Stonebridge Mitigation Project
Moore County, North Carolina

FINAL Year 5 Monitoring Report

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1.0 SUMMARY

The Stonebridge Stream Mitigation Project site is located north of the town of Carthage in Moore County, North Carolina. It lies within hydrologic unit 03030003 in the Cape Fear River Basin. This project was identified by EBX-Neuse I, LLC (EBX) as having potential to help meet the compensatory mitigation requirements of the NC Department of Transportation (NCDOT). NCDOT contracted with EBX to perform the mitigation work under Full Delivery Project S-1. Two unnamed tributaries (UT-1 and UT-2) to Crawley Creek were restored to create a total of 6,120 stream mitigation units (SMU). All restoration is being monitored for five years to document success. Baseline data on stream morphology and vegetation were collected immediately after construction and planting were complete. This information is documented in the As-Built Report dated April 27, 2006. The As-Built survey is included as **Appendix A** of this report. Information on stream morphology and vegetation will be collected each year and compared to the baseline data and data from previous monitoring years.

This Annual Monitoring Report presents the monitoring data collected during Monitoring Year 5 at the Stonebridge Stream Restoration Site. Data collected for 2010 include: monthly crest gauge readings, monthly observations of current conditions, vegetation monitoring, cross section survey, digital images, and observations of stream stability.

Fourteen 100-square-meter monitoring plots were used to measure survival of the planted woody vegetation. The 2010 vegetation monitoring documents a range of survival is from 364 to 769 stems per acre. With an average of 526 stems per acre, the site is has achieved the final vegetation success criteria of 260 stems per acre after the fifth growing season. Areas surrounding vegetation plots 4 and 5 were replanted with 2-year-old trees prior to the start of the 2007 growing season to address high mortality in these plots. These areas were also replanted with 3-year-old trees during the spring of 2008 due to continued high mortality rates. In 2009 and 2010 vegetation plots 4 and 5 did not exhibit high mortality compared to 2008 mortality rates.

At least three occurrences of out-of-bank or bankfull events occurred between the months of February and August 2010. The stream morphology remains stable and little fluvial erosion was observed during the 2010 monitoring season.

Based on the results presented in this Year 5 Monitoring Report, the project has achieved the stream and vegetative success criteria specified in the Mitigation Plan.

2.0 INTRODUCTION

2.1 PROJECT DESCRIPTION

The project site is located in Moore County, North Carolina, north of the town of Carthage (**Figure 1 & Figure 2**) within hydrologic unit 03030003 in the Cape Fear River Basin. The project site is accessed from the west via Glendon-Carthage Road. The 1,196-acre parcel has been used for agricultural purposes as a livestock operation. The surrounding area is rural, with a mix of farms, woodlands and home sites. Dominant soil types on this project site include Congaree, Mooshaunee, Pinkston, and Tetotum.

Two unnamed tributaries to Crawley Creek flow across the project site. The streams are referred to in this Annual Report as UT-1 and UT-2. UT-1 has a drainage area of 688 acres and UT-2 of 182 acres. Prior to implementation of the mitigation plan, the streams were in a disturbed

condition due to the impacts of unrestricted cattle access, dredging, and other anthropic channel manipulations.

UT-1 was the most degraded resource and was the focus of restoration efforts. A total of 5,556 stream mitigation units (SMU) were achieved by restoring plan form, cross section, and profile features on UT-1. This number is derived from the as-built survey of 5,676 linear feet of restored stream length minus 70 feet for a crossing reservation near the middle of the project and minus another 50 feet adjacent to the culvert at the downstream end of the project. UT-1 was restored to a Rosgen Classification of C4/E4.

UT-2 was similarly degraded and flows east-southeast from a small dam, entering UT-1 near the center of the project area. The design for this small tributary yielded an additional 564 linear feet of restored stream. The total SMUs generated from stream restoration on UT-1 and UT-2 are 6,120. The entire easement, including UT-1 and UT-2, is completely fenced in.

2.2 PROJECT PURPOSE

This project was identified by EBX-Neuse I, LLC as having potential to help meet the compensatory mitigation requirements of the NC Department of Transportation (NCDOT) as solicited through the NCDOT Full Delivery Project S-1. The objective of this project is to provide at least 5,556 stream mitigation units (SMU) to the NCDOT through the full delivery process. The mitigation units are to be accomplished through the restoration and enhancement of stream and riparian habitats as defined in the inter-agency Stream Mitigation Guidelines (USACE, 2003).

Table 1. Project Mitigation Structure and Objectives

Reach Name	Stream Mitigation Units (SMU)	Mitigation Approach
UT1	5,556	Restoration
UT2	564	Restoration
Total	**6,120**	

2.3 PROJECT HISTORY & SCHEDULE

This project was identified by EBX-Neuse I, LLC in the spring of 2003. **Table 2** outlines the project history and milestones. **Table 3** lists the project contacts.

Table 2. Project Activity and Reporting History

Month	Activity
June 2005	Mitigation Plan
December 2005	Final Design
February 2006	Construction
March 2006	Vegetation Planting
April 2006	As-built (Baseline) Report
November 2006	Year 2 Monitoring Report
March 2007	Supplemental Vegetation Planting
November 2007	Year 2 Monitoring Report
November 2008	Year 3 Monitoring Report
November 2009	Year 4 Monitoring Report
November 2010	Year 5 Monitoring Report

Table 3. Project Contacts

Contact	Firm Information
Project Manager Norton Webster	EBX-Neuse 1, LLC (919) 608-9688
Designer Michael Ellison	WK Dickson and Co., Inc (919) 782-0495
Monitoring Contractor Daniel Ingram	WK Dickson and Co., Inc (919) 782-0495

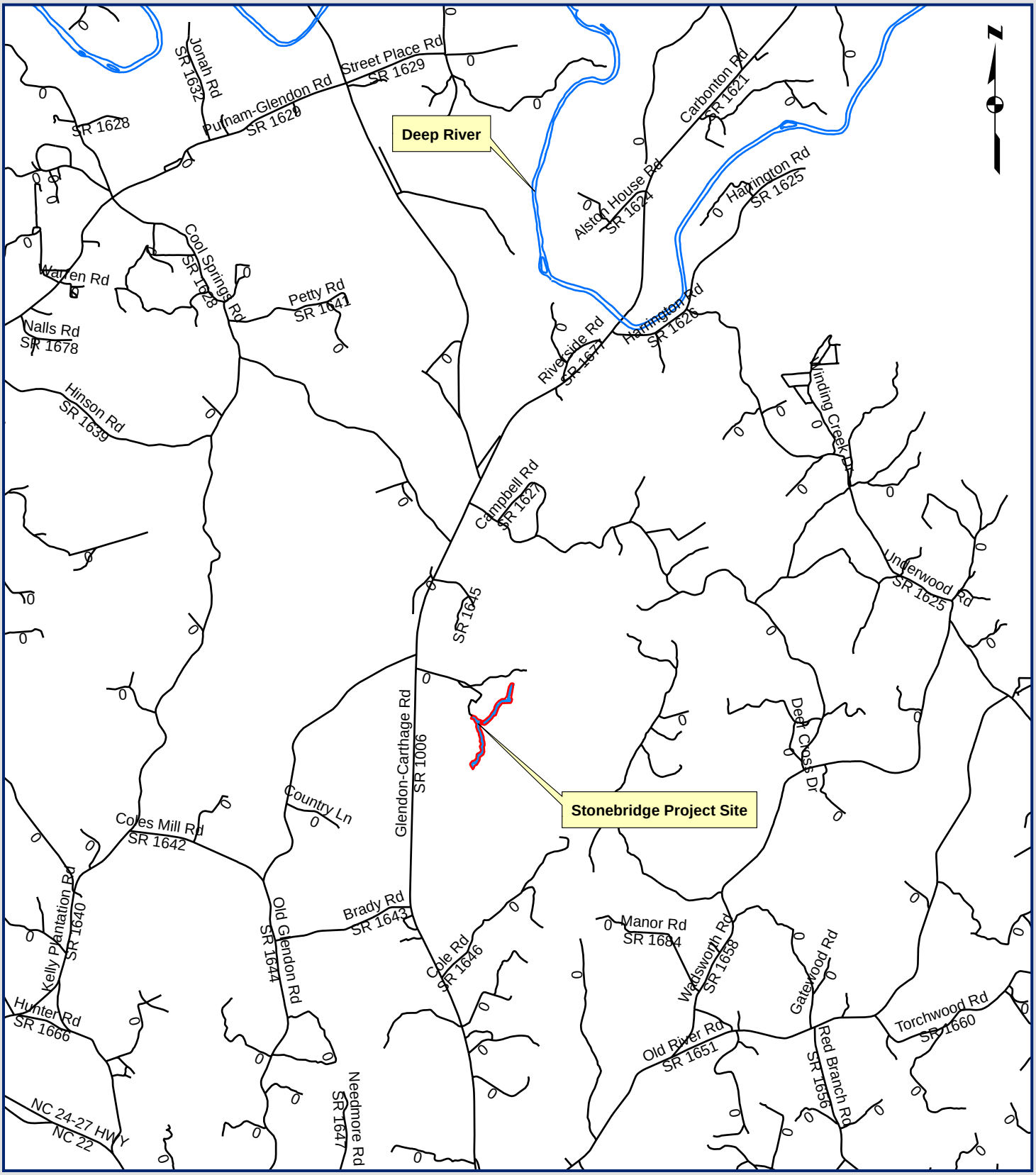
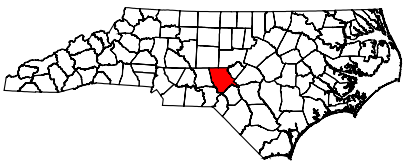


Figure 1.
Stonebridge Stream Mitigation Site
Project Location Map
Moore County, NC

1 inch equals 1 mile



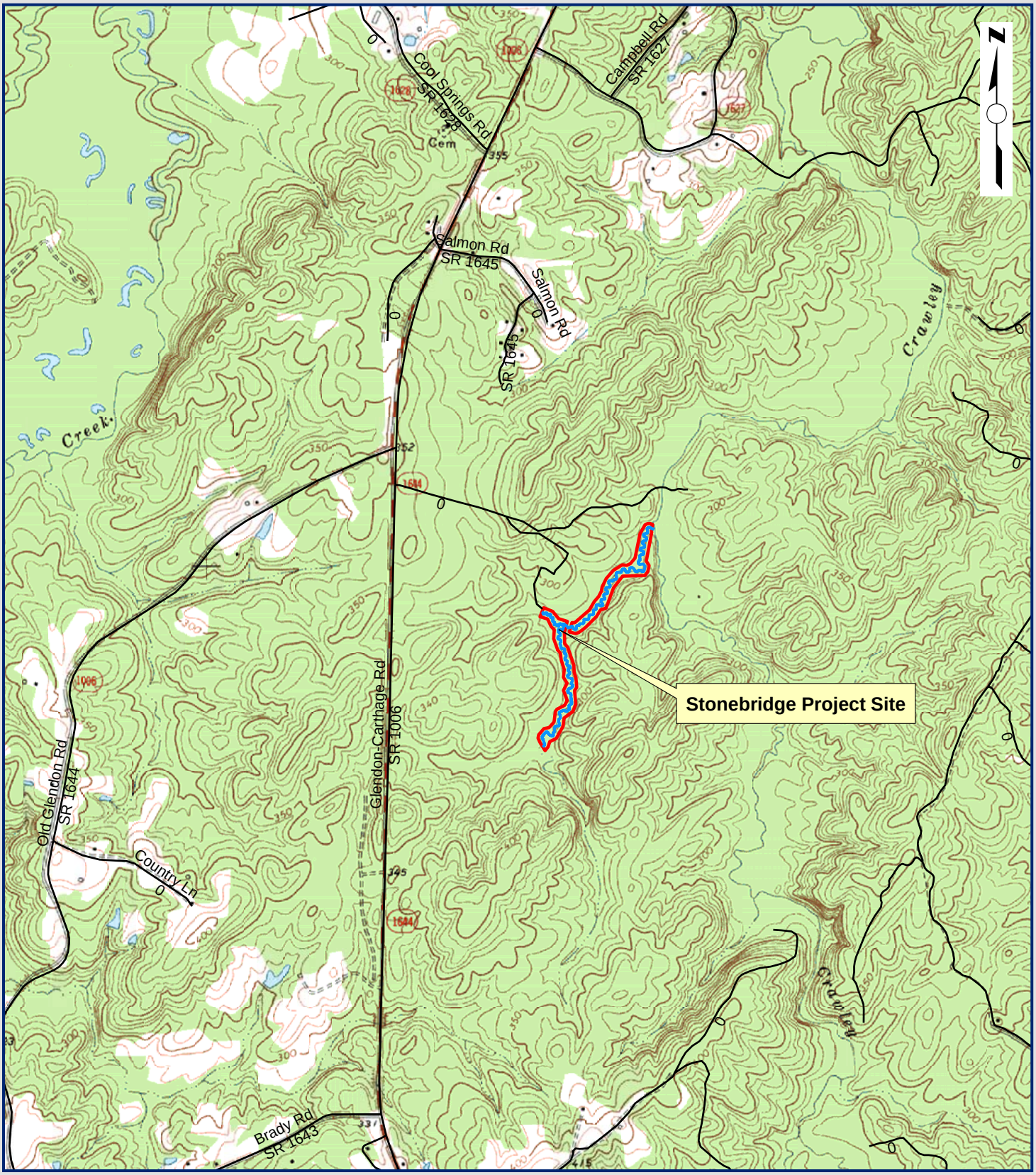
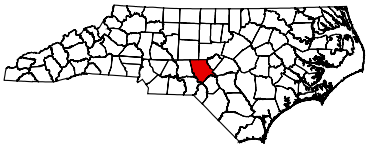


Figure 2.
Stonebridge Stream Mitigation Site
USGS Topographic Map
Moore County, NC

1 inch equals 2,000 feet



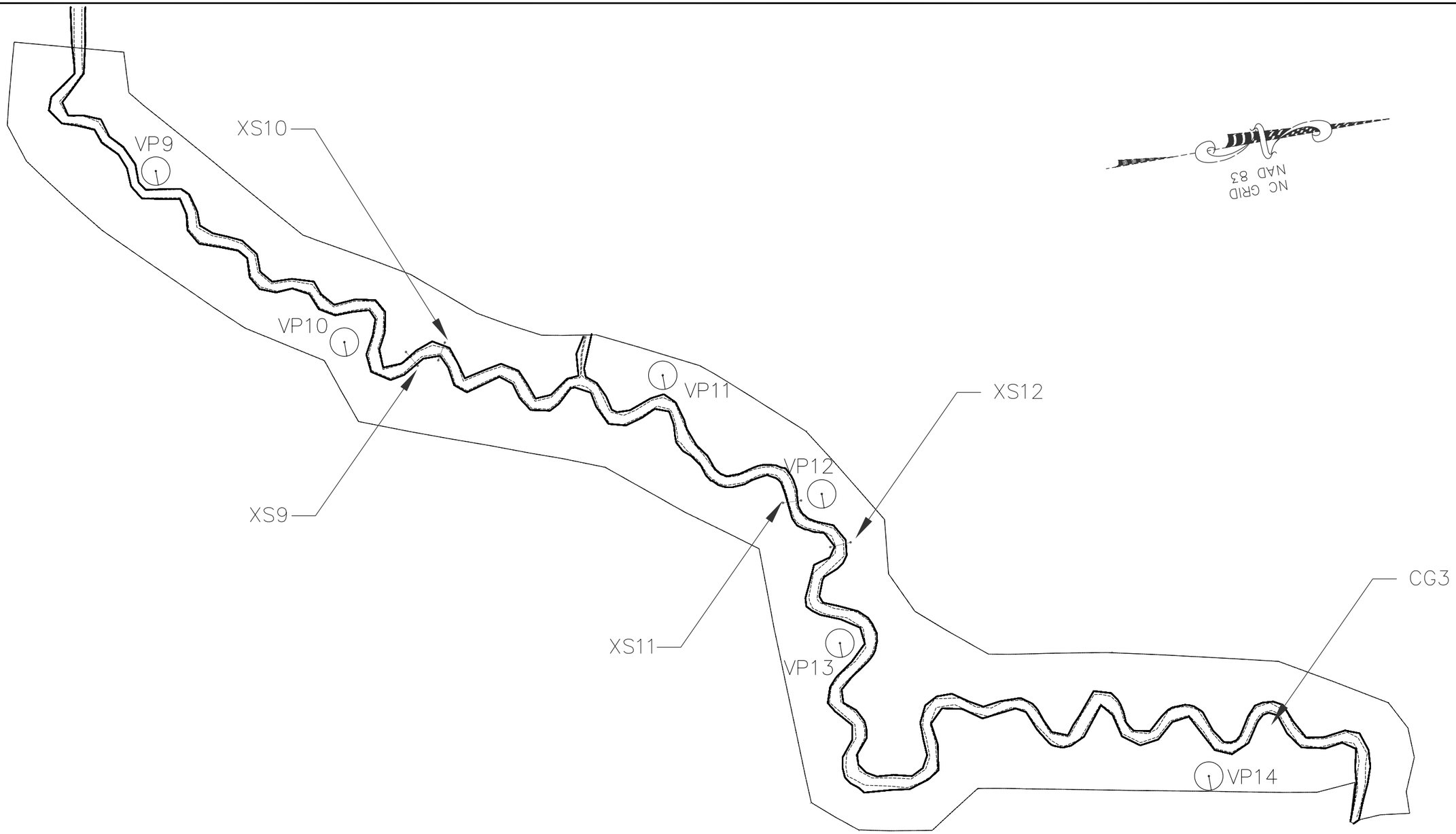
NC GRID
NAD 83

XS7
XS8
XS5
CG1
CG2
VP7
VP8
VP6
VP9
XS6
XS4
XS3
VP5
XS1
XS2
VP4
VP2
VP1
VP3

Stonebridge
Monitoring Overview

Figure 3A

60 30 0 60 120
SCALE (FT)



