City Pond Mitigation Project
Anson County, North Carolina

Year 5 Monitoring Report

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1.0 SUMMARY

The City Pond Stream Mitigation Project site is located near the town of Wadesboro in Anson County, North Carolina. The project involved the restoration and enhancement of 10,574 linear feet of channelized stream on several unnamed tributaries to City Pond. 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 completed in 2005. 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 Year 5 at the City Pond Stream Restoration Site. Data collected for 2009 include crest gauge readings, on-site rain gauge readings, monthly observations of current conditions, cross sections survey, profile survey, digital images, observations of potential stream stability problems and vegetation survival.

The design for the City Pond project involved the restoration of channel dimension, pattern, and profile on eight separate reaches, and the enhancement of dimension and profile on one reach. After construction, it was documented that 9,869 linear feet of stream had been restored, and 705 linear feet of stream had been enhanced.

The data presented in this Annual Monitoring Report is from 3 crest gauges, 20 cross sections, and 3,400 linear feet of longitudinal profile on 8 reaches, as required in the approved Restoration Plan for this site. Digital images were recorded at all 20 cross sections and all in-stream structures that could be located. Planted tree density from five 1/10th acre plots randomly located within the riparian buffer estimate trees per acre.

The 2009 stream monitoring data documents that little has changed in the stream channel pattern and cross-sectional dimensions since last year's monitoring efforts. Most in-stream structures are stable and continue to function as designed. There were minor cases of bed erosion in reaches R1 and S1. During 2009, the stream channel experienced multiple bankfull events. It was concluded that the site has achieved the stream success criteria as specified in the Restoration Plan.

Vegetation monitoring indicated a range of tree density between 490 and 670 stems per acre. The site met the initial vegetation survival criteria of 320 stems per acre surviving after the third growing season and has met the final vegetation survival criteria of 260 stems per acre surviving after the fifth growing season. The vegetation looks healthy and consistent throughout.

2.0 INTRODUCTION

2.1 PROJECT DESCRIPTION

The City Pond Stream Restoration Project is located near the town of Wadesboro in Anson County, North Carolina (**Figure 1** & **Figure 2**). The stream systems that historically flowed through the site were channelized and highly incised prior to restoration. The design for the restored streams involved the construction of new meandering channels across the low slope valleys, and restored step pool channels in the higher slope valleys.

The site has a history of pasture and hay production, preceded by row crop production. Ditches were used to increase land use and improve drainage when the land was under crop production. The streams on the project site were channelized, and riparian vegetation was cleared in most

locations. Stream and riparian functions on the site had been severely impacted as a result of agricultural conversion.

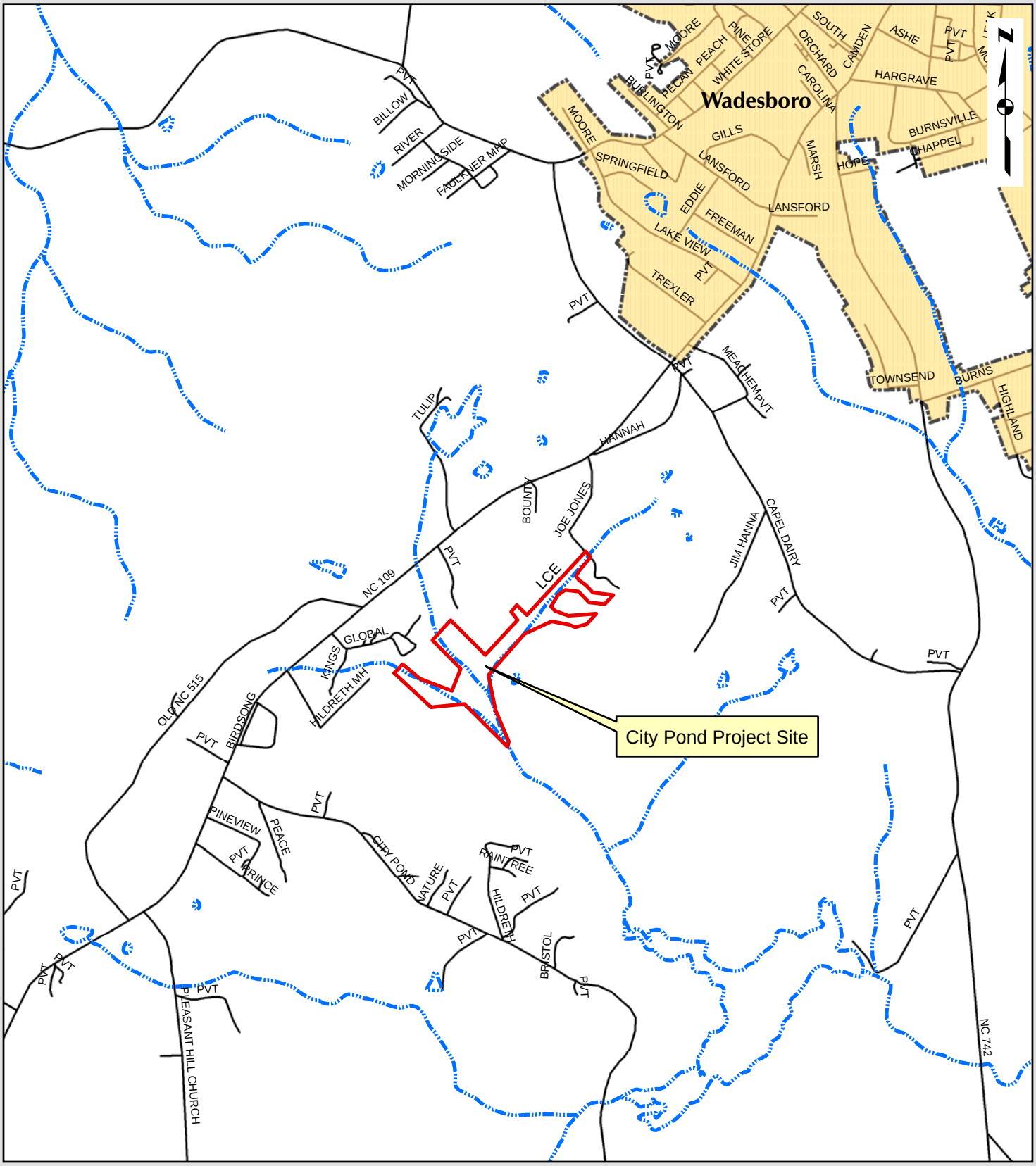
The project involved the restoration and enhancement of 10,574 linear feet of channelized stream on several unnamed tributaries to City Pond. The project restored 9,869 linear feet of channel dimension, pattern, and profile, and enhanced 705 linear feet of channel dimension and/or profile. **Table 1** shows the as-built lengths and restoration type for each reach. The 2009 monitoring season represents the fifth and final year of monitoring for this site.

Table 1. Project Mitigation Structure and Objectives

Reach Name	As-Built Length (feet)	Stream Mitigation Units	Restoration Approach
R1	705	470	Enhancement I
R2	2,611	2,611	Restoration
R3	777	777	Restoration
S1	734	734	Restoration
S2	1,150	1,150	Restoration
S3	710	710	Restoration
S4	1,711	1,711	Restoration
S5	1,744	1,744	Restoration
S6	432	432	Restoration
Total	**10,574**	**10,339**	

2.2 PROJECT PURPOSE

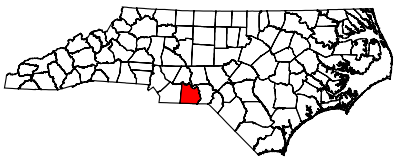
Monitoring of the City Pond Mitigation Site is required to demonstrate successful mitigation based on the criteria described in the City Pond Mitigation Plan. Both stream and vegetation monitoring are conducted throughout the growing season. Success criteria must be met for five consecutive years. This Annual Report details the results of the stream monitoring for 2009 at the City Pond Stream Mitigation Site.



EBX

Figure 1.
City Pond Stream Mitigation Site
Project Location Map
Anson County, NC

1 inch equals 2,000 feet



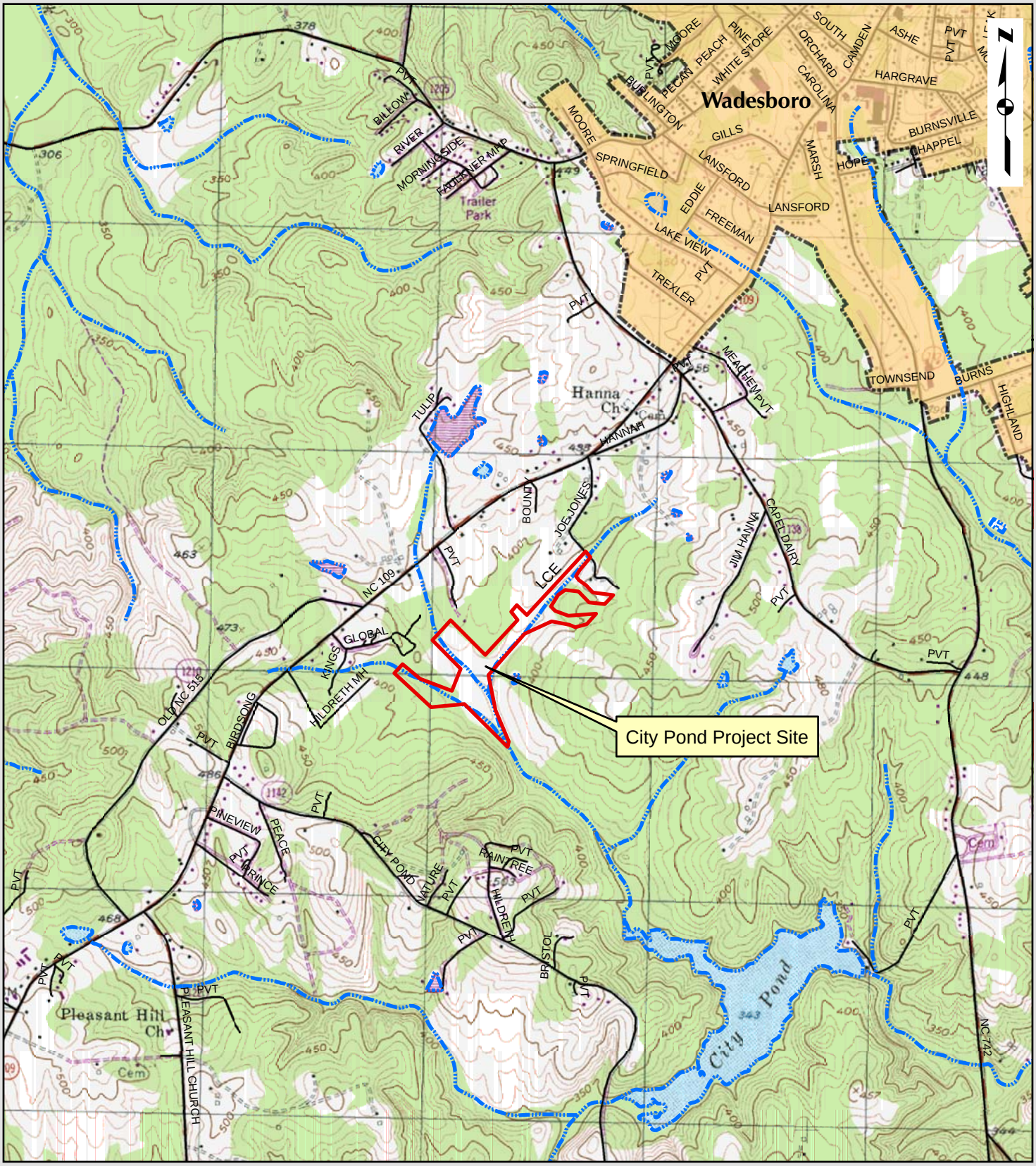


Figure 2.
City Pond Stream Mitigation Site
USGS Topographic Map
Anson County, NC

1 inch equals 2,000 feet

2.3 PROJECT HISTORY & SCHEDULE

This project was identified by EBX in the spring of 2004. The following table outlines project history and milestones, as well as background information (**Table 2**).

Table 2. Project Activity and Reporting History

Date	Action Performed
November 2004	Construction Began
May 2005	Construction Completed
May 2005	Planting Completed
June 2005	Post Construction Monitoring Gauges Installed
August 2005	As-Built Report Submitted
November 2005	1st Annual Monitoring Report
February 2006	Replanted 3.5 acres with two year old trees
November 2006	2nd Annual Monitoring Report
November 2007	3rd Annual Monitoring Report
November 2008	4th Annual Monitoring Report
November 2009	5th Annual Monitoring Report

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 final measure of vegetative success for the City Pond Mitigation Plan is the survival of 260 5-year-old planted trees per acre at the end of Year 5 of the monitoring period. Up to 20 percent of the site species composition may be comprised of volunteers. Remedial action may be required should volunteers (i.e., sweetgum, red maple, etc.) exceed 20 percent composition.

3.2 DESCRIPTION OF SPECIES AND VEGETATION MONITORING

The following tree species were planted in the riparian buffer:

Table 4. Planted Tree Species

No.	Common Name	Scientific Name	FAC Status
1	Shagbark Hickory	*Carya ovata*	FACU
2	Willow Oak	*Quercus phellos*	FACW-
3	Persimmon	*Diospyrus virginiana*	FAC
4	Green Ash	*Fraxinus pennsylvan.*	FACW
5	Yellow poplar	*Liriodendron tulipifera*	FAC
6	Sycamore	*Platanus occidentalis*	FACW-
7	Water Oak	*Quercus nigra*	FAC
8	American Elm	*Ulmus americana*	FACW
9	Laurel Oak	*Quercus laurifolia*	FACW

The following monitoring protocol was designed to predict vegetative survivability. Five plots were established on the City Pond Mitigation Site that covers approximately 2 percent of the site. The vegetation monitoring plots were designed to be 1/10th of an acre in size or 50 feet x 87 feet dimensionally. The plots were randomly located and randomly oriented within the riparian buffer.

Plot construction involved using metal fence posts at each of the four corners to clearly and permanently establish the area to be sampled. Ropes were then hung connecting all four corners to help in determining if trees close to the plot boundary were inside or outside of the plot. Trees right on the boundary and trees just outside of the boundary that appear to have greater than 50 percent of their canopy inside the boundary were counted inside the plot. A ten-foot piece of white PVC pipe was placed over the metal post on one corner to facilitate visual location of the site throughout the five-year monitoring period.

All of the planted stems inside the plot were marked with orange flagging and a 3-foot-tall piece of half-inch PVC to distinguish them from any colonizers, and to help in locating them in the future. Each stem was then tagged with a permanent, numbered aluminum tag.

3.3 RESULTS OF VEGETATION MONITORING

Table 5 presents stem counts for each of the monitoring plots. The species ID numbers across the top row correspond to the numbered species listed in **Table 4**. Each plot is identified down the left column.

Table 5. Results of 2009 Vegetation Monitoring

	Species ID Number (from Table 4)										
Plot	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**Total**	**Stems per acre**
CP1	0	19	6	1	4	9	5	10	0	55	550
CP2	0	23	0	1	1	4	0	28	0	57	570
CP3	2	4	27	1	2	8	0	7	0	51	510
CP4	0	9	11	20	0	1	13	13	0	67	670
CP5	0	10	3	5	9	9	5	4	4	49	490

Average Stems per Acre: 558
Range of Stems per Acre: 490-670

Volunteer woody species were observed in most of the vegetation plots, but were deemed too small to tally. Volunteer species have been monitored throughout the five year monitoring period. Sweetgum (*Liquidambar styraciflua*) is the most common volunteer, though privet (*Ligustrum spp.*), loblolly pine (*Pinus taeda*) and red maple (*Acer rubrum*) was also observed.

3.4 VEGETATION OBSERVATIONS & CONCLUSIONS

This site was planted in bottomland hardwood forest species in March 2005. The 2009 vegetation monitoring documented that the site has an average tree density of 558 stems per acre with a range of 490 to 670 stems per acre. This site met the minimum success interim criteria of 320 trees per acre at the end of the third growing season and met the final success criteria of 260 trees per acre at the end of the fifth growing season.

At the beginning of the 2006 growing season, two year old trees were replanted in proximity to and including Plot 5 due to high mortality the previous year. The five year old saplings are healthy and growing and the mortality rate is consistent with what is found throughout the site.

After construction of the mitigation site, a permanent ground cover seed mixture of Virginia wild-rye (*Elymus virginicus*), switch grass (*Panicum virgatum*), and fox sedge (*Carex vulpinoidea*) was broadcast on the site at a rate of 10 pounds per acre. These species are found on the site. Naturally occurring hydrophytic herbaceous vegetation is also occurring on site. Cattails (*Typha spp*.), rush (*Juncus effusus*), spikerush (*Eleocharis obtusa*), knotweed (*Polygonum persicaria*), iris (*Iris spp.*), arrow-leaf tearthumb (*Polygonum sagittatum*), and sedge (*Carex spp.*), all hydrophytic herbaceous plants, are frequently observed across the site, particularly in areas of inundation. Woolgrass (*Scirpus cyperinus*), an obligate wetland plant, is dominant in the central wetter zone of the site. The presence of these herbaceous wetland plants helps to confirm the presence of wetland hydrology on the site.

There are zones of weedy species occurring on the site, though none seem to be posing any problems for the woody or herbaceous hydrophytic vegetation. The majority of the weedy species are annuals and seem to pose very little threat to survivability onsite. Commonly seen weedy vegetation includes hay, dallisgrass (*Paspalum dilatatum*), dogfennel (*Eupatorium capillifolium*), broomsedge (*Andropogon spp.*), buttercup (*Ranunculus spp.*) and blackberry (*Rubus spp*.).

4.0 STREAM MONITORING

4.1 STREAM SUCCESS CRITERIA

As stated in the approved Restoration Plan, the stream restoration success criteria for the site includes 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. Cross section data will be collected annually.
- *Longitudinal Profile*: The longitudinal profiles should show that the bedform features are remaining stable, i.e. they are not aggrading or degrading. Bedforms observed should be

consistent with those observed in "E" or "C" type channels. Profile data will be collected in monitoring Years 1, 3, 4, and 5.

