CANDIFF CREEK RESTORATION PROJECT

ANNUAL MONITORING REPORT FOR 2012 (YEAR 1)

EEP Project Number: 92767

Submitted to:

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FINAL

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1.0 EXECUTIVE SUMMARY

This Annual Monitoring Report details the monitoring activities during the 2012 growing season (Monitoring Year 1) for the Candiff Creek Restoration Project ("Site"). As per the approved Mitigation Plan for the Site, this Annual Monitoring Report presents stream geometry data, stem count data from vegetation monitoring stations, and discusses any observed tendencies relating to stream stability and vegetation survival success.

Prior land use on the Site consisted primarily of pasture and forest. Candiff Creek had been channelized and riparian vegetation had been cleared in the lower half of the site. The upstream reaches of the project had a narrow, early successional buffer that included several exotic vegetation species. Prior to restoration, Candiff Creek was incised and lacked bedform diversity. As a result, channel degradation was widespread throughout the Site.

A total of 13 monitoring plots, 100 square meters (m^2) (10m x 10m) in size, were used to predict survivability of the woody vegetation planted on the Site. Data from Year 1 monitoring for the 13 vegetation plots exhibited a survivability range of 728 to 1,052 stems per acre. The data showed that the Site had an average survivability of 878 stems per acre following Year 1 monitoring.

According to the Year 1 vegetative monitoring data, the Site is on track to meet the interim success criteria of a minimum of 320 stems per acre by the end of Monitoring Year 3.

Cross-sectional monitoring data for stream stability were collected during Year 1 monitoring. A longitudinal profile survey was completed during Year 1 monitoring for approximately 3,674 linear feet (LF) of stream on the Site. The longitudinal profile was completed for Reach M3 only.

The cross-sectional data and the longitudinal profile indicate that Reach M3 is stable and functioning as designed.

According to the on-site crest gauge, the Site experienced at least one bankfull flow event during the Year 1 monitoring period. The largest on-site bankfull flow event documented by the M3 crest gauge during Year 1 monitoring, occurred sometime in April-May 2012. It was estimated that flows at the M3 crest gauge during this time period were approximately 1.60 feet above bankfull stage. Inspection of conditions during a spring site visit revealed visual evidence of out-of-bank flows.

In summary, the Site is on track to meet the hydrologic, vegetative, and stream success criteria as specified in the Site Restoration Plan.

2.0 PROJECT BACKGROUND

The project involved the proposed restoration of 4,109 linear feet (LF) of stream, 1,757 of stream Enhancement (265 LF of Enhancement I and 1,492 LF of Enhancement II) and 1,200 LF of stream preservation. The final stream lengths for all reaches are shown in Table 1 and Figure 2 summarize the restoration zones on the Site. A total of 27.54 acres of stream and riparian buffer are protected through a permanent conservation easement.

2.1 Project Objectives

The specific goals for the Candiff Creek Restoration Project were as follows:

- Create geomorphically stable conditions along Candiff Creek through the project area
- Prevent cattle from accessing the project reaches, reducing excessive bank erosion,
- Improve habitat quality in a riffle dominated stream by adding pool/riffle sequences and expanding the floodplain, while improving overall ecosystem functionality
- Improve water quality within the Candiff Creek Restoration Project area through reduction of bank erosion and reductions in nutrient and sediment loads
- Stabilize streambanks through installation of in-stream structures and establishing a riparian buffer consisting of native plant species
- Improve aquatic and terrestrial habitat through increased substrate and in-stream cover, additional woody debris, and reduced water temperature by increasing stream shading, and restored terrestrial habitat.

2.2 Project Structure, Restoration Type and Approach

For analysis and design purposes, Michael Baker Engineering, Inc. (Baker) divided on-site streams into reaches. The reaches were numbered sequentially from upstream to downstream, with a "M" designation for the "mainstem" and a "UT" designation for unnamed tributaries. Two UTs are located on the Site (labeled UT1 and UT2). The on-site streams are described as follows: M1 begins on the upstream section of the Site at the River-Siloam Road culvert, and then flows southward to the confluence with UT2. M2 begins at the M1/UT2 confluence and flows south 265 feet to the beginning of the restored portion of the mainstem. M3 begins at the restored channel and then flows southeastward for 4,123 feet and terminates at the property line adjacent to the Yakin Valley Railroad right-of-way located at the downstream end of the Site. UT1 flows onto the Site from the southern Wall property line and flows southward for 885 feet to the confluence with M1. UT2 flows onto the Site from the eastern Aztar Group, LLC property line and flows eastward for 1,162 feet and terminates at the M1/M2 transition. The reaches described above are presented in the plan sheets located in Figures 3A through Figure 3J.

The restoration design allows stream flows greater than the designed bankfull elevation, to spread onto the floodplain, dissipating flow energies and reducing stress on streambanks. In-stream structures were used to control streambed grade, reduce streambank stress, and promote bedform sequences and habitat diversity. The in-stream structures installed consist of constructed riffles, cover logs, log/rock vanes, log/rock j-hook vanes, rock cross vanes, vegetated geolifts, vegetated brush mattresses and root wads. These structures promote a diversity of habitat features in the restored channel. Where grade control was a consideration, constructed riffles, grade control rock j-hook vanes, and rock cross vanes were installed to provide long-term stability. Streambanks were

stabilized using a combination of erosion control matting, temporary and permanent seeding, bare-root planting, transplants, brush mattresses and geolifts. Transplants provide areas for living root mass to increase streambank stability and also to create holding areas for fish and aquatic biota.

The purpose of the project is to restore stream functions to the impaired reaches the Site. Native species vegetation was planted across the Site and the entire project area is protected through a permanent conservation easement

Table 1. Design Approach for the Candiff Creek Restoration Project

Candiff Creek Restoration Project: Project No. 92767								
Project Segment or Reach ID	**Existing Feet/Acres**	**Mitigation Type ***	**Approach ****	**Linear Footage/ Creditable Length**	**Mitigation Ratio**	**Mitigation Units**	**Stationing**	**Comment**
M1	690	E	EII	735/690	2.5:1	276	10+00 - 17+35	Invasive species vegetation removal and buffer planting; 45 LF of stream length removed for one stream crossing
M2	265	E	EI	265/265	1.5:1	177	17+35 - 20+00	Installed in-stream structures to control grade and reduce bank erosion
M3	3,828	R	P1, P2	4,123/4,081	1:1	4,081	20+00 - 61+23	Invasive species removal and buffer planting; 42 linear feet of stream length removed for two stream crossings
UT1 (Lower Reach)	885	E	EII	485/485	2.5:1	194	14+00 - 18+85	Invasive species vegetation removal, buffer planting, and livestock exclusion fencing.
UT1 (Upper Reach)		P	N/A	400/400	5:1	80	10+00 - 14+00	Preservation area - no construction activities in this area
UT2 (Lower Reach)	1,117	E	EII	362/317	2.5:1	127	18+00 - 21+62	Invasive species vegetation removal, buffer planting, and livestock exclusion fencing.
UT2 (Upper Reach)		P	N/A	800/800	5:1	160	10+00 - 18+00	Preservation area - no construction activities in this area

Mitigation Unit Summations					
Stream (LF)	Riparian Wetland (Ac)	Non-riparian Wetland (Ac)	Total Wetland (Ac)	Planted Riparian Buffer (Ac)	Permanent Conservation Easement (Ac)
5,095	0	0	0	17.31	27.54

* R = Restoration
E = Enhancement
P = Preservation

** P1 = Priority I
P2 = Priority II
EII = Enhancement II

2.3 Location and Setting

The Site is located in Surry County in western North Carolina, approximately 1.75 miles west of Siloam Township, and just north of the Surry-Yadkin County line, as shown in Figure 1. The Site lies in the Yadkin Pee-Dee River Basin, within the US Geological Survey (USGS) targeted local watershed 03040101, and the North Carolina Division of Water Quality (NCDWQ) sub-basin 03-07-02.

2.4 Project History and Background

Land use at the Site consists primarily of pasture and forest. Candiff Creek had been channelized and riparian vegetation had been cleared at the lower half of the Site. The upstream end of the Site had a narrow, early successional buffer that included several exotic vegetation species. Prior to restoration, Candiff Creek was incised and lacked bedform diversity. As a result, channel degradation was widespread throughout the Site.

The chronology of the Candiff Creek Restoration Project is presented in Table 2. The contact information for the designers, contractors, and relevant suppliers is presented in Table 3. Relevant project background information is provided in Table 4.

2.5 Project Plan

Plans illustrating the as-built conditions of the major project elements, locations of permanent monitoring cross-sections, and locations of permanent vegetation monitoring plots are presented in Figures 3A through 3G of this report.

Table 2. Project Activity and Reporting History

Candiff Creek Restoration Project: Project No. 92767			
Activity or Report	**Scheduled Completion**	**Data Collection Complete**	**Actual Completion or Delivery**
Restoration Plan Prepared	Jul-10	N/A	Jul-10
Restoration Plan Amended	Aug-10	N/A	Aug-10
Restoration Plan Approved	Aug-10	N/A	Aug-10
Final Design – (at least 90% complete)	Jul-10	N/A	Jun-11
Construction Begins	N/A	N/A	Sep-11
Temporary S&E mix applied to entire project area	N/A	N/A	Apr-12
Permanent seed mix applied to entire project area	N/A	N/A	Apr-12
Planting of live stakes	N/A	N/A	Apr-12
Planting of bare root trees	N/A	N/A	Apr-12
End of Construction	NA	N/A	Mar-12
Survey of As-built conditions (Year 0 Monitoring-baseline)	N/A	Mar-12	Mar-12
Year 1 Monitoring	Nov-12	Oct-12	Dec-12
Year 2 Monitoring	Scheduled Nov-13	Scheduled Nov-13	Scheduled Nov-13
Year 3 Monitoring	Scheduled Nov-14	Scheduled Nov-14	Scheduled Nov-14
Year 4 Monitoring	Scheduled Nov-15	Scheduled Nov-15	Scheduled Nov-15
Year 5 Monitoring	Scheduled Nov-16	Scheduled Nov-16	Scheduled Nov-16

Table 3. Project Contacts

Candiff Creek Restoration Project: Project No. 92767	
Designer Michael Baker Engineering, Inc.	8000 Regency Parkway, Suite 600 Cary, NC 27518 Contact: Scott Hunt, P.E., Telephone: 919-463-5488
Construction Contractor River Works, Inc.	6105 Chapel Hill Road Raleigh, NC 27607 Contact: Bill Wright, Telephone: 336-279-1002
Planting Contractor River Works, Inc.	6105 Chapel Hill Road Raleigh, NC 27607 Contact: Bill Wright, Telephone: 336-279-1002
Seeding Contractor River Works, Inc.	6105 Chapel Hill Road Raleigh, NC 27607 Contact: Bill Wright, Telephone: 336-279-102
Seed Mix Sources Nursery Stock Suppliers	Green Resources, 336-855-6363 ArborGen, Inc., 843-528-3204
Monitoring Performers Michael Baker Engineering, Inc. Stream Monitoring Point of Contact: Vegetation Monitoring Point of Contact:	8000 Regency Parkway, Suite 600 Cary, NC 27518 Scott Hunt, P.E., Tel. 919-463-5488 Scott Hunt, P.E., Tel. 919-463-5488

Table 4. Project Background Table

Candiff Creek Restoration Project: Project No. 92767		
Project County:		Surry County, NC
Drainage Area:		
	Reach:	square miles (mi^2):
	M1	2.35
	M2	2.53
	M3	2.74
	UT1	0.06
	UT2	0.14
Estimated Drainage % Impervious Cover:		
	M1, M2, M3, UT1, UT2	<5%
Stream Order:		
	UT1	1
	UT2	2
	M1, M2, M3	3
Physiographic Region		Piedmont
Ecoregion		Northern Inner Piedmont
Rosgen Classification* of As-built:		
	M1, M2, M3	C
	UT1 (Lower Reach)	N/A
	UT1 (Upper Reach)	N/A
	UT2 (Lower Reach)	N/A
	UT2 (Upper Reach)	N/A
Cowardin Classification*:		
	M1, M2, M3, UT2	Riverine, Upper Perennial, Cobble-Gravel
	UT1	Riverine, Intermittent, Cobble-Gravel
Dominant Soil Types*:		
	M1, M2, M3, UT1 (Lower Reach), UT2 (Lower Reach)	CsA
	UT1 (Upper Reach), UT2 (Upper Reach)	FsE
	UT1 (Upper Reach)	FeC2
Reference site ID		On-site
USGS HUC for Project		03040101
NCDWQ Sub-basin		03-07-02
NCDWQ classification for Project and Reference:		
	M1, M2, M3, UT1, UT2	C
Any portion of any project segment 303d listed?		No
Any portion of any project segment upstream of a 303d listed segment?		No
Reasons for 303d listing or stressor?		N/A
% of project easement fenced		100%

*Rosgen, 1994; *Cowardin;*-USDA, 2007

3.0 PROJECT CONDITION AND MONITORING RESULTS

3.1 Vegetation Assessment

3.1.1 Description of Vegetative Monitoring

As a final stage of construction, the stream margins and riparian areas of the Site were planted with bare root trees, live stakes, and a seed mixture of temporary and permanent herbaceous vegetation to establish ground cover. The woody vegetation was planted randomly from the top of the stream banks to the outer edge of the project's re-vegetation limits. In general, bare-root vegetation was planted at a target density of 680 stems per acre, in an 8-foot by 8-foot grid pattern. Live stakes were installed two to three feet apart in meander bends and six to eight feet apart in the riffle cross-sections. The live stakes were set up using triangular spacing along the stream banks between the toe of the stream bank and bankfull elevation. The tree species planted at the Site are shown in Table 5. The temporary seed planted following construction was rye grain. The permanent seed mix of herbaceous species planted in the project's riparian area included: redtop (*Agrostis alba*), big bluestem (*Andropogon gerardii*), beggartick (*Bidens frondosa*), lanceleaf tickseed (*Coreopsis lanceolata*), deertongue (*Pancium clandestinum*), Virginia wildrye (*Elymus virginicus*), soft rush (*Juncus effusus*), switchgrass (*Panicum virgatum*), smartweed (*Polygonum pensylvanicum*), little bluestem (*Schizachyrium scoparium*), Indian grass (*Sorghastrum nutan),* and eastern gamma grass (*Tripsacum dactyloides*). This seed mixture was broadcast on the Site at a rate of 15 pounds per acre. All planting was completed in April 2012.

At the time of planting, 13 vegetation plots – labeled 1 through 13 - were established on-site to monitor survival of the planted woody vegetation. Each vegetation plot is 0.025 acre in size, or 10 meters x 10 meters. All of the planted stems inside the plots were flagged to distinguish them from any colonizing individuals and to facilitate locating them in the future. The trees also were marked and labeled with aluminum metal tags to ensure that the correct identification is made during future monitoring of the vegetation plots. In addition to flagging and tags, the locations of planted stems and vegetation plot corners were recorded by use of survey equipment.

3.1.2 Vegetative Success Criteria

To characterize vegetation success criteria objectively, specific goals for woody vegetation density have been defined. Data from vegetation monitoring plots should display a surviving tree density of at least 320 trees per acre at the end of the third year of monitoring, and a surviving tree density of at least 260 five-year-old trees per acre at the end of the five-year monitoring period.

