LOWELL MILL DAM-LITTLE RIVER WATERSHED RESTORATION SITE
2007 Annual Monitoring Report (Year-2)

Johnston County, North Carolina
EEP Project No. D04008-2
Design Firm: Milone and MacBroom, Inc.

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Ecosystem Enhancement PROGRAM

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RESTORATION SITE
2007 Annual Monitoring Report (Year-2)

JOHNSTON COUNTY, NORTH CAROLINA

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EXECUTIVE SUMMARY

Introduction

Dam removal projects performed pursuant to the North Carolina Dam Removal Task Force (DRTF) are required to quantitatively demonstrate chemical and biological improvements to the watershed in order to achieve compensatory mitigation credit (DRTF 2001). The following monitoring report documents the latest efforts of Restoration Systems (RS), on behalf of the N.C. Ecosystem Enhancement Program (NCEEP), to document changes in the study area of the Lowell Mill Dam removal effort (Neuse Hydrologic Unit 03020201). 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 Lowell Mill Dam is approximately 0.3 mile downstream (south) of Interstate 95 between the towns of Micro and Kenly (Figure 1, Appendix A) on the Little River, a tributary of the Neuse. Approximately 36,875 linear feet of the Little River and certain tributaries (Little Buffalo Creek and an unnamed tributary) were impounded by the dam (Figure 2, Appendix A). 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 shifted from a free-flowing (lotic) river system towards an impounded (lentic) condition following construction of a dam at the site, ~200 years ago. Rare and endangered mussel and fish habitat, which depend on free-flowing lotic conditions, was greatly altered or diminished within areas of the Little River impounded by the former dam. The dam also blocked the passage of anadromous fish, extirpating them from upstream reaches.

The dam was removed in a manner that minimized impacts to water resources both upstream and downstream of the dam site. Gradual dewatering began in March of 2004, and dam removal began in December 2005. The dam structure and associated mill works were completely removed by January 18, 2006. For documentation and quantification of the Lowell Dam removal process and associated water quality impacts, see Riggsbee et al., (2007).

This report summarizes Year-2 (2007) project monitoring. Monitoring data continue to follow trends displayed during Year-1 (2006) project monitoring. These trends indicate a demonstrably favorable shift towards the restoration of the aquatic community and towards water quality attributes more typical of lotic flow conditions within the former Site Impoundment. In 2006, American shad (*Alosa sapidissima*) were captured within the Little River well upstream of the former dam, confirming the restoration of anadromous fish passage within (and upstream of) the former Site Impoundment.

Monitoring Plan

A monitoring plan was developed in accordance with DRTF guidelines to evaluate success in fulfilling the project's primary success criteria, which include 1) re-colonization of rare and

protected aquatic species, 2) improved water quality, 3) an improved aquatic community, and 4) restoration of anadromous fish passage (under former-crest pool). Reserve success criteria include 1) anadromous fish passage (above former-crest pool), 2) downstream benefits below the dam, and 3) human values (scientific value and human recreation).

In order to evaluate project success for the above criteria, a monitoring network was deployed throughout the former Site Impoundment and in reference areas both upstream and downstream of the former dam (Figure 3, Appendix A). Within the network, biological surveys were conducted to provide baseline (i.e., pre-dam removal) aquatic community data and to assess changes in community composition following dam removal. Monitoring cross-section stations were established to assess changes in bankfull channel geometry, channel substrate composition, and aquatic habitat. Fish, mussel, and snail surveys were conducted to record diversity and qualitative prevalence of taxa within these groups. Anadromous fish survey locations were also established to track the extent of anadromous fish passage within the upstream watershed (Figure 4A, Appendix A). Water quality data (i.e., dissolved oxygen concentrations) 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).

Year-2 (2007) Monitoring Results

Re-colonization of rare and protected aquatic species

The two federally endangered species that occur within the Little River sub-basin are the dwarf wedgemussel (*Alasmidonta heterodon*) and Tar spinymussel (*Elliptio steinstansanna*). Although baseline mollusk community data were obtained during pre-removal (baseline) biological surveys in 2005, mollusks will not be sampled again until the fourth year of project monitoring (2009) due to the length of time predicted for this taxonomic group to respond to habitat restoration. Favorable habitat for these mollusk species has developed within much of the former Site Impoundment.

Water quality

AMS data indicate that dissolved oxygen concentrations within the former Site Impoundment continued to persist above the established success criteria threshold of 6.0 mg/L, with the exception of three measurements sampled in July and August of 2006 when dissolved oxygen concentrations sampled at the reference station were also below 6.0 mg/L. Benthic biotic indices (used as a proxy for water quality) were again lower (i.e., more indicative of better water quality) in samples within the former Site Impoundment relative to those from reference samples, indicating continued improvement in water quality. Benthic biotic indices in samples within the former Site Impoundment were also lower during Year-2 monitoring relative to those from samples in the same locations during Year-1 monitoring, further indicating a progressive improvement in water quality. **In summary, water quality monitoring data demonstrate the achievement of project success criteria.**

Improved aquatic community
Benthic data from stations within the former Site Impoundment indicate that the number of EPT (Ephemeroptera [mayflies], Plecoptera [stoneflies], and Trichoptera [caddisflies]) taxa has exceeded the number of EPT taxa from reference samples. The total number of benthic taxa from samples within the former Site Impoundment also exceeded the total number of taxa from reference samples. Additionally, both the EPT richness and the total number of taxa from stations within the former Site Impoundment increased from Year-1 to Year-2. **In summary, benthic monitoring data has achieved success criteria**. Fish sampling data indicate that fish communities within the former Site Impoundment continue to transition from those associated with lentic conditions (i.e., pre-dam removal) to those characteristic of lotic, free-flowing conditions.

Anadromous fish passage
In 2006 (the first year of project monitoring), spawning adults of American shad (*Alosa sapidissima*) were captured in the Little River immediately below Atkinson Mill Dam (Figure 4B, Appendix A), indicating that anadromous fish passage under the crest pool has been achieved. American shad were also captured well above the limits of the former Site Impoundment within Buffalo Creek, indicating that the Lowell Mill Dam removal will likely generate additional SMUs (stream mitigation units) for sale in the watershed pursuant to the reserve success criteria guidelines (see discussion below).

In addition to the above primary criteria, the project has also achieved success in fulfilling reserve success criteria. The Lowell Mill Dam removal project has provided funding to the University of North Carolina at Chapel Hill to support original research by Adam Riggsbee, Ph.D, and to Joshua K. Raabe and Joseph E. Hightower, Ph.D of North Carolina State University. Dr. Riggsbee's research investigates the effects of the dam's removal on nutrient and sediment dynamics as they are transported from the former Site Impoundment. In addition to his published dissertation, Dr. Riggsbee has three papers in press and one in revision that detail his research. Mr. Raabe and Dr. Hightower's research involves the installation of a fish weir at the former dam location. The weir was used to observe fish movement patterns to better understand how anadromous fish use habitat in different parts of the Little River. The study results will enable scientists to better predict the potential benefits of fish passage devices (fish ladders) versus complete dam removal. Also, the Lowell Mill Dam project has funded the design and completion of a public park developed at the site of the former mill and dam. This new public facility has been donated to Johnston County for use as a family recreation park.

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1.0 PROJECT BACKGROUND

1.1 Location and Setting

The project location includes the site of the former Lowell Mill Dam and associated mill works at -78.159838N, 35.565991W situated within the Little River, approximately 0.3 mile south (downstream) of Interstate Highway 95 (I-95, Exit 105), between the towns of Micro and Kenly (Figure 1, Appendix A). For the purposes of this document, the former dam site and immediate adjacent areas will hereafter be referred to as the "Site."

Approximately 36,875 linear feet of the Little River, Little Buffalo Creek, and an unnamed tributary (Tributary 1) (Figure 2, Appendix A) were impounded by the Lowell Mill Dam. These stream reaches collectively comprise the "Site Impoundment."

The dam served to obstruct the movement of fish and other mobile aquatic organisms and further restricted the upstream dispersal of benthic organisms, which rely on mobile aquatic host species to complete life cycle events. The functional benefit area (FBA) for this restoration project is defined as the maximum extent of the watershed lying upstream of the dam, which could serve as anadromous fish spawning habitat. This area includes approximately 204,920 linear feet (38.8 miles) of main stream channel along the Little River, Buffalo Creek, Little Buffalo Creek, and Long Branch in Johnston County (Figure 2, Appendix A). The FBA begins at the Site and extends upstream along these waterways to include relatively free-flowing (i.e., unimpeded) tributaries in the watershed. Its upper limit is defined by dams (Atkinson Mill, Lake Wendell) or stream headwaters.

1.2 Restoration Structure and Objectives

The Lowell Mill Dam removal is one of the first stream restoration projects of its kind in North Carolina. The project entailed stream restoration via the removal of Lowell Mill Dam, a run-of-river dam, in which the bankfull channel is impounded but the river valley is typically not flooded as is often the case with larger storage dams.

Site restoration efforts consisted primarily of the physical removal of the Lowell Mill Dam and the adjacent mill works. Construction activities associated with the removal of the dam were phased in order to minimize impacts to aquatic resources upstream, downstream, and in the immediate vicinity of the Site (see Riggsbee et al., 2007). Furthermore, throughout the dam removal process, numerous construction practices were undertaken to minimize potential impacts to aquatic resources.

The project is expected to generate at least 36,875 Stream Mitigation Units (SMUs) for use by the North Carolina Ecosystem Enhancement Program (EEP) (Table 1). Primary and reserve success criteria are being monitored in accordance with the DRTF guidance. The mitigation ratios have also been derived from the DRTF guidance. Depending on project monitoring results (predominately anadromous survey data), up to 48,859 additional SMUs may potentially be generated in accordance with the DRTF guidance (Table 1).

Table 2 displays project mitigation success criteria, the parameters used to evaluate success, and the anticipated results of project monitoring. Project monitoring results are presented in Section 2.0.

Table 1. Potential Stream Mitigation Units (SMUs)[1] Generated by Removal of Lowell Mill Dam.

	Channel Restored (feet)	**Mitigation Ratio**	**SMUs**
Primary success criteria:			
1) Re-colonization of rare and endangered aquatic species 2) Improved water quality, 3) Improved aquatic community 4) Anadromous fish passage (under crest pool)	36,875 feet of free-flowing river and tributaries **under the crest pool**	1:1	36,875
Reserve success criteria:			
Anadromous fish passage (**above crest pool**)	Up to 204,920 feet of second order or higher, free-flowing tributaries	5:1	40,984
Downstream benefits below the dam	500 feet below dam	1:1	500
Human values 1) Scientific value 2) Human recreation	-----	Up to 20 percent bonus	7,375
Total potential additional SMUs			48,859
Committed SMUs			**36,875**

[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.

Table 2. Mitigation Success Criteria Evaluation

	Criterion	Parameter	Anticipated Change/Result
Primary success criteria:	Re-colonization of rare and endangered aquatic species	Presence/absence of rare/endangered individuals	Unknown
		Rare/endangered species habitat	Improvement/expansion
	Improved water quality	Benthic biotic indices	Decrease (= improve)
		AMS dissolved oxygen data	Increase within former Site Impoundment (must be ≥ 6.0 mg/L or consistent with reference station data)
	Improved aquatic community	Ephemeroptera, Plecoptera, and Trichoptera taxa, total number of benthic taxa	Increase (i.e., converge with reference station data)
		Fish, Mussel, and Snail community data	Affirm shifts in communities from lentic to lotic character
	Anadromous fish passage (under crest pool)	Presence/absence of spawning adults within or above former Site Impoundment	Presence
Reserve success criteria:	Anadromous fish passage (above crest pool)	Presence/absence of spawning adults above former Site Impoundment within FBA	Presence
	Downstream benefits below dam	Little River bankfull channel within formerly eddied/scoured areas below dam	Narrowing/increased stabilization of channel
	Scientific value	Published research	Successful completion
	Public recreation	Construction of planned on-Site park	Successful completion

1.3 Project History and Background

Table 3. Project Activities and Reporting History: Lowell Mill Dam Restoration Site

Activity Report	Scheduled Completion	Data Collection Complete	Actual Completion or Delivery
Restoration Plan	July 1, 2004	N/A	August 1, 2005
Final Design	July 1, 2004	N/A	August 1, 2005
Construction	January 2006	N/A	January 2006
Temporary S&E mix applied to entire project area	Dec.-Jan. 2006	N/A	Dec.-Jan. 2006
Permanent seed mix applied to reach/segments	January 2006	N/A	January 2006
Installation of trees, shrubs	February 2006	N/A	February 2006
Mitigation Plan	January 15, 2005	N/A	June 30, 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	August 2006	July 2006	July 2006
Year-2 Vegetation Monitoring	N/A	N/A	N/A
Year-2 Stream Monitoring	August 2007	July 2007	November 2007

1.4 Project Restoration Goals

The primary goal of the Lowell Mill Dam removal is the restoration of formerly impounded reaches of the Little River and affected tributaries to their pre-disturbance, lotic conditions. To demonstrate the achievement of this goal, the affected river and stream reaches have been and will continue to be monitored for successful reestablishment of several functional attributes, which include lotic flow and habitat improvements for aquatic communities that are characteristic of a coastal plain environment. Baseline data were collected in 2005 prior to the removal of the dam and mill works, and Year-1 monitoring activities were accomplished in 2006. Additionally, efforts will be made to confirm that anadromous fish species have been restored to their historical spawning grounds and that vertebrate and invertebrate species favoring lotic habitats, including rare or endangered species, are able to re-colonize these restored habitats. The specific goals of this project are to:

- **Restore approximately 36,875 linear feet of free-flowing river** and stream channels formerly inundated under the spillway crest pool elevation of Lowell Mill Dam.

- **Restore the natural flow** and corresponding sediment transport relationships through and well beyond the approximately 36,875 linear feet of former impoundment.

- **Improve water quality and aquatic communities within impaired (303[d]) rivers** and streams degraded by stagnated flow within the former Site Impoundment. A minimum of 36,875 feet of river and stream channel will be converted from impeded, lentic conditions into restored, lotic streams and rivers supporting a more diverse aquatic community characteristic of pre-impoundment conditions.

- **Restore rare and endangered species habitat** within rivers and streams formerly lost within the Site Impoundment. Twenty documented rare aquatic species will directly benefit from restoration of a continuous, free-flowing river, including dwarf wedgemussel and the only documented populations of Tar River spinymussel in the Neuse River Basin.

- **Restore anadromous fish passage**, foraging, and spawning opportunities within 36,875 linear feet within the former Site Impoundment, as well as an additional 204,920 linear feet of main stem stream and river channels within the FBA above the former Site Impoundment.

- **Provide new academic research and data** regarding the effects of dam removal on aquatic and terrestrial ecosystems.

- **Provide public recreation opportunities**, including the establishment of a park and canoe/kayak launch facilities at the Site.

- **Generate a minimum of 36,875 linear feet of Stream Mitigation Units (SMUs)** for use by the EEP to offset impacts to streams in the specific Neuse River hydrologic unit (see Table 1 for details). Additional SMUs may also be generated for use by the EEP, dependent upon results of post-project monitoring programs.

Table 4. Project contacts: Lowell Mill 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 Taylor's Nursery Coastal Plain Conservation Nursery International Paper Supertree Nursery	 1312 Woody Store Road Siler City, NC 27344 (919) 742-1200 3705 New Bern Avenue Raleigh, NC 27610 (919) 231-6161 3067 Conners Drive Edenton, NC 27932 (252) 482-5707 5594 Highway 38 South Blenheim, SC 29516 (800) 222-1290
Ecological Monitors EcoScience Corporation The Catena Group	1101 Haynes Street Suite 101 Raleigh, NC 27604 (919) 828-3433 410-B Millstone Drive Hillsborough, NC 27278
Stream Monitoring POC	Jens Geratz
Vegetation Monitoring POC	N/A (project does not require vegetation monitoring)

Table 5. Project background: Lowell Mill Dam Restoration Site

Project County	Johnston County, NC
Drainage Area	Approximately 215 square miles
Impervious cover estimate (%)	<10%
Stream Order	4th-order
Physiographic Region	Upper Coastal Plain
Ecoregion (Griffith and Omernik)	Rolling Coastal Plain/Northern Outer Piedmont
Rosgen Classification of As-built	N/A
Cowardin Classification	R2SB3/4
Dominant soil types	N/A (stream restoration project only)
Reference Site ID	N/A
USGS HUC for Project and Reference	03020201
NCDWQ Sub-basin for Project and Reference	03-04-06
NCDWQ classification for Project and Reference	WS-V NSW (Little River and Tributary 1), C NSW (Little Buffalo Creek, Buffalo Creek, and Long Branch)
Any portion of any project segment 303d listed?	Yes (Little River from confluence with Little Buffalo Creek to 4.2 miles upstream of NC 581)
Any portion of any project segment upstream of a 303d listed segment?	Yes (see above—reach extends downstream of project extents)
Reasons for 303d listing or stressor	Low dissolved oxygen
Percent of project easement fenced	N/A

2.0 PROJECT MONITORING RESULTS

Project monitoring results—discussed below—document Year-2 (2007) monitoring activities. Monitoring stations were established prior to dam removal to collect baseline (i.e., pre-dam removal) data (Figure 3, Appendix A). One additional station was added immediately downstream of the former dam in 2006 to evaluate the geomorphic restoration of the channel anomaly below the dam under the reserve success criterion (Table 1). Anadromous fish survey locations are displayed on Figure 4A (Appendix A). Pre-removal baseline data (2005), Year-1 monitoring data (2006), and Year-2 monitoring data (2007) will be referenced and compared to evaluate improvements in water quality, the aquatic community, re-colonization of rare and endangered species, and anadromous fish passage within the former Site Impoundment.

2.1 Water Quality

2.1.1 Biotic Indices

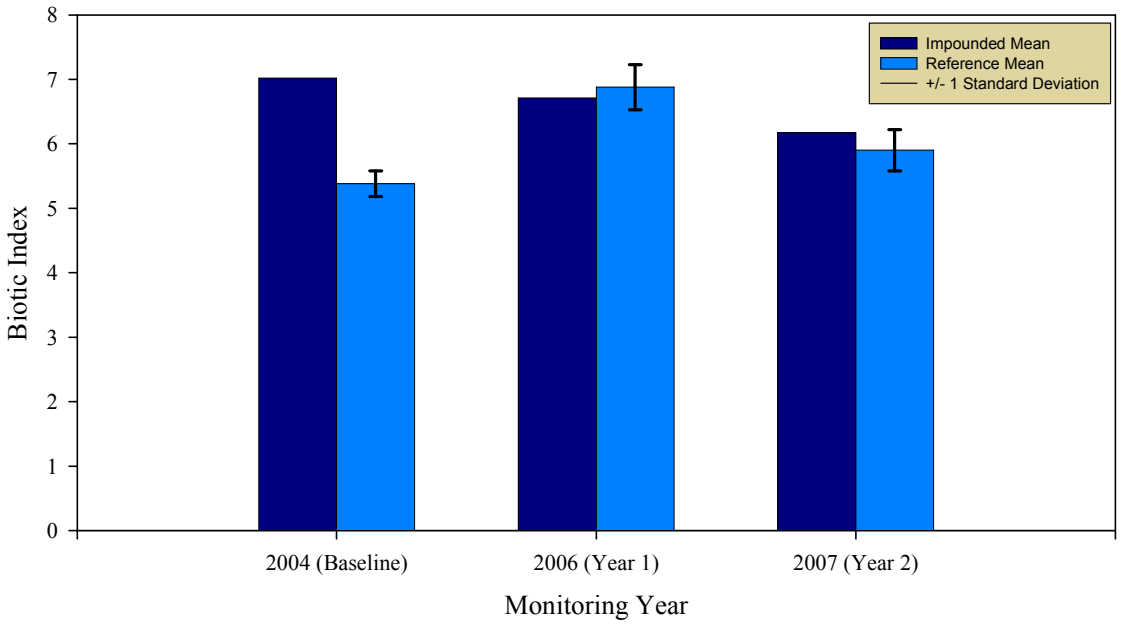
Table 6 displays the biotic index values for pre-removal (performed in 2004), Year-1, and Year-2 monitoring. According to the project's Mitigation Plan (Restoration Systems 2006b), success criteria will be achieved when the mean value of the biotic index from benthic stations within the former Site Impoundment falls within one standard deviation of the mean of the same dataset collected at the reference stations by the end of the project monitoring period.

Table 6. Benthic biotic indices of formerly impounded and reference stations

	2004 (Baseline)		2006 (Year-1)		2007 (Year-2)	
	FORMERLY IMPOUNDED STATIONS	**REFERENCE STATIONS**	**FOMERLY IMPOUNDED STATIONS**	**REFERENCE STATIONS**	**FORMERLY IMPOUNDED STATIONS**	**REFERENCE STATIONS**
	Biotic Index	Biotic Index	Biotic Index	Biotic Index	Biotic Index	Biotic Index
High	7.36	5.52	7.71	7.31	7.00	6.47
Low	6.72	5.24	6.11	6.56	5.57	5.32
Mean	**7.02**	5.38	**6.71**	6.88	**6.17**	5.90
Median	6.98	5.38	6.57	6.83	6.20	5.91
Standard Deviation	0.32	0.20	0.58	0.35	0.43	0.32
Standard Deviation of Reference mean **(Success Criterion)**	**5.58**		**7.23**		**6.22**	

Since the mean of the biotic index from the formerly impounded stations (μ=6.17) is within one standard deviation of the reference station (μ=6.22), success in this category may be inferred. The mean of the biotic index from the formerly impounded stations has also decreased from baseline and Year-1 monitoring data, showing an improvement since the removal of the dam (i.e., indicative of a benthic community less tolerant of poorer water quality). These trends are illustrated in Graph 1.

Graph 1: Mean Biotic Index of Formerly Impounded Stations vs. Mean Biotic Index of Reference Stations with Standard Deviation

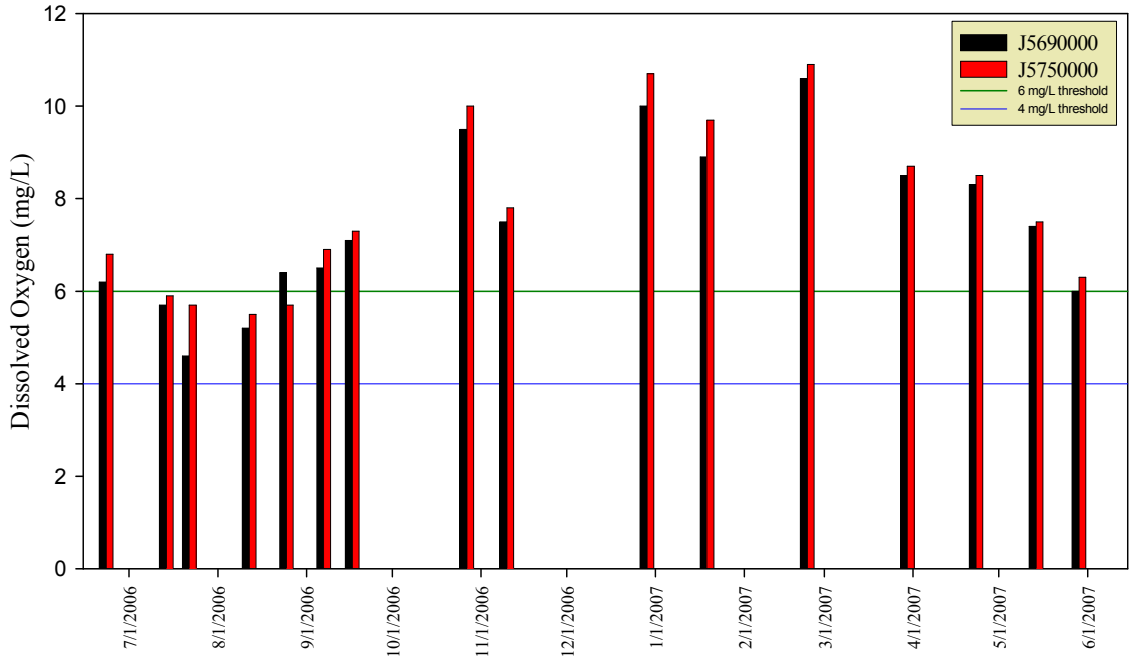


2.1.2 Ambient Monitoring Station Dissolved Oxygen Data

Dissolved oxygen concentrations at a 0.1-meter depth are measured at an Ambient Monitoring Station (AMS) within the former Site Impoundment on the Little River at US 301 (Station ID# J5690000), approximately 1.5 miles upstream of the Site. A reference AMS is located approximately 1.0 miles downstream of the Site on the Little River at State Road (SR) 2339 (Station ID# J5750000). Dissolved oxygen concentrations (mg/L) are measured at least once a month at both stations.

Graph 2 displays measured dissolved oxygen concentrations at both stations from June 23, 2006 to May 29, 2007. Data dating back to February 23, 2004 were included in the 2006 Annual Monitoring Report (AMR) (Restoration Systems 2006a). As stated in the Mitigation Plan (Restoration Systems 2006b), in order to achieve success criteria, dissolved oxygen concentrations measured within the former Site Impoundment (AMS J5690000) must not dip below 6.0 mg/L unless concentrations are also less than 6.0 mg/L at the reference station (AMS J5750000) within the same sampling timeframe. A dissolved oxygen concentration of 6.0 mg/L is commonly accepted as the threshold below which aquatic organisms are stressed. According to standards outlined in NCDWQ's "Redbook", dissolved oxygen concentrations within the former Site Impoundment cannot fall below the minimum NCDWQ standard for Class WS-V waters. The NCDWQ standard is an instantaneous value of no less than 4.0mg/L (daily average no less than 5.0 mg/L). The standard of 4.0 mg/L is used as a criterion for removal from the 303(d) list. Dissolved oxygen concentrations within the former Site Impoundment fell below 6.0 mg/L for three measurements in July and August of 2006, but concentrations at the reference station were also below 6.0 mg/L within the same time frame (Graph 2), indicating success criteria have been achieved. Dissolved oxygen concentrations have persisted above 4.0 mg/L in the former Site Impoundment.

Graph 2: AMS Dissolved Oxygen Concentrations



**The green line highlights a dissolved oxygen concentration of 6.0 mg/L, which must be exceeded by AMS #J5690000 in order to achieve success criteria (unless dissolved oxygen concentrations at reference AMS #J5750000 are also below 6.0 mg/L within the same sampling timeframe). The blue line highlights a dissolved oxygen concentration of 4.0 mg/L, which must be exceeded by AMS #J5690000 in order to achieve success criteria according to NCDWQ for WS-V streams (unless dissolved oxygen concentrations at reference AMS #J5750000 are also below 4.0 mg/L within the same sampling timeframe).*

2.2 Aquatic Communities

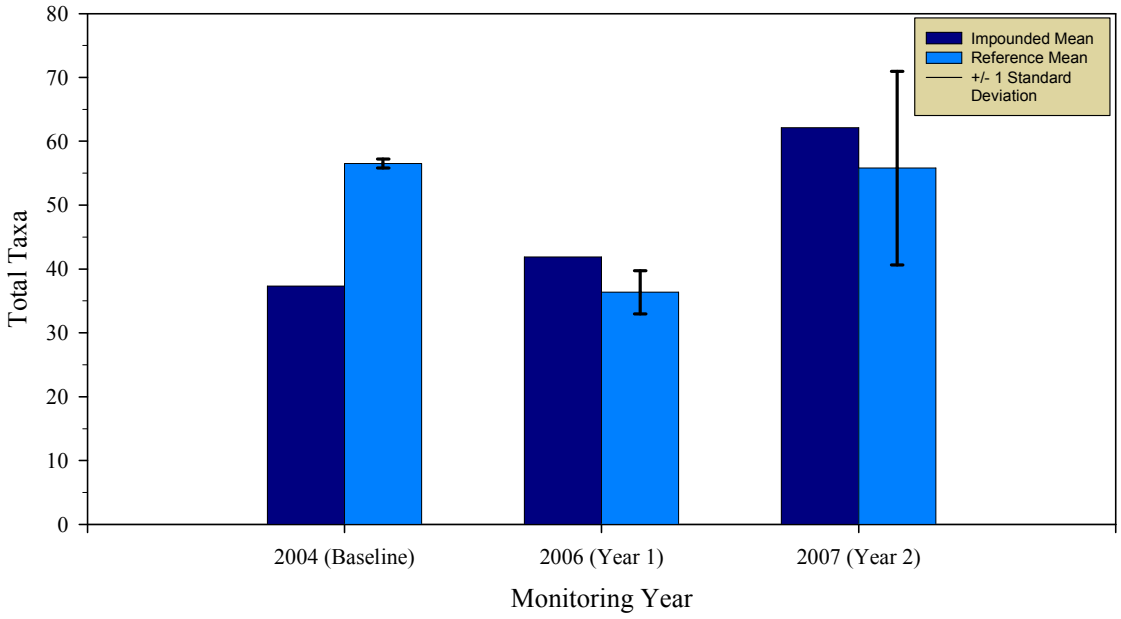
2.2.1 Benthic Macroinvertebrates

Table 7 displays baseline (performed in 2004), Year-1, and Year-2 benthic macroinvertebrate data for both formerly impounded and reference stations. Since the mean number of total taxa and EPT richness from the formerly impounded stations is within one standard deviation of the reference station means, success criteria is being achieved. Graph 3 displays the increase in total taxa since 2004 baseline monitoring. The total number of taxa in formerly impounded stations has shown growth in each of the first two monitoring years. Graph 4 displays the increase in EPT richness since 2004 baseline monitoring. As with the total taxa, the EPT richness in formerly impounded stations has seen growth over each of the first two monitoring years. Benthic macronivertebrate data is provided in Appendix B. Data 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 North Carolina Division of Water Quality (NCDWQ)-certified benthic identification laboratory.