- *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. Photos will be taken annually at permanent cross sections and grade control structures.
- *Benthic Macroinvertebrate Sampling*: Benthic macroinvertebrates will be sampled annually in monitoring years 1, 2, and 3. Benthic macroinvertebrate samples will be identified and a tolerance value will be calculated.

4.2 STREAM MORPHOLOGY MONITORING PLAN

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

4.2.1 Cross Sections

According to the As-Built Report written in August 2005, 20 cross sections are to be monitored along the restored tributaries R2, R3, S3, S4, S5, and S6. Locations of these cross sections are specified in **Figure 3**. Each cross section was marked on both banks with permanent pins to establish the exact transect used. Permanent cross section pins were surveyed and located relative to a common benchmark to facilitate easy comparison of year-to-year data. The annual cross section surveys include points measured at all breaks in slope, including floodplain, top of bank, bankfull, inner berm, edge of water, and thalweg. In addition, any fluvial features present will be documented. Permanent cross sections for 2009 (Year 5) were surveyed in July 2009. Data and photos of each cross section are included as **Appendix B**.

4.2.2 Longitudinal Profile

Longitudinal profile will be surveyed in years one, three, four, and five of the five-year monitoring period. The profile survey will be conducted for a length of restored channel of at least 30 percent of the total restoration length or 3,000 feet, whichever is greater. Features measured will include thalweg, inverts of stream structures, water surface, and top of bank on either side of the channel. The longitudinal survey of 3,400 linear feet of stream channel was conducted for 2009 (Year 5) in July of 2009.

4.2.3 Hydrology

Three crest gauges were installed on the site to document bankfull events. These gauges record the highest out-of-bank flow event that occurs each month and are checked in the last week of every month during the growing season. The gauges are located on the downstream portions of R1, R2, and S4 (**Figure 3**).

4.2.4 Photo Reference Stations

Photographs are used to visually document restoration success. Although specific photo points are not set up across the City Pond site, photos were taken at every located structure. Reference photos are taken at each permanent cross section from both stream banks, as well as facing upstream and downstream. The survey tape is centered in the photographs of the bank, and the water line is located in the lower edge of the frame with as much of the bank as possible included in each photo. Problem area photos and general photos of the site are located in **Appendix D**.

4.3 STREAM MORPHOLOGY MONITORING RESULTS

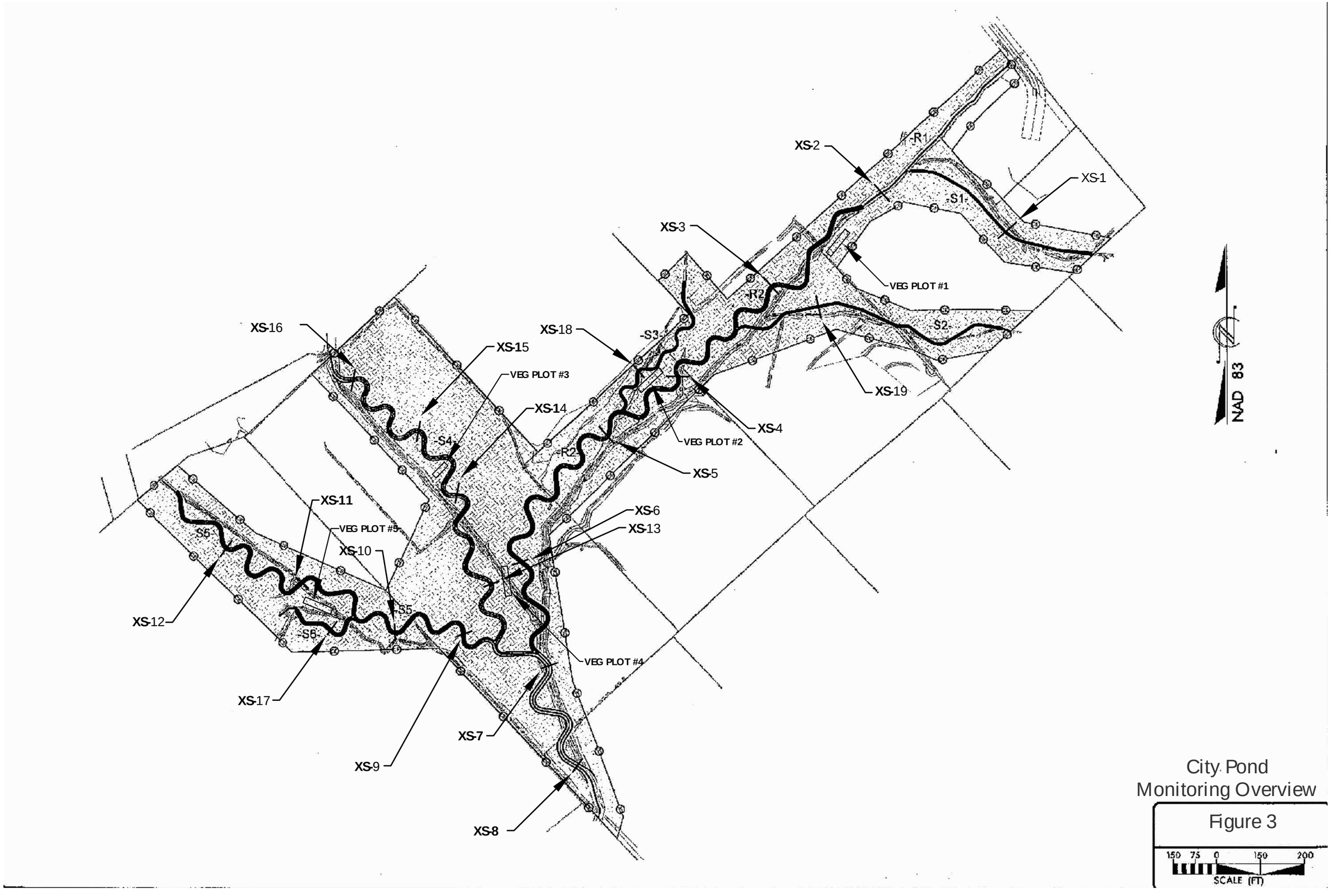
4.3.1 Cross Sections

The cross sections were surveyed during the monitoring set-up, Year 1, Year 2, Year 3, Year 4, and in July 2009 for Year 5. The baseline data has been compared with the Year 1 through Year 5 monitoring data in **Appendix B**. Also included in **Appendix B** are the surveyed cross sections for Year 4 and Year 5. Compared to the documented data from the Year 4 survey, the Year 5 channel cross sections showed that overall stream dimensions remained stable during this fifth growing season. Some localized areas of bed scour and/or aggradation were noted; however, these adjustments are common and indicate a movement toward greater stability. There is very little difference between the baseline cross sections, and Years 1 through 5 cross sections.

4.3.2 Longitudinal Profile

A longitudinal profile survey was conducted along four separate reaches of the restoration project, totaling approximately 3,400 linear feet. Survey was conducted in reach R2 from STA 27+50 (XS 4) to STA 39+50 (XS 6), in reach R3 from STA 44+00 (XS 7) to STA 49+00 (XS 8), in reach S4 from STA 15+50 (XS 13) to STA 23+50 (XS 15), and in reach S5 from STA 14+00 (XS 10) to STA 23+00 (XS 12). The longitudinal profile information documents the elevations and locations of streambed features and in-stream grade control structures. The profile and cross sections show there has been little adjustment to stream profile or dimension since construction.

Table 6 summarizes stream areas requiring observation. **Figures 4a-4e** shows the locations of the stream problem areas observed. All of the problem areas observed are minor and localized. SPA2 and SPA3 are localized and are expected to stabilize and become vegetated. Problem area SPA5, SPA6, and SPA7 are not affecting channel stability and have good vegetative cover on the adjacent banks and floodplain. SPA10 is a small head-cut that is expected to stabilize. Upstream of this are a number of stable grade control structures that will halt progression if necessary. Vegetation along the banks at this area is still filling in and is expected to provide additional stabilization. No remedial actions are necessary.

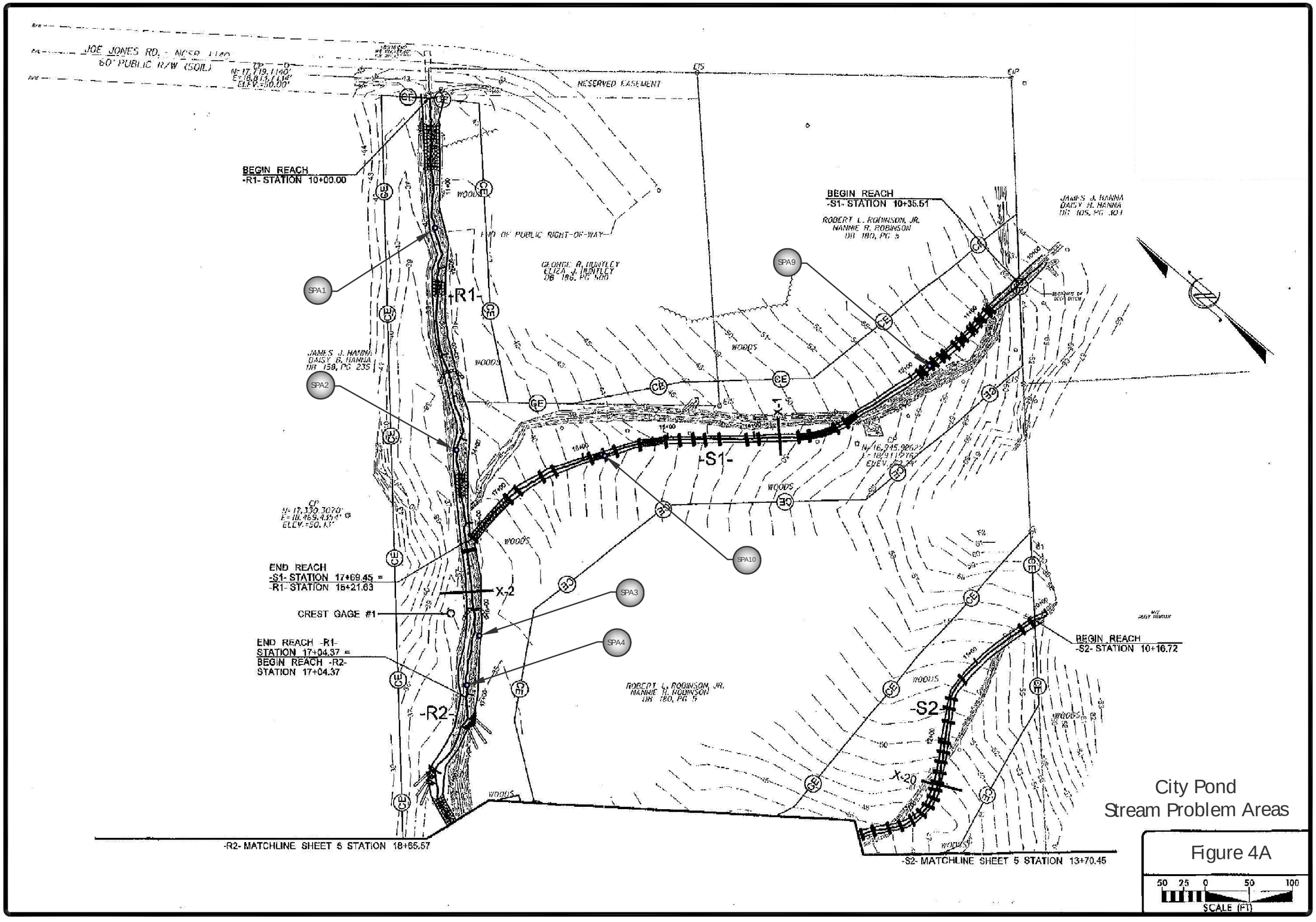


City Pond
Monitoring Overview

Figure 3

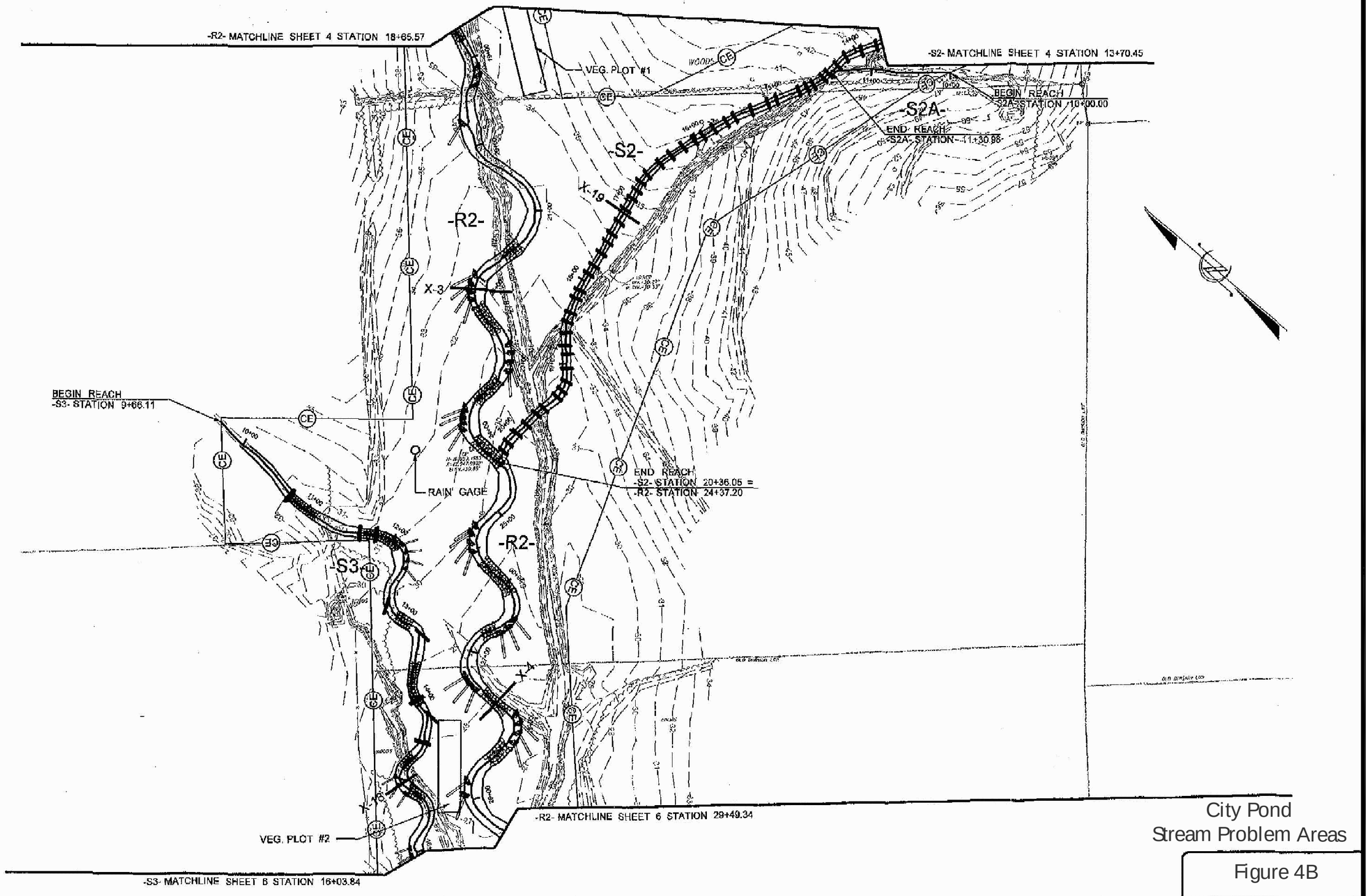
Table 6. Stream Areas Requiring Observation in 2009

ID	Station	Feature	Problem	Severity	Recommended Action
SPA1	R1 11+50	Channel	Small headcut	Minor	None
SPA2	R1 13+80 to R1 14+10	Left Bank	Lack of vegetation and erosion	Minor	None
SPA3	R1 16+30	Left Bank	Lack of vegetation	Minor	None
SPA4	R1 16+75	Channel	Aggradation of sand in channel	Minor	None
SPA5	R2 33+00	Channel	Beaver dam across channel	Minor	None
SPA6	R2 34+50	Channel	Beaver dam across channel	Minor	None
SPA7	R2 38+20	Channel	Beaver dam across channel	Minor	None
SPA8	R2 43+15	Channel	ATV Crossing	Minor	None
SPA9	S1 12+00	Log Weir	Erosion behind structure	Minor	None
SPA10	S1 15+85	Rock Vane	Erosion behind structure	Minor	None