Table 3.
Vegetation Species Planted Across the Restoration Project

Scientific Name	Common Name	Percent Planted by Species	Total Number of Stems
Bare Root Trees Species			
Betula nigra	river birch	23.3%	1,800
Diospyros virginiana	persimmon	7.8%	600
Fraxinus pennsylvanica	green ash	15.6%	1,200
Liriodendron tulipfera	tulip poplar	7.8%	600
Platanus occidentalis	sycamore	22.1%	1,700
Quercus michauxii	swamp chestnut oak	15.6%	1,200
Quercus phellos	willow oak	7.8%	600
Bare Root Shrub Species			
Asimina triloba	paw paw	9.5%	400
Carpinus caroliniana	ironwood	12%	500
Cercus canadensis	redbud	14%	600
Cornus amomum	silky dogwood	19%	800
Lindera benzoin	spicebush	9.5%	400
Sambucus canadensis	elderberry	19%	800
Viburnum dentatum	arrowwood	17%	700
Native Herbaceous Species			
Agrostis alba	redtop	10%	NA
Andropogon gerardii	big bluestem	5%	NA
Bidens frondosa	devil's beggartick	5%	NA
Coreopsis lanceolata	lanceleaf tickseed	10%	NA
Dichanthelium clandestinum	deertongue	15%	NA
Elymus virginicus	Virginia wild rye	15%	NA
Juncus effusus	soft rush	5%	NA
Panicum virgatum	switchgrass	15%	NA
Polygonum pennsylvanicum	Pennsylvania smartweed	5%	NA
Schizachyrium scoparium	little bluestem	5%	NA
Sorghastrum nutans	Indiangrass	5%	NA
Tripsacum dactyloides	eastern gamagrass	5%	NA
Woody Vegetation for Live Stakes			
Cornus amomum	silky dogwood	30%	2,100
Salix sericia	silky willow	30%	2,100
Salix nigra	black willow	10%	700
Sambucus canadensis	elderberry	30%	2,100

3.1.3 Vegetative Observations and Results

Permanent ground cover has been successfully established at the Site through the planting of the permanent seed mixture planted at the Site, as observed during Year 1 monitoring of the Site.

Tables A.1 through A.6 in Appendix A present vegetation metadata, vegetation vigor, vegetation damage and stem count data for the monitoring stations at the end of Year 4 monitoring. Data from Year 1 monitoring for the 13 vegetation plots exhibited a range of 728 to 1,052 stems per acre. The data show that the Site had an average survivability of 878 stems per acre following Year 1 monitoring. In comparison, following as-built conditions, the Site demonstrated an average survivability of 915 stems per acre.

Trees within each monitoring plot are re-flagged regularly to prevent planted trees from losing their identifying marks due to flag degradation. It is important for trees within the monitoring plots to remain marked to ensure they are all accounted for during the annual stem counts and calculation of tree survivability. Labeled aluminum tags with wire hangers are used on surviving stems to aid in relocation during future counts. The aluminum tags are removed from each stem once the tree becomes established and is recognizable by species during plot monitoring. Flags are also used to mark trees because they do not interfere with the growth of the tree.

All plots will continue to be assessed during Year 2 monitoring for occurrence of volunteer species.

3.1.4 Vegetative Problem Areas

During Year 1 monitoring, kudzu (*Pueraria montana*) was observed on the Site in the vicinity of vegetation Plot 13. This concentration of kudzu is located on the upstream portion of Reach M1, downstream of River-Siloam road. This area of kudzu was previously treated during construction. This area of kudzu is scheduled to be treated again during the appropriate time(s) in 2013.

There are relatively few weedy species occurring on the Site, and none of the on-site species seem to be posing any issues for the planted woody or herbaceous hydrophytic vegetation at this time.

3.1.5 Vegetation Photographs

Photographs are used to visually document vegetation plot success. A total of 13 reference stations were established to document tree conditions at each vegetation plot across the Site. Reference photos of tree plots are taken at least once per year. Photos of the tree plots for Year 1 monitoring that show the on-site planted stems are included in Appendix A of this report.

3.2 Stream Assessment

3.2.1 Morphometric Success Criteria

To document the stated success criteria, the following monitoring program was instituted following construction completion on the Site:

Cross-sections: Two permanent cross-sections were installed per 1,000 LF of stream restoration work, with one of the locations being a riffle cross-section and one location being a pool cross-section in each series. A total of 10 permanent cross-sections were established across the Site. Each cross-section was marked on both banks with permanent pins to establish the exact transect used. The permanent cross-section pins are surveyed and located relative to a common benchmark to facilitate easy comparison of year-to-year data. The annual cross-section surveys include points measured at all breaks in slope, including top of bank, bankfull, inner berm, edge of water, and thalweg.

The approved Mitigation Plan requires the following criteria be met to achieve stream restoration success:

- There should be little change in as-built cross-sections
- If changes do take place, they will be evaluated to determine if they represent a movement toward a more unstable condition (e.g., down-cutting or erosion) or a movement toward increased stability (e.g., settling, vegetative changes, deposition along the banks, or decrease in width/depth ratio)
- Cross-sections will be classified using the Rosgen Stream Classification System (Rosgen, 1994), and all monitored cross-sections should fall within the quantitative parameters defined for channels of the design stream type.

Longitudinal Profiles: A complete longitudinal profile was surveyed following construction completion to record as-built conditions and to establish a baseline profile. The profile was conducted for the entire length of each restored channel for all reaches. Measurements included thalweg, water surface, inner berm, bankfull, and top of low bank. Each of these measurements was taken at the head of each feature (e.g., riffle, pool, and glide). In addition, maximum pool depth was recorded. All surveys were tied to a single, permanent benchmark.

The approved Mitigation Plan requires the following criteria be met to achieve stream restoration success:

- A longitudinal profile will be completed annually for the five-year monitoring period
- The profile will be conducted for 3,000 LF of restored Candiff Creek channel
- The longitudinal profiles should show that the bedform features are remaining stable; i.e., they are not aggrading or degrading
- Pools should remain deep, with flat water surface slopes, and the riffles should remain steeper and shallower than the pools
- Bedforms observed should be consistent with those observed for channels of the designed stream type.

3.2.2 Morphometric Results

Year 1 cross-section monitoring data for stream stability was completed during October 2012. The 10 permanent cross-sections along the restored channels (5 located across riffles and 5 located across pools) were re-surveyed to document stream dimension at the end of Monitoring Year 1. Data from each of these cross-sections are presented in Appendix B.

Cross-sections 1, 4, 6, 8 and 10 are situated across riffles that are located between pools. Based on the survey data, Cross-sections 6, 8 and 10, located on the mid-downstream portion of M3, showed relatively little change since as-built conditions. Cross-sections 1 and 4 are located on the upstream portion of M3 and demonstrated minor fluctuations in riffle dimensions during the first year of monitoring. Cross-sections 1 and 4 appear to have aggraded in channel dimension slightly since as-built conditions. The left bank of Cross-section 1 also appears to have increased in elevation. It is likely that the changes observed in Cross-sections 1 and 4, both at riffles, are due to the spring rains which also marked the highest bankfull readings for Year 1 monitoring. These two cross-sections will be closely observed during Year 2 monitoring.

Cross-sections 2, 3, 5, 7 and 9 are situated across pools which are located at the apex of meander bends. Based on the survey data, Cross-sections 2, 3 and 5 have shown relatively little change since as-built conditions. However, Cross-sections 7 and 9 have demonstrated minor fluctuations in pool dimensions since as-built conditions. Cross-sections 7 and 9 are located on the downstream portion of M3 and appear to have aggraded slightly since as-built conditions. It is likely that the morphological changes observed in Cross-sections 7 and 9, both at pools, are also due to the spring rains. Based on the Year 4 monitoring survey data, all pool cross-sections show the slow development of point bar features on the inside banks of the meander bends.

The longitudinal profile for Year 1 monitoring was completed in October 2012. The Year 1 monitoring data were compared to the data collected during the as-built condition survey completed in April 2012. During Year 1 monitoring, the longitudinal profile survey was only completed for Reach M3. A total stream length of 3,674 LF was surveyed for M3. The longitudinal profiles for these reaches are presented in Appendix B.

Year 1 monitoring data for the M3 longitudinal profile indicate that the riffles in this reach have essentially maintained the same bed elevations since as-built conditions. However, some pools in M3 have continued to increase in depth since as-built conditions. It is noted that increased pool depths were observed mostly in the middle of portion of M3. The deeper pools in M3 are providing increased channel stability while promoting greater habitat diversity. It is likely that the morphological changes observed in Cross-sections 7 and 9, both at pools, are again attributed to the spring rains. Overall, the longitudinal profile for M3 demonstrates that the in-stream structures within the reach are stable and functioning as designed.

In-stream structures installed within the restored stream included constructed riffles, log vanes, grade control rock and log j-hook vanes, rock cross vanes, root wads and stream crossings. Visual observations of these structures throughout Year 1 monitoring indicated that all structures are functioning as designed and holding their post-construction grade. Structures that were installed to develop deep pools, such as cross vanes and j-hooks, are performing their designed functions. Log vanes placed in meander pool areas have provided scour to keep pools deep and provide cover for fish. J-hooks placed in lower end of the riffle areas have maintained riffle elevations and provided downstream scour holes that provides aquatic habitat. Root wads placed on the outside of meander bends have provided bank stability and in-stream cover for fish and other aquatic organisms.

3.2.3 Hydrologic Criteria

One crest gauge was installed on the Site to document bankfull events. The gauge is checked during each site visit and records the stage of the highest out-of-bank flow between site visits. The gauge is located on the left bank on the downstream portion of M3 at station 55+50.

The approved Mitigation Plan requires the following criteria be met to achieve stream restoration success: Two bankfull flow events must be documented within the five-year monitoring period. The two bankfull events must occur in separate years, otherwise, the stream monitoring will continue until two bankfull events have been documented in separate years.

3.2.4 Hydrologic Monitoring Results

According to the on-site crest gauge, the Site experienced at least one bankfull flow event during Year 1monitoring. The largest on-site bankfull flow event documented at the UT1 crest gauge during Year 1 monitoring, occurred in April-May 2012. It is estimated that the stage of the highest flow at the M3 crest gauge during April-May 2012 was approximately 1.60 feet above bankfull stage. Following the April-May 2012 storm events, the crest gauge on M3 did not document additional out of channel bankfull flows for the remainder of Year 1 monitoring.

Crest gauge readings are presented in Table 6 and photos of the crest gauges and out-of-bank evidence are presented in Appendix B.

Table 6. Verification of Bankfull Events

Candiff Creek Restoration Project: Project No. 92767

Date of Data Collection	Estimated Occurrence of Bankfull Event	Method of Data Collection	M3 Crest (feet)
4/18/2012	Gauge Installed	Crest Gauge	N/A
5/22/2012	April-May 2012 storms	Crest Gauge	1.60

3.2.5 Stream Problem Areas

During Monitoring Year 1, there were no stream problem areas observed at the Site.

3.2.6 Stream Photographs

Photographs are used to document restoration success visually. A total of 59 reference stations were installed and photographed after construction. Photographs of these reference stations will be collected for at least five years following construction. Reference photos are taken at least twice per year, and are taken in enough locations to document the condition of the restored system. Permanent markers were established to ensure that the same locations (and view directions) on the Site are documented in each monitoring period.

The stream systems are photographed longitudinally, beginning at the downstream portion of the restoration reaches, and moving upstream to the beginning of the reaches. Photographs are taken looking upstream at designated locations. Reference photo locations are marked and described for future reference. Points are spaced sufficiently close to provide an overall view of the reach. The angle of the photograph depends on which direction provides the best view and is noted and will be continued for future photos. When modifications to photo position and/or direction are made due to obstructions or other reasons, the modified photo position and/or direction is noted, along with any landmarks. The same position is used in the future.

Additional photographs are taken to document any observed evidence of flooding patterns such as debris, wrack lines, water marks, channel features, etc.

Also, both stream banks are photographed at all permanent cross-section photo stations. For each stream bank photo, the photo view line follows a survey tape placed across the channel, perpendicular to flow (representing the cross-section line). The photograph is framed so that the survey tape is centered in the photo (appears as a vertical line at the center of the photograph), keeping the channel water surface line horizontal and near the lower edge of the frame. In each cross-section photo showing the left bank, flow is moving to right. Conversely, in each cross-section photo showing the right bank, flowing is moving to the left.

A photo log of the restored channel is presented in the attached CD of this report. Photos for each of the 10 permanent cross-sections are included in Appendix B.

Photographs of the restored channel were taken in October 2012 to document the evolution of the stream geometry. Herbaceous vegetation and shrubs were dense along the banks of M2 and M3, making the photography of some of the stream channel areas difficult.

3.2.7 Stream Stability Assessment

Table B.1 provides a summary of the results obtained from the visual inspection of in-stream structures performed during Year 1 monitoring. The percentages noted are a general, overall field evaluation of the how the features were performing at the time of the photo point survey. According to the visual stability assessment following Year 1 monitoring, and after a visual evaluation throughout 2012, it was determined that all features at the Site are currently performing as designed. However, it is noted that the pool in Cross-section 7 has aggraded slightly. This pool will be closely observed during Year 2 monitoring and future site visits.

3.2.8 Quantitative Measures Summary Tables

The quantitative pre-construction, reference reach, and design data used to determine restoration approach, as well as the as-built baseline data used during the project's post construction monitoring period are summarized in Appendix B.

4.0 OVERALL CONCLUSIONS AND RECOMMENDATIONS

Stream Monitoring - The total length of stream channel restored on the Site was 4,123 LF. This entire length was inspected during Year 1 monitoring to assess stream performance. Year 1 monitoring did not reveal any significant problem areas within the boundaries of the Site.

Cross-section monitoring data for stream stability were collected during Year 1 monitoring. A longitudinal profile survey was also completed during Year 1 monitoring for approximately 3,674 LF of stream on the Site. The longitudinal profile was completed for Reach M3 only. Year 1 monitoring data for the M3 longitudinal profile show that the riffles in this reach have maintained relatively the same bed elevations since as-built conditions. The longitudinal profile demonstrates that the in-stream structures within M3 are stable and functioning as designed.

The cross-sectional data and the longitudinal profile indicate that Reach M3 is stable and functioning as designed.

According to the on-site crest gauge, the Site experienced at least one bankfull or greater flow event during Year 1 monitoring. The largest on-site bankfull flow event documented by the M3 crest gauge during Year 1 monitoring occurred approximately in April-May 2012. It was estimated that the stage associated with these flows at the M3 crest gauge during this period was approximately 1.60 feet above bankfull stage. Inspection of conditions during a spring site visit revealed visual evidence of out-of-bank flows.

Vegetation Monitoring - Data from Year 1 monitoring for the 13 vegetation plots exhibited a range of 728 to 1,052 stems per acre. The data showed that the Site had an average of survivability of 878 stems per acre.

During Year 1 vegetation monitoring, kudzu was observed on the Site in the vicinity of vegetation Plot 13. This concentration of kudzu is located on the upstream portion of Reach M1, downstream of River-Siloam road. This area of kudzu was previously treated during construction. This area is scheduled to be treated again in 2013 during appropriate treatment window(s).

According to the Year 1 vegetative monitoring data, the Site is on track to meet the interim success criteria of 320 stems per acre by the end of Year 3 monitoring.

5.0 WILDLIFE OBSERVATIONS

Observations of deer and raccoon tracks are common at the Site. During Year 1 monitoring, many small animals such as snakes, frogs and rodents were periodically observed. Various songbirds and birds of prey were observed on the Site throughout Year 1 monitoring. Wild turkeys are also commonly observed in the area.

6.0 REFERENCES

Rosgen, D. L. 1994. *A Classification of Natural Rivers*. Catena 22: 169-199.

Cowardin, L. M., V. Carter, F. C. Golet, E. T. LaRoe. 1979. Classification of wetlands and deepwater habitats of the United States. U.S. Department of the Interior, Fish and Wildlife Service, Washington, D.C

USDA, Natural Resource Conservation Service, *Soil Survey of Surry County*, North Carolina, 2007.

