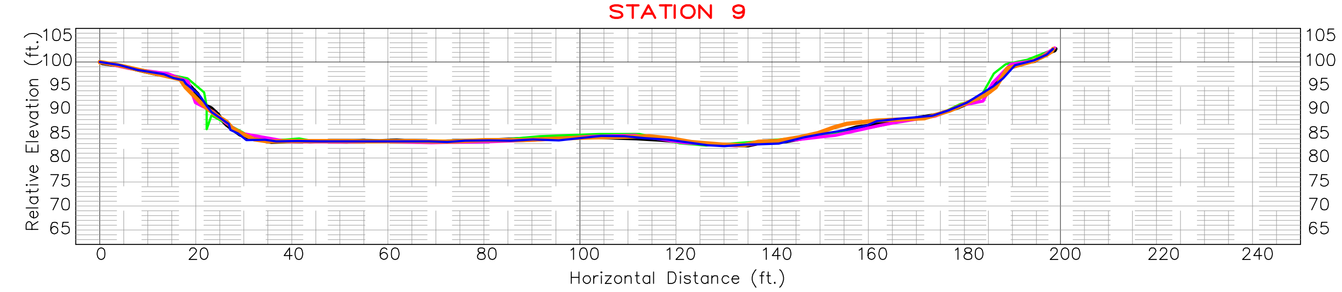

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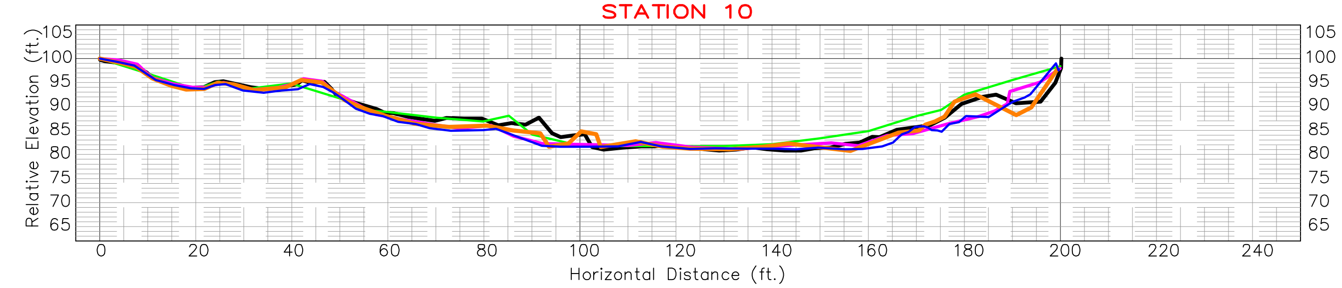

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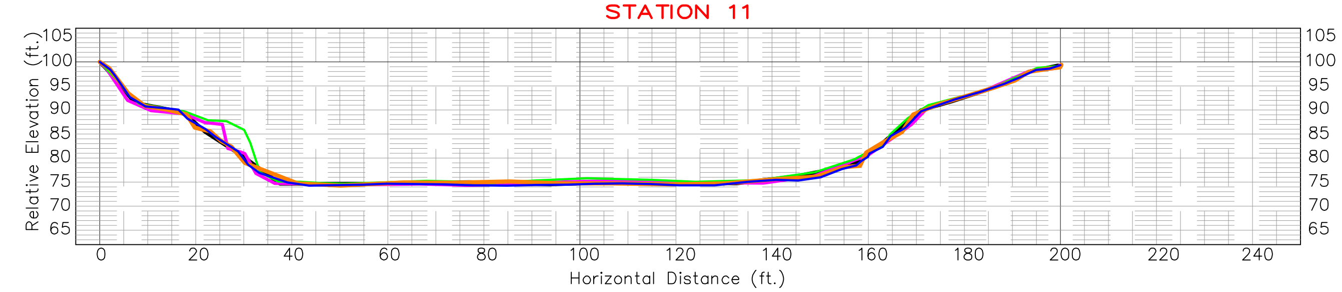

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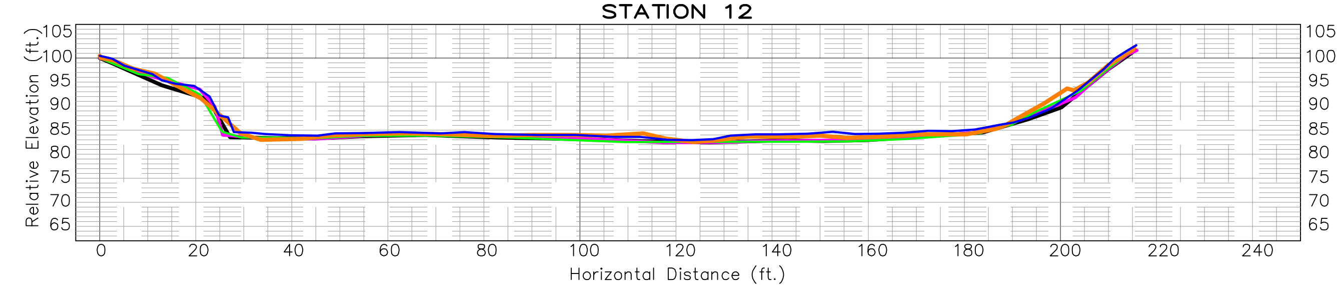


PBS&J

LEGEND:

- YEAR 2005 PRE–DAM REMOVAL
- YEAR 2006 MONITORING
- YEAR 2007 MONITORING
- YEAR 2008 MONITORING
- YEAR 2009 MONITORING
- STATION 1 — STATION–REFERENCE
- STATION 1 — STATION–FORMERLY IMPOUNDED

Client:

Ecosystem Enhancement

Project:

CARBONTON DAM DEEP RIVER WATERSHED RESTORATION SITE

CHATHAM, LEE, AND MOORE COUNTIES, NORTH CAROLINA

Title:

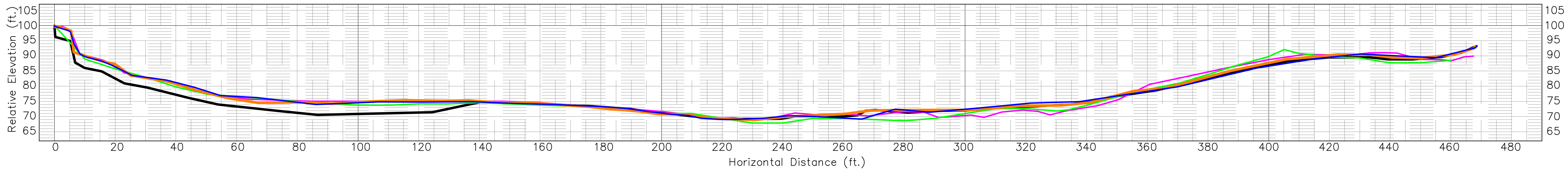
MONITORING CROSS-SECTIONS

Dwn. By: TAL	Ckd. By: MCG
Date: NOV 2009	Scale: AS SHOWN
Project No.: 100007916	

SHEET

4A

STATION 14



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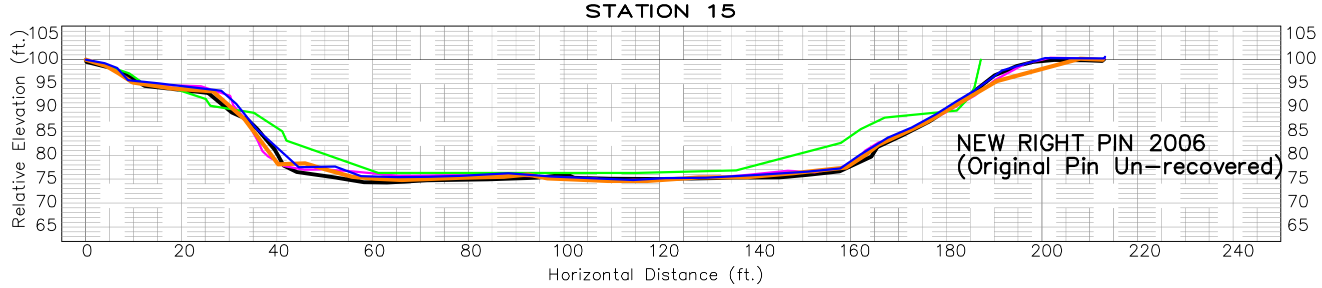

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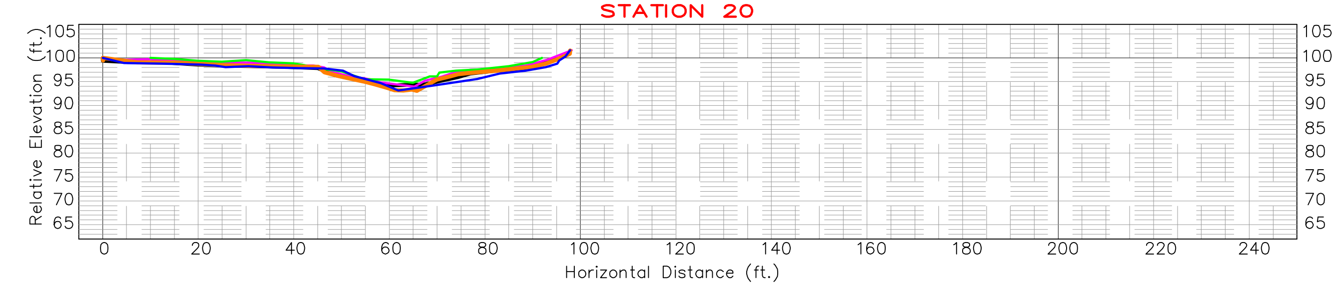

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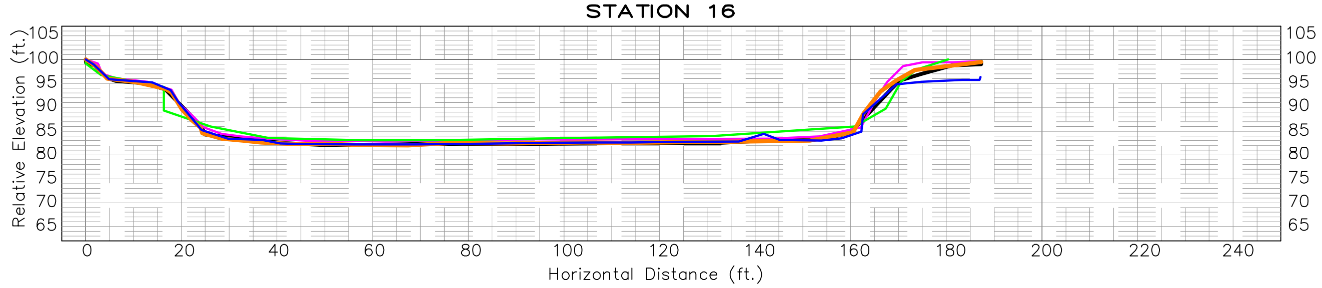

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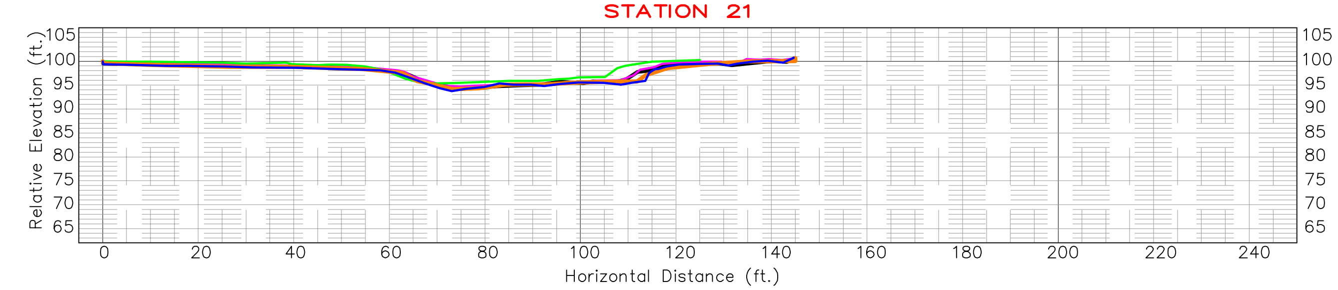