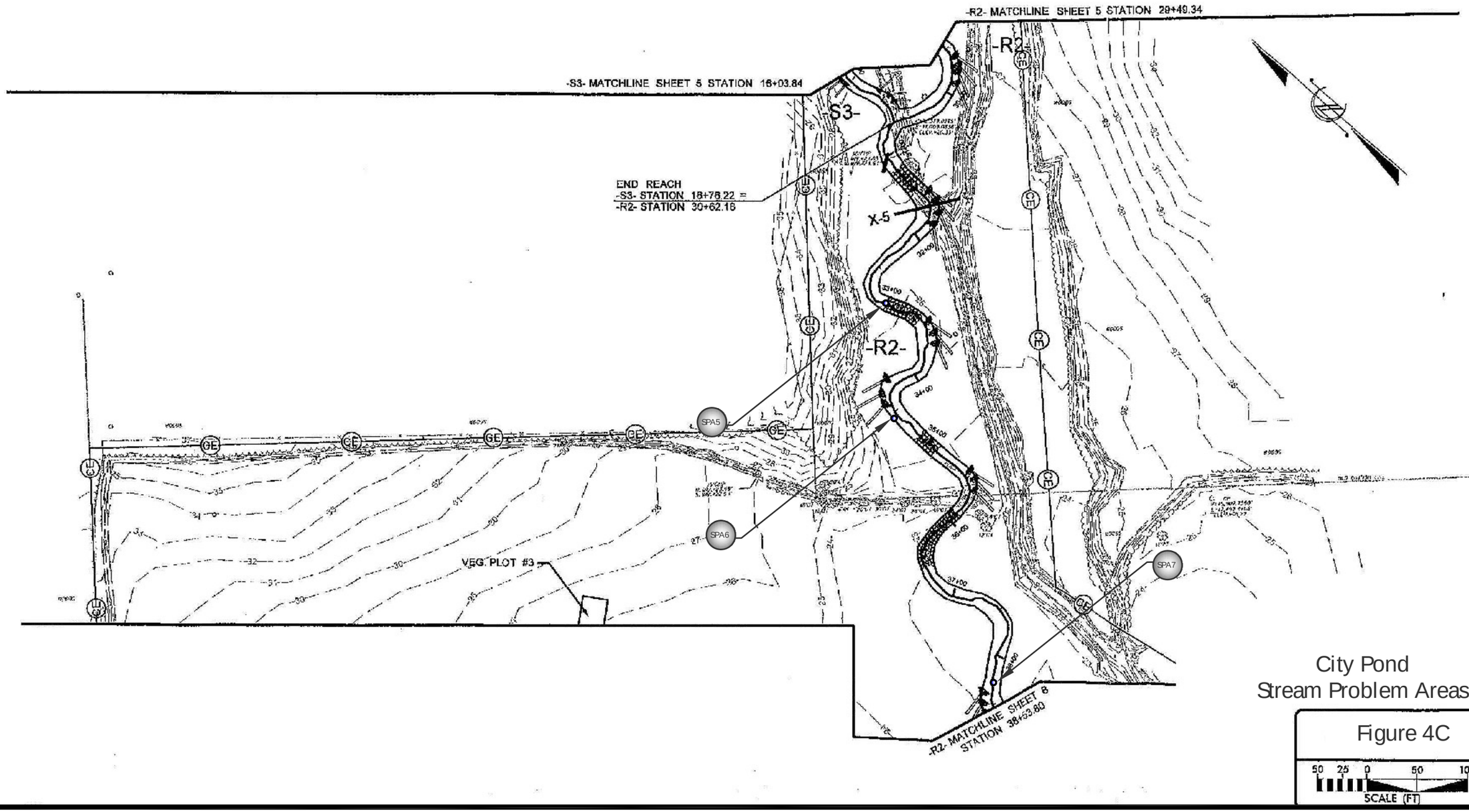
City Pond
Stream Problem Areas

Figure 4A



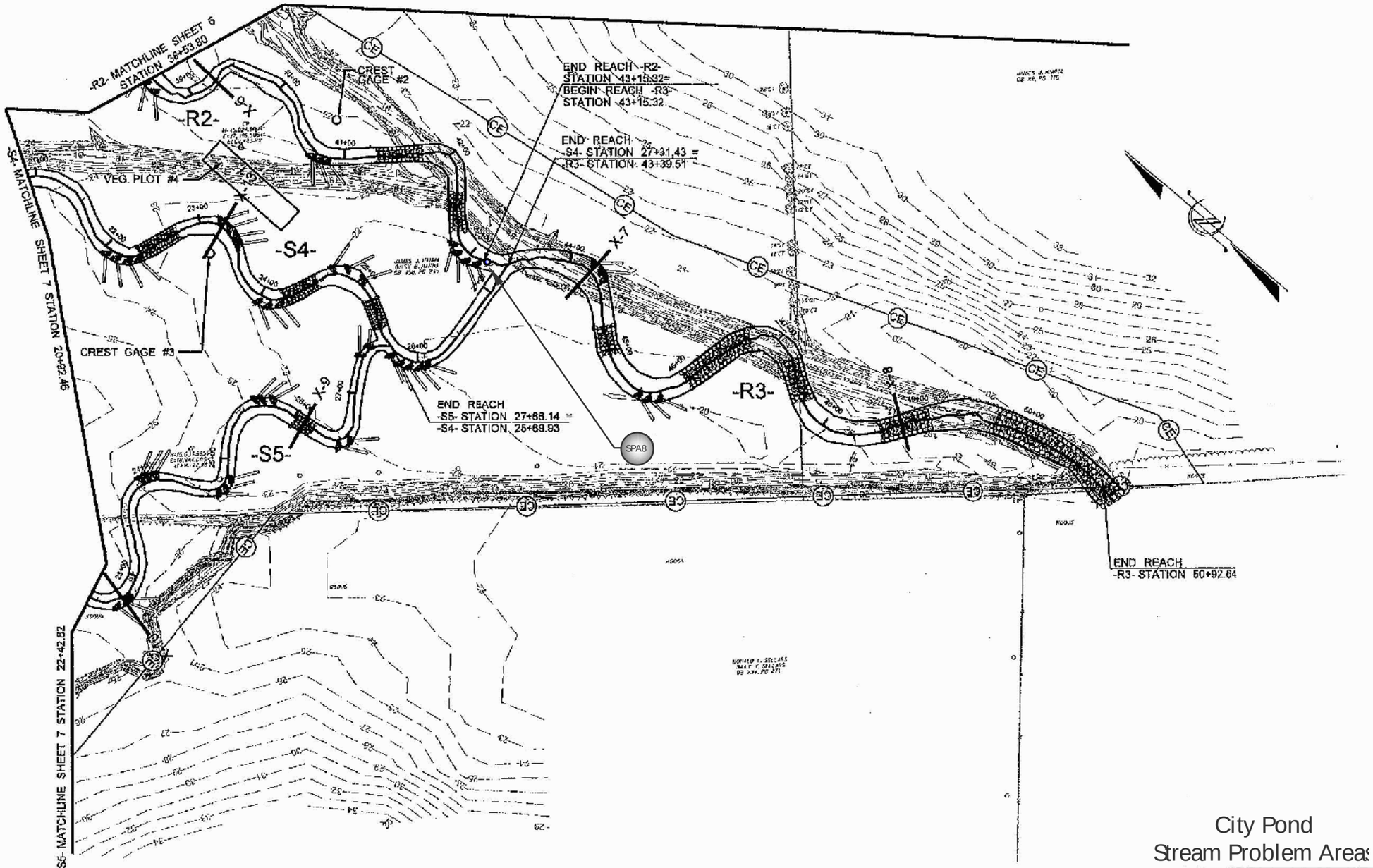
City Pond
Stream Problem Areas

Figure 4B



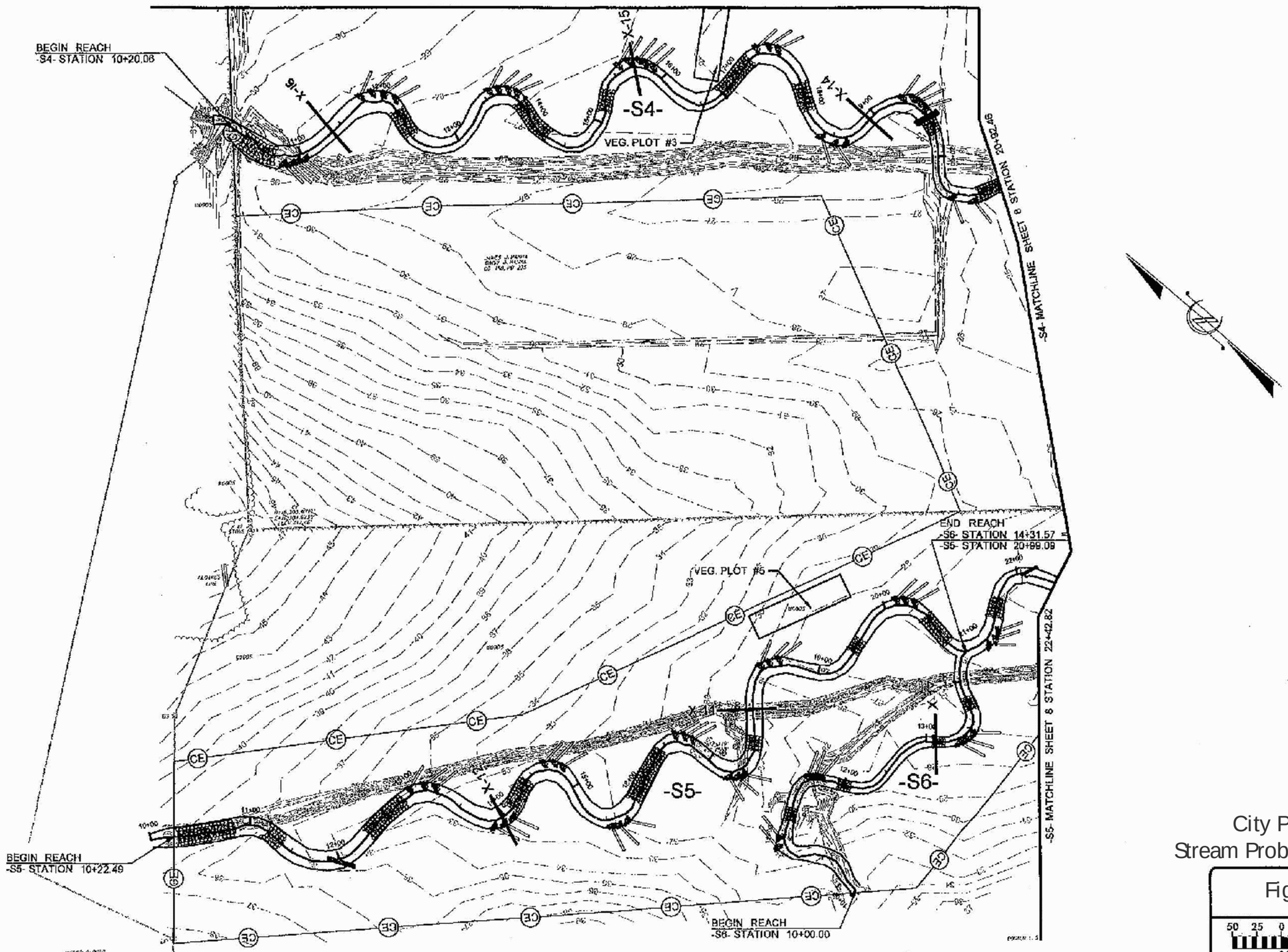
City Pond
Stream Problem Areas

Figure 4C



City Pond
Stream Problem Areas

Figure 4D



City Pond
Stream Problem Areas

Figure 4E

4.3.3 Hydrology

During the 2009 monitoring season, three crest gauges were monitored to determine if there were any out-of-bank flow events in the City Pond stream channel. Between the months of February and July, three bankfull events have been documented during the monthly onsite visits. Crest Gauge 1 (Reach R1) and Crest Gauge 3 (in Reach S4) did not register any out-of-bank flows. Crest Gauge 2 (Reach R2) registered three out-of-bank flows. The largest stream flow documented for Year 5 by the onsite crest gauges was a flow that occurred during February and was 0.95 feet above the bankfull stage. The hydrology success criteria have also been satisfied by bankfull events in previous monitoring years.

Table 7. Crest Gauge Summary Data for Years 1 - 5

Month Recorded	Crest Gauge 1					Crest Gauge 2					Crest Gauge 3				
	YR 1	YR 2	YR 3	YR 4	YR 5	YR 1	YR 2	YR 3	YR 4	YR 5	YR 1	YR 2	YR 3	YR 4	YR 5
January	NA	---	---	---	---	NA	---	---	---	---	NA	---	---	---	---
February	NA	---	---	0.00	0.00	NA	---	---	0.60	0.95	NA	---	---	0.00	0.00
March	NA	1.50	0.00	0.00	0.00	NA	1.75	1.00	0.65	0.80	NA	1.50	1.20	0.00	0.00
April	NA	1.50	0.00	0.00	0.00	NA	0.00	0.70	1.05	0.35	NA	0.00	0.10	0.20	0.00
May	NA	0.00	0.00	0.00	0.00	NA	0.00	2.10	0.00	0.00	NA	0.00	0.10	0.00	0.00
June	NA	1.35	0.00	0.00	0.00	NA	2.10	0.00	0.00	0.00	NA	1.35	0.00	0.00	0.00
July	NA	0.50	0.00	0.00	0.00	NA	2.10	0.00	3.50	0.00	NA	0.75	0.00	0.00	0.00
August	NA	0.12	0.00	0.40	0.00	NA	1.60	0.00	1.50	0.00	NA	0.05	0.00	0.70	0.00
September	NA	0.75	0.00	0.70	0.00	NA	0.15	0.00	2.30	0.00	NA	0.00	0.00	0.00	0.00
October	NA	0.00	0.00	0.00		NA	0.15	0.00	0.00		NA	0.00	0.00	0.00	
November	NA	0.15	---	---		NA	0.55	---	---		NA	1.45	---	---	
December	NA	---	---	---		NA	---	---	---		NA	---	---	---	

NA - Data not available.

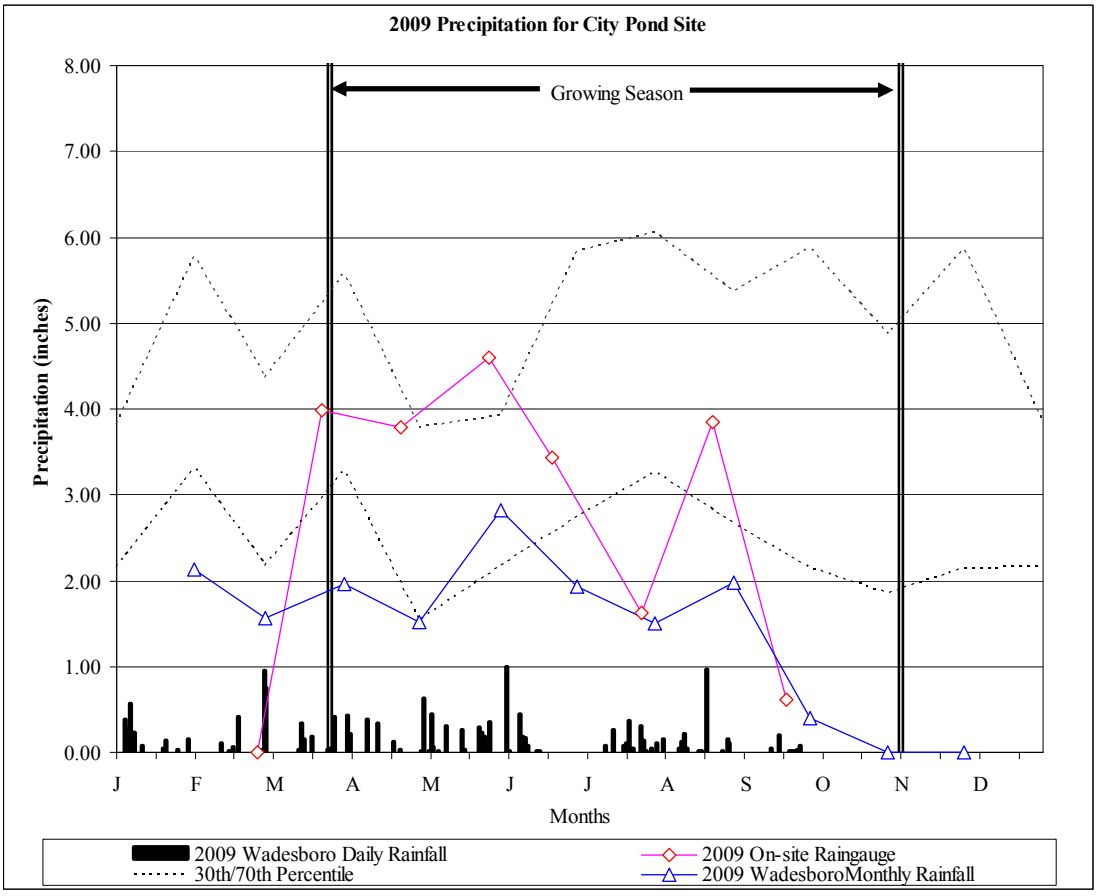
4.3.4 Climate Data

Precipitation levels at the Wadesboro monitoring station near the City Pond site fell below the normal range for much of the spring and summer. In May, the precipitation level fell within the normal range (**Figure 5** and **Table 8**).

Table 8. County and On-site Rainfall Data

Month	Average	Normal Limits		Wadesboro Precipitation	On-Site Precipitation
		30 Percent	70 Percent		
January	4.66	3.31	5.78	2.13	---
February	3.56	2.18	4.37	1.57	---
March	4.61	3.28	5.58	1.96	3.98
April	2.94	1.54	3.78	1.51	3.78
May	3.44	2.18	3.93	2.82	4.60
June	4.56	2.74	5.84	1.93	3.43
July	5.26	3.26	6.06	1.45	1.63
August	4.41	2.67	5.36	1.98	3.85
September	4.25	2.15	5.87	0.40	0.62
October	3.66	1.85	4.87	---	---
November	3.1	2.14	3.86	---	---
December	3.28	2.16	3.83	---	---
Average	**---**	**43.21**	**50.80**	**---**	**---**
Total	**47.72**	**---**	**---**	15.80	21.89

Figure 5. 2009 Precipitation for City Pond



The on-site rain gauge recorded normal to above normal rainfall for most of the spring and summer. In May, the precipitation was above normal. In July, the precipitation was below normal. By July, the Wadesboro rainfall total was 6.44 inches below the monthly averages.

4.4 STREAM CONCLUSIONS

All potential problem areas are minor and localized, and no corrective actions are recommended at this time. All monitored cross sections fell within the quantitative parameters defined for "E" or "C" type channels. Three bankfull events in 2009 were documented on Reach 2 during site visits with the on site crest gauge and visual evidence of out-of-bank flow. The hydrology success criteria have been satisfied by bankfull events in previous monitoring years and 2009.

In-stream structures installed within the channel include constructed riffles, cross vanes, log vanes, log weirs, root wads, and step-pools. Visual observations of structures throughout the 2009 growing season indicated the structures are stable and that most structures are functioning as designed. Localized bank erosion is occurring in several spots along R1. No remedial action is recommended. One log weir on reach S1 was undercutting but is still functioning properly. A small head cut has formed in S1 at a rock grade-control structure, but does not appear to pose any problem because of multiple grade control structures upstream and increasing vegetative stabilization in the channel. Except for localized minor erosion, the banks appear stable throughout the site and no action is required. This site meets the success criteria and no remedial actions are necessary. **Appendix D** summarizes the morphologic parameter.