Stonebridge
Monitoring Overview

Figure 3B

60 30 0 60 120
SCALE (FT)

3.0 VEGETATION

3.1 VEGETATION SUCCESS CRITERIA

Specific and measurable success criteria for plant density within the riparian buffer on the site are based on the recommendations found in the WRP Technical Note and correspondence from review agencies on mitigation sites recently approved under the Neu-Con Mitigation Banking Instrument. The interim measure of vegetative success for the Stonebridge Mitigation Site—at least 320 planted stems per acre at the end of the Year 3 monitoring period—was met in 2008. The final vegetative success criterion for the survival of 260-planted trees per acre at the end of Year 5 of the monitoring period was met in 2010 (U.S. Army Corps of Engineers et. al. 2003).

Success of riparian vegetation was evaluated annually through monitoring planted stem survival and photo documentation of vegetation plots. An assessment of the natural regeneration of woody stems and herbaceous cover was also performed. Up to 20 percent of the species composition may be comprised of volunteers. Remedial action would have been required should these volunteers (i.e. loblolly pine (*Pinus taeda*), red maple (*Acer rubrum),* sweet gum (*Liquidambar styraciflua*), etc.) exceed 20 percent composition.

3.2 DESCRIPTION OF SPECIES AND VEGETATION MONITORING

All vegetation was planted in March 2006 after construction was complete. Bare root native tree and shrub species were planted to establish forested riparian buffers of at least fifty feet on both sides of the restored stream. The plants were selected to establish vertical habitat structure and a diverse mix of species **(Table 4)**. The planted area consists of two zones. The first is a wetter zone predominantly consisting of moist soil species such as green ash (*Fraxinus pennslyvanica*), ironwood (*Carpinus caroliniana*), and elderberry (*Sambucus canadensis*). The second is a drier zone predominantly consisting of more mesic species such as yellow poplar (*Liriodendron tulipifera*) and Northern red oak (*Quercus rubra*). Black locust (*Robinia pseudo-acacia*) was planted as a nurse tree in the upland zone. The initial stocking of riparian plantings across the site was approximately 758 stems per acre. In addition to the riparian plantings, black willow (*Salix nigra*) cuttings bundles were installed on the outside of bends.

Fourteen 100-square-meter vegetation-sampling plots were established at the restoration site to monitor the success of riparian buffer vegetation. The locations of these plots were randomly distributed across the planted portions of the site. The plots cover approximately 2% of the site. The center of each plot is located with a ten-foot section of metal fence post with a white PVC cover. Each planted woody stem was located with a three-foot section of white PVC and identified with an aluminum tag. Planted woody species were be monitored twice per year for the first three years and herbaceous plant cover was monitored annually using the notched-boot method. The total number of each species planted is listed in **Table 5**.

Table 4. Planted Tree Species

Common Name	Scientific Name	FAC Status
Shrubs		
Elderberry	*Sambucus canadensis*	FACW-
Silky Dogwood	*Cornus amomum*	FACW+
Trees		
Black Locust	*Robiinia pseudocacia*	FACU-
Green ash	*Fraxinus pennsylvanica*	FACW
Ironwood	*Carpinus caroliniana*	FAC
Red Oak	*Quercus rubra*	FACU
Red Bud	*Cercis canadensis*	FACU
River Birch	*Betula nigra*	FACW
Sweet Bay	*Magnolia virginiana*	FACW+
Sycamore	*Platanus occidentalis*	FACW-
Tulip Tree	*Liriodendron tulipifera*	FAC

Because of high mortality and the low stems per acre documented in 2006 for Plots 4 and 5, these portions of the site were planted with approximately 600 2-year-old trees in the spring of 2007 to supplement the surviving stems per acre. This area also received a supplemental planting in Spring 2008 with 3-year old trees due to mortality resulting from 2007 drought conditions. The stem counts reflect both the surviving original live stems and the supplemental stems planted.

3.3 RESULTS OF VEGETATION MONITORING

Stem counts were conducted at each monitoring plot during July 2010. All 14 vegetation-monitoring plots were evaluated for success, and the overall condition of vegetation at the site was assessed. **Table 5** shows the number of woody stems recorded for each plot and the success rate of each plot. Early above-average mortality in 2006 and 2007 necessitated that some areas be replanted to maintain adequate density. The surviving planted stems per acre after the fifth year ranged from 324 to 769, with an average of 520-planted trees per acre surviving at the site. Two photos of each vegetation plot were taken at the time of the stem counts, one facing upstream and the other facing downstream (**Appendix C**).

All vegetation plots met the final success criteria of 260 planted trees per acre after 5 years. Slight positive changes in survival have also occurred because of the resprouting ability of some species. In a number of plots, individual stems previously recorded as dead had resprouted from the root crown. This pattern was observed in several plots with redbud, green ash and elderberry. All of the plots met the five-year success criteria of 260 stems per acre.

In 2008 and again in 2010, livestock entered a portion of the easement and temporarily damaged the herbaceous vegetation. This problem was corrected, and no reduction in planted stem survival was observed. The earlier impact resulted in an increase in the dominance of grasses in plot 2. The incursion in 2010 resulted in only minor damage to the herbaceous vegetation and no impacts to woody vegetation were observed.

Plot 4 has the lowest density, but with 324 stems per acre, it still meets the final success criteria of 260 stems per acre after 5 years. The higher mortality experienced in this plot over the three previous monitoring years appears to be due to locally shallow bedrock around this plot.

Table 5. Summary of Vegetation Monitoring Results

Plots	Stems Planted	Additional Stems Planted	Total Stems Planted	Stems Year 5	Stems per Acre Year 5
1	16	14	30	15	607
2	20	6	26	14	567
3	21		21	19	769
4	16	5	21	8	324
5	24	1	25	10	405
6	29	1	30	19	769
7	14		14	11	405
8	16		16	10	405
9	17		17	13	526
10	19	1	20	12	486
11	20		20	17	688
12	17		17	11	445
13	14		14	9	364
14	19		19	13	526
Average	**19**			**12.9**	**520**

Average Stems per Acre: 520
Range of Stems per Acre: 324-769
Replanted in Spring 2007 and Spring 2008

A plan view drawing of the vegetation plots is provided in **Figures 3A and 3B**. The drawing includes the appropriate information pertaining to vegetation monitoring of the project. The drawing also shows the locations of the following features:

- Vegetation monitoring plots,
- Vegetation plot photo points,
- Locations of any vegetation problem areas, and
- Symbology to represent vegetative problem types (if appropriate).

The vegetation at the site is dense, with greater than 95 percent herbaceous cover that is variable in composition, as would be expected in a natural riparian system. Areas previously observed to have bare soil, particularly around Plot 1 and Plot 4, now have good herbaceous cover. Plot 1 has the least coverage, likely due to the surrounding trees. Small-localized rocky areas also have sparse herbaceous coverage. The locally dominant and commonly dense species are panic grass (*Panicum anceps*) and Canada goldenrod (*Solidago canadensis*). Other prominent species include dog fennel (*Eupatorium capillifolium*), Canadian horseweed (*Conyza canadensis*), devil's darning needles (*Clematis virginiana*), sawtooth blackberry (*Rubus argutus*), trumpet creeper (*Campsis radicans*), Carolina horsenettle (*Solanum carolinense*), American pokeweed (*Phytolacca americana*), Pennsylvania smartweed (*Polygonum pensylvanicum*), common rush (*Juncus effusus*), sedges (*Carex* sp.), and grape (*Vitis* sp.).

Volunteer species are also monitored throughout the five-year monitoring period. **Table 6** shows the most commonly found woody volunteer species. The volunteer stems do not compromise more than five percent of species surveyed at the site.

Table 6. Volunteer Tree Species

Scientific Name	Common Name	FAC Status
Acer rubrum	Red Maple	FAC
Carpinus caroliniana	Ironwood	FAC
Cephalanthus occidentalis	Common Buttonbush	OBL
Diospyros virginiana	Persimmon	FAC
Fraxinus Pennsylvanica	Green Ash	FACW
Liquidambar styraciflua	Sweetgum	FAC+
Liriodendron tulipifera	Tulip Poplar	FAC
Pinus taeda	Loblolly Pine	FAC
Rhus copallinum	Winged Sumac	NI
Robinia pseudoacacia	Black Locust	UPL
Ulmus alata	Winged Elm	FACU+
Ulmus rubra	Slippery elm	FAC

3.4 VEGETATION OBSERVATIONS & CONCLUSIONS

Both herbaceous early successional vegetation and planted stems have become well established across the site. Natural recruitment of species is also beginning to develop but does not threaten to compete with the planted stems at this time. Despite the drought year in 2007 and below to normal rainfall in 2008, the vegetation at this site is generally healthy and appears to be thriving. A few areas, such as around plot 4, have experienced a slightly higher mortality than desired in the past, but the stem counts through 2010 indicate that this trend may be abating. The site meets the 5-year success criteria for the vegetation plots.

4.0 STREAM MONITORING

4.1 STREAM SUCCESS CRITERIA

As stated in the Mitigation Plan, success criteria for the stream restoration site include the following:

- *Bankfull Events*: Two bankfull flow events must be documented within the five-year monitoring period.
- *Cross sections*: There should be little change in as-built cross sections. Cross sections shall be classified using the Rosgen stream classification method, and all monitored cross sections should fall within the quantitative parameters defined for "E" or "C" type channels.
- *Longitudinal Profiles*: The longitudinal profiles should show that the bedform features are remaining stable, e.g. they are not aggrading or degrading. Bedforms observed should be consistent with those observed in "E" and "C" type channels.
- *Photo Reference Stations*: Photographs will be used to subjectively evaluate channel aggradation or degradation, bank erosion, success of riparian vegetation and effectiveness of erosion control measures.

- *Benthic Macroinvertebrate*: Sampling of benthic macroinvertebrates within the restored stream channel shall be conducted for the first three years of post-restoration monitoring.

Plan view drawings of the project site are provided in **Figures 4A- 4D**. The drawings include the appropriate information pertaining to monitoring of the project. These drawings show the locations of the following features (if applicable): Cross section survey locations and Crest gauge locations are shown on Figures 3A and 3B

- Bankfull channel limits
- Centerline of channel
- Easement boundary/Fencing
- Road crossings
- Root wads
- Log vanes
- Cuttings bundles
- Channel plugs
- Log toe protection
- Riffle grade control
- Cross weir structures
- Step pool structures
- Tributaries

4.2 STREAM MORPHOLOGY MONITORING PLAN

Along UT-1 and UT-2 a natural channel design approach was applied to develop stable hydraulic geometry parameters. Construction began in October 2005 and was completed in February 2006. The rebuilding of the channel established stable cross-sectional geometry, increased plan form sinuosity, and restored streambed diversity to improve benthic habitat. Approximately 6,120 linear feet of stream restoration has been constructed.

4.2.1 Cross Sections

The mitigation plan for the Stonebridge Stream Mitigation Project requires twelve permanent cross sections to be monitored along the restored tributaries UT-1 and UT-2. The cross sections were established during monitoring set-up in evenly distributed pairs of one riffle and one pool per 1,000 linear feet of restored stream. Locations of cross sections are specified in **Figures 3A and 3B**. The cross section surveys and photographs are shown in **Appendix B**. Each cross section was surveyed annually including measurements of floodplain, top of bank, bankfull, inner berm, edge of water, and thalweg. In addition, any fluvial features present were documented.

4.2.2 Longitudinal Profile

Longitudinal profiles were surveyed annually during the monitoring period. The cumulative length of the measured profiles was at least 3,664 linear feet. Features measured include thalweg, inverts of in-stream structures, water surface, bankfull, and top of low bank.

4.2.3 Hydrology

Three crest gauges were installed at the site: one on UT-1 (CG3) near the downstream end of the project and one each on UT-2 (CG2) and UT-1 (CG1) immediately above the confluence (see locations in **Figures 3A and 3B**). Crest gauges were checked monthly to document high flows. During each visit, a determination was made if an out-of-bank event had occurred since the prior

visit. During the gauge inspections, any high water marks or debris lines were documented and photographed.

4.2.4 Stream Photo Reference Stations

There are no designated photo reference stations on the Stonebridge Mitigation site. Photos are collected showing general conditions of the site (within the restoration easement), at all structures, cross-sections, as well as specific areas of concern along the stream corridor (**Appendix C**).

4.3 STREAM MORPHOLOGY MONITORING RESULTS

Photographs were taken throughout the monitoring season to document the evolution of the restored stream channel (**Appendix C**). Herbaceous vegetation is moderately dense along the restored stream. Pools have maintained a variety of depths and habitat qualities, depending on the location and type of scour features (logs, root wads, transplants, etc.). A consistent stream flow was present during the early monthly site visits, but the channel has been dry since May, except for a few of the larger pools. At the time of the annual monitoring survey, the channel was dry. Vegetation within and along the stream banks was observed to be often lush and provide stable conditions. A number of log control structures were not visible due to dense vegetation.

No problems with stream morphology were observed during the monitoring field visits. Photos of each located structure taken in July 2010 are included in **Appendix C**. The plan view drawings in **Figures 4A-4D** show the locations of the following features:

- As-built stream centerline and bankfull limits
- In-stream structures (e.g. root wads and log vanes)
- Locations of stream channel observation areas

4.3.1 Cross Sections

The cross sections were surveyed during the Year 5 monitoring activities in July 2010. The As-Built cross-section surveys are shown with the Year 1, Year 2, Year 3, Year 4, and Year 5 monitoring cross section surveys in **Appendix B**. The Year 5 cross sections do not differ significantly from the As-Built, Year 1, Year 2, Year 3, and Year 4 cross sections. All monitored cross sections for 2010 show very little adjustment in stream dimension.

4.3.2 Longitudinal Profile

A longitudinal profile survey was conducted during the Year 5 monitoring activities in July 2010. The previous surveys of profile and cross sections indicate that there has been very little adjustment to the stream profile or dimension since construction. Using the surveyed dimensions of the cross sections, morphological parameters were calculated for each reach and are included in **Tables 7a and 7b** below.

