Open Springs Mitigation Project
Randolph County, North Carolina

Year 4 Monitoring Report

Prepared for
Environmental Banc and Exchange, LLC
909 Capability Drive, Suite 3100
Raleigh, NC 27606

Prepared by
WK Dickson and Co., Inc.
720 Corporate Center Drive
Raleigh, NC 27607
(919) 782-0495

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1.0 SUMMARY

The Open Springs Stream Mitigation Project site is located in Randolph County, North Carolina, northeast of Ramseur within hydrologic unit 03030003 in the Cape Fear River Basin. The NC Department of Transportation (NCDOT) contracted with EBX Neuse I, LLC (EBX) to perform mitigation work at the site under Full Delivery Project S-1. A total of 4,835 stream mitigation units (SMU) were generated from this project through restoration and enhancement of stream and riparian habitats. The project is being monitored for five years to determine the success of the restoration and enhancement efforts. 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 July 25, 2005 (**Appendix A**). Information on stream morphology and vegetation will be collected each year and compared to the baseline data and data from previous monitoring years in order to determine whether the site is meeting success criteria.

This Annual Report details the monitoring data collected during Monitoring Year 4. Collected data includes: monthly crest gauge readings, monthly observations of current conditions, benthic macroinvertebrate survey, cross sections, digital images, and observations of potential problems with stream stability.

With an average of 570 stems per acre, the site remains on track to achieve the final success criteria at the end of Year 5, as specified in the Mitigation Plan. The site is covered with a diverse mix of herbaceous vegetation.

The stream morphology is stable with the site experiencing multiple bankfull events again in 2008. Very little fluvial erosion was observed, and many of the riffle features are collecting small gravel, as expected.

Overall, the project is on track to achieve the stream and vegetation success criteria specified in the Mitigation Plan. Habitat has been improved significantly throughout the project. Based on initial observations, site vegetation is expected to succeed and provide riparian habitat, water quality benefits, and cover for the stream system.

2.0 INTRODUCTION

2.1 PROJECT DESCRIPTION

The project site is located in Randolph County, North Carolina, northeast of the town of Ramseur (**Figure 1** & **Figure 2**) within hydrologic unit 03030003 in the Cape Fear River Basin. The project site is bound to the north and east by Ferguson Road and Low Bridge Road, respectively.

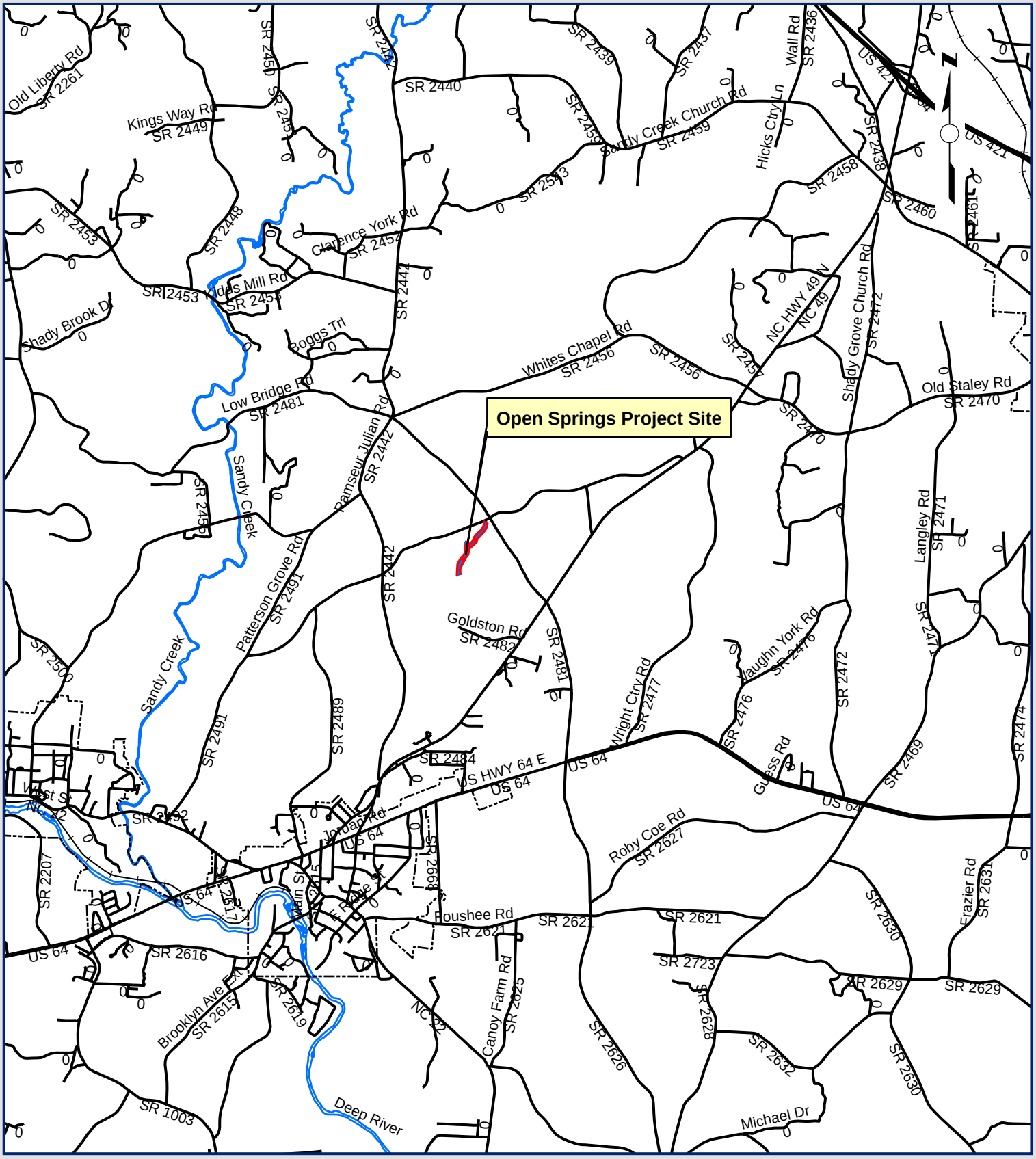
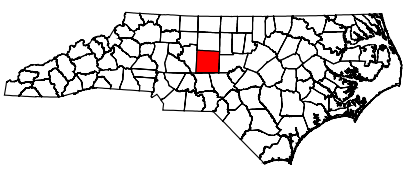
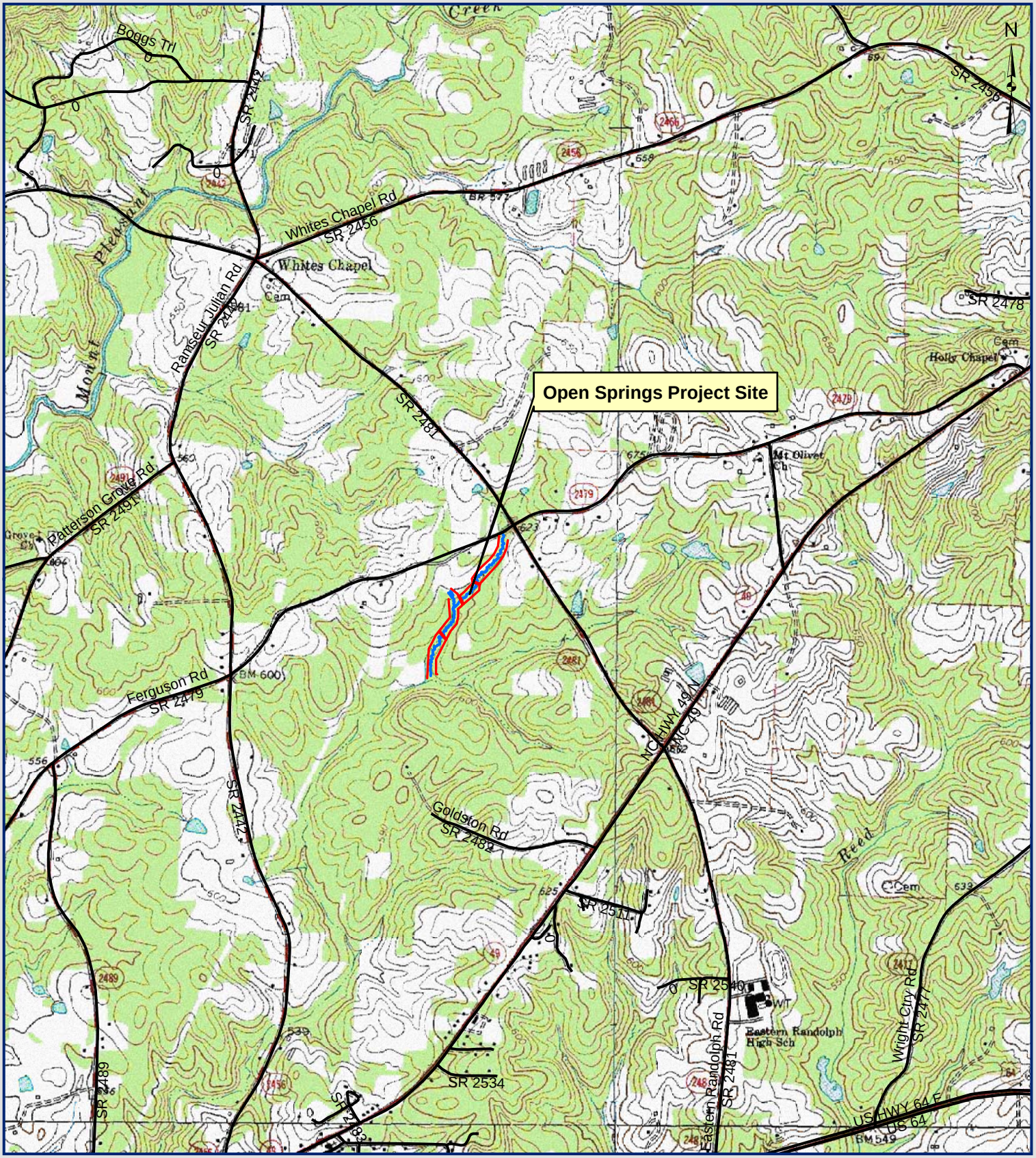


Figure 1.
Open Springs Stream Mititgation Site
Project Location Map
Randolph County, NC

1 inch equals 5,280 feet

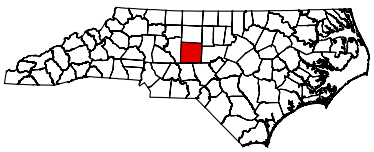


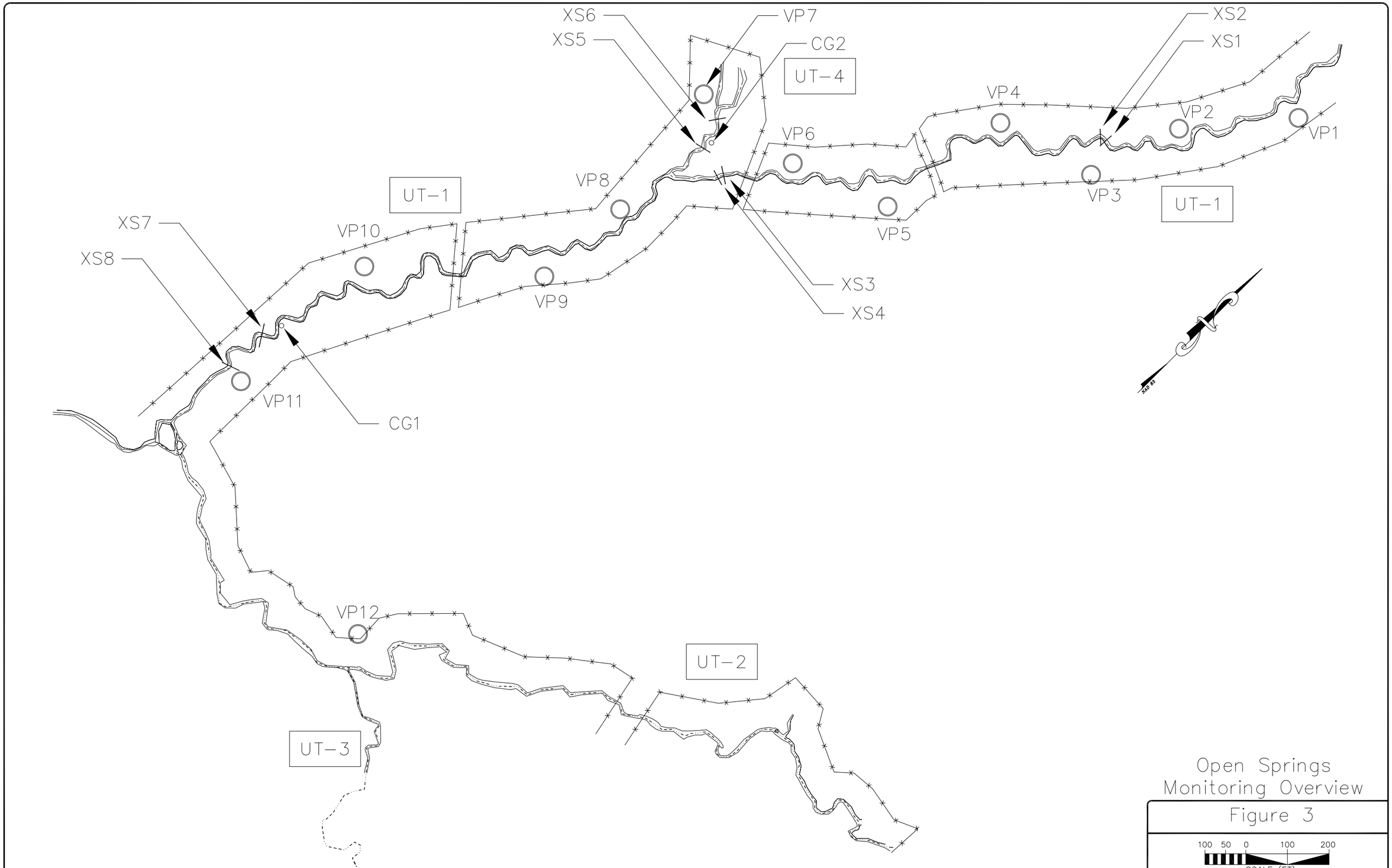


EBX

Figure 2.
Open Springs Stream Mititgation Site
USGS Topographic Map
Randolph County, NC

1 inch equals 2,000 feet




XS6
XS5
VP7
CG2
UT–4
XS2
XS1
VP4
VP2
VP1
VP6
VP8
UT–1
VP3
UT–1
XS7
VP10
VP5
XS8
XS3
XS4
VP9
VP11
CG1
VP12
UT–2
UT–3
NAD 83
Open Springs
Monitoring Overview
Figure 3
100 50 0 100 200
SCALE (FT)

2.2 PROJECT PURPOSE

The objective of this project is to provide at least 4,520 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).