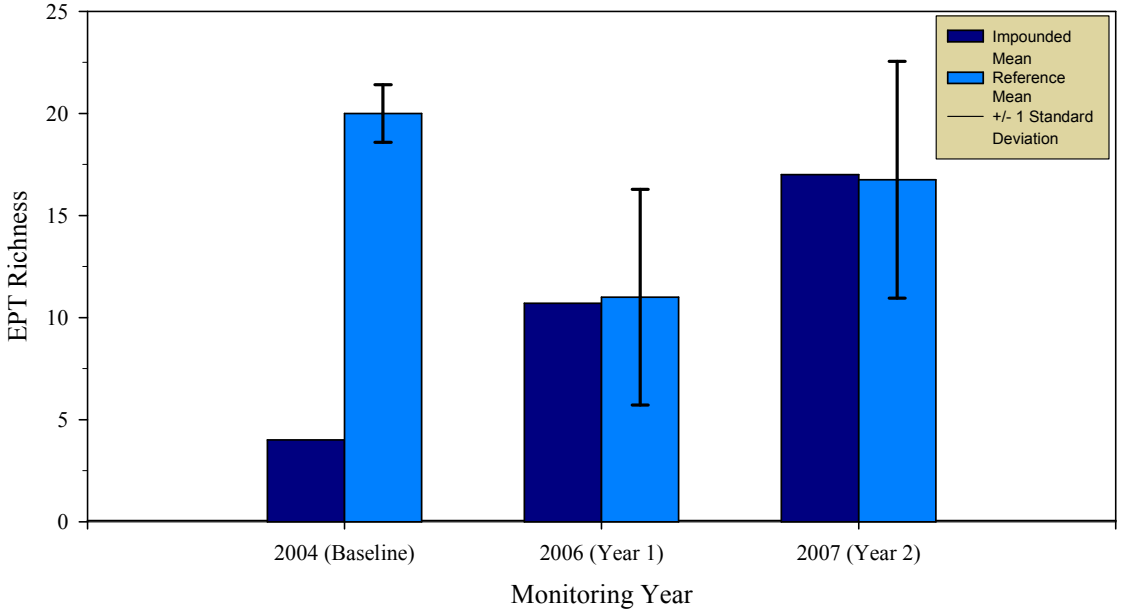
Table 7. EPT and total number of taxa

	2004 (Baseline)				2006 (Year-1)				2007 (Year-2)			
	FORMERLY IMPOUNDED		REFERENCE		FORMERLY IMPOUNDED		REFERENCE		FORMERLY IMPOUNDED		REFERENCE	
	Total Taxa	EPT Richness	Total Taxa	EPT Richness	Total Taxa	EPT Richness	Total Taxa	EPT Richness	Total Taxa	EPT Richness	Total Taxa	EPT Richness
HIGH	45.00	6.00	57.00	21.00	90.00	21.00	43.00	19.00	77.00	26.00	74.00	23.00
LOW	25.00	0.00	56.00	19.00	33.00	0.00	35.00	6.00	55.00	6.00	37.00	9.00
MEAN	37.33	4.00	56.50	20.00	**41.86**	**10.70**	39.75	11.00	**62.14**	**17.00**	55.50	16.75
MEDIAN	42.00	6.00	56.50	20.00	37.00	11.00	40.50	9.50	59.00	16.00	55.50	13.00
STANDARD DEVIATION	10.79	3.46	0.71	1.41	10.33	6.37	3.40	5.28	7.61	6.88	15.16	5.80
Success Criterion	**55.79**	**18.59**			**36.35**	**5.72**			**40.34**	**10.95**		

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



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



2.2.2 Fish

Year-2 fish sampling was performed by The Catena Group (TCG). Sampling was performed at stations displayed on Figure 3 (Appendix A). TCG's report summarizing fish sampling is located in Appendix C.

Data indicate that the former Site Impoundment fish communities are continuing to transition from those characteristic of impounded, lentic conditions to lotic, free-flowing conditions. Qualitative observations during aquatic surveys by TCG revealed that habitat for fish is continuing to transition from lentic to lotic conditions in direct response to dam removal. A total of 42 fish species were captured during baseline (2005) sampling, and an additional 11 species collected during the Year-1 monitoring. Four more fish species: mud sunfish, pumpkinseed, sawcheek darter, and swamp darter were captured for the first time during the Year-2 monitoring surveys, bringing the total number of fish species collected in the study area to 57. For additional information, please consult TCG's report (Appendix C).

2.2.3 Anadromous Fish

Year-2 anadromous fish sampling was performed in spring by TCG. Figure 4A (Appendix A) provides anadromous fish survey locations for Year-2 monitoring. Since the anadromous fish passage component of the success criteria had already been demonstrated in the Little River and lower portion of Buffalo Creek, the 2007 sampling focused primarily on Buffalo Creek; however, it should be noted that actual survey locations within a given stream reach may be adjusted in subsequent surveys due to ambient stream conditions.

American shad (*Alosa sapidissima*) were captured immediately below Atkinson Mill Dam on May 9, 2006, indicating that anadromous fish passage below the crest pool has been successfully achieved. The presence of American shad immediately below the dam was again confirmed on March 24, 2007, as several individuals were captured in the same location. A spawning American shad female was also captured in Buffalo Creek at Woodruff Road (SR 2129) on May 9, 2006, indicating anadromous fish species have begun to access tributary stream reaches within the FBA. The presence of American shad on Buffalo Creek was again confirmed during Year-2 monitoring. An American shad was observed at the Main Street (SR 2130) crossing of Buffalo Creek on March 22, 2007. For additional information, please consult TCG's report summarizing anadromous fish survey efforts (Appendix C). Figure 4B (Appendix A) displays the confirmed presence of American shad within the FBA.

2.2.4 Mollusks

Mussel, snail, and clam sampling data will be used to evaluate success for the aquatic community and threatened and endangered aquatic species criteria. Mollusks were sampled at the fish, mussel, and snail survey locations depicted on Figure 3 (Appendix A) by TCG preceding dam removal to obtain baseline community data in 2005. Since these fauna are slow colonizers, demonstrable changes in mollusk communities are not expected during the first few years of project monitoring. Mollusks will be re-sampled in the fourth year (2009) of project monitoring.

2.2.5 Habitat Assessment

2.2.5.1 Channel Cross-Sections

Twenty-four (24) cross-section stations have been established within the former Site Impoundment and at four reference locations to assess bankfull channel stability following dam removal. Cross-section locations are displayed on Figure 3 (Appendix A). Baseline (2005), Year-1, and Year-2 cross-sectional surveys are displayed on Figures 5A-5C (Appendix A). Table 8 displays baseline, Year-1, and Year-2 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).

Since the submittal of last year's AMR, two high-flow events occurred on November 23, 2006 and December 26, 2006 with discharges of 1930 cfs (cubic feet per second) and 1890 cfs, respectively, as recorded at the United States Geologic Survey (USGS) Princeton gage. According to recurrence interval analysis conducted by ESC (using the annual maximum series taken from the USGS Princeton gage), a discharge of the magnitude of these events occurs within the restoration reach approximately every 1.5 years. A return interval between 1.2 and 1.4 years is assumed to represent bankfull discharge and thus is responsible for the shape and size of channels (Wolman and Miller 1960, Rosgen 1994). Therefore, the aforementioned events with the approximate 1.5-year return interval represent channel forming flows.

In general, bankfull channel parameters were largely unchanged from Year-1 and baseline conditions in the second monitoring year. Based on this observation and the previously described recurrence interval analysis, channel geometry within the former site impoundment is likely stable. The following should be noted: 1) Cross-section 20, which was installed approximately

200 feet downstream of the former Lowell Mill dam on the Little River, was established following dam removal. Thus, there is no baseline bankfull channel geometry data for this station. 2) Cross-section 16, located just upstream of the former dam site, was impacted during dam removal activities. Hence the discrepancies in cross-sectional dimensions and bankfull channel geometry between baseline and Year-1 monitoring data. The bankfull channel parameters for Cross-section 16 appear to have stabilized from Year-1 to Year-2.

Table 8. Cross-section bankfull channel geometry

Station	2005 (Baseline)					2006 (Year 1)					2007 (Year 2)				
	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
1	547.3	84.5	9.1	6.5	13	583.1	84	9.5	6.9	12.2	594.5	83.8	9.8	7.1	11.8
2	614.3	88.2	9.4	7	12.6	579.3	85.5	8.6	6.8	12.6	599.4	87.9	8.8	6.8	12.9
3	304.6	52.3	6.8	5.8	9	308.6	52.3	6.7	5.9	8.9	311	52.1	6.8	6	8.7
4	420.1	72.2	9	5.8	12.4	432.8	63.7	9.5	6.8	9.4	437.8	73.7	9	5.9	12.4
5	344.2	62.9	6.5	5.5	11.4	326.7	62.8	6.5	5.2	12.1	326.5	63	6.3	5.2	12.1
6	425.8	71.6	8.5	5.9	12.1	403.4	71.3	8.1	5.7	12.5	405.4	71.7	8.2	5.7	12.7
7	618	91	9.4	6.8	13.4	607.5	89.1	9.1	6.8	13.1	627.5	92.2	9.6	6.8	13.6
8	514	78.6	10.5	6.5	12.1	506.2	77	10.2	6.6	11.7	497.8	81.6	10.1	6.1	13.4
9	615.2	72.1	11.4	8.5	8.5	517	67.7	10	7.6	8.9	591.7	72.8	11	8.1	8.9
10	467.5	67.4	10.1	6.9	9.8	459.9	67.4	10.1	6.8	9.9	457	67.7	10	6.7	10
11	612.5	121.8	9.2	5	24.4	605.5	122.8	9.3	4.9	25.1	560	127.7	8.2	4.4	29.1
12	848.2	111.5	9.9	7.6	14.7	781	111.6	9.4	7	15.9	719.4	111.1	8.9	6.5	17.2
13	666.7	89.7	11.1	7.4	12.1	645.8	88.6	10.2	7.3	12.1	676.4	87.9	11	7.7	11.4
14	786.9	105.6	10.6	7.4	14.3	780.3	104.9	10.4	7.4	14.2	780.4	105	10	7.4	14.1
15	940.5	114.8	12.3	8.2	14	915.5	113.9	12	8	14.2	940.1	121.4	12.4	7.7	15.7
16*	517.7	81.2	11	6.4	12.7	691.2	105.2	9.9	6.6	15.9	711.4	109.5	10.3	6.5	16.8
17	82.6	28.8	3.9	2.9	9.9	83.7	29.4	3.8	2.8	10.5	82.9	32	3.8	2.6	12.3
18	36.2	27.8	3.3	1.3	21.4	33.9	24.3	3	1.4	17.4	40.5	32.6	3.2	1.2	26.2
19	5.6	10.7	1	0.5	21.4	4.5	11.7	0.5	0.4	29.3	4	11	1.2	0.4	30.7
20	Cross-section not established in 2005					809.5	119.7	9.1	6.8	17.6	883.9	122.1	9.2	7.2	16.9
Reference 1	261.8	48.9	6.1	5.4	9.1	255.2	48.9	5.8	5.2	9.4	259.7	49.1	5.9	5.3	9.3
Reference 2	368.5	67.5	6.8	5.5	12.3	364.8	66.3	7.5	5.5	12.1	347.9	66.3	6.9	5.2	12.6
Reference 3	419	66	8.6	6.4	10.3	403.3	62.4	8.6	6.5	9.6	400.9	65.8	8.4	6.1	10.8
Reference 4	582.1	80.2	8.6	7.7	10.4	580.3	80.3	9.3	7.2	11.2	570.4	80	8.5	7.1	11.2

**Cross-section 16 was disturbed during dam removal activities; hence, the large discrepancies between baseline and Year-1 data.*

2.2.5.2 Sediment Class Size Distribution

Sediment grain size distributions were assessed at each channel cross-section location (Figure 3, Appendix A). Table 9 displays baseline, Year-1, and Year-2 sediment grain size distributions for each cross-section.

Sediment grain size classes are defined as follows (per 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

During baseline and Year-1 monitoring, weighted sieve analyses (using Rosgen [1994] methodology for performing bar samples) were performed to assess sediment grain size distributions of monitoring stations with water depths exceeding 3 feet, where a ponar dredge was used to collect sediment samples (see Mitigation Plan [Restoration Systems 2006b] for sampling methodology details). For water depths less than 3 feet (i.e., wadeable areas), 100-count pebble counts were performed consistent with the Wolman method (Wolman 1954). Since the sieve analyses provided substrate composition data based on sieve size, the sediment class sizes displayed on Table 9 reflect the sieve sizes that the particular grain size falls within (e.g., at Station 5 in 2006, the d50 occurred between the 4 mm and 8mm sieve sizes). In Year-2, drought conditions eliminated the need for ponar dredge sampling, and thus only 100-count pebble counts were performed at each monitoring section.

The d50 (median particle size) increased during the second year of project monitoring from the first year conditions at Stations 5 and 17. The d50 decreased during the second year of monitoring from the first year conditions at Stations 3, 9, 10, Reference 1, Reference 3, and Reference 4. With the exception of Stations 9 and Reference 1, each of these stations are underlain by bedrock. Thus, sediment size class distributions reflect the grain size classes of the sediment veneer overlaying the channel bed. As stated in the project's Mitigation Plan (Restoration Systems 2006b), substrate within the former Site Impoundment is expected to coarsen over time. However, the duration of time required for this change to occur may eclipse the five-year project monitoring period, and some stations may remain in a state of flux for the length of the monitoring period as sediment from the former Site Impoundment is being flushed out. Thus, project success evaluation is not contingent upon changes in channel substrate size class.

2.2.5.3 Habitat Assessment Form Scores

NCDWQ Habitat Assessment Forms were completed at each cross-section station to evaluate the quality and extent of aquatic habitat. Table 10 displays the NCDWQ Habitat Assessment Form scores for each cross-section station. A blank NCDWQ Habitat Assessment Form has been included in Appendix D for reference. The mean scores of formerly impounded stations have increased for the second year following dam removal and the subsequent establishment of lotic flow conditions. The mean score for formerly impounded stations increased from 48.3 in 2005 to 56.2 in 2006, and to 57.1 in 2007. The mean score for reference stations decreased slightly to 72.8 in 2007 from a score of 77.5 in 2006 and 74.8 in 2005. This can mainly be attributed to the loss of instream habitat at reference Station 1 as a result of heavy flow events transporting logs, sticks, and leafpacks downstream of the station's vicinity, and to an increase of sediment in the substrate as illustrated by a decreased d50 as shown in Table 9.

Table 9: Sediment class size distribution

Station	Baseline (2005)				Year 1 (2006)				Year 2 (2007)			
	d16	d50	d84	d100	d16	d50	d84	d100	d16	d50	d84	d100
1	<2 mm	<2 mm	<2 mm	16-32 mm	<2 mm	<2 mm	<2 mm	16-22 mm	<2 mm	<2 mm	<2 mm	<2 mm
2	<2 mm	<2 mm	<2 mm	8-16 mm	<2 mm	<2 mm	<2 mm	4-6 mm	<2 mm	<2 mm	<2 mm	16-22 mm
3*	<2 mm	<2 mm	<2 mm	16-32 mm	<2 mm	8-16 mm	16-32 mm	16-32 mm	<2 mm	<2 mm	11-16 mm	Bedrock
4*	<2 mm	<2 mm	8-16mm	16-32 mm	<2 mm	<2 mm	<2 mm	2-4 mm	<2 mm	<2 mm	32-45 mm	Bedrock
5	<2 mm	<2 mm	<2 mm	4-8 mm	<2 mm	4-8mm	16-32 mm	32-53 mm	11-16 mm	16-22 mm	32-45 mm	64-90 mm
6	<2 mm	<2 mm	<2 mm	4-8 mm	<2 mm	<2 mm	<2 mm	4-8 mm	<2 mm	<2 mm	<2 mm	22-32 mm
7	<2 mm	<2 mm	2-4 mm	16-32 mm	<2 mm	<2 mm	4-8 mm	16-32 mm	<2 mm	<2 mm	<2 mm	<2 mm
8	<2 mm	<2 mm	32-53 mm	32-53 mm	<2 mm	<2 mm	<2 mm	16-32 mm	<2 mm	<2 mm	16-22 mm	64-90 mm
9	<2 mm	<2 mm	<2 mm	32-53 mm	<2 mm	2-4 mm	16-32 mm	16-32 mm	<2 mm	<2 mm	45-64 mm	Bedrock
10*	<2 mm	<2 mm	16-32 mm	32-53 mm	2-4 mm	2-4 mm	16-32 mm	32-53 mm	<2 mm	<2 mm	<2 mm	Bedrock
11	<2 mm	<2 mm	<2 mm	2-4 mm	<2 mm	<2 mm	<2 mm	4-8 mm	<2 mm	<2 mm	<2 mm	<2 mm
12	<2 mm	<2 mm	4-8 mm	16-32 mm	<2 mm	<2 mm	4-8 mm	16-32 mm	<2 mm	<2 mm	<2 mm	<2 mm
13	<2 mm	<2 mm	<2 mm	< 2 mm	<2 mm	<2 mm	4-6 mm	4-6 mm	<2 mm	<2 mm	<2 mm	<2 mm
14	<2 mm	<2 mm	<2 mm	4-8 mm	<2 mm	<2 mm	4-6 mm	8-11 mm	<2 mm	<2 mm	<2 mm	<2 mm
15	<2 mm	<2 mm	<2 mm	8-16 mm	<2 mm	<2 mm	8-11 mm	64-90 mm	<2 mm	<2 mm	<2 mm	<2 mm
16	<2 mm	16-32 mm	32-53 mm	32-53 mm	<2 mm	8-11 mm	16-22 mm	64-90 mm	<2 mm	8-11 mm	45-64 mm	90-128 mm
17	<2 mm	<2 mm	<2 mm	<2 mm	4-6 mm	11-16 mm	16-22 mm	32-45 mm	8-11 mm	16-22 mm	32-45 mm	45-64 mm
18	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	8-16 mm	<2 mm	<2 mm	<2 mm	<2 mm
19	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm
20	Cross-section not established in 2005				<2 mm	<2 mm	4-6mm	16-22 mm	<2 mm	<2 mm	2-8 mm	16-32 mm
Reference 1	<2 mm	8-16 mm	16-32 mm	32-53 mm	6-8 mm	16-22 mm	32-45 mm	128-180 mm	<2 mm	<2 mm	22-32 mm	64-90 mm
Reference 2	<2 mm	<2 mm	<2 mm	4-8 mm	<2 mm	<2 mm	<2 mm	8-11 mm	<2 mm	<2 mm	<2 mm	<2 mm
Reference 3*	32-53 mm	53-64 mm	53-64 mm	53-64 mm	53-64 mm	53-64 mm	53-64 mm	53-64 mm	<2 mm	6-8 mm	22-32 mm	90-128 mm
Reference 4*	<2 mm	32-53 mm	32-53 mm	32-53 mm	4-8 mm	32-53 mm	53-64 mm	53-64 mm	<2mm	11-16 mm	90-128 mm	512-1024 mm

**Station underlain by bedrock—sediment analysis reflects the distribution of the sediment veneer overlaying the channel bed.*

Table 10: NCDWQ Habitat Assessment Form Scores

	Baseline (2005)									Year 1 (2006)									Year 2 (2007)								
Station	Channel Modification	Instream Habitat	Bottom Substrate	Pools	Riffles	Bank Stability	Light Penetration	Riparian Zone	TOTAL SCORE	Station	Channel Modification	Instream Habitat	Bottom Substrate	Pools	Riffles	Bank Stability	Light Penetration	Riparian Zone	TOTAL SCORE	Station	Channel Modification	Instream Habitat	Bottom Substrate	Pools	Riffles	Bank Stability	Light Penetration	Riparian Zone	TOTAL SCORE
XS-1	4	12	3	4	10	12	7	8	**60**	XS-1	4	7	3	10	3	12	7	8	**54**	XS-1	5	6	3	10	3	12	7	6	**52**
XS-2	4	10	3	8	0	12	2	10	**49**	XS-2	4	11	3	6	3	12	2	10	**51**	XS-2	5	6	3	6	3	14	7	10	**54**
XS-3	5	11	3	8	3	12	7	8	**57**	XS-3	5	11	8	8	3	14	7	8	**64**	XS-3	5	6	3	8	3	12	7	10	**54**
XS-4	5	11	3	8	3	12	7	8	**57**	XS-4	5	12	3	8	0	13	7	8	**56**	XS-4	5	7	3	8	0	12	7	9	**51**
XS-5	5	12	2	8	10	12	7	9	**65**	XS-5	5	14	8	8	3	12	7	9	**66**	XS-5	5	8	8	8	3	12	10	10	**64**
XS-6	4	11	3	8	0	12	7	10	**55**	XS-6	4	5	3	6	7	14	7	10	**56**	XS-6	4	6	3	6	7	14	2	10	**52**
XS-7	4	11	3	8	7	12	2	9	**56**	XS-7	4	10	3	6	7	12	2	9	**53**	XS-7	5	6	3	6	7	12	7	9	**55**
XS-8	5	11	2	8	0	12	7	9	**54**	XS-8	5	15	3	6	7	12	7	9	**64**	XS-8	5	10	3	6	7	14	7	10	**62**
XS-9	4	11	2	4	3	12	7	10	**53**	XS-9	4	15	1	6	0	12	7	10	**55**	XS-9	5	11	3	6	0	12	7	10	**54**
XS-10	4	11	2	0	0	12	7	10	**46**	XS-10	4	12	1	8	0	10	7	10	**52**	XS-10	4	5	3	8	0	12	7	9	**48**
XS-11	4	11	1	0	0	12	7	10	**45**	XS-11	4	9	3	4	7	12	7	10	**56**	XS-11	5	6	1	4	7	14	2	10	**49**
XS-12	4	11	1	0	0	12	2	10	**40**	XS-12	4	14	3	6	7	12	2	10	**58**	XS-12	5	6	1	6	7	14	7	10	**56**
XS-13	4	11	1	0	0	10	2	9	**37**	XS-13	4	10	3	6	10	12	2	9	**56**	XS-13	5	14	3	6	10	13	7	8	**66**
XS-14	4	11	3	0	0	11	2	8	**39**	XS-14	4	14	3	6	3	12	2	8	**52**	XS-14	5	18	3	6	3	14	7	9	**65**
XS-15	4	10	3	0	0	10	2	7	**36**	XS-15	4	11	8	8	7	14	2	7	**61**	XS-15	5	16	3	8	7	14	7	10	**70**
XS-16	5	10	3	0	0	11	7	6	**42**	XS-16	5	15	4	4	7	11	7	6	**59**	XS-16	4	16	6	4	7	14	2	4	**57**
XS-17	5	11	2	0	0	14	7	10	**49**	XS-17	5	11	8	6	3	13	7	10	**63**	XS-17	5	19	8	6	3	12	10	10	**73**
XS-18	5	10	1	0	0	14	7	10	**47**	XS-18	5	15	1	4	3	14	7	10	**59**	XS-18	5	6	1	4	3	14	10	10	**53**
XS-19	5	10	1	0	0	4	0	10	**30**	XS-19	5	5	1	6	7	4	0	10	**38**	XS-19	5	17	1	6	7	14	0	10	**60**
										XS-20*	4	11	3	4	7	12	2	8	**51**	XS-20*	5	7	3	4	7	14	2	4	**46**
MEAN	**4.4**	**10.8**	**2.2**	**3.4**	**1.9**	**11.5**	**5.1**	**9.0**	**48.3**	**MEAN**	**4.4**	**11.4**	**3.7**	**6.3**	**4.7**	**12.0**	**4.9**	**9.0**	**56.2**	**MEAN**	**4.9**	**9.8**	**3.3**	**6.3**	**4.7**	**13.2**	**6.1**	**8.9**	**57.1**
REF-1	4	11	8	10	14	12	7	9	**75**	REF-1	4	12	12	8	14	12	7	9	**78**	REF-1	5	6	3	8	14	12	7	8	**63**
REF-2	4	11	3	8	10	12	7	9	**64**	REF-2	4	11	3	8	10	12	7	9	**64**	REF-2	5	11	3	8	10	12	7	8	**64**
REF-3	5	11	14	10	14	11	7	8	**80**	REF-3	5	15	11	8	14	14	7	8	**82**	REF-3	5	16	11	8	14	11	10	7	**82**
REF-4	4	11	14	8	14	12	7	10	**80**	REF-4	4	15	14	8	14	14	7	10	**86**	REF-4	5	15	11	8	14	12	7	10	**82**
MEAN	**4.3**	**11.0**	**9.8**	**9.0**	**13.0**	**11.8**	**7.0**	**9.0**	**74.8**	**MEAN**	**4.3**	**13.3**	**10**	**8**	**13**	**13**	**7**	**9**	**77.5**	**MEAN**	**4.3**	**13.3**	**10**	**8**	**13**	**13**	**7**	**9**	**72.8**

*Cross-section 20 was not established until 2006

2.2.5.4 Photography and Videography

As discussed in the project's Mitigation Plan (Restoration Systems 2006b), photography and videography were conducted during baseline, Year-1, and Year-2 monitoring data collection to assess qualitative changes in channel cross-sections and in-stream habitat. Monitoring photographs and videos have been included on a data compact disc in Appendix E.

Cross-Section 18 on Little Buffalo Creek in July 2007. This formerly impounded reach now supports emergent vegetation. Note the high water mark on the large gum tree on the right.

Cross-Section 7 on the Little River. Note the stabilizing vegetation established on the far bank.

Fish weir for scientific research at the former dam location

2.3 Rare and Protected Species

Two federally endangered species have been documented in the Little River sub-basin: the dwarf wedgemussel (*Alasmidonta heterodon*) and Tar spinymussel (*Elliptio steinstansanna*). Both of these species are mollusks. As discussed in Section 2.2.4 ("Mollusks"), mollusks will be sampled during the fourth year of project monitoring. Favorable habitat (lotic flow conditions with gradually coarsening substrate) for these mollusk species has developed within much of the former Site Impoundment (see Appendix C). The pinewoods shiner (*Lythrurus matutinus*), listed as a Federal Species of Concern and on the state watch list, and the bull chub (*Nocomis raneyi*), listed on the state watch list, were found during fish sampling (see Appendix C).

2.4 Bonus Criteria

2.4.1 Public Recreation

A public park at the former dam site was dedicated on September 21, 2007. The park includes picnic and fishing areas, canoe and kayak launch areas, and vehicular parking. Plans for the park were developed by Milone and MacBroom, Inc. (MMI) and were included in Year-1 AMR Appendix F.