Table 7a. Summary of Morphologic Monitoring Parameters for UT1

Parameter	As-Built	Year 5
Avg. Bankfull Xsec Area, Abkf (sq ft)	31.0	31.4
Avg. Bankfull Width, Wbkf (ft)	15.6	18.6
Avg. Bankfull W/D	8.1	11.1
Avg. Bankfull Mean Depth, Dbkf (ft)	2.0	1.7
Avg. Bankfull Max Depth, Dmax (ft)	2.9	3.1

Table 7b. Summary of Morphologic Monitoring Parameters for UT2

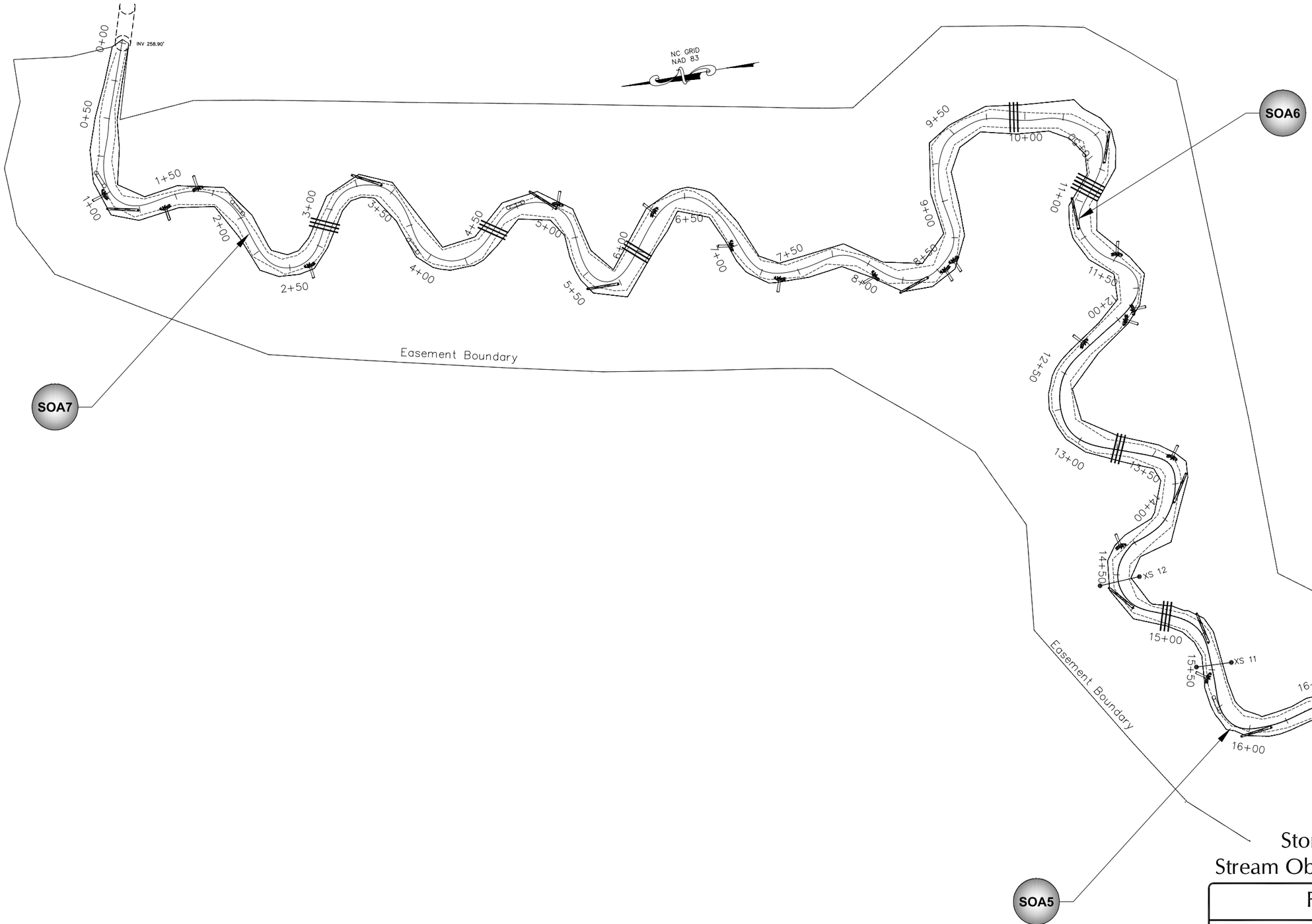
Parameter	As-Built	Year 5
Avg. Bankfull Xsec Area, Abkf (sq ft)	10.1	13.1
Avg. Bankfull Width, Wbkf (ft)	7.2	10.7
Avg. Bankfull W/D	5.1	8.7
Avg. Bankfull Mean Depth, Dbkf (ft)	1.4	1.2
Avg. Bankfull Max Depth, Dmax (ft)	1.7	2.3

Overall, the restored stream channel has remained stable with very little adjustment to the profile. Diverse habitat is present including pools, grade control structures, vanes, various types of vegetation along the banks, and the immediate buffer along the banks is providing shade to the channel.

A number of minor issues were observed, but no remedial action is recommended (**Table 8)**. Most previous issues have stabilized or are becoming stable. Minor erosion present along some of the banks is due to the cattle intrusion described earlier, and in the buffer area, trampled herbaceous vegetation is localized. No impacts to stream stability were observed and the cattle have been removed. Water is flowing around a log grade control structure and a log vane, causing minor erosion (SOA4, SOA5, and SOA6). A minor headcut has stabilized due to vegetation.

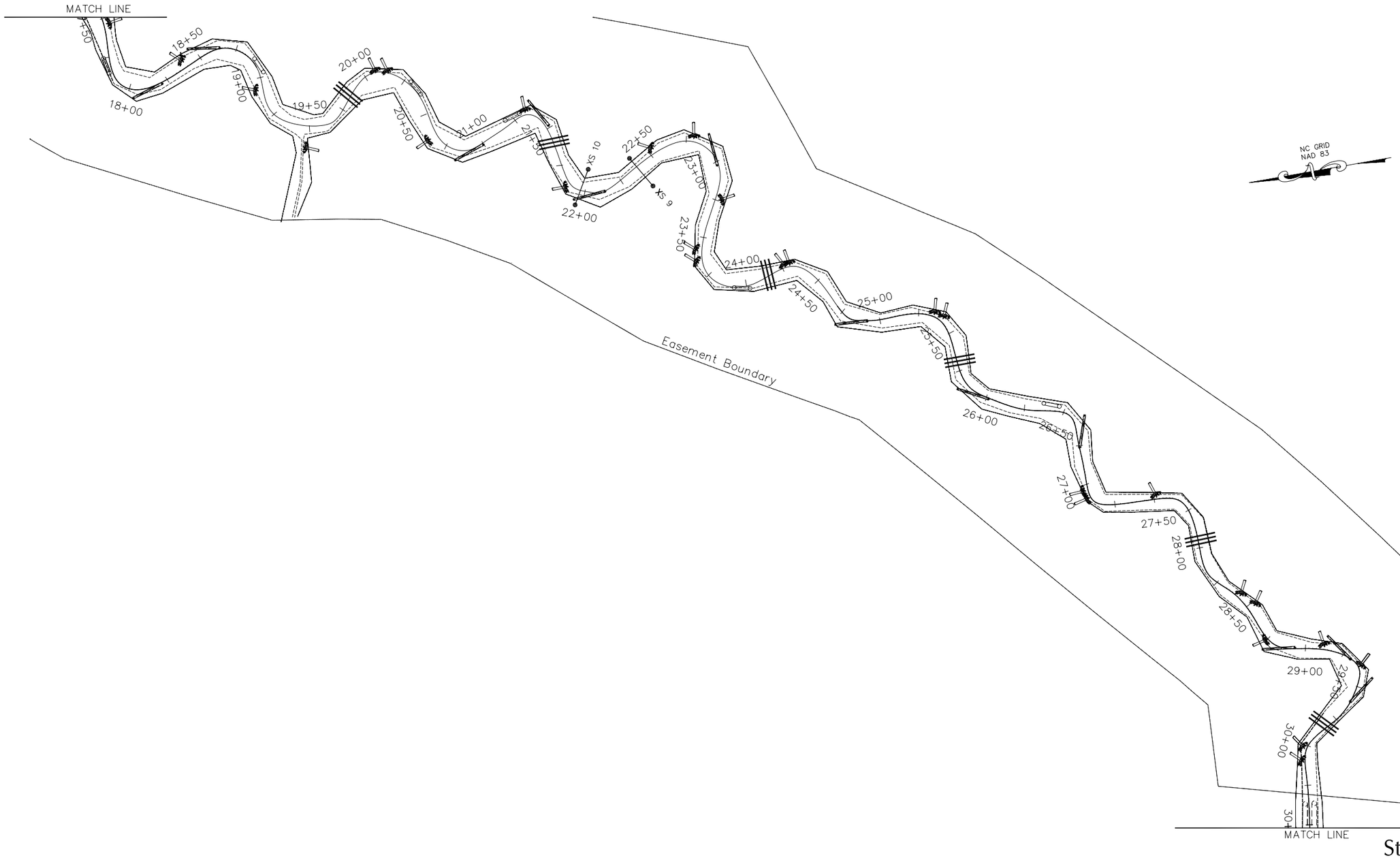
Table 8. Stream Observation Areas

Feature	STA	Description	Photo Number
Bank Erosion and Buffer Vegetation Trampled	UT1 48+50, 33+50 to 30+90 UT 2 throughout	Minor damage due to cattle incursion and bank remains stable. No action recommended.	SOA 1
Right Bank Erosion	UT1 47+50 to 47+80	Minor erosion on right bank. Area has nearly stabilized since previous monitoring survey observation in 2009.	SOA 2
Right Bank Erosion	UT1 40+15 to 40+60	Minor erosion on right bank.	SOA 3
Log Grade Control Right Bank	UT2 2+50	Bank undercut along right bank at log grade control. Channel is stable and no headcut was observed. No action recommended.	SOA 4
Log Vane	UT1 16+00	Log vane undercut with minor headcut upstream. Channel upstream and downstream stable. No action recommended.	SOA 5
Log Vane	UT1 11+00	Log vane undercut. Channel upstream and downstream are stable and unaffected. No action recommended.	SOA 6
Headcut	UT1 2+15	Minor headcut. Vegetation has stabilized the channel.	SOA 7



Stonebridge
Stream Observation Areas

Figure 4A



Stonebridge
Stream Observation Areas

Figure 4B

30 15 0 30 60
SCALE (FT)

NOTE:
TRAMPLED BUFFER VEGETATION AND BANK EROSION FROM STA. 30+90 THROUGH STA 33+50 AND THROUGHOUT REACH UT2

SOA1

SOA3

SOA4

MATCH LINE

MATCH LINE

Easement Boundary

Easement Boundary

Easement Boundary

0+50
1+00
1+50
2+00
2+50
3+00
3+50
4+00
4+50
5+00
5+44.48
31+50
32+00
32+50
33+00
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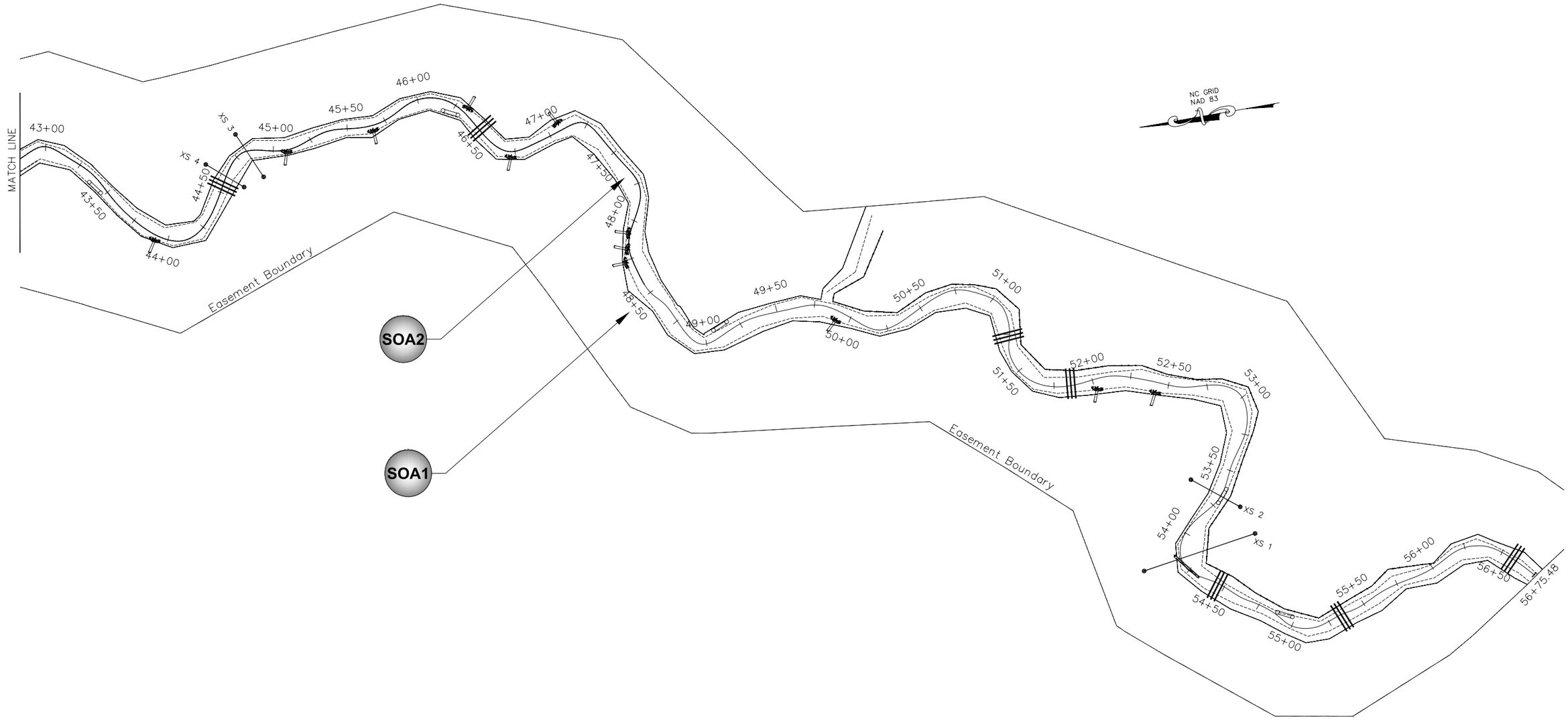
XS 8

NC GRID
NAD 83

Stonebridge
Stream Observation Areas

Figure 4C

30 15 0 30 60
SCALE (FT)



Stonebridge
Stream Observation Areas

Figure 4D

30 15 0 30 60
SCALE (FT)

4.3.3 Hydrology

The crest gauges were read on monthly sites visits from February through July 2010 (**Table 9**). All crest gauges recorded at least three out-of-bank or bankfull events that occurred during this period. Weather data were collected from a nearby weather station—Carthage Water Treatment Plant and the Moore County Airport. The precipitation data are summarized in **Table 10** and **Figure 5** and indicate that conditions were below normal through July. Data collected from the on-site gauge has only two monthly recordings, with one above normal and one below normal. The June reading includes May and June. The July data was lost due to disturbance of the on-site gauge from the cattle.