FIGURES

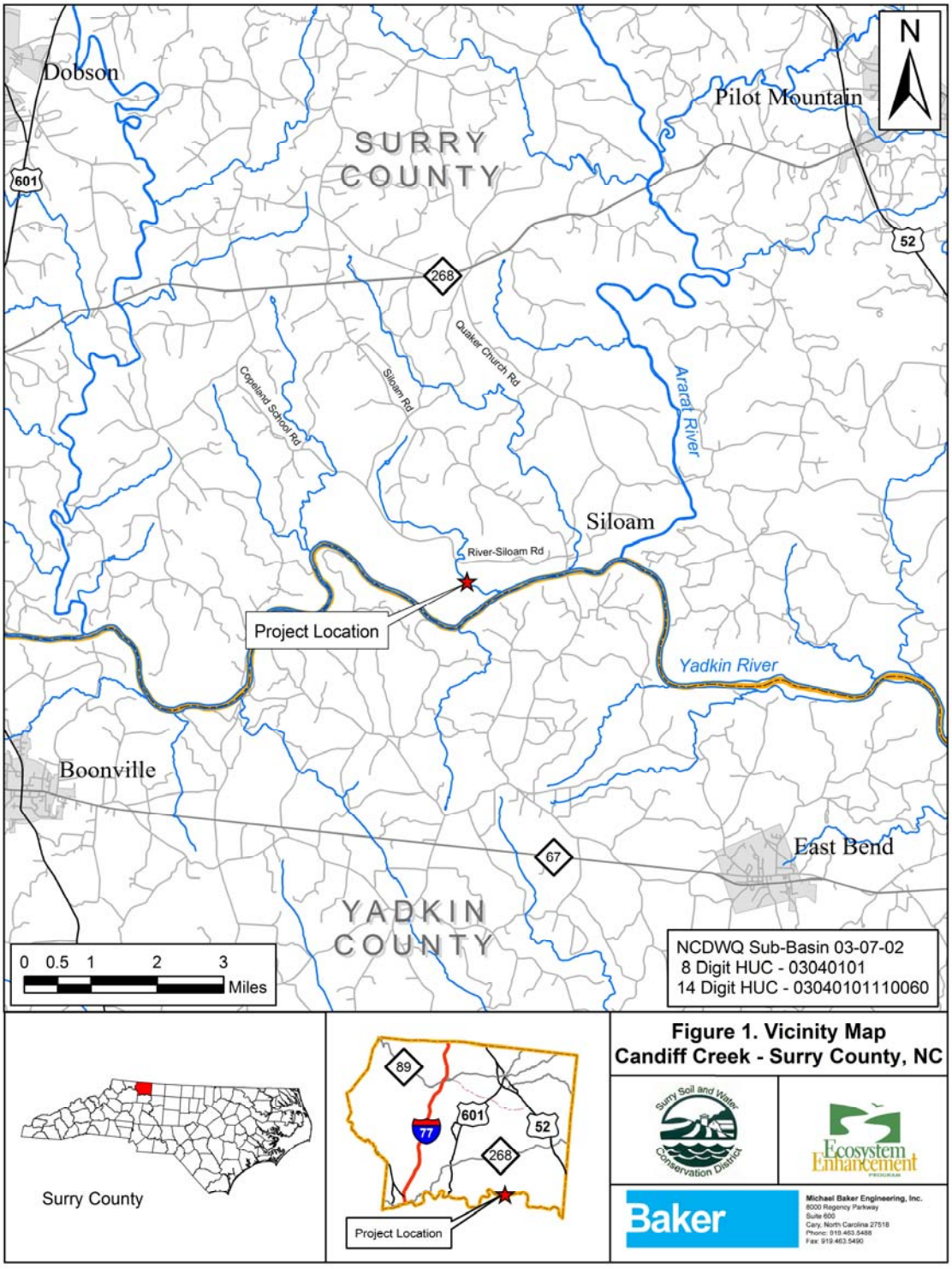


Figure 1. Vicinity Map of Candiff Creek Restoration Project.

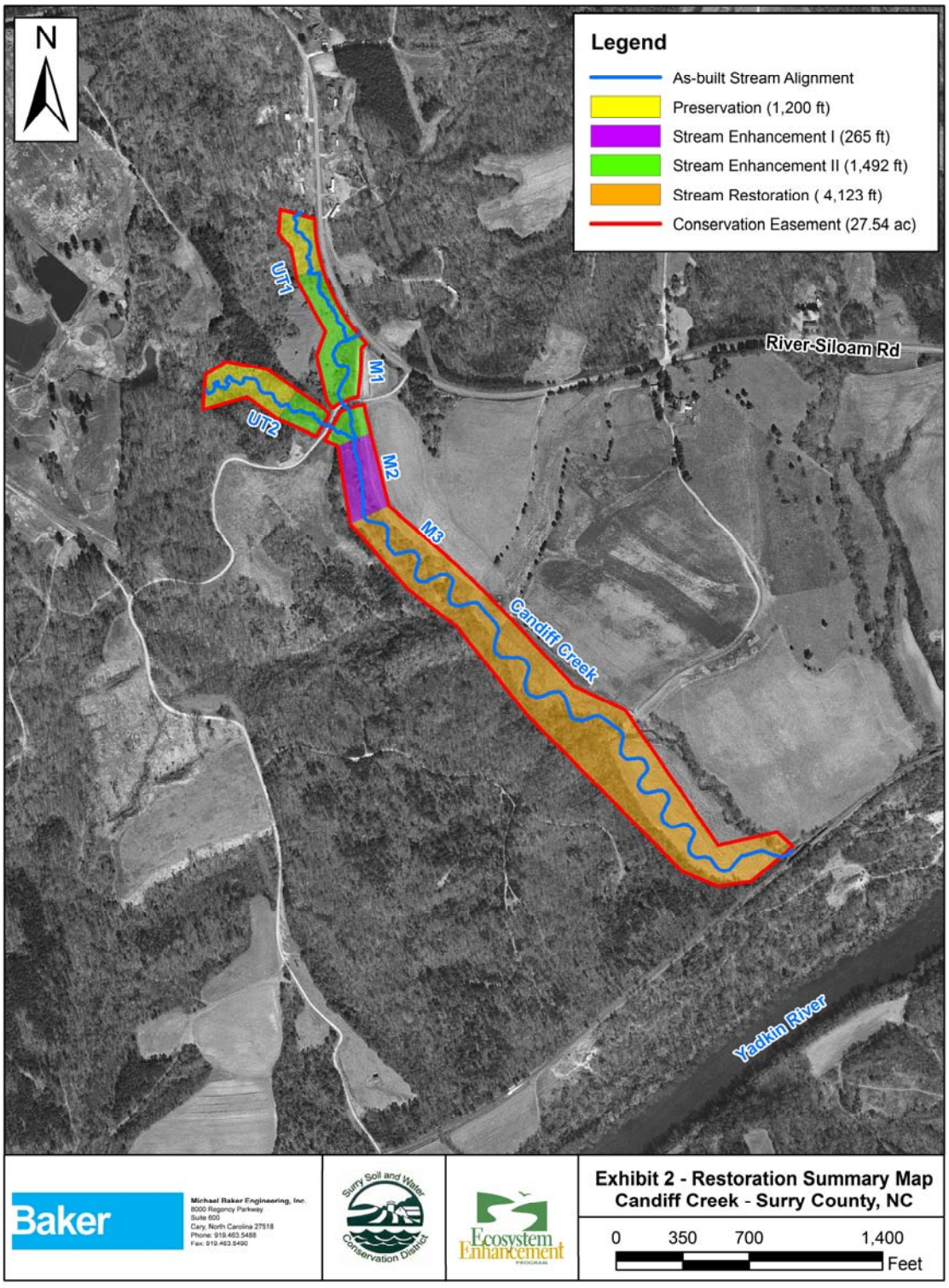


Figure 2. Summary Map of Candiff Creek Restoration Project.

STATE	BAKER PROJECT REFERENCE NO.	SHEET NO.	TOTAL SHEETS
NC	118335	1	7

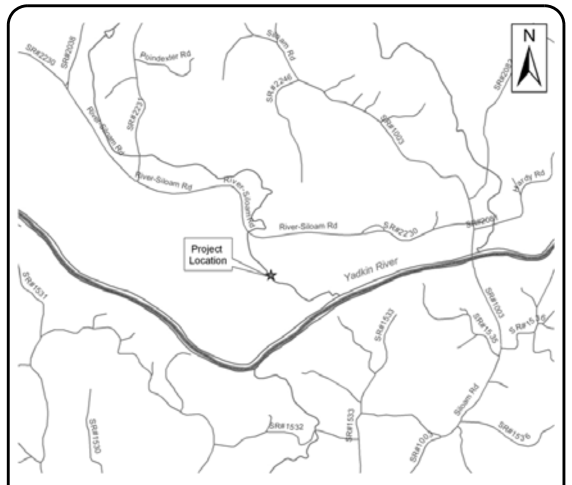
PROJECT: 118335 CANDIFF CREEK

NORTH CAROLINA ECOSYSTEM ENHANCEMENT PROGRAM

SURRY COUNTY

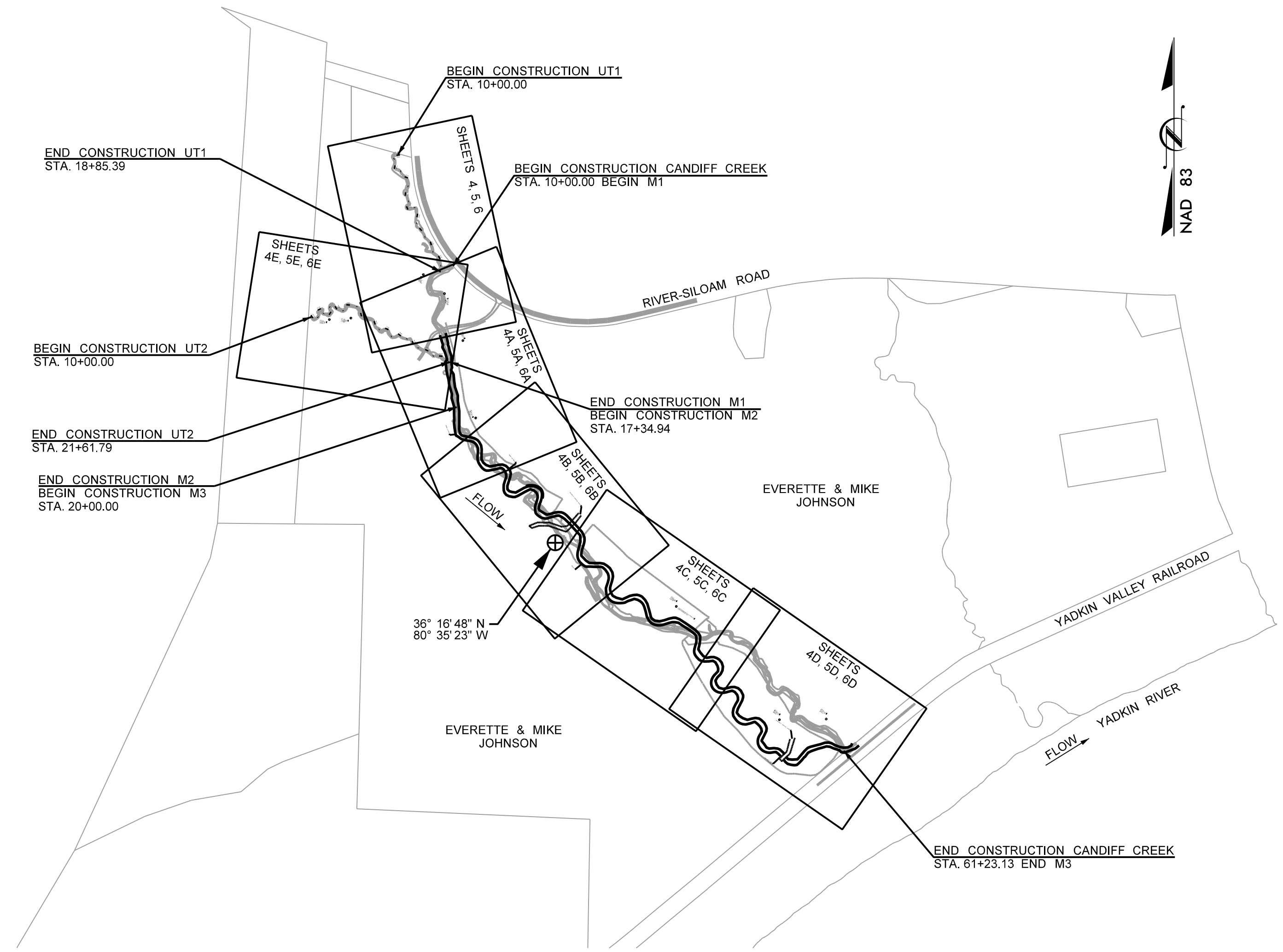
LOCATION: ON THE JOHNSON PROPERTY NEAR SILOAM, NC OFF RIVER–SILOAM ROAD

TYPE OF WORK: AS–BUILT PLANS FOR STREAM RESTORATION, ENHANCEMENT, AND PRESERVATION



VICINITY MAP

INDEX OF SHEETS



DATUM DESCRIPTION:

NORTH CAROLINA GRID COORDINATES (NAD83) FOR PRIMARY GPS DERIVED CONTROL POINTS WERE ESTABLISHED FOR MICHAEL BAKER ENGINEERING INC. CARY, NC.

SUPPLEMENT CONTROL POINTS (NAD83) UTILIZED FOR THIS SURVEY WERE ESTABLISHED BY MICHAEL BAKER ENGINEERING USING CONVENTIONAL METHODS.

FIGURE 3A

GRAPHIC SCALES

40 20 0 40 80
PLANS

50 25 0 50 100
PROFILE (HORIZONTAL)

5 0 5 10
PROFILE (VERTICAL)

PROJECT LENGTH

	CANDIFF	UT1	UT2
EXISTING REACH LENGTH =	4,783	885	1,117
DESIGN REACH LENGTH =	5,064	885	1,117
AS–BUILT REACH LENGTH =	5,078	885	1,117

PREPARED FOR THE OFFICE OF:

Ecosystem Enhancement PROGRAM

JULIE CAHILL
PROJECT MANAGER

SUBMITTED BY THE OFFICE OF:

Surry Soil and Water Conservation District

TONY DAVIS
PROJECT MANAGER

PREPARED IN THE OFFICE OF:

Baker
Michael Baker Engineering Inc.
8000 Regency Parkway, Suite 600
Cary, NORTH CAROLINA 27518
Phone: 919.463.5488
Fax: 919.463.5490
License #: F-1084

APRIL 2012
COMPLETION DATE:

WILLIAM SCOTT HUNT III, PE
PROJECT ENGINEER

JOSHUA WHITE, PG, PE
PROJECT MANAGER /GEOMORPHOLOGIST

PROJECT ENGINEER

THIS DOCUMENT ORIGINALLY ISSUED AND SEALED BY:

WILLIAM KENT
L-3708
JUNE 5, 2012

THIS MEDIA SHALL NOT BE CONSIDERED A CERTIFIED DOCUMENT

P.E.

SIGNATURE:

2/26/03

BAKER PROJECT REFERENCE NO.	SHEET NO.
118335	3B

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Cary, NORTH CAROLINA 27518
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FIGURE 3B

BEGIN CONSTRUCTION CANDIFF CREEK
STA. 10+00.00 = BEGIN CONSTRUCTION M1

BEGIN CONSTRUCTION UT1
STA. 10+00.00

END CONSTRUCTION UT1
STA. 18+85.39

RIVER - SILOAM ROAD

BILLY M. & KATHY LOU WALL

EVERETTE & MIKE JOHNSON

EVERETTE & MIKE JOHNSON

VEGPLOT #13

BCP 16
X=1530614.51
Y=926124.38
Z=827.14

BCP 14
X=1530494.61
Y=926231.76
Z=826.41

MATCHLINE SHEET 5A STA. 14+00.00

NAD 83

NOTE:
CONTOURS SHOWN ARE PRE-RESTORATION CONTOURS.