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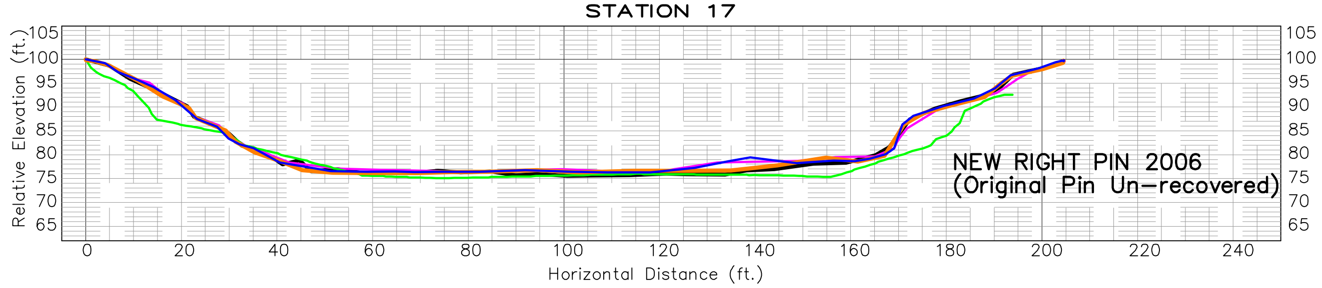

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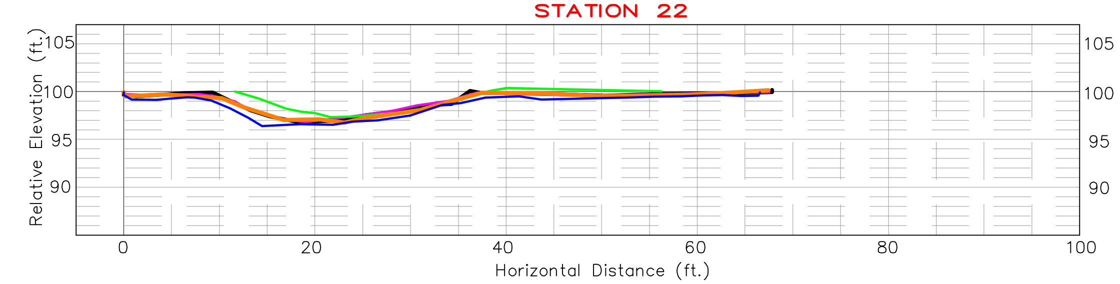

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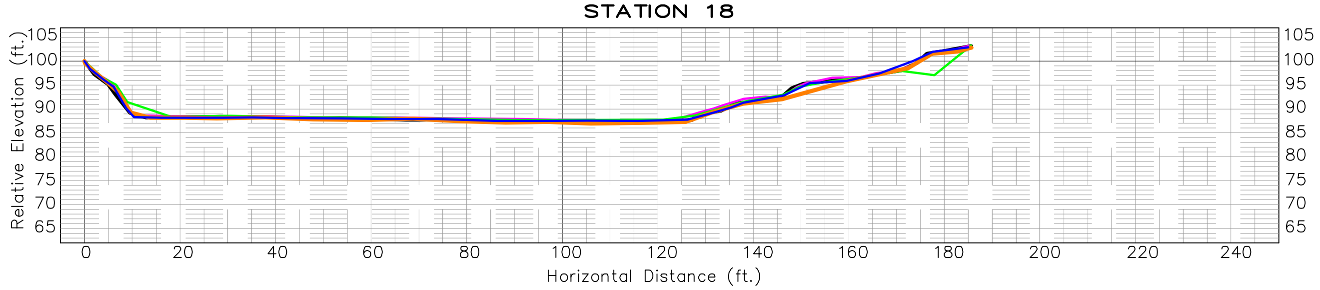

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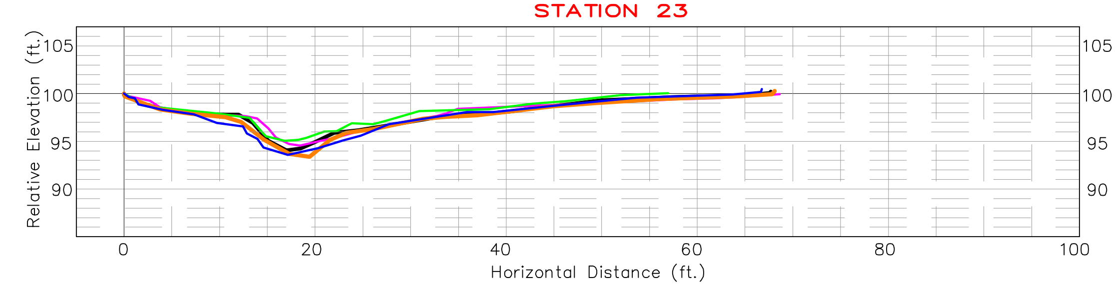

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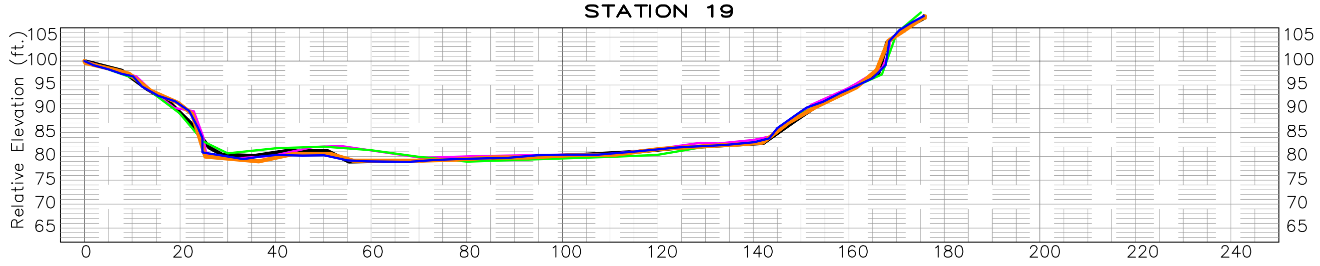

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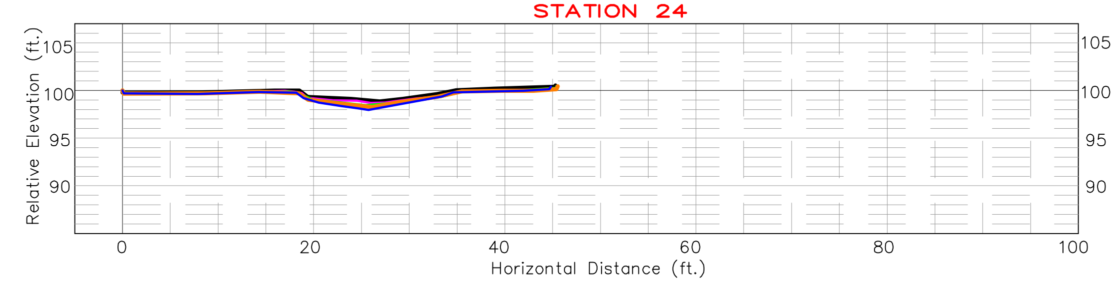


LEGEND:

- YEAR 2005 PRE–DAM REMOVAL
- YEAR 2006 MONITORING
- YEAR 2007 MONITORING
- YEAR 2008 MONITORING
- YEAR 2009 MONITORING
- STATION 1 — STATION–REFERENCE
- STATION 1 — STATION–FORMERLY IMPOUNDED

Client:

Project:

CARBONTON DAM DEEP RIVER WATERSHED RESTORATION SITE

CHATHAM, LEE, AND MOORE COUNTIES, NORTH CAROLINA

Title:

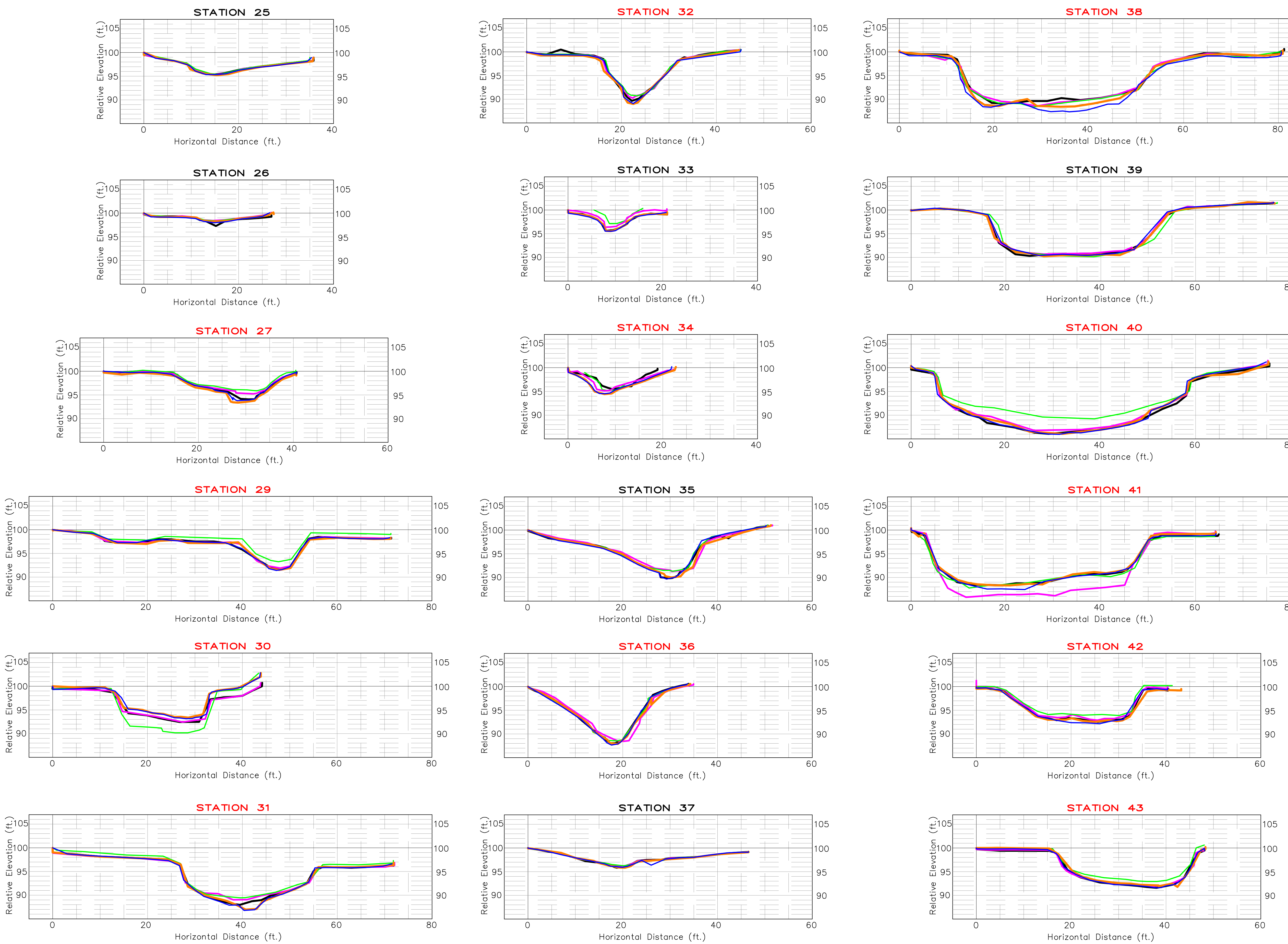
MONITORING CROSS-SECTIONS

Dwn. By:	Ckd. By:
TAL	MCG
Date:	Scale:
NOV 2009	AS SHOWN

Project No.: 100007916

SHEET

4B



PBS&J

LEGEND:

- YEAR 2005 PRE—DAM REMOVAL
- YEAR 2006 MONITORING
- YEAR 2007 MONITORING
- YEAR 2008 MONITORING
- YEAR 2009 MONITORING
- STATION 1 STATION—REFERENCE
- STATION 1 STATION—FORMERLY IMPOUNDED

Client:

Ecosystem Enhancement

Project:

CARBONTON DAM DEEP RIVER WATERSHED RESTORATION SITE

CHATHAM, LEE, AND MOORE COUNTIES, NORTH CAROLINA

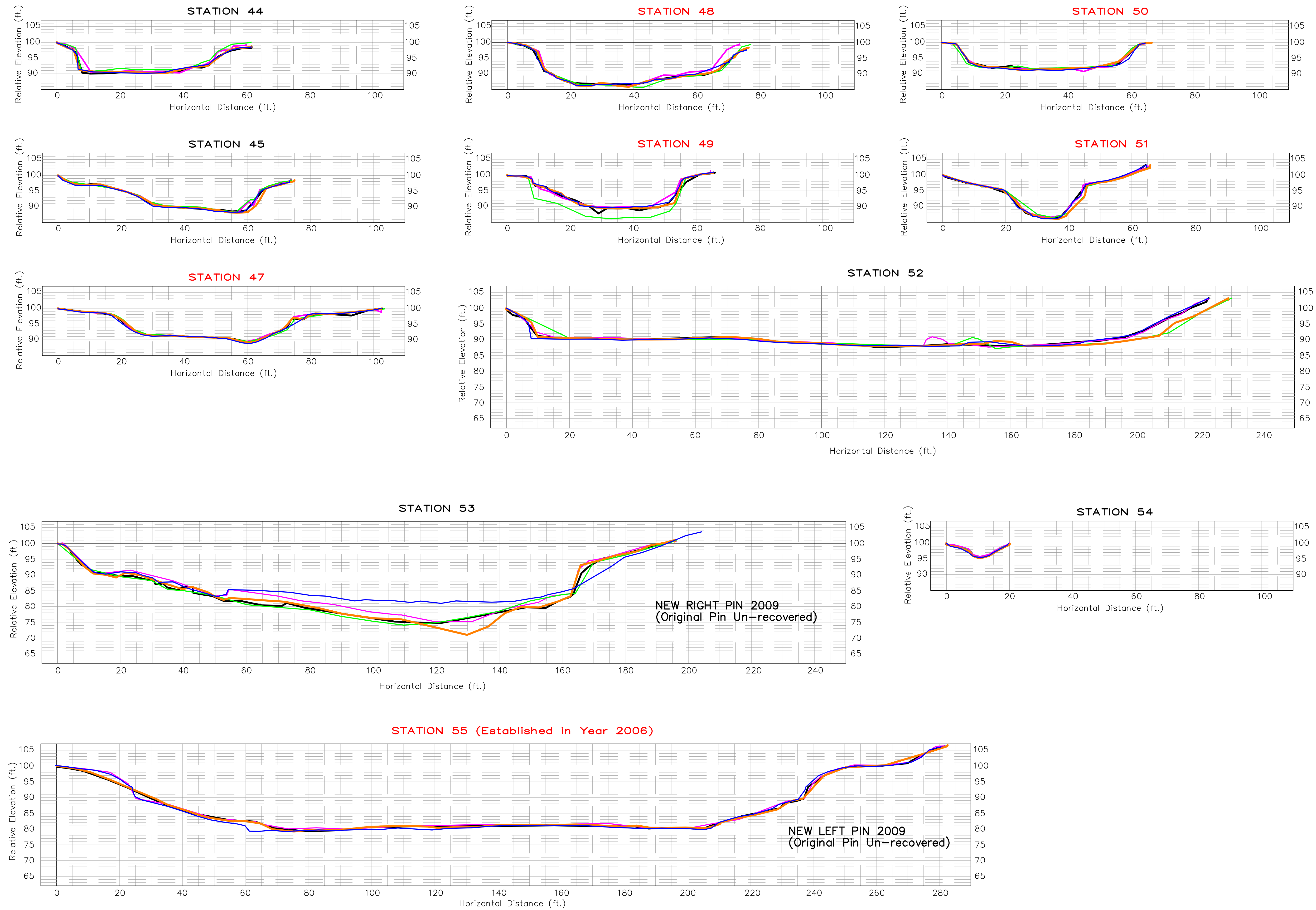
Title:

MONITORING CROSS-SECTIONS

Dwn. By: TAL	Ckd. By: MCG
Date: NOV 2009	Scale: AS SHOWN
Project No.: 100007916	

SHEET

4C



PBS&J

LEGEND:

- YEAR 2005 PRE-DAM REMOVAL
- YEAR 2006 MONITORING
- YEAR 2007 MONITORING
- YEAR 2008 MONITORING
- YEAR 2009 MONITORING
- STATION 1 STATION-REFERENCE
- STATION 1 STATION-FORMERLY IMPOUNDED

Client:

Ecosystem Enhancement

Project:

CARBONTON DAM DEEP RIVER WATERSHED RESTORATION SITE

CHATHAM, LEE, AND MOORE COUNTIES, NORTH CAROLINA

Title:

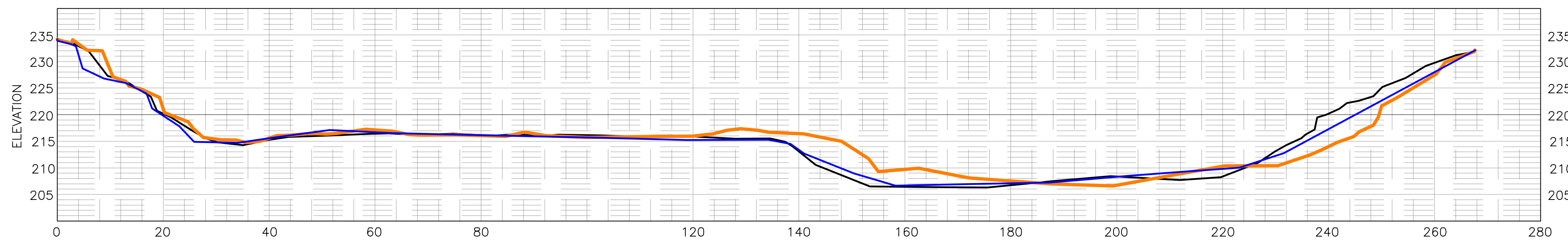
MONITORING CROSS-SECTIONS

Dwn. By: TAL	Ckd. By: MCG
Date: NOV 2009	Scale: AS SHOWN
Project No.: 100007916	

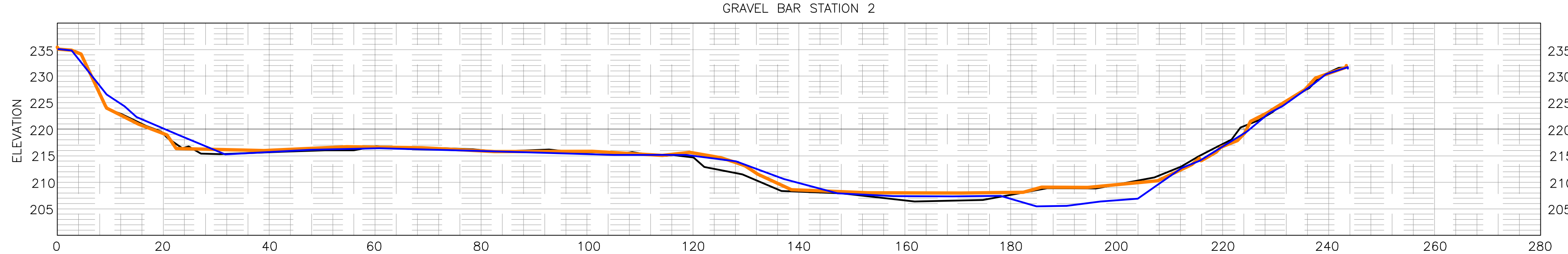
SHEET

4D

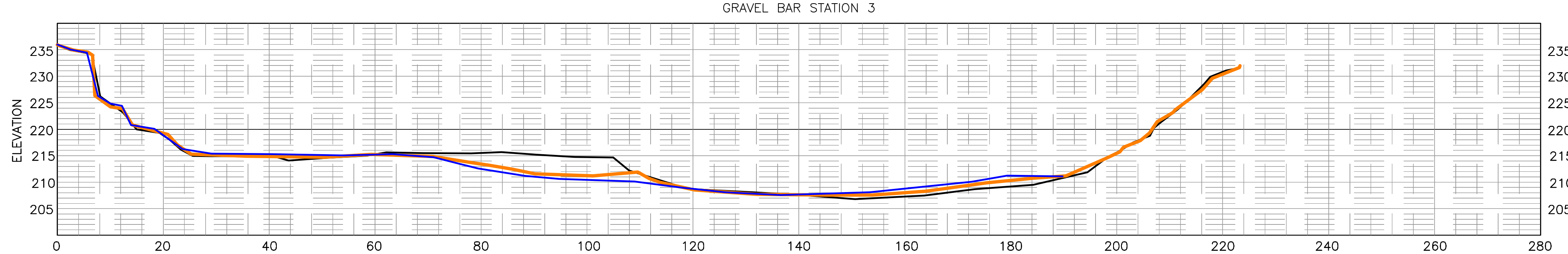
GRAVEL BAR STATION 1



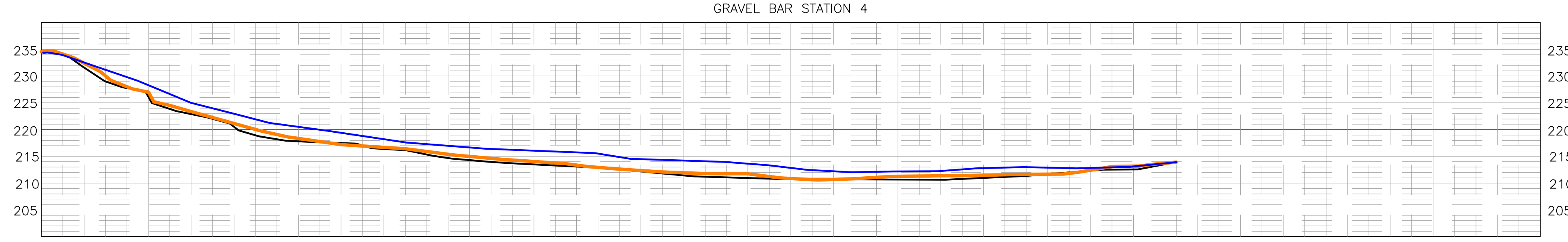
GRAVEL BAR STATION 2



GRAVEL BAR STATION 3



GRAVEL BAR STATION 4



PBS&J

LEGEND:

YEAR 2007 MONITORING

YEAR 2008 MONITORING

YEAR 2009 MONITORING

Client:

Ecosystem Enhancement

Project:

CARBONTON DAM DEEP RIVER WATERSHED RESTORATION SITE

CHATHAM, LEE, AND MOORE COUNTIES, NORTH CAROLINA

Title:

GRAVEL BAR MONITORING CROSS-SECTIONS

Dwn. By: TAL	Ckd. By: MCG
Date: NOV 2009	Scale: AS SHOWN
Project No.: 100007916	

SHEET

4E

APPENDIX B: BENTHIC MACROINVERTEBRATE DATA

			FORMERLY IMPOUNDED STATIONS											
SPECIES	**T.V.**	**F.F.G.**	**1**	**40**	**42**	**47**	**51**	**55**	**56**	**57**	**58**	**59**	**60**	**62**
PLATYHELMINTHES														
Turbellaria														
Dugesiidae														
Girardia (Dugesia) tigrina	**7.2**					1								1
MOLLUSCA														
Bivalvia														
Veneroida														
Sphaeriidae	***8**	**FC**												
Pisidium sp.	**6.5**	**FC**		1										
Sphaerium sp.	**7.6**	**FC**				1								
Gastropoda														
Mesogastropoda														
Hydrobiidae	***8**	**SC**												
Amnicola limosa	**5.2**	**SC**												
Pleuroceridae														
Elimia sp.	**2.5**	**SC**										1		
Basommatophora														
Ancylidae		**SC**												
Ferrissia rivularis	***6**	**SC**						1						
Physidae														
Physella sp.	**8.8**	**CG**		1	1								1	
Planorbidae	***6**	**SC**												
Helisoma anceps	**6.2**	**SC**				1								
ANNELIDA														
Oligochaeta	***10**	**CG**												
Tubificida														
Enchytraeidae	**9.8**	**CG**												
Lumbricidae		**SC**	2			1	5	2	1			4		
Naididae	***8**	**CG**						3						
Nais sp.	**8.9**	**CG**							1					
Slavina appendiculata	**7.1**	**CG**												1
Tubificidae w.h.c.	**7.1**	**CG**					4	1						
Branchiura sowerbyi	**8.3**	**CG**									2			
Tubificidae w.o.h.c.	**7.1**	**CG**	7				1	5			1			
Limnodrilus hoffmeisteri	**9.5**	**CG**					1							
Lumbriculida														
Lumbriculidae	**7**	**CG**	3	4	16	4	1	1	2	1			1	7
Hirudinea		**P**						3						
Arhynchobdellida														
Erpobdellidae		**P**	1											
Rhynchobdellida														
Glossiphoniidae		**P**										1		
Batrachobdella sp.		**P**					1							
Helobdella stagnalis	**8.6**	**P**		4										
Helobdella triserialis	**9.2**	**P**												
Placobdella papillifera	**9**	**P**												
Placobdella sp.	**9**	**P**	1						1	1	3			1
Piscicolidae														