Four unnamed tributaries to the Deep River flow across the project site. The streams are referred to in this report as UT-1, UT-2, UT-3, and UT-4. 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 3,202 mitigation units were achieved by restoring plan form, cross section, and profile features on UT-1. In addition, a small tributary enters UT-1 near station 14+50, referred to herein as UT-4. The bed of this tributary was raised to maintain a stable confluence with UT-1. An existing slope discontinuity approximately 175 feet upstream of the confluence was deemed the natural location to tie in grades. The sinuosity designed for this small tributary yielded an additional 307 linear feet of stream. Therefore, a total of 3,509 SMU were generated from stream restoration on UT-1 and UT-4.

UT-2 is the master stream and, although it has been locally disturbed by cattle, it was in relatively good physical condition. Enhancements to UT-2 include cattle exclusion, localized bank stabilization and debris removal, riparian buffer planting, and control of invasive/exotic vegetation. UT-2 has a total length of 2,397 feet on the subject property. An existing farm crossing was maintained, and 53 feet are being held near the east property line to accommodate a future crossing, leaving 2,329 linear feet for stream enhancement. Using the 2.5:1 ratio for Level II stream enhancement (USACE, 2003), 931 SMU were generated from UT-2. UT-3 flows through a regenerated pine plantation and is also in good physical condition. However, the riparian habitat along UT-3 is in poor condition and enhancement efforts included riparian buffer planting to increase diversity and control invasive/exotic vegetation. At the 2.5:1 enhancement ratio, 395 linear feet of UT-3 were enhanced to deliver the total 4,835 SMU.

Table 1. Project Mitigation Structure and Objectives

Reach Name	Stream Mitigation Units (SMU)	Restoration Approach
UT -1	3202	Restoration
UT-2	931	Enhancement
UT-3	395	Enhancement
UT-4	307	Restoration
Total	**4835**	

2.3 PROJECT HISTORY & SCHEDULE

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) as solicited through the NCDOT's Full Delivery Project S-1. This project was identified by EBX in the spring of 2003. **Table 2** outlines the project history and milestones.

Table 2. Project Activity and Reporting History

Month	Activity
Mitigation Plan	April-04
Final Design	November-04
Construction	April-05
Vegetation Planting	April-05
As-built (Baseline) Report	July-05
Year 1 Monitoring	November-05
Year 2 Monitoring	November-06
Year 3 Monitoring	November-07
Year 4 Monitoring	November-08
Year 5 Monitoring	November-09 (scheduled)

Table 3. Project Contacts

Contact	Firm Information
Project Manager Norton Webster	EBX-Neuse 1, LLC (919) 608-9688
Designer Kevin Tweedy, PE	Buck Engineering PC (919) 463-5488
Monitoring Contractor Daniel Ingram	WK Dickson and Co., Inc (919) 782-0495

3.0 VEGETATION

3.1 VEGETATION SUCCESS CRITERIA

The interim measure of vegetative success for the Open Springs Mitigation Site was survival of at least 320 planted stems per acre at the end of the year three monitoring period. The final vegetative success criteria will be the survival of 260 planted trees per acre at the end of year five of the monitoring period (U.S. Army Corps of Engineers et. al. 2003). Success of riparian vegetation will be evaluated annually through monitoring of planted stem survival and photo documentation of vegetation plots. An assessment of the natural regeneration of woody stems and herbaceous cover will also be performed. Up to 20 percent of the site species composition may be comprised of volunteers. Remedial action may be required should these volunteers (i.e. loblolly pine, red maple, sweet gum, etc.) present a problem and exceed 20 percent composition.

3.2 DESCRIPTION OF SPECIES AND VEGETATION MONITORING

All vegetation was planted in April 2005 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 multiple strata 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*) and Silky Dogwood (*Cornus amomum*). The second is a drier zone predominantly consisting of mesic species such as Yellow Poplar (*Liriodendron tulipifera*) and Slippery Elm (*Ulmus rubra*). The plots were planted at an average density of 693 stems per acre.

Table 4. Planted Tree Species

Common Name	Scientific Name	FAC Status
Shrubs		
Elderberry	*Sambucus canadensis*	FACW-
Paw Paw	*Asimina triloba*	FAC
Silky Dogwood	*Cornus amomum*	FACW+
Tag alder	*Alnus serrulata*	FACW+
Trees		
Black Gum	*Nyssa sylvatica*	FAC
Black Locust	*Robiinia pseudocacia*	FACU-
Green ash	*Fraxinus pennsylvanica*	FACW
Ironwood	*Carpinus caroliniana*	FAC
Red Oak	*Quercus rubra*	FACU
River Birch	*Betula nigra*	FACW
Slippery Elm	*Ulmus rubra*	FAC
Sycamore	*Platanus occidentalis*	FACW-
Tulip Poplar	*Liriodendron tulipifera*	FAC
Black Gum	*Nyssa sylvatica*	FAC

To monitor the success of riparian buffer vegetation, twelve plots were established on the Open Springs Mitigation Site. The plots cover approximately 2 percent of the site and were designed to be 1/40th of an acre in size. The locations of these plots were randomly distributed across the planted portions of the site. The center of each plot is marked with a ten-foot section of metal fence post with a white PVC cover. Within each established plot, the planted woody stems were identified with a numbered aluminum tag, and marked with a three-foot section of white PVC pipe. Total numbers of each species planted are listed in **Table 5**. Planted woody species will be monitored twice per year for the first three years. Herbaceous plant cover was monitored during the 2008 annual monitoring visit using the notched-boot method.

Table 5. Planted Trees Per Plot and Per Acre

Plot Number	Trees Planted per Plot	Trees Planted per Acre
Plot 1	18	720
Plot 2	17	680
Plot 3	18	720
Plot 4	20	800
Plot 5	17	680
Plot 6	21	840
Plot 7	19	760
Plot 8	16	640
Plot 9	19	760
Plot 10	10	400
Plot 11	14	560
Plot 12	19	760
Average	**17**	**693**

To compensate for the mortality observed in 2006, portions of the site were replanted in March 2007 with 2-year-old trees, and the site was treated with the herbicide Roundup to control fescue. Approximately 1,600 trees were planted around vegetation plots VP 1, VP 2, VP 4, VP 7, VP 9, and VP 12. Tree species planted include those shown in **Table 4**, except for slippery elm, tag alder, and black gum. Eastern redbud was an additional species planted.

3.3 RESULTS OF VEGETATION MONITORING

Stem counts were conducted at each monitoring plot during August 2008. All 12 vegetation monitoring plots were evaluated for success, and the overall condition of vegetation at the site was assessed. **Table 6** and **Table 7** show the number of each species of woody plants recorded for each plot and the success rate of each plot. The range of surviving planted stems after the fourth year range from 324 to 810 stems per acre, with an average of 570 planted trees per acre. Plots 9 and 10 were previously identified as problem areas due to low stem counts. Areas around these plots were replanted with 3-year old stems during the spring of 2008. The black willows in plot 9 were cut back to release surviving stems. Stems counts for year four show that plot 9 has 486 stems per acre and plot 10 has 324 stems per acre. All of the plots met the interim success criteria of 320 stems per acre and are on track to meet the five year success criteria of 260 stems per acre. Plots 6 and 9 should be assessed for control of black willow prior to the 2009 growing season.

Changes in survival have also occurred because of the re-sprouting ability of some species. A number of plots experienced resprouting from the root crown of individual stems that were previously recorded as dead. This pattern was observed across a number of plots for elderberry, iron wood, green ash, sycamore, and red oak. 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**).

Table 6. Results of Vegetation Monitoring – Year 4

	Plots											
Species	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Shrubs												
Elderberry	1											
Paw Paw		2		1		6	1					
Silky Dogwood			1		3			2			1	
Trees												
Black Locust			4									1
Blackgum		2				1	1					
Green Ash	10		2	14	3	6	8	8	3	4	1	3
Iron Wood		2	4		5		2	5	2	1	12	4
Red Oak		1	2						7	3		2
River Birch	2	1		5	1	1	4	1				
Sycamore	1	2			3	3	1					2
Tulip Poplar		1										

Table 7. Summary of Results – Year 4

Plots	Initial Stems Planted	Additional Stems Planted	Total Stems Planted	Stems Year 4	Stems per Acre Year 4
1	18	3	21	14	567
2	18	1	19	10	445
3	21		21	13	526
4	21		21	20	810
5	17		17	15	607
6	21		21	17	688
7	19	2	21	17	688
8	16		16	16	648
9	21	16	37	12	486
10	10	7	17	8	324
11	15		15	14	567
12	26	4	30	12	486
Average	18.6			14.0	570

Average Stems/Acre: 567
Range of Stems/Acre: 324-810

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
- Symbology to represent vegetative problem types (if appropriate)

The herbaceous vegetation coverage at the site is nearly 100% and is variable in composition, as would be expected in a natural riparian system. Areas previously observed to have bare soil have filled in with herbaceous cover except for a few small linear areas found just above top of bank in the section between vegetation plots 3 and 4. These areas are filling in with herbaceous vegetation and no remedial action is recommended at this time.

The locally dominant herbaceous species are dog fennel (*Eupatorium capillifolium*), Canadian horseweed (*Conyza canadensis*), panic grass (*Panicum anceps*), Carolina horsenettle (*Solanum carolinense*), and annual ragweed (*Ambrosia artemisiifolia*). The herbaceous vegetation across the site is becoming diverse, and some of the other species found include: American pokeweed (*Phytolacca americana*), blackberry (Rubus argutus), Canada goldenrod (*Solidago canadensis*), common boneset (Eupatorium perfoliatum), foxtail (*Setaria* sp.), New York ironweed (*Vernonia noveboracensis*), Pennsylvania smartweed (*Polygonum pensylvanicum*), shallow sedge (*Carex lurida*), and strawcolored flatsedge (*Cyperus strigosus*).

Volunteer species are also monitored throughout the five year monitoring period. **Table 6** shows the most commonly found woody volunteer species. Volunteer species were less obvious. This is most likely because of decreased germination, vigor, and survival due to the earlier drought. The herbaceous cover also obscures the smaller volunteer individuals.

Table 8 Volunteer Tree Species

Common Name	Scientific Name	FAC Status
Black Willow	*Salix nigra*	OBL
Persimmon	*Diospyros virginiana*	FAC
Red Maple	*Acer rubrum*	FAC
Slippery Elm	*Ulmus rubra*	FAC
Sweetgum	*Liquidambar styraciflua*	FAC+
Winged Elm	*Ulmus alata*	FACU+

3.4 VEGETATION OBSERVATIONS & CONCLUSIONS

Vegetation across the site has become well established, both herbaceous early successional and planted stems. Natural recruitment of species is also beginning to develop, but does not threaten to compete with the planted stems at this time. Despite the previous drought year in 2007 and a below to normal year for 2008, the vegetation at this site is mostly healthy and appears to be thriving. The area around plot 10 has experienced a slightly higher mortality than desired, but the stem counts indicate that the site is on track to meet the year five success criteria for the vegetation plots. Although a few areas have native black willow, no remedial actions are necessary at this time.

4.0 STREAM MONITORING

4.1 STREAM SUCCESS CRITERIA

As stated in the Mitigation Plan, the stream restoration success criteria for the 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.
- *Photos*: 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 and Fish Sampling*: Sampling of benthic macroinvertebrates and fish within the restored stream channel shall be conducted for the first three years of post-restoration monitoring.

4.2 STREAM MORPHOLOGY MONITORING PLAN

Along UT-1 and UT-4 a natural channel design approach was applied to develop stable hydraulic geometry parameters. Construction began in February 2005 and was completed in April 2005. The rebuilding of the channel established stable cross-sectional geometry, increased plan form sinuosity, and restored riffle-pool sequences and other streambed diversity to improve benthic habitat. Approximately 3,510 linear feet of stream restoration has been constructed.

4.2.1 Cross Sections

The mitigation plan for the Open Springs project requires eight permanent cross sections to be monitored along the restored tributaries UT-1 and UT-4. 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 **Figure 3a**. Each cross section will be surveyed annually, including measurements of floodplain, top of bank, bankfull, inner berm, edge of water, and thalweg. In addition, any fluvial features present will be documented.

4.2.2 Longitudinal Profile

Longitudinal profiles will be surveyed in all five years of the monitoring period. UT-4 will be surveyed for its entire length. Profiles along UT-1 will be measured at three representative sections, each comprising approximately 900 linear feet. The cumulative length of the measured profiles will be at least 3,000 linear feet. Features measured will include thalweg, inverts of in-stream structures, water surface, bankfull, and top of low bank.

4.2.3 Hydrology

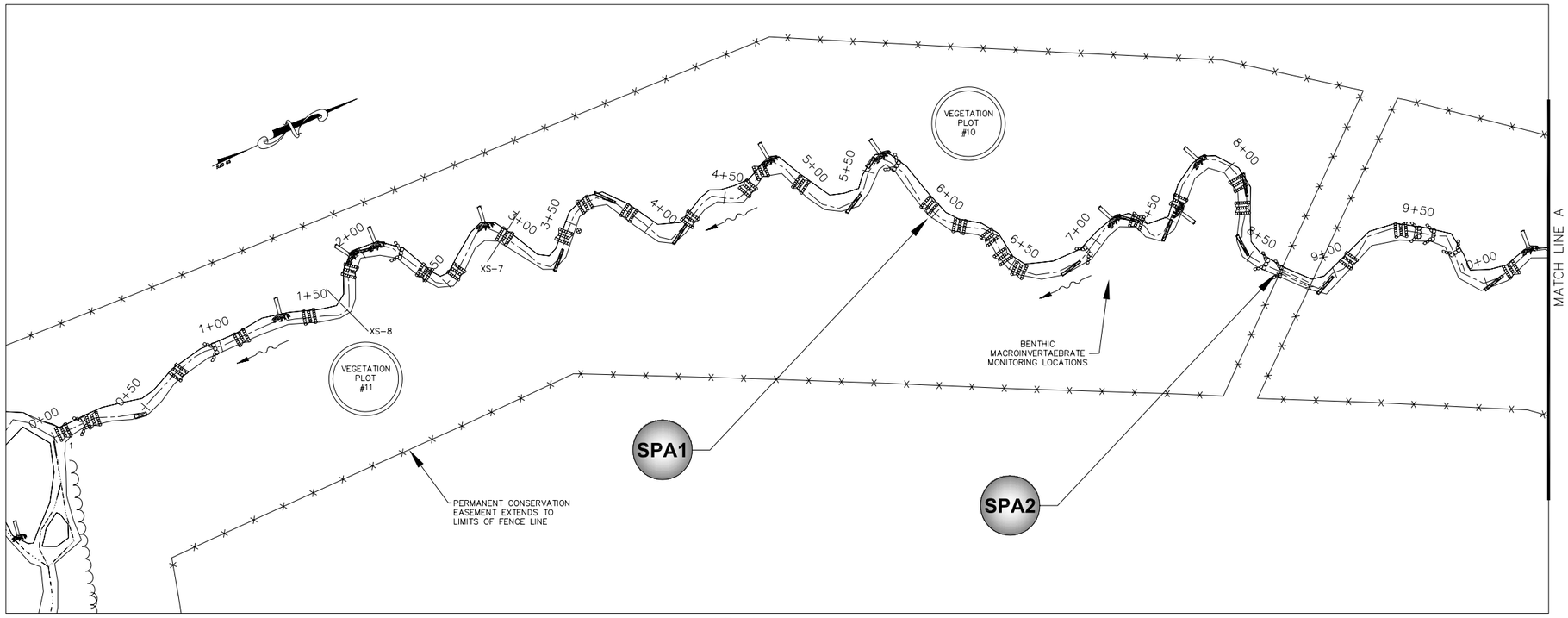
Two crest gauges were installed at the site; one on UT-1 near the downstream end of the project and one on UT-4 near the UT-1 confluence (see locations in **Figure 3a**). Crest gauges will be checked at least quarterly. During each visit, a determination of whether an out-of-bank event has occurred since the prior visit will be made. During the gauge inspections, any high water marks or debris lines will be documented and photographed.