Table 9. Crest Gauge Data

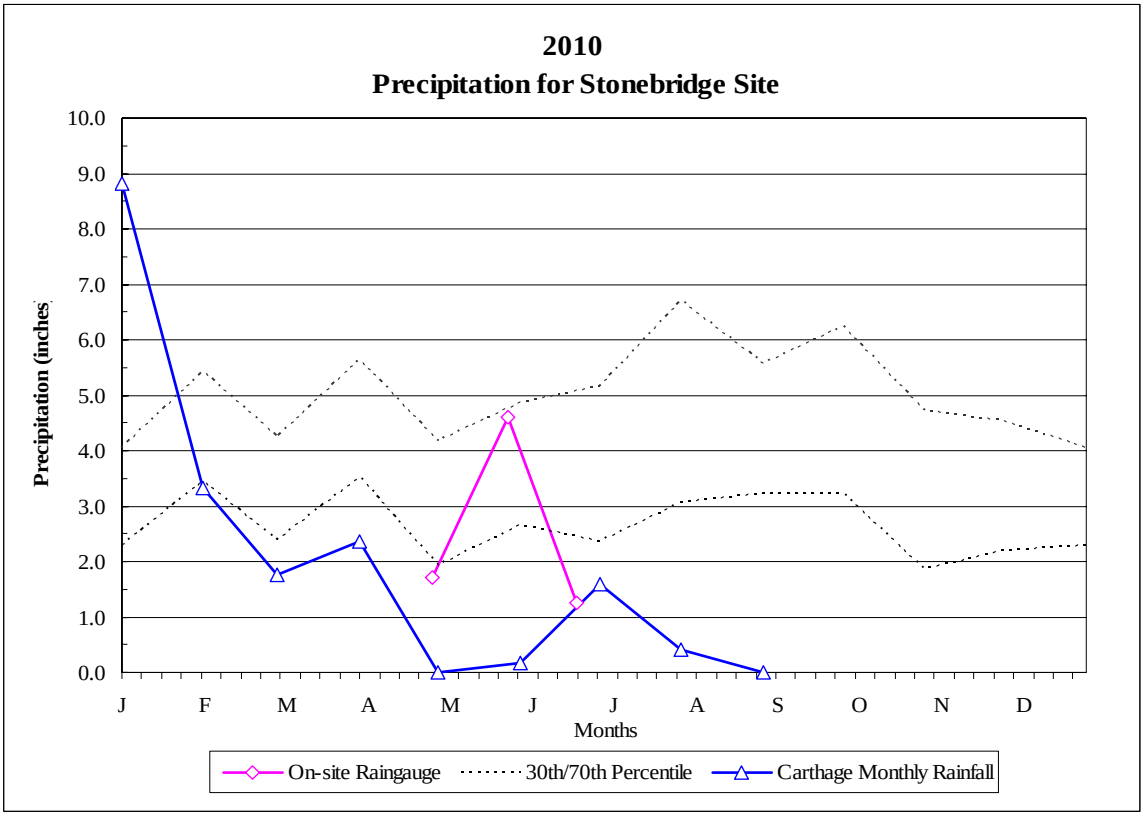
Month Recorded	Crest Gauge 1	Crest Gauge 2	Crest Gauge 3
January	---	---	---
February	3.10	2.90	3.00
March	0.75	0.30	0.50
April	0.00	0.00	0.00
May	0.10	0.60	0.20
June	0.00	0.00	0.00
July	0.00	0.00	0.00
August	---	---	---
September	---	---	---
October	---	---	---
November	---	---	---
December	---	---	---

Table 10. Summary Precipitation Data

Month	Average	Normal Limits		Carthage Precipitation	On-Site Precipitation
		30 Percent	70 Percent		
January	4.51	3.44	5.43	3.33	---
February	3.54	2.39	4.24	1.75	---
March	4.65	3.52	5.64	2.37	---
April	3.08	1.93	4.17	0.00	1.71
May	4.06	2.65	4.86	0.17	---
June	4.18	2.36	5.16	1.58	5.85
July *	5.37	3.06	6.7	0.82	---
August	4.65	3.22	5.57	---	---
September	4.45	3.23	6.24	---	---
October	3.54	1.86	4.73	---	---
November	3.47	2.2	4.52	---	---
December	3.38	2.28	4.04	---	---
Annual		**32.14**	**61.30**		
Total	**48.88**			**10.02**	**7.56**

*Raingauge data at site not recorded due to gauge dislodged
Data collected through July

Figure 5. 2010 Precipitation Data for Stonebridge



4.4 STREAM CONCLUSIONS

Overall, the restored stream channel is stable and providing the intended habitat and hydrologic functions. Water is flowing around a log grade control structure and a log vane, causing minor erosion (**Table 7**, SOA4 and SOA5). A minor head cut is present upstream of the log vane. Vegetation has stabilized the banks and channel at these structures. All monitored cross sections for 2010 show very little adjustment in stream dimension. Three bankfull events were recorded during the 2010 monitoring season, exceeding the requirement of two bankfull events within five years.

5.0 CONCLUSIONS AND RECOMMENDATIONS

The stream, hydrologic, and vegetation monitoring data for all five monitoring years at the site are summarized in **Tables 11-13**. Based on this data and the other data and comments provided above in Sections 3 and 4, it can be concluded that the site has achieved the stream, hydrologic, and vegetative success criteria specified in the Mitigation Plan.

Table 11. Summary of Stream Crest Gauge Data 2006-2010

	2006 Year 1	2007 Year 2	2008 Year 3	2009 Year 4	†2010 Year 5
Number of Bankfull Events	4	3	6	2	3
Maximum Height Above Bankfull (feet)	>4	3.7	2.8	3.7	3.1

† January – July

Table 12a. Summary of Morphologic Monitoring Parameters 2006-2010 for UT1

Parameter	2005 As-Built	2006 Year 1	2007 Year 2	2008 Year 3	2009 Year 4	2010 Year 5
Bankfull Cross Section Area, Abkf (sq ft)	31.0	27.0	28.4	23.5	29.9	31.4
Avg. Bankfull Width, Wbkf (ft)	15.6	14.2	14.5	15.3	15.1	18.6
Bankfull W/D	8.1	7.9	7.7	10.4	7.9	11.1
Bankfull Mean Depth, Dbkf (ft)	2.0	1.9	1.9	1.6	2.0	1.7
Bankfull Max Depth, Dmax (ft)	2.9	2.7	3.0	2.7	3.12	3.1

Table 12b. Summary of Morphologic Monitoring Parameters 2006-2010 for UT2

Parameter	2005 As-Built	2006 Year 1	2007 Year 2	2008 Year 3	2009 Year 4	2010 Year 5
Bankfull Cross Section Area, Abkf (sq ft)	10.1	11.5	11.5	9.8	10.6	13.1
Avg. Bankfull Width, Wbkf (ft)	7.2	8.7	8.5	7.9	8.3	10.7
Bankfull W/D	5.1	6.6	6.3	6.3	6.5	8.7
Bankfull Mean Depth, Dbkf (ft)	1.4	1.4	1.4	1.2	1.3	1.2
Bankfull Max Depth, Dmax (ft)	1.7	2.0	2.1	1.9	2.0	2.3

Table 13. Summary of Vegetative Monitoring Data 2006-2010

Plot	Planted Stems Per Acre					
	2005 Base	2006 Year 1	2007 Year 2	2008 Year 3	2009 Year 4	2010 Year 5
1	648	526	364	607	607	607
2	810	526	526	607	607	567
3	850	769	769	769	688	769
4	648	283	283	324	324	364
5	972	567	567	445	405	405
6	1174	972	972	891	850	769
7	567	486	445	405	405	445
8	648	526	486	364	405	405
9	688	648	607	607	648	526
10	769	567	526	486	486	486
11	810	607	688	688	607	688
12	688	526	486	445	445	445
13	567	526	526	364	364	364
14	769	607	526	445	526	526
Average	758	581	555	532	526	526

The stream morphology is stable, and little fluvial erosion was observed. Sedimentation that has occurred in the stream channel is minor. The vegetation is surviving well throughout the restoration project.

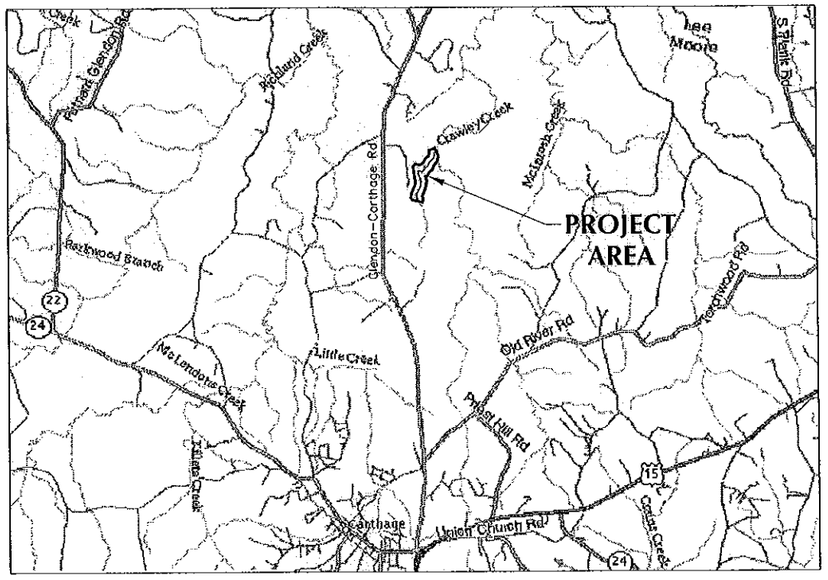
Overall, the project is performing as designed. Habitat has been improved significantly through this project. Fluvial erosion has been greatly reduced so that the project site no longer contributes excessive amounts of sediment to the receiving stream. Based on 2010 observations, the planted vegetation on site is providing the intended riparian habitat, water quality benefits, and shade for the stream system.

APPENDIX A

As-Built Survey

STONEBRIDGE STREAM AS-BUILT PLANS

APRIL 2006



VICINITY MAP
NTS

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OWINGS MILLS, MARYLAND 21117-4860

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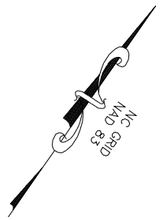
community infrastructure consultants
3101 JOHN HUMPHRIES WYND
RALEIGH, NC 27612
(919) 782-0495

EBX



I, MARK W. YARBROUGH, HEREBY CERTIFY THAT THE TOPOGRAPHIC AND PLANIMETRIC AS-BUILT INFORMATION SHOWN ON THIS MAP WAS DRAWN UNDER MY SUPERVISION FROM AN ACTUAL FIELD SURVEY PERFORMED UNDER MY SUPERVISION; THAT THE ORIGINAL FIELD DATA WAS OBTAINED BETWEEN MARCH 7, 2006 AND APRIL 20, 2006; THAT THE MAPPING ERROR AS REPRESENTED BY CONTOUR LINES PLOTTED HEREON, IF APPLICABLE, DOES NOT EXCEED 1/2 OF THE CONTOUR INTERVAL OVER 90% OF THE SURVEY AREA; THAT THE HORIZONTAL DATUM IS BASED ON NAD 83 AND THE VERTICAL DATUM IS BASED ON NGVD 88 DATUM; THAT THE HORIZONTAL AND VERTICAL DATUM WERE OBTAINED FROM 2 HOUR STATIC GPS SESSIONS USING L1/L2 GPS RECEIVERS AND THE POST PROCESSING WAS OBTAINED THROUGH NOAA OPUS (ONLINE POSITIONING USER SERVICE). WITNESS MY ORIGINAL SIGNATURE, REGISTRATION NUMBER AND SEAL THIS 25TH DAY OF APRIL, 2006 A.D.

MARK W. YARBROUGH L-3396 DATE

100 0 50 100 200
1 inch = 100ft.

REV. NO.	DESCRIPTION	DATE
	REVISIONS	

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DRAWN BY	TRS
APPROVED BY	ME
FILE NAME	as-built.dwg
DRAWING SCALE	1" = 100'
PROJECT DATE	03/30/2004
PROJECT NUMBER	3024600RA
PLOT DATE	10/4/07

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community infrastructure consultants

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RECORD DWG.	

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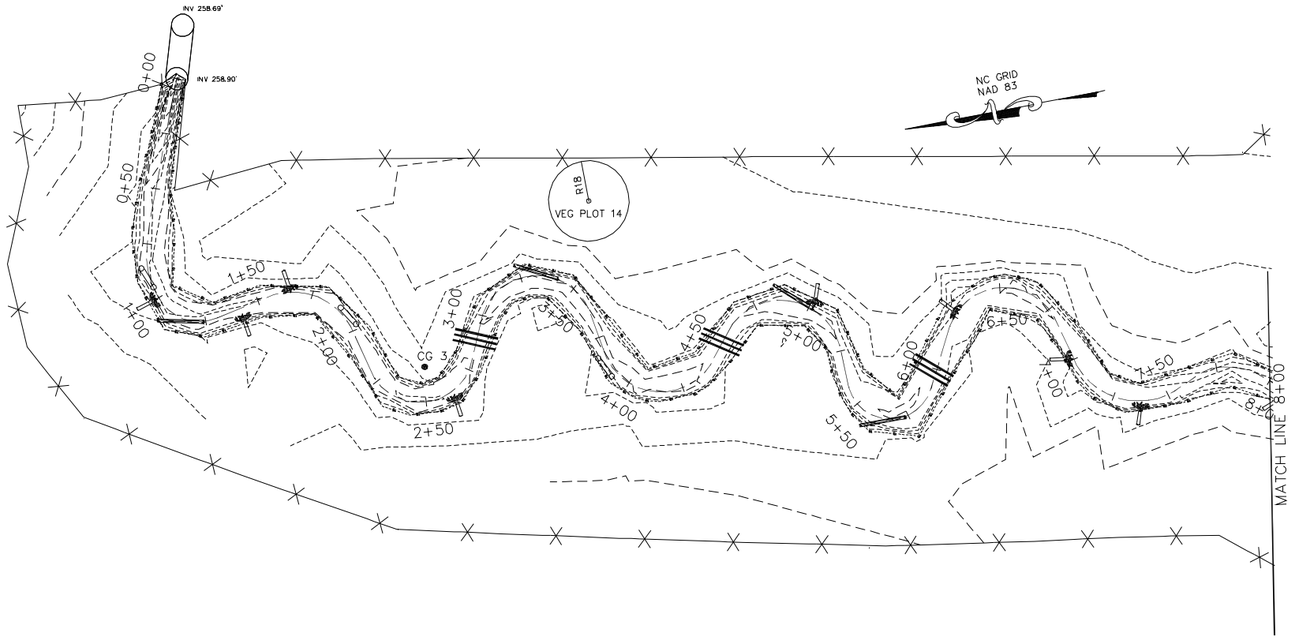
CARTHAGE, NORTH CAROLINA

STONEBRIDGE AS-BUILT PLANS
STREAM MITIGATION AS-BUILT SURVEY



LEGEND

- CENTER OF CHANNEL
- FENCE (LIMITS OF CONSERVATION EASMENT)
- MAJOR CONTOUR
- MINOR CONTOUR
- ROOTWAD
- LOG VANE
- LOG GRADE CONTROL
- LOG TOE PROTECTION
- CREST GAUGE
- SEMI-PERMANENT CROSS-SECTION

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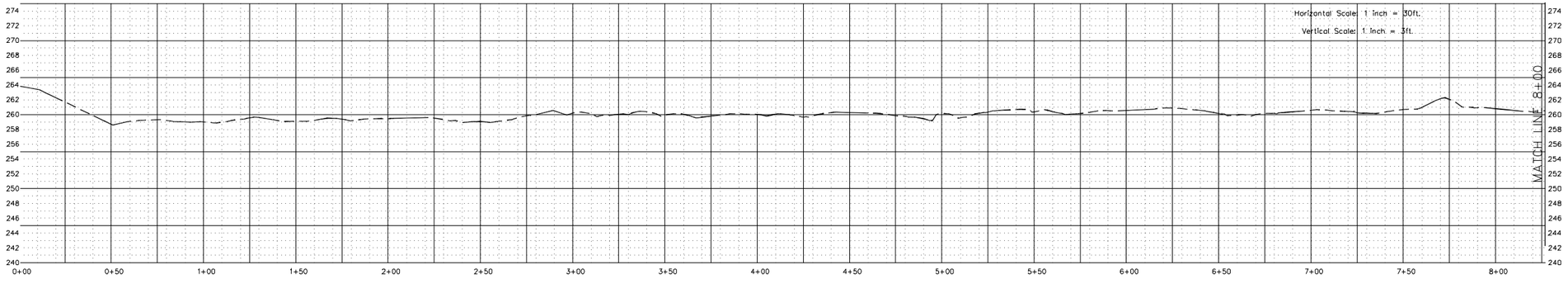
1 inch = 30ft.



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PROJECT DATE	03/30/2004
PROJECT NUMBER	3024600RA
PLOT DATE	10/4/07

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CONSTRUCTION	
RECORD DWG.	

