Sandy Creek Stream Enhancement & Wetland Restoration/Creation Durham County North Carolina

1st Year Monitoring Report

December 1, 2004

For:
Ecosystem Enhancement Program
Parker Lincoln Building
2728 Capital Boulevard, Suite 1H-103
Raleigh, North Carolina

2004 Sandy Creek Monitoring Abstract

Sandy Creek was restored through the North Carolina Ecosystem Enhancement Program (EEP). The goals and objectives of this project are as follows:

1. Enhance 2700 linear feet of Sandy Creek through the installation of log vanes to improve profile bed form.
2. Restoration of 3.6 Acres of wetlands by excavation of fill soils and replanting of wetland vegetation.

This is the 1st year of the 5-year monitoring plan for Sandy Creek Stream Enhancement and Wetland Restoration/Creation

Table 1A. Background Information

Project Name	Sandy Creek Stream Enhancement & Wetland Restoration/Creation
Designer's Name	Becky L. Ward Consulting 1512 Eglantyne Court Raleigh, North Carolina 27613
Contractor's Name	Shamrock Environmental, Inc.
Project County	Durham County
Directions to Project Site	From Raleigh follow 1-40 west to 15-501 north, pass under 15-501 Bypass, turn left onto Tower Blvd., turn left onto Pickett Rd, take first right after cross over 15-501 Bypass on Sandy Creek Rd. Follow to end of road and into City of Durham Park. The middle of th stream enhancements and the entrance of the wetlands to the west, are located at the bridge crossing of Sandy Creek in the park.
Drainage Area	6.4 Sq. Mi. (to culverts at 15-501)
USGS Hydro Unit	03030002
NCDWQ Subbasin	03-06-05
Project Area & Length	2700 linear feet (Stream enhancement) 3.6 Ac (Wetland Restoration)
Restoration Approach	2700 linear feet of stream profile enhancement 3.6 Ac of wetland restoration
Date of Completion	Construction June 2003 Replanting of partial vegetation Jan 2004
Monitoring Dates	September 2003 December 2004

Results and Discussion

Overall the Sandy Creek stream enhancement is doing excellent. The entire thirteen (13) log vanes are in excellent condition and are functioning properly stabilizing the banks and creating bed form features. There is no evidence of any problems with the log vane structures along the entire length. The stream cross-section dimensions have remained stable as measured at the permanent cross section.

Based on 2004 monitoring of vegetation and hydrology at the Sandy Creek Restoration Site, a majority of the site has been successfully restored to meet wetland success criteria. And is functioning as designed. This is evidenced by the survival of planted trees and herbaceous vegetation, establishment of additional native plant species, saturated soils within the top 12 inches for long periods during the growing season, and ponding/drainage patterns associated with fluctuating water levels and microtopographic variation. Problems associated with the site are 1) permanent ponding of Zone 1, resulting in poor plant survivorship and failure to meet the minimum stem density requirement (320 stem/acre) in Zone 1, and 2) ground water levels lower than expected in Plot 5 on the “island” region of Zone 3.

The following areas of concern should be monitored closely and considered for alterations as suggested in section 2.4 of this report:

- Permanent Ponding of Zone 1 – this area should be monitored to evaluate the further development of vegetation.
- Hydrology in the island area of Zone 3- should be monitored to evaluate the further development of soil conditions.

Photos

The following are photographs of the areas of concern on the wetland site.

Zone 1 : Permanent Ponding

Zone 3 : Island Hydrology

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Tables and Figures

Plan Drawings of Wetlands and Stream

1.0 BACKGROUND INFORMATION

This project is located in Durham County approximately 1000 feet north of the intersection of Chapel Hill Boulevard (US Business 15-501) and Sandy Creek. The site is in an abandoned treatment plant facility owned by the City of Durham that was recently converted to a city park in 2003, on Sandy Creek Road. The drainage area at the end of the project at the culverts under 15-501 is 6.4 square miles. The project was completed in 2003 and the as-built survey was completed in August 2003.

The project site was selected to mitigate impacts to Section 404 jurisdictional areas associated with the extension of the Martin Luther King, Jr. (MLK) Parkway between Cook Road and Hope Valley Road in Durham County North Carolina. The impacts of the MLK Roadway project on jurisdictional wetlands and non-wetland jurisdictional waters totaled 1.73 acres near Third Fork Creek. The Sandy Creek property provides 3.6 acres of wetland restoration/creation as mitigation for the impacts during construction of the MLK Parkway. The Ecosystem Enhancement Program (EEP) will be using the remaining 1.87 acres for mitigation for other impacts in the Cape Fear River Basin. In addition to the wetlands constructed for this project, Sandy Creek was enhanced with log vanes to create pool features, for habitat and water quality improvement, along 2700 linear feet of stream within the City of Durham property.