4.3 STREAM MORPHOLOGY MONITORING RESULTS

Photographs were taken throughout the monitoring season to document the evolution of the restored stream channel (see **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.). Throughout the monitoring season, both reaches had a steady flow. Very few problems with stream morphology were observed during the monitoring field visit. Throughout the project, many riffle structures were covered with vegetation. Many of the riffle features are collecting small gravel, as expected. Some minor siltation was observed, especially in the pool features, along UT-1. **Table 9** lists stream areas requiring further observation, as well as the station and description of the noted areas. Photographs of each area requiring observation can be found in **Appendix C**.

A plan view drawing of the stream problem areas is provided in **Figure 4**. The drawings show the locations of the following features:

- As-built stream centerline and bankfull limits
- All in-stream structures (e.g. root wads and log vanes)
- Locations of any stream channel problem areas



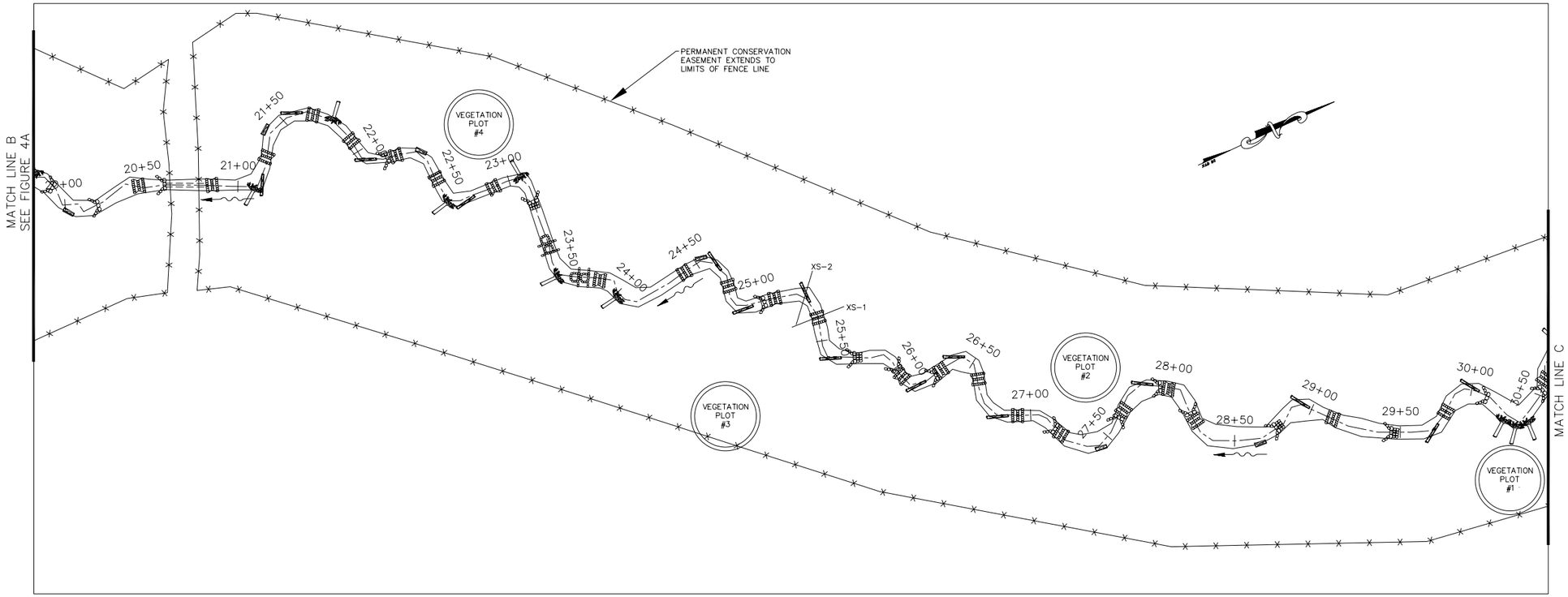
NOTE:
HEAVY VEGETATION IN CHANNEL THROUGHOUT REACH UT1

SPA4

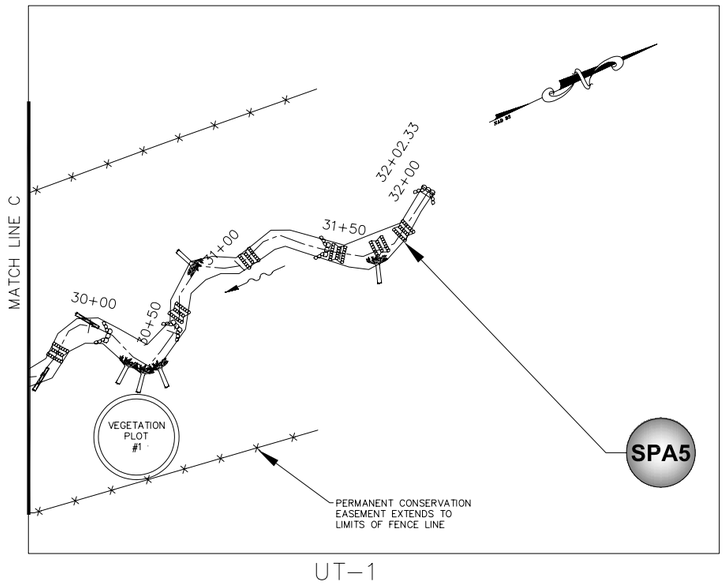
Open Springs Stream Problem Areas

Figure 4A

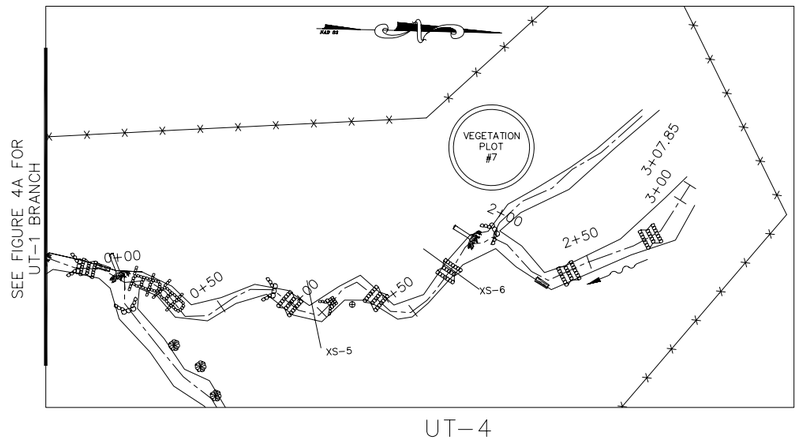
30 15 0 30 60
SCALE (FT)



UT-1



UT-1



UT-4

Open Springs Stream Problem Areas

Figure 4B

30 15 0 30 60

SCALE (FT)

Table 9. Stream Areas Requiring Observation

SPA	Reach	Station	Description
1	UT 1	5+00 - 6+00	Sparse vegetation on left floodplain
2	UT 1	8+65	Displaced rock cross vane
3	UT 1	13+90	Sparse vegetation on left floodplain
4	UT 1	Throughout Reach	Vegetation in channel
5	UT 1	31+85	Left bank erosion; headcut and rills forming.

4.3.1 Cross Sections

The cross sections were surveyed during Year 4 monitoring activities in July 2008. Year 4 monitoring cross sections are shown with baseline cross sections, and Year 1, Year 2, and Year 3 monitoring cross sections in **Appendix B**. There was very little difference between the Year 4 monitoring cross sections and the baseline, Year 1, Year 2, and Year 3 monitoring cross sections.

4.3.2 Longitudinal Profile

The baseline longitudinal profiles were derived from the As-Built survey data. Profiles were resurveyed during Year 4 monitoring activities in July 2008. The Year 4 monitoring profile is shown with the baseline profile in **Appendix B**. Very little difference between the baseline profile and the monitoring Year 4 profile was observed.

4.3.3 Hydrology

During each visit to the site, the crest gauges were read and recharged with cork. This was done March-September of 2008. At least seven out-of-bank or bankfull events occurred during this period on UT-1, and six on UT-2. Crest gauge data are included in **Table 10**. Weather data were collected from a nearby weather station - Asheboro 2 W (310286). These data are summarized in **Table 11** and **Figure 5**, and indicate that a rainfall deficit is accumulating throughout the year.

Table 10. Crest Gauge Data

Month Recorded	Crest Gauge - UT1	Crest Gauge - UT2
January	---	---
February	0.70	1.00
March	1.35	0.65
April	0.60	1.05
May	0.25	2.40
June	0.45	0.00
July	0.80	1.00
August	0.00	0.00
September	0.90	2.00
October	0.60	1.50
November	---	---
December	---	---

Table 11. County and On-site Rainfall Data

Month	Average	Normal Limits		Asheboro Precipitation	On-Site Precipitation
		30 Percent	70 Percent		
January	4.44	3.17	5.6	1.23	---
February	3.71	2.51	4.63	2.46	5.33
March	4.27	3.06	5.01	1.60	3.74
April	3.49	2.31	4.42	5.72	3.82
May	4.25	2.8	5.46	4.15	5.80
June	3.97	2.39	4.67	1.44	0.56
July	4.12	2.52	4.61	4.60	5.90
August	4.26	2.95	5.14	7.18	0.06
September	4.31	2.39	6.13	5.20	9.06
October	3.59	1.82	4.07	1.43	3.45
November	3.16	2.11	3.8	1.03	---
December	3.26	2.32	3.93	---	---
Total	**46.83**	**30.35**	**57.47**	**36.04**	**37.72**

*October on-site rainfall reflects data collected through Nov. 11th

Figure 5. 2008 Precipitation for Open Springs

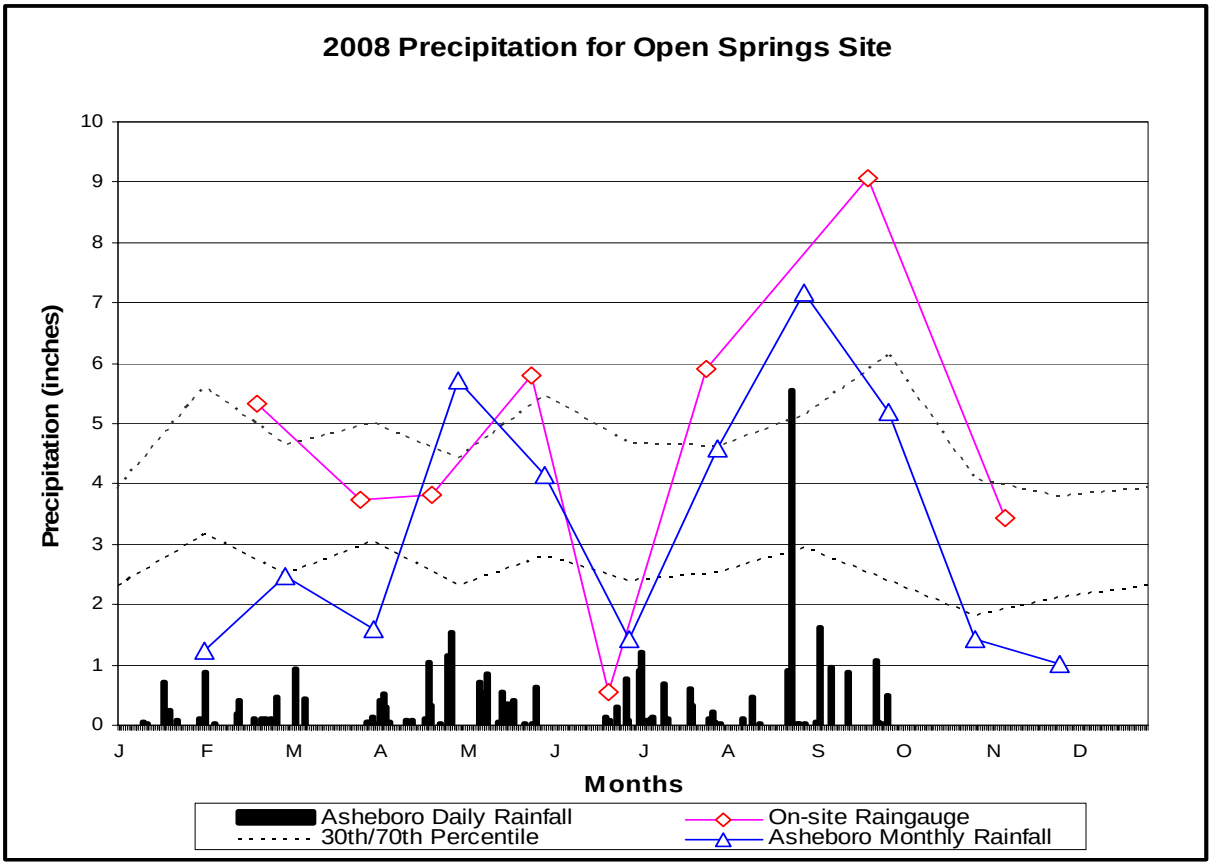


Table 12. Macroinvertebrate Data

Taxon		Tolerance Value	Count		
Order	PLECOPTERA		REF	US	DS
Genus Species	*Perlesta sp*	4.7	3	1	-
Genus Species	*Isoperla nr. bilineata*	5.4	4	-	-
Order	COLEOPTERA				
Genus Species	*Laccornis sp*	-	-	2	-
Genus Species	*Tropisternus spp*	9.7	-	-	2
Genus Species	*Neoporus mellitus gr*	4.0	1	-	-
Genus Species	*Peltodytes spp*	8.7	-	-	2
Order	ODONATA				
Genus Species	*Argia spp*	8.2	-	-	2
Genus Species	*Enallagma spp*	8.9	-	-	2
Order	DIPTERA				
Family	MISC.				
Genus Species	*Ephydridae*	-	-	1	-
Genus Species	*Chrysops sp*	6.7	-	-	1
Genus Species	*Simulium sp*	6.0	-	-	1
Order	DIPTEA				
Family	CHIRONOMIDAE				
Genus Species	*Conchapelopia group*	8.4	1	-	-
Genus Species	*Zavrelimyia sp*	9.1	-	1	-
Genus Species	*Orthocladius dorenus*	5.6	-	-	1
Genus Species	*O. robacki*	6.6	-	-	6
Genus Species	*O. obumbratus group*	8.5	-	1	5
Order	OLIGOCHAETA				
Genus Species	*Lumbriiculidae*	7.0	2	-	1
Genus Species	*Slavina appendiculata*	7.1	-	1	-
Order	CRUSTACEA				
Genus Species	*Crangonyx spp*	7.9	9	-	-
Genus Species	*Procambarus sp*	7.0	-	1	-
Genus Species	*Cambarus sp*	7.6	-	3	-
Order	MOLLUSCA				
Genus Species	*Physella sp*	8.8	1	4	-
Genus Species	*Helisoma anceps*	6.2	-	-	7
Genus Species	*Pisidium sp*	6.5	-	-	2
	Total Taxa Richness		7	8	12
	EPT Taxa Richness		2	1	-
	Number of organisms		21	15	32
	NC Biotic Index		6.8	7.9	7.3
	BI rating (not a bioclassification)		Fair	Poor	Poor

4.4 BENTHIC MACROINVERTEBRATE SURVEY RESULTS

The below average taxa richness (7-12 taxa per site) at the sites likely reflects the effects of the 2007-2008 drought (**Table 12**). However, taxa richness seems to be increasing, with only 4-6 taxa per site observed during the 2007 monitoring season. Restored sites were dominated by tolerant species, especially those that are tolerant of low flows or colonize quickly after flows are restored. Flow-dependent species were largely absent at restored sites due to the inconsistent flows and relative youth of the stream. More time will be required to establish a normal stream fauna.