			FORMERLY IMPOUNDED STATIONS											
SPECIES	**T.V.**	**F.F.G.**	**1**	**40**	**42**	**47**	**51**	**55**	**56**	**57**	**58**	**59**	**60**	**62**
ARTHROPODA														
Arachnoidea														
Acariformes	**5.5**													
Lebertiidae	**5.5**													
Lebertia sp.	**5.5**													
Crustacea														
Ostracoda							1							
Copepoda														
Cyclopoida			1											
Isopoda														
Asellidae		**SH**												
Caecidotea sp.	**9.1**	**CG**		67		15	5			1				3
Amphipoda		**CG**												
Crangonyctidae														
Crangonyx sp.	**7.9**	**CG**		8	20	7	5		2					
Hyalellidae														
Hyalella azteca	**7.8**	**CG**	2	13										
Decapoda														
Cambaridae	**7.5**													
Cambarus sp.	**7.6**	**CG**			1		2							
Palaemonidae														
Palaemonetes sp.	**7.1**	**CG**	6					1	1		1			
Insecta														
Collembola								1						
Ephemeroptera														
Baetidae		**CG**										2		
Acentrella sp.	**4**							1						
Acerpenna pygmaea	**3.9**		3			1		2						
Baetis intercalaris	**7**	**CG**	12					28	10	2	18	7	7	10
Callibaetis sp.	**9.8**	**CG**												
Centroptilum sp.	**6.6**	**CG**		1										
Heterocloeon sp.	**3.5**	**SC**						2						3
Plauditus sp.		**CG**	1			1		3	3	1		15		3
Pseudocloeon sp.	**4**	**CG**	2			16		5				3	3	
Caenidae		**CG**												
Caenis sp.	**7.4**	**CG**	3							2	1			1
Ephemeridae		**CG**												
Hexagenia sp.	**4.9**	**CG**				1								
Ephemerellidae		**SC**												
Attenella sp.			1								1			2
Danella sp.			2			17							1	
Ephemerella sp.	**2**	**SC**	5							2				
Ephemerella needhami	**0**	**CG**							7			1	2	2
Eurylophella sp.	**4.3**	**SC**	4	3	3	1	2	1						
Serratella sp.		**SC**	3							2	3		1	3
Timpanoga sp.		**CG**						4						
Heptageniidae		**SC**												
Heptagenia sp.	**2.6**	**SC**						1						
Leucrocuta sp.	**2.4**	**SC**	25					1	4	2	28	4	3	11
Maccaffertium (Stenonema) sp.		**SC**	223			33		113	61	73	111	68	160	88

			FORMERLY IMPOUNDED STATIONS											
SPECIES	**T.V.**	**F.F.G.**	**1**	**40**	**42**	**47**	**51**	**55**	**56**	**57**	**58**	**59**	**60**	**62**
Maccaffertium (Stenonema)	**3.8**	**SC**	3					7	4	3		3	5	2
Stenacron sp.		**SC**	1											
Stenacron pallidum	**2.7**		1											
Stenacron interpunctatum	**6.9**	**SC**				25				48	21		45	35
Stenonema femoratum	**7.2**	**SC**			1									
Isonychiidae		**FC**												
Isonychia sp.	**3.5**	**FC**	20			2		7	1	2	1	1	3	3
Leptophlebiidae		**CG**			1									
Leptophlebia sp.	**6.2**	**CG**		12	1									
Paraleptophlebia sp.	**0.9**	**CG**	1			1	9				1			
Potamanthidae		**CG**												
Anthopotamus (Potamanthus)	**1.5**		4					2	1	4	4	4	4	
Siphlonuridae														
Siphlonurus sp.	**5.8**	**CG**		19	1									
Odonata														
Aeshnidae		**P**			1									
Boyeria vinosa	**5.9**	**P**						1					1	3
Calopterygidae		**P**												
Calopteryx sp.	**7.8**	**P**												
Hetaerina americana														1
Hetaerina sp.	**5.6**	**P**												
Coenagrionidae		**P**												
Argia sp.	**8.2**	**P**	7			10		2	1	4	2	2	7	8
Enallagma sp.	**8.9**	**P**	9					2				1	2	1
Gomphidae		**P**										1		
Dromogomphus spinosus	**5.1**	**P**	1									1	1	3
Dromogomphus sp.	**5.9**	**P**												
Erpetogomphus designatus			1					2					1	12
Erpetogomphus sp.												1		
Gomphus sp.	**5.8**	**P**	3					14	2	1	4		5	18
Hagenius brevistylus	**4**	**P**	1					2						1
Libellulidae		**P**												
Didymops transversa	**2.4**	**P**												
Libellula sp.	**9.6**	**P**	2											
Macromiinae														
Epicordulia princeps	**5.6**	**P**	2					5			1		1	4
Macromia sp.	**6.2**	**P**						2		1		1	8	2
Neurocordulia cf. molesta	**1.8**	**P**						1						
Neurocordulia obsoleta	**5.2**							4	3	2		23	19	8
Neurocordulia sp.	**5**		4											
Somatochlora sp.	**9.2**	**P**												
Tetragoneruia sp.	**8.6**			5										
Plecoptera														
Leuctridae		**SH**												
Leuctra sp.	**2.5**	**SH**						1						
Nemouridae		**SH**												
Amphinemura sp.	**3.3**	**SH**			10			1	3	2				
Perlidae		**P**	2					1		5	5	4	1	
Acroneuria abnormis	**2.1**	**P**												
Acroneuria sp.		**P**							4	14	1	1		2

			FORMERLY IMPOUNDED STATIONS											
SPECIES	**T.V.**	**F.F.G.**	**1**	**40**	**42**	**47**	**51**	**55**	**56**	**57**	**58**	**59**	**60**	**62**
Agnetina sp.	**0**	**P**												1
Neoperla sp.	**1.5**	**P**	3					3	3	4	7	4	1	1
Paragnetina sp.	**1.5**	**P**						1						
Perlesta sp.	**4.7**	**P**	26								14	9		6
Perlesta placida sp. gp.	**4.7**	**P**	25			24		46	48	25	9	20	58	18
Perlodidae		**P**												
Clioperla clio	**4.7**	**P**												
Isoperla sp.		**P**	7	3	4	3			2					
Taeniopterygidae		**SH**												
Taeniopteryx sp.	**5.4**	**SH**	1						1	1				1
Hemiptera														
Corixidae	**9**	**PI**	1	12	2		3							
Belostomatidae														
Belostoma sp.	**9.8**			1						1				
Gerridae		**P**					1							
Aquarius sp.		**P**		1										
Nepidae		**-**												
Ranatra sp.	**7.8**	**P**	2											1
Pleidae														
Neoplea sp.			1											
Megaloptera														
Corydalidae		**P**												
Chauliodes sp.		**P**												
Corydalus cornutus	**5.2**	**P**								1	1	1	2	6
Sialidae		**P**												
Sialis sp.	**7.2**	**P**			1									
Trichoptera														
Hydropsychidae		**FC**												
Cheumatopsyche sp.	**6.2**	**FC**	13			1		9	13	13	28	7	20	45
Hydropsyche venularis	**5**	**FC**												
Hydropsyche sp.		**FC**	28					35	11	6	6	19	22	57
Hydroptilidae		**PI**												
Hydroptila sp.	**6.2**	**PI**						1						
Lepidostomatidae		**SH**												
Lepidostoma sp.	**0.9**	**FC**	2					2	4	1				15
Leptoceridae		**CG**	1					1				1	26	
Ceraclea sp.	**2**	**CG**											2	
Nectopsyche sp.	**2.9**	**SH**	1							4			9	
Nectopsyche exquisita	**4.1**	**SH**						13			1	3		16
Oecetis avara	**4.7**	**P**												
Oecetis sp.	**4.7**	**P**												1
Triaenodes ignitus	**4.6**							1	1	1			1	3
Triaenodes sp.	**4.5**	**SH**							1					
Limnephilidae														
Ironoquia sp.		**-**												
Philopotamidae		**FC**												
Chimarra aterrima	**2.8**	**FC**												
Chimarra obscurus	**2.8**	**FC**	2					2	5	5	12	14		5
Chimarra sp.	**2.8**	**FC**												
Polycentropodidae		**FC**												

SPECIES	T.V.	F.F.G.	FORMERLY IMPOUNDED STATIONS 1	40	42	47	51	55	56	57	58	59	60	62
Neureclipsis sp.	**4.2**	**FC**											1	
Polycentropus sp.	**3.5**	**FC**								1	2		1	
Rhyacophilidae		**P**												
Rhyacophila fenestrata/ledra		**P**												
Uenoidae														
Neophylax sp.	**2.2**	**SC**												
Coleoptera														
Carabidae									1					
Dytiscidae		**P**	2	1		1								
Copelatus sp.	**10**						1							
Neoporus sp.	**8.6**			71	3		5							
Dryopidae														
Helichus sp.	**4.6**	**SC**												
Elmidae		**CG**												
Ancyronyx variegata	**6.5**	**SC**	1							3				3
Dubiraphia sp.	**5.9**	**SC**										1		
Dubiraphia vittata	**4.1**	**SC**	1					2		1				1
Macronychus glabratus	**4.6**	**SH**	2			3		8	2	20	4	5	39	12
Microcylloepus pusillus	**2.1**	**SC**												2
Stenelmis sp.	**5.1**	**SC**	70			1		33	11	37	43	7	15	46
Gyrinidae		**P**												
Dineutus sp.	**5.5**	**P**				1								
Gyrinus sp.	**6.2**	**P**		2										
Haliplidae														
Peltodytes sp.	**8.7**	**SH**	5	2								1		
Peltodytes duocecimpunctatus						2		2					1	
Hydrophilidae		**P**						1						1
Berosus sp.	**8.4**	**CG**						4	1	2				4
Sperchopsis tesselatus	**6.1**	**CG**			2									
Tropisternus sp.	**9.7**	**P**					1							1
Psephenidae		**SC**												
Ectopria sp.		**SC**								1				
Psephenus herricki	**2.4**	**SC**	1					1	15	3	7	1	1	1
Scirtidae							2							2
Scirtes sp.					1									
Staphylinidae		**P**	1					1					1	
Diptera														
Blephariceridae		**SC**												
Blepharicera sp.	**2**	**SC**										1		
Ceratopogonidae		**P**	27			1								
Bezzia/Palpomyia gp.	**6.9**	**P**						3				1		
Chironomidae														
Ablabesmyia mallochi	**7.2**	**P**	6	6	2	11				1			5	
Ablabesmyia rhamphe gp.	**7.2**	**P**												
Cardiocladius obscurus	**5.9**	**P**												
Chironomus sp.	**9.6**	**CG**			1		61							
Cladopelma sp.	**3.5**	**CG**	1											
Cladotanytarsus sp.	**4.1**	**FC**				1								
Clinotanypus sp.		**P**				1								
Conchapelopia sp.	**8.4**	**P**			1			3	3	1	2	1	4	3

SPECIES	T.V.	F.F.G.	FORMERLY IMPOUNDED STATIONS											
			1	40	42	47	51	55	56	57	58	59	60	62
Corynoneura sp.	6	CG	1		1		11	5	2	1	1	13		
Cricotopus sp.		CG	10		9	1			15		41	10	18	
Cricotopus bicinctus	8.5	CG	1		1		1	17	7	1	8	6	13	1
Cryptochironomus sp.	6.4	P	1		1	2								1
Dicrotendipes neomodestus	8.1	CG												
Dicrotendipes simpsoni	10			5	11									
Dicrotendipes sp.	8.1	CG				1	2							
Eukiefferiella claripennis gp.	5.6	CG	5					3	7		3			
Glyptotendipes sp.	9.5	FC		1										
Kiefferulus sp.	8													
Kiefferulus dux					3									
Labrundinia sp.	5.9	P						1						
Lopescladius sp.									1					
Orthocladius sp.		CG				2	7	1	4		19	13	1	
Orthocladius (Euorthocladius)sp.								1	3		1	1		
Nanocladius distinctus	7.1	CG					1						1	
Nilotanypus sp.	3.9	P								1				
Nilothauma sp.	5	CG				1							1	
Paracladopelma sp.	5.5	CG	1											
Parakiefferiella sp.	5.4	CG	3	5	4	3	25	15	33	3	2	7		1
Parametriocnemus sp.	3.7	CG												
Paratanytarsus sp.	8.5	CG				2								
Paratendipes sp.	5.1	CG		1	1	1								
Pentaneura sp.	4.7	CG											3	
Phaenopsectra punctipes gp.						2								
Polypedilum fallax	6.4	SH			7									
Polypedilum flavum (convictum)	4.9	SH	25	1				9	4	1	7	46	15	17
Polypedilum illinoense	9	SH	12	1	11			30	3	4			21	23
Polypedilum scalaenum	8.4		1					5				2	15	3
Procladius sp.	9.1	P	1	1			7							
Psectrocladius sp.	3.6	SH			13									
Pseudochironomus sp.	5.4	CG											1	1
Rheocricotopus robacki	7.3	CG						5	1			1		1
Rheotanytartsus exiguus gp.	5.9		7	1		3		17	10	4	7	11	10	3
Robackia demeijerei	3.7	CG							2					
Stenochironomus sp.	6.5	SH			1					1				
Stictochironomus devinctus		CG	1											
Tanytarsus sp.	6.8	FC	4	5	8	1	24	3		3	3		10	
Thienemanniella xena	5.9	CG			4			21	13		12	10	13	1
Tribelos jucundum	6.3			2		52		1					3	
Tvetenia paucunca	3.7	CG												
Tvetenia vitracies	3.6	CG	1					4				1		1
Zavrelimyia sp.	9.1	P		1	1									
Culicidae		FC					1							
Empididae	7.6	P												
Hemerodromia sp.		P						1						
Simuliidae		FC												
Prosimulium sp.	6	FC			1									
Simulium sp.	6	FC	36		1	2		8	14	2		6		2
Tabanidae		PI												