AS-BUILT PLAN VIEW

40 20 0 40 80
SCALE (FT)

9/17/2012
R:\118335_Candiff\Design\as-built\monitoring\118335_ Candiff_FIGURE_3B.dgn

2/26/03

BAKER PROJECT REFERENCE NO.	SHEET NO.
118335	3C

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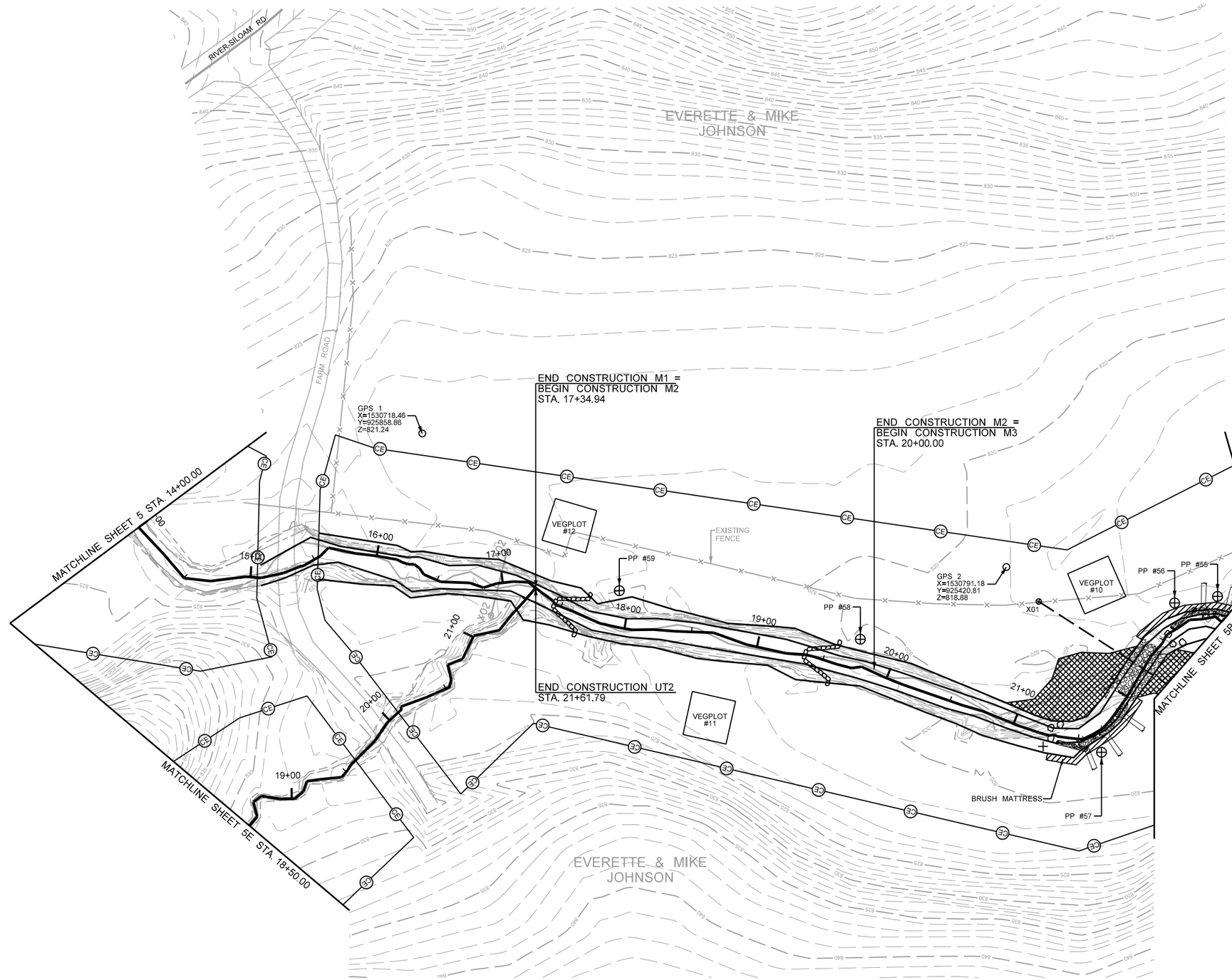
FIGURE 3C



PLUGGED DITCH

FILLED EXISTING DITCH

NOTES:
CONTOURS SHOWN ARE PRE-RESTORATION CONTOURS.

AS-BUILT PLAN VIEW

40 20 0 40 80
SCALE (FT)

9/17/2012
R:\118335_Cardiff\Design\as-built\monitoring\118335_ Cardiff_FIGURE_3C.dgn

BAKER PROJECT REFERENCE NO.	SHEET NO.
118335	3D

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FIGURE 3D

NAD 83

EVERETTE & MIKE JOHNSON

EMERGENCY LIVESTOCK ACCESS

EXISTING FENCE

BRUSH MATTRESS

MATCHLINE SHEET 5A STA. 23+00.00

MATCHLINE SHEET 5C STA. 37+00.00

VEGPLOT #8

VEGPLOT #7

VEGPLOT #9

GEOLIFT

PP #35 PP #36 PP #37 PP #38 PP #39 PP #40 PP #41 PP #42 PP #43 PP #44 PP #45 PP #46 PP #47 PP #48 PP #49 PP #50 PP #51 PP #52 PP #53 PP #54

X01 X02 X03 X04 X05

23+00 24+00 26+00 28+00 29+00 30+00 31+00 32+00 33+00 34+00 35+00 36+00 37

PLUGGED DITCH

FILLED EXISTING DITCH

NOTE:
CONTOURS SHOWN ARE PRE-RESTORATION CONTOURS.

AS-BUILT PLAN VIEW

40 20 0 40 80
SCALE (FT)

2/26/03

9/17/2012
P:\118335_Candiff\Design\as-built\monitoring\118335_ Candiff_FIGURE_3D.dgn

2/26/03

BAKER PROJECT REFERENCE NO.	SHEET NO.
118335	3E

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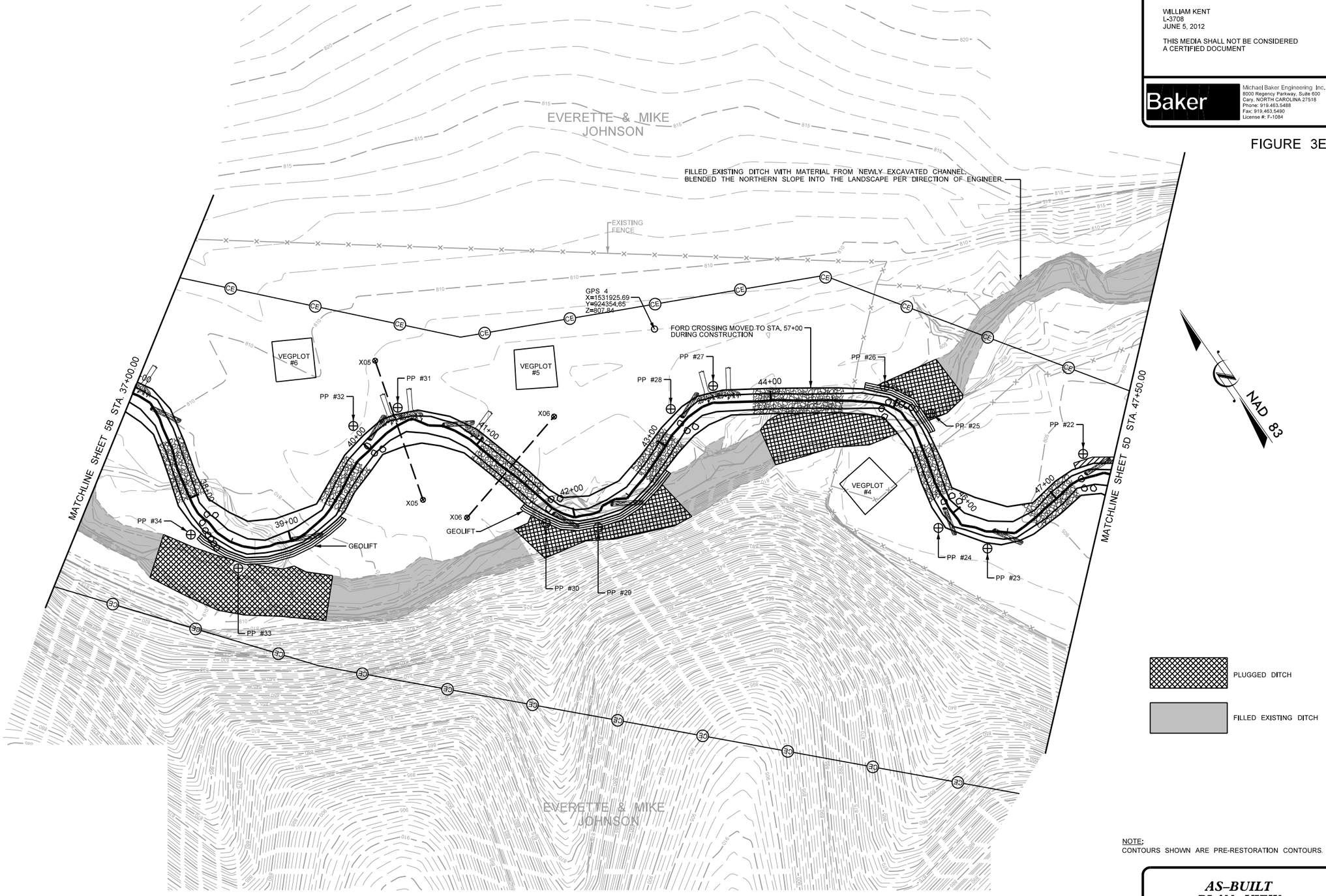
FIGURE 3E



NOTE:
CONTOURS SHOWN ARE PRE-RESTORATION CONTOURS.

AS-BUILT PLAN VIEW

40 20 0 40 80
SCALE (FT)

9/17/2012
R:\118335_Cardiff\Design\as-built\monitoring\118335_ Cardiff_FIGURE_3E.dgn

BAKER PROJECT REFERENCE NO.	SHEET NO.
118335	3F

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FIGURE 3F

NAD 83

EVERETTE & MIKE JOHNSON

FILLED EXISTING DITCH WITH MATERIAL FROM NEWLY EXCAVATED CHANNEL. BLENDED THE NORTHERN SLOPE INTO THE LANDSCAPE PER DIRECTION OF ENGINEER.

BCP 32
X=1532773.38
Y=923717.68
Z=811.01

END CONSTRUCTION CANDIFF CREEK M3
STA. 61+23.13

MATCHLINE SHEET 5C STA. 47+50.00

X07
PP #21
48+00
PP #18
PP #17
VEGPLOT #3
51+00
X07
50+00
49+00
PP #20
PP #19
X08
X08
PP #14
PP #13
54+00
52+00
53+00
PP #16
PP #15
PP #12
PP #11
PP #30
CREST GAUGE
55+00
PP #9
PP #10
56+00
57+00
PP #8
X09
58+00
GEOLIFT
PP #7
X09
PERMANENT FORD CROSSING
EXISTING FENCE
GPS 6
X=1532508.71
Y=923713.58
Z=802.46
EMERGENCY LIVESTOCK ACCESS
PP #1
PP #2
PP #3
PP #4
61+00
60+00
X10
VEGPLOT #2
PP #5
59+00
X10
PP #6
VEGPLOT #1
KANNAPOLIS - YADKIN VALLEY RAILROAD RIGHT-OF-WAY
KANNAPOLIS - YADKIN VALLEY RAILROAD RIGHT-OF-WAY
EVERETTE & MIKE JOHNSON

PLUGGED DITCH
FILLED EXISTING DITCH

NOTE:
CONTOURS SHOWN ARE PRE-RESTORATION CONTOURS.

AS-BUILT PLAN VIEW

40 20 0 40 80
SCALE (FT)

9/17/2012
R:\118335_Candiff\Design\as-built\monitoring\118335_ Candiff_FIGURE_3F.dgn

2/26/03

BAKER PROJECT REFERENCE NO.	SHEET NO.
118335	3G

PROJECT ENGINEER

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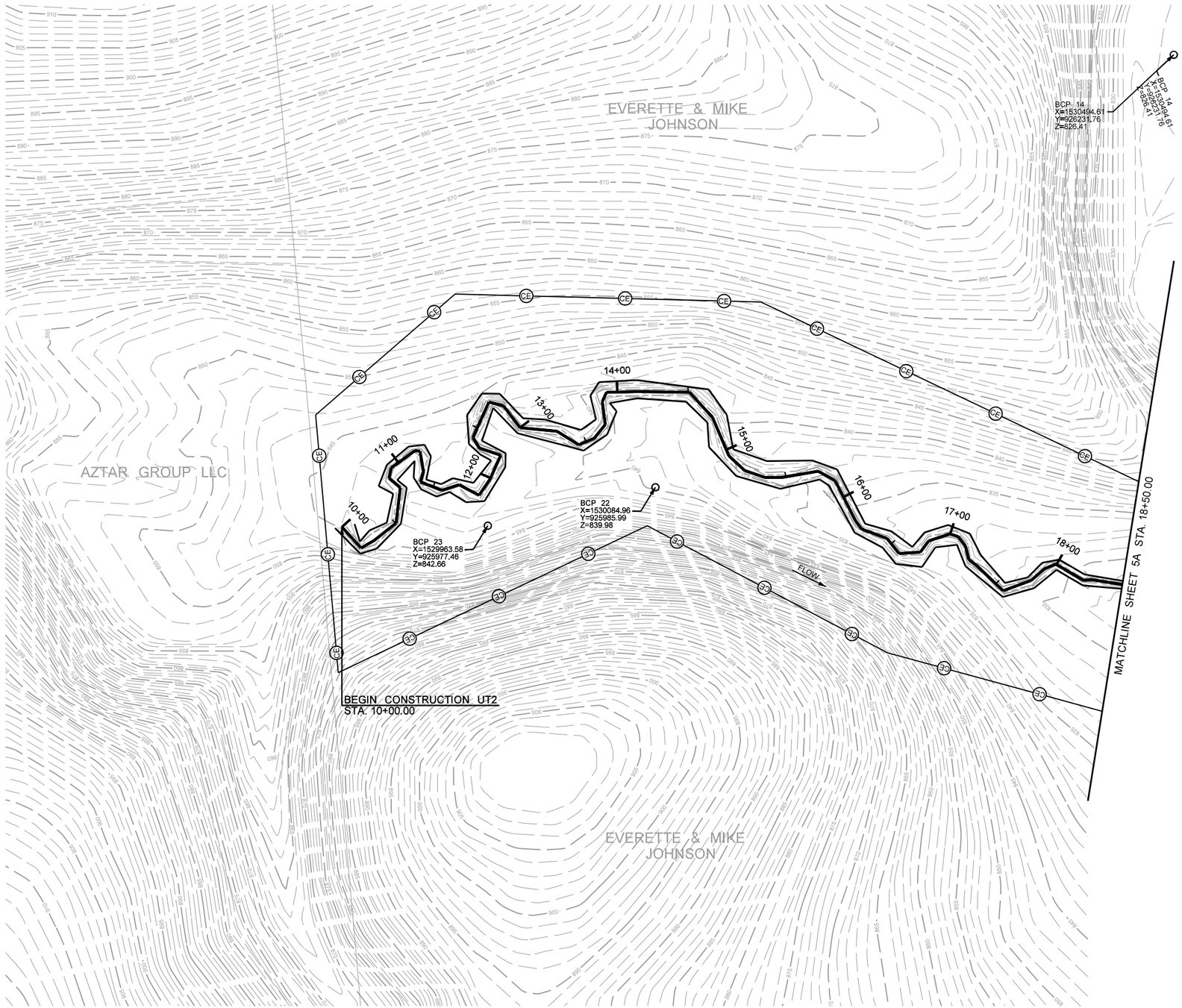
FIGURE 3G



NOTE:
CONTOURS SHOWN ARE PRE-RESTORATION CONTOURS.