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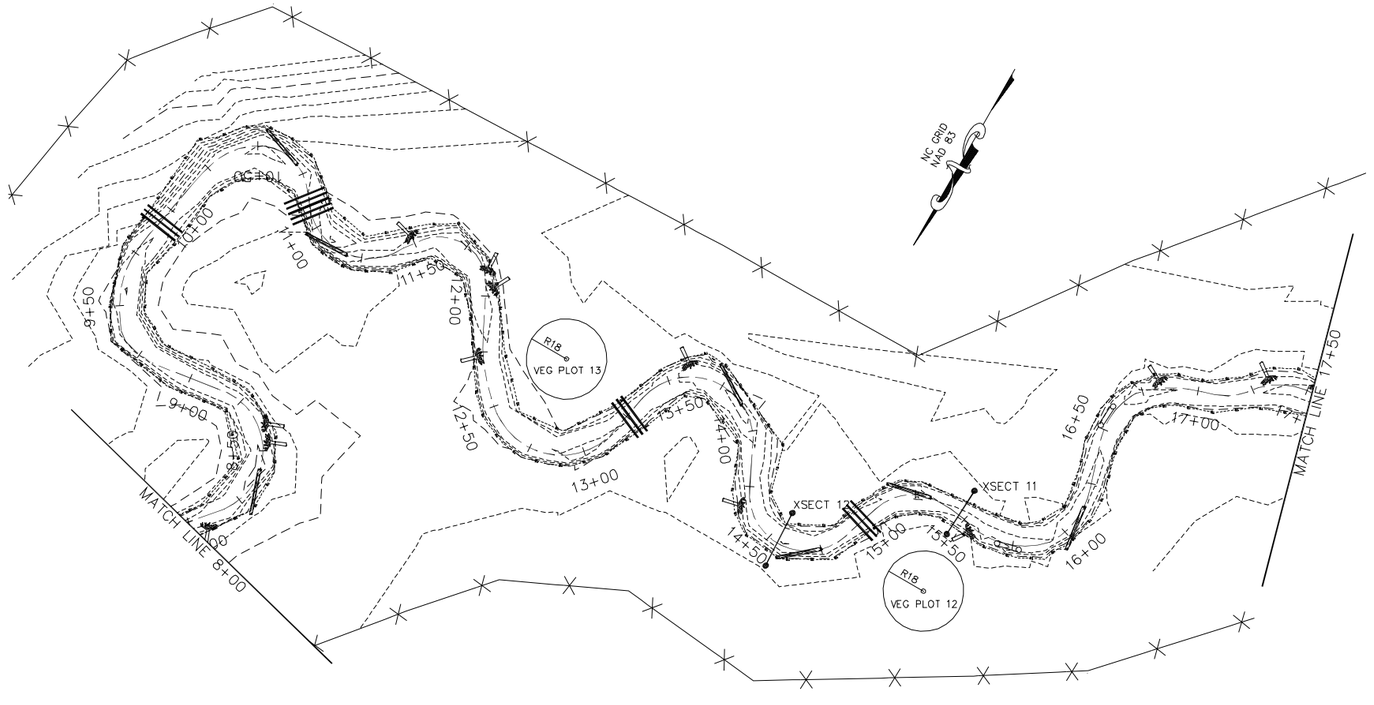
CARTHAGE, NORTH CAROLINA

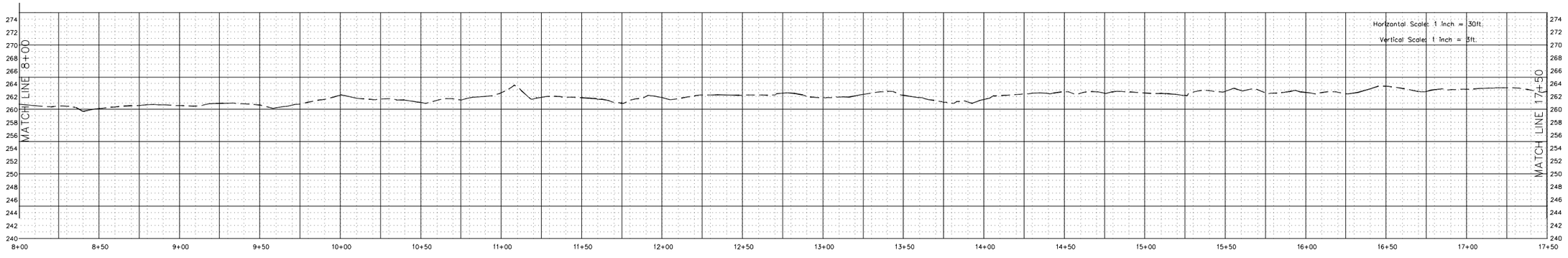
STONEBRIDGE AS-BUILT PLANS
UT-1 STA. 0+00 TO STA. 8+00



LEGEND

- CENTER OF CHANNEL
- FENCE (LIMITS OF CONSERVATION EASMENT)
- MAJOR CONTOUR
- MINOR CONTOUR
- ROOTWAD
- LOG VANE
- LOG GRADE CONTROL
- LOG TOE PROTECTION
- CREST GAUGE
- SEMI-PERMANENT CROSS-SECTION

30 0 15 30 60
1 inch = 30ft.



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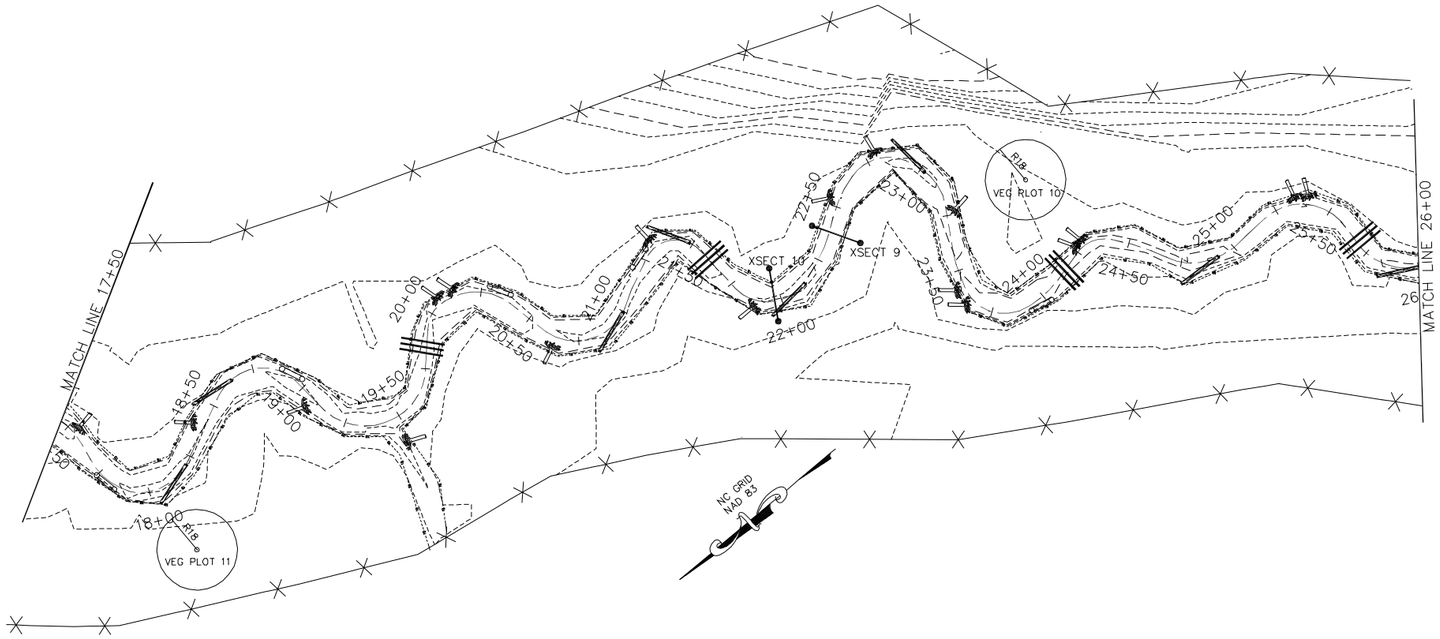
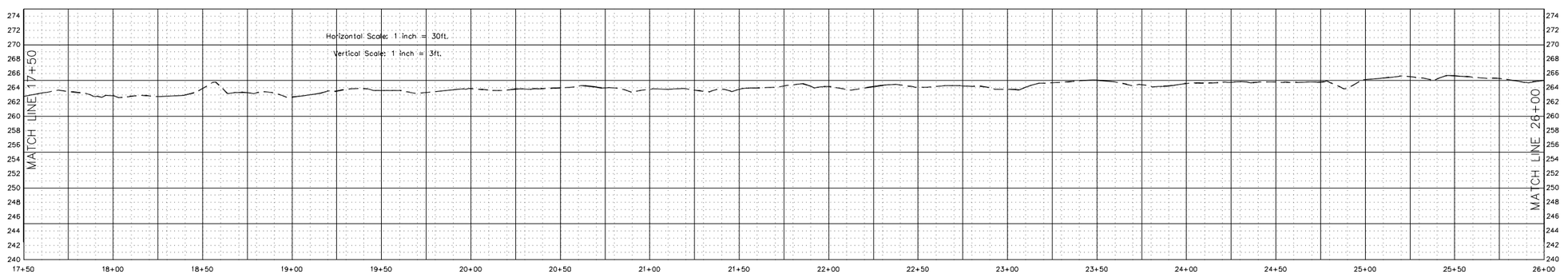
UT-1 STA. 8+00 TO 17+50



LEGEND

- CENTER OF CHANNEL
- FENCE (LIMITS OF CONSERVATION EASMENT)
- MAJOR CONTOUR
- MINOR CONTOUR
- ROOTWAD
- LOG VANE
- LOG GRADE CONTROL
- LOG TOE PROTECTION
- CREST GAUGE
- SEMI-PERMANENT CROSS-SECTION

30 0 15 30 60
1 inch = 30ft.



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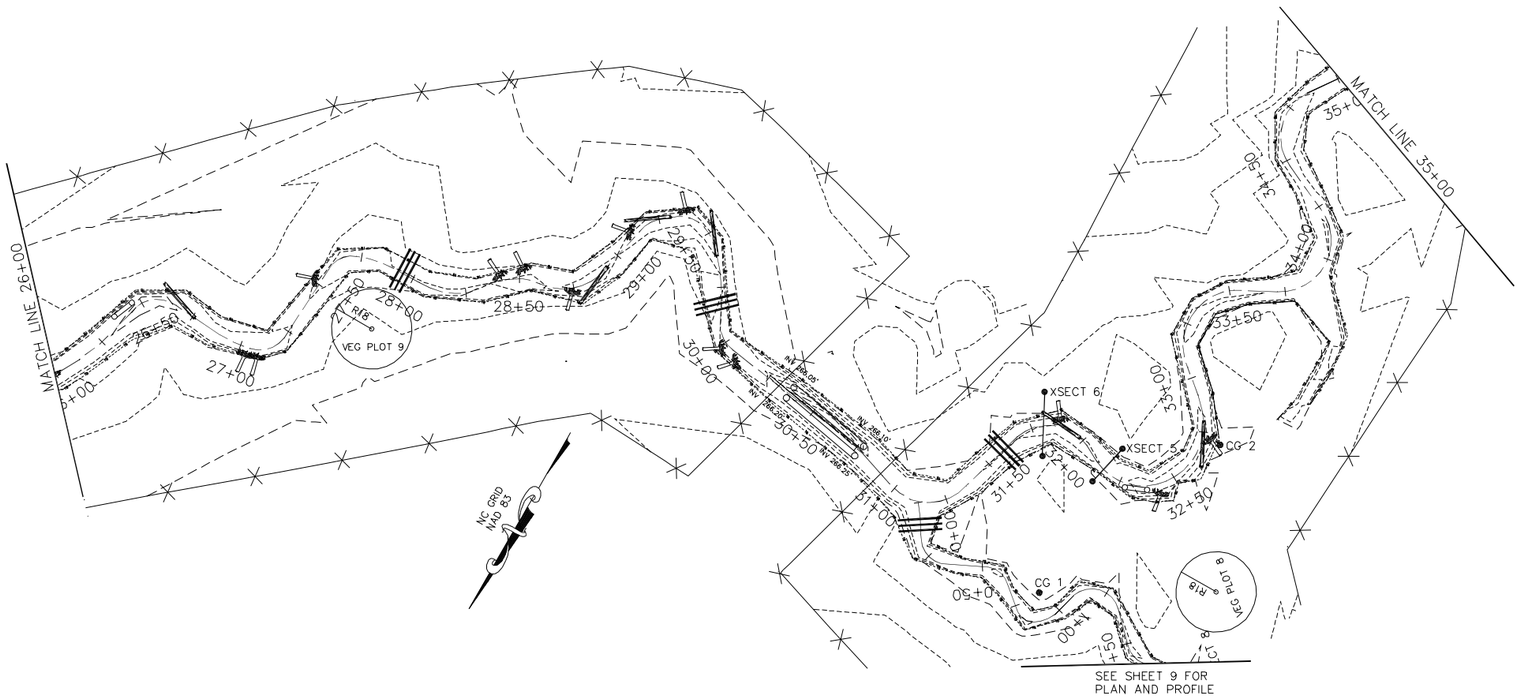
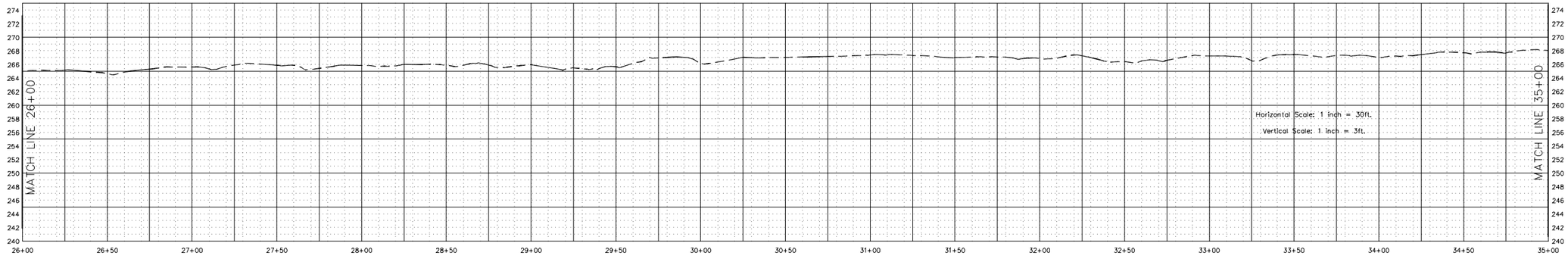
UT-1 STA. 17+50 TO 26+00



LEGEND

- CENTER OF CHANNEL
- FENCE (LIMITS OF CONSERVATION EASMENT)
- MAJOR CONTOUR
- MINOR CONTOUR
- ROOTWAD
- LOG VANE
- LOG GRADE CONTROL
- LOG TOE PROTECTION
- CREST GAUGE
- SEMI-PERMANENT CROSS-SECTION

30 0 15 30 60
1 inch = 30ft.