4.5 STREAM CONCLUSION

The stream morphology is stable, with the site experiencing multiple bankfull events again in 2008. Very little fluvial erosion was observed, and many of the riffle features are collecting small gravel, as expected. All potential problem areas are minor, and no repairs are recommended. It appears that the site is moving toward stability.

5.0 CONCLUSIONS AND RECOMMENDATIONS

Overall, the project is performing well and is on track to achieve the stream and vegetative success criteria specified in the Mitigation Plan. 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 2008 observations, site vegetation is expected to succeed and provide riparian habitat, water quality benefits, and cover for the stream system.

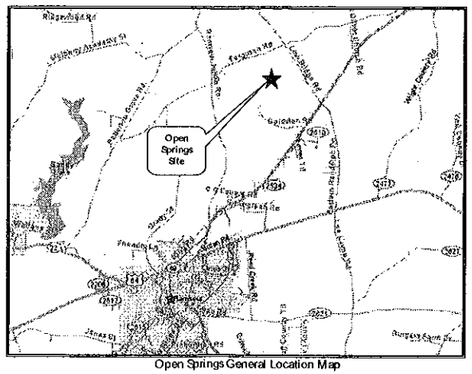
APPENDIX A

As-Built Survey

November 2008

OPEN SPRINGS STREAM
AS-BUILT PLANS

July 07, 2005



Open Springs General Location Map

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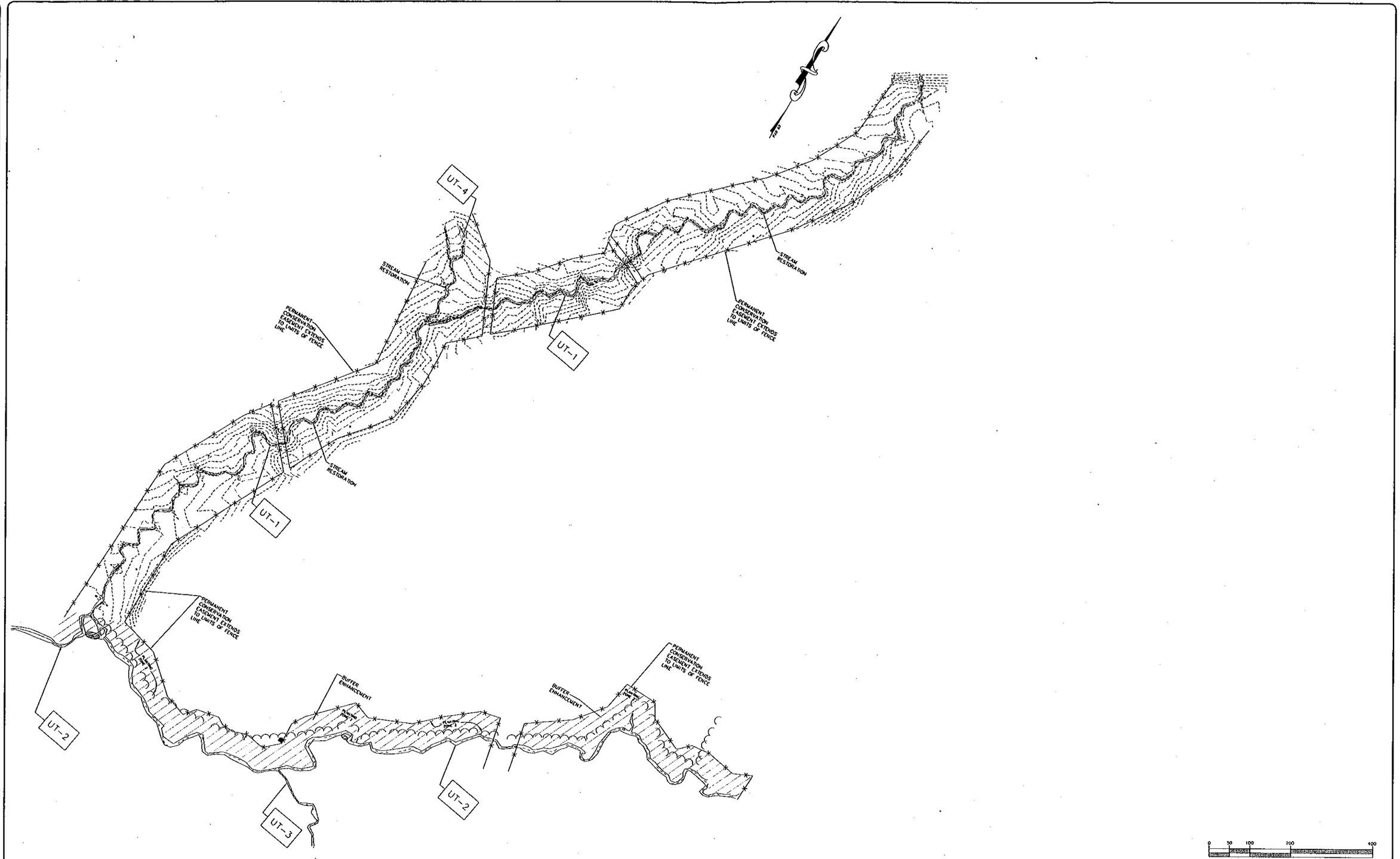

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	REVISIONS	

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DRAWN BY	PROJECT DATE
TRS	05/31/2005
APPROVED BY	PROJECT NUMBER
JMK	30440.00.RA
FILE NAME	PLOT DATE
design-layout	07/26/05

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community infrastructure consultants

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RALEIGH, NC 27612
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CONSTRUCTION	1-19-05
RECORD DWG.	

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OPEN SPRINGS STREAM MITIGATION PLAN
PREPARED FOR
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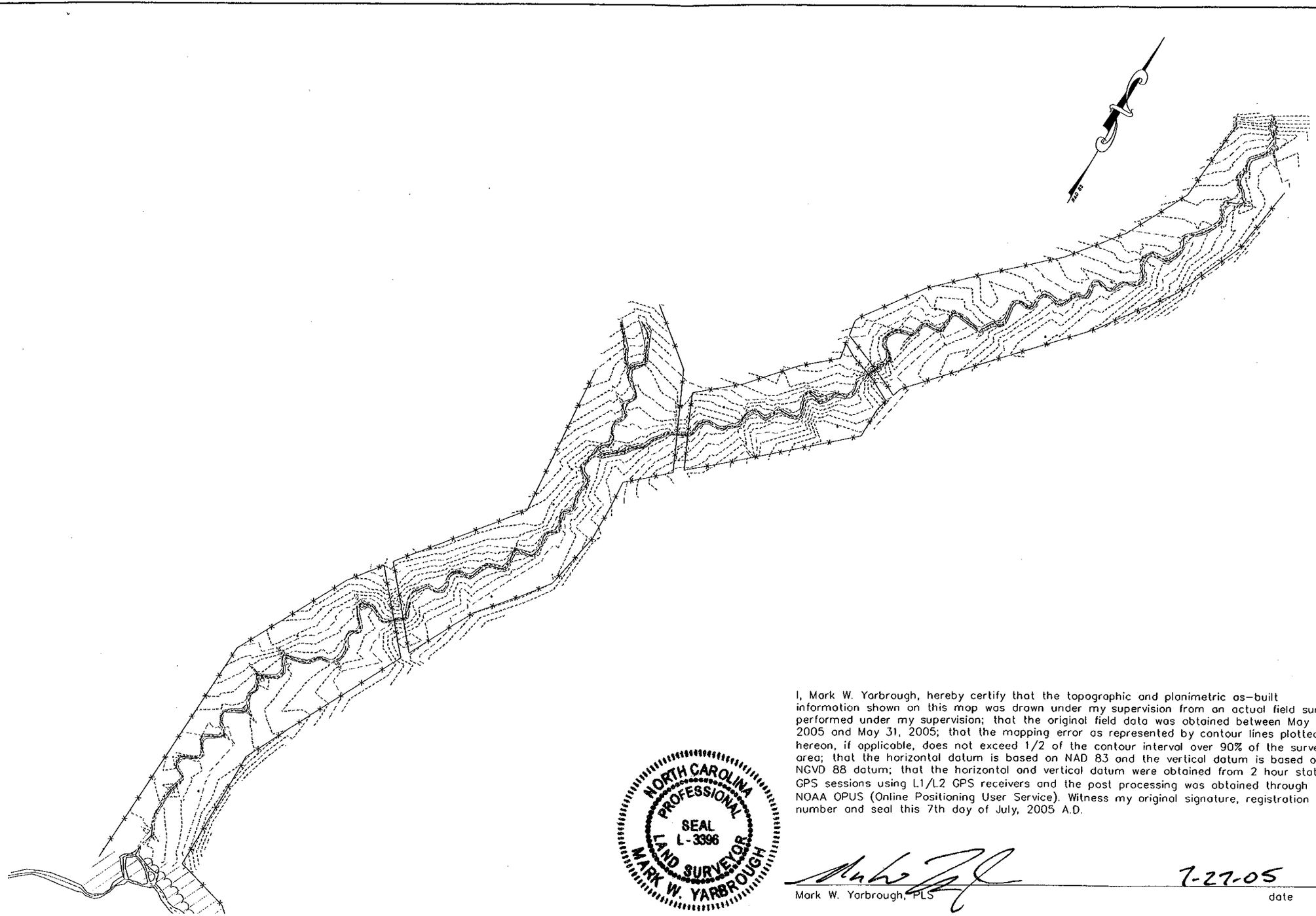
OPEN SPRINGS ASBUILT PLANS
PROJECT SITE

1/6



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 May 18, 2005 and May 31, 2005; 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 7th day of July, 2005 A.D.

NORTH CAROLINA PROFESSIONAL SEAL L-3396 LAND SURVEYOR MARK W. YARBROUGH

Mark W. Yarbrough, PLS — 7-27-05 date

0 40 80 160 320
SCALE

REV. NO.	DESCRIPTION	DATE
	REVISIONS	

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APPROVED BY	JMK
FILE NAME	design-layout
DRAWING SCALE	1" = 60'
PROJECT DATE	05/31/2005
PROJECT NUMBER	30440.00.RA
PLOT DATE	07/26/05

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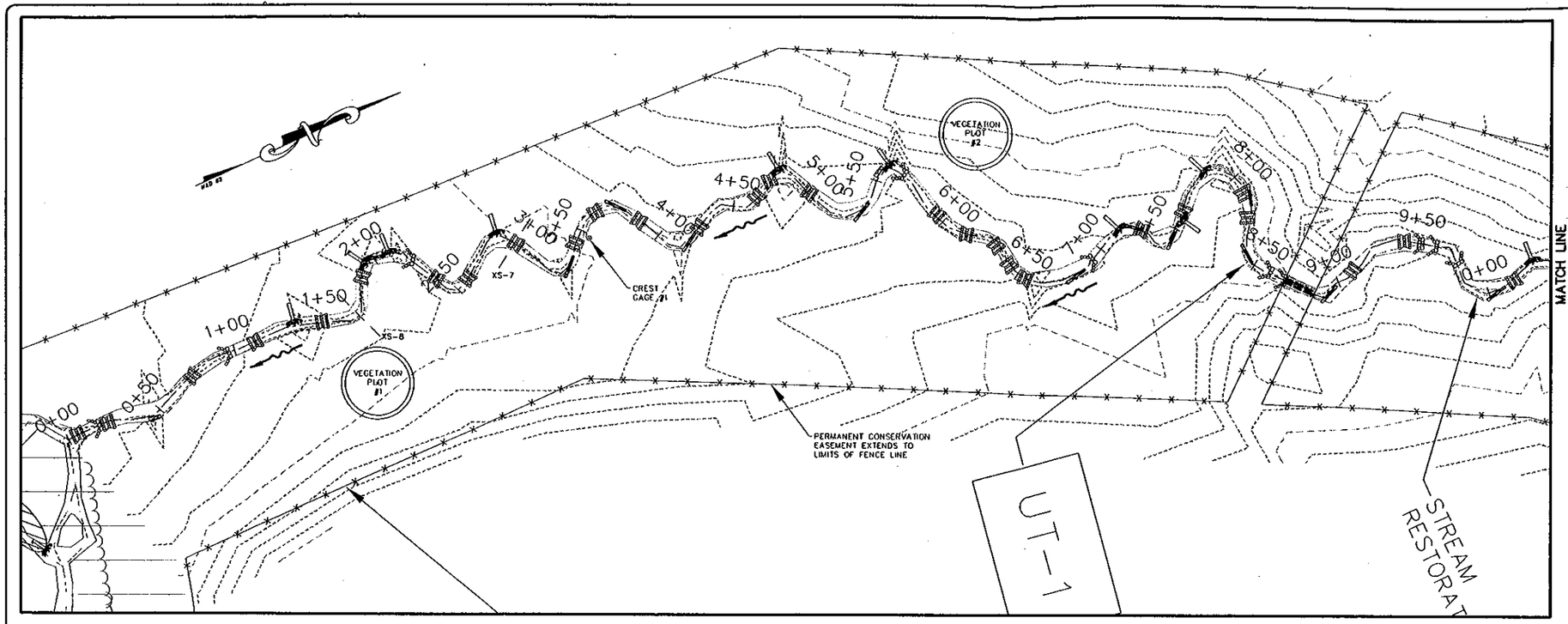
OPEN SPRINGS ASBUILT PLANS
STREAM MITIGATION AS-BUILT SURVEY