2.4.2 Scientific Research

The former Site Impoundment is subject to a study by University of North Carolina at Chapel Hill scientist Adam Riggsbee, Ph.D. (Riggsbee 2006, 2007A-D). Sediment accumulated for many decades within the former Site Impoundment before the dam's removal. Dr. Riggsbee's study investigated the flushing of these sediments and associated nutrients and organic materials as they were routed through the downstream channel network. Additionally, the study assesses physical and biological controls on nitrogen and phosphorous leaching from wetland sediments exposed

by dam removal. Dr. Riggsbee has also given numerous oral presentations at professional conferences regarding his research.

From March to May of 2007 and 2008, a study investigating fish passage within and upstream of the former Site Impoundment was conducted at the former dam location. During these months, Joshua K. Raabe and Dr. Joseph E. Hightower of North Carolina State University installed a fish weir in the former dam location to capture, quantitate and observe the movement of fish in order to better understand how anadromous fish use habitat in different parts of the Little River. The study results will enable scientists to better predict the potential benefits of fish passage (fish ladders) versus complete dam removal. Results from the first year of this study will not be available until late 2007. If available, a report of the study's findings will be included in next year's AMR. A copy of a handout summarizing this research (Raabe 2007) is included in Appendix G.

3.0 EROSION EVALUATION

ESC performed two erosion evaluations of the former Site Impoundment following rain events that resulted in river discharge of greater than 750 cubic feet per second (cfs) at the Princeton gauging station. The erosion evaluations consist of a canoe transit of the Little River within the former Site Impoundment. The evaluations were performed to document any evidence of erosion within the former Site Impoundment including but not limited to bank failure, loss of stream bank trees, severe head-cuts, and the loss or gain of large depositional features. The erosion evaluations were performed on November 28, 2006 and January 3, 2007. Detailed reports documenting these evaluations are included in Appendix F. River banks were found to be fairly stable, with limited evidence of erosion.

4.0 REFERENCES

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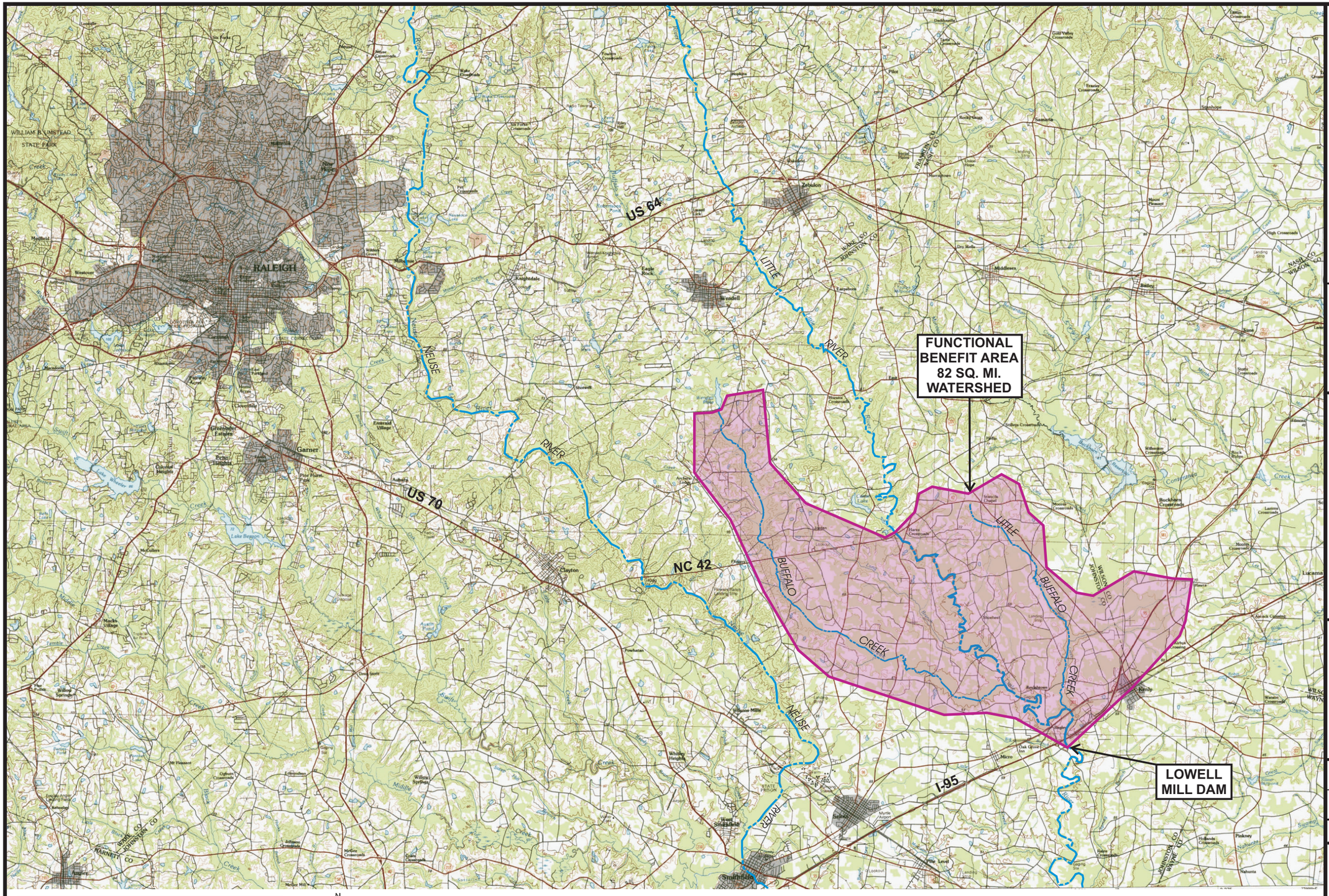
APPENDIX A: Figures



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Project:

LOWELL MILL DAM- LITTLE RIVER WATERSHED RESTORATION SITE

Johnston County
North Carolina

Title:

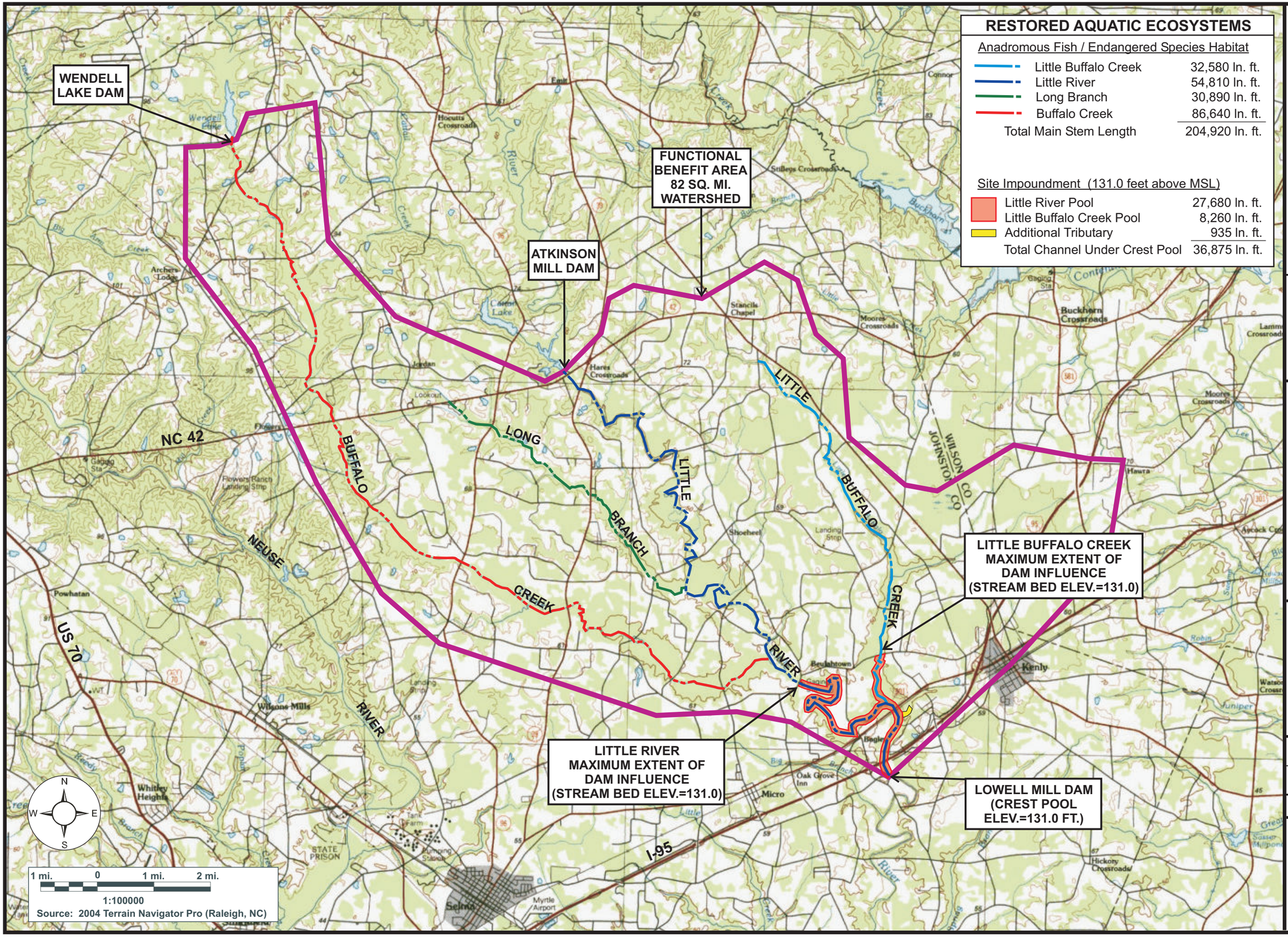
SITE LOCATION

Dwn By:	Date:
MAF	SEPT 2006
Ckd By:	Scale:
JDC	As Shown

ESC Project No.: 07-342.00

FIGURE

1



RESTORED AQUATIC ECOSYSTEMS

Anadromous Fish / Endangered Species Habitat

Little Buffalo Creek	32,580 ln. ft.
Little River	54,810 ln. ft.
Long Branch	30,890 ln. ft.
Buffalo Creek	86,640 ln. ft.
Total Main Stem Length	204,920 ln. ft.

Site Impoundment (131.0 feet above MSL)

Little River Pool	27,680 ln. ft.
Little Buffalo Creek Pool	8,260 ln. ft.
Additional Tributary	935 ln. ft.
Total Channel Under Crest Pool	36,875 ln. ft.

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FUNCTIONAL BENEFIT AREA

Dwn By: MAF	Date: SEPT 2006
Ckd By: JDC	Scale: As Shown

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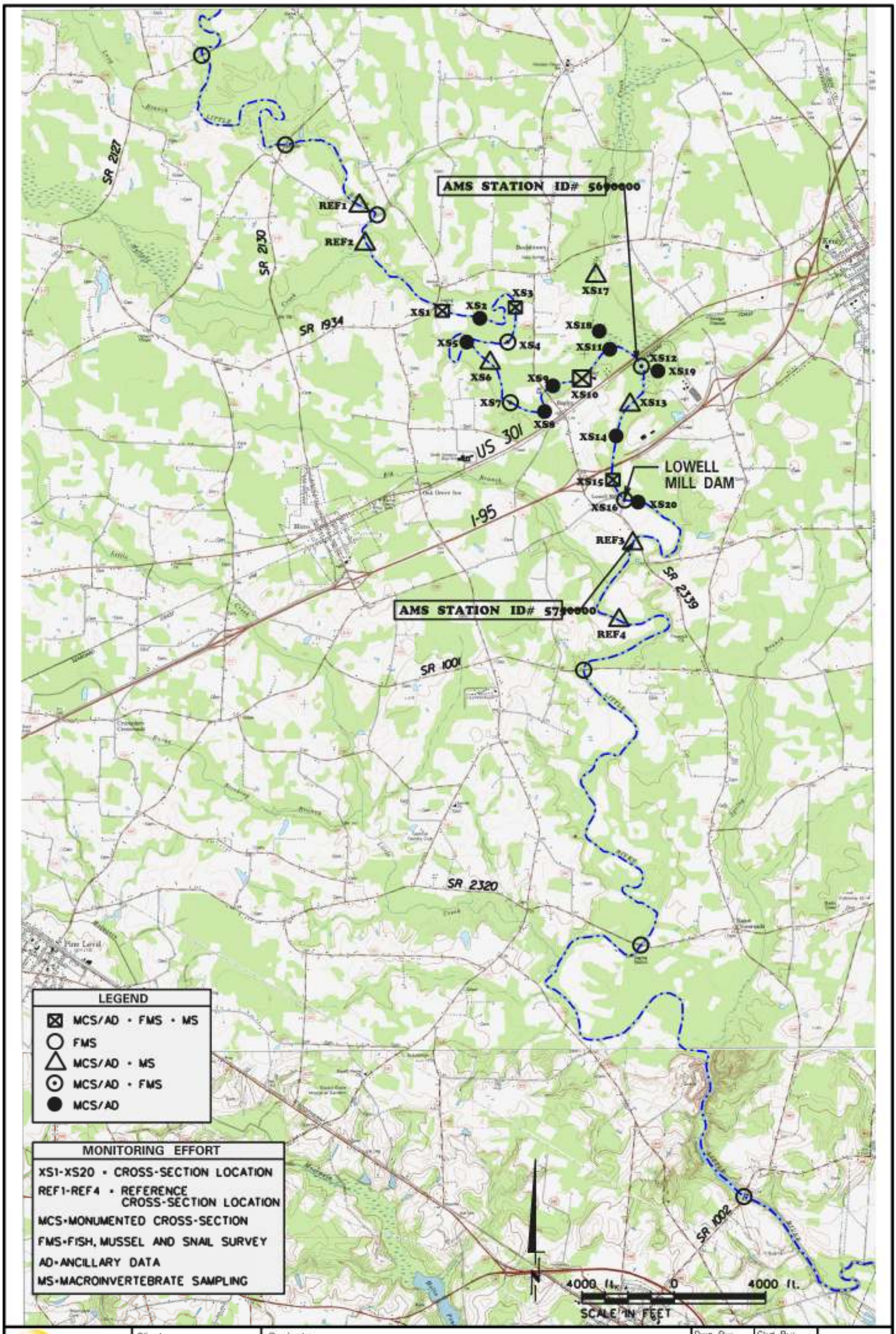
FIGURE

2



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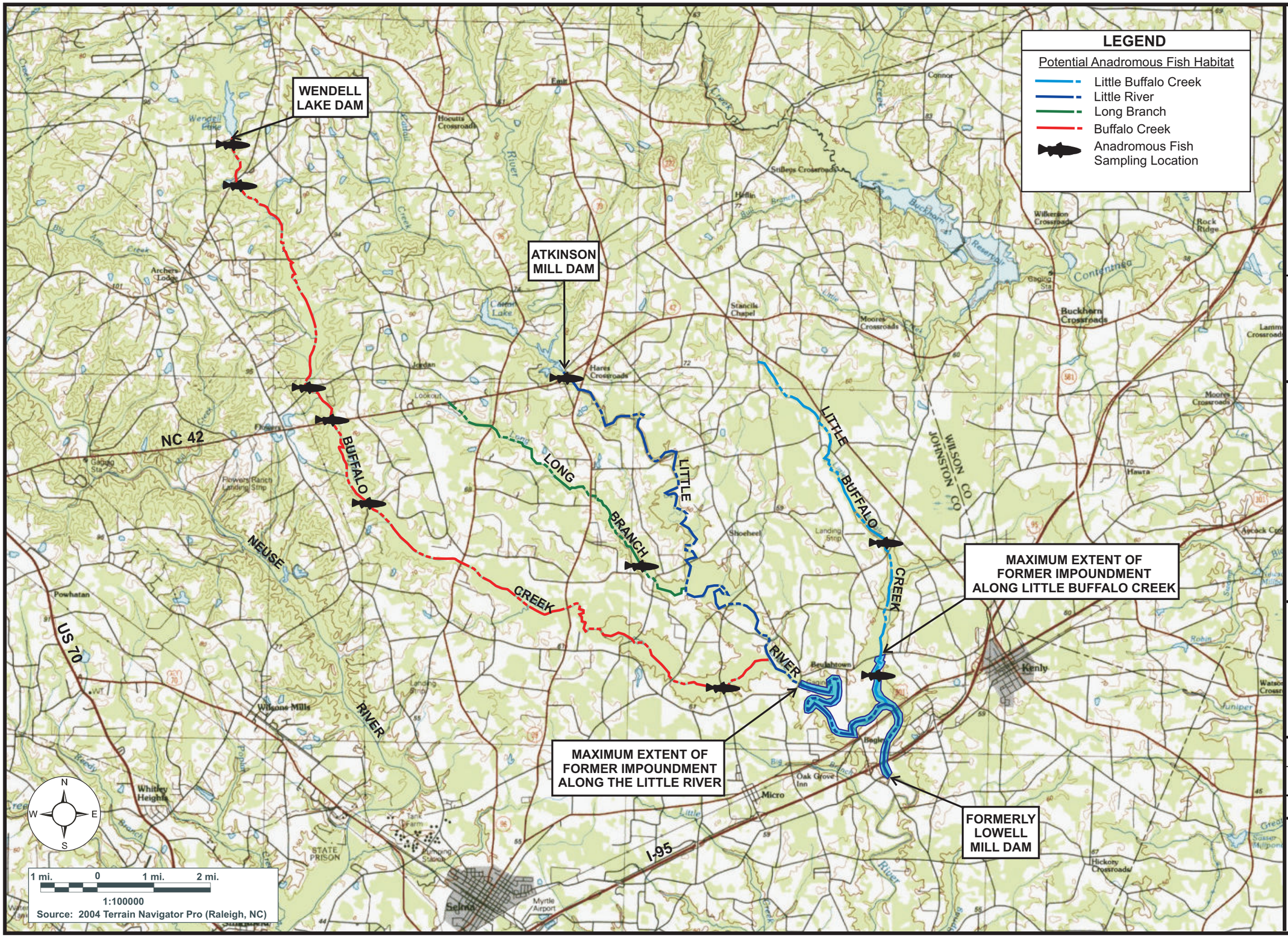
MONITORING NETWORK DEPLOYMENT

LOWELL MILL DAM - LITTLE RIVER WATERSHED RESTORATION SITE

Johnston County, North Carolina

Dwn By:	Ckd By:	FIGURE
MAF	JDC	3
Date: SEPT 2006		
Scale: 1"=4000'		
ESC Project No.: 07-342		



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North Carolina

Title:

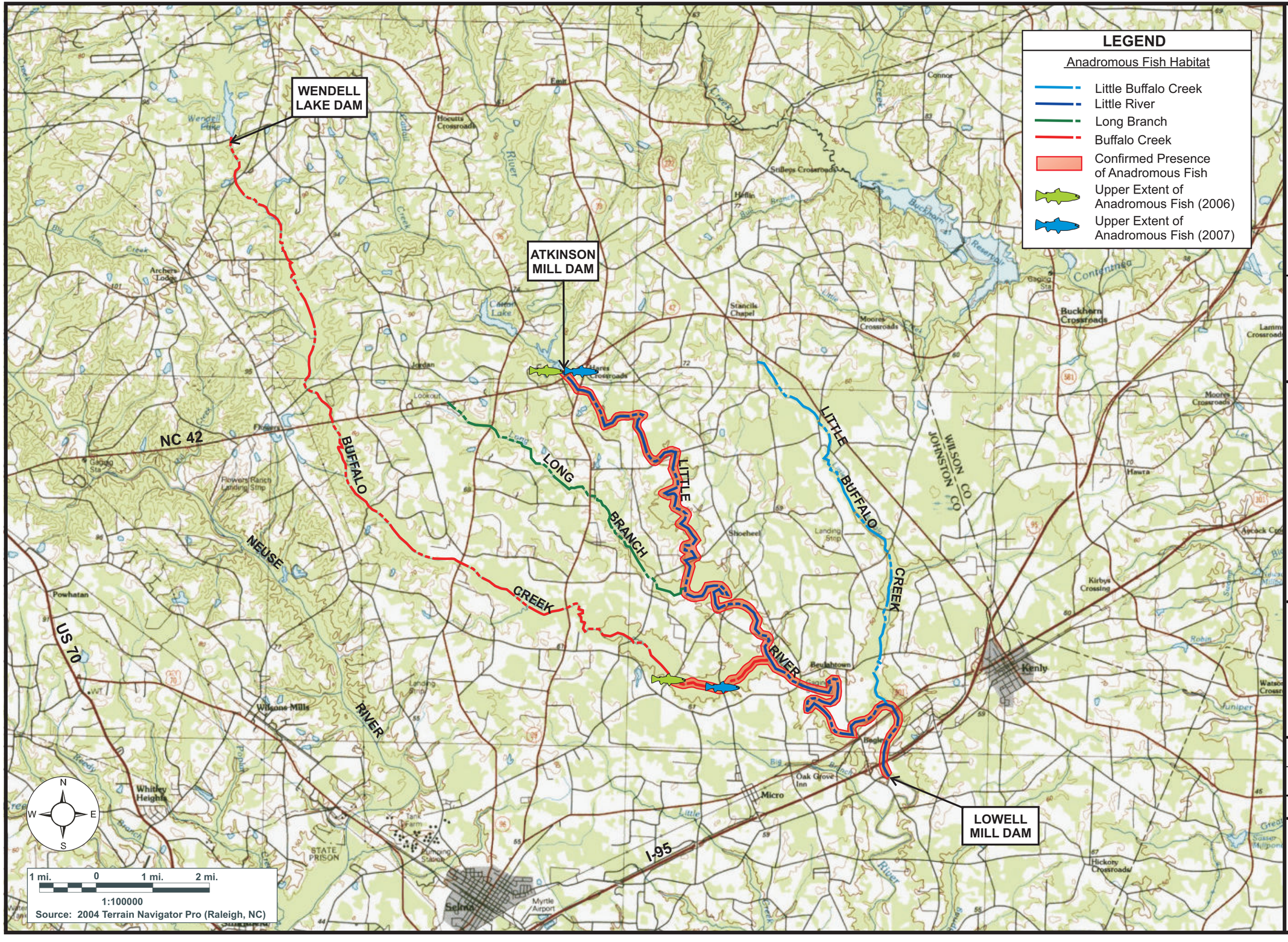
ANADROMOUS FISH SURVEY STATION LOCATIONS

Dwn By:	Date:
MAF	SEPT 2006
Ckd By:	Scale:
JDC	As Shown

ESC Project No.: 07-342.00

FIGURE

4A



LEGEND

Anadromous Fish Habitat

- Little Buffalo Creek
- Little River
- Long Branch
- Buffalo Creek
- Confirmed Presence of Anadromous Fish
- Upper Extent of Anadromous Fish (2006)
- Upper Extent of Anadromous Fish (2007)

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Johnston County
North Carolina

Title:

REPORTED PRESENCE OF ANADROMOUS FISH

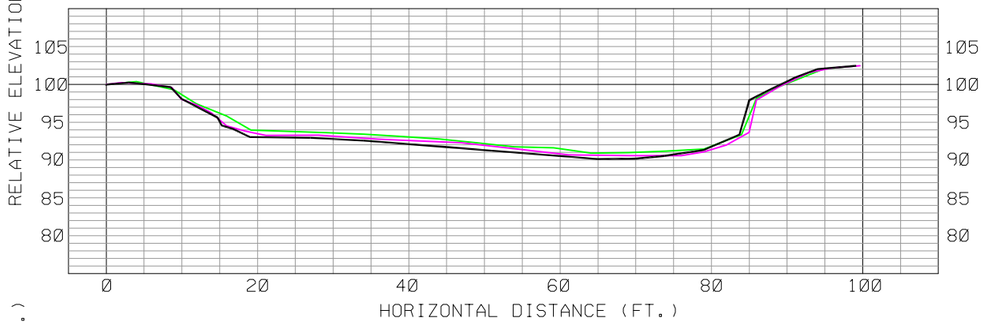
Dwn By:	Date:
JRW	OCT 2007
Ckd By:	Scale:
JDC	As Shown

ESC Project No.: 07-342.00

FIGURE

4B

CROSS-SECTION 1



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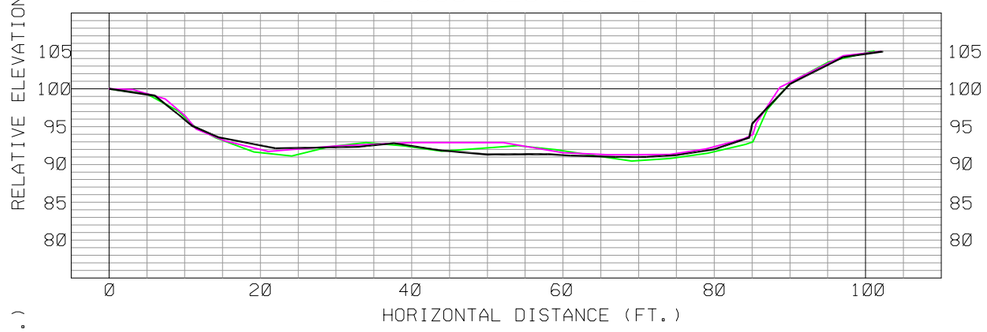

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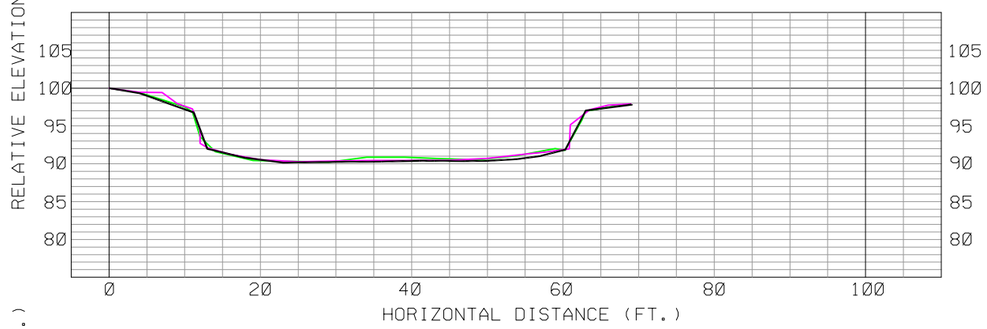

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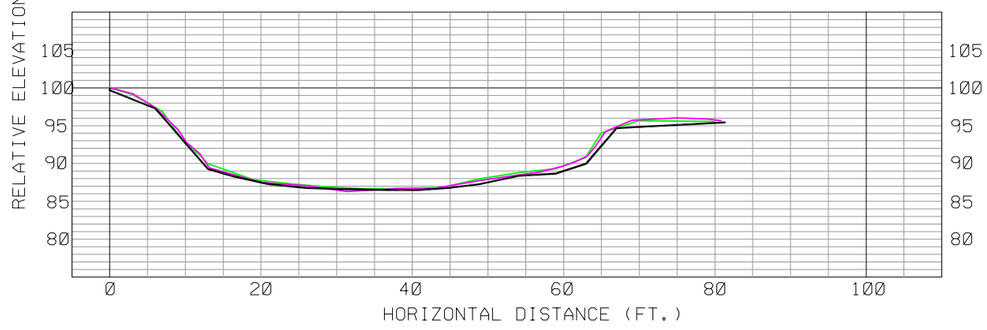

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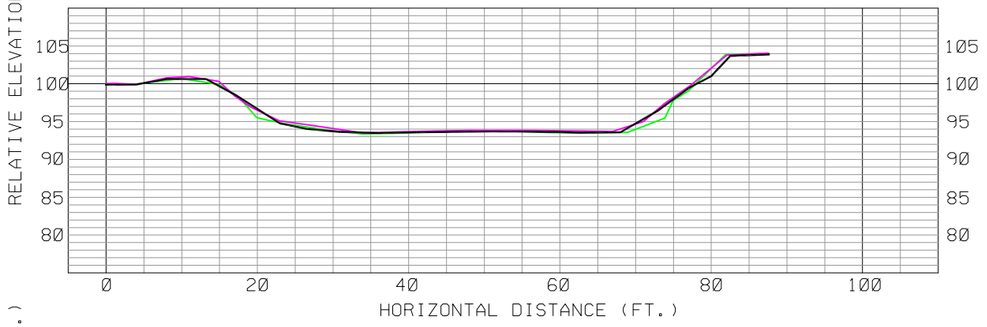