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APPROVED BY	ME
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DRAWING SCALE	1" = 30'
PROJECT DATE	03/30/2004
PROJECT NUMBER	3024600RA
PLOT DATE	10/4/07

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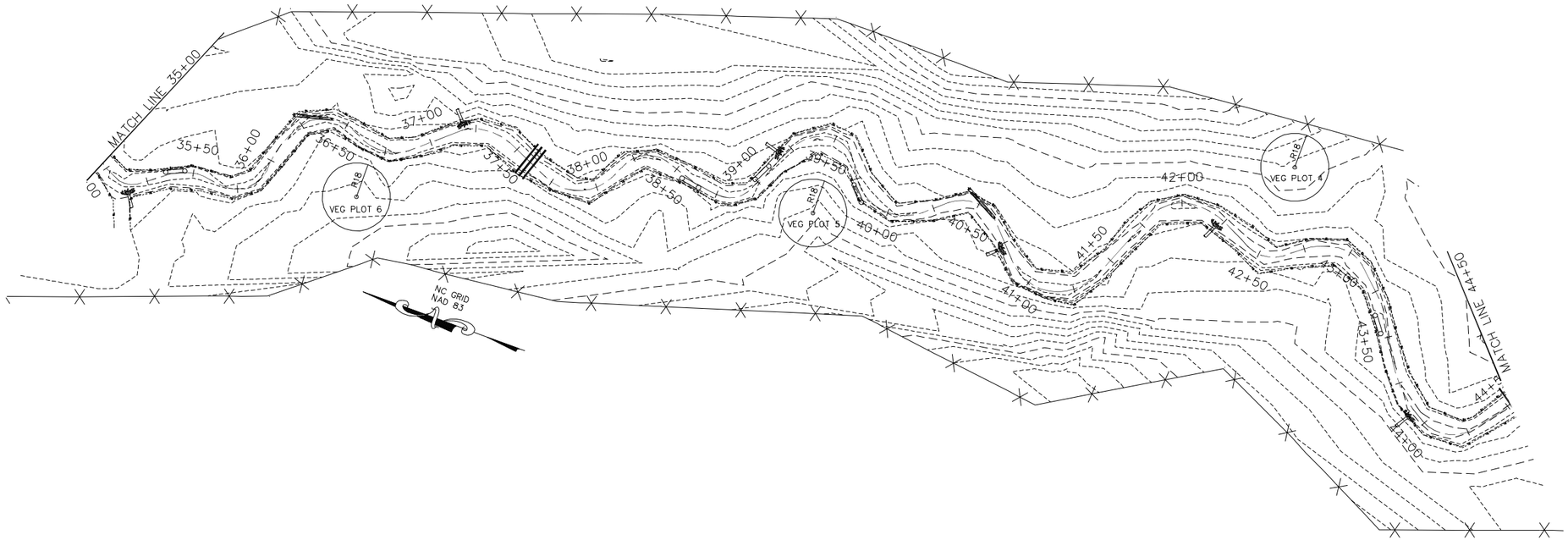
UT-1 STA. 26+00 TO 35+00



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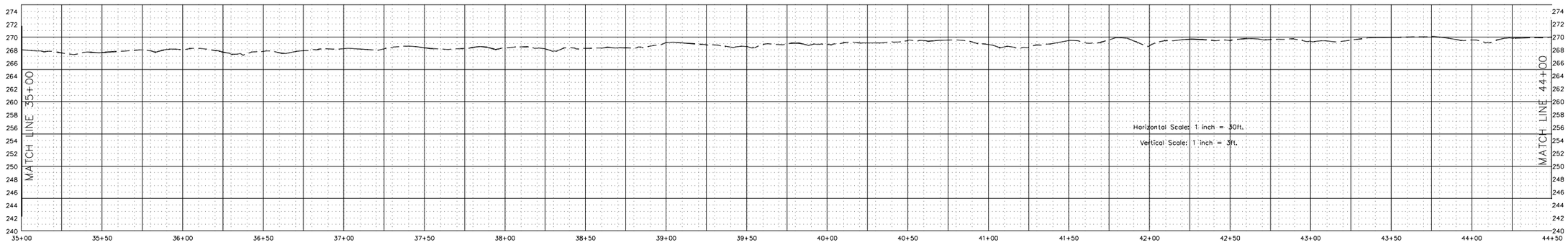
- MAJOR CONTOUR
- MINOR CONTOUR
- ROOTWAD
- LOG VANE
- LOG GRADE CONTROL
- LOG TOE PROTECTION
- CREST GAUGE
- SEMI-PERMANENT CROSS-SECTION

30 0 15 30 60
1 inch = 30ft.



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APPROVED BY	ME
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PROJECT DATE	03/30/2004
PROJECT NUMBER	3024600RA
PLOT DATE	10/4/07

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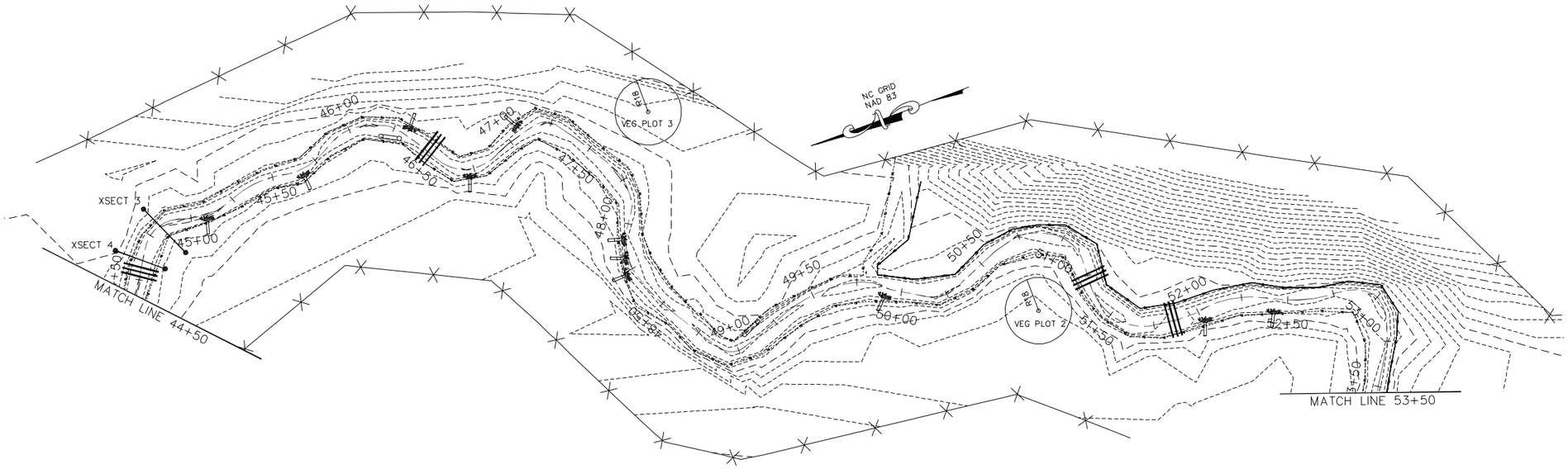
STONEBRIDGE AS-BUILT PLANS
UT-1 STA. 35+00 TO 44+00

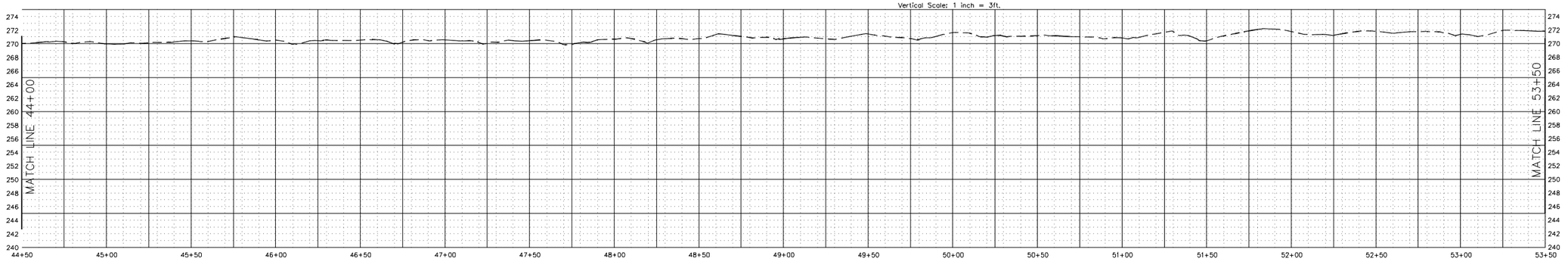


LEGEND

- CENTER OF CHANNEL
- FENCE (LIMITS OF CONSERVATION EASMENT)
- MAJOR CONTOUR
- MINOR CONTOUR
- ROOTWAD
- LOG VANE
- LOG GRADE CONTROL
- LOG TOE PROTECTION
- CREST GAUGE
- SEMI-PERMANENT CROSS-SECTION

30 0 15 30 60
1 inch = 30ft.

Horizontal Scale: 1 inch = 30ft.
Vertical Scale: 1 inch = 3ft.



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FILE NAME	as-built.dwg
DRAWING SCALE	1" = 30'
PROJECT DATE	03/30/2004
PROJECT NUMBER	3024600RA
PLOT DATE	10/4/07

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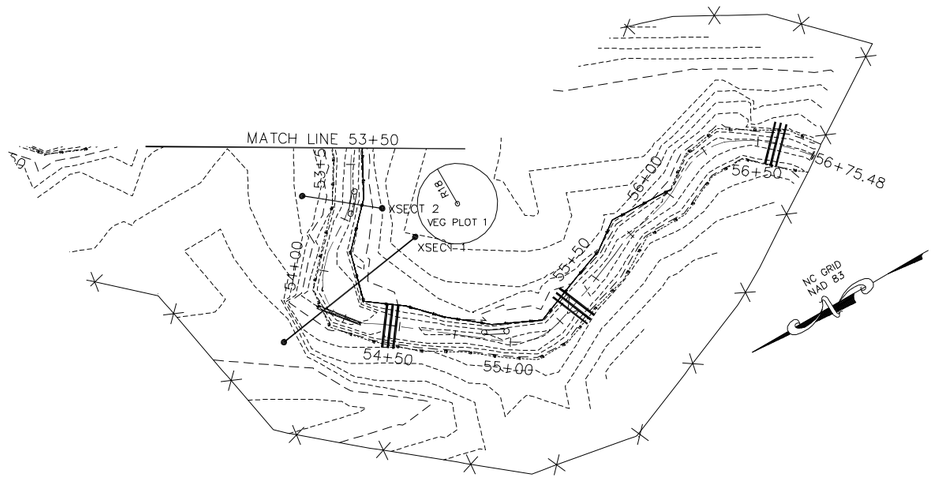
STONEBRIDGE AS-BUILT PLANS
UT-1 STA. 44+00 TO 53+50



LEGEND

- CENTER OF CHANNEL
- FENCE (LIMITS OF CONSERVATION EASMENT)
- MAJOR CONTOUR
- MINOR CONTOUR
- ROOTWAD
- LOG VANE
- LOG GRADE CONTROL
- LOG TOE PROTECTION
- CREST GAUGE
- SEMI-PERMANENT CROSS-SECTION

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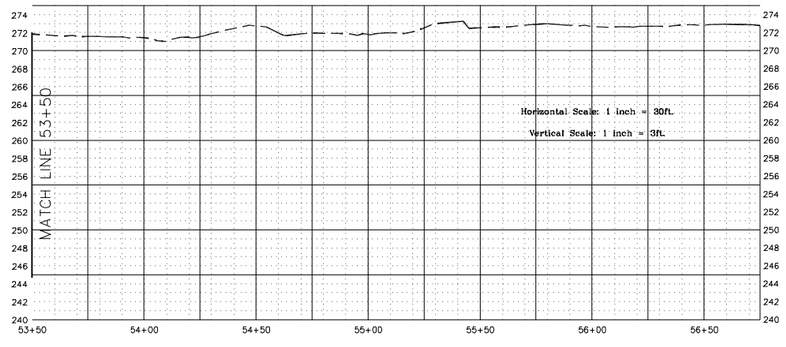
1 inch = 30ft.



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APPROVED BY	ME
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PROJECT DATE	03/30/2004
PROJECT NUMBER	
PLOT DATE	10/4/07

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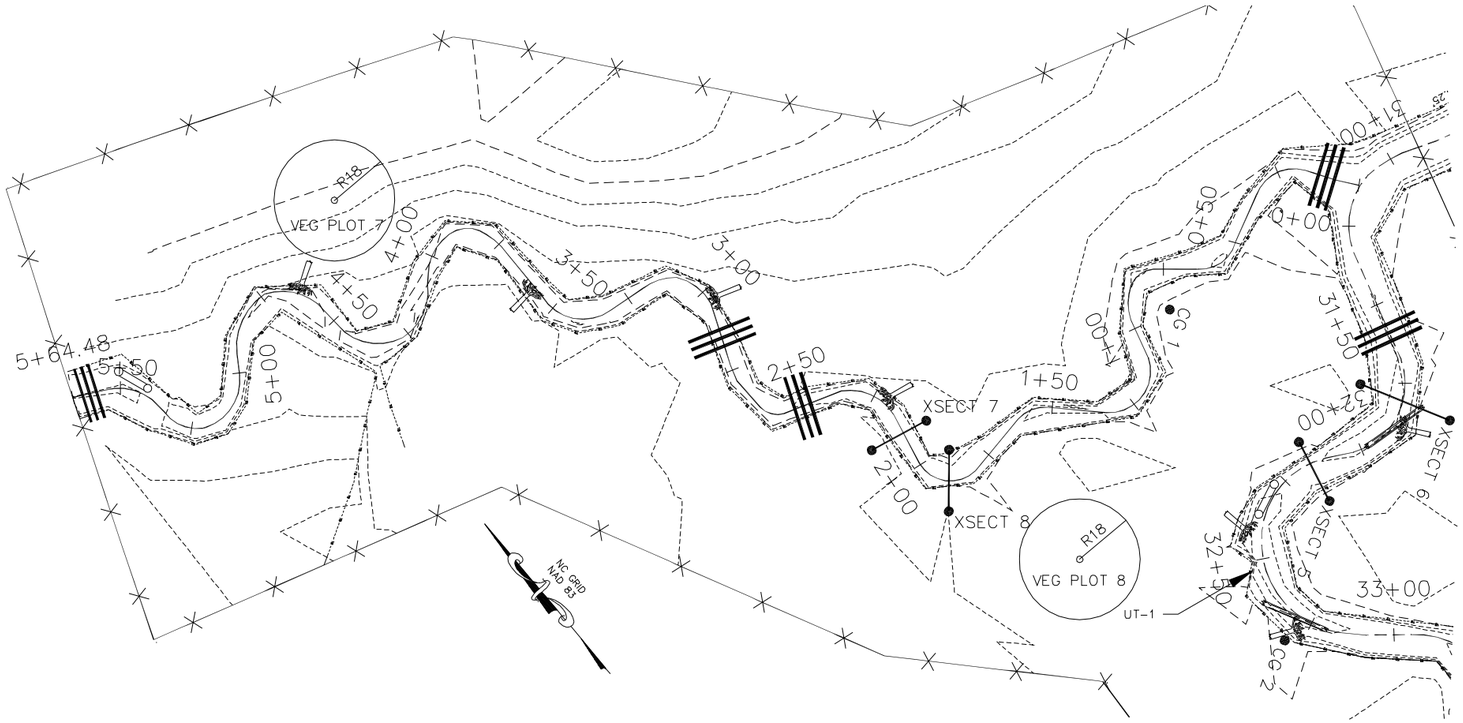
CARTHAGE, NORTH CAROLINA

STONEBRIDGE AS-BUILT PLANS
UT-1 STA. 53+50 TO 56+75

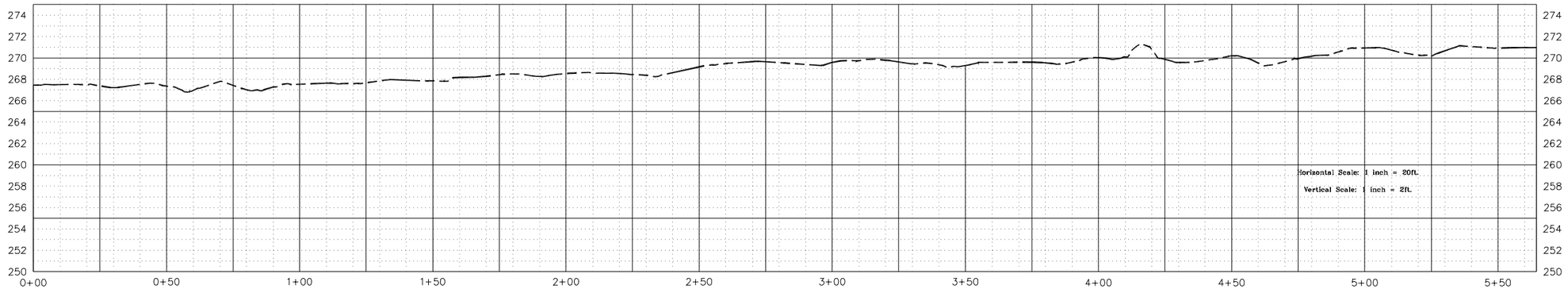


LEGEND

- CENTER OF CHANNEL
- FENCE (LIMITS OF CONSERVATION EASEMENT)
- MAJOR CONTOUR
- MINOR CONTOUR
- ROOTWAD
- LOG VANE
- LOG GRADE CONTROL
- LOG TOE PROTECTION
- CREST GAUGE
- SEMI-PERMANENT CROSS-SECTION

20 0 10 20 40

1 inch = 20ft.