2/6



UT-1

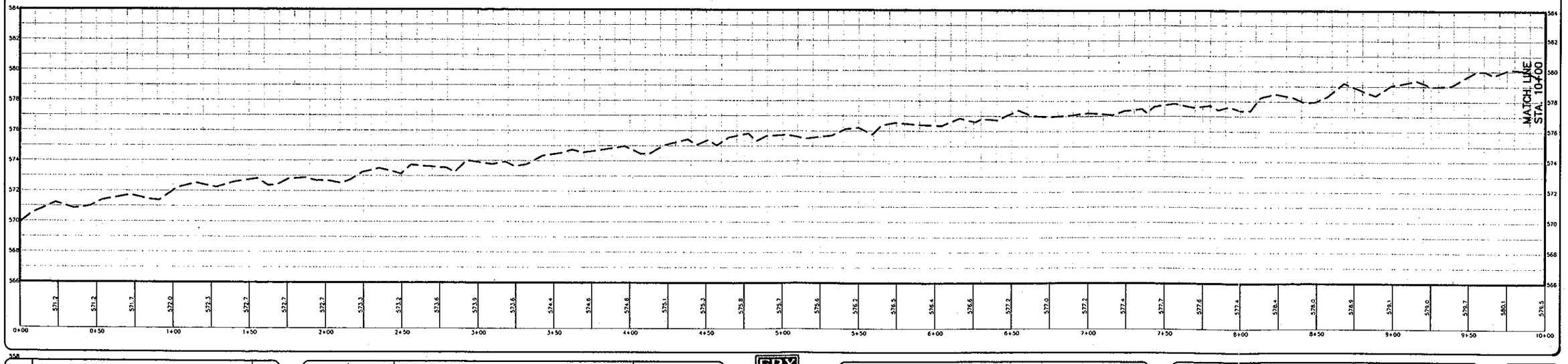
LEGEND

EXISTING

- FENCE LINE
- MAJOR CONTOUR
- MINOR CONTOUR
- CENTER OF CHANNEL
- LIMITS OF BANKFULL CHANNEL
- ROOTWAD
- LOG VANE
- CUTTINGS BUNDLE
- CHANNEL PLUG
- LOG TOE PROTECTION
- CULVERT CROSSING
- RIFFLE GRADE CONTROL
- RIFFLE GRADE CONTROL/CROSS WEIR STRUCTURE
- STEP POOL
- CROSS WEIR

0 15 30 60 120
HORZ SCALE

0 3 6 12
VERT SCALE



REV. NO.	DESCRIPTION REVISIONS	DATE

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APPROVED BY	JWK
FILE NAME	design-layout
DRAWING SCALE	1" = 30'
PROJECT DATE	05/31/2005
PROJECT NUMBER	3046.00.RA
PLOT DATE	07/26/05

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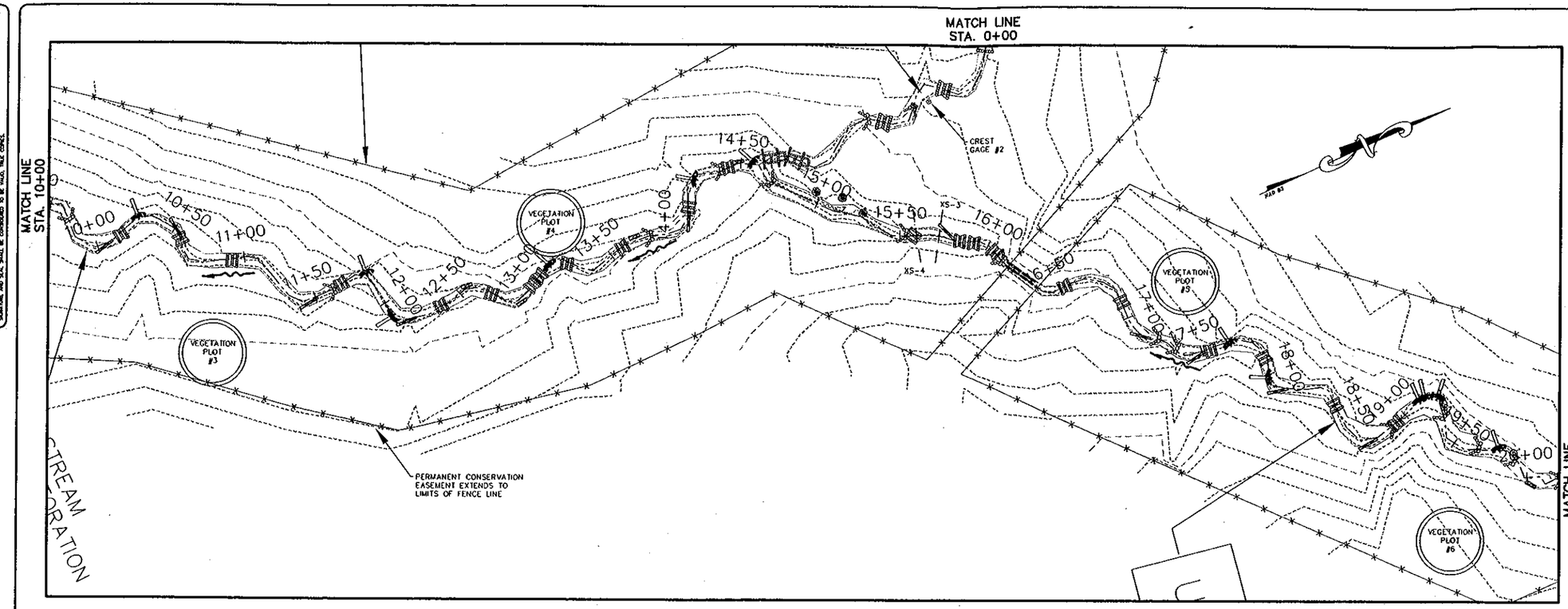
OPEN SPRINGS ASBUILT PLANS
UT-1 STA. 0+00 TO STA. 10+00

3/6



UT-1

LEGEND

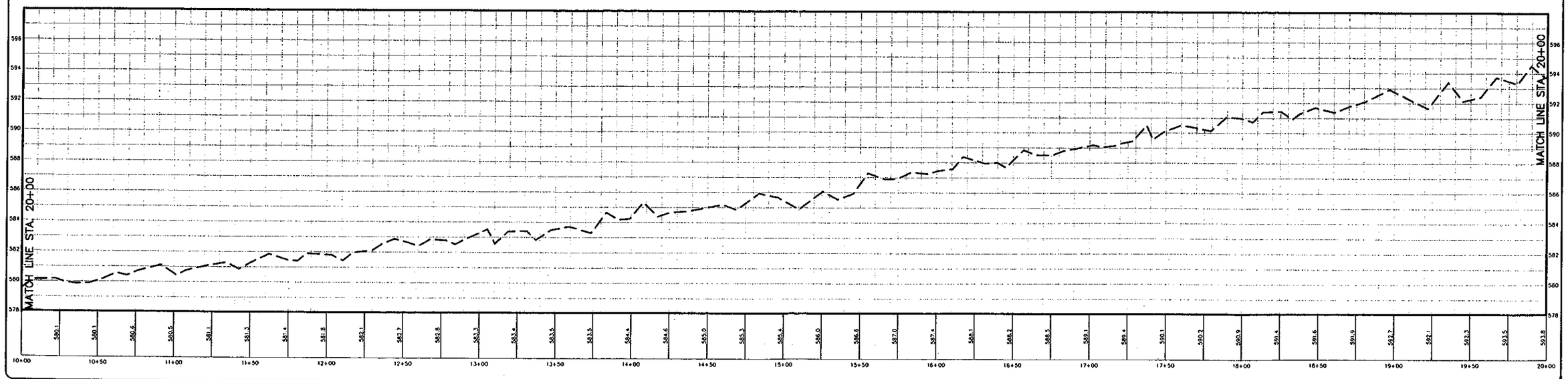
EXISTING

- FENCE LINE
- MAJOR CONTOUR
- MINOR CONTOUR
- CENTER OF CHANNEL
- LIMITS OF BANKFULL CHANNEL

- ROOTWAD
- LOG VANE
- CUTTINGS BUNDLE
- CHANNEL PLUG
- LOG TOE PROTECTION
- CULVERT CROSSING
- RIFFLE GRADE CONTROL
- RIFFLE GRADE CONTROL/CROSS WEIR STRUCTURE
- STEP POOL
- CROSS WEIR

HORZ SCALE: 0 15 30 60 120

VERT SCALE: 0 3 6 12



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APPROVED BY	JMK
FILE NAME	design-layout
DRAWING SCALE	1" = 30'
PROJECT DATE	05/31/2005
PROJECT NUMBER	30440.00.RA
PLOT DATE	07/28/05

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CONSTRUCTION	1-19-06
RECORD DWG.	

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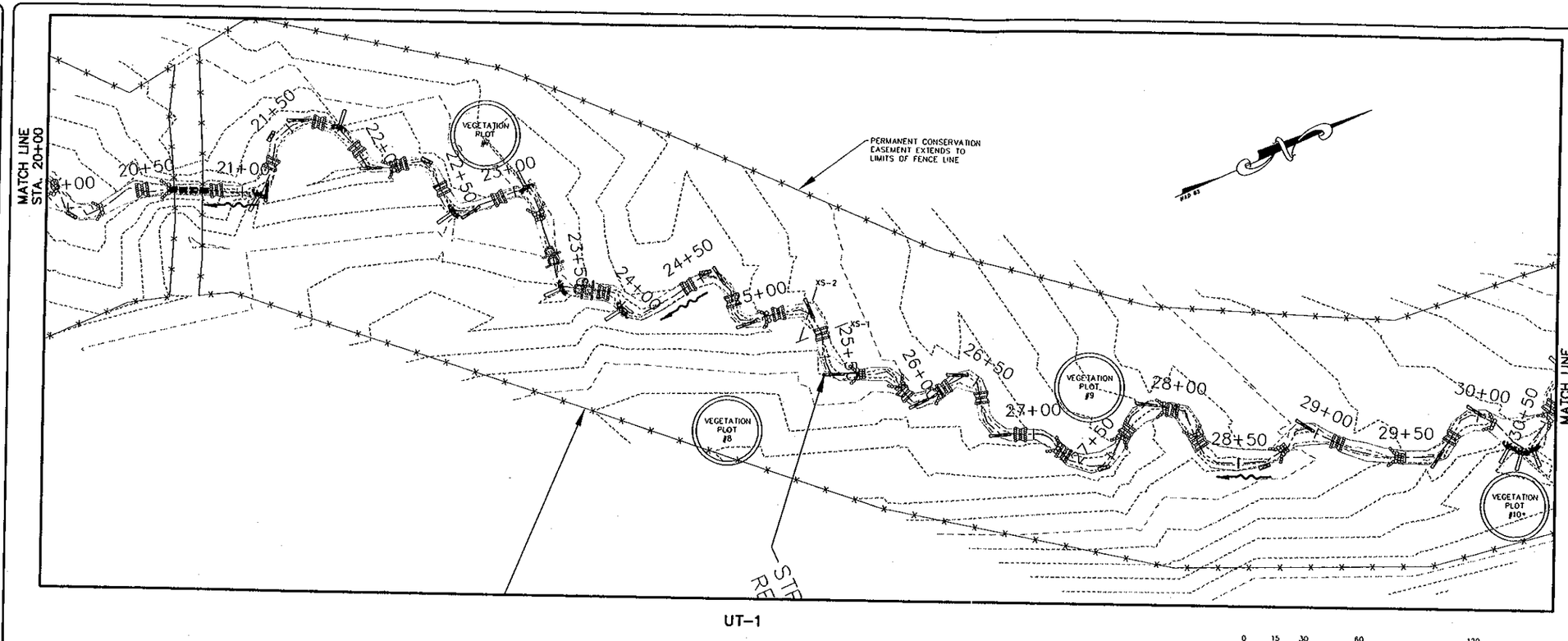
OPEN SPRINGS ASBUILT PLANS

UT-1 STA. 10+00 TO STA. 20+00



UT-1

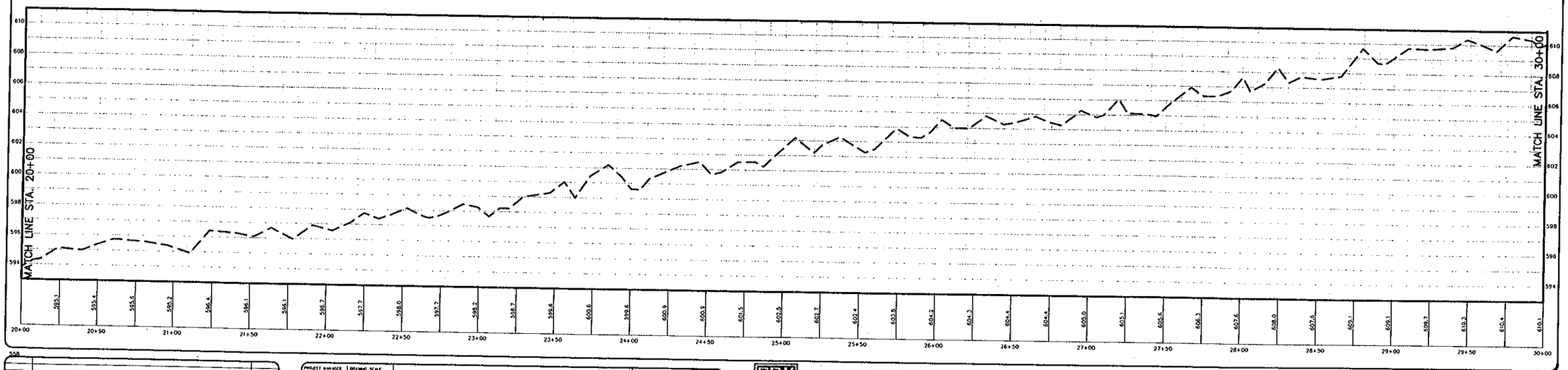
LEGEND

EXISTING

- FENCE LINE
- MAJOR CONTOUR
- MINOR CONTOUR
- CENTER OF CHANNEL
- LIMITS OF BANKFULL CHANNEL
- ROOTWAD
- LOG VANE
- CUTTINGS BUNDLE
- CHANNEL PLUG
- LOG TOE PROTECTION
- CULVERT CROSSING
- RIFFLE GRADE CONTROL
- RIFFLE GRADE CONTROL/CROSS WEIR STRUCTURE
- STEP POOL
- CROSS WEIR

HORZ SCALE: 0, 15, 30, 60, 120

VERT SCALE: 0, 3, 6, 12



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APPROVED BY	JMK
PLT TIME	design-layout
DRAWING SCALE	1" = 30'
PROJECT DATE	05/31/2005
PROJECT NUMBER	30440.00.RA
PLOT DATE	07/26/05

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RECORD DWG.	