AS-BUILT PLAN VIEW

40 20 0 40 80
SCALE (FT)

9/17/2012
R:\118335_Candiff\Design\as-built\monitoring\118335_ Candiff_FIGURE_3G.dgn

APPENDIX A

VEGETATION DATA

VEGETATION TABLES

Table A.1. Vegetation Metadata

Candiff Creek Restoration Project: Project No. 92767	
Report Prepared By	Dwayne Huneycutt
Date Prepared	11/12/2012 16:17
database name	cvs-eep-entrytool-v2.3.1.mdb
database location	L:\Monitoring\Veg Plot Info\CVS Data Tool\Candiff
computer name	CARYLDHUNEYCUTT
file size	60329984
DESCRIPTION OF WORKSHEETS IN THIS DOCUMENT----------	
Metadata	Description of database file, the report worksheets, and a summary of project(s) and project data.
Proj, planted	Each project is listed with its PLANTED stems per acre, for each year. This excludes live stakes.
Proj, total stems	Each project is listed with its TOTAL stems per acre, for each year. This includes live stakes, all planted stems, and all natural/volunteer stems.
Plots	List of plots surveyed with location and summary data (live stems, dead stems, missing, etc.).
Vigor	Frequency distribution of vigor classes for stems for all plots.
Vigor by Spp	Frequency distribution of vigor classes listed by species.
Damage	List of most frequent damage classes with number of occurrences and percent of total stems impacted by each.
Damage by Spp	Damage values tallied by type for each species.
Damage by Plot	Damage values tallied by type for each plot.
Planted Stems by Plot and Spp	A matrix of the count of PLANTED living stems of each species for each plot; dead and missing stems are excluded.
PROJECT SUMMARY----------	
Project Code	92767
project Name	Candiff
Description	Stream and Buffer Restoration
River Basin	Yadkin-Pee Dee
length(ft)	
stream-to-edge width (ft)	
area (sq m)	
Required Plots (calculated)	
Sampled Plots	13

Table A.2. Vegetation Vigor by Species

Candiff Creek Restoration Project: Project No. 92767								
	Species	**4**	**3**	**2**	**1**	**0**	**Missing**	**Unknown**
	Asimina triloba		1					
	Betula nigra	35	21	3				
	Cornus amomum	10	15	2				
	Diospyros virginiana	10	15	11				
	Fraxinus pennsylvanica	5	4					
	Quercus michauxii	16	11	2	1			
	Quercus phellos	4	5	1				
	Sambucus canadensis		2					
	Viburnum dentatum	2						
	Carpinus caroliniana	5	4					
	Cercis canadensis	2	9	3				
	Ulex					1		
	Quercus rubra	1	4	1				
	Liriodendron tulipifera	3	2	1				
	Platanus occidentalis	34	26	6				
	Unknown		2	1	2	12	3	
TOTAL	**16**	**127**	**121**	**31**	**3**	**13**	**3**	

Table A.3. Vegetation Damage by Species

Candiff Creek Restoration Project: Project No. 92767							
	Species	Common Name	Count of Damage Categories	No Damage	Rodents	Unknown	
	Asimina triloba	pawpaw	0	1			
	Betula nigra	river birch	3	56	2	1	
	Carpinus caroliniana	American hornbeam	0	9			
	Cercis canadensis	eastern redbud	1	13		1	
	Cornus amomum	silky dogwood	0	27			
	Diospyros virginiana	common persimmon	0	36			
	Fraxinus pennsylvanica	green ash	3	6	3		
	Liriodendron tulipifera	tuliptree	0	6			
	Platanus occidentalis	American sycamore	6	60	6		
	Quercus michauxii	swamp chestnut oak	1	29	1		
	Quercus phellos	willow oak	0	10			
	Quercus rubra	northern red oak	0	6			
	Sambucus canadensis	Common Elderberry	0	2			
	Ulex	gorse	0	1			
	Unknown	N/A	6	14		6	
	Viburnum dentatum	southern arrowwood	0	2			
TOTAL	**16**	**15**	**20**	**278**	**12**	**8**	

Table A.4. Vegetation Damage by Plot

Candiff Creek Restoration Project: Project No. 92767						
	Plot	Count of Damage Categories	No Damage	Rodents	Unknown	
	92767-01-0001	0	26			
	92767-01-0002	1	24		1	
	92767-01-0003	3	20	1	2	
	92767-01-0004	0	24			
	92767-01-0005	9	14	8	1	
	92767-01-0006	2	17	1	1	
	92767-01-0007	0	22			
	92767-01-0008	2	19		2	
	92767-01-0009	0	19			
	92767-01-0010	0	21			
	92767-01-0011	2	23	2		
	92767-01-0012	1	24		1	
	92767-01-0013	0	25			
TOTAL	**13**	**20**	**278**	**12**	**8**	

Table A.5. Planted Stems by Plot and Species

Candiff Creek Restoration Project: Project No. 92767

	Comment	Species	SpType	CommonName	Total Planted Stems	# of Plots	Average # of Stems	Plot 92767-01-0001	Plot 92767-01-0002	Plot 92767-01-0003	Plot 92767-01-0004	Plot 92767-01-0005	Plot 92767-01-0006	Plot 92767-01-0007	Plot 92767-01-0008	Plot 92767-01-0009	Plot 92767-01-0010	Plot 92767-01-0011	Plot 92767-01-0012	Plot 92767-01-0013
		Asimina triloba	Shrub Tree	pawpaw	1	1	1										1			
		Betula nigra	Tree	river birch	59	12	4.92	12	3	5	4	7	1	3	5	10	7		1	1
		Carpinus caroliniana	Shrub Tree	American hornbeam	9	4	2.25	2				1					4		2	
		Cercis canadensis	Shrub Tree	eastern redbud	14	5	2.8				9		2		1		1			1
		Cornus amomum	Shrub	silky dogwood	27	7	3.86	1	4	6			4	7					3	2
		Diospyros virginiana	Tree	common persimmon	36	11	3.27		4	1	2	3		5	5	1	1	9	4	1
		Fraxinus pennsylvanica	Tree	green ash	9	8	1.12		1	1		1		2		1		1	1	1
		Liriodendron tulipifera	Tree	tuliptree	6	2	3								1				5	
		Platanus occidentalis	Tree	American sycamore	66	11	6	10	1	5	5	7	6	1		4		10	7	10
		Quercus michauxii	Tree	swamp chestnut oak	30	9	3.33		4	2	2	2	3	3	5		6	3		
		Quercus phellos	Tree	willow oak	10	4	2.5		7	1			1			1				
		Quercus rubra	Tree	northern red oak	6	1	6													6
		Sambucus canadensis	Shrub Tree	Common Elderberry	2	2	1	1					1							
		Unknown	unknown		5	4	1.25				1				1	2	1			
		Viburnum dentatum	Shrub Tree	southern arrowwood	2	2	1							1	1					
TOTAL	**0**	**15**	**15**	**14**	**282**	**15**		**26**	**24**	**21**	**23**	**21**	**18**	**22**	**19**	**19**	**20**	**24**	**23**	**22**

Table A.6. Plot Species and Densities

Candiff Creek Restoration Project: Project No. 92767

Tree Species	Plots													Year 1 Totals	
	1	2	3	4	5	6	7	8	9	10	11	12	13		
Betula nigra	12	3	5	4	7	1	3	5	10	7		1	1	59	
Diospyros virginiana		4	1	2	3		5	5	1	1	9	4	1	36	
Fraxinus Pennsylvanica		1	1		1		2		1		1	1	1	9	
Liriodendron tulipifera								1				5		6	
Platanus occidentalis	10	1	5	5	7	6	1		4		10	7	10	66	
Quercus michauxii		4	2	2	2	3	3	5		6	3			30	
Quercus phellos		7	1			1			1					10	
Quercus rubra													6	6	
Unknown				1				1	2	1				5	**Yearly Average Stems/acre**
Shrub Species															
Asimina triloba											1			1	
Carpinus caroliniana	2				1					4		2		9	
Cercis canadensis				9		2		1		1			1	14	
Cornus amomum	1	4	6			4	7					3	2	27	
Lindera benzoin														0	
Sambucus canadensis	1					1								2	
Viburnum dentatum							1	1						2	
Number of stems/plot	26	24	21	23	21	18	22	19	19	20	24	23	22	282	
Stems/acre Year 1	1052	971	850	931	850	728	890	769	769	809	971	931	890	878	
Stems/acre Initial	1052	931	1012	931	809	728	890	850	769	890	1012	1012	1012	915	

VEGETATION PHOTOS

Vegetation Plot 1

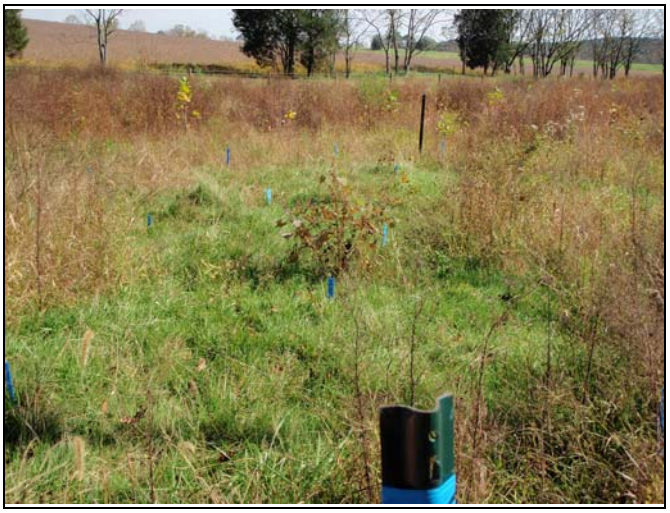
Vegetation Plot 2

Vegetation Plot 3

Vegetation Plot 4

Vegetation Plot 5

Vegetation Plot 6



Vegetation Plot 7

Vegetation Plot 8

Vegetation Plot 9

Vegetation Plot 10

Vegetation Plot 11

Vegetation Plot 12

Vegetation Plot 13

Kudzu growth in M1 and vegetation plot 13 vicinity

APPENDIX B

GEOMORPHIC DATA

STREAM TABLES

Table B.1. Categorical Stream Feature Visual Stability Assessment

Candiff Creek Restoration Project: Project No. 92767						
Performance Percentage						
Feature	**Initial**	**MY-01**	**MY-02**	**MY-03**	**MY-04**	**MY-05**
A. Riffles	100%	100%				
B. Pools	100%	96%				
C. Thalweg	100%	100%				
D. Meanders	100%	100%				
E. Bed General	100%	100%				
F. Bank Condition	100%	100%				
G. Wads	100%	100%				

Table B.2. Baseline Stream Summary

Candiff Creek Restoration Project: Project No. 92767

Candiff Creek - M2

Parameter	USGS Gauge		Regional Curve Interval			Pre-Existing Condition			Reference Reach(es) Data			Design			As-built		
Dimension - Riffle			LL	UL	Eq.	Min	Mean	Max	Min	Mean	Max	Min	Med	Max	Min	Mean	Max
BF Width (ft)	-----	-----	-----	-----	-----	-----	19.8	-----	-----	-----	-----	-----	19.8	-----	-----	-----	-----
Floodprone Width (ft)	-----	-----	-----	-----	-----	-----	23.8	-----	-----	-----	-----	27.7	-----	30.0	-----	-----	-----
BF Mean Depth (ft)	-----	-----	-----	-----	-----	-----	1.42	-----	-----	-----	-----	-----	1.42	-----	-----	-----	-----
BF Max Depth (ft)	-----	-----	-----	-----	-----	-----	1.85	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
BF Cross-sectional Area (ft²)	-----	-----	-----	-----	-----	-----	28.2	-----	-----	-----	-----	-----	29.0	-----	-----	-----	-----
Width/Depth Ratio	-----	-----	-----	-----	-----	-----	13.9	-----	11	-----	14	-----	13.9	-----	-----	-----	-----
Entrenchment Ratio	-----	-----	-----	-----	-----	-----	1.2	-----	-----	-----	-----	1.4	-----	1.5	-----	-----	-----
Bank Height Ratio	-----	-----	-----	-----	-----	-----	2.6	-----	1	-----	1.1	1	-----	1.1	-----	-----	-----
BF Velocity (fps)	-----	-----	-----	-----	-----	-----	3.7	-----	3.5	-----	5	-----	3.6	-----	-----	-----	-----
Pattern																	
Channel Beltwidth (ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Radius of Curvature (ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Meander Wavelength (ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Meander Width Ratio	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Profile																	
Riffle Length (ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Riffle Slope (ft/ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	0.005	-----	0.0081	-----	-----	-----
Pool Length (ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Pool Spacing (ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	29.7	-----	99	-----	-----	-----
Substrate and Transport Parameters																	
d16 / d35 / d50 / d84 / d95	-----	-----	-----	-----	-----	8.3/24.4/36.7/82.0/119.3			-----			8.3/24.4/36.7/82.0/119.3			-----	-----	-----
Reach Shear Stress (competency) lb/f²	-----	-----	-----	-----	-----	-----	0.35	-----	-----	-----	-----	-----	0.36	-----	-----	-----	-----
Stream Power (transport capacity) W/m²	-----	-----	-----	-----	-----	-----	21.7	-----	-----	-----	-----	-----	21.7	-----	-----	-----	-----
Additional Reach Parameters																	
Channel length (ft)	-----	-----	-----	-----	-----	-----	265	-----	-----	-----	-----	-----	265	-----	-----	265	-----
Drainage Area (SM)	-----	-----	-----	-----	-----	-----	2.53	-----	-----	-----	-----	-----	2.53	-----	-----	2.53	-----
Rosgen Classification	-----	-----	-----	-----	-----	-----	F4/1	-----	-----	-----	-----	-----	B4c/1	-----	-----	B4c/1	-----
BF Discharge (cfs)	-----	-----	-----	-----	-----	-----	105	-----	-----	-----	-----	-----	105	-----	-----	-----	-----
Sinuosity	-----	-----	-----	-----	-----	-----	1.00	-----	1.2	-----	1.4	-----	1.00	-----	-----	1.00	-----
BF slope (ft/ft)	-----	-----	-----	-----	-----	-----	0.0045	-----	-----	-----	-----	-----	0.0045	-----	-----	0.0045	-----