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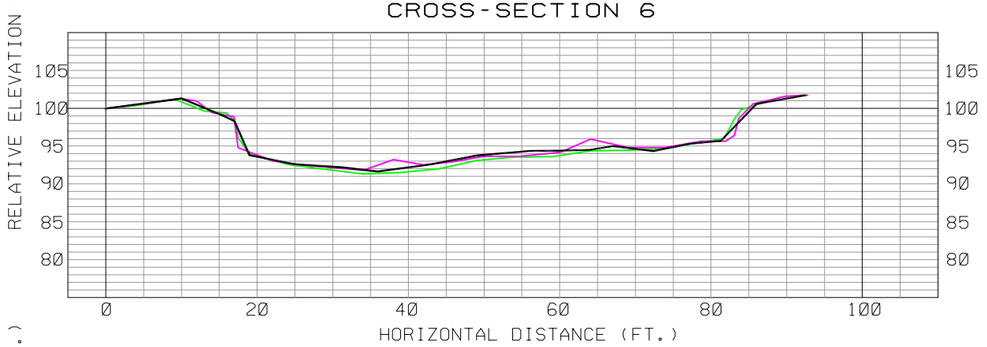

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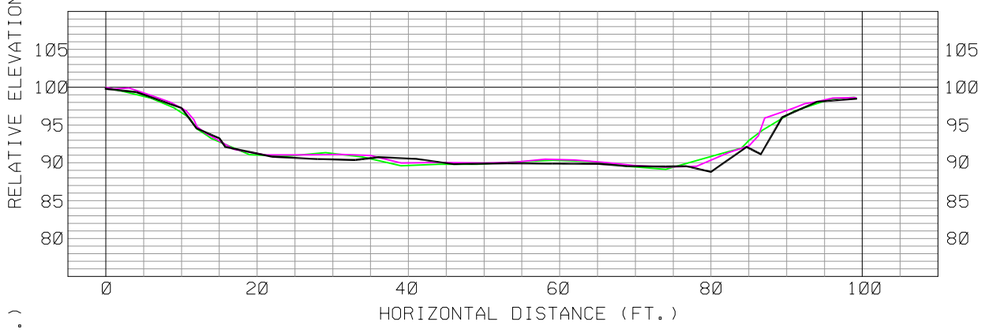

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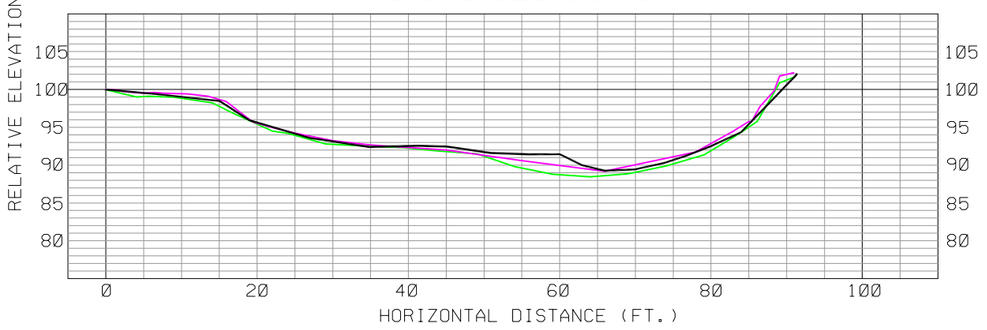

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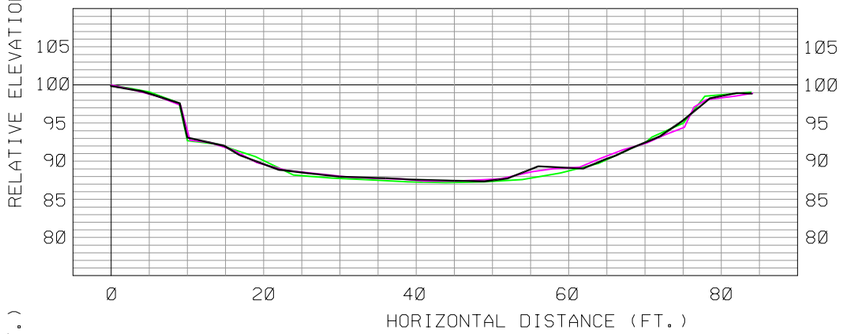
5A

CROSS-SECTION 9



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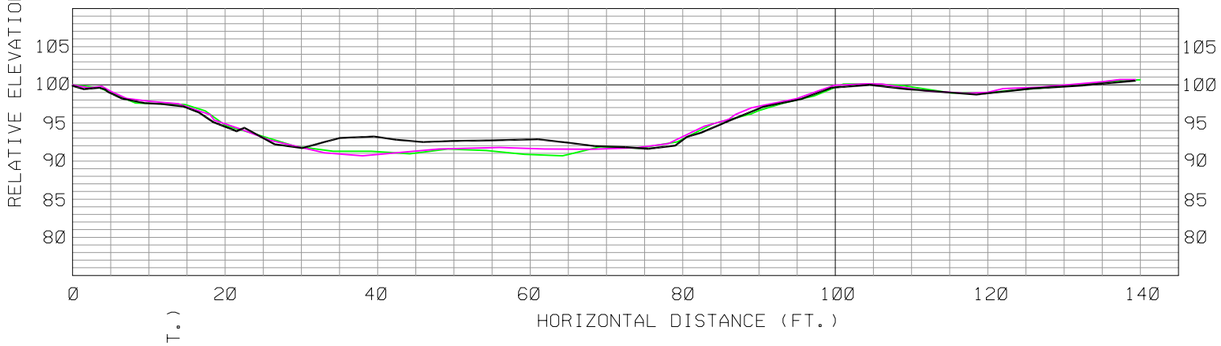

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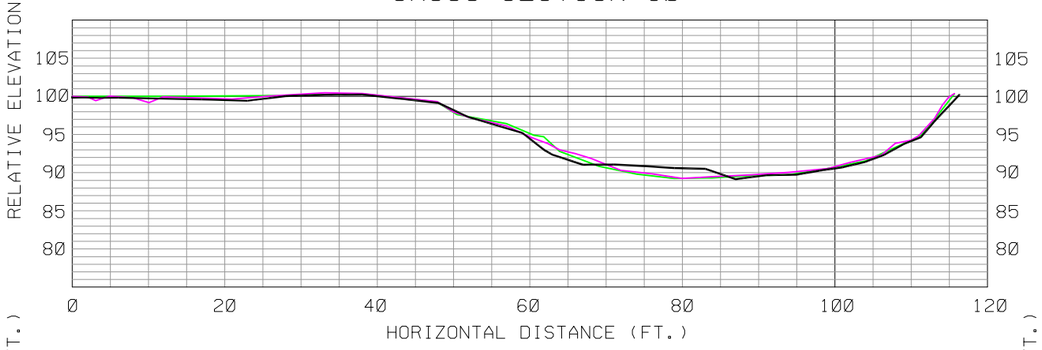

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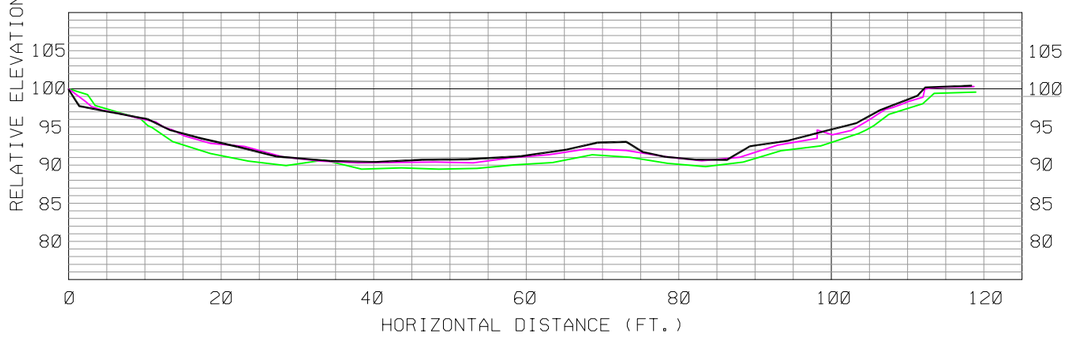

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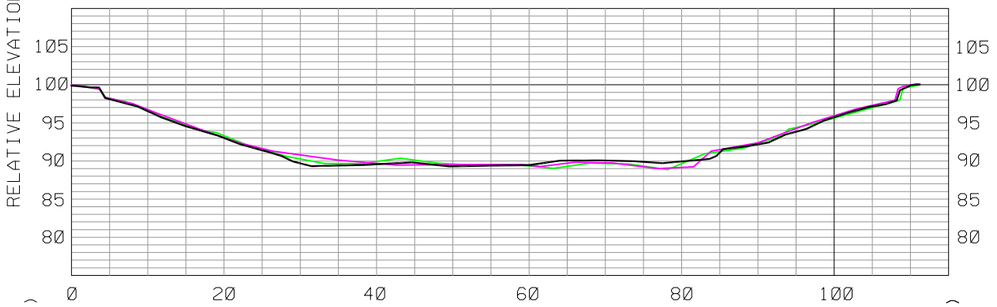

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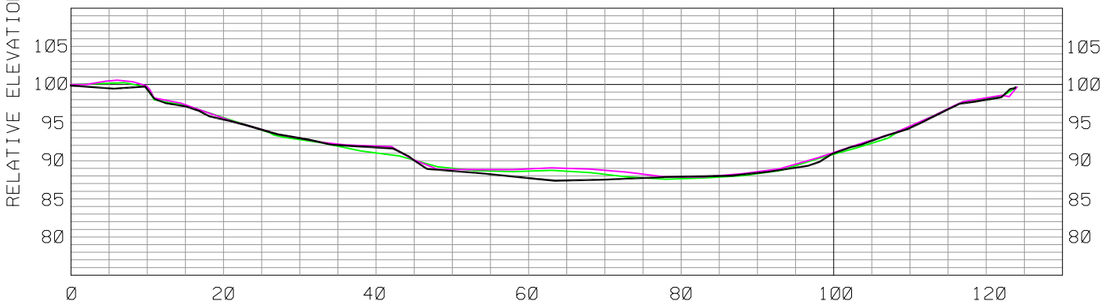

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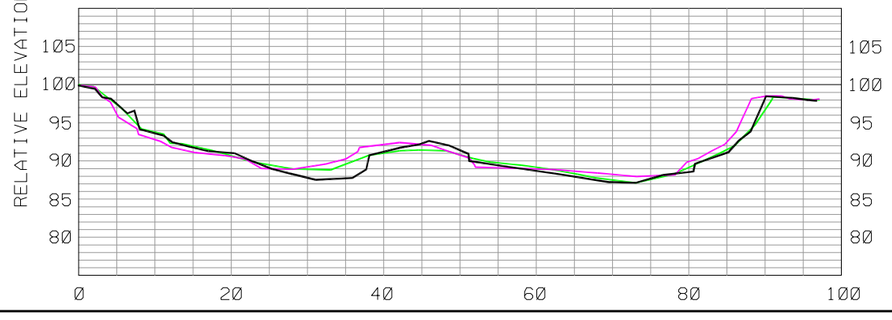

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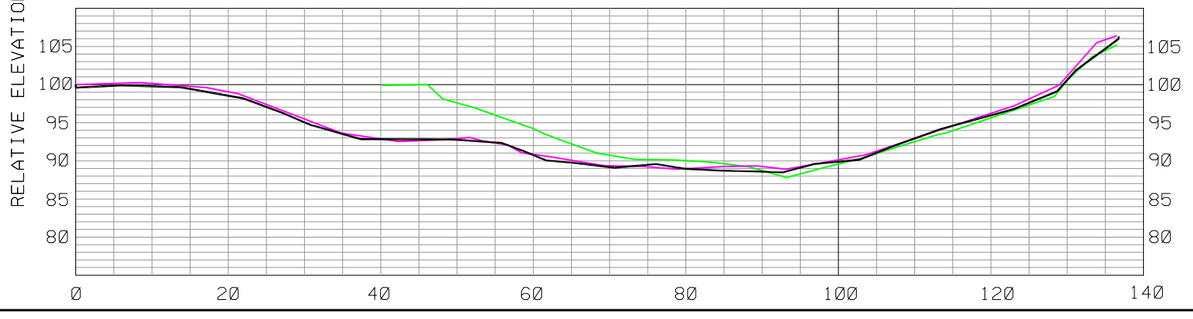

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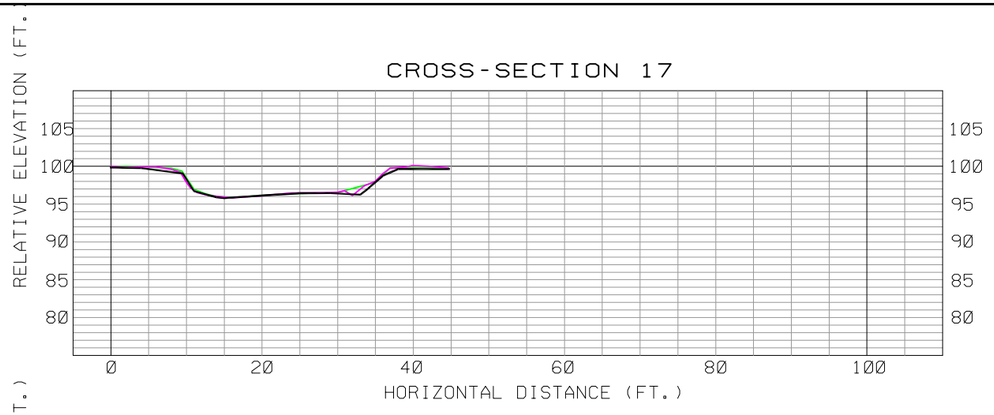

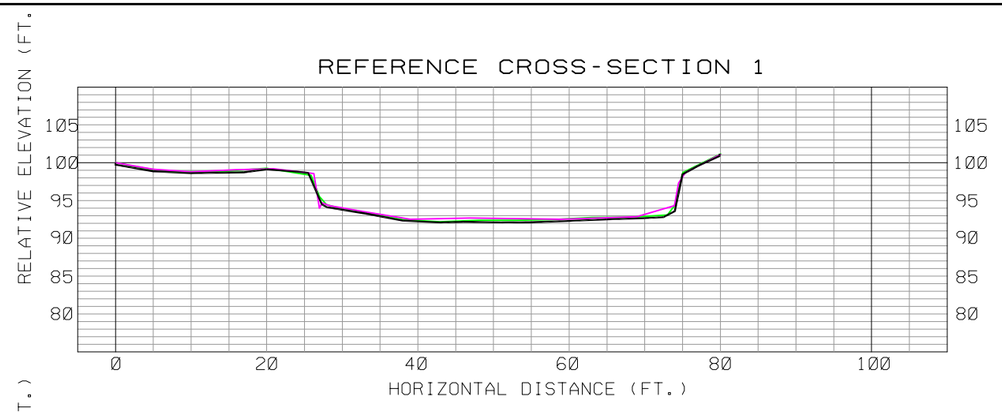

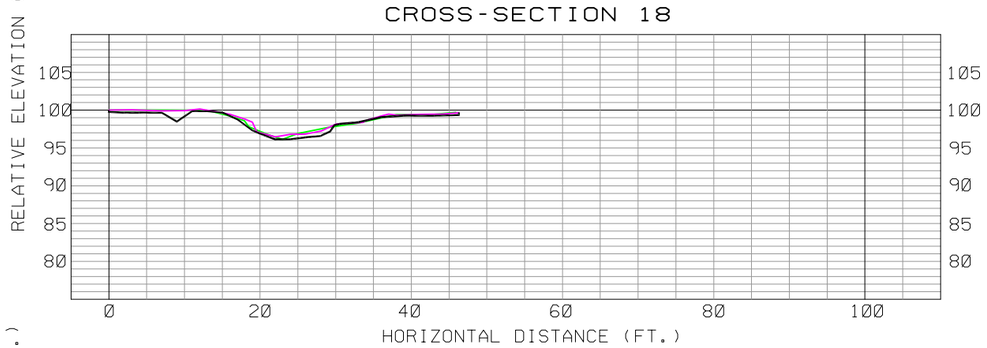

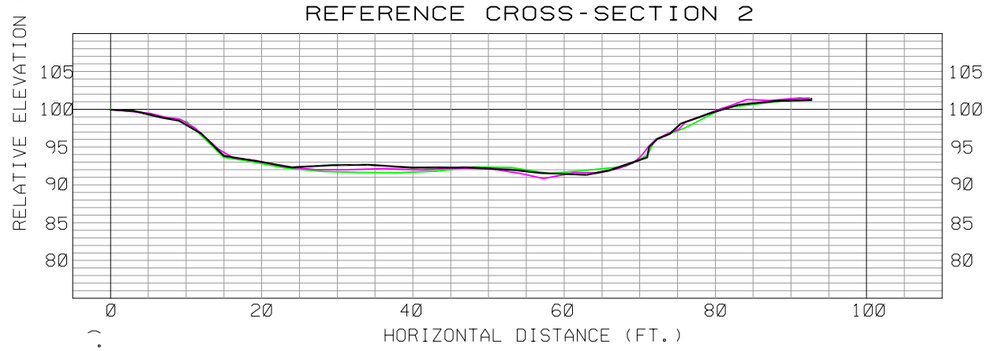

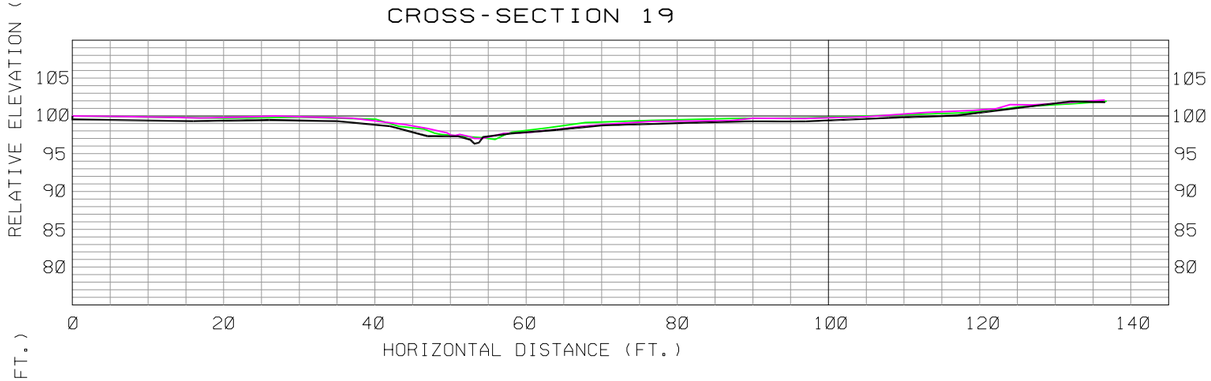

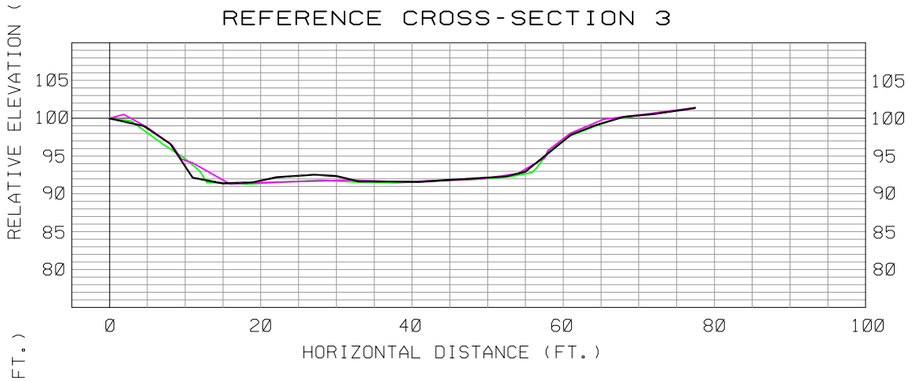

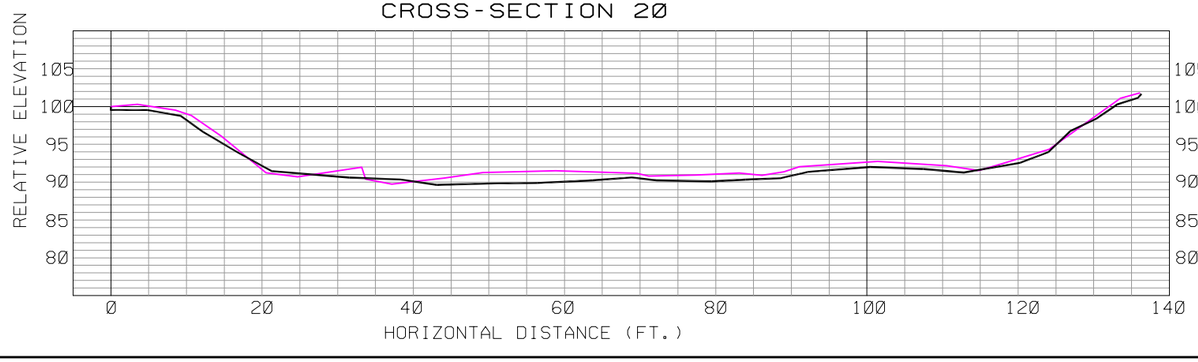

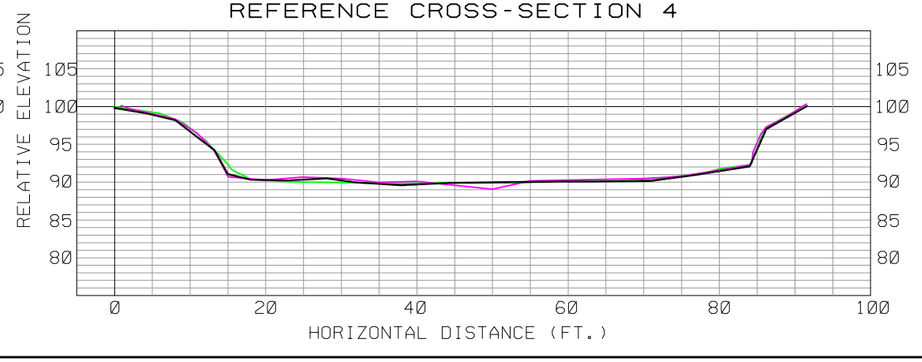

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APPENDIX B: Benthic Macroinvertebrate Data

			FORMERLY IMPOUNDED STATIONS						
SPECIES			**Sta. 1**	**Sta. 3**	**Sta. 6**	**Sta. 10**	**Sta. 13**	**Sta. 15**	**Sta. 17**
PLATYHELMINTHES									
Turbellaria									
Tricladida									
Planariidae									
Girardia (Dugesia) tigrina	**7.2**			3		2	2		
NEMERTEA									
Enopla									
Tertastemmatidae									
Prostoma sp.								1	
NEMATODA	**6**								
MOLLUSCA									
Bivalvia									
Veneroida									
Corbiculidae									
Corbicula fluminea	**6.12**	**FC**		4					
Gastropoda									
Mesogastropoda									
Pleuroceridae	**3.4**								
Elimia sp.	**2.46**	**SC**		1					
Viviparidae									
Campeloma decisum	**6.5**	**SC**		2					
Basommatophora									
Physidae									
Physella sp.	**8.8**	**CG**					1		
Planorbidae									
Helisoma anceps	**6.2**	**SC**				1			
ANNELIDA									
Oligochaeta		**CG**							
Tubificida									
Lumbricidae		**CG**			1	5	1	1	
Naididae	***8**	**CG**							1
Nais sp.	**8.9**	**CG**			3				
Tubificidae w.h.c.	**7.1**	**CG**	1						
Tubificidae w.o.h.c.	**7.1**	**CG**		2		9	4		2
Lumbriculida									
Lumbriculidae	**7.03**	**CG**	1	1	1	3	8	1	6
Branchiobdellida									4
Hirudinea		**P**							
Rhynchobdellida									
Glossiphoniidae		**P**					34	1	
Placobdella sp.	**9**	**P**				1	3		
ARTHROPODA									
Arachnoidea									
Acariformes				3		2		2	
Hygrobatidae									
Atractides sp.	**5.5**						3		
Lebertiidae	**5.5**								
Lebertia sp.	**5.5**		2		2		4	1	
Pionidae	**5.5**								
Crustacea									
Ostracoda					5	6	7		1
Cladocera									
Chydoridae									
Isopoda									
Asellidae		**SH**							
Caecidotea sp.	**9.1**	**CG**			1				1

FORMERLY IMPOUNDED STATIONS

SPECIES			Sta. 1	Sta. 3	Sta. 6	Sta. 10	Sta. 13	Sta. 15	Sta. 17
Lirceus sp.	**7.9**	**CG**							8
Amphipoda									
Crangonyctidae									
Crangonyx sp.	**7.9**	**CG**							32
Hyalellidae									
Hyalella azteca	**7.75**	**CG**					2		
Decapoda									
Cambaridae	**7.5**			1					
Cambarus sp.	**7.62**	**CG**				1			3
Palaemonidae									
Palaemonetes kadiakensis	**7.1**	**CG**		1			2		5
Insecta									
Collembola							2		
Ephemeroptera									
Baetidae		**CG**						3	
Acerpenna pygmaea	**3.9**		2						
Baetis intercalaris	**7**	**CG**		8			20	11	
Centroptilum sp.	**6.6**	**CG**	4			7	1	1	
Procloeon sp.	**5**			4	2				
Pseudocloeon sp.	**4**	**CG**	1	1	1		1	6	
Caenidae		**CG**							
Brachycercus nitidus		**CG**					1		
Caenis sp.	**7.4**	**CG**	15	31	4	8	3	2	2
Ephemeridae		**CG**							
Hexagenia sp.	**4.9**	**CG**				12	13	1	
Ephemerellidae		**SC**							
Eurylophella sp.	**4.34**	**SC**				1			
Heptageniidae									
Maccaffertium (Stenonema) sp.	***4**	**SC**	40	62	15		78		
Maccaffertium (Stenonema) exiguum	**3.8**	**SC**	6	7	2	2	1	1	
Maccaffertium (Stenonema) integrum	**5.8**	**SC**					2		
Maccaffertium (Stenonema) modestum	**5.5**	**SC**	96	52	40	48	41	33	4
Stenacron interpunctatum	**3.58**	**SC**	5	3		9	1	1	11
Isonychiidae		**FC**							
Isonychia sp.	**3.5**	**FC**	32	17	6	5	15	20	
Tricorythidae	***4**	**CG**							
Tricorythodes sp.	**5.06**	**CG**	2	52	6	2	20	11	
Odonata									
Aeshnidae	**5.6**	**P**				1			
Boyeria vinosa	**5.97**	**P**	4	4	3		7	4	1
Nasiaeschna pentacantha	**8.14**							1	
Coenagrionidae	***9**	**P**					2	17	
Argia sp.	**8.17**	**P**	8	4	11	43	26	8	
Enallagma sp.	**8.9**	**P**							1
Ischnura sp.	**9.5**								3
Corduliidae	***5**	**P**							
Macromia sp.	**6.16**	**P**	3	4	2	2		1	2
Neurocordulia sp.	**5**					3			
Neurocordulia obsoleta	**5.2**			1	1				1
Gomphidae	***1**	**P**		1					
Dromogomphus spinosus	**5.1**	**P**	1		2	5	5	2	
Gomphus sp.	**5.8**	**P**	2		2	3	2	5	4
Hagenius brevistylus	**4**	**P**	2	1					
Progomphus obscurus	**8.2**	**P**		2		1		3	
Stylurus sp.		**P**					6		
Libellulidae	**6.7**	**P**							
Perithemis sp.	**9.9**	**P**							3