5.0 CONCLUSIONS AND RECOMMENDATIONS

- Stream stability data collected during monitoring Year 5 and observations of conditions at the site indicate that the project continues to be successful. The stream morphology is stable. Several in-stream structures are experiencing slight scour, but appear to still be functioning properly. Vegetative growth along the channel banks has increased channel stability. Some siltation is occurring throughout the various reaches, resulting in vegetation growth in the channel. It was concluded that the site has achieved the stream success criteria specified in the Restoration Plan.

- Vegetation monitoring efforts documented that the average number of stems per acre on site to be 558, which is a survival rate of 88 percent based on the initial planting count of 632 stems per acre. The range of surviving planted stem density is 490 to 670 stems per acre. The vegetation success criteria have been met for the fifth growing season.

APPENDIX A

As-Built Survey

JOE JONES RD. - NCSR 1140
60' PUBLIC R/W (SOIL)

CP
N=17,719.1140'
E=18,813.7134'
ELEV.=50.00'

RESERVED EASEMENT

EIS

EIP

BEGIN REACH
-R1- STATION 10+00.00

END OF PUBLIC RIGHT-OF-WAY

GEORGE R. HUNTLEY
ELIZA J. HUNTLEY
DB 186, PG 500

JAMES J. HANNA
DAISY B. HANNA
DB 158, PG 235

-R1-

WOODS

BEGIN REACH
-S1- STATION 10+35.51

ROBERT L. ROBINSON, JR.
NANNIE R. ROBINSON
DB 180, PG 5

JAMES J. HANNA
DAISY B. HANNA
DB 105, PG 301

BEGINNING OF DITCH

-S1-

X-1

CP
N=16,945,926.2'
E=18,911,276.2'
ELEV.=52.74'

CP
N=17,330.3070'
E=18,469.4354'
ELEV.=50.13'

END REACH
-S1- STATION 17+69.45 =
-R1- STATION 15+21.63

X-2

CREST GAGE #1

END REACH -R1-
STATION 17+04.37 =
BEGIN REACH -R2-
STATION 17+04.37

-R2-

ROBERT L. ROBINSON, JR.
NANNIE R. ROBINSON
DB 180, PG 5

W/E
RUBY HANNAH

BEGIN REACH
-S2- STATION 10+16.72

-S2-

X-20

-R2- MATCHLINE SHEET 5 STATION 18+65.57

-S2- MATCHLINE SHEET 5 STATION 13+70.45

NOTE:
ALL COORDINATES AND
ELEVATIONS ARE RELATIVE TO AN
ARBITRARY BENCHMARK ON-SITE.

50 25 0 50 100
SCALE (FT)

2/26/03

PROJECT REFERENCE NO.	SHEET NO.
0166R	5

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027337
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Cary, North Carolina 27511
Phone: 919-463-5488
Fax: 919-463-5490

-R2- MATCHLINE SHEET 4 STATION 18+65.57

-S2- MATCHLINE SHEET 4 STATION 13+70.45

VEG. PLOT #1

BEGIN REACH
-S2A- STATION 10+00.00

END REACH
-S2A- STATION 11+30.98

-S2-

-S2A-

-R2-

X-19

X-3

JAMES J. HARRIS
DAISY B. HARRIS
DB 158, PG 235

JAMES J. HARRIS
DB 86, PG 505

JAMES J. HARRIS
DB 105, PG 501

BEGIN REACH
-S3- STATION 9+66.11

RAIN GAGE

END REACH
-S2- STATION 20+36.05 =
-R2- STATION 24+37.20

-S3-

-R2-

X-4

X-18

OLD DIVISION LINE

JAMES J. HARRIS
DB 294, PG 167

JAMES J. HARRIS
DAISY B. HARRIS
DB 126, PG 439

GEORGIA WAYNE
AND OTHERS
DB 235, PG 1

VEG. PLOT #2

-R2- MATCHLINE SHEET 6 STATION 29+49.34

-S3- MATCHLINE SHEET 6 STATION 16+03.84

AS - BUILT PLAN

50 25 0 50 100
SCALE (FT)

10/18/2005
F:\0166R\Design\Plans\As_Built\0166R_EBX_AB_PSH_05.dgn

PROJECT REFERENCE NO.	SHEET NO.
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Fax: 919-463-5490

-R2- MATCHLINE SHEET 5 STATION 29+49.34

-S3- MATCHLINE SHEET 5 STATION 16+03.84

END REACH
-S3- STATION 16+76.22 =
-R2- STATION 30+62.18

VEG. PLOT #3

-R2- MATCHLINE SHEET 8
STATION 38+53.80

AS - BUILT PLAN

50 25 0 50 100
SCALE (FT)

2/25/03

10/18/2005
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PROJECT REFERENCE NO.	SHEET NO.
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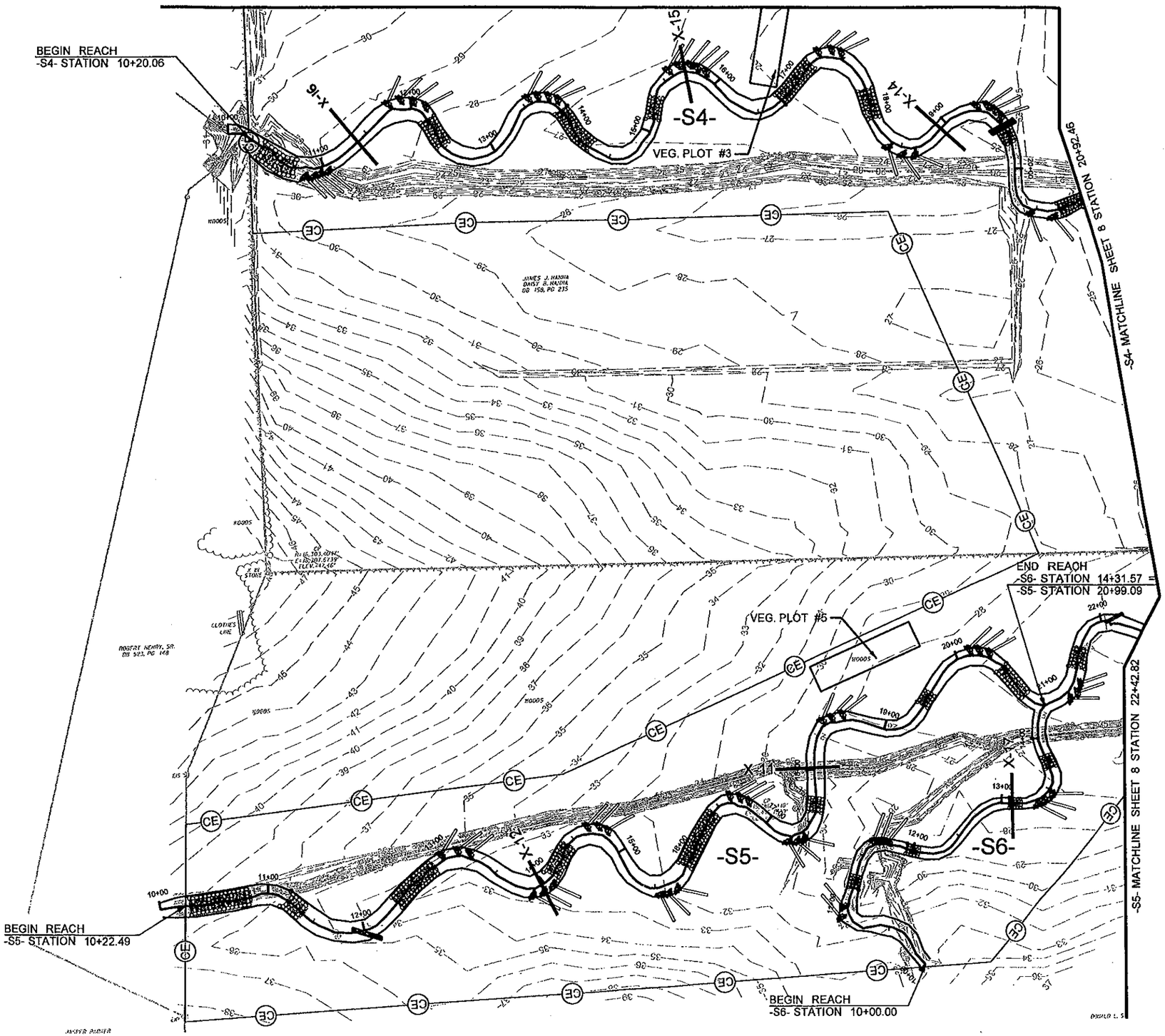
Fax: 919-463-5490



AS – BUILT PLAN

50 25 0 50 100
SCALE (FT)

10/18/2005
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PROJECT REFERENCE NO.	SHEET NO.
0166R	8

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Cary, North Carolina 27511
Phone: 919-463-5488
Fax: 919-463-5490

-R2- MATCHLINE SHEET 6 STATION 38+53.80

-S4- MATCHLINE SHEET 7 STATION 20+92.46

-S5- MATCHLINE SHEET 7 STATION 22+42.82

-R2-

-S4-

-S5-

-R3-

CREST GAGE #2

CREST GAGE #3

VEG. PLOT #4

END REACH -R2- STATION 43+15.32= BEGIN REACH -R3- STATION 43+15.32

END REACH -S4- STATION 27+31.43 = -R3- STATION 43+39.51

END REACH -S5- STATION 27+66.14 = -S4- STATION 25+69.93

END REACH -R3- STATION 50+92.64

JAMES J. HARRIS DAISY B. HARRIS DB 158, PG 255

DONALD L. SELLARS SKEET T. SELLARS DB 207, PG 874

JAMES J. HARRIS DB 89, PG 375

AS - BUILT PLAN

50 25 0 50 100
SCALE (FT)

10/18/2005
I:\0166R\Design\Plans\As_Built\0166R_EBX_AB_PSH_08.dgn

2/25/03

VEGETATION SELECTION

TREES

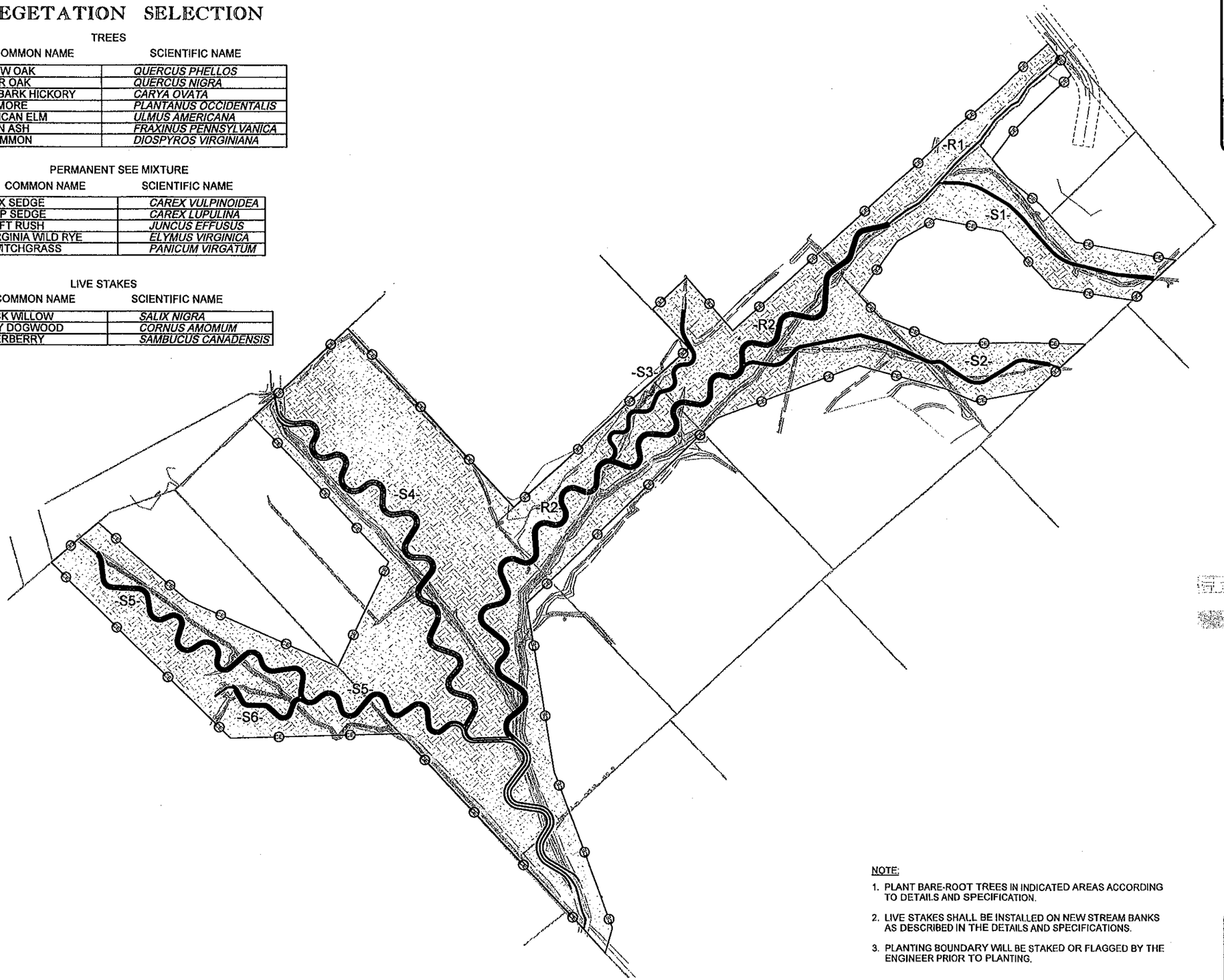
COMMON NAME	SCIENTIFIC NAME
WILLOW OAK	*QUERCUS PHELLOS*
WATER OAK	*QUERCUS NIGRA*
SHAGBARK HICKORY	*CARYA OVATA*
SYCAMORE	*PLANTANUS OCCIDENTALIS*
AMERICAN ELM	*ULMUS AMERICANA*
GREEN ASH	*FRAXINUS PENNSYLVANICA*
PERSIMMON	*DIOSPYROS VIRGINIANA*

PERMANENT SEE MIXTURE

COMMON NAME	SCIENTIFIC NAME
FOX SEDGE	*CAREX VULPINOIDEA*
HOP SEDGE	*CAREX LUPULINA*
SOFT RUSH	*JUNCUS EFFUSUS*
VIRGINIA WILD RYE	*ELYMUS VIRGINICA*
SWITCHGRASS	*PANICUM VIRGATUM*

LIVE STAKES

COMMON NAME	SCIENTIFIC NAME
BLACK WILLOW	*SALIX NIGRA*
SILKY DOGWOOD	*CORNUS AMOMUM*
ELDERBERRY	*SAMBUCUS CANADENSIS*



NAD 83

BARE ROOT PLANTING BOUNDARY

EXISTING CHANNEL FILL BOUNDARY

NOTE:

1. PLANT BARE-ROOT TREES IN INDICATED AREAS ACCORDING TO DETAILS AND SPECIFICATION.
2. LIVE STAKES SHALL BE INSTALLED ON NEW STREAM BANKS AS DESCRIBED IN THE DETAILS AND SPECIFICATIONS.
3. PLANTING BOUNDARY WILL BE STAKED OR FLAGGED BY THE ENGINEER PRIOR TO PLANTING.

REVEGETATION PLAN

150 75 0 150 200
SCALE (FT)

PROJECT REFERENCE NO.	SHEET NO.
0166R	13

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APPENDIX B

2009 Profile and Cross Section Data

City Pond
Reach R2 Station 27+50 to 39+50

2007 R2 Profile
2009 R2 Profile
2009 WS
2007 LTOB
2009 LTOB
2007 RTOB
2009 RTOB

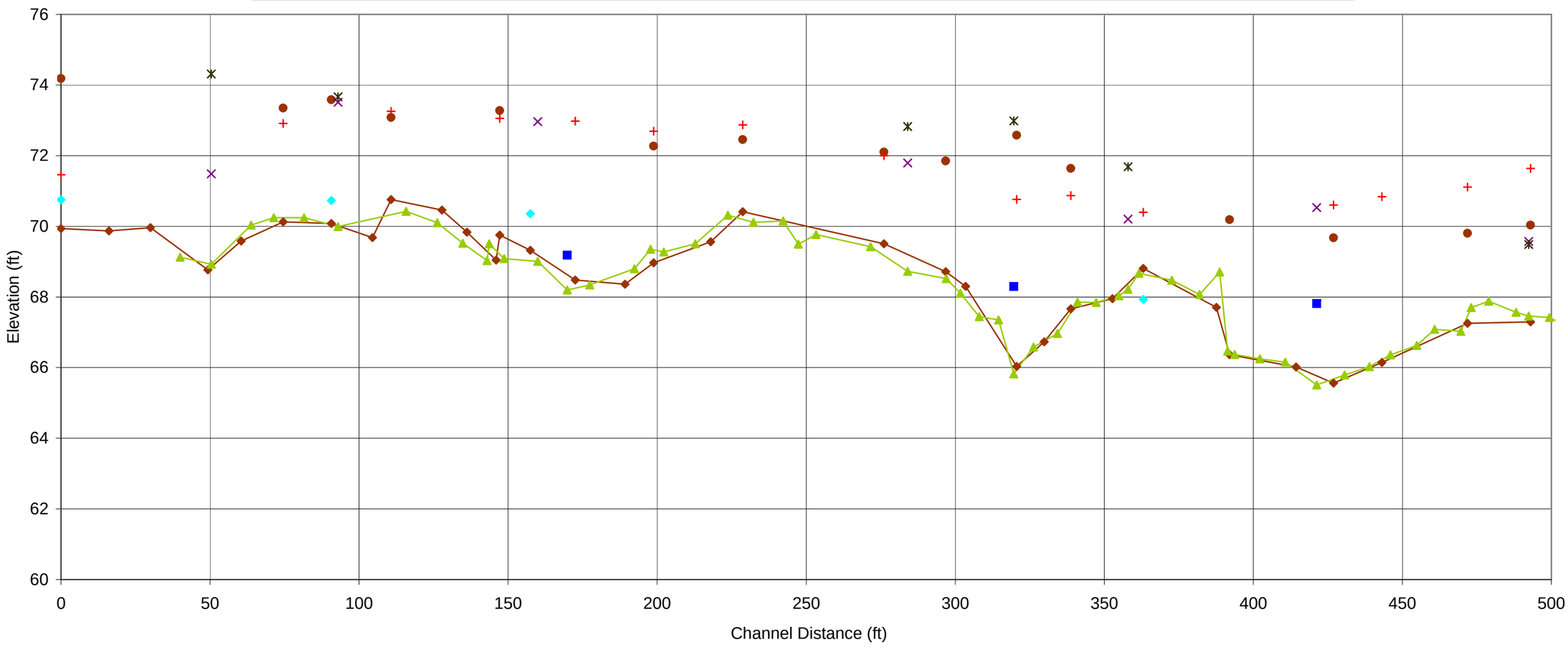
Elevation (ft)