Candiff Creek - M3

Parameter	USGS Gauge		Regional Curve Interval			Pre-Existing Condition			Reference Reach(es) Data			Design			As-built		
Dimension - Riffle			LL	UL	Eq.	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max
BF Width (ft)	-----	-----	-----	-----	-----	20.7	-----	32.2	-----	-----	-----	-----	20.4	-----	19.8	25.6	21.6
Floodprone Width (ft)	-----	-----	-----	-----	-----	35.5	-----	94.1	-----	-----	-----	60.0	-----	120.0	108.0	139.9	120.2
BF Mean Depth (ft)	-----	-----	-----	-----	-----	0.9	-----	1.4	-----	-----	-----	-----	1.6	-----	1.24	1.58	1.44
BF Max Depth (ft)	-----	-----	-----	-----	-----	2.0	-----	2.4	-----	-----	-----	1.9	-----	2.2	1.96	2.43	2.15
BF Cross-sectional Area (ft²)	-----	-----	-----	-----	-----	29.2	-----	32.6	-----	-----	-----	-----	32.0	-----	28.62	32.44	30.77
Width/Depth Ratio	-----	-----	-----	-----	-----	14.6	-----	34.6	11	-----	14	-----	13.0	-----	12.6	20.7	15.4
Entrenchment Ratio	-----	-----	-----	-----	-----	1.7	-----	2.9	-----	-----	-----	2.9	-----	5.9	4.2	7.0	5.6
Bank Height Ratio	-----	-----	-----	-----	-----	1.0	-----	2.5	1	-----	1.1	1	-----	1.1	1.0	1.1	1.0
BF Velocity (fps)	-----	-----	-----	-----	-----	3.5	-----	3.9	3.5	-----	5	3.5	-----	5	-----	-----	-----
Pattern																	
Channel Beltwidth (ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Radius of Curvature (ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Meander Wavelength (ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Meander Width Ratio	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	3.5	-----	7	-----	-----	-----
Profile																	
Riffle Length (ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Riffle Slope (ft/ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	0.0078	-----	0.0104	-----	-----	-----
Pool Length (ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Pool Spacing (ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	81.6	-----	142.8	-----	-----	-----
Substrate and Transport Parameters																	
d16 / d35 / d50 / d84 / d95	-----	-----	-----	-----	-----	8.3/24.4/36.7/82.0/119.3			-----			8.3/24.4/36.7/82.0/119.3			-----	-----	-----
Reach Shear Stress (competency) lb/f²	-----	-----	-----	-----	-----	-----	0.32	-----	-----	-----	-----	-----	0.44	-----	-----	-----	-----
Stream Power (transport capacity) W/m²	-----	-----	-----	-----	-----	-----	22.1	-----	-----	-----	-----	-----	26.6	-----	-----	-----	-----
Additional Reach Parameters																	
Channel length (ft)	-----	-----	-----	-----	-----	-----	3,828	-----	-----	-----	-----	-----	4,109	-----	-----	4,123	-----
Drainage Area (SM)	-----	-----	-----	-----	-----	-----	2.74	-----	-----	-----	-----	-----	2.74	-----	-----	2.74	-----
Rosgen Classification	-----	-----	-----	-----	-----	-----	C4/1, F4/1	-----	-----	-----	-----	-----	C4/1	-----	-----	C4/1	-----
BF Discharge (cfs)	-----	-----	-----	-----	-----	-----	115	-----	-----	-----	-----	-----	115	-----	-----	-----	-----
Sinuosity	-----	-----	-----	-----	-----	-----	1.29	-----	-----	-----	-----	-----	1.33	-----	-----	1.41	-----
BF slope (ft/ft)	-----	-----	-----	-----	-----	-----	0.0055	-----	-----	-----	-----	-----	0.0052	-----	-----	0.0052	-----

Table B.3. Morphology and Hydraulic Monitoring Summary

Candiff Creek Restoration Project: Project No. 92767																				
Reach: M3																				
Parameter	Cross-section 1 Riffle					Cross-section 2 Pool					Cross-section 3 Pool					Cross-section 4 Riffle				
	MY1	MY2	MY3	MY4	MY5	MY1	MY2	MY3	MY4	MY5	MY1	MY2	MY3	MY4	MY5	MY1	MY2	MY3	MY4	MY5
Dimension																				
BF Width (ft)	19.49					30.60					33.08					18.17				
BF Mean Depth (ft)	1.09					1.14					1.81					1.41				
Width/Depth Ratio	17.82					26.96					18.31					12.86				
BF Cross-sectional Area (ft^2)	21.3					34.7					59.8					25.7				
BF Max Depth (ft)	1.56					3.38					4.35					2.03				
Width of Floodprone Area (ft)	73.64					153.88					124.67					120.72				
Entrenchment Ratio	3.80					5.00					3.80					6.60				
Bank Height Ratio	1.10					1.00					1.00					1.10				
Wetted Perimeter (ft)	21.67					32.88					36.7					20.99				
Hydraulic Radius (ft)	0.98					1.06					1.63					1.22				
Substrate																				
d50 (mm)																				
d84 (mm)																				

Parameter	MY-1 (2012)			MY-2 (2013)			MY-3 (2014)			MY-4 (2015)			MY-5 (2016)		
	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med
Pattern															
Channel Beltwidth (ft)															
Radius of Curvature (ft)															
Meander Wavelength (ft)															
Meander Width Ratio															
Profile															
Riffle length (ft)															
Riffle Slope (ft/ft)															
Pool Length (ft)															
Pool Spacing (ft)															
Additional Reach Parameters															
Valley Length (ft)			4826												
Channel Length (ft)			3674												
Sinuosity			1.41												
Water Surface Slope (ft/ft)			0.0051												
BF Slope (ft/ft)			0.0072												
Rosgen Classification			C												

Reach: M3																				
Parameter	Cross-section 5 Pool					Cross-section 6 Riffle					Cross-section 7 Pool					Cross-section 8 Riffle				
	MY1	MY2	MY3	MY4	MY5	MY1	MY2	MY3	MY4	MY5	MY1	MY2	MY3	MY4	MY5	MY1	MY2	MY3	MY4	MY5
Dimension																				
BF Width (ft)	35.08					19.57					41.11					19.35				
BF Mean Depth (ft)	1.61					1.41					1.06					1.45				
Width/Depth Ratio	21.78					13.78					38.84					13.36				
BF Cross-sectional Area (ft²)	56.5					27.8					43.5					28.0				
BF Max Depth (ft)	4.04					2.01					2.57					2.09				
Width of Floodprone Area (ft)	119.00					108.03					118.58					115.23				
Entrenchment Ratio	3.40					5.50					2.90					6.00				
Bank Height Ratio	1.00					1.00					1.00					1.10				
Wetted Perimeter (ft)	38.30					22.39					43.23					22.25				
Hydraulic Radius (ft)	1.48					1.24					1.01					1.26				
Substrate																				
d50 (mm)																				
d84 (mm)																				

Parameter	MY-1 (2012)			MY-2 (2013)			MY-3 (2014)			MY-4 (2015)			MY-5 (2016)		
	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med
Pattern															
Channel Beltwidth (ft)															
Radius of Curvature (ft)															
Meander Wavelength (ft)															
Meander Width Ratio															
Profile															
Riffle length (ft)															
Riffle Slope (ft/ft)															
Pool Length (ft)															
Pool Spacing (ft)															
Additional Reach Parameters															
Valley Length (ft)			4826												
Channel Length (ft)			3674												
Sinuosity			1.41												
Water Surface Slope (ft/ft)			0.0051												
BF Slope (ft/ft)			0.0072												
Rosgen Classification			C												

Reach: M3																				
Parameter	Cross-section 9 Pool					Cross-section 10 Riffle														
	MY1	MY2	MY3	MY4	MY5	MY1	MY2	MY3	MY4	MY5										
Dimension																				
BF Width (ft)	24.25					24.40														
BF Mean Depth (ft)	1.30					1.30														
Width/Depth Ratio	18.67					14.37														
BF Cross-sectional Area (ft²)	31.50					24.40														
BF Max Depth (ft)	3.24					1.83														
Width of Floodprone Area (ft)	88.14					117.32														
Entrenchment Ratio	3.60					6.30														
Bank Height Ratio	1.00					1.00														
Wetted Perimeter (ft)	26.85					27.00														
Hydraulic Radius (ft)	1.17					0.90														
Substrate																				
d50 (mm)																				
d84 (mm)																				

Parameter	MY-1 (2012)			MY-2 (2013)			MY-3 (2014)			MY-4 (2015)			MY-5 (2016)		
	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med
Pattern															
Channel Beltwidth (ft)															
Radius of Curvature (ft)															
Meander Wavelength (ft)															
Meander Width Ratio															
Profile															
Riffle length (ft)															
Riffle Slope (ft/ft)															
Pool Length (ft)															
Pool Spacing (ft)															
Additional Reach Parameters															
Valley Length (ft)			4826												
Channel Length (ft)			3674												
Sinuosity			1.41												
Water Surface Slope (ft/ft)			0.0051												
BF Slope (ft/ft)			0.0072												
Rosgen Classification			C												

STREAM DATA

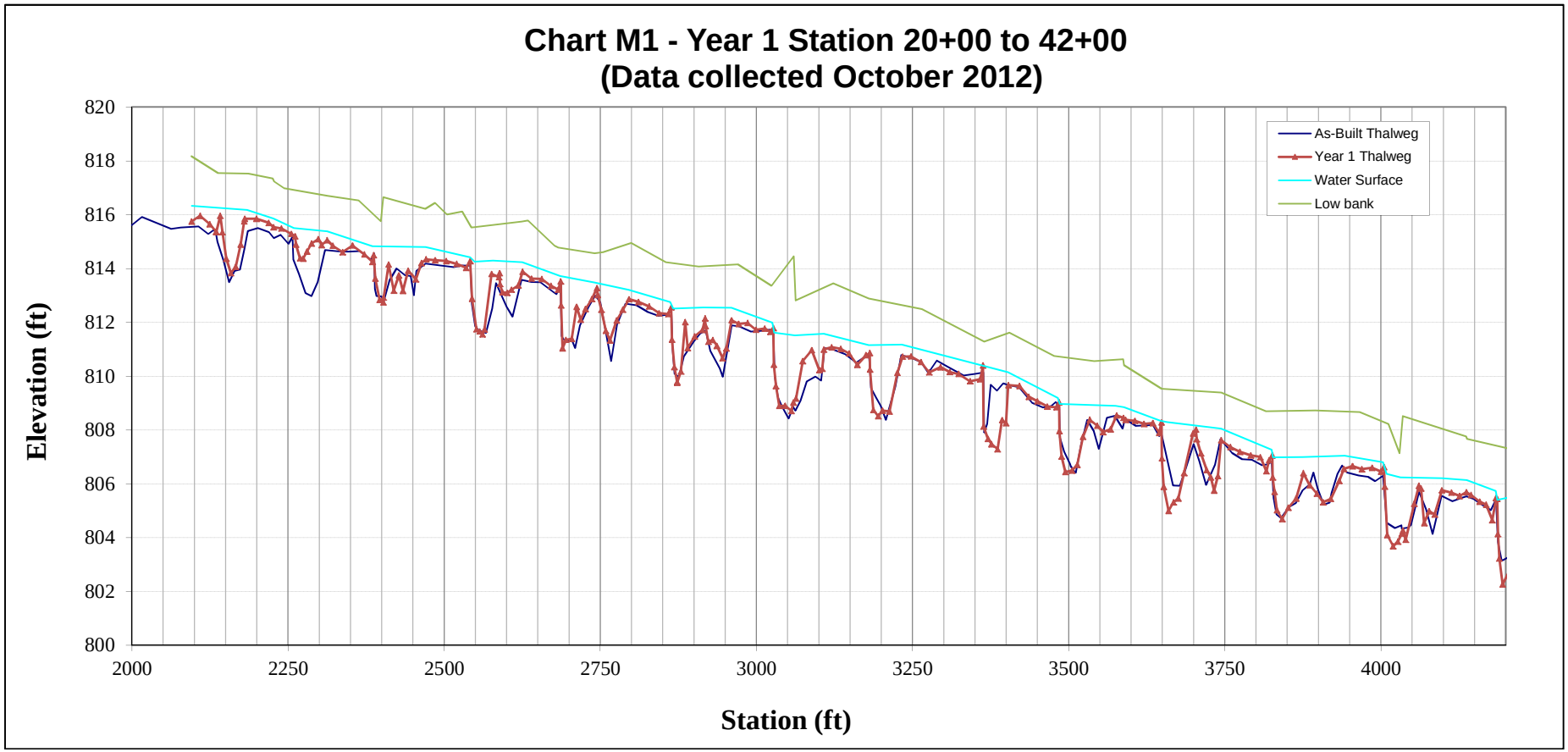


Chart M1 - Year 1 Station 20+00 to 42+00
(Data collected October 2012)
Elevation (ft)
820
818
816
814
812
810
808
806
804
802
800
2000
2250
2500
2750
3000
3250
3500
3750
4000
Station (ft)
As-Built Thalweg
Year 1 Thalweg
Water Surface
Low bank

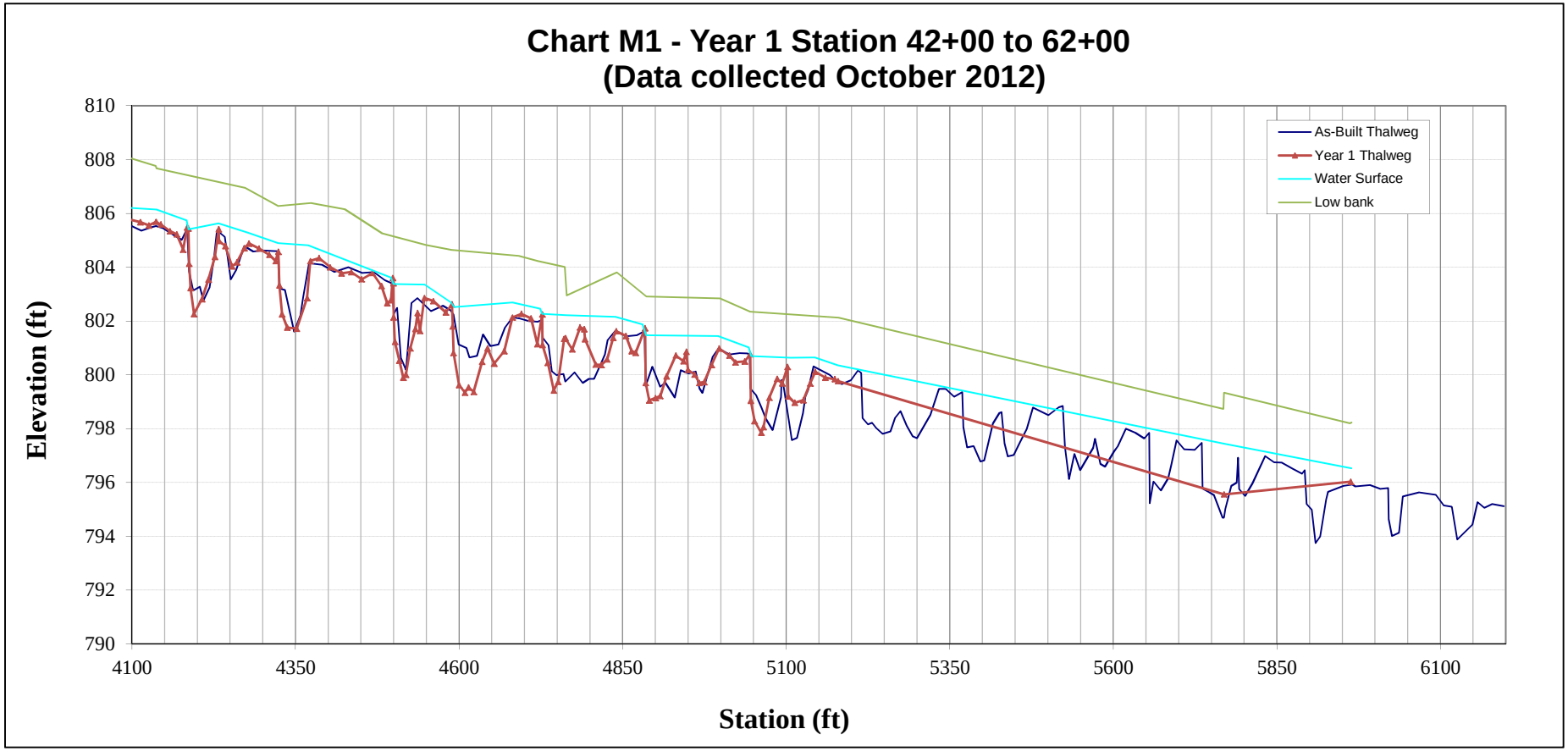


Chart M1 - Year 1 Station 42+00 to 62+00
(Data collected October 2012)
Elevation (ft)
810
808
806
804
802
800
798
796
794
792
790
4100
4350
4600
4850
5100
5350
5600
5850
6100
Station (ft)
As-Built Thalweg
Year 1 Thalweg
Water Surface
Low bank