FORMERLY IMPOUNDED STATIONS

SPECIES			Sta. 1	Sta. 3	Sta. 6	Sta. 10	Sta. 13	Sta. 15	Sta. 17
Plecoptera									
Perlidae	***1**	**P**							
Neoperla sp.	**1.5**	**P**	1	1			1		
Perlesta placida sp. gp.	**4.7**	**P**	40	27	8	4	10		1
Perlodidae	***2**	**P**							
Paragnetina sp.	**1.5**	**P**					1		
Paragnetina kansensis	**2**	**P**	3	1			1		
Pteronarcidae	**1.6**	**SH**							
Pteronarcys (Allonarcys) sp.	**1.7**	**SH**	1						
Hemiptera									
Corixidae	**9**	**PI**					1		
Gelastocoridae		**-**							
Gelastocoris sp.		**P**				1			1
Gerridae									
Metrobates sp.		**P**					2		
Nepidae		**-**							
Ranatra sp.	**7.8**	**P**	1		1				3
Megaloptera									
Corydalidae		**P**							
Chauliodes rastricornis	**8.4**	**P**		1					
Corydalus cornutus	**5.2**	**P**	2	1				2	
Sialidae		**P**							
Sialis sp.	**7.17**	**P**	1		1	8	5	1	21
Trichoptera									
Dipseudopsidae									
Phylocentropus sp.	**6.2**	**FC**							1
Hydropsychidae	***4**	**FC**	7	1		1	3		
Cheumatopsyche sp.	**6.2**	**FC**	27	53	10	25	62	32	
Hydropsyche sp.	**5**	**FC**	46	12	3	7	7	13	
Hydropsyche simulians							3		
Hydroptilidae	***4**	**PI**							
Hydroptila sp.	**6.2**	**PI**		2					
Leptoceridae	***4**	**CG**							
Ceraclea sp.	**2**	**CG**	1						
Nectopsyche sp.	**2.9**	**SH**						1	
Nectopsyche exquisita	**4.1**	**SH**	2	2	1		1		
Nectopsyche pavida	**4.1**		1		1	1	2		
Oecetis avara			17	3			1		
Philopotamidae		**FC**							
Chimarra cf. feria								1	
Chimarra sp.	**2.8**	**FC**	1	2			2	1	
Polycentropodidae		**FC**				1			
Neureclipsis sp.	**4.2**	**FC**	1		1		1		
Coleoptera									
Dytiscidae		**P**		1		7			
Agabus sp.	**8.9**	**P**							1
Hydroporus sp.	**8.62**	**PI**					2		3
Elmidae		**CG**							
Ancyronyx variegata	**6.49**	**SC**	4	5	10	8	3		7
Dubiraphia sp.	**5.93**	**SC**			1	4	2		
Dubiraphia vittata	**4.1**	**SC**	2	6	5	4	8	4	
Macronychus glabratus	**4.58**	**SH**	39	30	69	28	63	15	
Stenelmis sp.	**5.1**	**SC**	3	3	4		2		
Gyrinidae		**P**							
Dineutus sp.	**5.54**	**P**	33	20	7	7	35	19	
Haliplidae									
Peltodytes sp.	**8.73**	**SH**	2					1	1

FORMERLY IMPOUNDED STATIONS

SPECIES			Sta. 1	Sta. 3	Sta. 6	Sta. 10	Sta. 13	Sta. 15	Sta. 17
Hydrophilidae						1		1	
Berosus sp.	**8.43**	**CG**				2	3	4	
Enochrus sp.	**8.8**	**CG**	1			1		1	
Helochares sp.	***5**	**P**						1	
Sperchopsis tesselatus	**6.13**	**CG**	1	4			2	2	2
Tropisternus sp.	**9.68**	**P**					1		1
Noteridae									
Hydrocanthus sp.									1
Diptera									
Blephariceridae		**SC**							
Blepharicera sp.	**2**	**SC**			1				
Ceratopogonidae	***5**	**P**	2				5	1	5
Atrichopogon sp.	**6.49**	**P**					2		
Bezzia/Palpomyia gp.	**6.9**	**P**		1	2	7			
Chironomidae									
Ablabesmyia mallochi	**7.2**	**P**	7	1	11	86	39	42	13
Ablabesmyia rhamphe gp.	**7.2**	**P**		3		3	16		
Chironomus sp.	**9.63**	**CG**		1	3		67		
Cladotanytarsus sp.	**4.09**	**FC**	4	1				9	
Corynoneura sp.	**6.01**	**CG**	3						
Cricotopus sp.	***7**	**CG**		3	11		4		
Cricotopus bicinctus	**8.5**	**CG**	18	14	32	13	16	56	
Cryptochironomus sp.	**6.4**	**P**						2	3
Dicrotendipes neomodestus	**8.1**	**CG**					20	5	1
Dicrotendipes simpsoni	**10**								2
Labrundinia sp.	**5.9**	**P**				3	4		1
Microtendipes pedellus gp.	**5.5**	**CG**							1
Nanocladius sp.	**7.07**	**CG**			3			2	1
Orthocladius sp.		**CG**	1	10	11	8			
Paracladopelma sp.	**5.51**	**CG**	1		19	27	16		
Parakiefferiella sp.	**5.4**	**CG**			2				
Parametriocnemus sp.	**3.65**	**CG**		1					
Paratanytarsus sp.	**8.5**	**CG**							1
Pentoneura inconspicia				1	16	8			
Polypedilum fallax	**6.4**	**SH**	25		2	8	4	2	1
Polypedilum flavum (convictum)	**4.9**	**SH**	3	12	15			7	6
Polypedilum halterale gp.	**9**	**SH**		1					
Polypedilum illinoense	**7.3**	**SH**	33	72	16	8		25	6
Procladius sp.	**9.1**	**P**	3	1	6	73	181	25	18
Rheocricotopus robacki	**7.3**	**CG**	5	1	5	8	4		
Rheotanytartsus exiguus gp.	**5.9**		9	3	5	11	4	9	1
Stenochironomus sp.	**6.45**	**SH**	3		5			5	2
Synorthocladius semivirens	**4.36**	**CG**		1					
Tanytarsus sp.	**6.76**	**FC**	7		39		4	33	4
Thienemanniella xena	**5.86**	**CG**	1	6	6		4	2	2
Tribelos jucundum	**6.3**		7		2	24	12		58
Tvetenia vitracies	**3.6**	**CG**	13	27	5	8	12		
Xenochironomus xenolabis	**7.1**	**P**				5			
Xylotopus par	**6**	**SH**							4
Zavrelimyia sp.	**9.11**	**P**		1					
Culicidae		**FC**							3
Anopheles sp.	**8.6**	**FC**			1				
Dolichopodidae		**P**							1
Empididae	**7.6**	**P**							
Hemerodromia sp.		**P**		1					
Muscidae	**8.4**								1
Ptychopteridae									

FORMERLY IMPOUNDED STATIONS

SPECIES			Sta. 1	Sta. 3	Sta. 6	Sta. 10	Sta. 13	Sta. 15	Sta. 17
Bittacomorpha clavipes								1	
Tipulidae	***3**	**SH**							
Tipula sp.	**7.33**	**SH**	1	1		23	3	1	1
TOTAL NO. OF ORGANIMS			**610**	**610**	**450**	**615**	**959**	**464**	**274**
TOTAL NO. OF TAXA			**62**	**67**	**57**	**59**	**77**	**58**	**55**
EPT INDEX			**23**	**20**	**14**	**15**	**26**	**16**	**5**
BIOTIC INDEX			**5.45**	**5.57**	**5.98**	**6.71**	**6.72**	**6.61**	**6.97**
Assigned BIOTIC INDEX VALUE			**5.57**	**5.58**	**6.20**	**6.34**	**6.19**	**6.34**	**7.00**
EPT ABUNDANCE			**351**	**341**	**100**	**133**	**292**	**138**	**19**

REFERENCE STATIONS						
SPECIES			**Sta. R1**	**Sta. R2**	**Sta. R3**	**Sta. R4**
PLATYHELMINTHES						
Turbellaria						
Tricladida						
Planariidae						
Girardia (Dugesia) tigrina	**7.2**					1
NEMERTEA						
MOLLUSCA						
Bivalvia						
Veneroida						
Corbiculidae						
Corbicula fluminea	**6.12**	**FC**	1		1	1
Basommatophora						
Planorbidae						
Helisoma anceps	**6.2**	**SC**				1
Menetus dilatatus	**8.2**	**SC**			2	
ANNELIDA						
Oligochaeta		**CG**				
Tubificida						
Lumbricidae		**CG**			1	
Tubificidae w.h.c.	**7.1**	**CG**				
Spirosperma sp.	**10**	**CG**	1			
Tubificidae w.o.h.c.	**7.1**	**CG**	1			
Lumbriculida						
Lumbriculidae	**7.03**	**CG**		2	1	2
Hirudinea		**P**				
Rhynchobdellida						
Glossiphoniidae		**P**		1	2	1
ARTHROPODA						
Arachnoidea						
Acariformes					10	3
Pionidae	**5.5**		1			
Crustacea						
Ostracoda			2	3	1	1
Cladocera						
Chydoridae			1		1	
Isopoda						
Asellidae		**SH**				
Caecidotea sp.	**9.1**	**CG**	1			
Decapoda						
Cambaridae	**7.5**					
Cambarus sp.	**7.62**	**CG**				
Palaemonidae						
Palaemonetes kadiakensis	**7.1**	**CG**	1		1	
Insecta						
Collembola					1	
Ephemeroptera						
Baetidae		**CG**		2	3	
Baetis intercalaris	**7**	**CG**	1		7	
Centroptilum sp.	**6.6**	**CG**		1	1	2
Plauditus sp.	***4**	**CG**				1
Pseudocloeon sp.	**4**	**CG**		2	3	1
Caenidae		**CG**				
Brachycercus nitidus		**CG**			1	
Caenis sp.	**7.4**	**CG**	18	9		7
Ephemeridae		**CG**				
Hexagenia sp.	**4.9**	**CG**	2			1

REFERENCE STATIONS

SPECIES			Sta. R1	Sta. R2	Sta. R3	Sta. R4
Ephemerellidae		SC				
Ephemerella sp.	2.04	SC	2			
Heptageniidae						
Maccaffertium (Stenonema) sp.	*4	SC	45			66
Maccaffertium (Stenonema) exiguum	3.8	SC	1		11	2
Maccaffertium (Stenonema) integrum	5.8	SC			2	
Maccaffertium (Stenonema) modestum	5.5	SC		23	223	59
Stenacron interpunctatum	3.58	SC	1		5	48
Isonychiidae		FC				
Isonychia sp.	3.5	FC	9	3	32	2
Tricorythidae	*4	CG				
Tricorythodes sp.	5.06	CG	6		44	68
Odonata						
Aeshnidae	5.6	P				
Boyeria vinosa	5.97	P	1	2	3	2
Coenagrionidae	*9	P				
Argia sp.	8.17	P	8	5	14	13
Ischnura sp.	9.5					1
Corduliidae	*5	P				
Macromia sp.	6.16	P	2		2	1
Neurocordulia obsoleta	5.2		1		1	1
Gomphidae	*1	P	1			1
Dromogomphus spinosus	5.1	P	2	1	2	
Erpetogomphus designatus					1	
Gomphus sp.	5.8	P			2	
Hagenius brevistylus	4	P	1			
Libellulidae	6.7	P				1
Plecoptera						
Perlidae	*1	P				
Acroneuria sp.		P			1	
Neoperla sp.	1.5	P			15	3
Perlesta placida sp. gp.	4.7	P	20	4	13	
Megaloptera						
Corydalidae		P				
Corydalus cornutus	5.2	P			1	
Nigronia serricornis	5	P				1
Sialidae		P				
Sialis sp.	7.17	P	1	1	1	
Trichoptera						
Brachycentridae		SH				
Brachycentrus sp.		FC			1	
Dipseudopsidae						
Phylocentropus sp.	6.2	FC		1		
Hydropsychidae	*4	FC	18			
Cheumatopsyche sp.	6.2	FC	4	4	62	6
Hydropsyche sp.	5	FC	1		30	1
Hydroptilidae	*4	PI				
Hydroptila sp.	6.2	PI			1	1
Leptoceridae	*4	CG				1
Nectopsyche sp.	2.9	SH			3	
Nectopsyche exquisita	4.1	SH	3		1	2
Nectopsyche pavida	4.1		1			
Oecetis avara			1		3	
Lepidostomatidae		SH				
Lepidostoma sp.	0.9	FC	1			
Philopotamidae		FC				
Chimarra sp.	2.8	FC			2	

REFERENCE STATIONS

SPECIES			Sta. R1	Sta. R2	Sta. R3	Sta. R4
Polycentropodidae		FC				
Neureclipsis sp.	**4.2**	FC			7	2
Coleoptera						
Dytiscidae		P		1	1	
Elmidae		CG				
Ancyronyx variegata	**6.49**	SC	3		19	15
Dubiraphia sp.	**5.93**	SC	1		1	
Dubiraphia vittata	**4.1**	SC	2	1	8	2
Macronychus glabratus	**4.58**	SH	23	3	50	56
Stenelmis sp.	**5.1**	SC	1			1
Gyrinidae		P				
Dineutus sp.	**5.54**	P		3	33	5
Hydrophilidae				1		
Berosus sp.	**8.43**	CG	6			
Enochrus sp.	**8.8**	CG	1			
Sperchopsis tesselatus	**6.13**	CG	1	1		
Noteridae						
Hydrocanthus sp.			1			
Staphylinidae		P			2	
Diptera						
Ceratopogonidae	***5**	P	2			2
Chironomidae						
Ablabesmyia mallochi	**7.2**	P	12	9	12	14
Ablabesmyia rhamphe gp.	**7.2**	P			4	1
Corynoneura sp.	**6.01**	CG	3		1	
Cricotopus sp.	***7**	CG	3		8	10
Cricotopus bicinctus	**8.5**	CG	33	7	25	24
Dicrotendipes neomodestus	**8.1**	CG		1		
Eukiefferiella claripennis gp.	**5.6**	CG			1	
Labrundinia sp.	**5.9**	P		1		
Nanocladius sp.	**7.07**	CG		1	1	
Nilotanypus sp.	**3.9**	P			2	
Paracladopelma sp.	**5.51**	CG		3	2	2
Pentoneura inconspicia					1	2
Polypedilum fallax	**6.4**	SH			4	
Polypedilum flavum (convictum)	**4.9**	SH	6	2	12	3
Polypedilum halterale gp.	**9**	SH			1	
Polypedilum illinoense	**7.3**	SH	51	5	15	1
Potthastia longimana	**9**	CG		2		
Procladius sp.	**9.1**	P	3	5		
Pseudochironomus sp.	**5.4**	CG				3
Rheocricotopus robacki	**7.3**	CG		1	8	2
Rheotanytartsus exiguus gp.	**5.9**		9	1	14	3
Stelechomyia perpulchra	**5**	CG			1	
Stenochironomus sp.	**6.45**	SH			2	1
Synorthocladius semivirens	**4.36**	CG			10	6
Tanytarsus sp.	**6.76**	FC	39	8	19	26
Thienemanniella xena	**5.86**	CG	71	3	4	1
Tribelos jucundum	**6.3**				3	
Tvetenia vitracies	**3.6**	CG			10	5
Zavrelimyia sp.	**9.11**	P			1	1
Anopheles sp.	**8.6**	FC	1			1
Simuliidae	***6**	FC				
Simulium sp.	**6**	FC		1		
Tipulidae	***3**	SH				
Tipula sp.	**7.33**	SH			1	

REFERENCE STATIONS

SPECIES	Sta. R1	Sta. R2	Sta. R3	Sta. R4
TOTAL NO. OF ORGANIMS	432	124	795	491
TOTAL NO. OF TAXA	54	37	74	57
EPT INDEX	17	9	23	18
BIOTIC INDEX	6.02	6.47	5.51	5.32
Assigned BIOTIC INDEX VALUE	5.99	6.27	5.51	5.83
EPT ABUNDANCE	134	49	471	273

APPENDIX C: Lowell Dam Removal Year-2 Monitoring Report (The Catena Group)

The Catena Group

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LOWELL DAM REMOVAL YEAR-2 MONITORING REPORT

Little River Watershed Restoration Site
Neuse River Basin Cataloging Unit 03020201

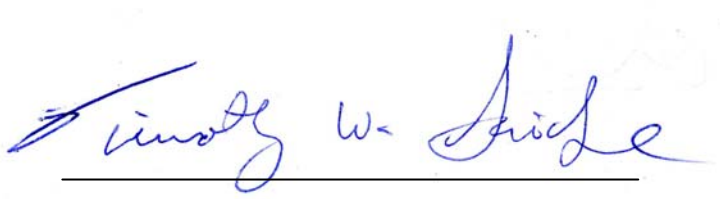
Prepared For:

Restoration Systems LLC
1101 Haynes Street, Suite 107
Raleigh, NC 27604

Prepared By:

The Catena Group
Hillsborough, North Carolina

October 15, 2007



Timothy W. Savidge

EXECUTIVE SUMMARY

The removal of Lowell Dam on the Little River by Restoration Systems, LLC (RS) is projected to result in the restoration of approximately 37,000 linear feet of river and tributaries within the Neuse River Basin. This effort is expected to restore habitat for mussels, fish (including anadromous species), and other lotic adapted aquatic species. Lowell Mill Dam was recognized as an impediment to anadromous species spawning runs and its removal was designated by the North Carolina Dam Removal Task Force (DRTF) as the highest priority for dam removal in North Carolina (DRTF 2001).

The restoration success criteria established by the DRTF and the goals of RS required documenting the diversity of aquatic fauna and characterizing habitat within the reservoir pool created by the dam, and the subsequent monitoring of changes in faunal composition and habitat following dam removal. The Catena Group Inc. (TCG) was retained by RS in 2005, to conduct the pre-dam removal aquatic species surveys for freshwater mussels and clams, aquatic snails, aquatic salamanders, and freshwater fish, the results of which are provided in the Lowell Pre-Removal Survey Report (April 04, 2006).

Following the dam removal in January 2006, a five-year monitoring plan of aquatic communities (freshwater mussels, aquatic snails, aquatic salamanders and freshwater fish communities) and anadromous species was developed. Additionally, for freshwater mussels, a specific quantitative study was designed to monitor potential adverse sedimentation effects resulting from the dam's removal.

As stated in the Year-1 monitoring report, based on the relatively slow growth rates, qualitative surveys for mollusks will not be conducted until year 3, when newly recruited individuals will be detectable. The river's transition from lentic to lotic conditions is likely to result in broad shifts in the distribution of aquatic species, including mussels, clams and snails; however, life cycles and other natural history characteristics predict some lag in the time between actual habitat conversion to large-scale dispersal and recruitment to these restored habitats. Qualitative fish community surveys will also be conducted in years 3 and 5.

The results of the 2006 Year-1 monitoring studies, which are provided in the Lowell Dam Removal Year- 1 Monitoring Report (September 11, 2006), demonstrated that migration runs of the anadromous American shad (*Alosa sapidissima*) has been restored throughout the Little River main stem, upstream to the existing Atkinson's Mill Dam, as well as within the lower portion of Buffalo Creek. Further, the fish community surveys indicated lotic adapted aquatic communities were developing in the former reservoir pool following dam removal. The quantitative freshwater mussel study suggested that release of sediment from the dam had some adverse effect on the mussel beds below the former dam; however, further monitoring was needed to determine the extent of the impacts.

The monitoring plan for 2007 (Year-2 Monitoring) called for anadromous species surveys in Buffalo Creek, Little Buffalo Creek and Long Branch, as well as continued quantitative mussel community monitoring, the results of which follow.

Anadromous Fish Surveys:
A combination of survey methodologies were employed in an effort to document spawning runs of anadromous species in Buffalo Creek, Long Branch, and Little Buffalo Creek upstream of the former Lowell Dam. These included active (electoshocking and seining) and passive (gill netting) fish capture methods and creel surveys.

Buffalo Creek
The Year-1 Monitoring surveys demonstrated that migrating American shad were moving into Buffalo Creek from the Little River at least upstream to SR 2129 (Woodruff Road). This was again confirmed during the Year-2 Monitoring surveys as an American shad was observed at the SR 2130 (Main Street) crossing of Buffalo Creek. However, American shad were not captured at any sites in the middle and upper sections of Buffalo Creek. The lack of American shad from the upper portions of Buffalo Creek is likely attributable to a combination of factors; 1) prolonged low flow and 2) low flow barriers in the creek above SR 2129 (Woodruff Road). General habitat evaluation of Buffalo Creek above SR 2129 (Woodruff Road) is needed to determine if such barriers exist that would preclude American shad from reaching Lake Wendell during low spring flows.

Long Branch
Although fish abundances and species diversity are comparatively high in Long Branch, general habitats (narrow, shallow channel) in the lower reaches of the stream are not typically utilized as spawning habitats for American shad. It is likely that during low-flow and normal flow years, American shad will not utilize Long Branch as spawning habitat, but may do so in years with high spring flows.

Little Buffalo Creek
Numerous beaver dams are located throughout Little Buffalo Creek, creating large, braided-channel, wetland complexes. Although these habitats are utilized by a number of aquatic species as well as water fowl, they are not typically utilized by American shad. This species was not observed in Little Buffalo Creek during any survey effort undertaken for this project. Given these conditions and the lack of capture, the likelihood that American shad will utilize Little Buffalo Creek during spawning migrations is low.

Creel Surveys
A total of 42 creel survey questionnaires were posted at various businesses in the Little River watershed or given to fishermen when encountered during Year-1 Monitoring and Year-2 Monitoring surveys. Although several people expressed interest in participating in the survey, to date, no questionnaires have been returned.

Quantitative Mussel Community Monitoring:

Freshwater mussels were quantitatively sampled in the Little River at varying intervals (approximately 30, 200, and 400 meters) below the Lowell dam, as well as at an upstream control site (Micro Road/SR 2130) on December 28, 2005, and January 09, 2006, just prior to dam removal. Transects were established at each location across the river. The location of each transect was marked and recorded using a GPS unit with sub-meter accuracy. Transect sampling was employed to allow analysis of near shore and mid–channel habitats.

Transects were resurveyed approximately three months after dam removal on March 9 and 10, 2006. The 3-month monitoring assessed initial mortality resulting from dam removal and detected movement of mussels within and outside the transects. Survey methodology during the 3-month monitoring followed the methods used for the pre-removal surveys, however water depths had decreased at the 30 meter and 200 meter downstream transects to a level that wading with bathyscopes replaced SCUBA as the primary sampling method used. Untagged (immigrated) mussels which were captured during the 3-month monitoring were measured, assigned a tag ("newly tagged"), and returned to their respective quadrates as before. Mortality was assessed by the number of recovered dead, tagged shells. Recapture of individual mussels two meters (e.g. two quadrates) or greater in any direction from their original quadrate was considered movement. Mussels recovered in quadrates adjacent to their original ones were not considered to have moved, since exact location of replacement within a respective quadrate was not recorded during the initial sampling.

The mussel transects were again monitored on March 13 and 14, 2007 (15 months post removal). Collection and recovery/mortality/movement determinations methodologies followed those previously described; however, SCUBA was not needed at any transect. Untagged mussels were recorded, but not tagged, as further monitoring of these sites will not be conducted.

A total of 605 freshwater mussels were tagged in the four study transects prior to dam removal. The eastern elliptio (*Elliptio complanata*) accounted for 98% (591) and six other species comprised the remaining 2% (14). Significant freshwater mussel mortality attributable to the dam removal was not evident during the 3-month quantitative mussel survey monitoring. However, mark/recapture (recovery) rates of the tagged mussels decreased dramatically with increased proximity to the former dam site; 45.2% at 30 meters, 59.4% at 200 meters, and 80.4% at 400 meters. The lower recovery rate is believed to be primarily caused by a wedge of sediment that was released when the dam was removed and gradually migrated downstream.

Recovery of the original tagged mussels remained relatively high (76.3 %) at the upstream control site, while recovery at the 400 meter site dropped significantly from 80.4 % (3-months) to 25.6% (15-months). Recovery rate of original tagged mussels continued to drop at the 30 meter transect (45.2% to 3.2%); however at the 200 meter transect there was little change in recovery rate of original tagged mussels (59.4% to

52.6%). Recovery rates of the "newly tagged" (tagged during the 3-month monitoring) mussels was lower at all three transects (20 m, 200 m, 400 m) below the former dam (16.7%, 38.2% and 21.8% respectively) than at the upstream control transect (61.8%). Observed mortality of original tagged mussels and "newly tagged" mussels was low at all transects; however a large number of fresh-dead untagged mussels were found at the three transects below the former dam (65, 137 and 97 respectively) compared to only 5 at the upstream control transect.

Significant freshwater mussel mortality attributed to dam removal was not evident during the 3-month or 15-month quantitative mussel survey monitoring. However, mark/recapture recovery rates of tagged mussels (original tagged and newly tagged) are much lower below the dam site than at the upstream control.

In addition to having the lowest recapture (recovery) rates, the 30 meter and 200 meter transects also had the highest percentage of recaptured mussels exhibiting movement (71.4% and 42.1% respectively) during the 3-month monitoring, especially when compared to the little movement of recaptured mussels in the 400 meter and upstream control transects (1.7% and 6.2% respectively). Similarly, movement of recovered "newly tagged" mussels was relatively high at these transects (50% and 30.7% respectively) during the 15-month monitoring.

Although observed mortality of tagged mussels (original and "newly tagged") was low at all transects, the number of fresh-dead untagged mussels was much higher at transects below the dam (65, 137, and 97 respectively) than at the upstream control site (5). While much of this mortality is likely attributable to bedload sediment transport associated with dam removal, it is not expected to have significant effects on the overall mussel populations in the river.

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1.0 INTRODUCTION

The removal of Lowell Dam on the Little River by Restoration Systems, LLC (RS) is projected to result in the restoration of approximately 37,000 linear feet of river and tributaries within the Neuse River Basin. This effort is expected to restore habitat for mussels, fish (including anadromous species), and other lotic adapted aquatic species. Lowell Mill Dam was recognized as an impediment to anadromous species spawning runs and its removal was designated by the North Carolina Dam Removal Task Force (DRTF) as the highest priority for dam removal in North Carolina (DRTF 2001).

The restoration success criteria established by the DRTF and the goals of RS required documenting the diversity of aquatic fauna and characterizing habitat within the reservoir pool created by the dam, and the subsequent monitoring of changes in faunal composition and habitat following dam removal. The Catena Group Inc. (TCG) was retained by RS in 2005, to conduct the pre-dam removal aquatic species surveys for freshwater mussels and clams, aquatic snails, aquatic salamanders, and freshwater fish, the results of which are provided in the Lowell Pre-Removal Survey Report (April 04, 2006).

Following the dam removal in January 2006, a five-year monitoring plan of aquatic communities (freshwater mussels, aquatic snails, aquatic salamanders and freshwater fish communities) and anadromous species was developed. For freshwater mussels, a specific quantitative study was designed to monitor potential adverse sedimentation effects resulting from the dam's removal.

As stated in the Year-1 monitoring report, based on the relatively slow growth rates, qualitative surveys for mollusks will not be conducted until year 3, when newly recruited individuals will be detectable. The river's transition from lentic to lotic conditions is likely to result in broad shifts in the distribution of aquatic species, including mussels, clams and snails; however, life cycles and other natural history characteristics predict some lag in the time between actual habitat conversion to large-scale dispersal and recruitment to these restored habitats. Qualitative fish community surveys will also be conducted in years 3 and 5.

The results of the 2006 Year-1 monitoring studies, which are provided in the Lowell Dam Removal Year- 1 Monitoring Report (September 11, 2006), demonstrated that migration runs of the anadromous American shad (*Alosa sapidissima*) has been restored throughout the Little River main stem, upstream to the existing Atkinson's Mill Dam, as well as within the lower portion of Buffalo Creek. Further, the fish community surveys indicated lotic adapted aquatic communities were developing in the former reservoir pool following dam removal. The quantitative freshwater mussel study suggested that release of sediment from the dam had some adverse effect on the mussel beds below the former dam; however, further monitoring was needed to determine the extent of the impacts.

The monitoring plan for 2007 (Year-2 Monitoring) called for anadromous species surveys in Buffalo Creek, Little Buffalo Creek and Long Branch, as well as continued quantitative mussel community monitoring, the results of which follow.