			FORMERLY IMPOUNDED STATIONS											
SPECIES	**T.V.**	**F.F.G.**	**1**	**40**	**42**	**47**	**51**	**55**	**56**	**57**	**58**	**59**	**60**	**62**
Chrysops sp.	**6.7**	**PI**						1						
Tipulidae		**SH**												
Antocha sp.	**4.3**	**CG**												
Limnophila sp.		**P**												
Tipula sp.	**7.3**	**SH**	1		1	1	1	1	2					2
TOTAL NO. OF ORGANISMS			**710**	**261**	**152**	**262**	**191**	**554**	**355**	**326**	**449**	**372**	**616**	**548**
TOTAL NO. OF TAXA			**78**	**32**	**38**	**44**	**29**	**77**	**51**	**52**	**43**	**52**	**55**	**67**
EPT TAXA			**30**	**5**	**7**	**13**	**2**	**28**	**20**	**24**	**20**	**20**	**22**	**25**
BIOTIC INDEX ASSIGNED			**5.47**	**7.60**	**6.78**	**6.37**	**7.21**	**5.79**	**5.21**	**5.32**	**5.19**	**4.97**	**5.92**	**5.41**

SPECIES	T.V.	F.F.G.	REFERENCE STATIONS 12	14	18	19	39	45	52	53
PLATYHELMINTHES										
Turbellaria										
Dugesiidae										
Girardia (Dugesia) tigrina	7.2									
MOLLUSCA										
Bivalvia										
Veneroida										
Sphaeriidae	*8	FC								
Pisidium sp.	6.5	FC								
Sphaerium sp.	7.6	FC								
Gastropoda										
Mesogastropoda										
Hydrobiidae	*8	SC								
Amnicola limosa	5.2	SC	1							
Pleuroceridae										
Elimia sp.	2.5	SC	1							
Basommatophora										
Ancylidae		SC								
Ferrissia rivularis	*6	SC	1							
Physidae										
Physella sp.	8.8	CG					4			
Planorbidae	*6	SC								
Helisoma anceps	6.2	SC								
ANNELIDA										
Oligochaeta	*10	CG								
Tubificida										
Enchytraeidae	9.8	CG			1					2
Lumbricidae		SC	13	14	1					4
Naididae	*8	CG							3	
Nais sp.	8.9	CG								
Slavina appendiculata	7.1	CG								
Tubificidae w.h.c.	7.1	CG		1						
Branchiura sowerbyi	8.3	CG								
Tubificidae w.o.h.c.	7.1	CG		2		1				
Limnodrilus hoffmeisteri	9.5	CG					2			
Lumbriculida										
Lumbriculidae	7	CG	1	14		2	3	3	1	1
Hirudinea		P								
Arhynchobdellida										
Erpobdellidae		P								
Rhynchobdellida										
Glossiphoniidae		P								
Batrachobdella sp.		P								
Helobdella stagnalis	8.6	P					1			
Helobdella triserialis	9.2	P					1			
Placobdella papillifera	9	P						1		
Placobdella sp.	9	P								
Piscicolidae						1				
ARTHROPODA										
Arachnoidea										
Acariformes	5.5									
Lebertiidae	5.5									
Lebertia sp.	5.5				4					

SPECIES	T.V.	F.F.G.	REFERENCE STATIONS							
			12	14	18	19	39	45	52	53
Crustacea										
Ostracoda										
Copepoda										
Cyclopoida										
Isopoda										
Asellidae		**SH**								
Caecidotea sp.	**9.1**	**CG**		3	5	1	5	3		15
Amphipoda		**CG**							1	
Crangonyctidae										
Crangonyx sp.	**7.9**	**CG**	4		3		44	2		3
Hyalellidae										
Hyalella azteca	**7.8**	**CG**	4	3				7		
Decapoda										
Cambaridae	**7.5**							1		
Cambarus sp.	**7.6**	**CG**		1						
Palaemonidae										
Palaemonetes sp.	**7.1**	**CG**	2	3		5		2		
Insecta										
Collembola								1		
Ephemeroptera										
Baetidae		**CG**		1						
Acentrella sp.	**4**									
Acerpenna pygmaea	**3.9**				3	2		3	1	1
Baetis intercalaris	**7**	**CG**	10	2	1				1	
Callibaetis sp.	**9.8**	**CG**					2			
Centroptilum sp.	**6.6**	**CG**								
Heterocloeon sp.	**3.5**	**SC**								
Plauditus sp.		**CG**		5	3		6	9		
Pseudocloeon sp.	**4**	**CG**			1					
Caenidae		**CG**								
Caenis sp.	**7.4**	**CG**	1	2	22	1				1
Ephemeridae		**CG**								
Hexagenia sp.	**4.9**	**CG**								
Ephemerellidae		**SC**								
Attenella sp.							4		1	1
Danella sp.									2	
Ephemerella sp.	**2**	**SC**		5	3	2			6	
Ephemerella needhami	**0**	**CG**	7	6	2	4			9	
Eurylophella sp.	**4.3**	**SC**	1			1	9			1
Serratella sp.		**SC**	6	1						
Timpanoga sp.		**CG**		3	4	1	1			
Heptageniidae		**SC**		1						
Heptagenia sp.	**2.6**	**SC**		1					2	2
Leucrocuta sp.	**2.4**	**SC**	21	8	6	3			3	1
Maccaffertium (Stenonema) sp.		**SC**	65	162	147	129	25	8	133	52
Maccaffertium (Stenonema)	**3.8**	**SC**	3	1	1				1	
Stenacron sp.		**SC**								
Stenacron pallidum	**2.7**									
Stenacron interpunctatum	**6.9**	**SC**	7	5			7	1		
Stenonema femoratum	**7.2**	**SC**					1			
Isonychiidae		**FC**			1					
Isonychia sp.	**3.5**	**FC**	6	2		7			7	
Leptophlebiidae		**CG**								

			REFERENCE STATIONS							
SPECIES	**T.V.**	**F.F.G.**	**12**	**14**	**18**	**19**	**39**	**45**	**52**	**53**
Paraleptophlebia sp.	**0.9**	**CG**		1	4				1	7
Potamanthidae		**CG**								
Anthopotamus (Potamanthus) sp.	**1.5**		4	1		3			3	3
Siphlonuridae										
Siphlonurus sp.	**5.8**	**CG**					1			
Odonata										
Aeshnidae		**P**								
Boyeria vinosa	**5.9**	**P**					1	1		
Calopterygidae		**P**								
Calopteryx sp.	**7.8**	**P**						1		
Hetaerina americana										
Hetaerina sp.	**5.6**	**P**		2		1				
Coenagrionidae		**P**								
Argia sp.	**8.2**	**P**		5	2	9			1	6
Enallagma sp.	**8.9**	**P**	1			1				
Gomphidae		**P**		8						1
Dromogomphus spinosus	**5.1**	**P**								1
Dromogomphus sp.	**5.9**	**P**				1				
Erpetogomphus designatus										
Erpetogomphus sp.				1						
Gomphus sp.	**5.8**	**P**			1	4			3	2
Hagenius brevistylus	**4**	**P**		3		3				
Libellulidae		**P**								
Didymops transversa	**2.4**	**P**						1		
Libellula sp.	**9.6**	**P**		3						
Macromiinae										
Epicordulia princeps	**5.6**	**P**		3					2	
Macromia sp.	**6.2**	**P**				1			2	
Neurocordulia cf. molesta	**1.8**	**P**								
Neurocordulia obsoleta	**5.2**			9	8	11			17	2
Neurocordulia sp.	**5**									
Somatochlora sp.	**9.2**	**P**					1	1		
Tetragoneruia sp.	**8.6**									
Plecoptera										
Leuctridae		**SH**								
Leuctra sp.	**2.5**	**SH**			1					
Nemouridae		**SH**								
Amphinemura sp.	**3.3**	**SH**	3		7	5	25	24	14	1
Perlidae		**P**	2				1			
Acroneuria abnormis	**2.1**	**P**	1							
Acroneuria sp.		**P**		2	1				2	
Agnetina sp.	**0**	**P**	2							
Neoperla sp.	**1.5**	**P**	18			2			2	
Paragnetina sp.	**1.5**	**P**								
Perlesta sp.	**4.7**	**P**							30	13
Perlesta placida sp. gp.	**4.7**	**P**	30	8	39	10	13	3	37	
Perlodidae		**P**				1				
Clioperla clio	**4.7**	**P**						1		
Isoperla sp.		**P**	4	1	7	4	53	121	25	5
Taeniopterygidae		**SH**								
Taeniopteryx sp.	**5.4**	**SH**				1			1	
Hemiptera										
Corixidae	**9**	**PI**								

			REFERENCE STATIONS							
SPECIES	**T.V.**	**F.F.G.**	**12**	**14**	**18**	**19**	**39**	**45**	**52**	**53**
Belostomatidae										
Belostoma sp.	**9.8**									
Gerridae		**P**								
Aquarius sp.		**P**								
Nepidae		**-**								
Ranatra sp.	**7.8**	**P**	5							
Pleidae					1					
Neoplea sp.										
Megaloptera										
Corydalidae		**P**								
Chauliodes sp.		**P**		1						
Corydalus cornutus	**5.2**	**P**	1						1	
Sialidae		**P**								
Sialis sp.	**7.2**	**P**								
Trichoptera										
Hydropsychidae		**FC**						1		
Cheumatopsyche sp.	**6.2**	**FC**	45	8	3	3	1	1	6	2
Hydropsyche venularis	**5**	**FC**	73							
Hydropsyche sp.		**FC**		42	12	4			31	1
Hydroptilidae		**PI**								
Hydroptila sp.	**6.2**	**PI**				1				
Lepidostomatidae		**SH**								
Lepidostoma sp.	**0.9**	**FC**	8	9		1				
Leptoceridae		**CG**								
Ceraclea sp.	**2**	**CG**								
Nectopsyche sp.	**2.9**	**SH**		2	2					
Nectopsyche exquisita	**4.1**	**SH**								
Oecetis avara	**4.7**	**P**			1					
Oecetis sp.	**4.7**	**P**								
Triaenodes ignitus	**4.6**		1			1			1	1
Triaenodes sp.	**4.5**	**SH**								
Limnephilidae										
Ironoquia sp.		**-**					2			
Philopotamidae		**FC**								
Chimarra aterrima	**2.8**	**FC**								
Chimarra obscurus	**2.8**	**FC**	54	3	2				6	
Chimarra sp.	**2.8**	**FC**								
Polycentropodidae		**FC**								
Neureclipsis sp.	**4.2**	**FC**	1	1						
Polycentropus sp.	**3.5**	**FC**			1					1
Rhyacophilidae		**P**								
Rhyacophila fenestrata/ledra		**P**							1	
Uenoidae										
Neophylax sp.	**2.2**	**SC**						1		
Coleoptera										
Carabidae										
Dytiscidae		**P**	1							
Copelatus sp.	**10**									
Neoporus sp.	**8.6**				2		2			1
Dryopidae										
Helichus sp.	**4.6**	**SC**						1		1
Elmidae		**CG**								
Ancyronyx variegata	**6.5**	**SC**		1						