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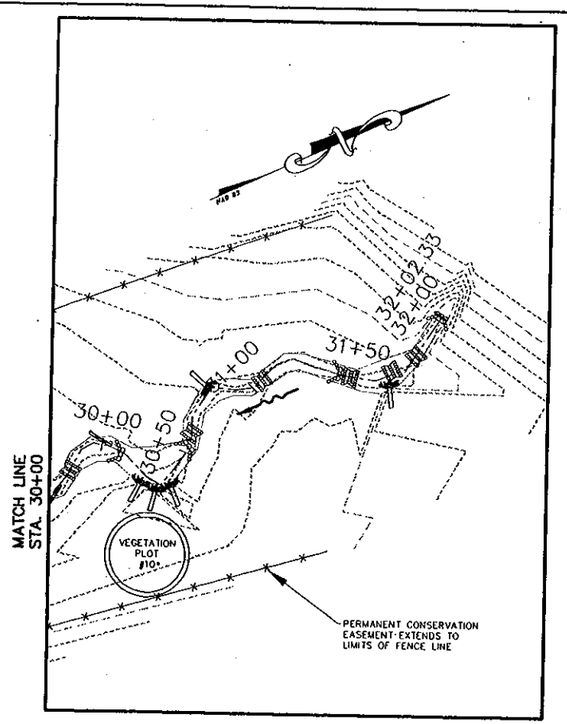
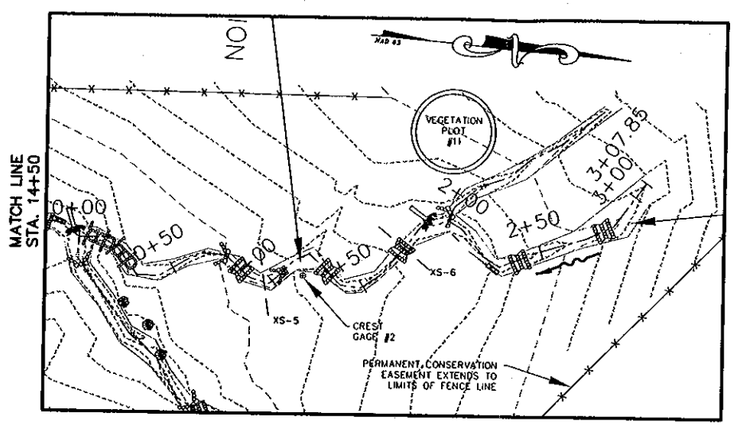
OPEN SPRINGS ASBUILT PLANS
UT-1 STA. 20+00 TO STA. 30+00



UT-1



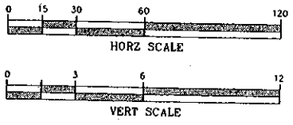
UT-4

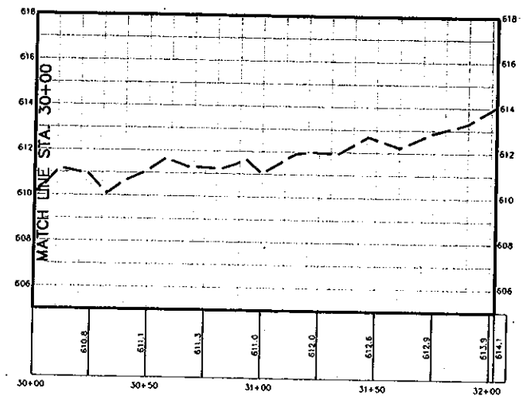
LEGEND

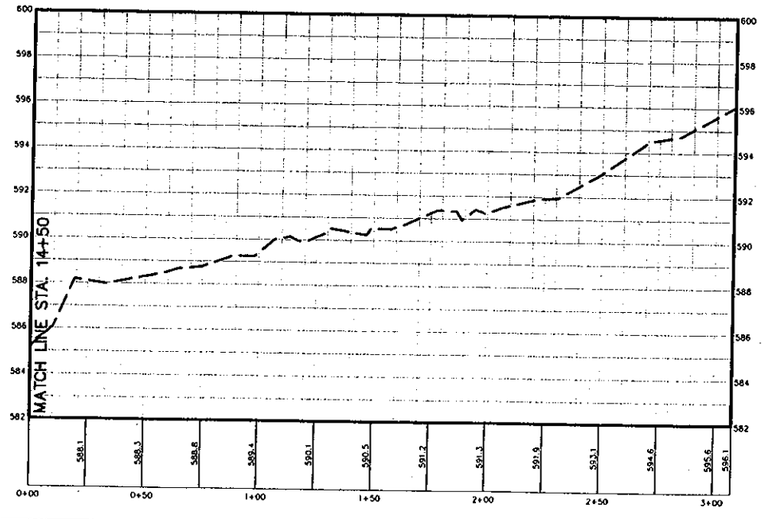
EXISTING

- FENCE LINE
- MAJOR CONTOUR
- MINOR CONTOUR
- CENTER OF CHANNEL
- LIMITS OF BANKFULL CHANNEL

- ROOTWAD
- LOG VANE
- CUTTINGS BUNDLE
- CHANNEL PLUG
- LOG TOE PROTECTION
- CULVERT CROSSING
- RIFFLE GRADE CONTROL
- RIFFLE GRADE CONTROL/CROSS WEIR STRUCTURE
- STEP POOL
- CROSS WEIR







REV. NO.	DESCRIPTION	DATE
	REVISIONS	

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APPROVED BY	JMK
FILE NAME	design-layout
DRAWING SCALE	1" = 30'
PROJECT DATE	05/31/2005
PROJECT NUMBER	3044.00.RA
AS OF DATE	07/28/05

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OPEN SPRINGS ASBUILT PLANS
UT-1 STA. 30+00 TO STA. 32+02.33
UT-4 STA. 0+00 TO STA. 3+07.85