2.0 ANADROMOUS SPECIES SURVEY EFFORTS

Based on habitat conditions, watershed size, biology, distribution, and data from the pre-dam removal surveys, it was reasonable to predict that American shad and hickory shad (*Alosa mediocris*) would be the most likely of all anadromous species to benefit from removal of the dam. Since the anadromous fish passage component of the success criteria had already been demonstrated in the Little River and lower portion of Buffalo Creek, the 2007 sampling focused primarily on Buffalo Creek (upstream of Woodruff Road-SR 2129), Long Branch, and Little Buffalo Creek. The surveys were conducted by the following personnel from TCG on the listed dates:

Tom Dickinson –March 22, 30; April 12
Josh Jones- May 18
John Lancaster- April 12, 26
Jennifer Logan- March 22; May 3
Fred C. Rhode Ph.D * - March 22, 30; April 12, 26
Bryant Savidge - March 22, March 30, April 18
Tim Savidge - March 30; April 18, 27; May 3, 18
Chris Sheats – April 18, 26; May 3, May 11
*** Contracted by TCG to assist field crew**

Additionally, Joseph Hightower, PhD, Assistant Unit Leader (Fisheries Unit) with the North Carolina State University Zoology Department and Joshua Raabe (Graduate Student) set up a resistance board fish weir at the former dam site to quantify fish passage at the old dam site. The weir was operational from mid-March to late May 2007. The fish weir is designed to capture migrating fish that pass through the weir from either upstream or downstream locations. Captured fish were marked and released, to allow for identification of re-captured individuals, which aided in determining peak upstream migration and downstream emigration within the restored river. Progress updates, provided by Joshua Raabe, were utilized by TCG in scheduling the anadromous species surveys.

2.1 Survey Methodologies

A combination of survey methodologies were employed in an effort to document spawning runs of anadromous species in Buffalo Creek, Long Branch, and Little Buffalo Creek upstream of the former Lowell Dam.

2.1.1 Fish Capture

A number of active and passive fish collection methods were used during this effort, often in conjunction with one another.

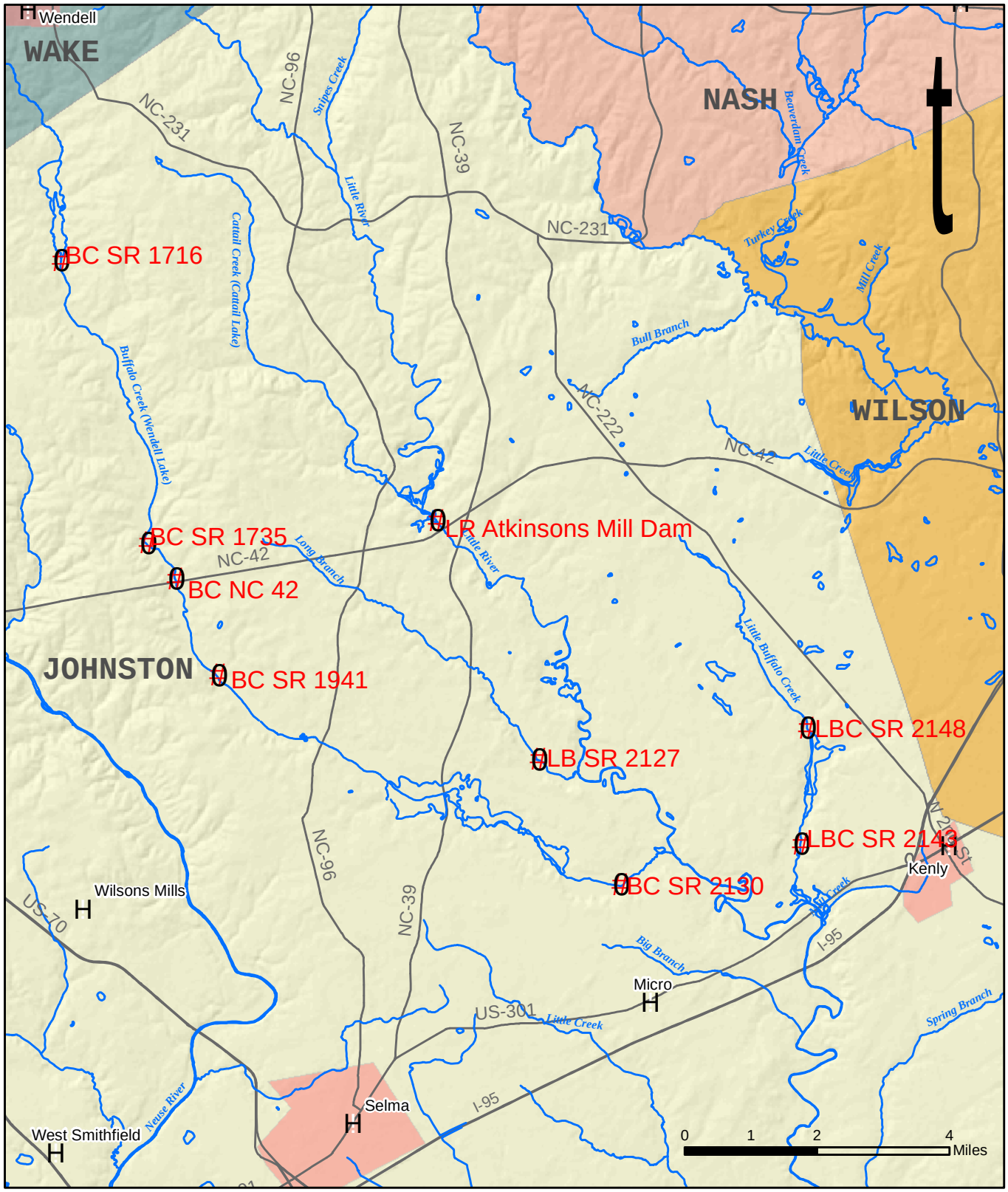
Passive/ Active Capture (Gill netting)
Gill netting was used as both a passive and active capture technique during anadromous fish sampling. During likely peak spawning periods, a gill net was set (tied across an appropriate section of river) at the beginning of a sampling day and checked at the end of the day, or allowed to soak over night. At times this was used in conjunction with electro-fishing (herding fish into the gill net). The active capture technique consisted of two people slowly dragging a gill net through a pool or slow run areas (gill net sweep).

Active Capture (Electro-fishing/Seine) Methods
Active capture typically employed a combination of electro-fishing and seine netting. The survey team began at the downstream point of the survey site and proceeded upstream. Two back-pack electroshocking units were used in most reaches. One person with a dip net accompanied each shocker and a straight haul seine net was positioned downstream of the shockers where appropriate. The two shockers often worked in concert to herd fish towards the seine net, or gill net, a technique termed "block-shocking", in the middle of the channel and close to each bank, in order to survey all habitats (riffle/run, pool). This method was effective in riffle and run habitats of shallow to moderate depths, but was fairly ineffective in deep runs and wide deep pools.

All captured fish were placed in a water bucket until they could be identified and counted. The length of time required to identify, count, and release the fish depended on the number of fish in the bucket and their condition. Any fish that did not recover from electroshocking were preserved in 95% ethanol. Habitat notes were recorded and a relative abundance assigned to each species captured or observed. Relative abundance was estimated upon 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

Habitat types, substrate composition, and water levels were all considered in deciding which sections of river would be best to sample and which survey methods would be most effective. Potential fish barriers upstream of the impoundment area (Wendell Lake on Buffalo Creek) were also targeted as sampling areas. General site location, survey dates, and GPS location of the midpoint of the survey sites are included in Table 1 and the locations graphically depicted in Figure 1.



The Catena Group

Survey Location Map
Lowell Dam Removal Project
Year- 2 Monitoring
AnadromousSpecies Surveys
Johnston County, North Carolina

Date: October 2007
Scale: As Shown
Job No.: 3199

Figure 1

Table 1. Anadromous Survey Locations Year-2 Monitoring

Site #/Location*	Survey Dates 2007	GPS Location
LR Atkinsons Mill Dam	5/18	35.66832ºN, -78.26021ºW
LB SR 2127	3/30, 4/18	35.61582°N, -78.23340°W
BC SR 2130 (Main Street)	3/22	35.58831°N, -78.21168°W
BC SR 1941	3/22, 3/30, 5/2	35.63482°N, -78.31921°W
BC NC 42	3/22	35.65592°N, -78.33041°W
BC SR 1735 (Jordan Road)	3/22	35.66382°N, -78.33789°W
BC SR 1716 (Lake Wendell Road)	3/22, 3/30, 4/18, 5/18	35.72581°N, 78.36069°W
LBC SR 2143 (Old Route 22)	4/26	35.59691ºN, -78.16331ºW
LBC SR 2148 (Beulahtown Road)	3/30	35.62232ºN, -78.16138ºW

*LR,LB,BC and LBC denote Little River, Long Branch, Buffalo Creek and Little Buffalo Creek respectively

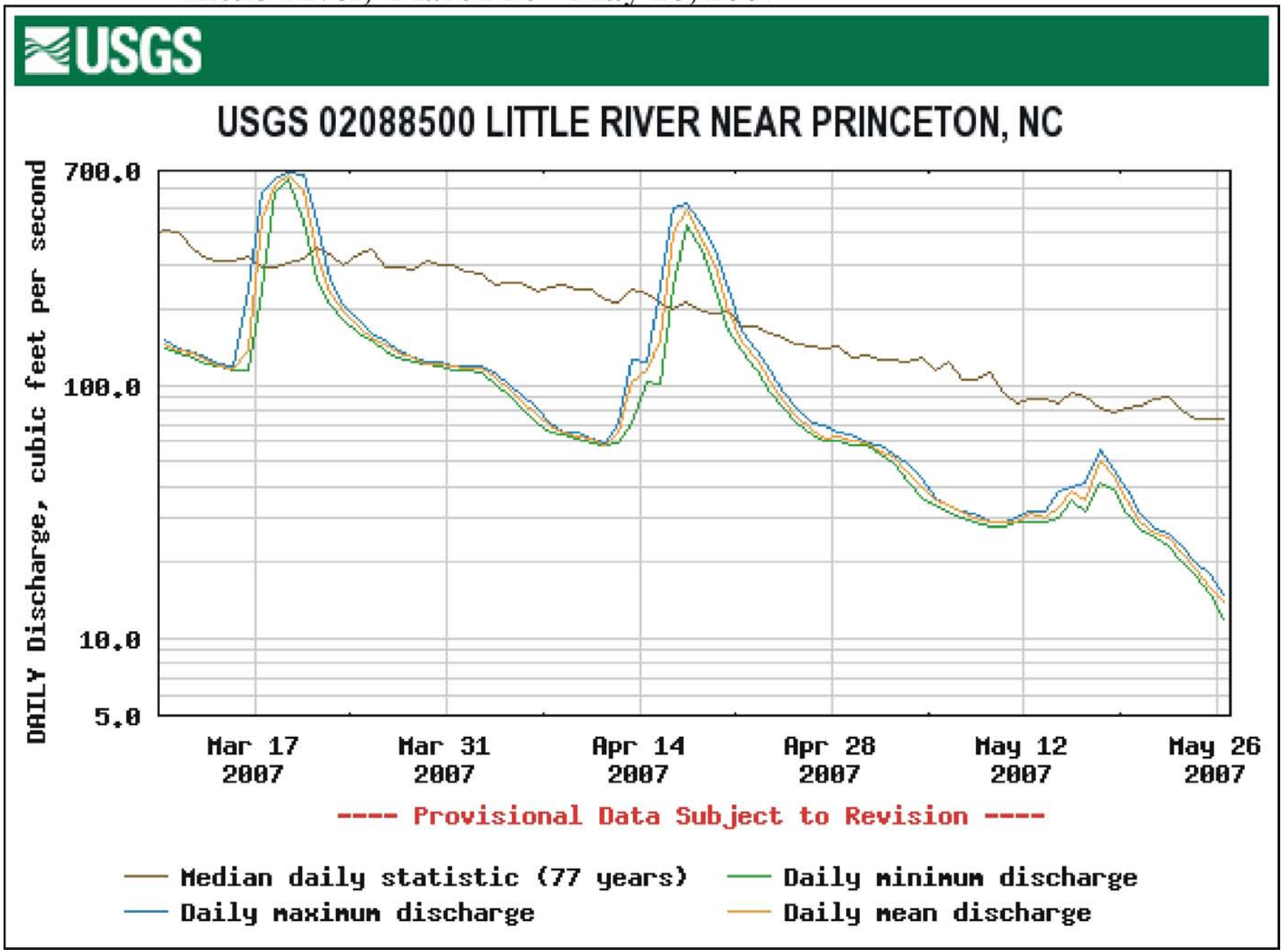
2.1.2 Creel Surveys

Valuable information of specific fisheries can be gathered through interviews with anglers (creel surveys). A questionnaire was developed and posted at various businesses (country stores/bait shops, restaurants, gas stations) within the Little River watershed during the Year-1 Monitoring surveys and again during the Year-2 Monitoring Surveys. Anyone interested in participating in the survey was asked to fill out the questionnaire and mail it to the TCG office in Raleigh. The participants had the option of being identified in the survey reports for this project. A self addressed stamped envelope was attached to the questionnaires. Efforts were also made to interview local fisherman in the watershed while conducting the fish surveys. Fisherman were asked questions pertaining to their fishing activities (catch and methods) and prior fishing experience in the Little River, particularly with regards to the targeted anadromous species (shad, herring etc.).

3.0 ANADROMOUS SPECIES SURVEY RESULTS

Survey efforts began once the fish weir study determined that American shad had migrated upstream of the former Lowell Dam. Surveys were to be conducted on a bi-weekly basis and increased to weekly during the expected “peak” spawning period. However, daily mean discharge in the Little River was well below the 76-year daily mean for the majority of the fish sampling efforts, only exceeding the mean flow for short periods of time (March 18-24 and April 15-21) following moderate rain events (Figure 2). As a result, the surveys were undertaken mainly only after these rain events.

Figure 2. Lowell Dam Removal Anadromous Species Surveys: Flow Data for Little River, March 10 - May 26, 2007



3.1 Anadromous Fish Sampling Efforts

The results of the anadromous fish sampling efforts are presented by date and the corresponding survey locations:

3.1.1 March 22

Site 1: Buffalo Creek - Tail Race of Lake Wendell Dam:

Approximately 150 meter (492 feet) of Buffalo Creek below the Lake Wendell Dam near Lake Wendell Road was surveyed. Electro-fishing was conducted for 1,462 seconds of electro-shocking time. A gill net sweep was also conducted at the base of the dam.

Table 2. March 22 Site 1: Buffalo Creek - Tail Race of Lake Wendell Dam: Species Found

Scientific Name	Common Name	Relative Abundance
Anguilla rostrata	American eel	Uncommon
Erimyzon oblongus	creek chubsucker	Uncommon
Lepomis auritus	redbreast sunfish	Uncommon
Lepomis macrochirus	Bluegill	Abundant
Lepomis microlophus	redear sunfish	Uncommon
Notemigonus crysoleucas	golden shiner	Uncommon
Micropterus salmoides	largemouth bass	Uncommon

Site 2: Buffalo Creek - (SR 1735-Jordan Road):

An approximate 250 meter (820 foot) stretch of Buffalo Creek, beginning at the bridge crossing and proceeding upstream, was sampled using electro-fishing for 1,381 seconds of electro-shocking time.

Table 3. March 22 Site 2 Buffalo Creek at SR 1735: Species Found

Scientific Name	Common Name	Relative Abundance
Anguilla rostrata	American eel	Uncommon
Centrachus macropterus	Flier	Common
Esox americanus	redfin pickerel	Uncommon
Etheostoma olmstedi	tessellated darter	Common
Etheostoma nigrum	Johnny darter	Common
Lepomis auritus	redbreast sunfish	Common
Lepomis macrochirus	Bluegill	Common
Noturus insignis	Margined madtom	Rare
Notropis cummingsae	dusky shiner	Common

Site 3: Buffalo Creek - Above NC 42:

Buffalo Creek was sampled in an approximately 200 meter (656 feet) reach above the NC 42 crossing using electro-fishing for 449 seconds of electro-shocking time. Fish were generally uncommon.

Table 4. March 22 Site 3: Buffalo Creek - Above NC 42: Species Found

Scientific Name	Common Name	Relative Abundance
Ameiurus sp.	bullhead	Rare
Anguilla rostrata	American eel	Rare
Esox americanus	redfin pickerel	Common
Etheostoma olmstedi	tessellated darter	Uncommon
Lepomis auritus	redbreast sunfish	Common

Site 4: Buffalo Creek - Above SR 1941:

An approximate 250 meter (820 foot) stretch of Buffalo Creek, beginning at the bridge crossing and proceeding upstream, was sampled using electro-fishing for 1,149 seconds of electro-shocking time.

Table 5. March 22 Site 4: Buffalo Creek - Above SR 1941: Species Found

Scientific Name	Common Name	Relative Abundance
Ameiurus platycephalus	flat bullhead	Rare
Anguilla rostrata	American eel	Uncommon
Aphredoderus sayanus	pirate perch	Rare
Erimyzon oblongus	creek chubsucker	Rare
Esox americanus	redfin pickerel	Common
Etheostoma olmstedi	tessellated darter	Common
Lepomis auritus	redbreast sunfish	Abundant
Lythrurus matutinus	pinewoods shiner	Common
Micropterus salmoides	largemouth bass	Rare
Notropis procne	swallowtail shiner	Rare
Percina roanoka	Roanoke darter	Rare

Site 5: Buffalo Creek - Above SR 2130 (Main Street):

An approximate 200 meter (656 foot) stretch of lower Buffalo Creek, beginning at the bridge crossing and proceeding upstream, was sampled using electro-fishing for 876 seconds of electro-shocking time. American shad were documented from the lower portions of Buffalo Creek during the Year-1 Monitoring, thus this site was chosen with the objective of determining if American shad had moved into Buffalo Creek during the 2007 spawning migration. One American shad was observed.

Table 6. March 22 Site 5: Buffalo Creek above SR 2130: Species Found

Scientific Name	Common Name	Relative Abundance
Alosa sapidissima	American shad	Rare (1)
Anguilla rostrata	American eel	Uncommon
Aphredoderus sayanus	pirate perch	Rare
Erimyzon oblongus	creek chubsucker	Rare
Esox americanus	redfin pickerel	Common
Etheostoma olmstedi	tessellated darter	Common
Lepomis auritus	redbreast sunfish	Common
Lepomis macrochirus	bluegill	Uncommon
Lythrurus matutinus	pinewoods shiner	Common
Micropterus salmoides	largemouth bass	Rare
Moxostoma collapsum	notchlip redhorse	Rare
Notropis procne	swallowtail shiner	Common
Percina nevisense	chainback darter	Rare

3.1.2 March 30

Site 1: Buffalo Creek - Tail Race of Lake Wendell Dam:

A total of four gill net sweeps were conducted at the base of the dam. Several gizzard shad (*Dorosoma cepedianum*) and one longnose gar (*Lepiosteus osseus*) were captured. Additionally, a single swamp darter (*Etheostoma fusiforme*) was found in a discarded drink bottle in the stream. This species was not observed at any location previously during the pre-removal surveys, or Year-1 Monitoring surveys.

Table 7. March 30 Site 1: Buffalo Creek - Tailrace of Lake Wendell Dam: Species Found

Scientific Name	Common Name	Relative Abundance
Dorosoma cepedianum	gizzard shad	Common
Etheostoma fusiforme	swamp darter	Rare
Lepisosteus osseus	longnose gar	Rare

Site 2: Buffalo Creek - Above SR 1941:

The same section of Buffalo Creek that was sampled on March 22 (Site 4) was re-sampled. Using electro-fishing, sampling began at the bridge crossing and preceded upstream and then downstream into a gill net stretched across the channel. The survey was conducted for a total of 1,367 seconds of electro-shocking time. Additionally, one seine net sweep of a deep pool just upstream of the bridge was conducted.

Table 8. March 30 Site 2: Buffalo Creek – Above SR 1941: Species Found

Scientific Name	Common Name	Relative Abundance
Anguilla rostrata	American eel	Uncommon
Aphredoderus sayanus	pirate perch	Rare

Scientific Name	Common Name	Relative Abundance
Esox americanus	redfin pickerel	Rare
Etheostoma olmstedi	tessellated darter	Uncommon
Gambusia hollbrooki	Eastern mosquitofish	Common
Lepisosteus osseus	longnose gar	Rare
Lepomis auritus	redbreast sunfish	Abundant
Lepomis macrochirus	bluegill	Uncommon
Lythrurus matutinus	pinewoods shiner	Rare
Umbrea pygmaea	Eastern mudminnow	Rare

Site 3: Long Branch - SR 2127 (Shoeheel Road):

Active sampling was conducted in Long Branch in an approximately 200 meter (660 feet) reach in the vicinity of Shoeheel Road using electro-fishing and block-shocking for 866 seconds of electro-shocking time.

Table 9. March 30 Site 3: Long Branch at SR 2127: Species Found

Scientific Name	Common Name	Relative Abundance
Aphredoderus sayanus	pirate perch	Uncommon
Centrarchus macropterus	Flier	Rare
Enneacanthus gloriosus	bluespotted sunfish	Common
Erimyzon oblongus	creek chubsucker	Common
Esox americanus	redfin pickerel	Common
Etheostomafusiforme	swamp darter	Rare
Etheostoma nigrum	Johnny darter	Common
Etheostoma olmstedi	tessellated darter	Common
Gambusia holbrookii	Eastern mosquitofish	Abundant
Lepomis auritus	redbreast sunfish	Common
Lepomis macrochirus	bluegill	Abundant
Luxilus albeolus	white shiner	Common
Micropterus salmoides	largemouth bass	Rare
Notropis procne	swallowtail shiner	Abundant

Site 4: Little Buffalo Creek - SR 2148 (Beulahtown Road):

The braided channel swamp upstream of the Beulahtown Road crossing of Little Buffalo Creek was surveyed for approximately 200 meters (656 feet) to the base of a large beaver (*Castor canadensis*) dam complex upstream. Electro-fishing sampling was conducted for 678 seconds of electro-shocking time. Twelve fish species, including a single sawcheek darter (*Etheostoma serrifer*) were captured. This species was not observed at any location previously during the pre-removal surveys, or Year-1 Monitoring surveys for this project.

Table 10. March 30 Site 4: Little Buffalo Creek above SR 2148: Species Found

Scientific Name	Common Name	Relative Abundance
Anguilla rostrata	American eel	Rare
Centrarchus macropterus	flier	Uncommon
Enneacanthus gloriosus	bluespotted sunfish	Common
Erimyzon oblongus	creek chubsucker	Common
Esox americanus	redfin pickerel	Common
Esox niger	chain pickerel	Rare
Etheostoma serrifer	sawcheek darter	Rare
Gambusia holbrooki	Eastern mosquitofish	Abundant
Lepomis auritus	redbreast sunfish	Common
Lepomis gulosus	warmouth	Uncommon
Lepomis macrochirus	bluegill	Common
Notemigonus crysoleucas	golden shiner	Abundant

3.1.3 April 18

Site 1: Buffalo Creek - Tail Race of Lake Wendell Dam:

A total of three gill net sweeps were conducted at the base of the dam. A total of 24 gizzard shad were captured along with three bluegill (*Lepomis macrochirus*) and two black crappie (*Pomoxis nigromaculatus*).

Table 11. April 18 Site 1: Buffalo Creek - Tail Race of Lake Wendell Dam: Species Found

Scientific Name	Common Name	Relative Abundance
Dorosoma cepedianum	gizzard shad	Abundant
Lepomis macrochirus	bluegill	Uncommon
Pomoxis nigromaculatus	black crappie	Rare

Site 2: Long Branch - SR 2127 (Shoeheel Road):

The same reach of Long Branch that was sampled on March 30 (Site 3) was re-sampled, with most efforts focused on two relatively deep pools upstream of the bridge for a total of 968 seconds of electro-shocking time.

Table 12. April 18 Site 2: Long Branch - Shoeheel Road: Species Found

Scientific Name	Common Name	Relative Abundance
Aphredoderus sayanus	pirate perch	Abundant
Centrarchus macropterus	Flier	Rare
Enneacanthus gloriosus	bluespotted sunfish	Common
Erimyzon oblongus	creek chubsucker	Common
Esox americanus	redfin pickerel	Uncommon
Etheostoma nigrum	Johnny darter	Uncommon
Etheostoma olmstedi	tessellated darter	Uncommon
Gambusia holbrookii	Eastern mosquitofish	Abundant

Scientific Name	Common Name	Relative Abundance
Lepomis auritus	redbreast sunfish	Abundant
Luxilus albeolus	white shiner	Common
Nocomis raneyi	bull chub	Rare
Notropis procne	swallowtail shiner	Uncommon

Site 3: Buffalo Creek - SR 1701 (Wendell Road):

A gill net was set across the channel just below the bridge and allowed to soak for 1.5 hours. Additionally, dip net sweeps were conducted along the banks. One largemouth bass was captured in the gill net. All other species were captured by dip netting.

Table 13. April 18 Site 3: Buffalo Creek - SR 1701: Species Found

Scientific Name	Common Name	Relative Abundance
Aphredoderus sayanus	pirate perch	Abundant
Enneacanthus gloriosus	bluespotted sunfish	Rare
Etheostoma serrifer	sawcheek darter	Rare
Gambusia holbrooki	Eastern mosquitofish	Abundant
Lepomis macrochirus	bluegill	Common
Micropterus salmoides	largemouth bass	Rare

3.1.4 April 26

Site 1: Buffalo Creek - Tail Race of Lake Wendell Dam:

A total of three gill net sweeps were conducted at the base of the dam. Three gizzard shad were captured on the first sweep and no fish were captured on the subsequent two sweeps. All other species were captured during 880 seconds of electro-shocking below the dam.

Table 14. April 26 Site 1: Buffalo Creek - Tail Race of Lake Wendell Dam: Species Found

Scientific Name	Common Name	Relative Abundance
Amia calva	Bowfin	Rare
Anguilla rostrata	American eel	Common
Aphredoderus sayanus	pirate perch	Rare
Dorosoma cepedianum	gizzard shad	Uncommon
Erimyzon oblongus	creek chubsucker	Common
Esox americanus	redfin pickerel	Uncommon
Etheostoma fusiforme	swamp darter	Uncommon
Etheostoma olmstedi	tessellated darter	Rare
Gambusia hollbrooki	Eastern mosquitofish	Common
Lepomis auritus	redbreast sunfish	Common
Lepomis gibbosus	pumpkinseed	Rare
Lepomis gulosus	warmouth	Uncommon
Lepomis macrochirus	bluegill	Abundant

Scientific Name	Common Name	Relative Abundance
Notemigonus crysoleucas	golden shiner	Abundant
Pomoxis nigromaculatus	black crappie	Rare

Site 2: Buffalo Creek - at SR 1701 (Wendell Road):

A gill net was set across the channel just below the bridge and allowed to soak for 4.5 hours. One largemouth bass and one gizzard shad were captured.

Table 15. April 26 Site 2: Buffalo Creek - at SR 1701 : Species Found

Scientific Name	Common Name	Relative Abundance
Dorosoma cepedianum	gizzard shad	Rare
Micropterus salmoides	largemouth bass	Rare

Site 3: Buffalo Creek- SR 1735 (Jordan Road):

The section of Buffalo Creek that was sampled on March 22 (Site 2) was re-sampled for 897 seconds of electro-shocking time.

Table 16. April 26 Site 3: Buffalo Creek – Above SR 1735: Species Found

Scientific Name	Common Name	Relative Abundance
Anguilla rostrata	American eel	Uncommon
Aphredoderus sayanus	pirate perch	Common
Enneacanthus gloriosus	bluespotted sunfish	Rare
Esox americanus	redfin pickerel	Common
Etheostoma fusiforme	swamp darter	Rare
Etheostoma olmstedi	tessellated darter	Common
Etheostoma nigrum	Johnny darter	Common
Lepomis auritus	redbreast sunfish	Uncommon
Notemigonus crysoleucas	golden shiner	Rare
Notropis procne	swallowtail shiner	Rare

Site 4: Little Buffalo Creek – Above SR 2143 (Old Route 22):

Little Buffalo Creek was surveyed for approximately 200 meters (656 feet) upstream of the bridge. Electro-fishing sampling was conducted for 1,089 seconds of electro-shocking time. Nine species, including two mud sunfish (*Acantharchus pomotis*) were captured. This species was not observed at any location previously during the pre-removal surveys, or Year-1 Monitoring surveys.

Table 17. April 26 Site 4: Little Buffalo Creek – Above SR 2143: Species Found

Scientific Name	Common Name	Relative Abundance
Acantharchus pomotis	mud sunfish	Rare
Aphredoderus sayanus	pirate perch	Common
Enneacanthus gloriosus	Bluespotted sunfish	Common

Scientific Name	Common Name	Relative Abundance
Erimyzon oblongus	creek chubsucker	Uncommon
Esox americanus	redfin pickerel	Uncommon
Etheostoma olmstedi	tessellated darter	Uncommon
Lepomis auritus	redbreast sunfish	Abundant
Lepomis macrochirus	bluegill	Uncommon
Notropis procne	swallowtail shiner	Common

Site 5: Buffalo Creek – Above SR 1941:

The same section of stream that was sampled on March 22 (Site 4) and March 30 (Site 2) was re-sampled using electro-fishing for 1,367 seconds of electro-shocking time.