SPECIES	T.V.	F.F.G.	REFERENCE STATIONS 12	14	18	19	39	45	52	53
Dubiraphia sp.	**5.9**	**SC**								
Dubiraphia vittata	**4.1**	**SC**		2	2					
Macronychus glabratus	**4.6**	**SH**	1			1			1	5
Microcylloepus pusillus	**2.1**	**SC**	1	1						
Stenelmis sp.	**5.1**	**SC**	30	13	4	2			8	
Gyrinidae		**P**								
Dineutus sp.	**5.5**	**P**								
Gyrinus sp.	**6.2**	**P**								
Haliplidae										
Peltodytes sp.	**8.7**	**SH**		4						3
Peltodytes duocecimpunctatus			6		1	1	1			
Hydrophilidae		**P**								
Berosus sp.	**8.4**	**CG**		2	1					
Sperchopsis tesselatus	**6.1**	**CG**								
Tropisternus sp.	**9.7**	**P**								
Psephenidae		**SC**								
Ectopria sp.		**SC**			5					
Psephenus herricki	**2.4**	**SC**	12		2					
Scirtidae										
Scirtes sp.			1							
Staphylinidae		**P**	1							
Diptera										
Blephariceridae		**SC**								
Blephariceera sp.	**2**	**SC**								
Ceratopogonidae		**P**			1					
Bezzia/Palpomyia gp.	**6.9**	**P**	2	2	1					
Chironomidae										
Ablabesmyia mallochi	**7.2**	**P**				1	8	4		15
Ablabesmyia rhamphe gp.	**7.2**	**P**		1						
Cardiocladius obscurus	**5.9**	**P**	4							
Chironomus sp.	**9.6**	**CG**					2			
Cladopelma sp.	**3.5**	**CG**								
Cladotanytarsus sp.	**4.1**	**FC**		1	1				1	
Clinotanypus sp.		**P**								
Conchapelopia sp.	**8.4**	**P**	1	1	2	5	8			
Corynoneura sp.	**6**	**CG**		2	1	2		1	1	1
Cricotopus sp.		**CG**	3	2	1	2	3	2		1
Cricotopus bicinctus	**8.5**	**CG**			2		1			2
Cryptochironomus sp.	**6.4**	**P**			1			1		
Dicrotendipes neomodestus	**8.1**	**CG**			3					
Dicrotendipes simpsoni	**10**						27			
Dicrotendipes sp.	**8.1**	**CG**								1
Eukiefferiella claripennis gp.	**5.6**	**CG**	3				10		4	
Glyptotendipes sp.	**9.5**	**FC**								
Kiefferulus sp.	**8**									
Kiefferulus dux							1			
Labrundinia sp.	**5.9**	**P**								
Lopescladius sp.			1							
Orthocladius sp.		**CG**	5				36	12	2	
Orthocladius (Euorthocladius)sp.										
Nanocladius distinctus	**7.1**	**CG**				1		4		
Nilotanypus sp.	**3.9**	**P**							1	2
Nilothauma sp.	**5**	**CG**								

SPECIES	T.V.	F.F.G.	12	14	18	19	39	45	52	53
						REFERENCE STATIONS				
Paracladopelma sp.	**5.5**	**CG**		1						1
Parakiefferiella sp.	**5.4**	**CG**	2	2	5			2		3
Parametriocnemus sp.	**3.7**	**CG**	1				1			
Paratanytarsus sp.	**8.5**	**CG**								
Paratendipes sp.	**5.1**	**CG**		2			22			
Pentaneura sp.	**4.7**	**CG**	1		1					3
Phaenopsectra punctipes gp.										
Polypedilum fallax	**6.4**	**SH**								2
Polypedilum flavum (convictum)	**4.9**	**SH**	17	3	11	1	1		8	5
Polypedilum illinoense	**9**	**SH**		3	4		1			1
Polypedilum scalaenum	**8.4**			5					1	
Procladius sp.	**9.1**	**P**		2						
Psectrocladius sp.	**3.6**	**SH**					5			
Pseudochironomus sp.	**5.4**	**CG**								
Rheocricotopus robacki	**7.3**	**CG**								
Rheotanytartsus exiguus gp.	**5.9**		6	2	3				2	1
Robackia demeijerei	**3.7**	**CG**								
Stenochironomus sp.	**6.5**	**SH**	1				1			
Stictochironomus devinctus		**CG**								
Tanytarsus sp.	**6.8**	**FC**		2	1		3	15		2
Thienemanniella xena	**5.9**	**CG**		1	4		1			15
Tribelos jucundum	**6.3**						44	3	3	
Tvetenia paucunca	**3.7**	**CG**			1					
Tvetenia vitracies	**3.6**	**CG**	1	1						
Zavrelimyia sp.	**9.1**	**P**					1			
Culicidae		**FC**								
Empididae	**7.6**	**P**								
Hemerodromia sp.		**P**								
Simuliidae		**FC**								
Prosimulium sp.	**6**	**FC**								
Simulium sp.	**6**	**FC**	22	15	10		12		8	5
Tabanidae		**PI**								
Chrysops sp.	**6.7**	**PI**					1			
Tipulidae		**SH**								
Antocha sp.	**4.3**	**CG**					4			
Limnophila sp.		**P**					1			
Tipula sp.	**7.3**	**SH**	2	1			4	2	1	
TOTAL NO. OF ORGANISMS			**592**	**501**	**460**	**338**	**609**	**469**	**658**	**465**
TOTAL NO. OF TAXA			**64**	**73**	**63**	**48**	**55**	**39**	**52**	**51**
EPT TAXA			**25**	**27**	**25**	**22**	**16**	**12**	**26**	**17**
BIOTIC INDEX ASSIGNED			**4.54**	**5.71**	**5.50**	**4.95**	**6.47**	**6.01**	**4.52**	**6.02**

APPENDIX C: CARBONTON DAM REMOVAL YEAR-4 FISH MONITORING REPORT PROVIDED BY THE CATENA GROUP

CARBONTON DAM REMOVAL YEAR-4 MONITORING REPORT: Tributary Fish Surveys

Deep River Watershed Restoration Site Cape Fear River
Basin Cataloging Unit 030300003

Prepared For:

Restoration Systems, LLC
1101 Haynes Street, Suite 211
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Prepared by:

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410-B Millstone Drive
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July 23, 2009

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1.0 INTRODUCTION

The removal of the Carbonton dam on the Deep River by Restoration Systems LLC (RS) is projected to result in the restoration of ~10 river miles (RM) of the mainstem Deep River, as well as portions of three major tributaries (McLendons Creek, Big Governors Creek and Little Governors Creeks) and fifteen smaller tributaries, all within the Cape Fear River Basin. Specific goals of the project are to restore habitat for the federally Endangered Cape Fear shiner *(Notropis mekistocholas)*, several species of rare mussels, and other riverine aquatic species. Restoration of lotic conditions in this stretch of river has resulted in a re-connection the upstream and downstream populations of Cape Fear shiner, which have been essentially isolated[1] since the dam was constructed in the early 1900's, as this species was documented within the former impounded reach during the Year-2 and Year-3 post removal monitoring (TCG 2007, TCG 2008).

The restoration success criteria established by the interagency Dam Removal Task Force (DRTF) and the goals of RS require documenting the diversity of aquatic fauna and characterizing habitat within the reservoir pool created by the dam, and then monitoring changes in faunal composition and habitat following the dam's removal. The Catena Group Inc. (TCG) was retained by RS in 2005 to conduct the pre-dam removal aquatic species surveys. Eighteen sites were surveyed for freshwater mussels and clams, aquatic snails, and freshwater fish, the results of which were provided in the August 07, 2006 Pre-removal Survey Report (TCG 2006). The success criteria for the Cape Fear Shiner within the main stem Deep River were met during the 2-year post removal studies, and documented in the October 01, 2007 Carbonton Dam Removal Year-2 Monitoring Report (TCG 2007). The Year-3 monitoring effort documented post-removal recruitment of juvenile freshwater mussels (TCG 2008) in the upper sections of the river previously impounded by the dam. The continued evolution of lentic to lotic habitats throughout the entire former reservoir pool was also documented (TCG 2008).

In Year-4, surveys targeting fish species, particularly shiner species, were conducted at each of the established impoundment monitoring stations on McLendons and Big Governors Creeks. General observations of in-stream habitat condition were recorded in addition to fish collection.

1.1 Monitoring Plan

The five-year monitoring plan that has been initiated to evaluate the success of the dam removal identified a number of success criteria, including the documentation of Cape Fear shiner recruitment into the formerly impounded reach of the river, and establishment of lotic fish, freshwater mussel and aquatic snail communities throughout the entire former reservoir pool (mainstem and tributaries). This monitoring plan involves

[1] In the strictest sense, the isolation has been substantial, but not total, since fish from upstream groups can transit over the dam during full flows. This would theoretically enable some genetic exchange between upstream and downstream groups.

conducting aquatic species (fish, freshwater mussels and aquatic snails) surveys at 16 permanent monitoring stations within the former reservoir pool that were established in the pre-removal surveys. Fourteen stations are in the Deep River and one each in McClendons Creek and Big Governors Creek. Targeted Aquatic Communities (TAC) were established for each of the monitoring stations by sampling sections of each water body outside of the effects of the impoundment (TCG 2006).

As mentioned above, the success criteria of Cape Fear shiner recruitment in the formerly impounded section of the Deep River has been met (TCG 2007). The other success criteria, establishment of lotic fish, freshwater mussel and aquatic snail communities, throughout the entire former reservoir pool, has been met in portions of the former reservoir pool: 1) lotic fish communities in the Deep River (TCG 2007), lotic freshwater mussel and snail communities in the upper section of the Deep River (TCG 2008).

In Year-4, the impetus for monitoring was to continue to document the development of fish diversity, with special attention to the potential presence of Cape Fear Shiner, in the two major tributaries, McLendons Creek, and Big Governors Creek.

2.0 SURVEY EFFORTS

Freshwater fish surveys were conducted for the Year-4 monitoring effort at the two tributary monitoring locations (Table 1) on May 28, 2009,by the following TCG personnel: Tim Savidge, Tom Dickinson and Chris Sheats. The locations of the sampled sites are also depicted in Figure 1.

Table 1. Permanent Monitoring Survey Locations-Carbonton Dam Reservoir Pool

Site #	Site Location	GPS Location
1	McLendons Creek (impoundment)	35.45894ºN, -79.39803ºW
2	Big Governors Creek (impoundment)	35.47434ºN, -79.3564ºW

2.1 Survey Methodology

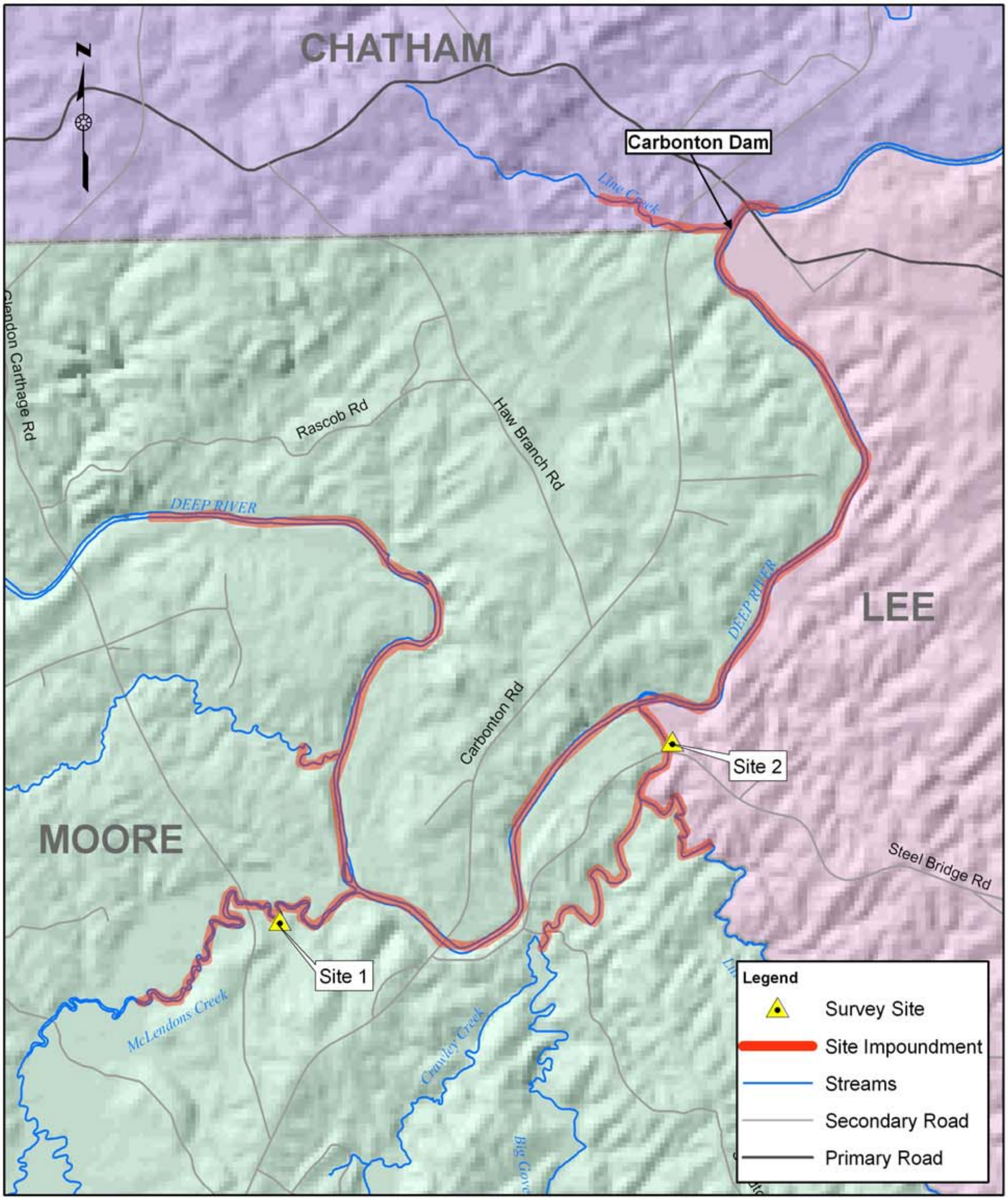
The surveys had two components, habitat reconnaissance and fish sampling.