The land on the west side of Sandy Creek had been impacted with fill material used to construct sludge drying beds for the treatment plant. The City of Durham Parks and Recreation Department provided the demolition of the existing concrete, piping, control building, and fencing of the existing sludge drying beds on the wetland site prior to the start of wetlands construction. Remaining demolition of the bed sand, gravel, under drains, manholes, and miscellaneous storm drainage remaining at the sludge drying beds was preformed by the EEP wetlands contractor. The City of Durham had completed phase one of the Sandy Creek Trail, a walking/biking trail on the east side of Sandy Creek from the City property to Pickett Road prior to construction of the EEP project. The City also concurrently worked on demolition of the abandoned treatment plant on the east side of Sandy Creek and improvements to convert the area into a city park through out the construction of the EEP project.

1.1 Goals and Objectives

The goal of the project is to restore riparian wetlands and improve in-stream habitats in sandy Creek for the Ecosystem Enhancement Program. The goals and objectives of this project are as follows:

1. Restoration of 3.6 Acres of wetlands adjacent to Sandy Creek
2. Enhancement of 2,700 linear feet of Sandy Creek through profile modifications.

1.2 Project Location

This project is located in Durham North Carolina near the intersection of Bypass 15-501 and Pickett Road off of Sandy Creek Road. From Raleigh follow I-40 west to 15-501 north. Pass under 15-501 bypass and turn left onto Tower Boulevard at the McDonalds. Take Tower Boulevard until it dead ends at Pickett Road and turn left. Sandy Creek Road will be on the left directly after Bypass 15-501 is crossed. Take Sandy Creek Road to the end and enter into the City Park. The entrance to the wetland site is at the end of the asphalt roadway and wooden bridge that crosses Sandy Creek. The stream enhancement portion of the project begins approximately 1,175 feet downstream of the bridge at the culverts under 15-501. The upper end of the stream enhancement ends approximately 1,525 feet upstream of the bridge. The site is accessible through a public City of Durham Park and greenway trail system.

1.3 Project Description

The wetland restoration on the Sandy Creek project was created in an existing waste and spoil area that was overrun with nuisance weeds, construction debris, and abandoned treatment plant equipment and changed it into a functioning wetland ecosystem, providing habitat for wildlife and improving water quality within the Sandy Creek drainage basin. The wetland restoration project also provides opportunities to current park visitors to view a wetland restoration project and learn the benefits of the wetland ecosystem. The wetlands were restored with native vegetation and the removal of the existing treatment plant equipment, facilities, and fill dirt to design elevations that represented similar landforms prior to the construction of the treatment plant. The enhancement of Sandy Creek provided additional bed form features to a currently uniform bed and introduced woody debris with the construction of log vanes into the stream to create habitat and enhance water quality.