Table 18. March 30 Site 2: Buffalo Creek – Above SR 1941: Species Found

Scientific Name	Common Name	Relative Abundance
Ameiurus platycephalus	flat bullhead	Rare
Anguilla rostrata	American eel	Common
Aphredoderus sayanus	pirate perch	Common
Esox americanus	redfin pickerel	Uncommon
Etheostoma olmstedi	tessellated darter	Common
Lepomis auritus	redbreast sunfish	Abundant
Luxilus albeolus	white shiner	Rare
Notropis procne	swallowtail shiner	Rare
Noturus insignis	margined madtom	Rare
Umbrea pygmaea	Eastern mudminnow	Rare

3.1.5 April 27

Site 1: Buffalo Creek - SR 1701 (Wendell Road):

A gill net was set on the evening of April 26 and allowed to soak overnight for 13.5 hours. No fish were captured.

3.1.6 May 2

Site 1: Buffalo Creek - below SR 1941:

A gill net was set just below the bridge on the evening of May 1 and allowed to soak overnight for 13.5 hours. No fish were captured.

3.1.7 May 18

Site 1: Buffalo Creek - Tail Race of Lake Wendell Dam:

A total of three gill net sweeps were conducted at the base of the dam. Eleven gizzard shad, two black crappie, and one bluegill were captured.

Table 19. May 18 Site 1: Buffalo Creek - Tail Race of Lake Wendell Dam: Species Found

Scientific Name	Common Name	Relative Abundance
Dorosoma cepedianum	gizzard shad	Common
Lepomis macrochirus	bluegill	Rare
Pomoxis nigromaculatus	black crappie	Rare

Site 2: Little River - Tailrace of Atkinson Mill Dam):

The tailrace of Atkinson Mill Dam was sampled to determine if the gill net sweep was an effective method for capturing American shad, since the species was known to be congregating below the dam. One gill net sweep was conducted and four American shad along with seven gizzard shad and one flat bullhead were captured. The flat bullhead appeared to be diseased and close to death.

Table 20. March 24 Site 2: Little River - Tailrace of Atkinson Mill Dam: Species Found

Scientific Name	Common Name	Relative Abundance
Alosa sapidissima	American shad	Uncommon (4)
Ameiurus platycephalus	flat bullhead	Rare
Dorosoma cepedianum	gizzard shad	Common

3.2 Results Creel Surveys

A total of 42 creel survey questionnaires were posted at various businesses in the Little River watershed or given to fishermen when encountered during Year-1 Monitoring and Year-2 Monitoring surveys. Although several people expressed interest in participating in the survey, to date, no questionnaires have been returned.

4.0 ANADROMOUS SPECIES SURVEY DISCUSSION/CONCLUSONS

Despite extreme low flow conditions throughout the Little River watershed during much of the spring of 2007, 496 American shad were still captured during the fish weir study (Joshua Raabe, personal communication). Fish migration activity was relatively slow throughout the study period with most activity coinciding with rains and subsequent increases in daily discharge rates.

4.1 Buffalo Creek

Survey efforts in Buffalo Creek began on March 22, 2007, after reports of American shad being captured in the fish weir. While the surveys primarily focused on the tailrace of Lake Wendell dam, which is the next known barrier to fish migration in Buffalo Creek, other sites downstream of Lake Wendell were also sampled in the event that there are unknown barriers that would limit migrating fish from reaching Lake Wendell.

The Year-1 Monitoring surveys demonstrated that migrating American shad were moving into Buffalo Creek from the Little River at least upstream to SR 2129 (Woodruff Road). This was again confirmed during the Year-2 Monitoring surveys as an American shad was observed at the SR 2130 (Main Street) crossing of Buffalo Creek (Table 6). However, American shad were not captured at any sites in the middle and upper sections of Buffalo Creek. To ensure that the lack of American shad captures was not a result of ineffective survey methodologies, the Little River was sampled at the tailrace of Atkinsons Mill using the same methodologies as those employed in Buffalo Creek. Since four American shad were captured with relative ease in one gill net sweep at the base of the dam (Table 19), it was determined that the techniques were sound and additional effort was not needed at the Tail Race of Atkinsons Mill Dam.

The lack of American shad from the upper portions of Buffalo Creek is likely attributable to a combination of factors; 1) prolonged low flow and 2) low flow barriers in the creek above SR 2129 (Woodruff Road). The fish weir study indicated that migration of American shad was sparse during low flow periods, and appeared to coincide with increased flow events (Joshua Raabe, personal communication). Since the channel in the lower sections of Buffalo Creek is fairly narrow (10-20 feet wide), beaver (*Castor canadensis*) dams or log jams may pose a functional barrier to fish migration during periods of low flow. Although two relatively significant rain events did occur during the Year-2 Monitoring period which resulted in substantially increased flow rates in the Little River (Figure 2), it cannot be assumed that flows in Buffalo Creek responded as dramatically. Much of the upper portions of Buffalo Creek are associated with large adjacent wetland systems. Given the low water levels in the basin prior to the two significant rain events, it is possible that these wetland systems slowed the rate at which rainfall runoff reached the channel, thus buffering substantial rises in discharge values. Unfortunately there are no gauge stations on Buffalo Creek to confirm this. However, survey efforts were mainly conducted following rain events and subsequent rises in discharge rate in the Little River, yet water levels in Buffalo Creek appeared to remain consistently very low at the surveyed sites. General habitat evaluation of Buffalo Creek above SR 2129 (Woodruff Road) is needed to determine if any such barriers exist that would preclude American shad from reaching Lake Wendell during low spring flows.

4.2 Long Branch

Although fish abundances and species diversity are comparatively high in Long Branch, general habitats (narrow, shallow channel) in the lower reaches of the stream are not

typically utilized as spawning habitats for American shad. It is likely that during low-flow and normal flow years, American shad will not utilize Long Branch as spawning habitat, but may do so in years with high spring flows.

4.3 Little Buffalo Creek

Numerous beaver dams are located throughout Little Buffalo Creek, creating large, braided-channel, wetland complexes. Although these habitats are utilized by a number of aquatic species as well as water fowl, they are not typically utilized by American shad. This species was not observed in Little Buffalo Creek during any survey effort undertaken for this project. Given these conditions and the lack of capture, the likelihood that American shad will utilize Little Buffalo Creek during spawning migrations is low.

4.4 Summary

As discussed in the Year-1 Monitoring Report, the surveys targeting anadromous species demonstrated how seasonality affects species composition and apparent relative abundances at a particular site. The Year-2 Monitoring further demonstrates this relationship. A total of 42 fish species were captured during the pre-removal surveys conducted during the summer of 2005, and an additional 11 species collected during the Year-1 Monitoring. Four more fish species: mud sunfish, pumpkinseed, sawcheek darter and swamp darter, were captured for the first time during the Year-2 Monitoring surveys, bringing the total number of fish species collected in the study area to 57.

5.0 QUANTITATIVE MUSSEL SURVEY EFFORTS

5.1 Quantitative Mussel Surveys Methodology

Freshwater mussels were quantitatively sampled in the Little River at varying intervals (approximately 30, 200 and 400 meters) below the Lowell dam, as well as at an upstream control site (Micro Road/SR 2130) on December 28, 2005, and January 09, 2006, just prior to dam removal. Transects were established at each location across the river. The river width is approximately 16 meters (52 feet) at the 400 meter transect, 18 meters (59 feet) at the 200 meter transect, 20 meters (65 feet) at the 30 meter transect and 10 meters (33 feet) at the upstream control site. Each transect was divided into 16, 18, 20, and 10 (depending on the exact width of each transect) 1-m^2 quadrates respectively. The location of each transect was marked by driving rebar stakes into both banks (to serve as a semi-permanent marker) and recorded using a GPS unit with sub-meter accuracy. Transect sampling was employed to allow analysis of near shore and mid–channel habitats.

Quadrates were surveyed using SCUBA at the three transects below the dam and wading with bathyscopes (glass-bottom view buckets) at the upstream control site. One out of every six quadrates in each transect was randomly selected (roll of dice) to serve as controls for handling effects in winter months and were not sampled. Each mussel found in each quadrate was identified, measured (total length), and tagged before being returned

to their respective quadrates. The tags (Hallprint Tags) are made of polyethylene, oval in shape, and approximately 9 mm long by 4 mm wide. Each tag is colored and has a unique 4-character code, which begins with a letter followed by 3 numbers. The tags were applied to both valves of the mussels using Instant Krazy Glue©, or another quick dry epoxy. A portable 1-m^2 quadrate constructed from 5-cm schedule 40 polyvinyl chloride (PVC) positioned along a rope stretched across the river was used to delineate each quadrate sampled.

Transects were resurveyed approximately three months after dam removal on March 9 and 10, 2006. The 3-month monitoring assessed initial mortality resulting from dam removal and detected movement of mussels within and outside the transects. Survey methodology during the 3-month monitoring followed the methods used for the pre-removal surveys, however water depths had decreased at the 30 meter and 200 meter downstream transects to a level that wading with bathyscopes replaced SCUBA as the primary sampling method used. Every quadrate (including the random controls) was sampled during the 3-month monitoring. The river was also sampled for a distance of 10 meters (33 feet) upstream and downstream of the transect locations to detect movement of mussels. Recaptured (recovered) tagged mussels were recorded and returned to their respective quadrates. Untagged (immigrated) mussels which were captured during the 3-month monitoring were measured, assigned a tag ("newly tagged"), and returned to their respective quadrates as before. Mortality was assessed by the number of recovered dead, tagged shells. Recapture of individual mussels two meters (e.g. two quadrates) or greater in any direction from their original quadrate was considered movement. Mussels recovered in quadrates adjacent to their original ones were not considered to have moved, since exact location of replacement within a respective quadrate was not recorded during the initial sampling.

The mussel transects were again monitored on March 13 and 14, 2007 (15 months post removal). Collection and recovery/mortality/movement determinations methodologies followed those previously described; however, SCUBA was not needed at any transect. Untagged mussels were recorded, but not tagged, as further monitoring of these sites will not be conducted.

6.0 QUANTITATIVE MUSSEL SURVEY RESULTS

A total of 605 freshwater mussels were tagged in the four study transects prior to dam removal. The eastern elliptio (*Elliptio complanata*) accounted for 98% (591) and six other species comprised the remaining 2% (14). Significant freshwater mussel mortality attributable to the dam removal was not evident during the 3-month quantitative mussel survey monitoring. However, mark/recapture (recovery) rates of the tagged mussels decreased dramatically with increased proximity to the former dam site; 45.2% at 30 meters, 59.4% at 200 meters, and 80.4% at 400 meters. The lower recovery rate is believed to be primarily caused by a wedge of sediment that was released when the dam was removed and gradually migrated downstream. At the 3-month monitoring, the wedge had reached the 30 meter and 200 meter transects, covering the substrate with

anywhere from 1-5 centimeters of sediment. However, the wedge had not progressed to the 400 meter transect, and recovery rates (80.4 %) similar to those at the upstream control site (84.2%). The sediment wedge did move past the 400 meter transect shortly after the 3-month monitoring (personal observations), though no additional surveys were conducted at that time. These data were displayed in Table 43 of the Year-1 Monitoring Report. Table 21 and 22 below compare recovery and survival rates of the 3-month and 15-month surveys.

Recovery of the original tagged mussels remained relatively high (76.3 %) at the upstream control site, while recovery at the 400 meter site dropped significantly from 80.4 % (3-months) to 25.6% (15-months). Recovery rate of original tagged mussels continued to drop at the 30 meter transect (45.2% to 3.2%); however at the 200 meter transect there was little change in recovery rate of original tagged mussels (59.4% to 52.6%). Recovery rates of the "newly tagged" (tagged during the 3-month monitoring) mussels was lower at all three transects (20 m, 200 m, 400 m) below the former dam (16.7%, 38.2% and 21.8% respectively) than at the upstream control transect (61.8%). Observed mortality of original tagged mussels and "newly tagged" mussels was low at all transects; however a large number of fresh-dead untagged mussels were found at the three transects below the former dam (65, 137 and 97 respectively) compared to only 5 at the upstream control transect.

Table 21. Quantitative Mussel Study: Group 1 – Mussels tagged at study inception (0-months). 3-month and 15-month Monitoring Results.

	30 Meter Transect		**200 Meter Transect**		**400 Meter Transect**		**Upstream Control**	
# Tagged Mussels	31		96		439		38	
	3-months	**15-months**	**3-months**	**15-months**	**3-months**	**15-months**	**3-months**	**15-months**
% Recovered - Tagged (% Moved*)	45.2 (71.4)	3.2 (100)	59.4 (42.1)	52.6 (18)	80.4 (17)	25.6 (6.25)	84.2 (6.2)	76.3 (0)
% Dead – Tagged	0	0	1	2.1	0.2	0.5	0	0
# Dead - Untagged	4	65	37	137	25	97	0	5

*Moved = any tagged mussel found greater that 2 meters (e.g. two quadrates) in any direction from its original quadrate

Table 22. Quantitative Mussel Study: Group 2 – Mussels Tagged at 3-months. 15-month Monitoring Results.

	30 Meter Transect	200 Meter Transect	400 Meter Transect	Upstream Control
#Tagged Mussels	24	170	417	34
% Recovered (% Moved*)	16.7 (50)	38.2 (30.7)	21.8 (10.9)	61.8 (0)
% Dead	0	4.6	0	0
# Live - Untagged	4	99	293	46

*Moved = any tagged mussel found greater that 2 meters (e.g. two quadrates) in any direction from its original quadrate

7.0 QUANTITATIVE MUSSEL SURVEY DISCUSSION/CONCLUSIONS

Significant freshwater mussel mortality attributed to dam removal was not evident during the 3-month or 15-month quantitative mussel survey monitoring; however, mark/recapture recovery rates of tagged mussels (original tagged and newly tagged) were much lower below the dam site than at the upstream control.

In addition to having the lowest recapture (recovery) rates, the 30 meter and 200 meter transects also had the highest percentage of recaptured mussels exhibiting movement (71.4% and 42.1% respectively) during the 3-month monitoring, especially when compared to the little movement of recaptured mussels in the 400 meter and upstream control transects (1.7% and 6.2% respectively). Similarly, movement of recovered "newly tagged" mussels was relatively high at these transects (50% and 30.7% respectively) during the 15-month monitoring. Lower recapture rates and higher movement rates were predicted to occur in the 15-month monitoring of the 400 meter transect since encroachment of the sediment wedge had occurred. While recovery rates did drop significantly (80.4% to 25.6%), only one (6.3 %) of the recovered original tagged mussels and only 10.9% of recovered "newly tagged" mussels had moved. Reasons for the comparatively low percentage of recovered mussels exhibiting movement at this transect are unclear. It is possible that many of the mussels in the three transects below the dam moved beyond the10 meter upstream/downstream survey limits, as one mussel from the 30 meter transect was found by chance (walking downstream from the 30 m transect to the 200 m transect) 25 meters from its original quadrant. Additional surveys, which are beyond the scope of this project, would be needed to investigate this hypothesis.

Although observed mortality of tagged mussels (original and "newly tagged") was low at all transects, the number of fresh-dead untagged mussels was much higher at transects below the dam (65, 137, and 97 respectively) than at the upstream control site (5). While much of this mortality is likely attributable to bedload sediment transport associated with dam removal, it is not expected to have significant effects on the overall mussel populations in the river. The pre-removal surveys demonstrated that "good" mussel beds occur throughout the Little River both upstream and downstream of the former

impoundment site that will serve as a source for recruitment into the impacted reach. Additionally, a fair number of mussels still persist in the Little River just below the former dam site. In addition to the recovered tagged mussels, a total of 99 and 293 mussels had immigrated into the 200 meter and 400 meter transects respectively. However, only 5 (1 original tagged and 4 "newly tagged") live tagged mussels and 4 live untagged mussels were found in the 30 meter transect. This section of the river appears to still be adjusting to dam removal, which likely explains the low numbers. Recruitment and immigration of mussels into this area is expected to occur in the future.

The below average rainfall/discharge levels that have persisted in the watershed since dam removal may have prolonged the sediment effects on the mussel beds. Average or above average rainfall incidence might have "flushed" the sand wedge well downstream and even dispersed the sediment more homogenously throughout the downstream reaches of the river. In other words, while post dam removal sediment effects are predictable following dam removal, their impacts on benthic communities might be lessened by more frequent storm events.

APPENDIX D: NCDWQ Habitat Assessment Form

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.

A. Pools present	Score
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

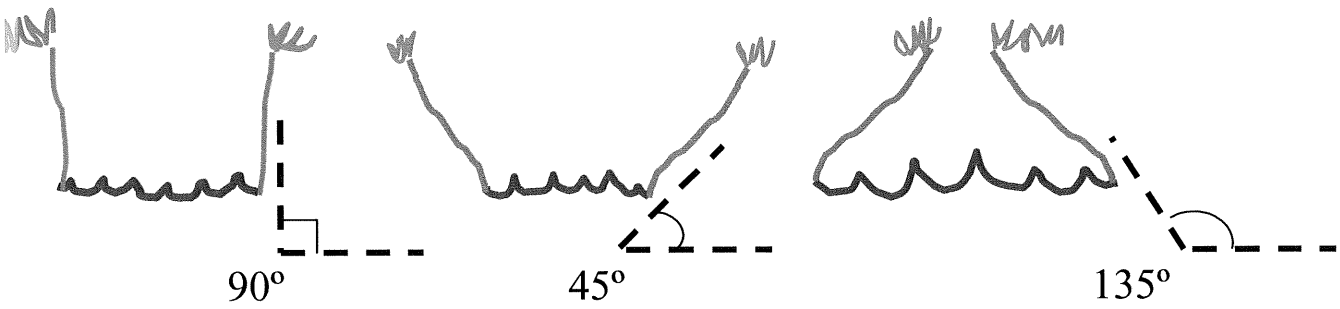
Remarks_____ Total_____

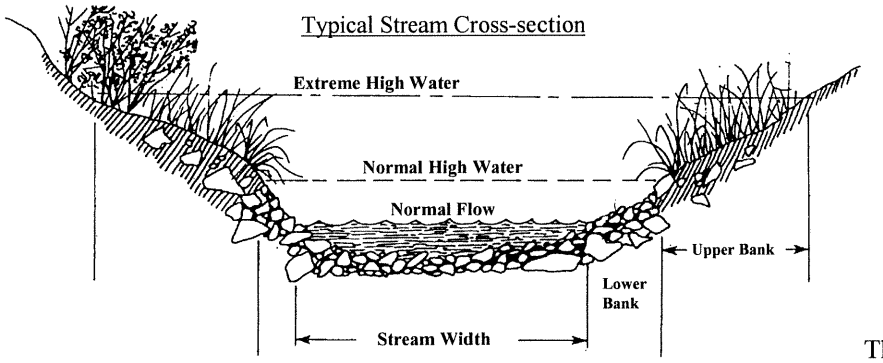
Page Total_____

☐ 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 Photographs

APPENDIX F: Erosion Evaluation Reports

EcoScience

EcoScience Corporation

1101 Haynes Street, Suite 101 Raleigh,
North Carolina 919-828-3433

MEMORANDUM

TO:	George Howard,	
	Restoration Systems, LLC (RS)	
FROM:	Jens Geratz	
DATE:	December 21, 2006	
RE:	Erosion Evaluation No. 2 (11-28-2006)	**06-276**

INTRODUCTION

The North Carolina Division of Water Quality (NCDWQ) Section 401 permit condition #8 associated with the Lowell Mill Dam – Little River Watershed Restoration Site requires that a "survey [of] the present lake bed and its flooded tributaries [shall occur] at least every two weeks (bi-weekly) or within three days of a rain more than or equal to one inch at Princeton, NC." Modifications to the permit condition described above are proposed. The text below describes the reason behind the modification and proposed methodology to satisfy, in spirit, the permit condition set forth in the permit.

The permit condition requested by NCDWQ presents several logistical difficulties. First, only a USGS river gauge is present near Princeton. No publicly available or trustworthy real-time weather data are available in or around Princeton, NC. The nearest weather station to Princeton is located in Smithfield, NC. Second, because the Smithfield weather station is outside the Little River watershed, ESC believes using data from this source is not indicative of accurate river stage conditions within the former impoundment. Thus, ESC has investigated and developed a new method for determining when a field evaluation should be performed.

In preparation of the erosion evaluation, EcoScience Corporation (ESC) collected three years of continuous daily precipitation and river stage data from 1990 through 1993. The data showed that a one inch rainfall event is a relatively commonplace weather occurrence. If the permit condition #8 remains as stated, then more than 33 field evaluations (>10 per year) would have been required during the period for which ESC collected the correlated rain/river stage data. It is important to note that one inch rain events do not appear to have a corresponding rise in river stage. Since the perceived purpose of the NCDWQ permit condition is to evaluate the former impoundment after increased river stage to monitor for erosion, then a one inch rainfall event is not the best indicator for the initiation of a site evaluation. Isolated thunderstorms can produce large amounts of precipitation in a localized area, without contributing significant rain to the overall watershed. To monitor multiple weather stations in real-time throughout the watershed to identify a regional precipitation

event is time consuming and not practicable. Alternatively, ESC proposes to use the correlation between large, regional rain events that cause more than a 750 cubic feet per second (cfs) reading at the Princeton gauging station (USGS 02088500) to be the "initiation threshold" for a field evaluation. ESC estimates that this initiation threshold will occur after a river stage rise equal to approximately 30 percent of bankfull. Once the initiation threshold for evaluation has been exceeded, ESC proposes that we monitor the river stage until the river falls below 500 cfs, which is proposed as an "evaluation threshold" river stage. Once the river stage falls below the evaluation threshold, ESC personnel will perform an erosion evaluation within a 72 hour period. Using the initiation and evaluation thresholds for the field effort will facilitate ESC personnel in reviewing the former impoundment under the safest and most data productive periods after a substantial rise in river stage.

In order to satisfy the modified permit condition #8, RS has authorized EcoScience Corporation (ESC) to conduct weather related erosion evaluation within the former Lowell Mill Dam Impoundment (ESC Proposal P06-004 January 19, 2006). The purpose of the evaluation is to document any evidence of erosion within the former dam impoundment including but not limited to bank failure, loss of stream bank trees, severe head-cuts, and the loss or gain of large depositional features.

The initiation threshold occurred on November 16th and the evaluation threshold occurred on November 27th (Figure 1). An erosion evaluation was conducted within the former impounded reaches of the Little River on November 28, 2006.

A nor'easter produced heavy rainfall over a large portion of eastern North Carolina on November 17th. As a result of the storm, the State Climate Office of NC Station 317994 (Smithfield, NC) recorded almost an inch of rainfall (Figure 1). An additional 12.35 inches of rain were recorded at the same station between November 8th and 23rd. The initiation threshold of 750 cfs occurred twice within the span of a week on November 16th and November 22nd (Figure 1). Two corresponding evaluation thresholds of 500 cfs occurred on November 21st and November 27th (Figure 1). The resulting events caused the USGS gauge at Princeton to register a peak discharge on November 17th and November 23rd of 1740 and 1930 cfs, respectively.

LITTLE RIVER EROSION EVALUATION

A two-person team performed a 7-mile canoe transit of the Little River. The point of ingress was the bridge crossing at Old Beulah Road (SR1934) and the point of egress was the former Lowell Mill Dam location (Figure 2). The team stopped at the mouth of the two credited tributaries as well as at previously established observation points along the river. At each observation point photographs were taken if significant changes had occurred since the first transit or to note continued stability of certain stream features.

River Observation Point 1

River Observation Point 1 is located on the Little River within Horsehead Bend (Figure 2). At this point on the Little River, the sediment deposition on vegetation was clearly observed at or above bankfull height following the rise in storm flow. Numerous other areas along the canoe transit were observed to have sediment deposition at a similar stage (Photo 1).

River Observation Point 2

River Observation Point 2 is located on the Little River at the Wildlife Resource Commission boat ramp (Figure 2). At this location sediment was observed to have been deposited approximately 15 feet up the ramp signifying the high water mark following the rise in storm flow (Photo 2).

River Observation Point 3

River Observation Point 3 is located on the Little River approximately 1000 feet downstream of the Wildlife Resource Commission boat ramp (Figure 2). At this location during the last transit, a newly formed log jam caused by a recent tree fall was creating an obstruction across the entire width of the Little River. Since the last transit, the log jam has been dislodged with minor woody debris remaining near the banks (Photo 3).

River Observation Point 4

River Observation Point 4 is located approximately 600 feet below the US 301 bridge crossing (Figure 2). Battery Bar, named for the presence of discarded batteries, was formerly a large depositional area constricting flow at this location. During the first transit, the sand bar was observed to have been downsized significantly due to an increase in sediment transport capacity. The sand bar is continuing to erode as the channel is still in the process of reestablishing bankfull dimensions at this location.

River Observation Point 5

River Observation Point 5 is located on the Little River approximately 1100 feet below the CSX Seaboard Rail crossing (Figure 2). At this location well established herbaceous vegetation was observed during the first transit along both banks of the river below the elevation of the former dam crest pool. The establishment of herbaceous vegetation aids in stabilizing the banks and preventing loss of bank material following the rise in storm flow. The vegetation is currently dormant but is still visible and will continue to help stabilize the banks as it continues to grow next spring.

River Observation Point 6

River Observation Point 6 is located on the Little River approximately half way between the CSX Seaboard Rail crossing and the I-95 overpass (Figure 2). Formerly inundated banks remain stable with dormant herbaceous vegetation. Conditions remain the same since the first transit.

River Observation Point 7

River Observation Point 7 is located on the Little River at the I-95 overpass (Figure 2). At this location well-established herbaceous vegetation was observed along both banks of the river below the elevation of the former dam crest pool. The establishment of herbaceous vegetation aids in stabilizing the banks and preventing loss of bank material following the rise in storm flow. The vegetation is currently dormant but is still visible and will continue to help stabilize the banks as it continues to grow next spring. The bridge piers located within the Little River contained only a small amount of debris and no evidence of scouring was observed (Photo 4).

River Observation Point 8

River Observation Point 8 is located approximately 300 feet upstream of the former dam site (Figure 2). At this location a change in river dynamics was observed during the first transit as a result of a log jam break directly upstream of the former dam. In addition to the removal of large woody debris, several feet of sediment and organic debris had been scoured from the river bank and transported downstream. Some woody debris remains along the banks, however flow is no longer impeded (Photo 5). Water levels were high during the current transit making it difficult to determine if any additional scouring had occurred.

River Observation Point 9

River Observation Point 9 is located along the inside bend (north bank) of the Little River at the former dam site (Figure 2). At this location, fluvial deposition continues to accumulate on the point bar that was constructed at the time of dam demolition. Volunteer herbaceous vegetation in addition to the planted vegetation has established along the bar. Swift moving water was observed flowing in the center of the channel, with slack water present along the north bank, where the channel remains over-widened. Additional sediment is expected to continue to deposit along the point bar as the Little River narrows to a width and depth consistent with bankfull dimensions. Toe of slope protection and vegetation along the south embankment of the former dam site was intact following the rise in storm flow (Photos 6-7).

SUMMARY

Conditions observed during the current transit are similar to conditions observed during the first transit. The formerly exposed banks of the Little River below the elevation of the former dam crest pool are covered with dormant herbaceous vegetation and continue to appear stable. Exposed banks along the channel were rarely observed, suggesting limited occurrences of bank failure or erosion. Erosion is restricted to channel bed and bank associated with channel adjustments in locations where sediments have accumulated due to woody debris jams, low water slope, and high sediment input locations near confluences with larger tributaries. After the occurrence of this second large storm event since the dam was removed, woody debris was less evident throughout the former impoundment. Most of the large debris jams that were prevalent prior to dam removal have been

dislodged. The bridge piers and abutments at the various bridge locations crossing the Little River held only a small amount of woody debris and continue to exhibit no visible evidence of scouring.