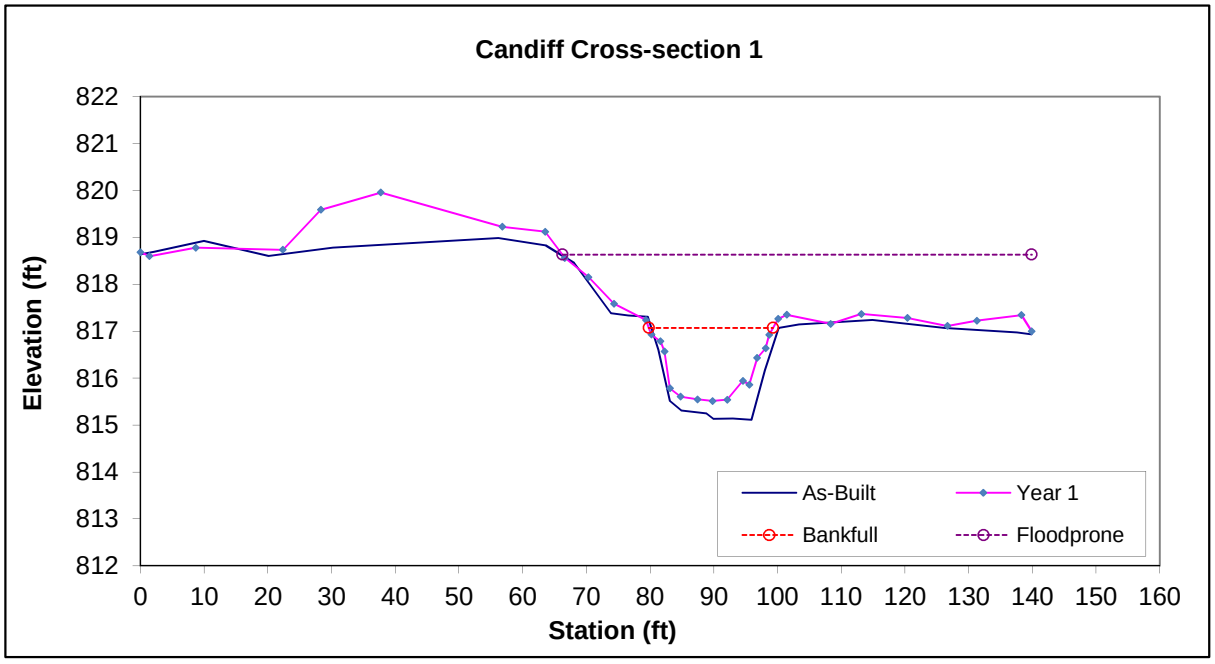
Permanent Cross-section 1

(Year 1 Data - Collected October 2012)

Looking at the Left Bank

Looking at the Right Bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	C	21.3	19.49	1.09	1.56	17.82	1.1	3.8	817.07	817.24



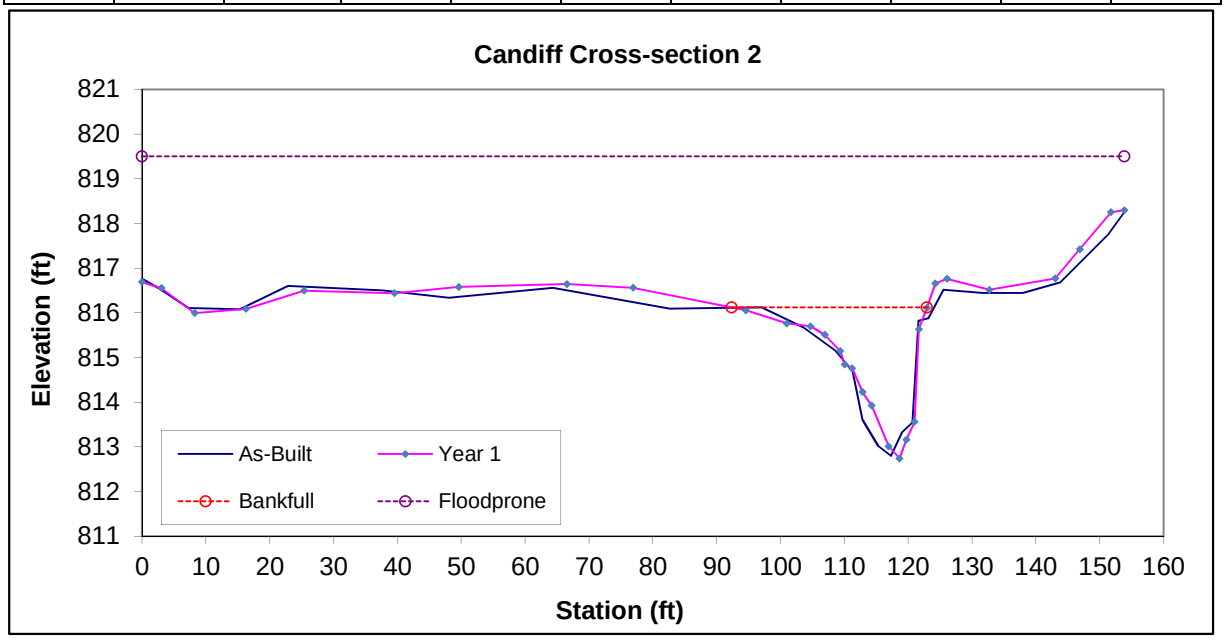
Permanent Cross-section 2

(Year 1 Data - Collected October 2012)

Looking at the Left Bank

Looking at the Right Bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Pool		34.7	30.6	1.14	3.38	26.96	1	5	816.12	816.06



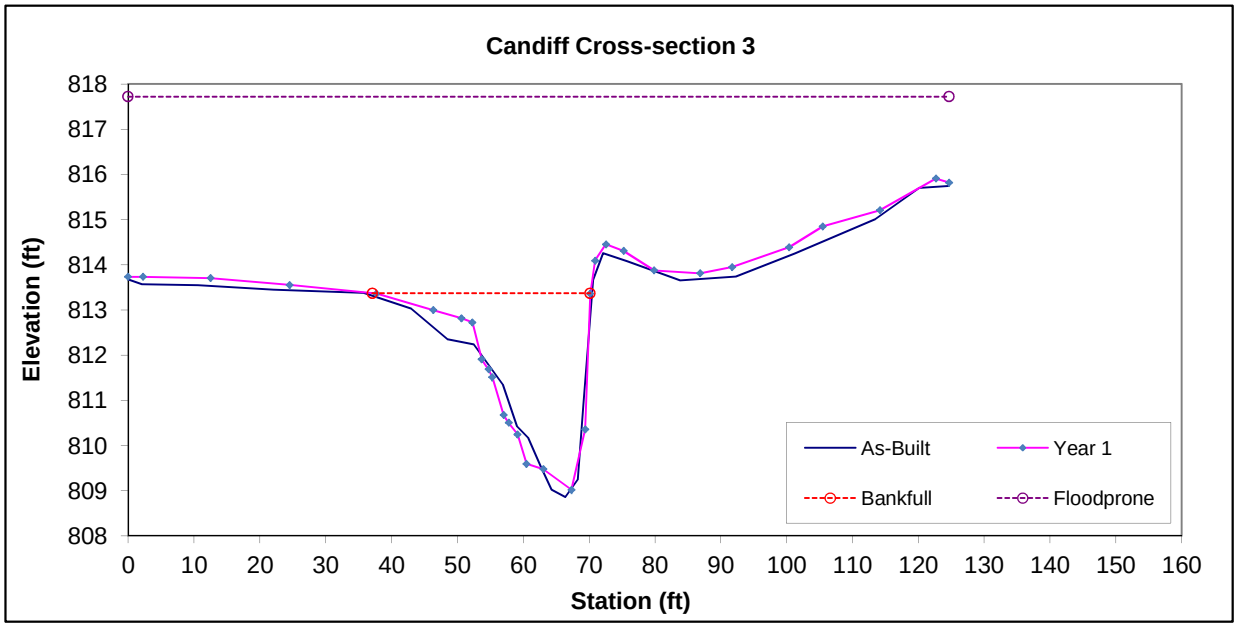
Permanent Cross-section 3

(Year 1 Data - Collected October 2012)

Looking at the Left Bank

Looking at the Right Bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Pool		59.8	33.08	1.81	4.35	18.31	1	3.8	813.37	813.36



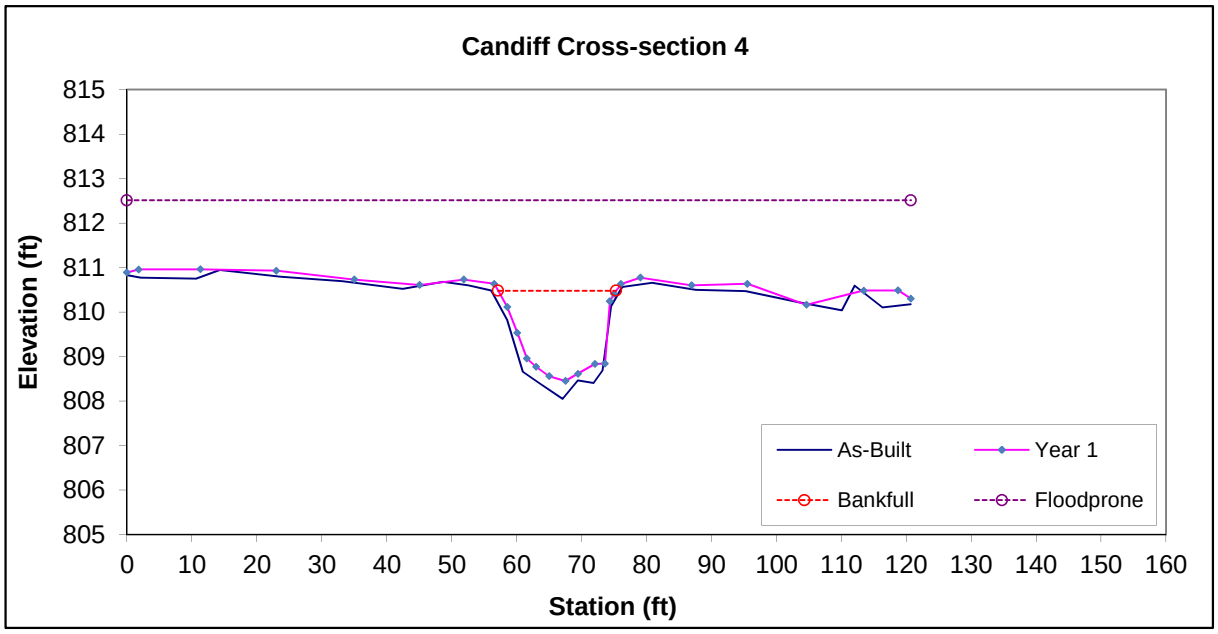
Permanent Cross-section 4

(Year 1 Data - Collected October 2012)

Looking at the Left Bank

Looking at the Right Bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	C	25.7	18.17	1.41	2.03	12.86	1.1	6.6	810.48	810.63



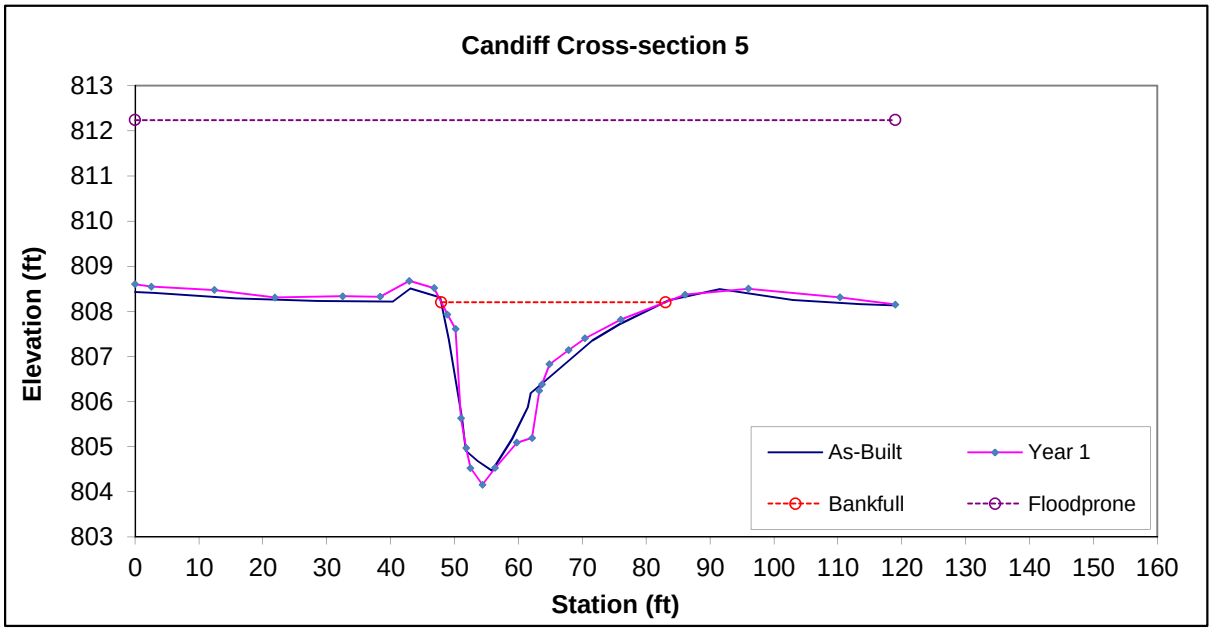
Permanent Cross-section 5

(Year 1 Data - Collected October 2012)

Looking at the Left Bank

Looking at the Right Bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Pool		56.5	35.08	1.61	4.04	21.78	1	3.4	808.2	808.37



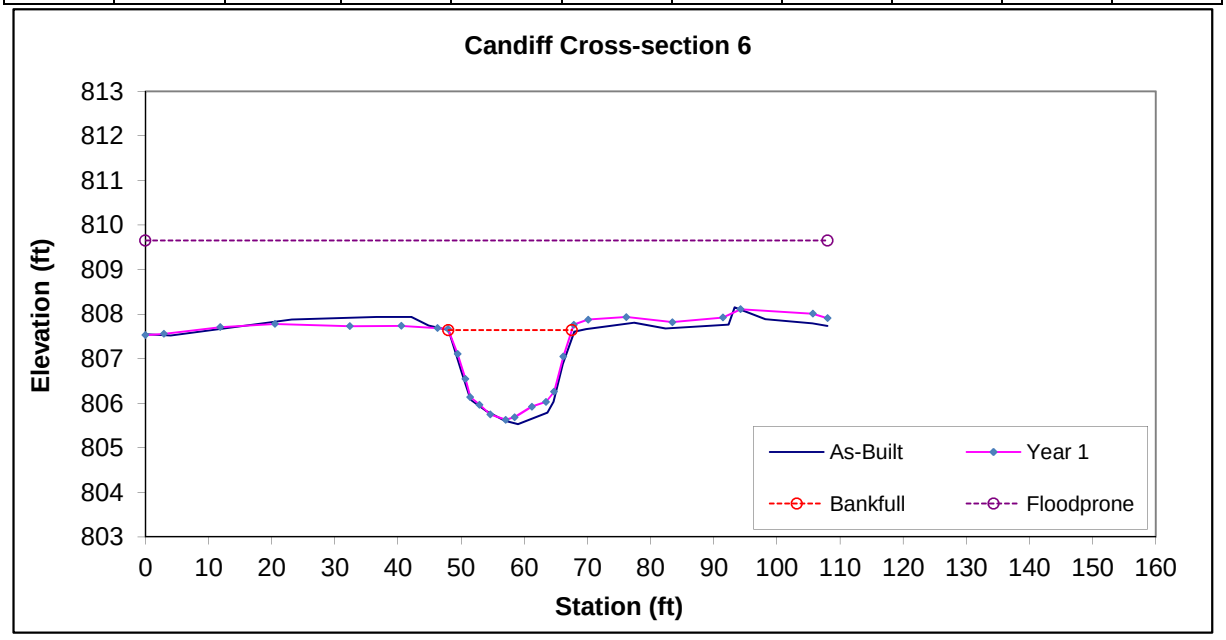
Permanent Cross-section 6

(Year 1 Data - Collected October 2012)