81
80
79
78
77
76
75
74
73
72
71
70

0
100
200
300
400
500
600
700
800
900
1000
1100
1200

Channel Distance (ft)

City Pond
Reach R3 Station 44+00 to 49+00



City Pond
Reach S4 Station 15+50 to 23+50

2007 Channel Bed
2009 Channel Bed
2007 WS
2009 WS
2007 LTOB
2009 LTOB
2007 RTOB
2009 RTOB

Elevation (ft)

77
76.5
76
75.5
75
74.5
74
73.5
73
72.5
72
71.5

0
100
200
300
400
500
600
700
800

Channel Distance (ft)

City Pond
Reach S5 Station 14+00 to 23+00

2007 Channel Bed
2009 Channel Bed
2009 WS
2007 LTOB
2009 LTOB
2007 RTOB
2009 RTOB

Elevation (ft)

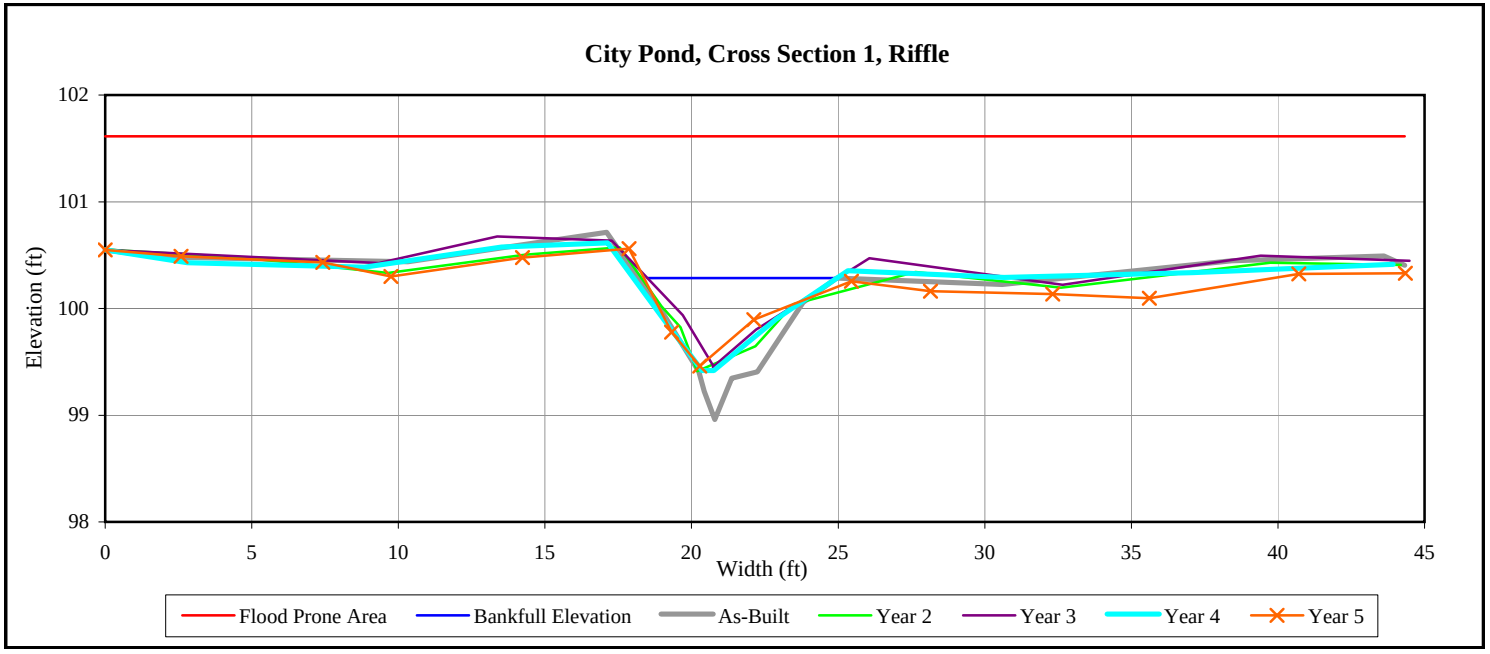
88
86
84
82
80
78
76
74

0
100
200
300
400
500
600
700
800
900

Channel Distance (ft)