LITTLE RIVER EROSION EVALUATION PHOTOS

Photo 1. River Observation Point 1. Wrack on vegetation indicating discharge at or near bankfull in Horsehead Bend. Little River, Johnston County.

Photo 2. River Observation Point 2. Sediment deposition and high water mark (dashed line) at the Wildlife Resource Commission boat ramp. Little River, Johnston County.

Photo 3. River Observation Point 3. Previous log jam caused by recent tree fall has been dislodged. Little River, Johnston County.

Photo 4. River Observation Point 7. The bridge pilings (I-95) located within the Little River contained only a small amount of debris and no evidence of scouring was observed. Little River, Johnston County.

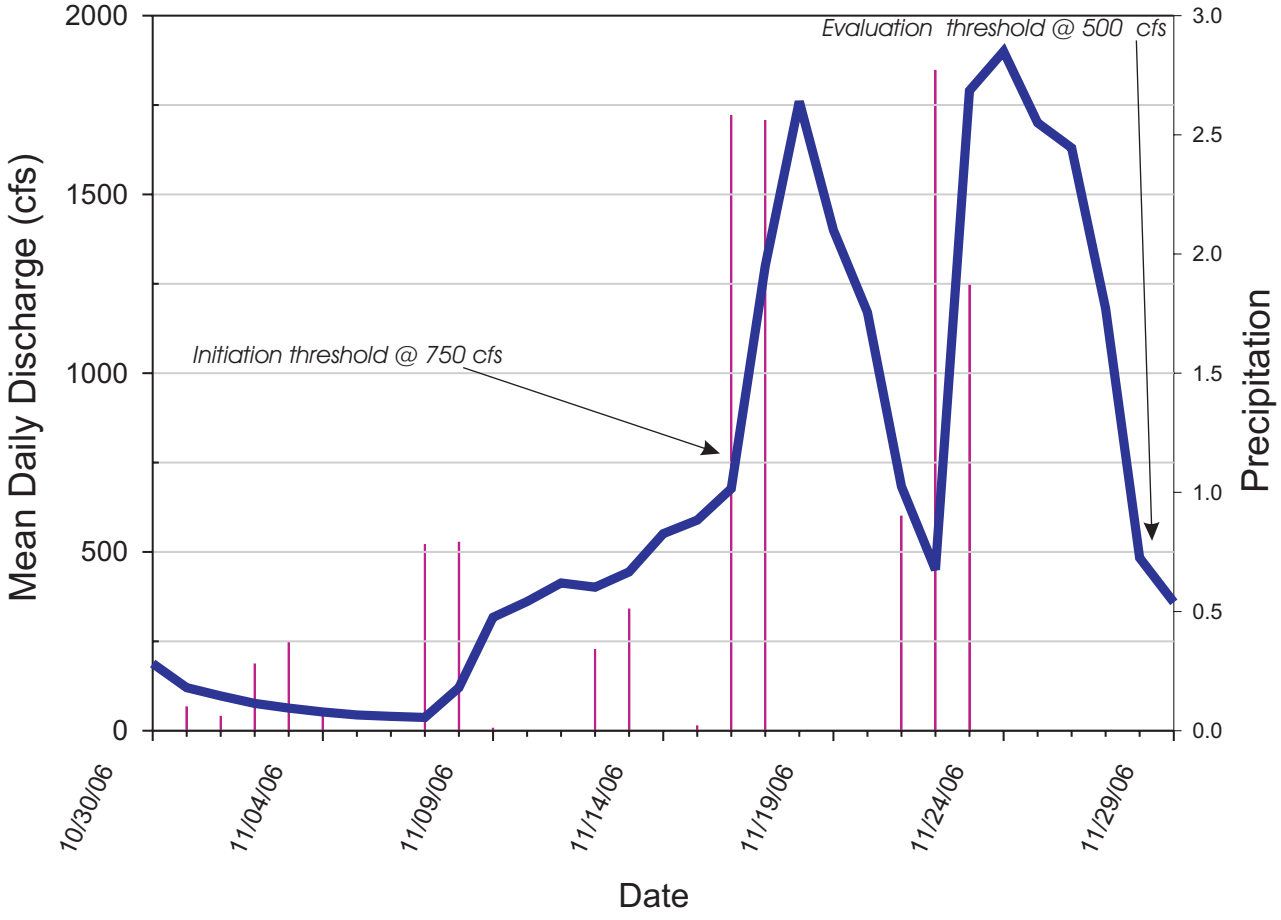
Photo 5. River Observation Point 8. Since the first transit, there has been a significant amount of debris that has built up along the scoured bank that was initially observed during the first transit. Also, water levels were higher then when the first transit was conducted and it was difficult to determine if any additional scouring has occurred. Little River, Johnston County.

Photo 6. River Observation Point 9. Sediment deposition and elongation of the constructed point bar located at the inside bend of the river at the former dam site. Note the slack water at the over widened reach of river at the toe of the remnant dam structure. Little River, Johnston County.

Photo 7. River Observation Point 9. Another picture from Observation Point 9 looking from left bank to right bank with slack water in foreground. Little River, Johnston County.

LITTLE RIVER EROSION EVALUATION FIGURES

USGS 02088500 Little River near Princeton, NC



Precipitation (SCONC Station 317994, Smithfield, NC)
Daily Discharge

EcoScience Corporation
Raleigh, North Carolina

EVENT DISCHARGE AT GAUGE NEAR PRINCETON
LOWELL MILL DAM RESTORATION SITE
Erosion Evaluation (11-28-2006)
Johnston County, North Carolina

Dwn. by:	JWG
Ckd by:	JWG
Date:	Nov 2006
Project:	06-276

FIGURE 1

EcoScience

EcoScience Corporation

1101 Haynes Street, Suite 101 Raleigh,
North Carolina 919-828-3433

MEMORANDUM

TO:	George Howard,	
	Restoration Systems, LLC (RS)	
FROM:	Jens Geratz	
DATE:	January 25, 2007	
RE:	Erosion Evaluation No. 3 (01-03-2007)	**06-276.03**

INTRODUCTION

The North Carolina Division of Water Quality (NCDWQ) Section 401 permit condition #8 associated with the Lowell Mill Dam – Little River Watershed Restoration Site requires that a "survey [of] the present lake bed and its flooded tributaries [shall occur] at least every two weeks (bi-weekly) or within three days of a rain more than or equal to one inch at Princeton, NC." Modifications to the permit condition described above are proposed. The text below describes the reason behind the modification and proposed methodology to satisfy, in spirit, the permit condition set forth in the permit.

The permit condition requested by NCDWQ presents several logistical difficulties. First, only a USGS river gauge is present near Princeton. No publicly available or trustworthy real-time weather data are available in or around Princeton, NC. The nearest weather station to Princeton is located in Smithfield, NC. Second, because the Smithfield weather station is outside the Little River watershed, ESC believes using data from this source is not indicative of accurate river stage conditions within the former impoundment. Thus, ESC has investigated and developed a new method for determining when a field evaluation should be performed.

In preparation of the erosion evaluation, EcoScience Corporation (ESC) collected three years of continuous daily precipitation and river stage data from 1990 through 1993. The data showed that a one inch rainfall event is a relatively commonplace weather occurrence. If the permit condition #8 remains as stated, then more than 33 field evaluations (>10 per year) would have been required during the period for which ESC collected the correlated rain/river stage data. It is important to note that one inch rain events do not appear to have a corresponding rise in river stage. Since the perceived purpose of the NCDWQ permit condition is to evaluate the former impoundment after increased river stage to monitor for erosion, then a one inch rainfall event is not the best indicator for the initiation of a site evaluation. Isolated thunderstorms can produce large amounts of precipitation in a localized area, without contributing significant rain to the overall watershed. To monitor multiple weather stations in real-time throughout the watershed to identify a regional precipitation

event is time consuming and not practicable. Alternatively, ESC proposes to use the correlation between large, regional rain events that cause more than a 750 cubic feet per second (cfs) reading at the Princeton gauging station (USGS 02088500) to be the "initiation threshold" for a field evaluation. ESC estimates that this initiation threshold will occur after a river stage rise equal to approximately 30 percent of bankfull. Once the initiation threshold for evaluation has been exceeded, ESC proposes that we monitor the river stage until the river falls below 500 cfs, which is proposed as an "evaluation threshold" river stage. Once the river stage falls below the evaluation threshold, ESC personnel will perform an erosion evaluation within a 72 hour period. Using the initiation and evaluation thresholds for the field effort will facilitate ESC personnel in reviewing the former impoundment under the safest and most data productive periods after a substantial rise in river stage.

In order to satisfy the modified permit condition #8, RS has authorized EcoScience Corporation (ESC) to conduct weather related erosion evaluation within the former Lowell Mill Dam Impoundment (ESC Proposal P06-004 January 19, 2006). The purpose of the evaluation is to document any evidence of erosion within the former dam impoundment including but not limited to bank failure, loss of stream bank trees, severe head-cuts, and the loss or gain of large depositional features.

A rainfall event ranging from 2.0 to 3.7 inches occurred in the upstream watershed (Figure 1) between December 22 and December 26, 2006. The resulting peak in river stage of over 1890 cubic feet per second (cfs) was recorded at the USGS Princeton river gage on December 26, 2006 (Figure 3). The "initiation threshold" from this storm occurred on December 25 and the "evaluation threshold" on December 31. An erosion evaluation was conducted within the formerly impounded reaches of the Little River on January 3, 2007.

LITTLE RIVER EROSION EVALUATION

A two-person team performed a 7-mile canoe transit of the Little River. The point of ingress was the bridge crossing at Old Beulah Road (SR1934) and the point of egress was the former Lowell Mill Dam location (Figure 3). The team stopped at the mouth of the two credited tributaries as well as at previously established observation points along the river. At each observation point photographs were taken if significant changes had occurred since the first transit or to note continued stability of certain stream features.

River Observation Point 1

River Observation Point 1 is located within Horsehead Bend (Figure 3). At this point on the Little River, the sediment deposition on vegetation was clearly observed at or above bankfull height following the rise in storm flow. Numerous other areas along the canoe transit were observed to have sediment deposition at a similar stage (Photo 1).

River Observation Point 2

River Observation Point 2 is located at the Wildlife Resource Commission boat ramp (Figure 3). At this location sediment was observed to have been deposited approximately 8 feet up the ramp signifying the high water mark following the rise in storm flow (Photo 2).

River Observation Point 3

River Observation Point 3 is located approximately 1000 feet downstream of the Wildlife Resource Commission boat ramp (Figure 3). At this location a log jam caused by a tree fall was creating an obstruction across the entire width of the Little River. The log jam has been completely dislodged. No new observations since last report.

River Observation Point 4

River Observation Point 4 is located approximately 600 feet below the US Highway 301 (US 301) bridge crossing (Figure 3). Battery Bar, named for the presence of discarded batteries, was formerly a large depositional area constricting flow at this location. Since dam removal and the return of lotic conditions on the Little River, the sand bar has eroded significantly due to an increase in sediment transport capacity. Slight channel adjustments are expected to continue until the Little River dimensions are in regime with discharge and sediment transport rates (Photo 3-4).

River Observation Point 5

River Observation Point 5 is located approximately 1100 feet below the CSX Seaboard Rail crossing (Figure 3). At this location well established herbaceous vegetation was observed during the first transit along both banks of the river below the elevation of the former dam crest pool. The vegetation is currently dormant but is still visible and will continue to help stabilize the banks as it continues to grow next spring. No new observations since last report.

River Observation Point 6

River Observation Point 6 is located approximately half way between the CSX Seaboard Rail crossing and the Interstate 95 (I-95) overpass (Figure 3). Formerly inundated banks remain stable with dormant herbaceous vegetation. Conditions remain the same since the last transit.

River Observation Point 7

River Observation Point 7 is located at the I-95 overpass (Figure 3). Most vegetation along the banks is currently dormant but is still visible and will continue to help stabilize the banks as it continues to grow next spring. The bridge piers located within the Little River contained no debris and no evidence of scouring was observed (Photo 5).

River Observation Point 8

River Observation Point 8 is located approximately 300 feet upstream of the former dam site (Figure 3). At this location a change in river dynamics was observed during the first transit as a result of a log jam break directly upstream of the former dam. In addition to the removal of large woody

debris, several feet of sediment and organic debris had been scoured from the river bank and transported downstream. Some woody debris remains along the banks, however flow is no longer impeded. Vegetation has covered the banks and no signs of erosion were observed (Photo 6).

River Observation Point 9

River Observation Point 9 is located along the inside bend (left bank) of the Little River at the former dam site (Figure 3). At this location, fluvial deposition continues to accumulate on the point bar that was constructed at the time of dam demolition. Volunteer herbaceous vegetation in addition to the planted vegetation has established along the bar. Swift moving water was observed flowing in the center of the channel, with slack water present along the north bank, where the channel remains over-widened (Photo 7-8). Additional sediment is expected to continue to deposit along the point bar as the Little River narrows to a width and depth consistent with bankfull dimensions. Toe of slope protection and vegetation along the south embankment of the former dam site was intact following the rise in storm flow. Newly installed stairs serving as a canoe launch to the Little River were also intact and stable (Photo 9).

River Observation Point 10

River Observation Point 10 is located at the bridge crossing of Weaver Street (Figure 3). Most vegetation along the banks is currently dormant but is still visible and will continue to help stabilize the banks as it continues to grow next spring. The bridge piers located within the Little River contained no debris and no evidence of scouring was observed (Photo 10).

River Observation Point 11

River Observation Point 11 is located on the along the outside bend (right bank) of the Little River approximately 200 feet downstream from the WRC boat ramp (Figure 3). At this location the outside bank of a bend in the river has experienced scour from increased flow. Alluvial banks with underlying bedrock have been exposed at the location of the scour (Photo 11). This feature is common on banks along the outer bends in the river, where the underlying bedrock maintains stability.

River Observation Point 12

River Observation Point 12 is located at the confluence with Little Buffalo Creek (Figure 3). The flow pattern at this location is very dynamic due to the presence of mid-channel islands created by a meander cut-off. The confluence to Little Buffalo Creek is stable with no signs of erosion (Photo 12). Immediately downstream of the confluence are two mid-channel islands that divert the flow of water around them (Photo 13-14). Woody debris was present on the upstream side of both islands, but flow was not impeded between them. Scouring was observed on the perimeter of the islands were water flow is being diverted, as well as on the surface from overland flow during high river stage.

River Observation Point 13

River Observation Point 13 is located at the bridge crossing US 301 (Figure 3). Most vegetation along the banks is currently dormant but is still visible and will continue to help stabilize the banks as it continues to grow next spring. The bridge piers located within the Little River contained no debris and no evidence of scouring was observed (Photo 15).

SUMMARY

Conditions observed during the current transit are similar to conditions observed during the previous transits. The formerly exposed banks of the Little River below the elevation of the former dam crest pool are covered with dormant herbaceous vegetation and continue to appear stable. Exposed banks along the channel were rarely observed, suggesting limited occurrences of bank failure or erosion. Erosion is restricted to channel bed and bank associated with channel adjustments in locations where sediments have accumulated due to low water slope, and high sediment input locations near confluences with larger tributaries. Woody debris was less evident throughout the former impoundment during this erosion transit. The bridge piers and abutments at the various bridge crossings over the Little River have accumulated only small amounts of woody debris and continue to exhibit no visible evidence of scouring.

LITTLE RIVER EROSION EVALUATION PHOTOS

Photo 1. River Observation Point 1: Sediment on vegetation indicating discharge at or above bankfull in Horseshoe Bend. Little River, Johnston County.

Photo 2. River Observation Point 2: Sediment deposition and high water mark (red line) at the Wildlife Resource Commission boat ramp. Little River, Johnston County.

Photo 3. River Observation Point 4: Looking downstream at Battery Bar. Little River, Johnston County.

Photo 4. River Observation Point 4: Looking upstream towards Battery Bar at the point at which channel dimension have reestablished. Little River, Johnston County.

Photo 5. River Observation Point 7: The bridge pilings (I-95) located within the Little River contained no woody debris and no evidence of scouring was observed. Little River, Johnston County.

Photo 6. River Observation Point 8: Stable, vegetated bank that was previously a site of erosion. Little River, Johnston County.

Photo 7. River Observation Point 9: Continued sediment deposition and bar formation along the inside bend of the river at the former dam site. Little River, Johnston County.

Photo 8. River Observation Point 9: Increasing size of the bar forming as a result of additional sediment deposition. Note slack water the right of the dam remnant from over widened channel. Little River, Johnston County.

Photo 9. River Observation Point 9: Toe of slope protection and canoe launch staircase along the south embankment. Little River, Johnston County.

Photo 10. River Observation Point 10: The bridge pilings (Weaver Street) located within the Little River contained no woody debris and no evidence of scouring was observed. Little River, Johnston County.

Photo 11. River Observation Point 11: Undercut alluvial banks exposing the underlying bedrock. Little River, Johnston County.

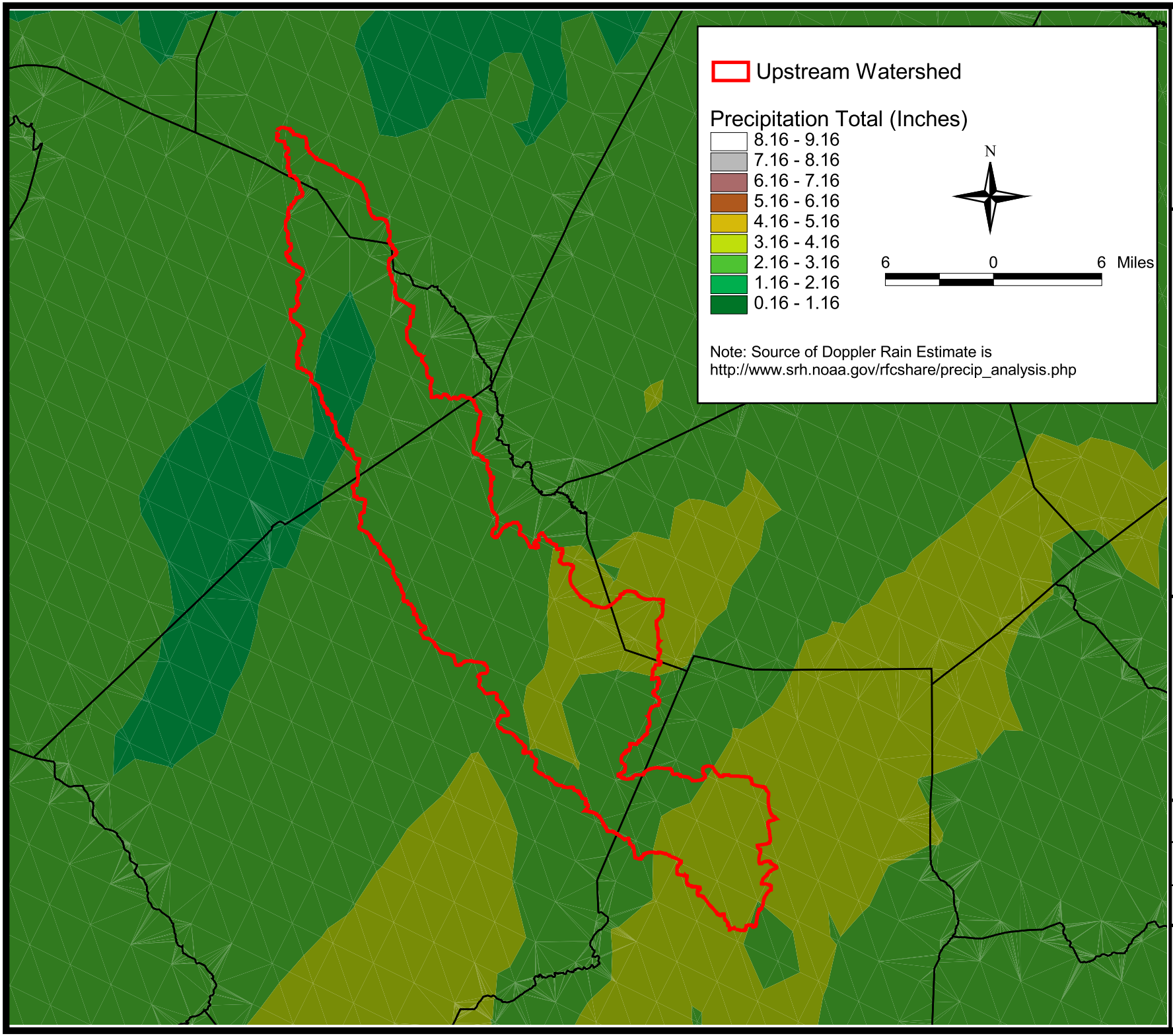
Photo 12. River Observation Point 12: Stable confluence to Little Buffalo Creek. Little River, Johnston County.

Photo 13. River Observation Point 12: Meander cut-off immediately downstream of the confluence with Little Buffalo Creek. Water flows both behind and in front of the pictured stand of trees. Little River, Johnston County.

Photo 14. River Observation Point 12: Meander cut-off with woody debris deposition. Little River, Johnston County.

Photo 15. River Observation Point 13: The bridge pilings (US 301) located within the Little River contained no woody debris and no evidence of scouring was observed. Little River, Johnston County.

LITTLE RIVER EROSION EVALUATION FIGURES



EcoScience Corporation
Raleigh, North Carolina

Project:

LOWELL MILL DAM EROSION EVALUATION

Johnston County, North Carolina

Title:

Total Rainfall Estimate for 12-22 to 12-26 Rain Event

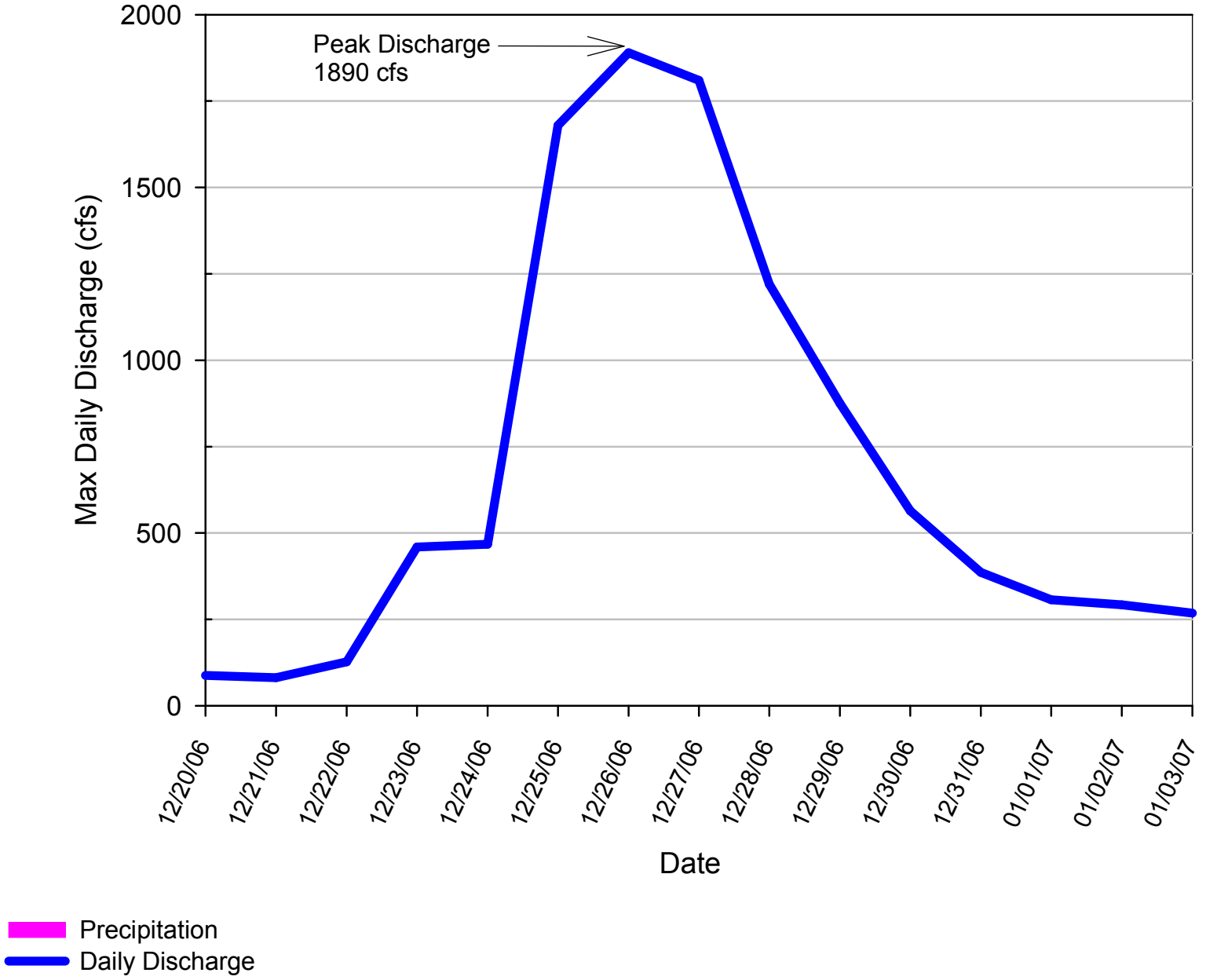
Dwn By:	Ckd By:
MG	JG
Date:	Scale:
JAN 2007	AS SHOWN

ESC Project No.: 06-276.03

FIGURE

1

Figure 2: Event Discharge at the Princeton, NC USGS Gauge
Lowell Mill Dam Restoration Site
01-03-07 Erosion Evaluation



APPENDIX G: Fish Weir Study Handout

Additional Information

The weir will be operated during March through May of 2007 and 2008.

Funding for this project was provided by the U. S. Fish and Wildlife Service and Restoration Systems, LLC.

By restoring spawning habitat, fishery managers hope to increase the runs of migratory fish, like this American shad.

For more information, please contact:

Joseph E. Hightower
NC Cooperative Fish and Wildlife Research Unit
Campus Box 7617, NC State University
Raleigh, NC 27695-7617

Phone: (919) 515-8836
Email: jhightower@ncsu.edu

Cover Photo: Weir with cages to collect upstream and downstream migrating fish.

USGS *NC Cooperative Fish and Wildlife Research Unit*

Little River fish weir project

Joshua K. Raabe

Joseph E. Hightower

Project Description

A fish weir has been installed on the Little River as part of a study by the North Carolina Cooperative Fish and Wildlife Research Unit, at NC State University. The weir is located at the site where Lowell Dam was removed in order to better understand how migratory fish use habitat in different parts of the river. The study results will enable scientists to better predict the potential benefits of fish passage (fish ladders) or dam removal.

Migratory fishes include anadromous species, such as the American shad and hickory shad, that live in the ocean but spawn in coastal rivers. At one time, North Carolina produced more American shad than any other state (and the Neuse River produced more than any other NC river). However, statewide catches have plummeted from more than 8 million pounds in 1896 to 205 thousand pounds in 1995. One strategy for rebuilding the stock is to increase the amount of spawning habitat available. A mature American shad can produce up to 600,000 eggs, so they have the potential to rebound quickly when good quality habitat becomes available.

American shad. Painting by D. Raver, courtesy of U. S. Fish and Wildlife Service.

Weir Information

The main approach being used in this study is the operation of a "resistance board" weir. The name comes from the plywood boards underneath the PVC panels (see figure, right). The boards provide lift to the PVC panels but still allow them to rise and fall with the river. The panels are designed to be "self-cleaning" if debris builds up on them. Also, canoes or other boats should be able to drift downstream over the PVC panels.

The PVC sections are located in the strongest river flows. To the sides are stationary panels made up vertical metal pickets. The weir is completed with two cages, one for upstream and one for downstream moving fish. The weir blocks fish from moving upstream or downstream and funnels them into the respective cages where they will be temporarily captured. After information is recorded about each fish, it will be released to continue its upstream or downstream migration.

Additional Study Methods

Some fish will be tagged in order to find out how long fish stay on the spawning grounds, and whether fish return to the same spawning grounds in successive years. The American shad in this picture has been given a small green tag, so that it can be identified if caught at another location or after returning to the weir.

Researchers also will sample for eggs and larvae using plankton nets. These samples will be taken at different locations in the watershed to determine where and when spawning is occurring. Habitat characteristics at spawning locations can be used to identify other river systems where American shad spawning habitat might be restored, either through fish passage or dam removal.

Josh Raabe, who is leading the Little River study, measures a shad captured in the weir.