2.1.1 Habitat Reconnaissance

Habitat reconnaissance was conducted in each tributary site in Year-4 by recording observations of in-stream habitat conditions and bank stability. Fish surveys targeting Cape Fear shiner were also conducted at the tributary monitoring stations, as navigated to with GPS. In addition, areas where riffles have formed, or are in the process of forming, were sampled.

2.1.2 Fish Sampling

In McClendons Creek and Big Governors Creek, electro-shocking in conjunction with dip netting was used as the primary sampling method. The large amount of heavy woody debris in both streams precluded the effectiveness of seine netting for the target species (shiners). For each survey, the survey team began at the downstream point of the site and proceeded upstream. Two double handled backpack electro-shocking units were employed followed by a dip netter to collect the fish. The sampling was performed in the middle of the channel and close to each bank in order to survey the entire habitat. This method was effective in riffle and run habitats of shallow to moderate depths as well as shallow pools, but was fairly ineffective in deeper pools.



The Catena Group

Site Map
Four-Year Fish Monitoring
(Carbonton Dam Removal Project)

Moore and Lee Counties, North Carolina

Date: June 2009

Scale: 0 0.25 0.5 Miles

Job No.: 3254

Figure 1

3.0 RESULTS

3.2 Fish Surveys

A total of 19 fish species were collected at the two surveyed sites (Figure 1). Relative abundance was estimated using the following criteria:

- Very abundant: > 30 collected at survey station
- Abundant: 15-30 collected at survey station
- Common: 6-15 collected at survey station
- Uncommon: 3-5 collected at survey station
- Rare: 1-2 collected at survey station

It should be noted that relative abundances of particular species can be affected by survey methodologies and site conditions. Thus some species, particularly those that are found in deeper pools and runs and those that can seek cover quickly, may be under-represented at a sample site. Survey results for each site are further described below.

3.2.15 Site 1 (McLendons Creek-Impoundment):

It appears that natural riffle/run/pool sequences with coarse sand and pea gravel over clay substrate continue to develop. Much of the fine sediments appear to have been flushed from the site; however a large amount of woody debris still remains in the channel and mud/silt areas persist in deeper pools. Electro-shocking was conducted for 2,076 seconds. The targeted aquatic community anticipated to develop is expected to be similar to the TAC-3 which occurs in the upstream reaches of McLendons Creek (TCG 2006).

A total of 16 species (Table 2) were found at this site in Year-4 compared with the 25 species found in Year-2, seven collected during Year-1 and the nine found at the target site (TAC-3). Many of the species documented during Year-2, but not Year-4 prefer habitats that are not typical of the shiner habitats that were the focus of the Year-4 effort and likely still occupy the reach. The Year-4 efforts were also conducted during higher spring flows in order to capture shiner species during their typical spawning period, as opposed to the low clear flows during the Year-2 collection period. Two more shiner species (whitemouth shiner and spottail shiner) were captured in the Year-4 and a significantly greater abundance of Piedmont darter and tessellated darter were captured, both indicative of improved lotic habitat. Eight of the species located in Year-4 are shared with the TAC-3 site.

Table 2. McLendons Creek: Fish Species Collected Year 4

Scientific Name	Common Name	Relative Abundance
Aphredoderus sayanus	pirate perch	Rare
Erimyzon oblongus	creek chubsucker	Rare
Etheostoma olmstedi	tessellated darter	Very Abundant
Gambusia holbrookii	eastern mosquitofish	Common
Hybognathus regius	eastern silvery minnow	Uncommon

Scientific Name	Common Name	Relative Abundance
Lepomis auritus	redbreast sunfish	Very Abundant
Lepomis macrochirus	bluegill	Uncommon
Luxilus albeolus	white shiner	Rare
Micropterus salmoides	largemouth bass	Rare
Nocomis leptocephalus	bluehead chub	Common
Notropis alborus	whitemouth shiner	Rare
Notropis altipinnis	highfin shiner	Rare
Notropis hudsonius	spottail shiner	Rare
Notropis petersoni	coastal shiner	Uncommon
Notropis scepticus	sandbar shiner	Uncommon
Percina crassa	Piedmont darter	Very Abundant

3.2.16 Site 2 (Big Governors Creek-Impoundment):

This site continues to exhibit limited development of riffle/run/pool habitats. Below the boulder fall, downstream from the Underwood Road crossing, there is a deep, mud/silt substrate entrenched channel that appears to continue far downstream. However, a new riffle/run area appears to be developing upstream of the road crossing. Woody debris and fine sediments are still common through the reach but are anticipated to continue to washout over time. The aquatic community anticipated to develop is expected to be similar to the TAC-4, which occurs in the upstream reaches of Big Governors Creek. Electro-shocking was conducted through the site for 869 seconds of shock time.

A total of 12 species were found at this site (Table 3) in Year-4 compared with the 15 species found in Year-2 and six collected during Year-1 and the six found at the target site (TAC-4). Again, some of the species documented during Year-2, but not Year-4, may be the result of sampling biases; time of year and water levels. Specifically, fish collected during Year-2 surveys were concentrated in pools, the only section of the channel that retained water at that time. However, the increased number of native shiner species, in Year-4 (3) compared to Year-2 (1), along with a greater abundance of tessellated darter and the addition of Piedmont darter may be indicative of improving lotic habitat. Three of the species located in Year-4 are shared with the TAC-4 site.

Table 3. Big Governors Creek: Fish Species Collected Year 4

Scientific Name	Common Name	Relative Abundance
Aphredoderus sayanus	pirate perch	Uncommon
Cyprinella analostana	satinfin shiner	Common
Centrarchus macropterus	flier	Rare
Etheostoma olmstedi	tessellated darter	Common
Gambusia holbrookii	eastern mosquitofish	Abundant
Lepomis auritus	redbreast sunfish	Abundant
Lepomis macrochirus	bluegill	Uncommon
Luxilus albeolus	white shiner	Rare
Notemigonus crysoleucas	golden shiner	Common
Nocomis leptocephalus	bluehead chub	Rare
Notropis petersoni	coastal shiner	Common
Percina crassa	Piedmont darter	Rare

4.0 DISCUSSION/CONCLUSIONS

Semi-quantitative surveys for various freshwater fish were conducted at the two major tributary locations formerly impounded by Carbonton dam to document establishment of lotic habitats and associated fish communities.

4.1 Habitat Reconnaissance

The Year-4 lotic habitats are more developed than during Year-2 Monitoring within McLendons Creek and to a lesser degree in Big Governors Creek. However, these tributary reaches are developing more slowly than anticipated. This may be related a variety of factors such as persistent drought conditions in previous years, and the heavy accumulations of large woody debris, which has caused sluggish conditions in the majority of both channels that will likely continue to persist for years until they naturally decompose, or are carried out during flood conditions.

4.2 Fish Surveys

The results of the habitat reconnaissance and Year-4 monitoring fish surveys demonstrate further re-establishment of lotic conditions and many lotic-adapted species within the former reservoir pool. This is exemplary in Year-4 through the increase in abundance (and diversity in the case of Big Governors Creek) of darter species at both sites. As riffle habitats and habitat complexity continue to develop, the Cape Fear shiner may use McLendons and Big Governors Creeks. However, utilization of tributaries by the Cape Fear shiner remains poorly understood. While it is possible that the species will use these habitats as they develop further, current conditions may remain unsuitable for their use for some time. Of the two tributaries surveyed during this effort, McLendons Creek appears to have more potential than Big Governors Creek to support this species. However, as discussed above, severe drought conditions in previous years and heavy woody debris presence may be limiting their use.

Tables 4 and 5 are included below to show the species collected at each site over the various monitoring years. While total numbers of species have fluctuated from Year-2 to Year-4, there has been a steady increase in the number of lotic adapted species into Year-4.

Table 4. McLendons Creek: Monitoring Year Comparison

TAC	YEAR-1	YEAR-2	YEAR-4
Scientific Name	~	~	~
Etheostoma olmstedi	*Hybognathus regius*	*Ameiurus brunneus*	*Aphredoderus sayanus*
Lepomis macrochirus	*Lepomis macrochirus*	*Ameiurus natalis*	*Erimyzon oblongus*
Luxilus albeolus	*Luxilus albeolus*	*Ameiurus platycephalus*	*Etheostoma olmstedi*
Nocomis leptocephalus	*Nocomis leptocephalus*	*Anguilla rostrata*	*Gambusia holbrookii*
Notropis alborus	*Notropis hudsonius*	*Aphredoderus sayanus*	*Hybognathus regius*
Notropis altipinnis	*Notropis petersoni*	*Erimyzon oblongus*	*Lepomis auritus*
Notropis hudsonius	*Notropis scepticus*	*Esox americanus*	*Lepomis macrochirus*
Notropis procne		*Etheostoma olmstedi*	*Luxilus albeolus*
Percina crassa		*Fundulus rathbuni*	*Micropterus salmoides*
		Gambusia holbrookii	*Nocomis leptocephalus*
		Ictalurus punctatus	*Notropis alborus*
		Lepomis auritus	*Notropis altipinnis*
		Lepomis cyanellus	*Notropis hudsonius*
		Lepomis gulosus	*Notropis petersoni*
		Lepomis macrochirus	*Notropis scepticus*
		Lepisosteus osseus	*Percina crassa*
		Luxilus albeolus	
		Minytrema melanops	
		Moxostoma pappillosum	
		Nocomis leptocephalus	
		Notropis altipinnis	
		Notropis petersoni	
		Notropis scepticus	
		Percina crassa	
		Semotilus lumbee	

Table 5. Big Governors Creek: Monitoring Year Comparison

TAC	YEAR-1	YEAR-2	YEAR-4
Scientific Name		~	~
Esox americanus	*Lepomis macrochirus*	*Aphredoderus sayanus*	*Aphredoderus sayanus*
Etheostoma olmstedi	*Luxilus albeolus*	*Erimyzon oblongus*	*Cyprinella analostana*
Etheostoma serriferum	*Micropterus salmoides*	*Esox americanus*	*Centrarchus macropterus*
Lepomis macrochirus	*Nocomis leptocephalus*	*Etheostoma olmstedi*	*Etheostoma olmstedi*
Micropterus salmoides	*Notropis petersoni*	*Gambusia holbrookii*	*Gambusia holbrookii*
Nocomis leptocephalus	*Notropis scepticus*	*Hybognathus regius*	*Lepomis auritus*
		Lepomis auritus	*Lepomis macrochirus*
		Lepomis cyanellus	*Luxilus albeolus*
		Lepomis macrochirus	*Notemigonus crysoleucas*
		Micropterus salmoides	*Nocomis leptocephalus*
		Moxostoma sp.	*Notropis petersoni*
		Notemigonus crysoleucas	*Percina crassa*
		Nocomis leptocephalus	
		Notropis altipinnis	
		Semotilus lumbee	

4.3 Future Fish Survey Monitoring

The results of the Year-4 monitoring fish survey demonstrate that the fish communities in McLendons and Big Governors Creeks continue to develop as lotic habitat improves. However, Year-4 fish surveys did not establish the presence or use of these reaches by the Cape Fear Shiner.

While lotic habitat conditions and riffle-adapted species continue to become established in McClendons Creek, the success criteria for improved aquatic habitat and colonization by the Cape Fear shiner have not been fully met at this point. Future monitoring efforts in this stream should take place during spring flows when shiner species are moving to new territory. This will allow for the best potential to capture Cape Fear shiner in this stream.