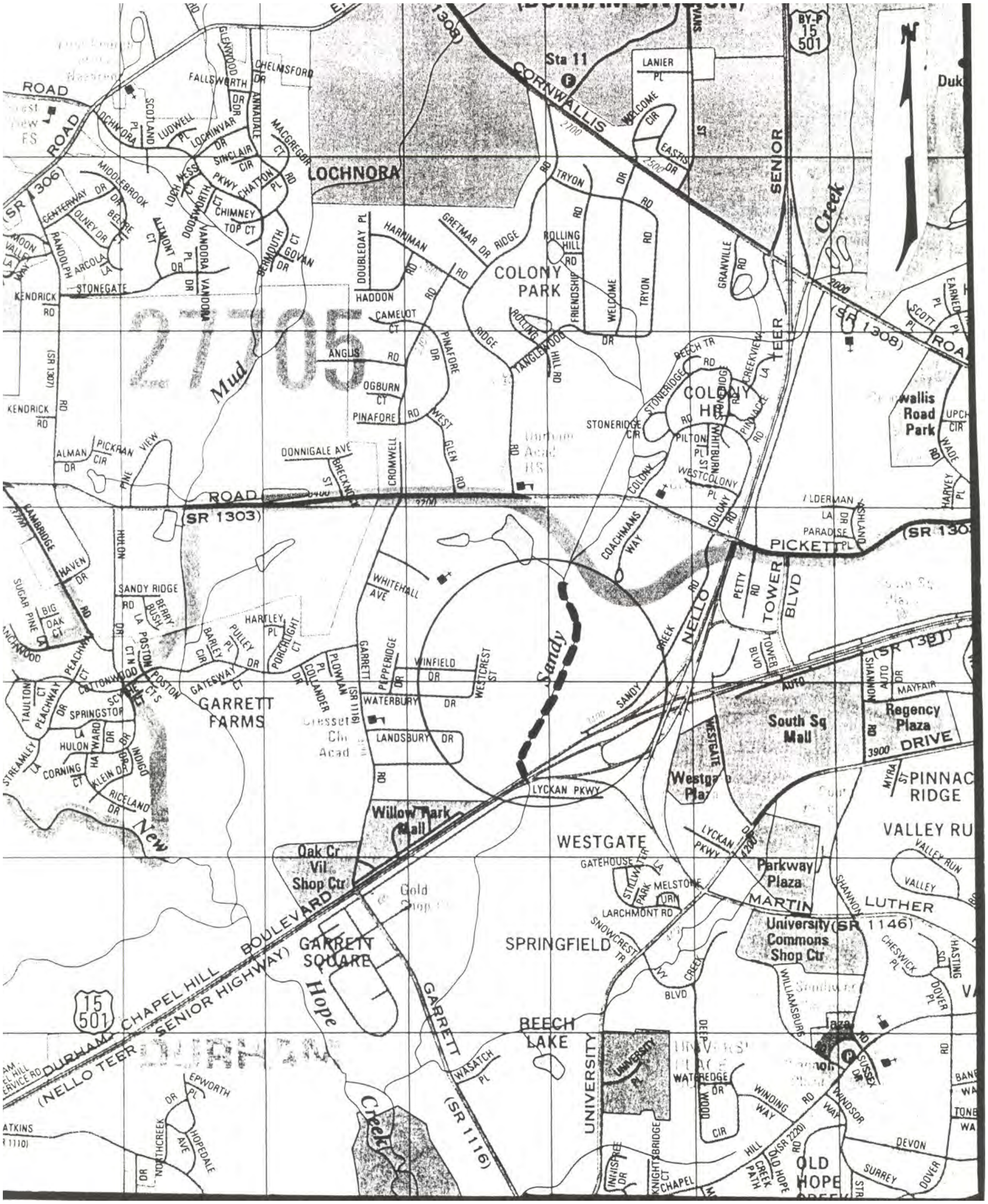
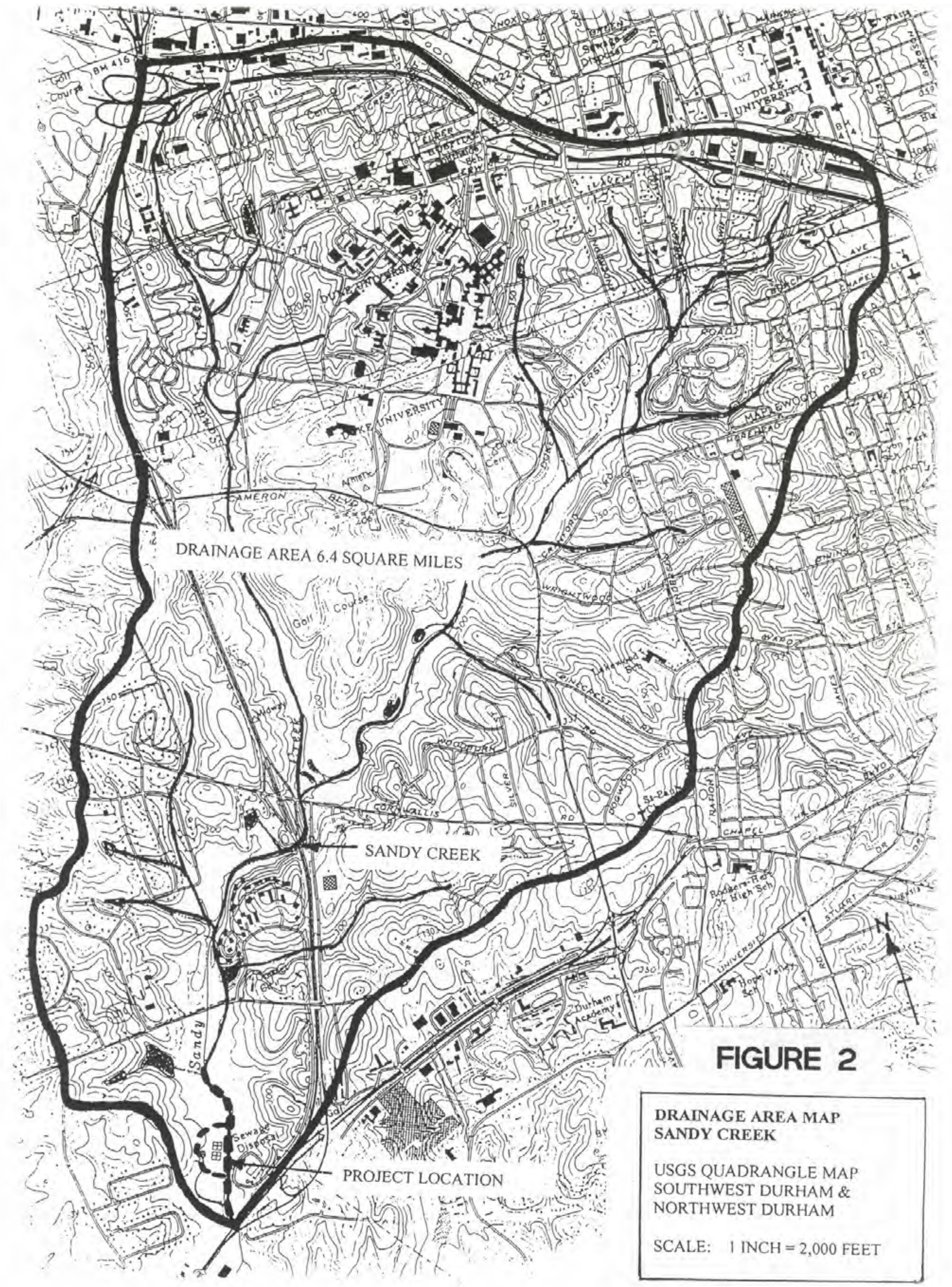