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REVISIONS

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PROJECT NUMBER: 3024600RA
PLOT DATE: 10/4/07

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CONSTRUCTION	
RECORD DWG.	

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STONEBRIDGE STREAM MITIGATION PROJECT
CARTHAGE, NORTH CAROLINA

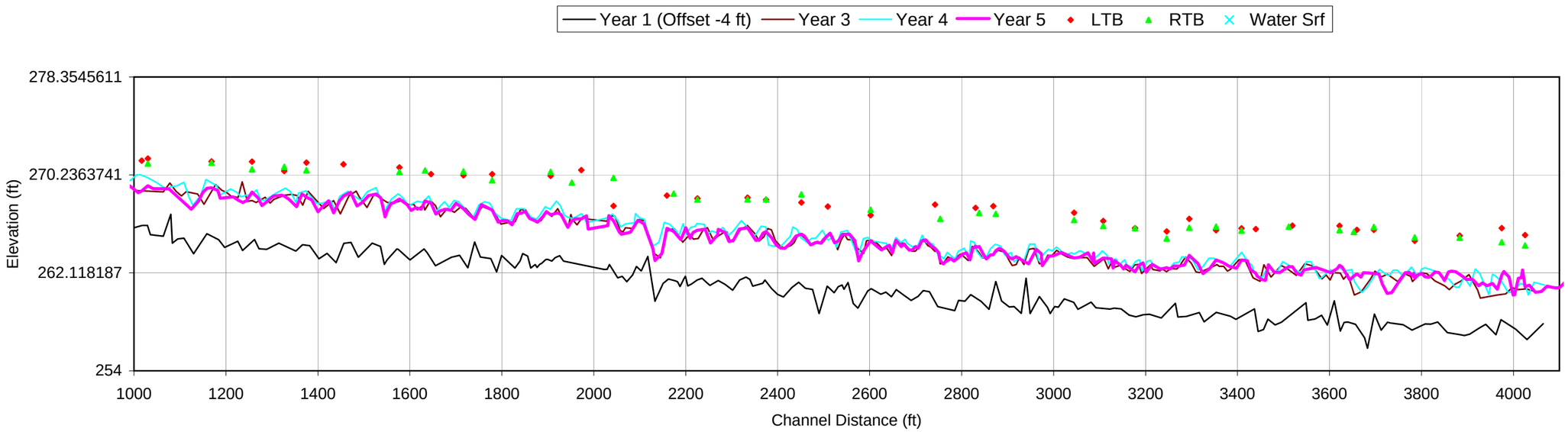
STONEBRIDGE AS-BUILT PLANS

UT-2 STA. 0+00 TO 5+64

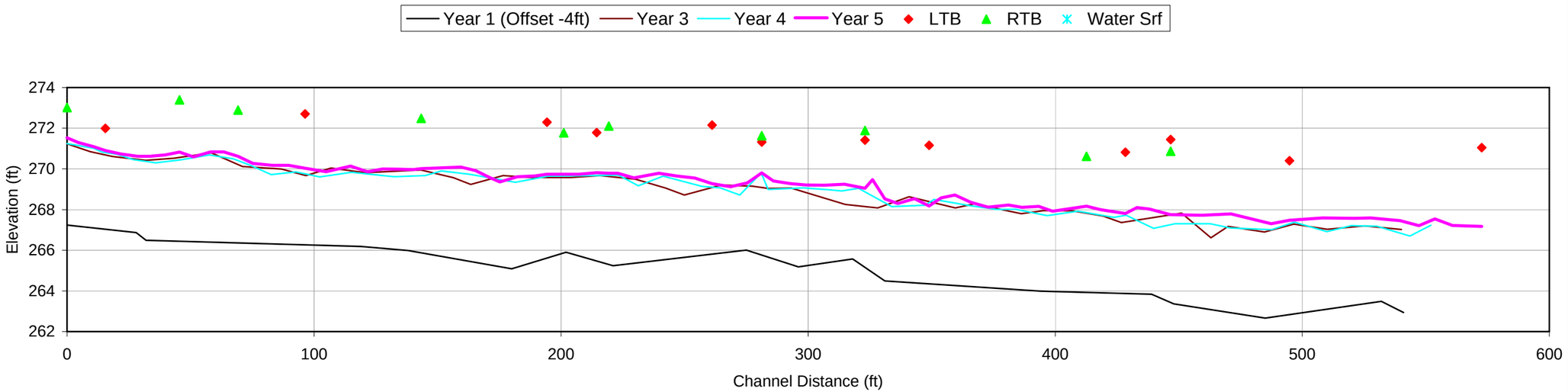
APPENDIX B

2010 Profile and Cross Section Data

Stonebridge
UT-1 Station 10+00 - 41+00

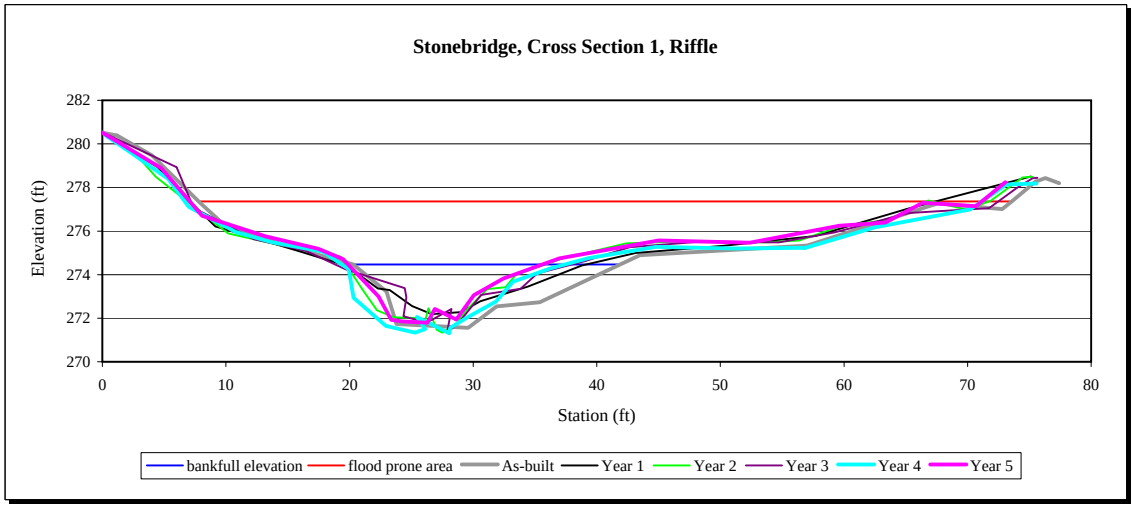


Stonebridge
UT-2 Station 0+00 - 5+64



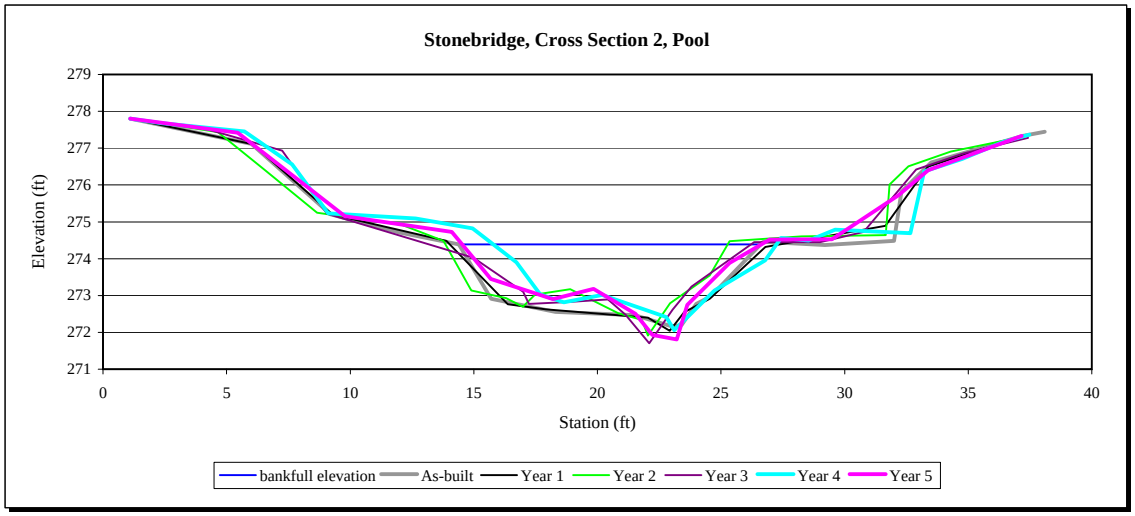
Left Bank

Right Bank

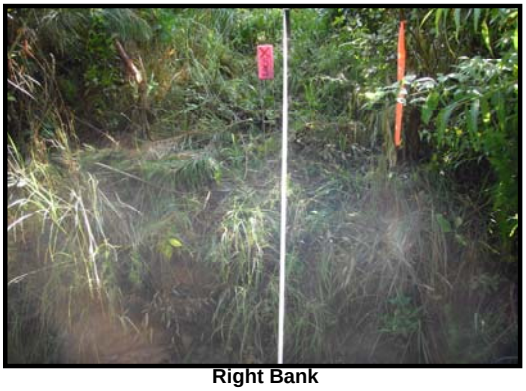


Left Bank

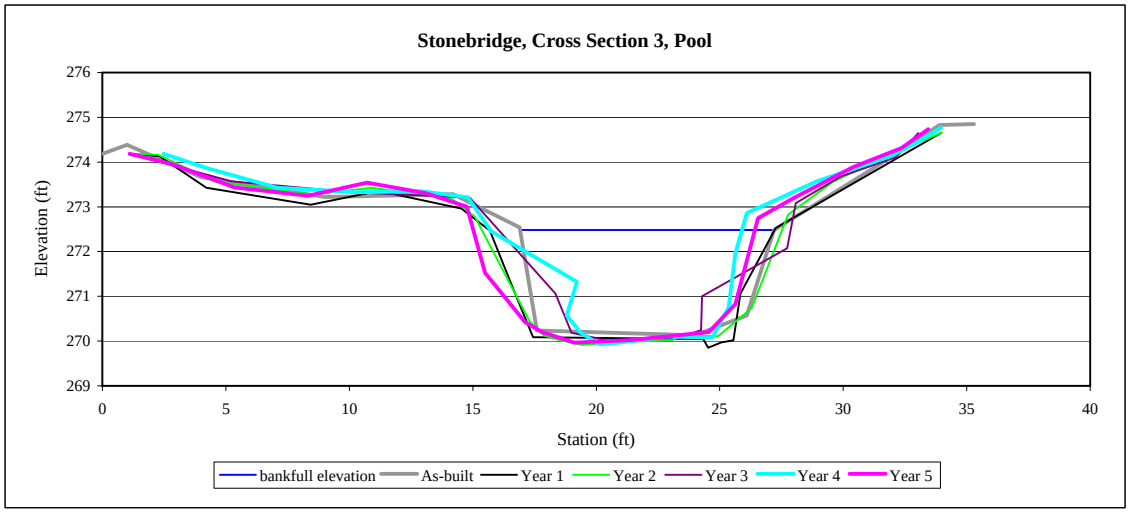
Right Bank



Left Bank

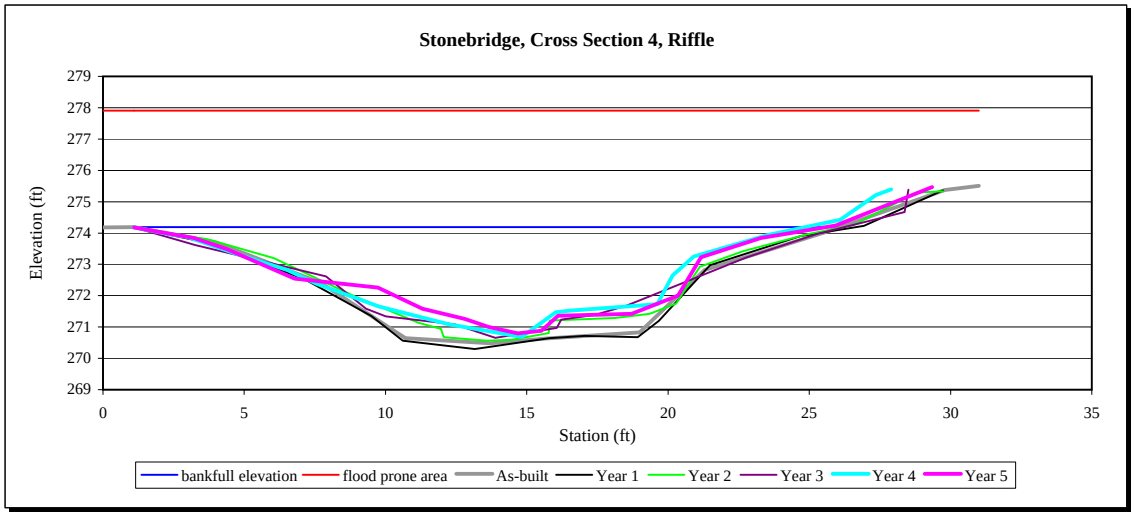


Right Bank



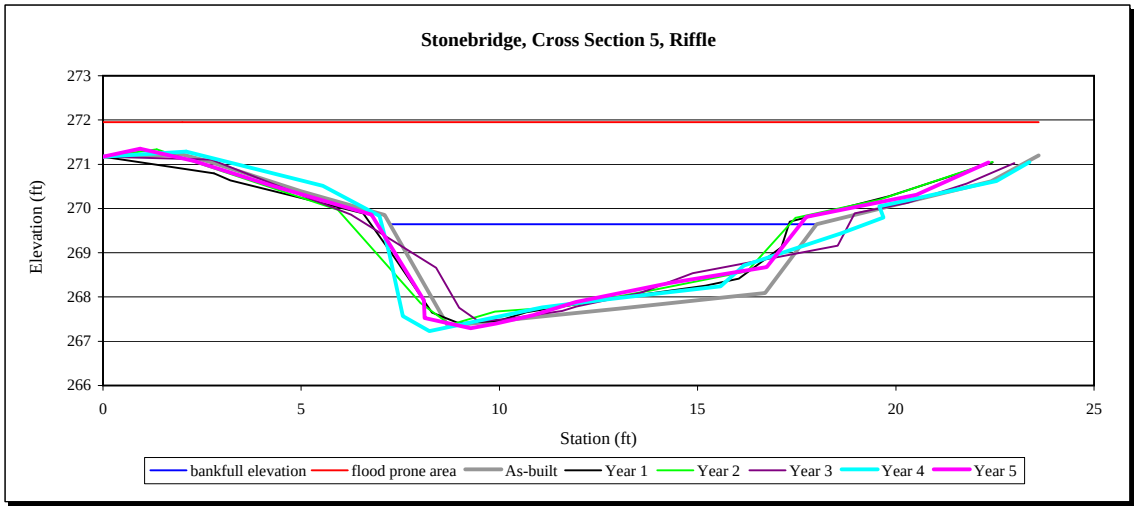
Left Bank

Right Bank



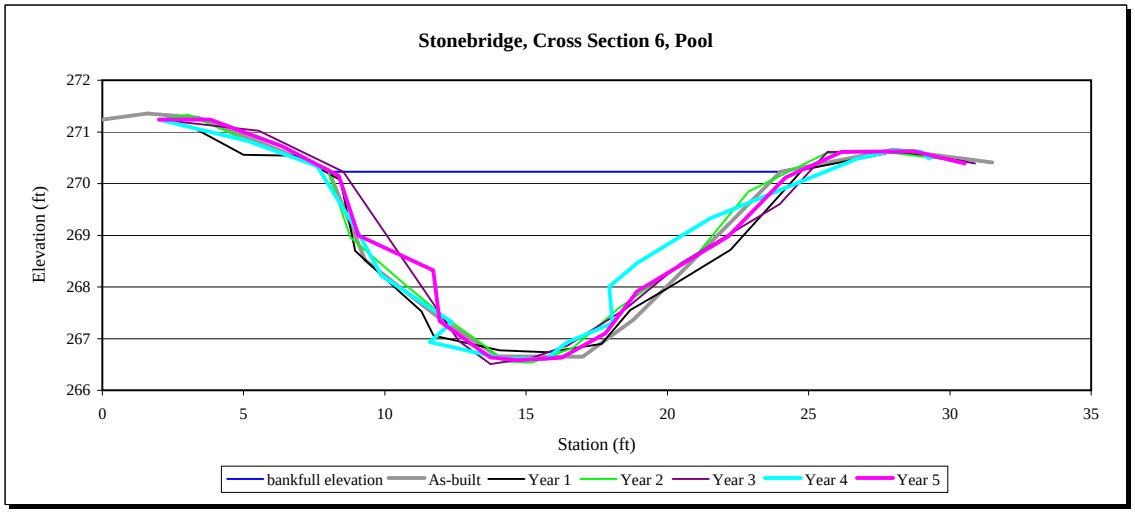
Left Bank

Right Bank



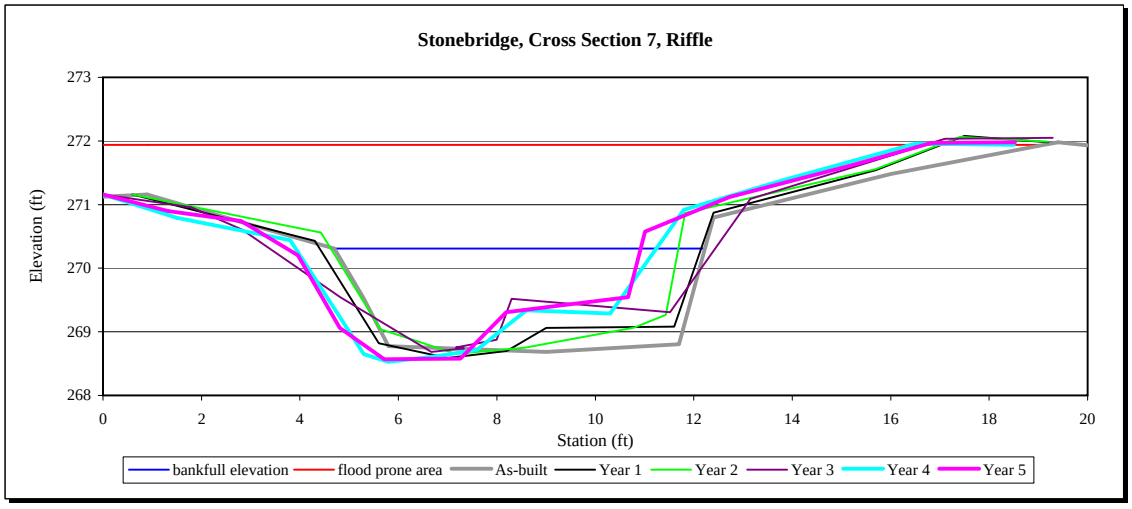
Left Bank

Right Bank



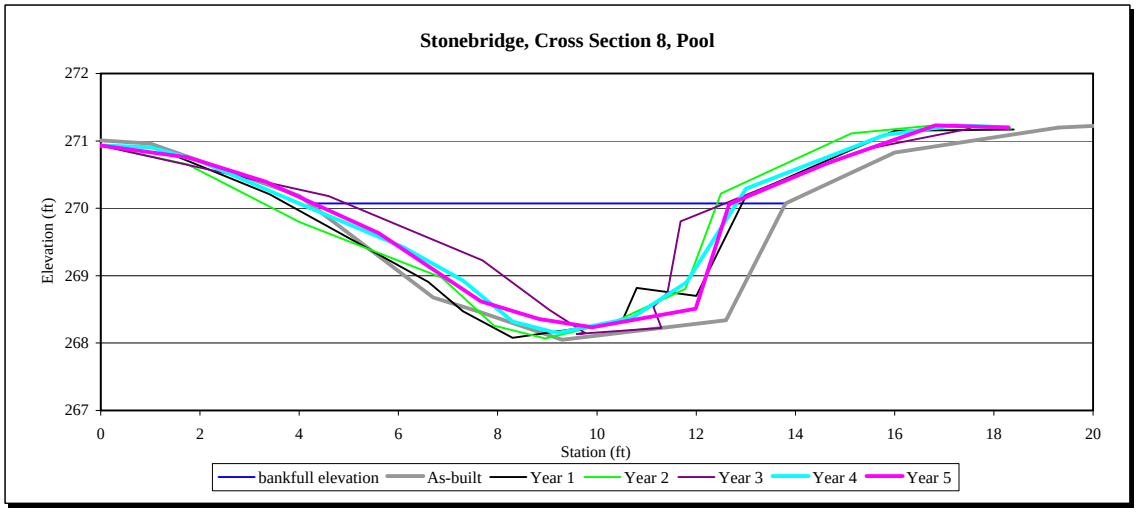
Left Bank

Right Bank



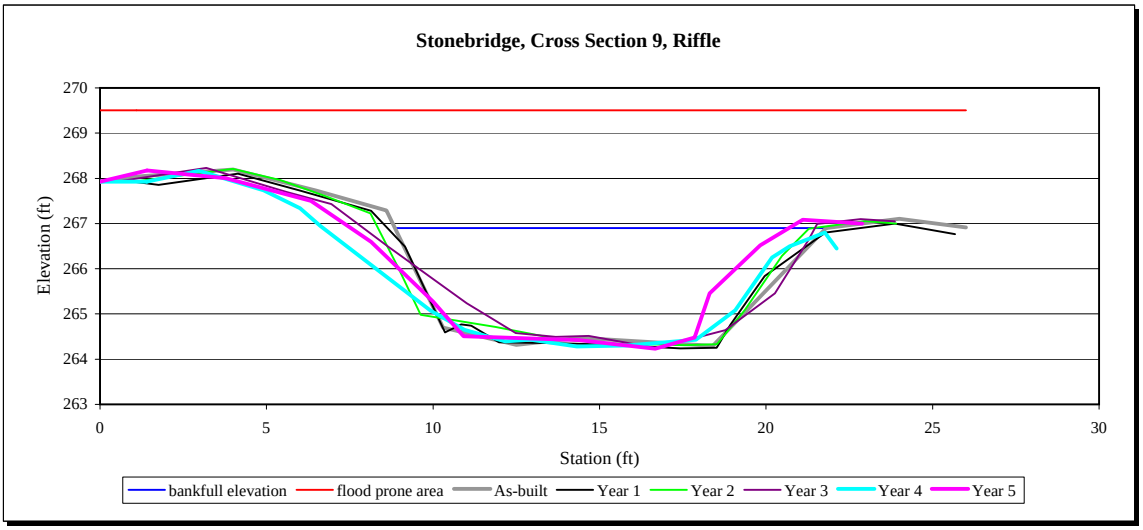
Left Bank

Right Bank



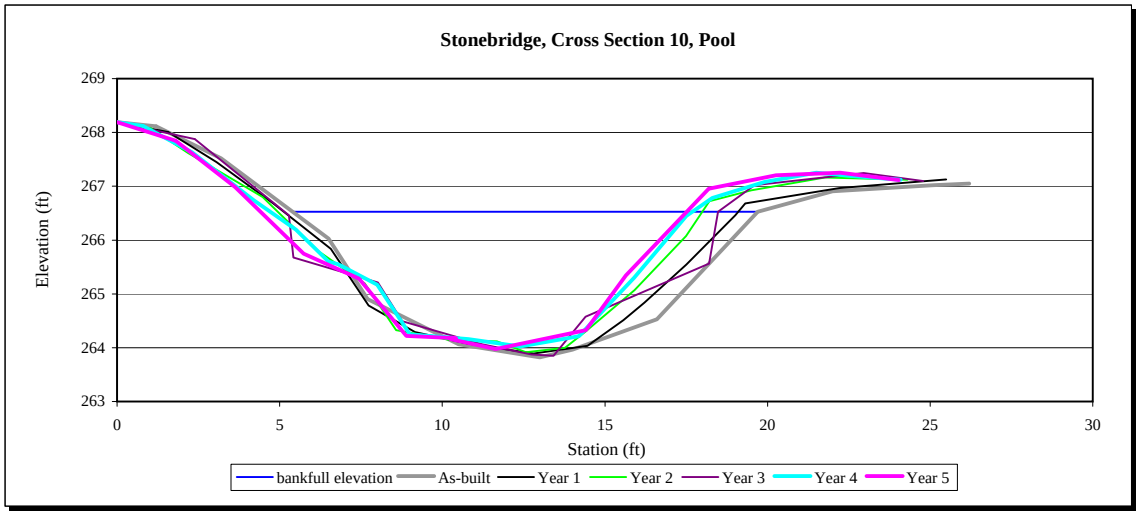
Left Bank

Right Bank



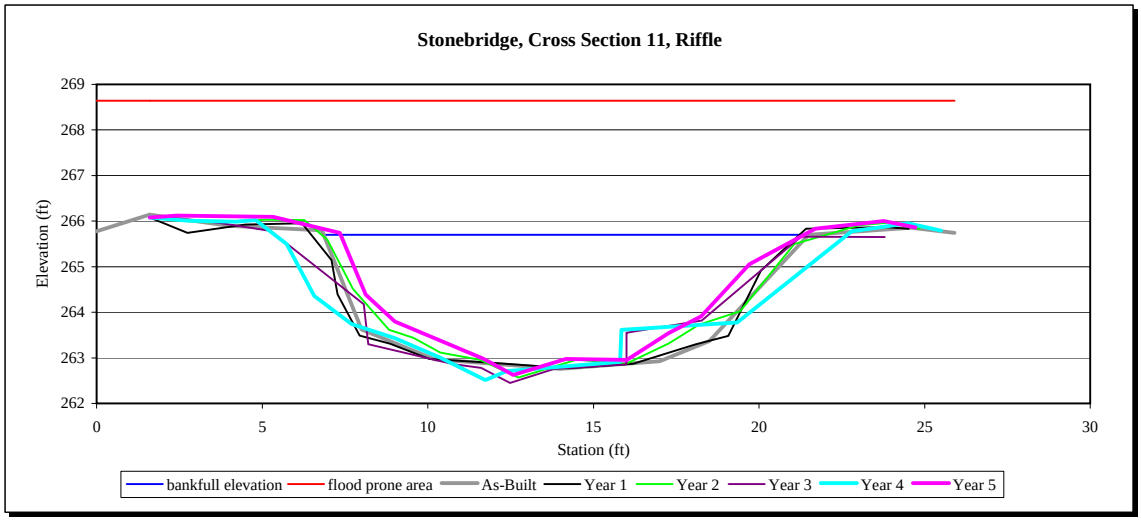
Left Bank

Right Bank



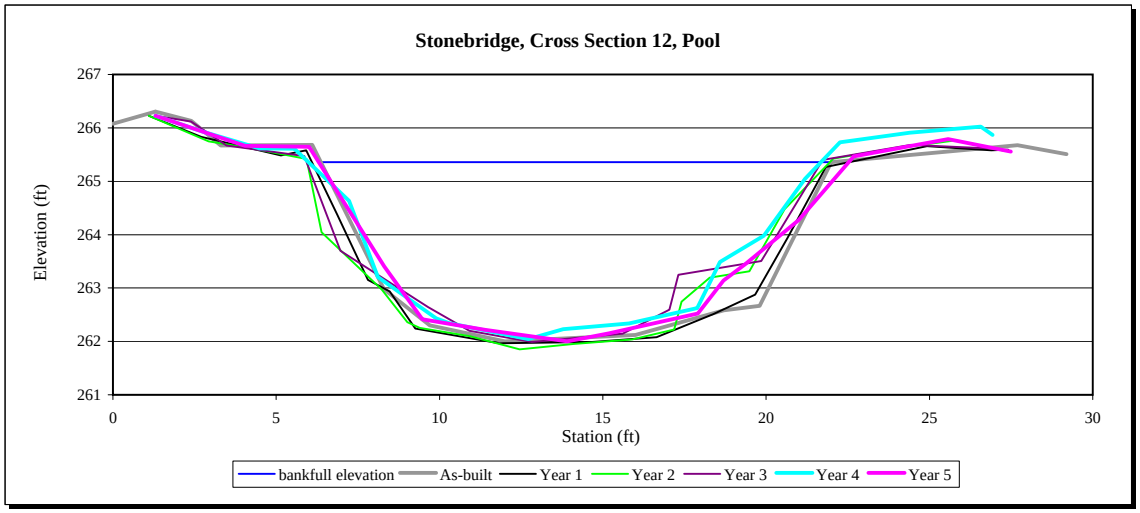
Left Bank

Right Bank



Left Bank

Right Bank



APPENDIX C

2010 Site Photos

Appendix C
2010 Site Photos
Stream Observation Area Photos

SOA 1 – Minor bank damage due to cattle incursion, upper reaches of UT1.

SOA 1 – Minor vegetation damage due to cattle incursion, upper reaches of UT1.

Appendix C
2010 Site Photos
Stream Observation Area Photos

SOA 2 – Minor right bank erosion, UT1 Sta. 47+50 to 47+80.

SOA 3 – Minor right bank erosion, UT1 Sta. 40+15 to 45+10.

Appendix C
2010 Site Photos
Stream Observation Area Photos