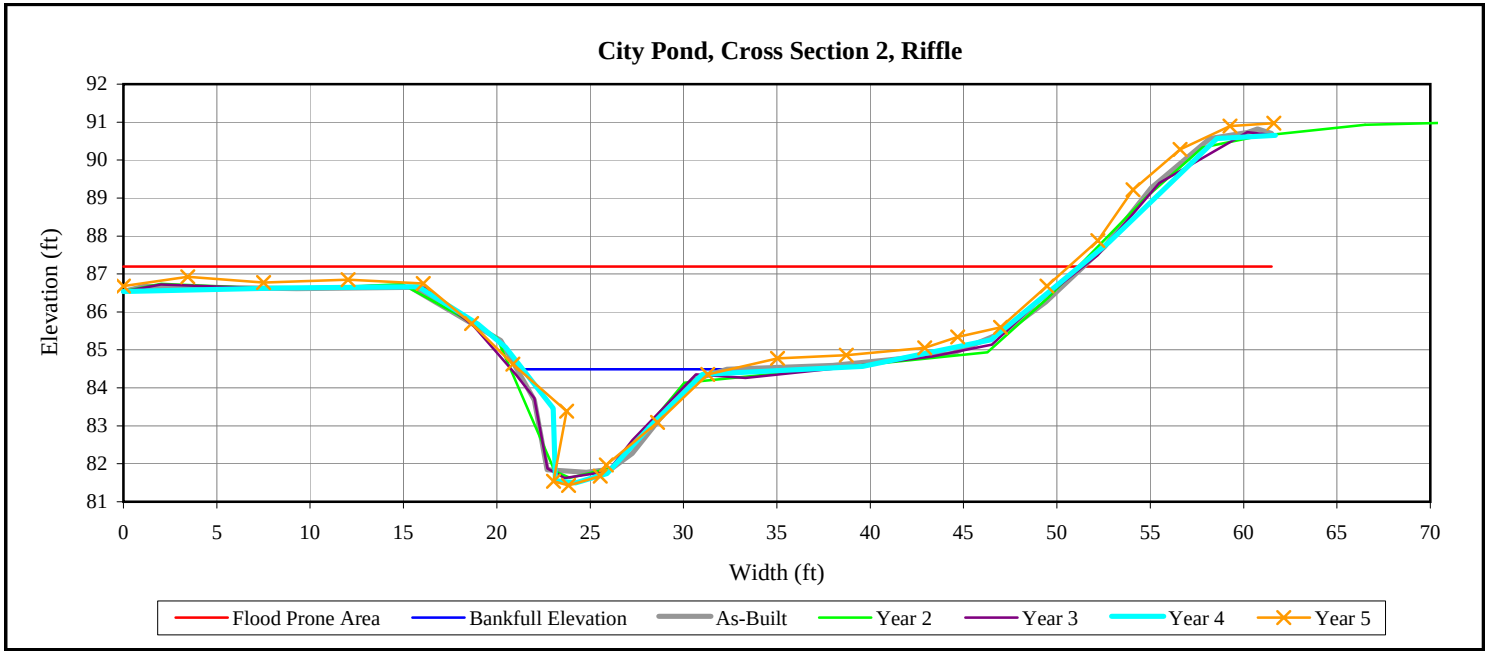
Looking at Left bank

Looking at Right bank



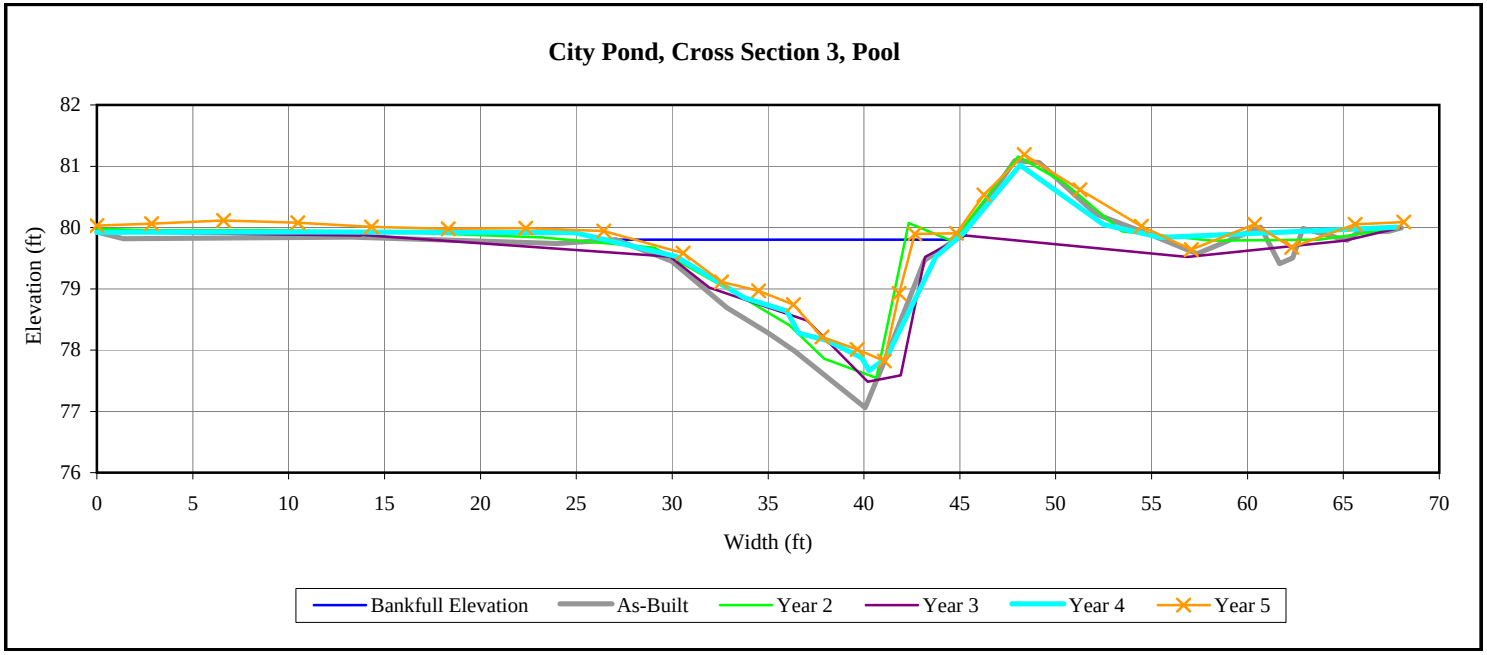
Looking at Left bank

Looking at Right bank



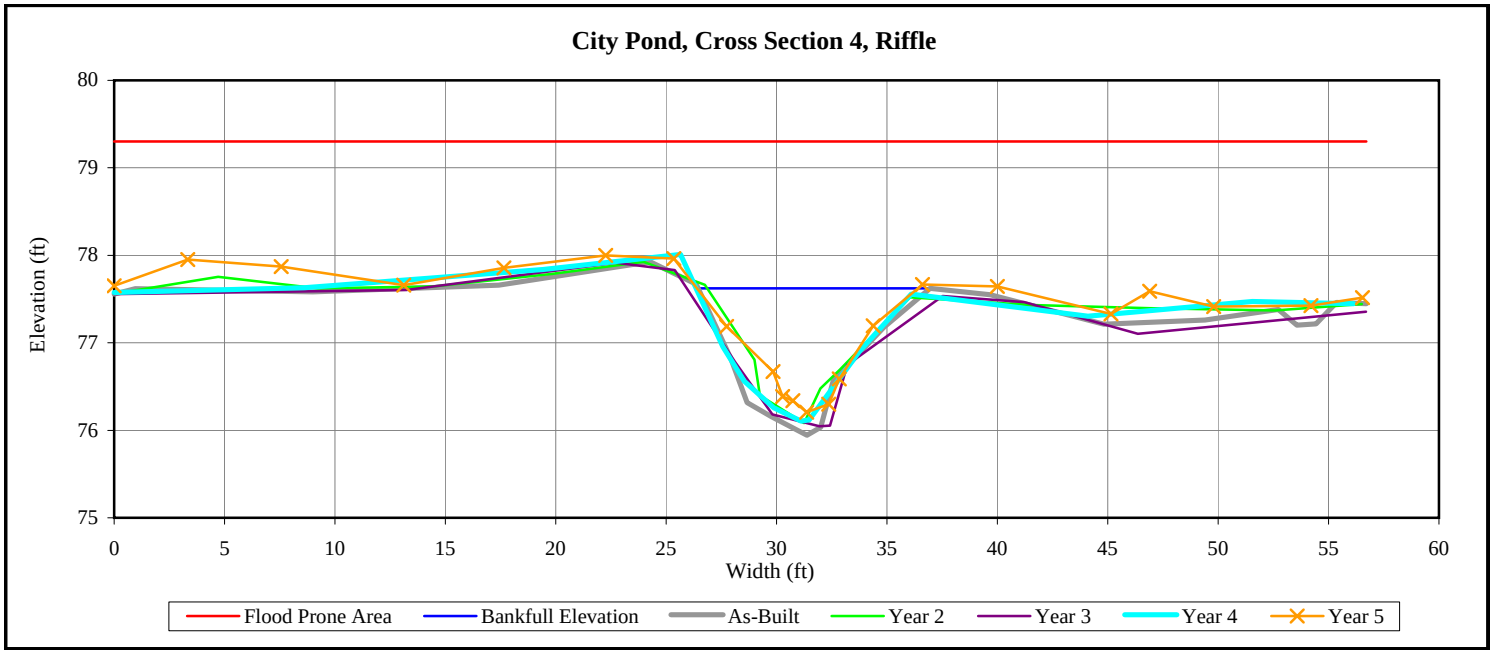
Looking at Left bank

Looking at Right bank



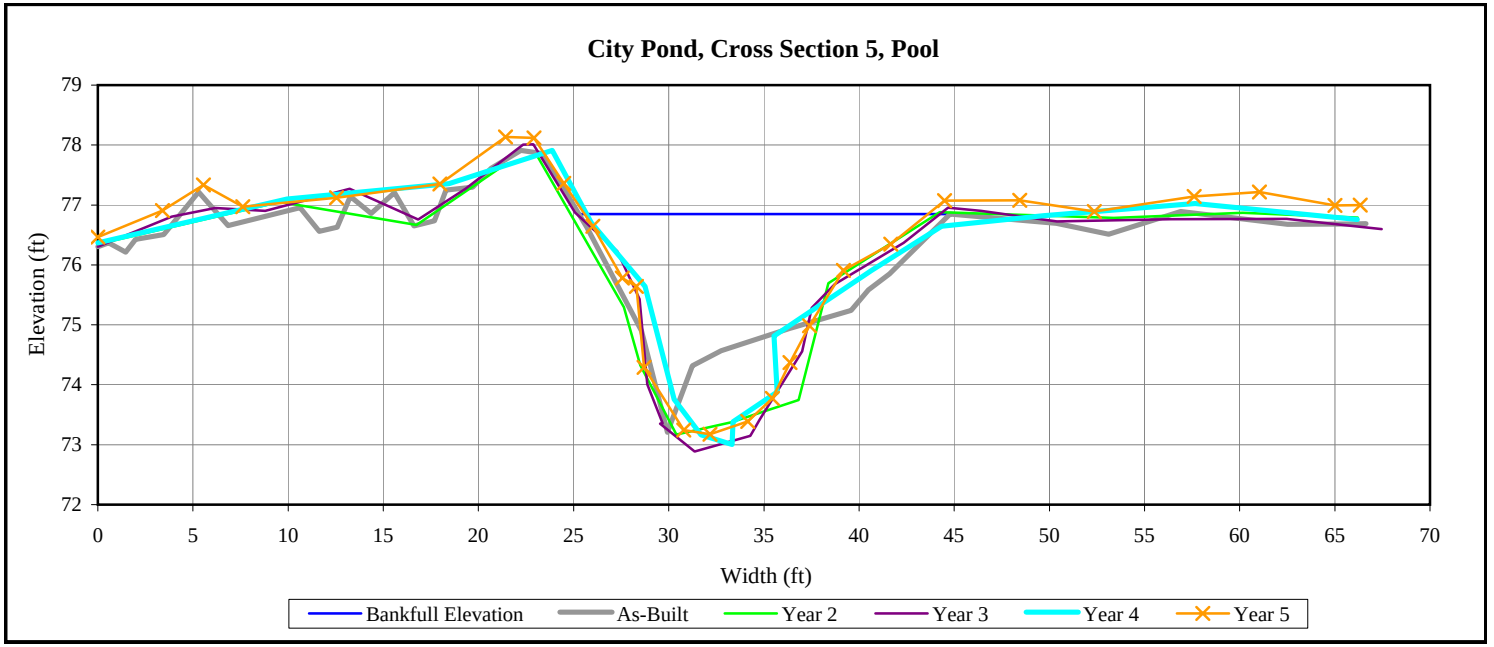
Looking at Left bank

Looking at Right bank



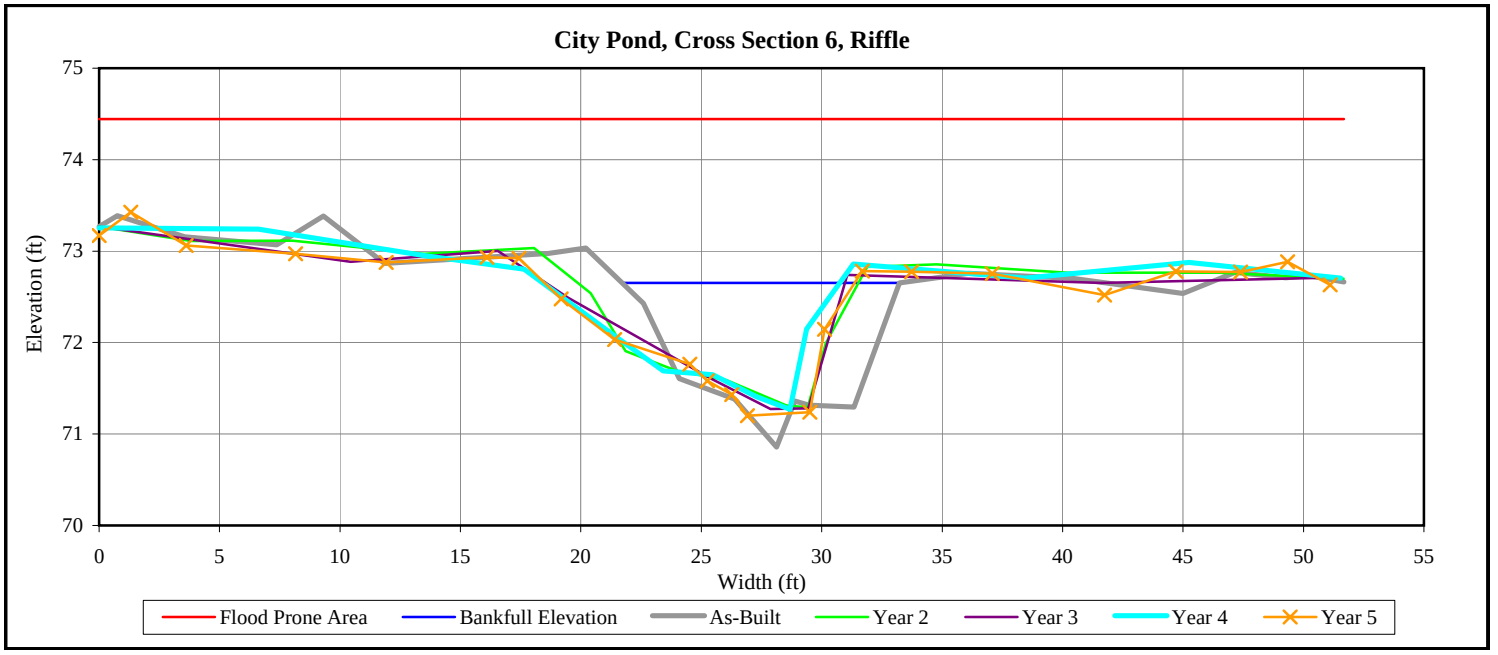
Looking at Left bank

Looking at Right bank



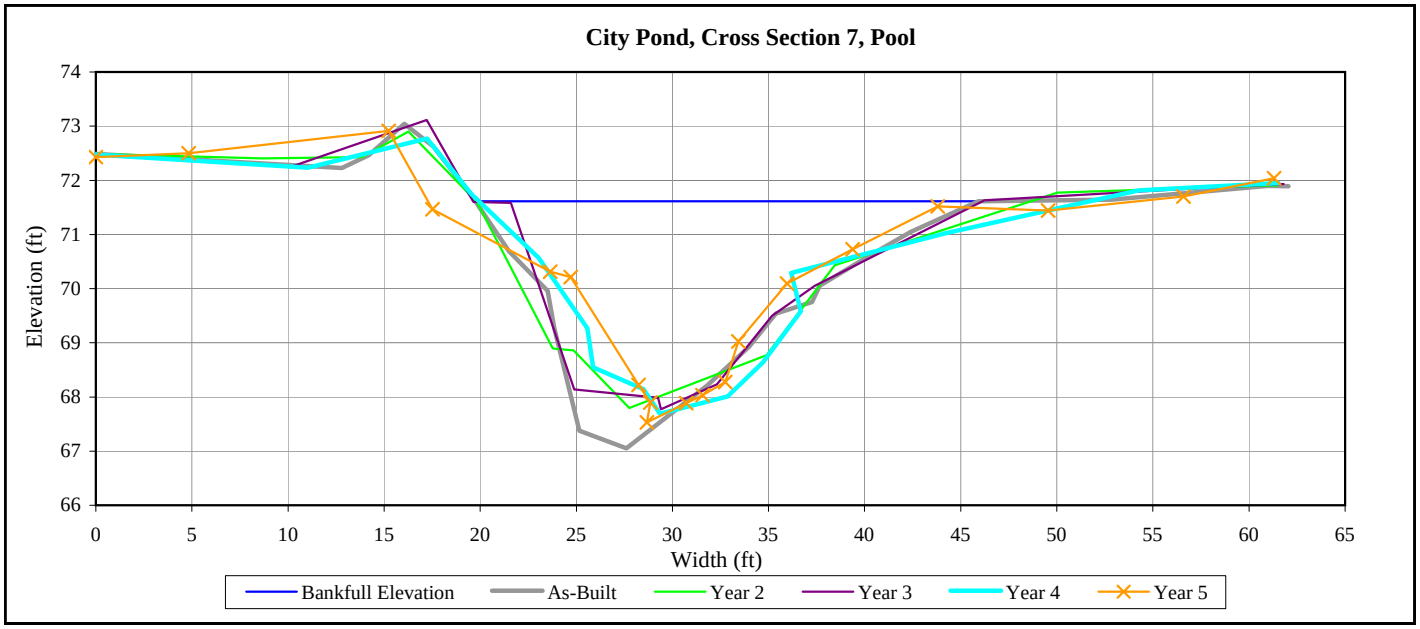
Looking at Left bank

Looking at Right bank



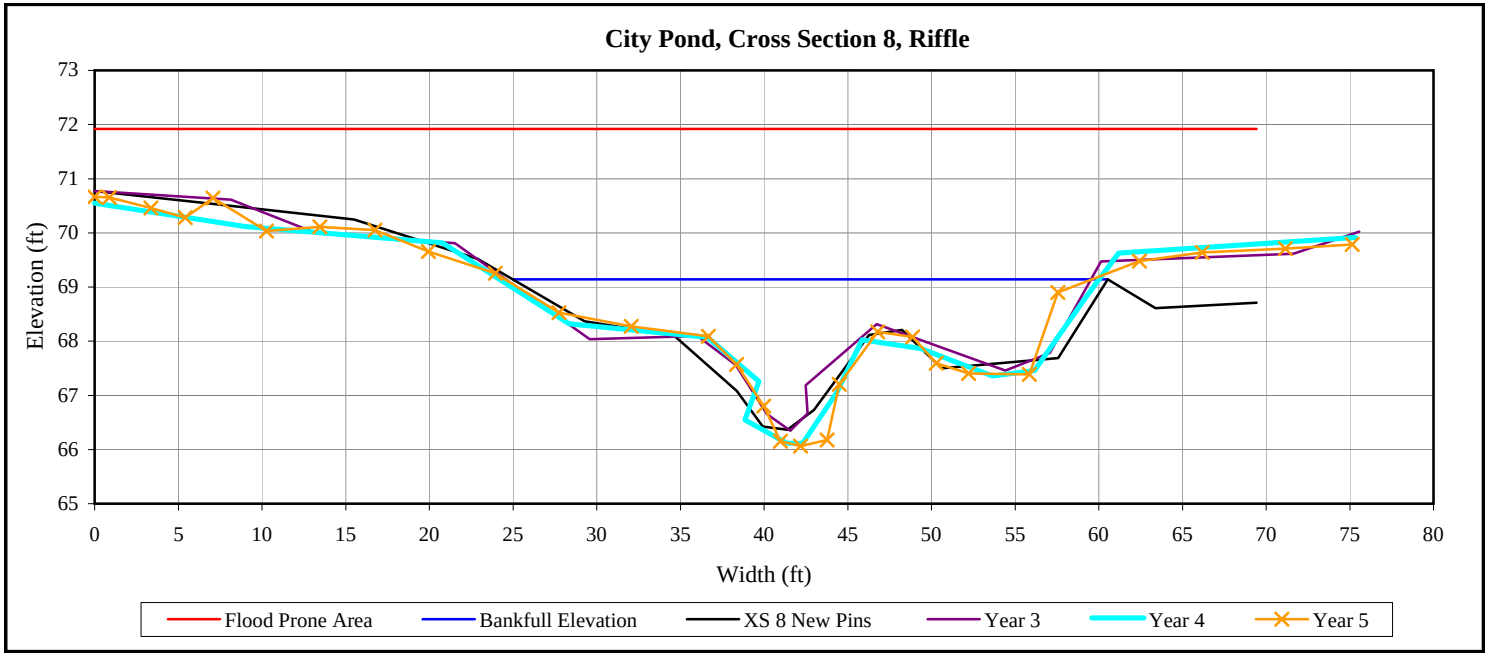
Looking at Left bank

Looking at Right bank



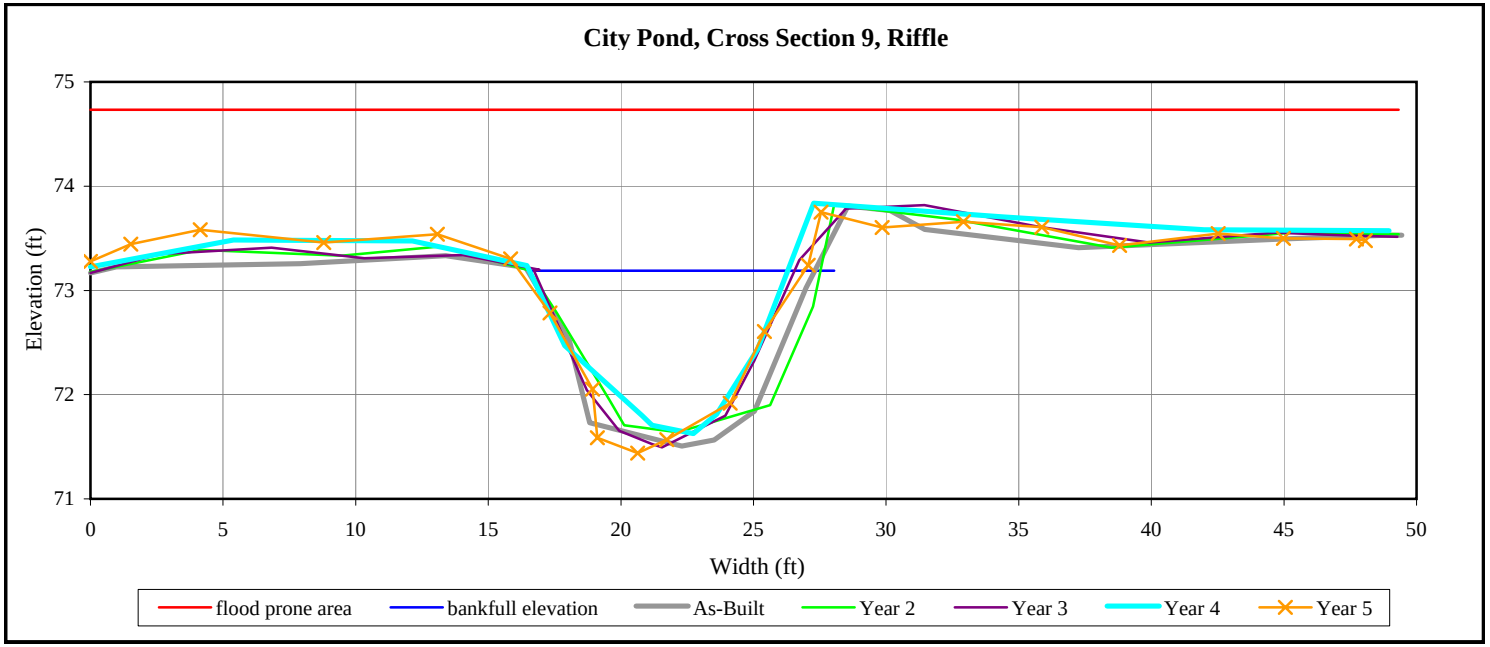
Looking at Left bank

Looking at Right bank