Looking at the Left Bank

Looking at the Right Bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	C	27.8	19.57	1.42	2.01	13.78	1	5.5	807.64	807.67



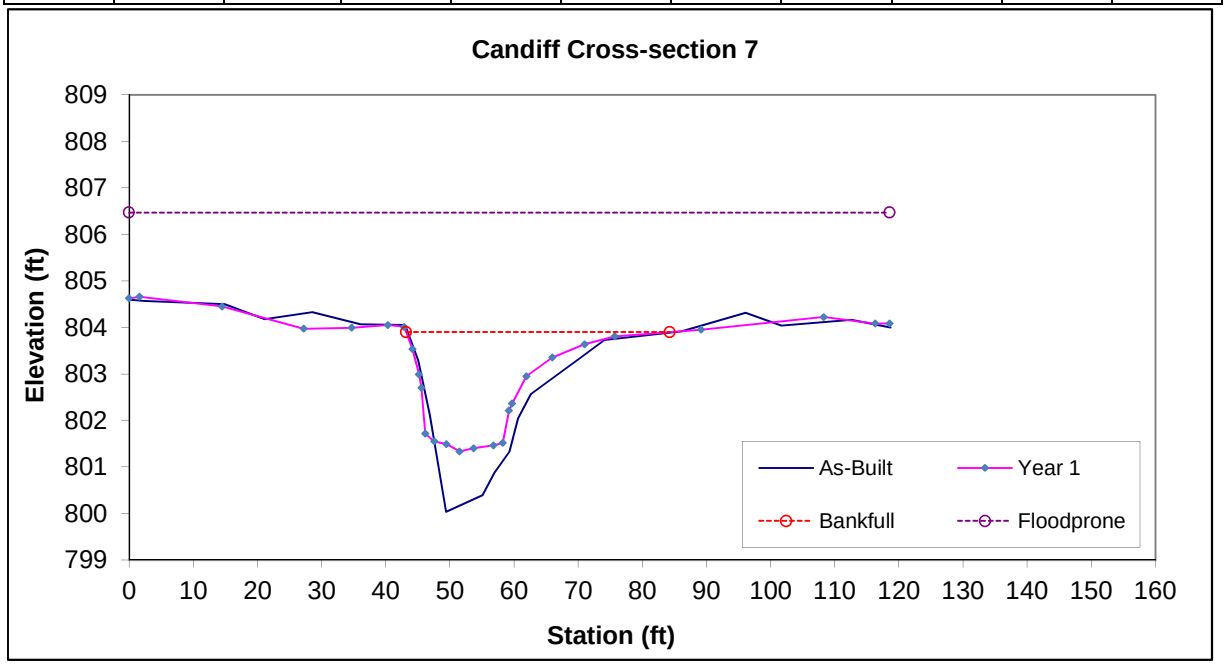
Permanent Cross-section 7

(Year 1 Data - Collected October 2012)

Looking at the Left Bank

Looking at the Right Bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Pool		43.5	41.11	1.06	2.57	38.84	1	2.9	803.9	803.81



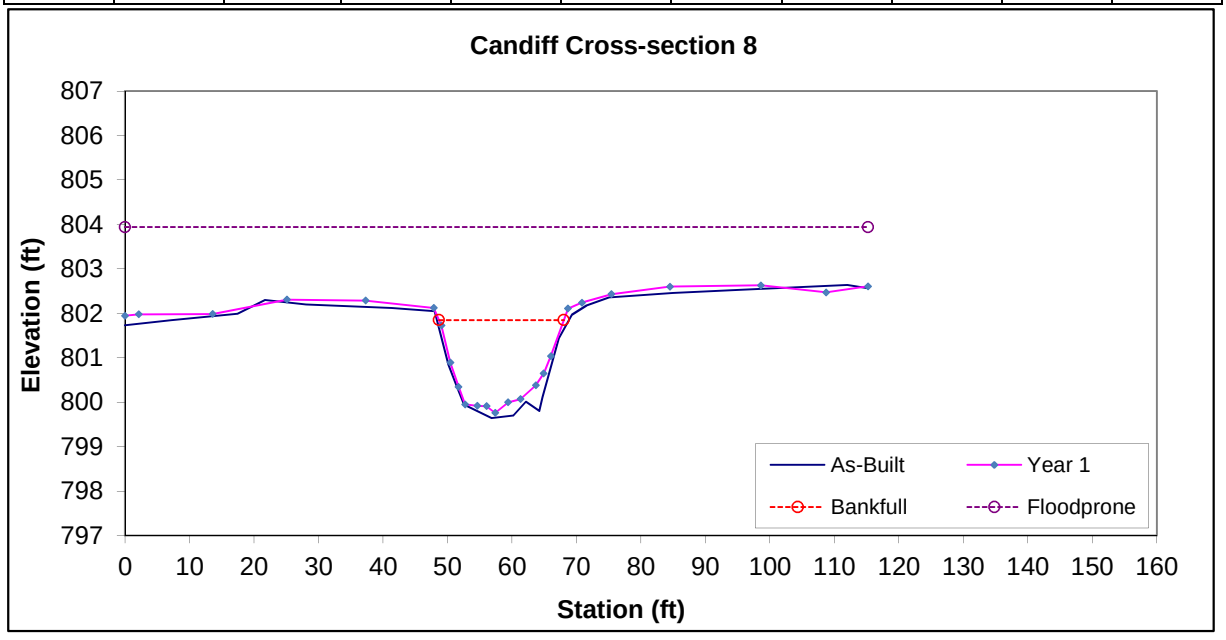
Permanent Cross-section 8

(Year 1 Data - Collected October 2012)

Looking at the Left Bank

Looking at the Right Bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	C	28	19.35	1.45	2.09	13.36	1.1	6	801.85	802.11



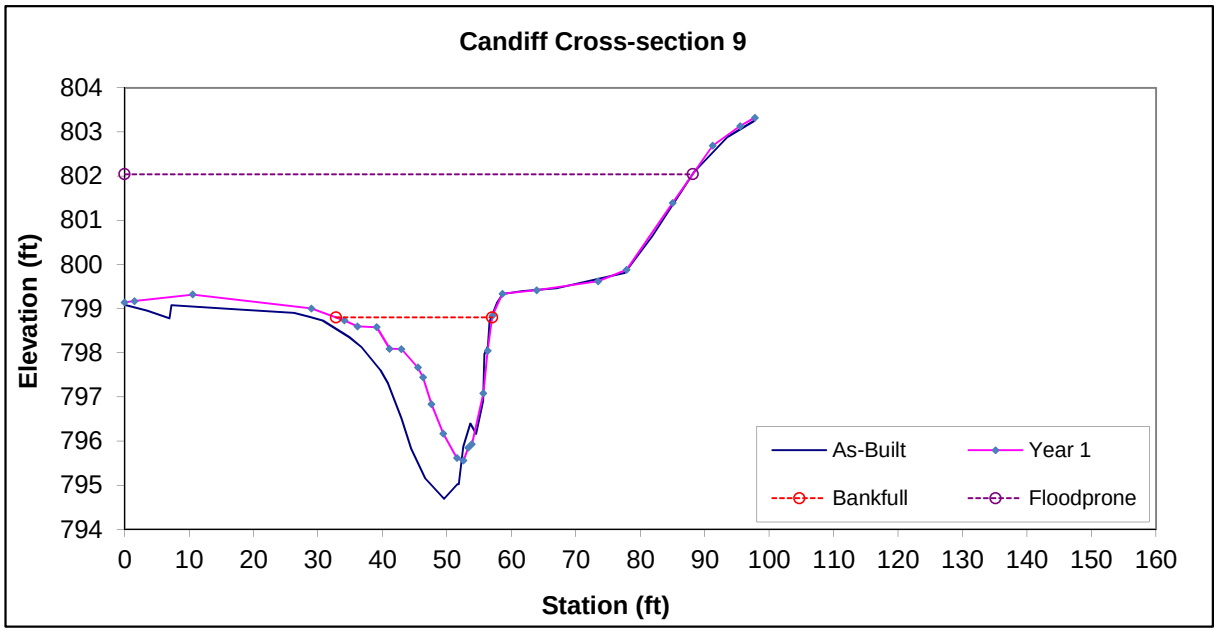
Permanent Cross-section 9

(Year 1 Data - Collected October 2012)

Looking at the Left Bank

Looking at the Right Bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Pool		31.5	24.25	1.3	3.24	18.67	1	3.6	798.8	798.73



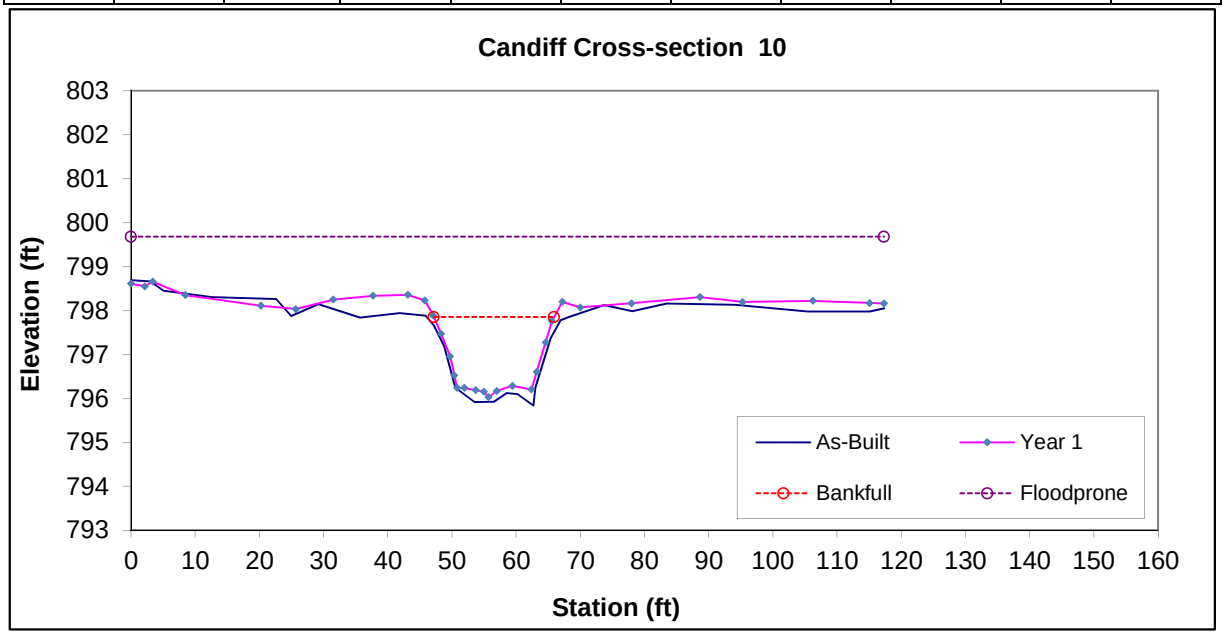
Permanent Cross-section 10

(Year 1 Data - Collected October 2012)

Looking at the Left Bank

Looking at the Right Bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	C	24.4	18.72	1.3	1.83	14.37	1.2	6.3	797.85	798.2



PP1 STA 61+60, Constructed Riffle

PP 2 61+25, Constructed Riffle

PP 3 STA 60+25, Rock J-Hook

PP 4 STA 60+10, Constructed Riffle

PP 5 STA 59+10, Log J-Hook

PP 6 STA 58+85, Constructed Riffle

PP 7 STA 57+65, Log J-Hook

PP 8 STA 57+50, Stream Crossing

PP 9 STA 56+70, Log J-Hook

PP 10 STA 56+50, Constructed Riffle

PP 11 STA 55+40, Log J-Hook

PP 12 STA 55+15, Constructed Riffle

PP 13 STA 53+95, Rock J-Hook

PP 14 STA 53+75, Constructed Riffle

PP 15 STA 52+35, Log J-Hook

PP 16 STA 52+05, Constructed Riffle

PP 17 STA 50+75, Log J-Hook

PP 18 STA 50+40, Constructed Riffle

PP 19 STA 49+15, Log J-Hook

PP 20 STA 48+75, Constructed Riffle

PP 21 STA 47+50, Log J-Hook

PP 22 STA 47+25, Constructed Riffle

PP 23 STA 46+15, Log J-Hook

PP 24 STA 46+00, Constructed Riffle

PP 25 STA 45+25, Rock J-Hook

PP 26 STA 44+90, Constructed Riffle

PP 27 STA 43+50, Log J-Hook

PP 28 STA 43+25, Constructed Riffle

PP 29 STA 42+10, Log J-Hook

PP 30 STA 41+80, Constructed Riffle

PP 31 STA 40+25, Log J-Hook

PP 32 STA 40+00, Constructed Riffle

PP 33 STA 38+50, Rock J-Hook

PP 34 STA 38+25, Constructed Riffle

PP 35 STA 36+75, Rock J-Hook

PP 36 STA 36+45, Constructed Riffle

PP 37 STA 35+05, Log J-Hook

PP 38 STA 34+80, Constructed Riffle

PP 39 STA 33+90, Rock J-Hook

PP 40 STA 33+60, Constructed Riffle

PP 41 STA 33+00, Stream Crossing

PP 42 STA 32+10, Log J-Hook

PP 43 STA 32+75, Constructed Riffle

PP 44 STA 30+55, Log J-Hook

PP 45 STA 30+20, Constructed Riffle

PP 46 STA 28+80, Log J-Hook

PP 47 STA 28+65, Constructed Riffle

PP 48 STA 27+75, Log Vein/Pool

PP 49 STA 27+10, Log J-Hook

PP 50 STA 26+75, Constructed Riffle

PP 51 STA 25+65, Rock J-Hook

PP 52 STA 25+45, Constructed Riffle

PP 53 STA 24+25, Log J-Hook

PP 54 STA 24+00, Constructed Riffle

PP 55 STA 22+90, Log J-Hook

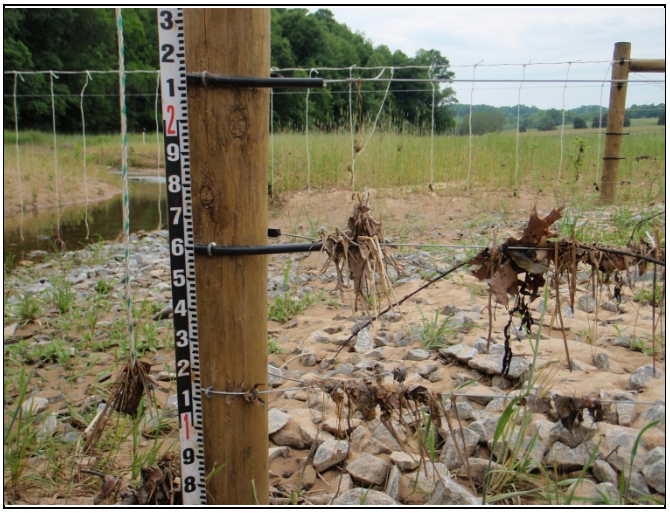
PP 56 STA 22+70, Constructed Riffle

PP 57 STA 21+65, Log J-Hook

PP 58 STA 19+75, Rock Cross Vane

PP 59 STA 17+75, Rock Cross Vane

M3 crest gauge STA 55+50



Bankfull evidence from April 2012 storms, photos taken May 23, 2012. Approximately 1.60 feet.

Bankfull evidence from April 2012 storms

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