SOA 4 – Bank undercut along right bank at log grade control, UT2 Sta. 2+50.

SOA 5 – Log vane undercut, UT1, Sta. 16+00.

Appendix C
2010 Site Photos
Stream Observation Area Photos

SOA 6– Log vane undercut., UT1, Sta. 11+00.

SOA 7 – Minor headcut. Vegetation has stabilized the channel., UT1 Sta. 2+15.

Appendix C
2010 Site Photos - Vegetation Plot Photos

Vegetation Plot #1 - upstream

Vegetation Plot #1 – downstream

Appendix C
2010 Site Photos - Vegetation Plot Photos

Vegetation Plot #2 – upstream

Vegetation Plot #2 – downstream

Appendix C
2010 Site Photos - Vegetation Plot Photos

Vegetation Plot #3 – upstream

Vegetation Plot #3 – downstream

Appendix C
2010 Site Photos - Vegetation Plot Photos

Vegetation Plot #4 – upstream

Vegetation Plot #4 – downstream

Appendix C
2010 Site Photos - Vegetation Plot Photos

Vegetation Plot #5 – upstream

Vegetation Plot #5 – downstream

Appendix C
2010 Site Photos - Vegetation Plot Photos

Vegetation Plot #6 – upstream

Vegetation Plot #6 – downstream

Appendix C
2010 Site Photos - Vegetation Plot Photos

Vegetation Plot #7 – upstream

Vegetation Plot #7 – downstream

Appendix C
2010 Site Photos - Vegetation Plot Photos

Vegetation Plot #8 – upstream

Vegetation Plot #8 – downstream

Appendix C
2010 Site Photos - Vegetation Plot Photos

Vegetation Plot #9 – upstream

Vegetation Plot #9 – downstream

Appendix C
2010 Site Photos - Vegetation Plot Photos

Vegetation Plot #10 – upstream

Vegetation Plot #10 – downstream

Appendix C
2010 Site Photos - Vegetation Plot Photos

Vegetation Plot #11 – upstream

Vegetation Plot #11 – downstream

Appendix C
2010 Site Photos - Vegetation Plot Photos

Vegetation Plot #12 – upstream

Vegetation Plot #12 – downstream

Appendix C
2010 Site Photos - Vegetation Plot Photos

Vegetation Plot #13 –upstream

Vegetation Plot #13 –downstream

Appendix C
2010 Site Photos - Vegetation Plot Photos

Vegetation Plot #14 –upstream

Vegetation Plot #14 –downstream