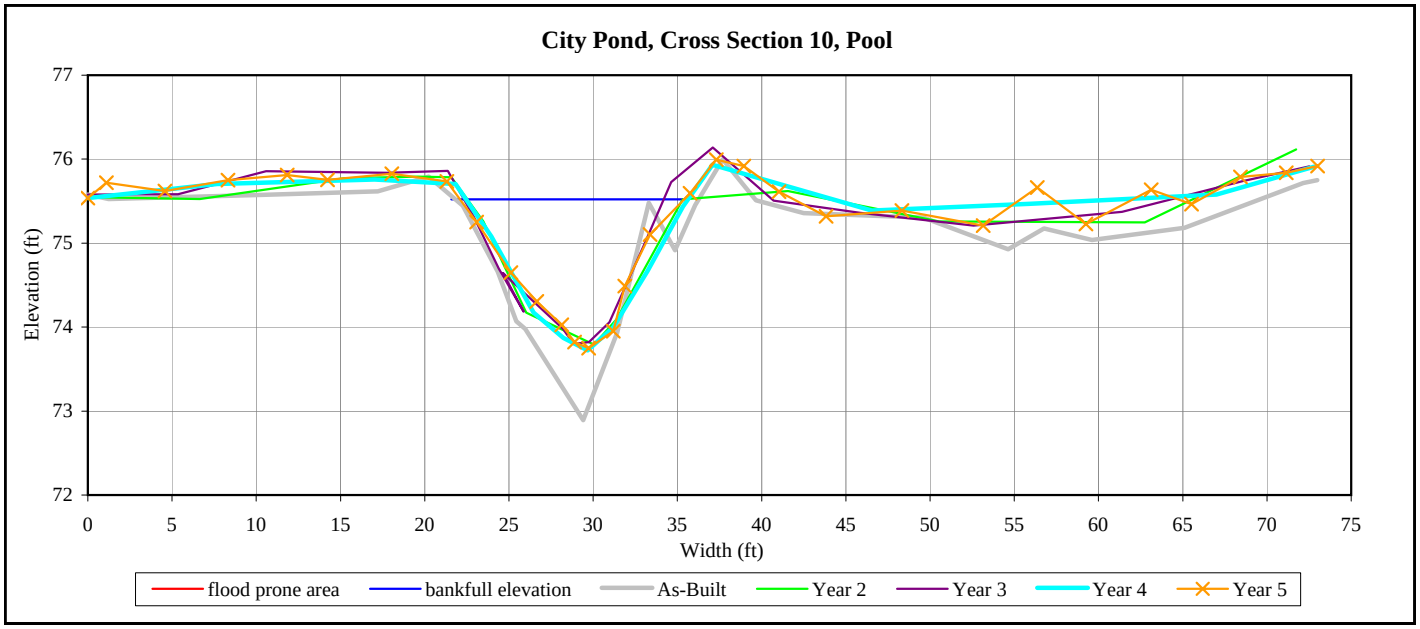
Looking at Left bank

Looking at Right bank



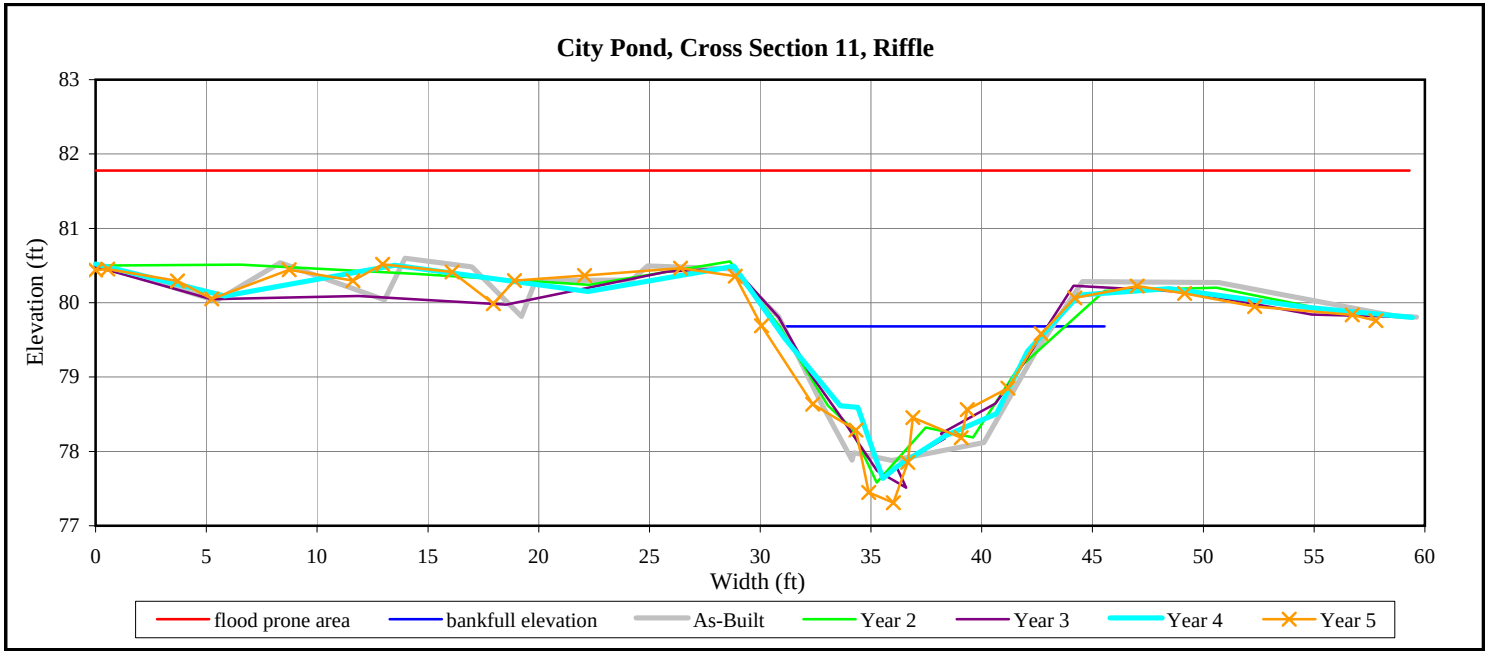
Looking at Left bank

Looking at Right bank



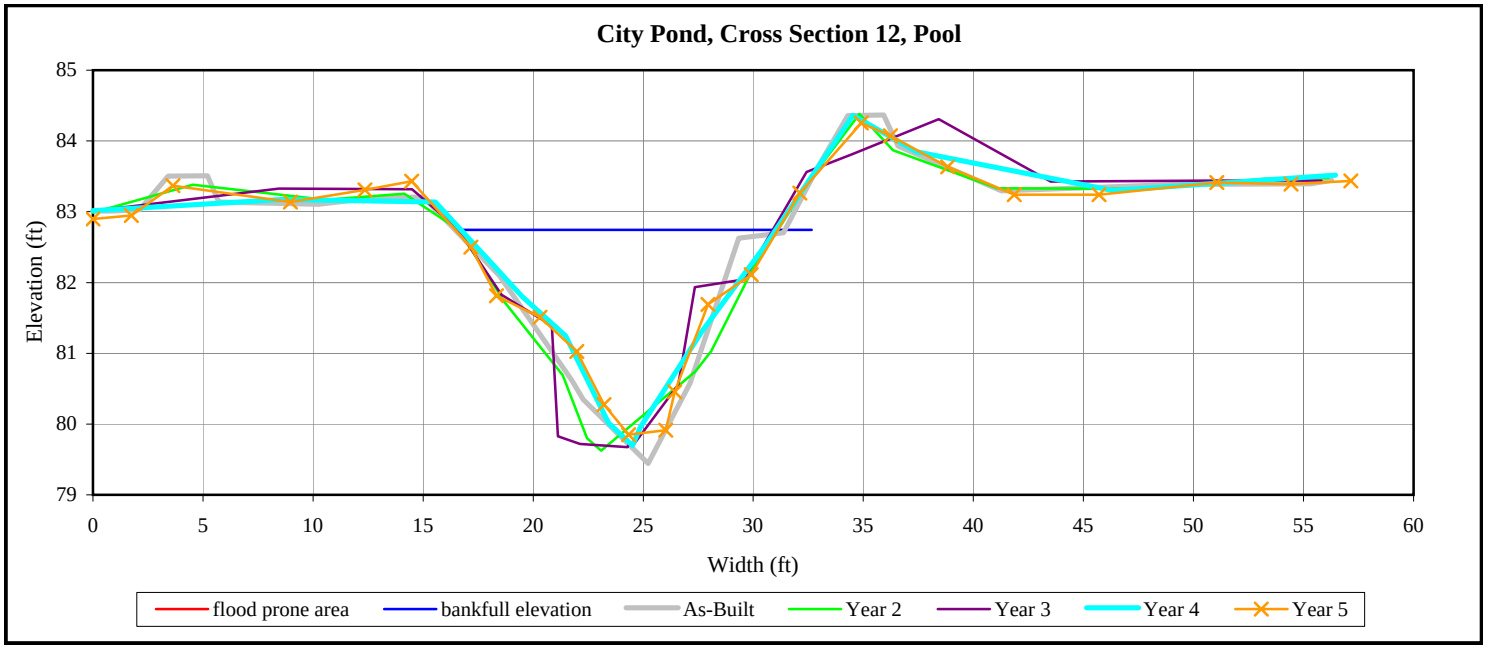
Looking at Left bank

Looking at Right bank

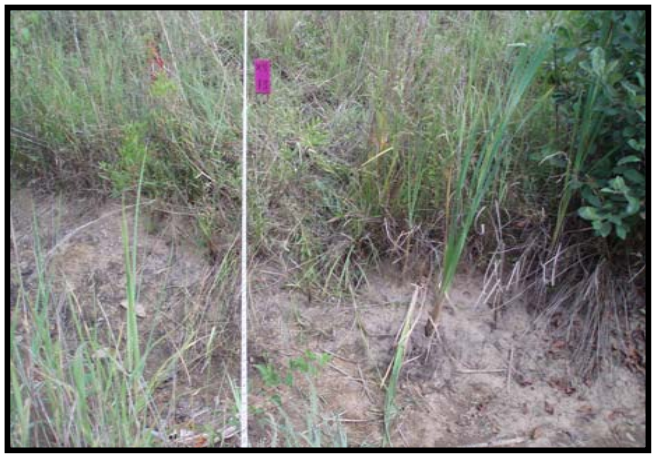


Looking at Left bank

Looking at Right bank



Looking at Left bank



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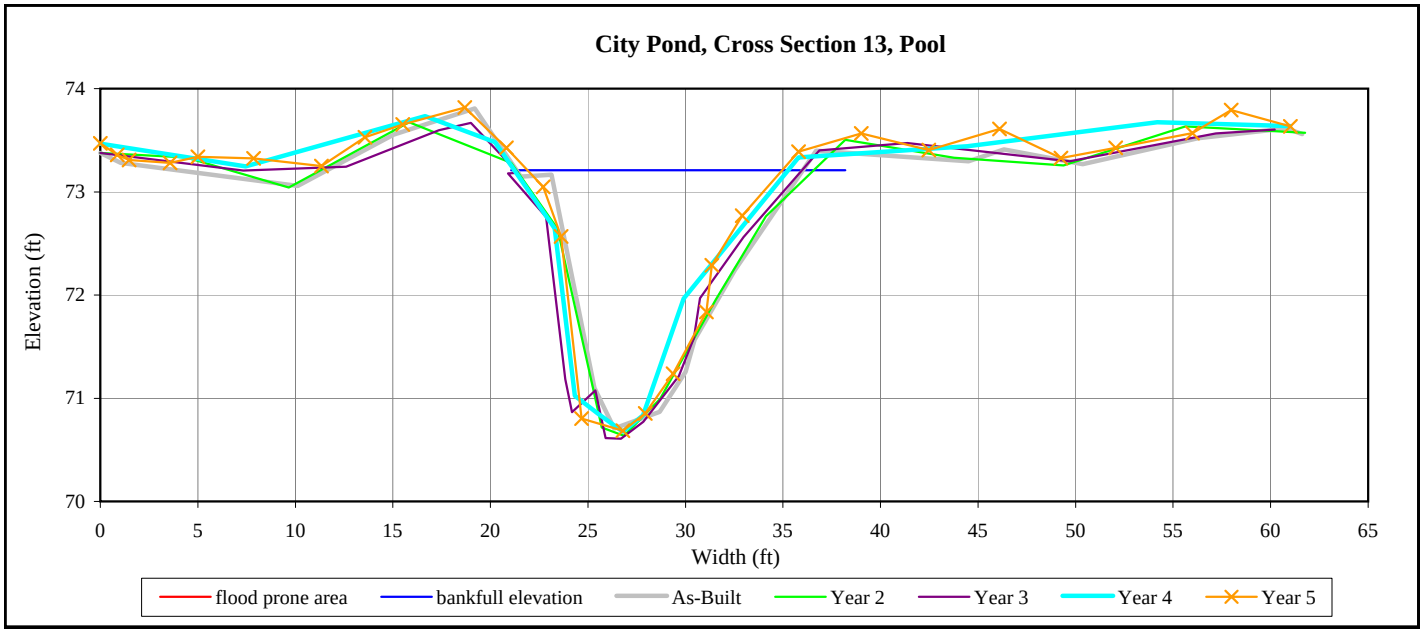
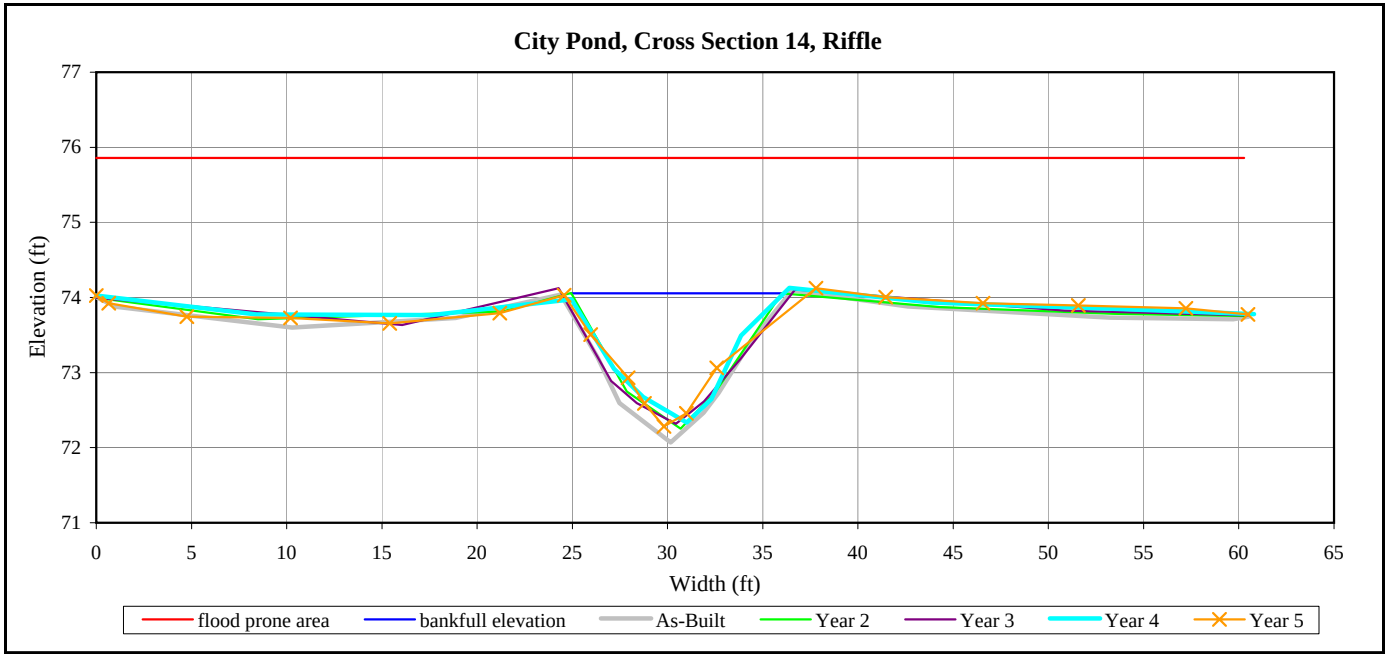


Looking at Left bank

Looking at Right bank



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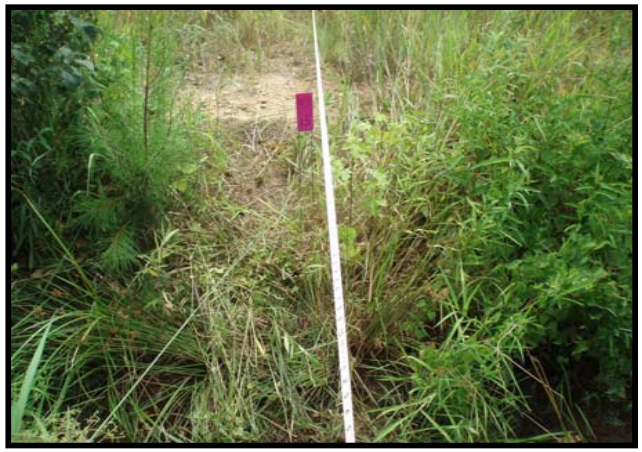
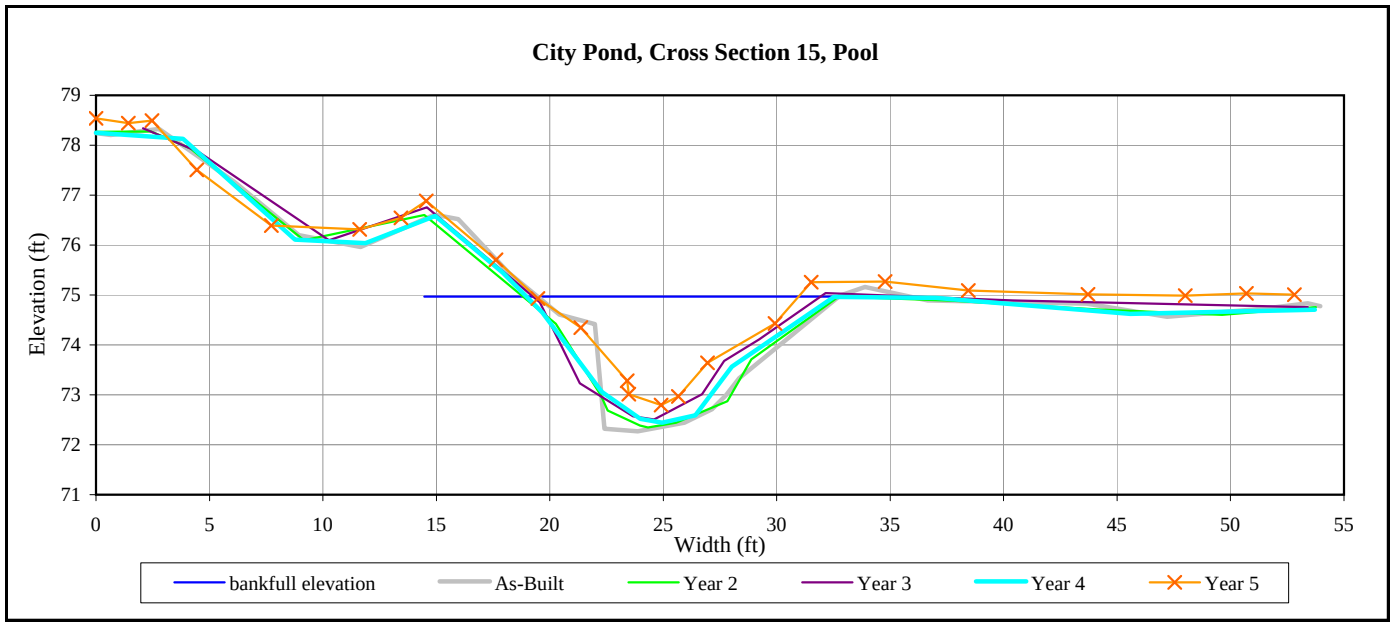
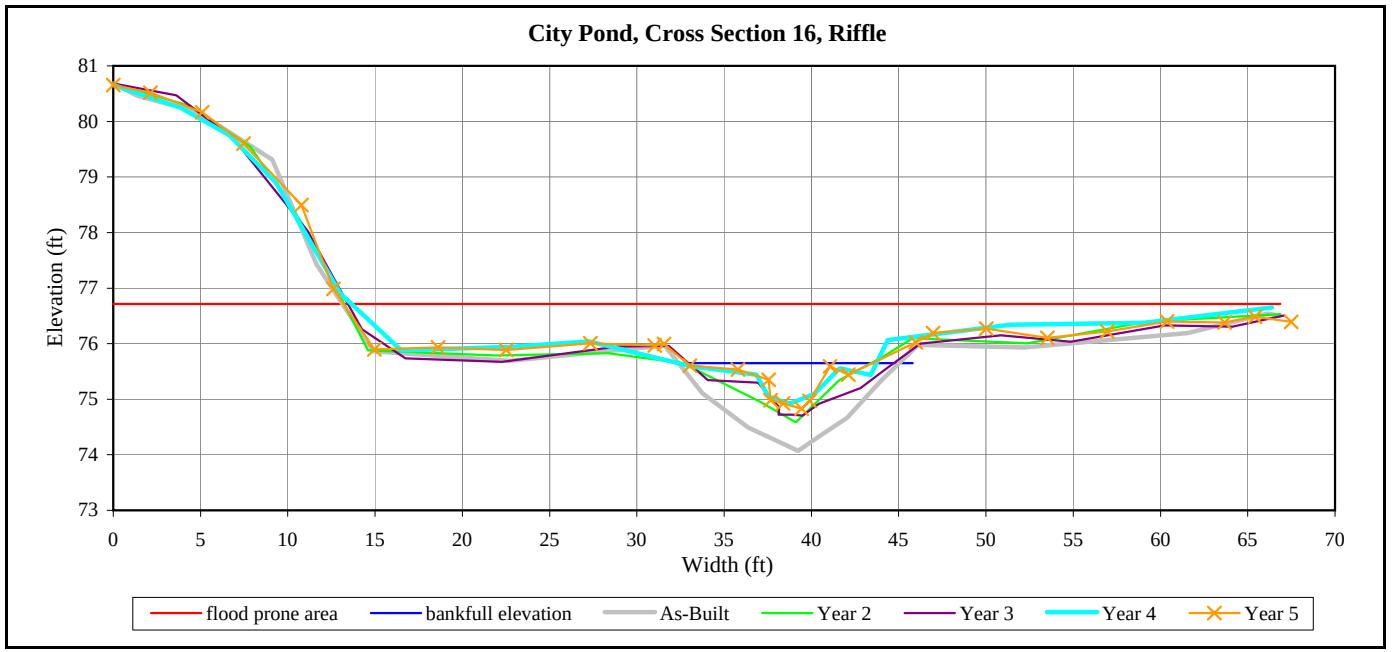