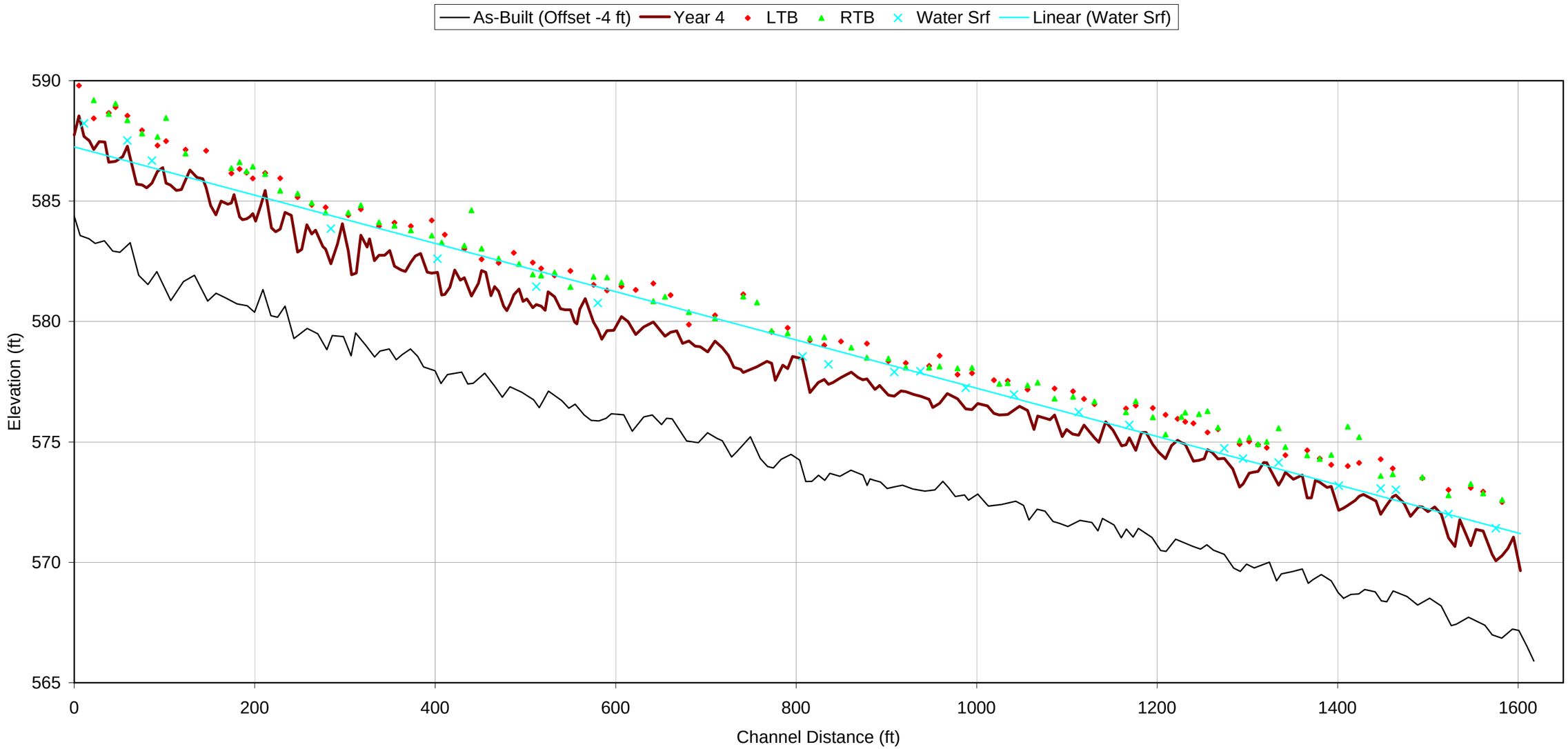
6/6

APPENDIX B

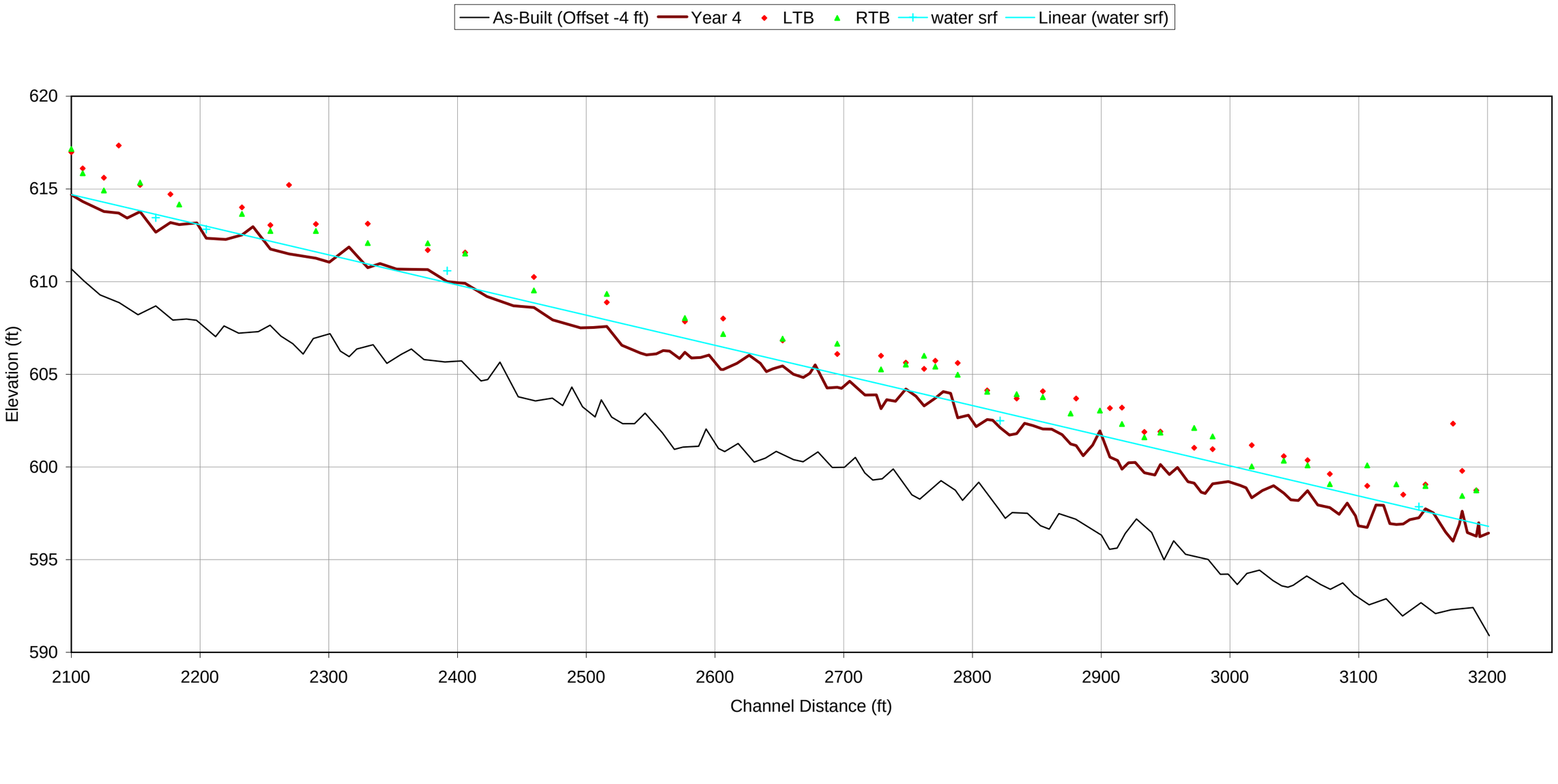
2008 Profile and Cross Section Data

November 2008

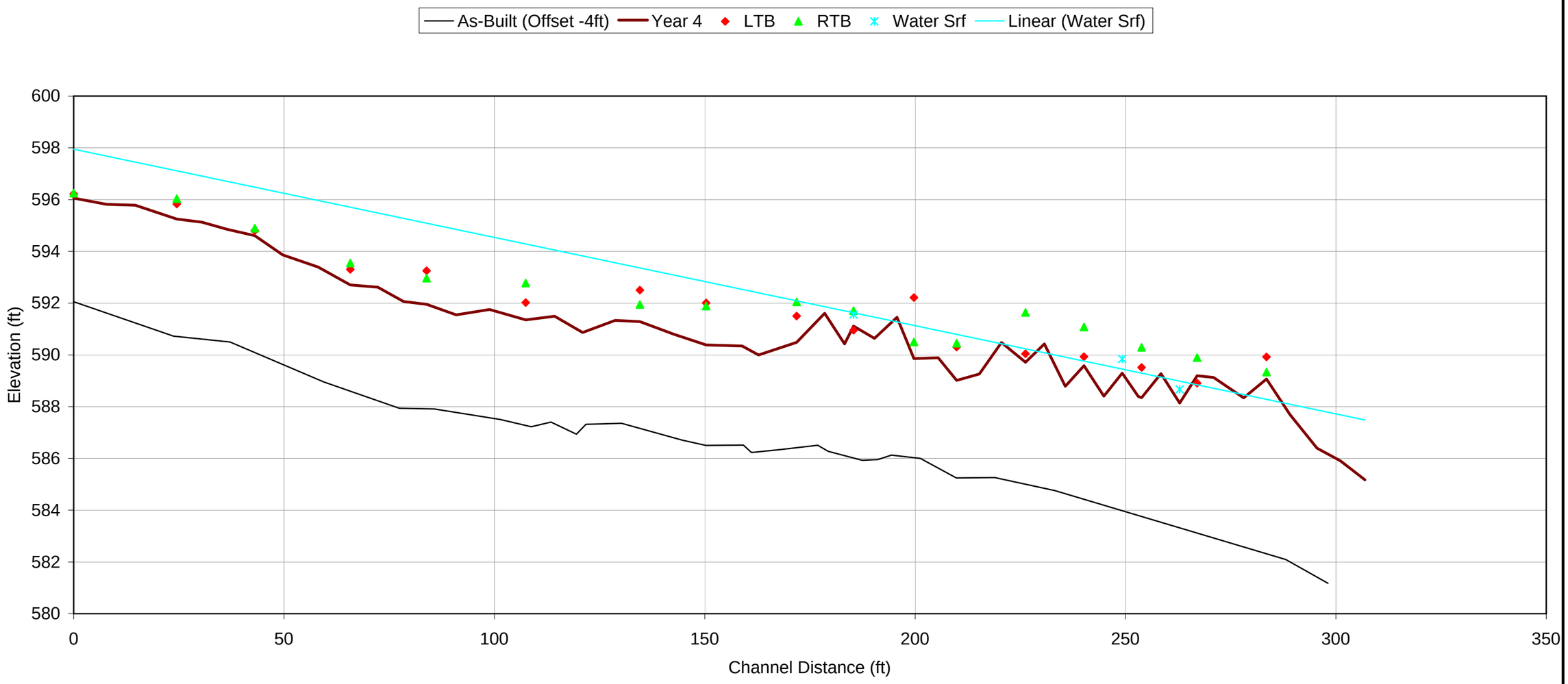
Open Springs
UT-1 Station 0+00 - 16+00



Open Springs
UT-1 Station 21+00 - 32+02.33

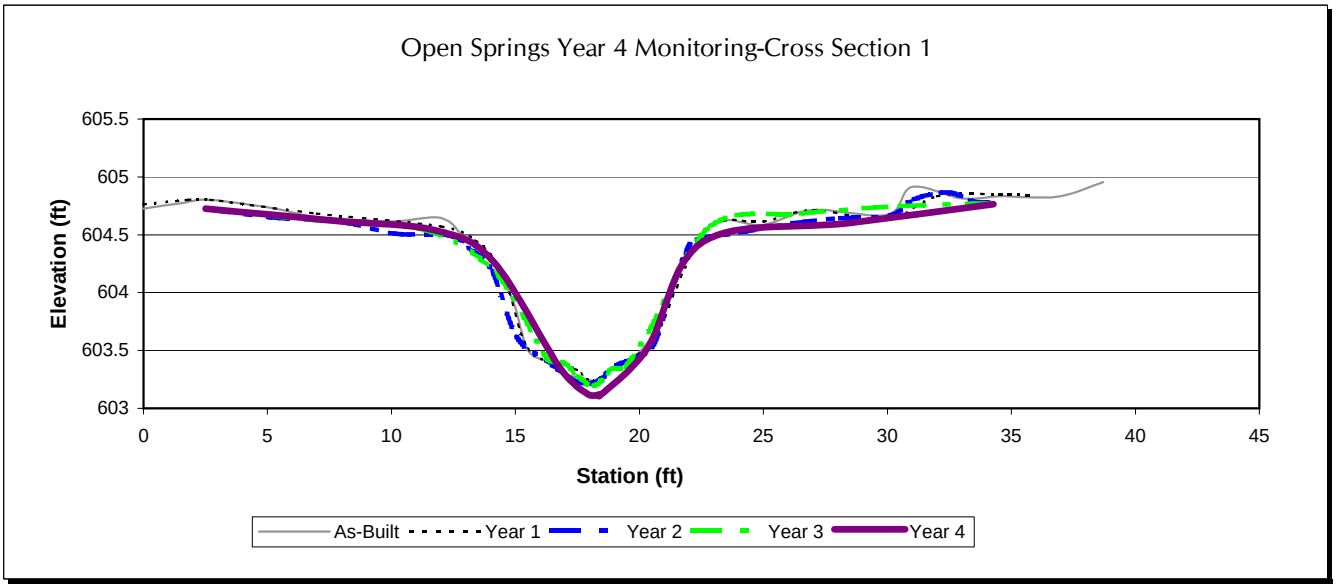


Open Springs
UT-4 Station 0+00 - 3+07.85



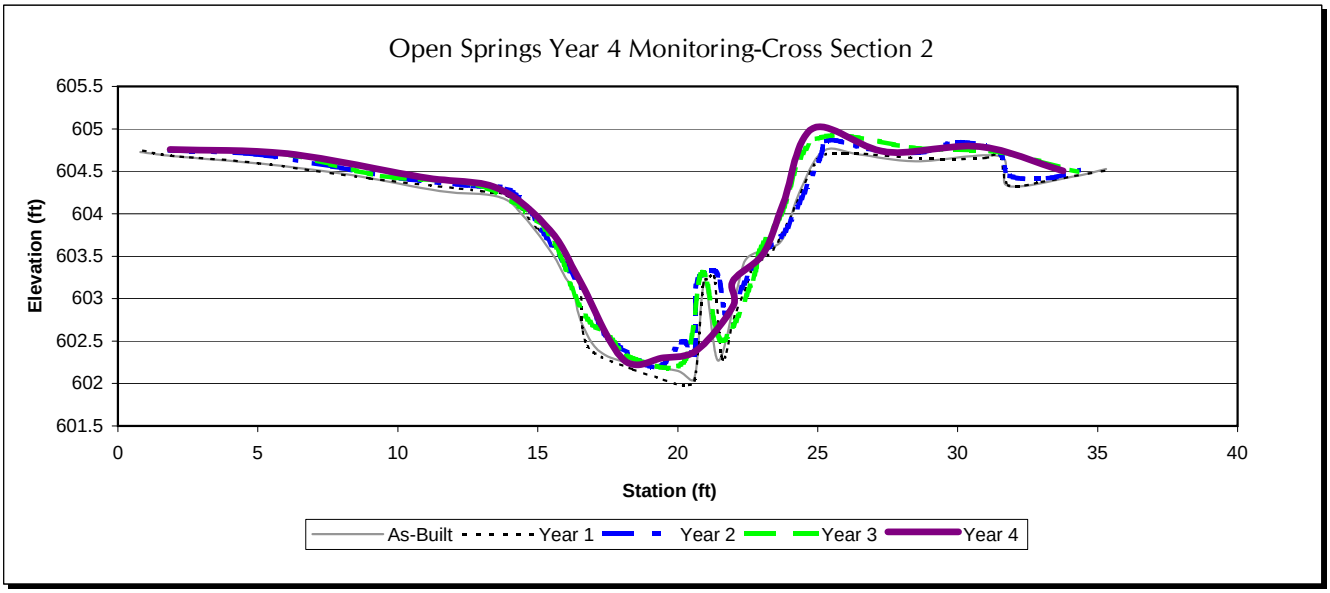
Left bank

Right bank



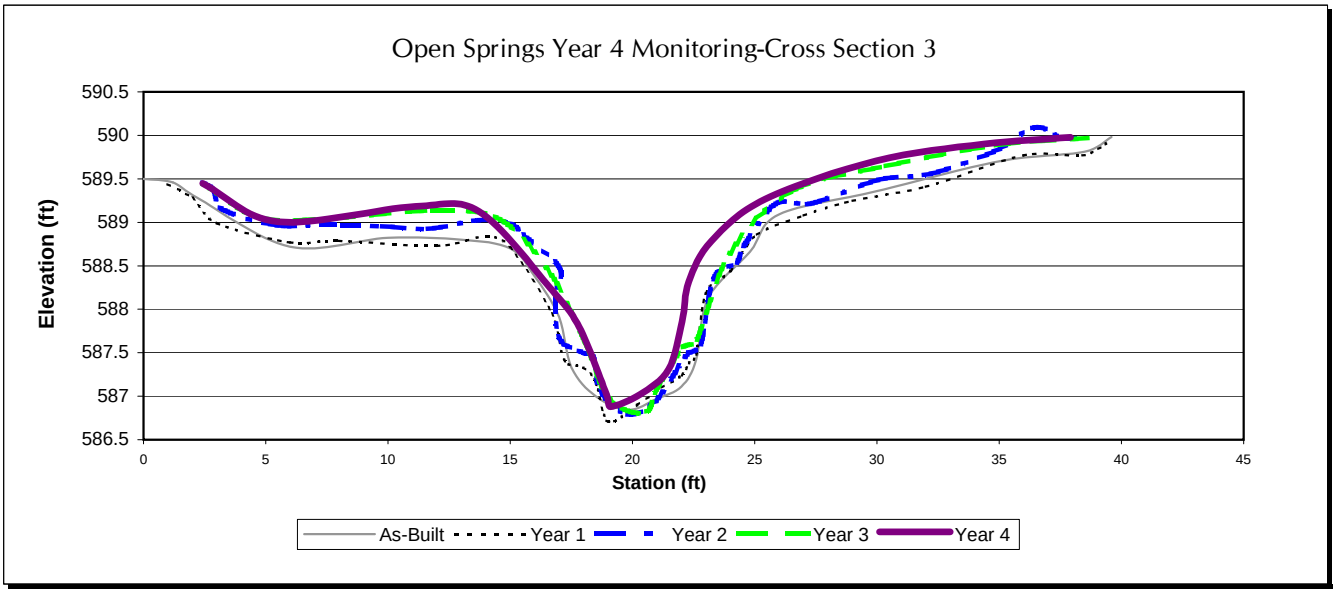
Left bank

Right bank



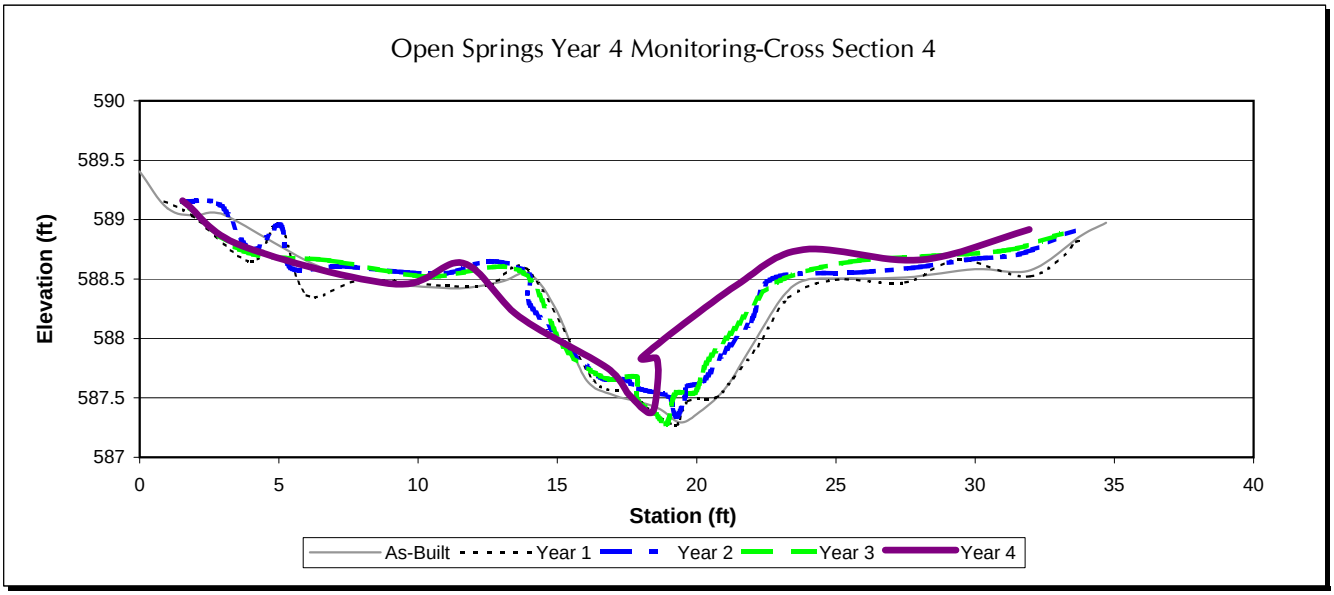
Left bank

Right bank



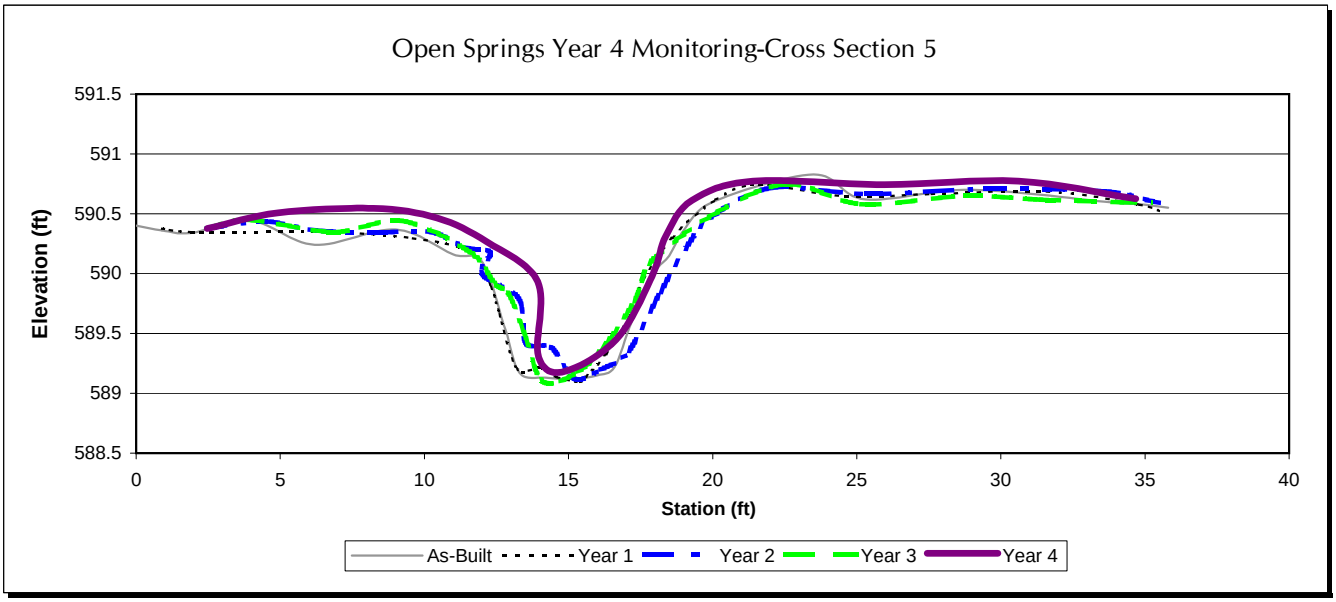
Left bank

Right bank



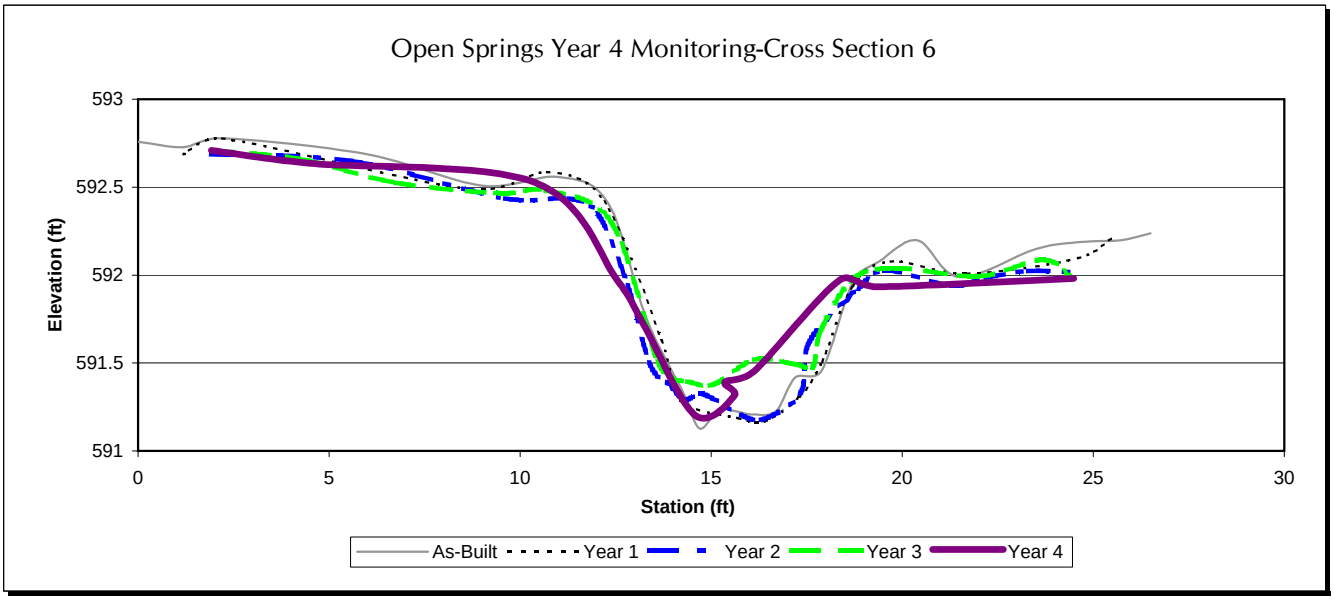
Left bank

Right bank



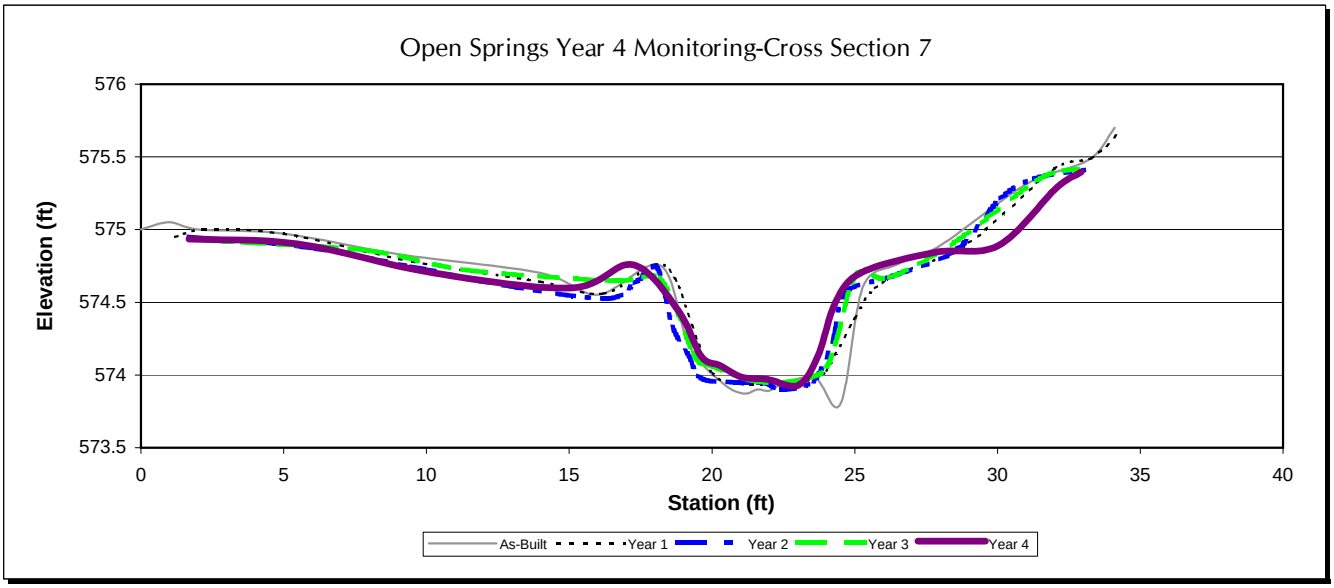
Left bank

Right bank



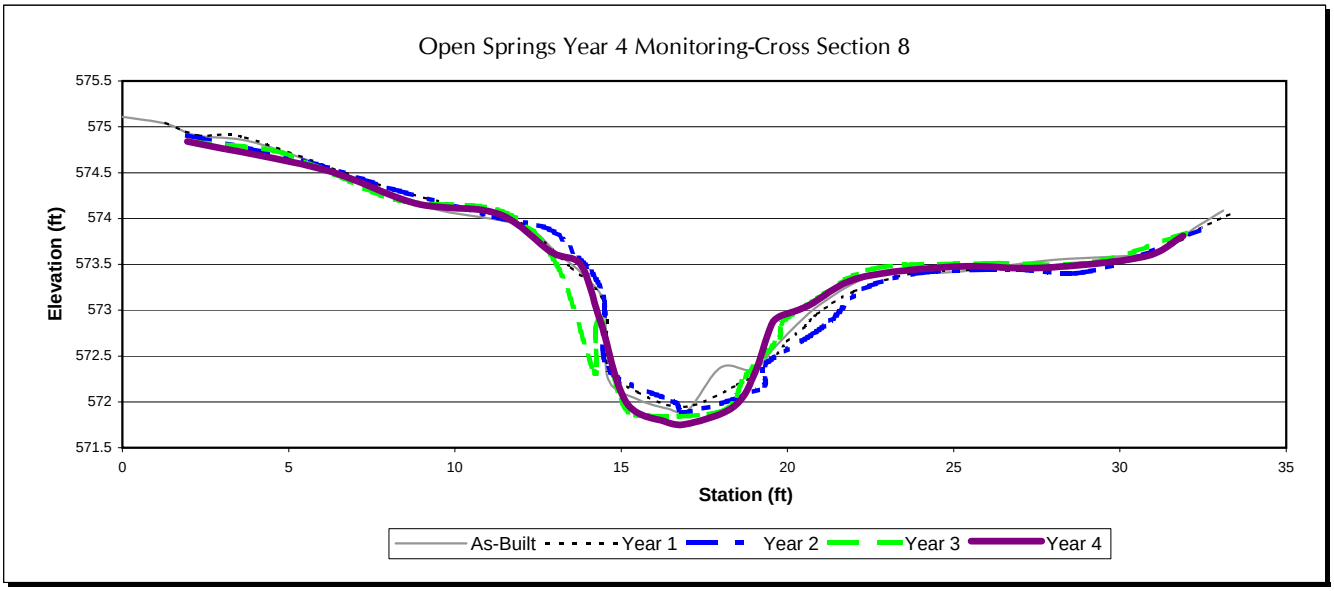
Left bank

Right bank



Left bank

Right bank



APPENDIX C

2008 Site Photos

November 2008

SPA1. Sparse vegetation on left floodplain from station 5+00 to 6+00.

SPA2. Displaced RCV at station 8+65.

SPA3. Sparse vegetation on left floodplain at station 13+90.

SPA4. Vegetation in channel throughout Reach UT 1.