As discussed above, significant riffle habitats have not yet developed in Big Governors Creek, and colonization by the Cape Fear shiner is questionable. Therefore, restoration success criteria for this stream should not be based on presence of riffle-adapted species. An increase in species diversity overtime is thus a better measure of success with this stream. As with McClendons Creek, any future monitoring of Big Governors Creek should take place during spring flows.

APPENDIX D: NCDWQ HABITAT ASSESSMENT FIELD DATA SHEET

Habitat Assessment Field Data Sheet
Mountain/ Piedmont Streams

Biological Assessment Unit, DWQ **TOTAL SCORE________**

Directions for use: The observer is to survey a **minimum of 100 meters with 200 meters preferred** of stream, preferably in an **upstream** direction starting above the bridge pool and the road right-of-way. The segment which is assessed should represent average stream conditions. To perform a proper habitat evaluation the observer needs to get into the stream. To complete the form, select the description which best fits the observed habitats and then circle the score. If the observed habitat falls in between two descriptions, select an intermediate score. A final habitat score is determined by adding the results from the different metrics.

Stream______________________Location/road: _____________(Road Name____________)County________________

Date__________________**CC#**_______________Basin_____________________Subbasin________________________

Observer(s)_________ Type of Study: ☐ Fish ☐Benthos ☐ Basinwide ☐Special Study (Describe) ________________

Latitude ____________Longitude _____________Ecoregion: ☐ MT ☐ P ☐ Slate Belt ☐ Triassic Basin

Water Quality: Temperature_______^{0}C DO _______mg/l Conductivity (corr.) ______µS/cm pH _____

Physical Characterization: Visible land use refers to immediate area that you can see from sampling location - include what you estimate driving thru the watershed in watershed land use.

Visible Land Use: ______%Forest ______%Residential ______%Active Pasture _______% Active Crops
_____%Fallow Fields ______% Commercial ______%Industrial ______%Other - Describe:_____________

Watershed land use : ☐Forest ☐Agriculture ☐Urban ☐ Animal operations upstream

Width: (meters) Stream_________ Channel (at top of bank)_______ **Stream Depth**: (m) Avg______Max ____
☐ Width variable ☐ Large river >25m wide

Bank Height (from deepest part of riffle to top of bank-first flat surface you stand on): (m)________

Bank Angle: _________ ° or ☐ NA (Vertical is 90°, horizontal is 0°. Angles > 90° indicate slope is towards mid-channel, < 90° indicate slope is away from channel. NA if bank is too low for bank angle to matter.)

☐ Channelized Ditch
☐Deeply incised-steep, straight banks ☐Both banks undercut at bend ☐Channel filled in with sediment
☐ Recent overbank deposits ☐Bar development ☐Buried structures ☐Exposed bedrock
☐ Excessive periphyton growth ☐ Heavy filamentous algae growth ☐Green tinge ☐ Sewage smell
Manmade Stabilization: ☐N ☐Y: ☐Rip-rap, cement, gabions ☐ Sediment/grade-control structure ☐Berm/levee
Flow conditions : ☐High ☐Normal ☐Low
Turbidity: ☐Clear ☐ Slightly Turbid ☐Turbid ☐Tannic ☐Milky ☐Colored (from dyes)
Good potential for Wetlands Restoration Project?? ☐ YES ☐NO Details____________________________

Channel Flow Status

Useful especially under abnormal or low flow conditions.

A. Water reaches base of both lower banks, minimal channel substrate exposed .... ☐
B. Water fills >75% of available channel, or <25% of channel substrate is exposed....................... ☐
C. Water fills 25-75% of available channel, many logs/snags exposed... ☐
D. Root mats out of water.. ☐
E. Very little water in channel, mostly present as standing pools.. ☐

Weather Conditions:________________________**Photos:** ☐N ☐Y ☐ Digital ☐35mm

Remarks:____
____

I. Channel Modification Score

A. channel natural, frequent bends	5
B. channel natural, infrequent bends (channelization could be old)	4
C. some channelization present	3
D. more extensive channelization, >40% of stream disrupted	2
E. no bends, completely channelized or rip rapped or gabioned, etc	0

☐ Evidence of dredging ☐Evidence of desnagging=no large woody debris in stream ☐Banks of uniform shape/height

Remarks____ Subtotal____

II. Instream Habitat: Consider the percentage of the reach that is favorable for benthos colonization or fish cover. If >70% of the reach is rocks, 1 type is present, circle the score of 17. Definition: leafpacks consist of older leaves that are packed together and have begun to decay (not piles of leaves in pool areas). Mark as **R**are, **C**ommon, or **A**bundant.

____**Rocks** ____**Macrophytes** ____**Sticks and leafpacks** ____**Snags and logs** ____**Undercut banks or root mats**

AMOUNT OF REACH FAVORABLE FOR COLONIZATION OR COVER

	>70% Score	40-70% Score	20-40% Score	<20% Score
4 or 5 types present	20	16	12	8
3 types present	19	15	11	7
2 types present	18	14	10	6
1 type present	17	13	9	5
No types present	0			

☐ No woody vegetation in riparian zone Remarks_______________________________________ Subtotal_____

III. Bottom Substrate (silt, sand, detritus, gravel, cobble, boulder) Look at entire reach for substrate scoring, but only look at riffle for embeddedness, and use rocks from all parts of riffle-look for "mud line" or difficulty extracting rocks.

	Score
A. substrate with good mix of gravel, cobble and boulders	
1. embeddedness <20% (very little sand, usually only behind large boulders)	15
2. embeddedness 20-40%	12
3. embeddedness 40-80%	8
4. embeddedness >80%	3
B. substrate gravel and cobble	
1. embeddedness <20%	14
2. embeddedness 20-40%	11
3. embeddedness 40-80%	6
4. embeddedness >80%	2
C. substrate mostly gravel	
1. embeddedness <50%	8
2. embeddedness >50%	4
D. substrate homogeneous	
1. substrate nearly all bedrock	3
2. substrate nearly all sand	3
3. substrate nearly all detritus	2
4. substrate nearly all silt/ clay	1

Remarks____Subtotal_____

IV. Pool Variety Pools are areas of deeper than average maximum depths with little or no surface turbulence. Water velocities associated with pools are always slow. Pools may take the form of "pocket water", small pools behind boulders or obstructions, in large high gradient streams, or side eddies.

	Score
A. Pools present	
1. Pools Frequent (>30% of 200m area surveyed)	
a. variety of pool sizes	10
b. pools about the same size (indicates pools filling in)	8
2. Pools Infrequent (<30% of the 200m area surveyed)	
a. variety of pool sizes	6
b. pools about the same size	4
B. Pools absent	0

Subtotal_____

☐ Pool bottom boulder-cobble=hard ☐ Bottom sandy-sink as you walk ☐ Silt bottom ☐ Some pools over wader depth

Remarks____

Page Total_____

V. Riffle Habitats

Definition: Riffle is area of reaeration-can be debris dam, or narrow channel area.

	Riffles **Frequent** Score	Riffles **Infrequent** Score
A. well defined riffle and run, riffle as wide as stream and extends 2X width of stream....	16	12
B. riffle as wide as stream but riffle length is not 2X stream width	14	7
C. riffle not as wide as stream and riffle length is not 2X stream width	10	3
D. riffles absent..	0	

Channel Slope: ☐Typical for area ☐Steep=fast flow ☐Low=like a coastal stream Subtotal_____

VI. Bank Stability and Vegetation

FACE UPSTREAM

	Left Bank Score	Rt. Bank Score
A. Banks stable		
1. little evidence of erosion or bank failure(except outside of bends), little potential for erosion..	7	7
B. Erosion areas present		
1. diverse **trees**, shrubs, grass; plants healthy with good root systems..................................	6	6
2. few trees or small trees and **shrubs**; vegetation appears generally healthy..........................	5	5
3. sparse **mixed** vegetation; plant types and conditions suggest poorer soil binding................	3	3
4. mostly **grasses**, few if any trees and shrubs, high erosion and failure potential at high flow..	2	2
5. little or no bank vegetation, mass erosion and bank failure evident...	0	0

Total______

Remarks____

VII. Light Penetration Canopy is defined as tree or vegetative cover directly above the stream's surface. Canopy would block out sunlight when the sun is directly overhead. Note shading from mountains, but not use to score this metric.

	Score
A. Stream with **good** canopy with some breaks for light penetration	10
B. Stream with **full canopy** - breaks for light penetration absent..	8
C. Stream with **partial** canopy - sunlight and shading are essentially equal..................................	7
D. Stream with **minimal** canopy - full sun in all but a few areas...	2
E. **No canopy** and no shading...	0

Remarks____Subtotal____

VIII. Riparian Vegetative Zone Width

Definition: Riparian zone for this form is area of natural vegetation adjacent to stream (can go beyond floodplain). Definition: A break in the riparian zone is any place on the stream banks which allows sediment or pollutants to directly enter the stream, such as paths down to stream, storm drains, uprooted trees, otter slides, etc.

FACE UPSTREAM

Dominant vegetation: ☐ Trees ☐ Shrubs ☐ Grasses ☐ Weeds/old field ☐Exotics (kudzu, etc)

	Lft. Bank Score	Rt. Bank Score
A. Riparian zone **intact** (no breaks)		
1. width > 18 meters..	5	5
2. width 12-18 meters..	4	4
3. width 6-12 meters..	3	3
4. width < 6 meters..	2	2
B. Riparian zone **not intact** (breaks)		
1. breaks rare		
a. width > 18 meters..	4	4
b. width 12-18 meters..	3	3
c. width 6-12 meters..	2	2
d. width < 6 meters..	1	1
2. breaks common		
a. width > 18 meters..	3	3
b. width 12-18 meters..	2	2
c. width 6-12 meters..	1	1
d. width < 6 meters..	0	0

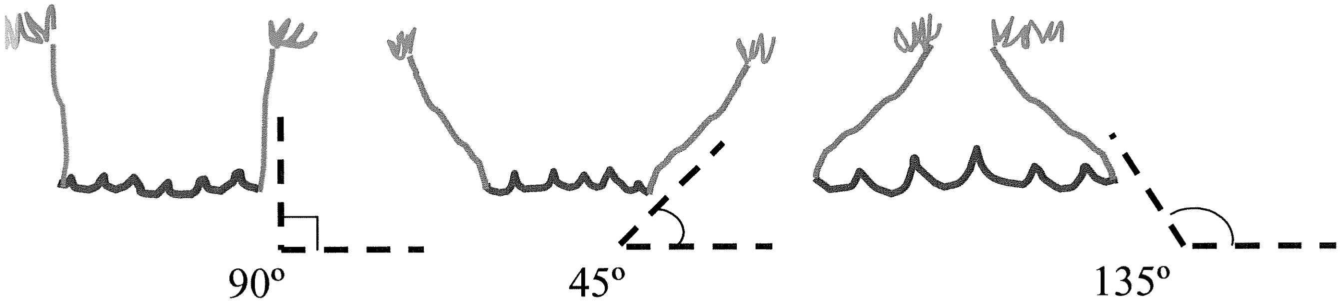
Remarks____ Total______

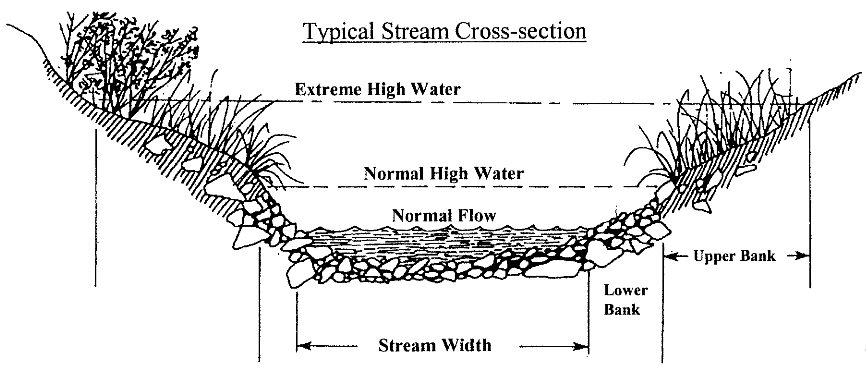
Page Total_______

☐ Disclaimer-form filled out, but score doesn't match subjective opinion-atypical stream. **TOTAL SCORE**_______

Supplement for Habitat Assessment Field Data Sheet

Diagram to determine bank angle:





This side is 45° bank angle.

Site Sketch:

Other comments:____

____

____

____

____

APPENDIX E: MONITORING PICTURES AND VIDEOS (DATA DVD)