Looking at Right bank



Looking at Left bank

Looking at Right bank



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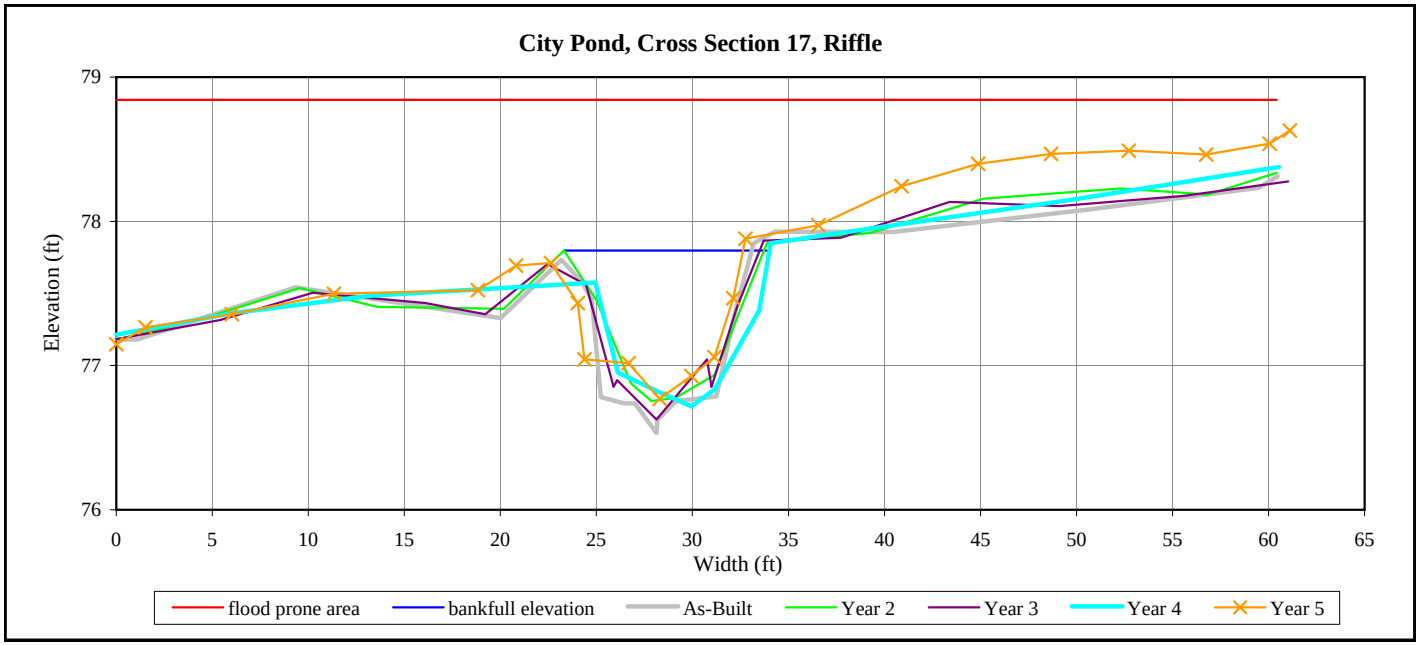

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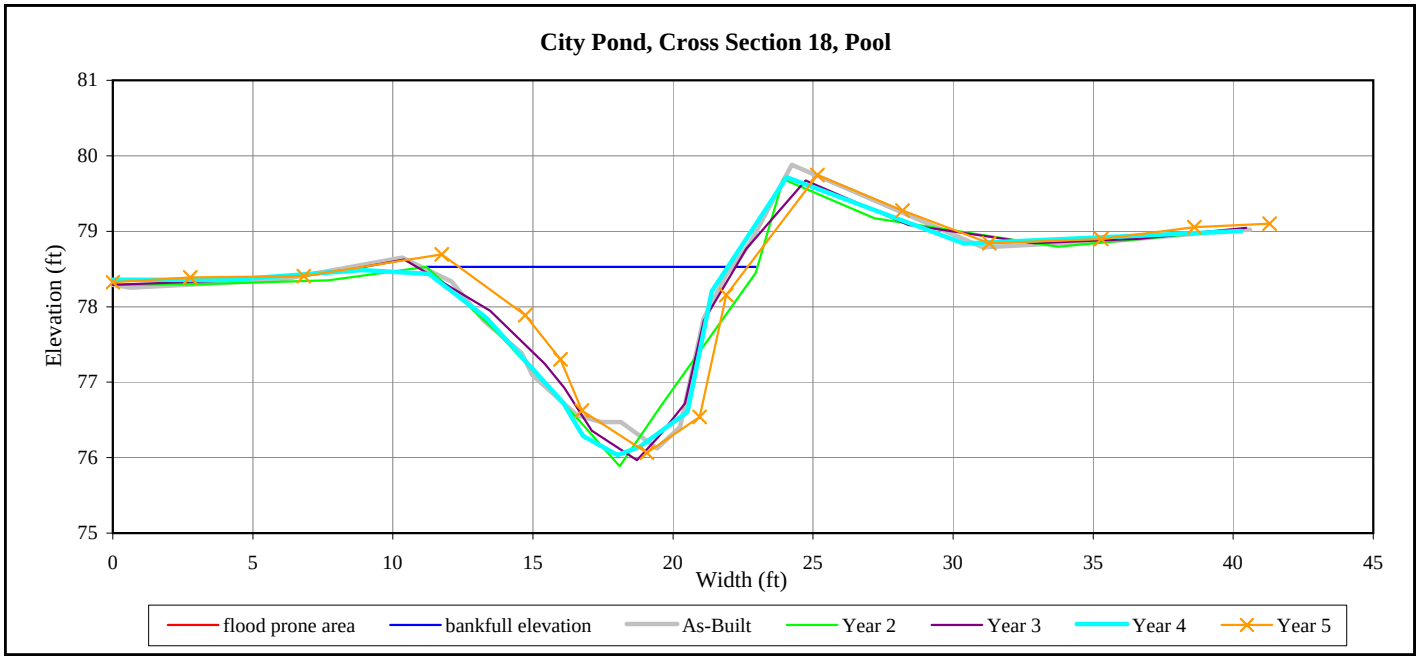

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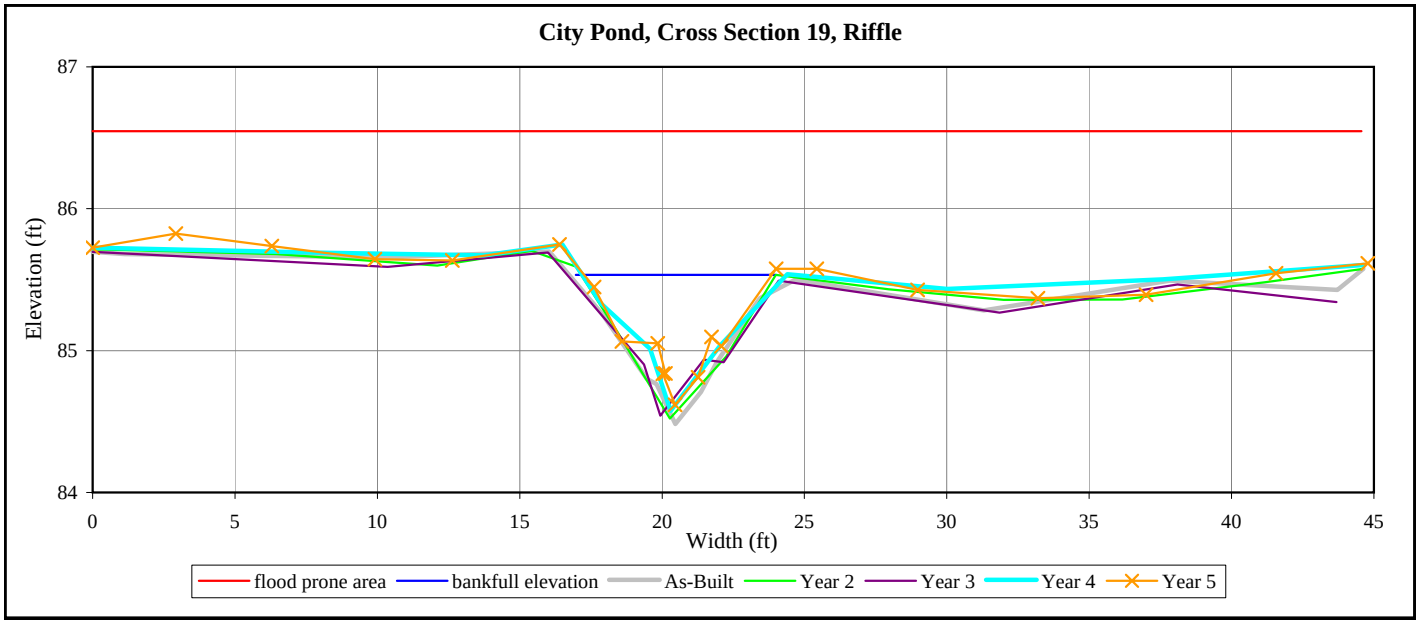

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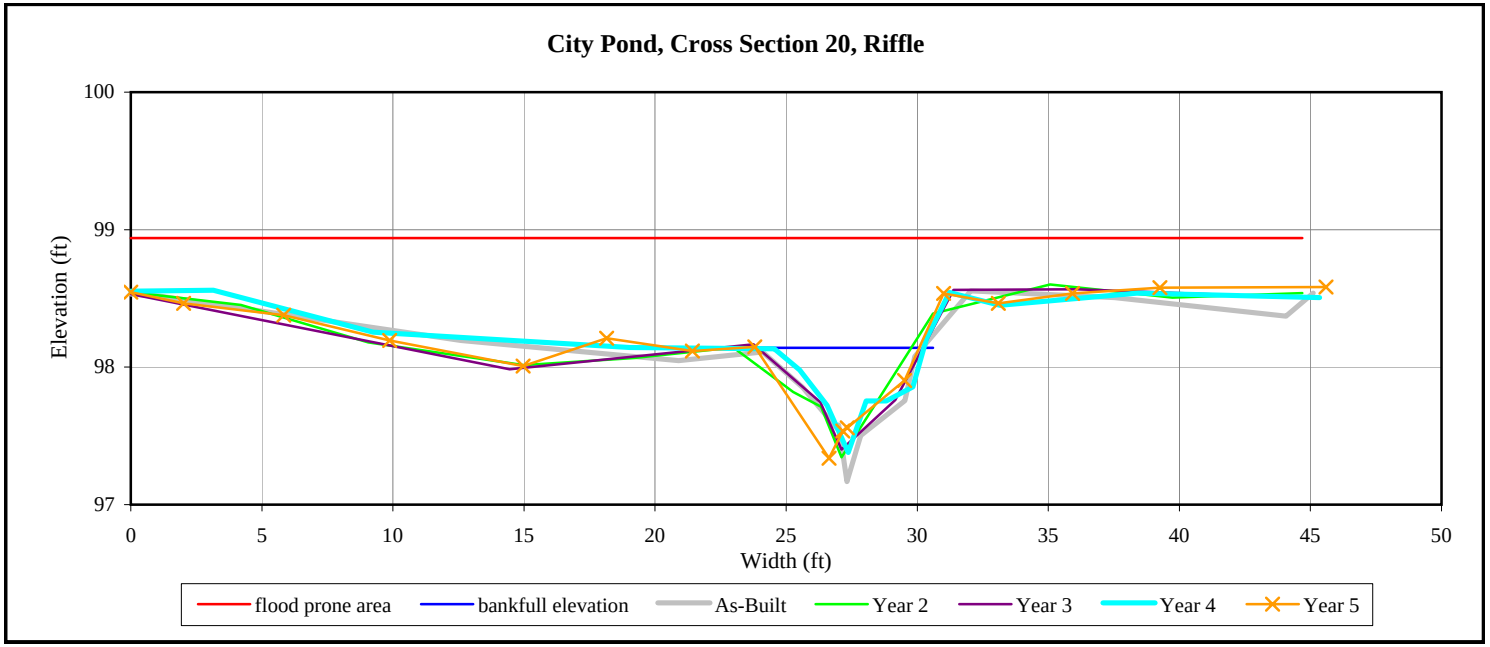


APPENDIX C

2009 Site Photos

SPA1 - Small head cut in channel @ station 11+50 (R1)

SPA2 - Left bank erosion and lack of vegetation from station 13+80 to 14+10 (R1)

SPA3 - Left bank erosion and loss of vegetation @ station 16+30 (R1)

SPA4 - Sand aggradation in channel @ station 16+75 (R1)

SPA5 - Beaver dam across channel @ station 33+00 (R2)

SPA6 - Beaver dam across channel @ station 34+50 (R2)

SPA7 - Beaver dam across channel @ station 38+20 (R2)

SPA8 - Right bank ATV trail crossing channel @ station 43+15 (R2)

SPA8 - Left bank ATV trail crossing channel @ station 43+15 (R2)

SPA9 - Erosion behind log weir structure @ station 12+00 (S1)

SPA10 - Erosion behind rock vane structure @ station 15+85 (S1)

Constructed Riffle (typical)

Pool (typical)

Riffle (typical)

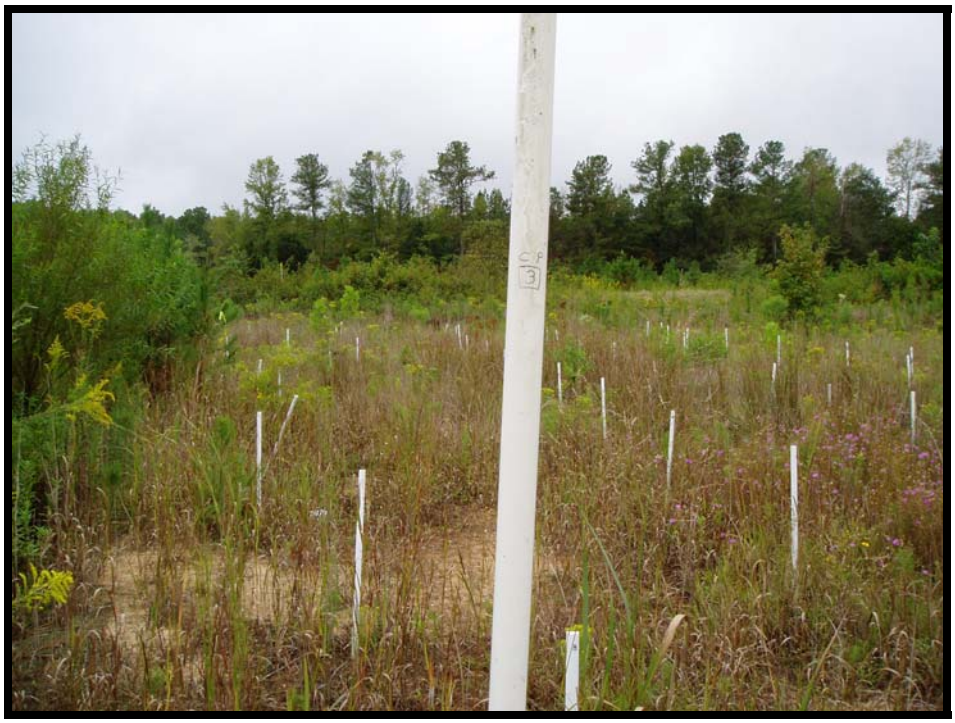
Log grade control (typical)

Root wad (typical)

Log vane (typical)

City Pond Vegetation Plot 1

City Pond Vegetation Plot 2



City Pond Vegetation Plot 3

City Pond Vegetation Plot 4

City Pond Vegetation Plot 5

Appendix D

Morphological Parameters

	Reach R1						Reach R2						Reach R3					
Dimension	Base	MY1	MY2	MY3	MY4	MY5	Base	MY1	MY2	MY3	MY4	MY5	Base	MY1	MY2	MY3	MY4	MY5
BF Cross Sectional Area (ft^2)	15.0	16.6	14.1	15.7	15.4	14.3	20.6	10.4	8.3	9.9	9.7	10.0	40.6	40.3*	11.4	7.8	9.9	10.9
BF Width (ft)	9.2	10.2	9.0	9.6	9.5	9.8	15.0	11.2	10.3	12.2	11.6	12.0	19.5	18.9	11.6	9.9	9.0	9.9
Width/Depth Ratio	5.6	6.2	5.7	5.9	5.8	6.7	11.8	12.2	13.0	15.1	13.9	14.7	9.3	8.9	11.9	12.6	8.3	9.0
BF Mean Depth (ft)	1.6	1.6	1.6	1.6	1.6	1.5	1.3	0.9	0.8	0.8	0.8	0.8	2.1	2.1	1.0	0.8	1.1	1.1
BF Max Depth (ft)	2.5	2.7	2.5	2.7	2.9	2.9	2.7	1.6	1.4	1.5	1.5	1.6	3.3	3.4	1.8	1.8	1.9	2.0
	Reach S1						Reach S2						Reach S3					
Dimension	Base	MY1	MY2	MY3	MY4	MY5	Base	MY1	MY2	MY3	MY4	MY5	Base	MY1	MY2	MY3	MY4	MY5
BF Cross Sectional Area (ft^2)	3.9	3.0	3.7	3.8	3.8	2.5	2.9	3.1	3.0	2.9	2.5	3.2	15.9	15.4	15.2	15.4	14.2	15.4
BF Width (ft)	6.8	6.0	9.5	8.2	7.6	7.0	6.9	6.7	6.8	6.9	6.5	6.9	12.0	11.7	11.8	12.0	10.1	11.3
Width/Depth Ratio	11.7	11.9	24.3	17.7	15.0	19.8	16.4	14.7	16.4	16.8	16.9	15.1	9.1	8.9	9.1	13.5	7.2	8.2
BF Mean Depth (ft)	0.6	0.5	0.4	0.5	0.5	0.4	0.5	0.5	0.4	0.5	0.4	0.5	1.3	1.3	1.3	1.3	1.4	1.4
BF Max Depth (ft)	1.3	1.1	0.9	1.0	1.0	0.8	1.0	1.0	0.9	0.9	0.9	1.0	2.5	2.7	2.6	2.7	2.4	2.6
	Reach S4						Reach S5						Reach S6					
Dimension	Base	MY1	MY2	MY3	MY4	MY5	Base	MY1	MY2	MY3	MY4	MY5	Base	MY1	MY2	MY3	MY4	MY5
BF Cross Sectional Area (ft^2)	14.5	11.5	8.4	11.4	9.9	9.1	15.0	14.8	13.0	16.8	14.7	16.3	7.3	6.2	6.8	6.3	5.3	6.0
BF Width (ft)	13.2	12.1	10.9	13.3	14.0	13.5	11.9	11.6	12.1	13.8	12.3	13.1	9.8	8.7	10.4	10.8	8.8	9.9
Width/Depth Ratio	12.1	13.0	16.3	16.9	20.9	21.3	9.4	9.2	11.2	12.1	10.4	10.6	13.1	12.1	16.0	18.4	14.6	16.2
BF Mean Depth (ft)	1.1	1.0	0.8	0.9	0.8	0.7	1.3	1.3	1.1	1.2	1.2	1.3	0.8	0.7	0.7	0.6	0.6	0.6
BF Max Depth (ft)	2.0	1.6	1.4	1.6	1.4	1.5	1.8	1.9	1.8	2.3	2.1	2.4	1.2	1.1	1.0	1.1	0.9	0.9

* Due to maintenance on the downstream end of Reach R3, dimension data changed from Year 1 to Year 2