SPA5. Left bank erosion, head cut and rills forming at station 31+85.

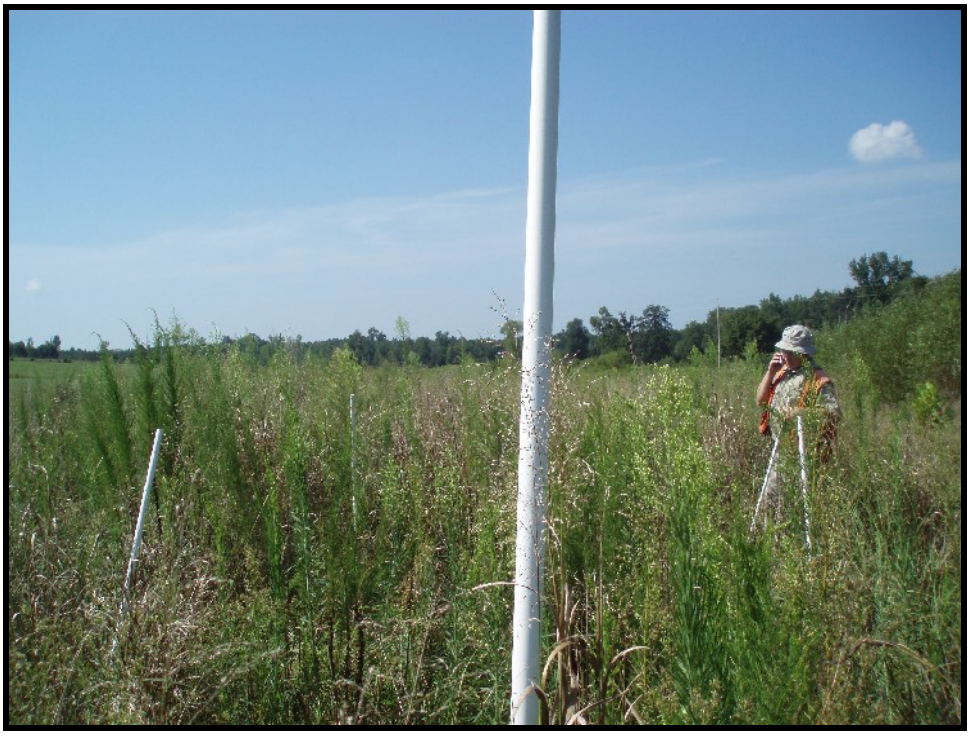
Vegetation Plot #1 facing upstream

Vegetation Plot #1 facing downstream

Vegetation Plot #2 facing upstream

Vegetation Plot #2 facing downstream

Vegetation Plot #3 facing upstream



Vegetation Plot #3 facing downstream

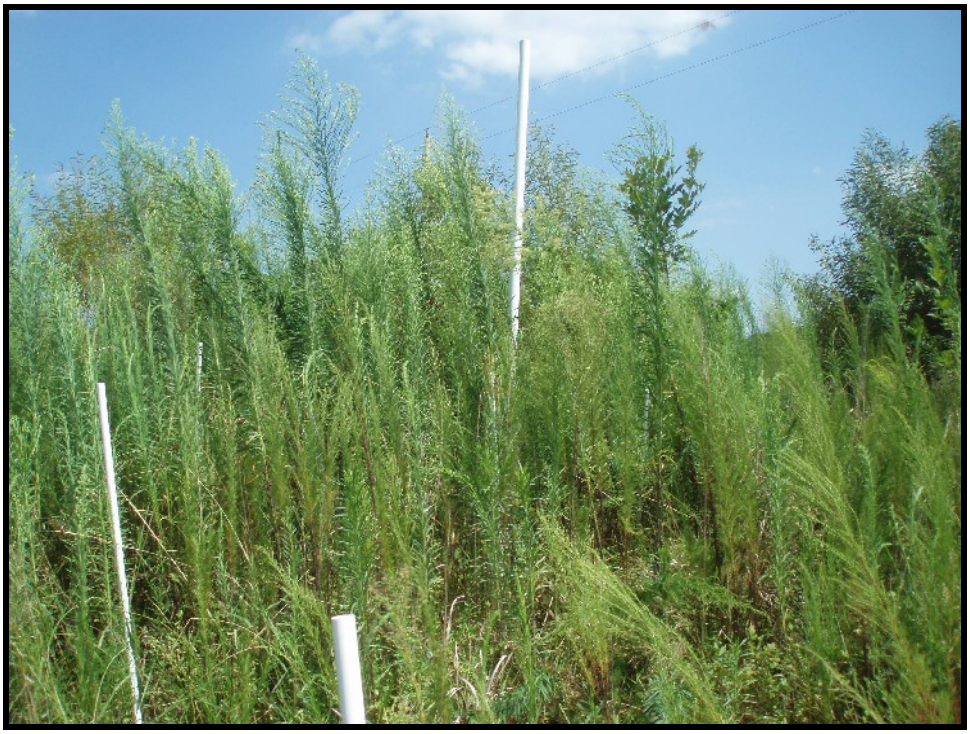
Vegetation Plot #4 facing upstream

Vegetation Plot #4 facing downstream

Vegetation Plot #5 facing upstream

Vegetation Plot #5 facing downstream

Vegetation Plot #6 facing upstream



Vegetation Plot #6 facing downstream

Vegetation Plot #7 facing upstream

Vegetation Plot #7 facing downstream

Vegetation Plot #8 facing upstream

Vegetation Plot #8 facing downstream

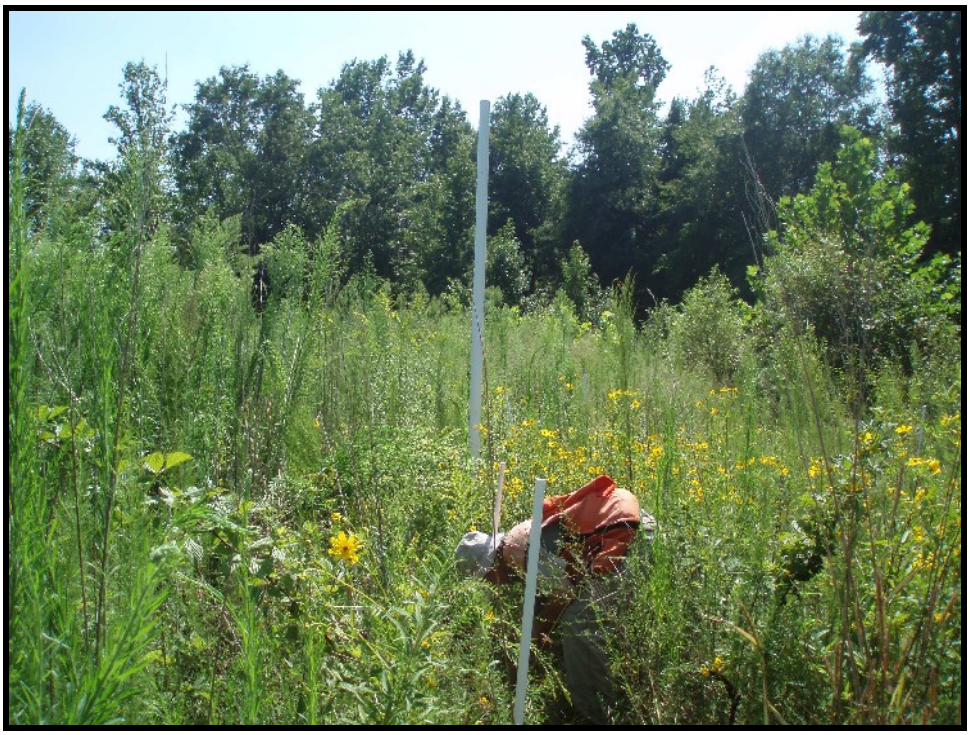
Vegetation Plot #9 facing upstream

Vegetation Plot #9 facing downstream

Vegetation Plot #10 facing upstream

Vegetation Plot #10 facing downstream

Vegetation Plot #11 facing upstream



Vegetation Plot #11 facing downstream

Vegetation Plot #12 facing upstream

Vegetation Plot #12 facing downstream