FIGURE 1

Site Location Map

1inch = 2000 feet

Becky L. Ward Consulting


DRAINAGE AREA 6.4 SQUARE MILES
SANDY CREEK
PROJECT LOCATION
FIGURE 2
DRAINAGE AREA MAP
SANDY CREEK
USGS QUADRANGLE MAP
SOUTHWEST DURHAM &
NORTHWEST DURHAM
SCALE: 1 INCH = 2,000 FEET
DUKE UNIVERSITY
CAMERON BLVD
WRIGHTWOOD AVE
CORNWALLIS RD
CHAPEL HILL
Golf Course
Sandy
N

2.0 YEAR 2004 RESULTS AND DISCUSSION

2.1 Wetland Vegetation

The vegetation development should be observed to show progressive growth over the five-year monitoring period. Vegetative success will be determined by the survival of target species within the sample plots. The minimum survival rate is 260 stems/acre at end of the fifth year. Included in the required survival criteria are planted seedlings and natural recruitment of the same species. At least six different representative species should be present on the entire site.

Five vegetation 30' x 30' vegetation plots were placed within the wetland portion of the sites, which includes Planting Zones 1-3. Vegetation Plot 4 is in Planting Zone 1, Vegetation Plots 1 and 3 are in Zone 2, and Vegetation Plot 2 and 5 are in Zone 3.

2.1.1 Results and Discussion

The second vegetation monitoring count was performed May 28, 2004 for Plot 2 (following replanting portions of Zone 3) and September 29, 2004. Results of sampled vegetation stem counts within the five plots are shown in Table 1, and estimated density of tree stems (target species) and percent cover of the herb and shrub stratum is shown in Table 2. Locations of vegetation plots are shown on plan sheet 1 of 5 and photographs of the respective plots are in the Photo Log. Repeated field observations of the site have, over the last year, suggests that survivorship of planted tree species is less than expected. Within the combined sample plots, 12 tree and 2 shrub species were recorded, and measured stem density is well over the minimum requirement of 320 stems per acre for two out of the three zones (Zones 2 and 3); however, volunteer species green ash (*Fraxinus pennsylvanica*) and black willow (*Salix nigra*) make up the bulk of measured density. Although average density for Zone 3 (2259 stems/acre) meets the minimum success criteria, planted tree survivorship was poor in Plot 5 on the "island" region. Zone 1 (Plot 4) does not meet vegetation success criteria, having stem densities of 97 stems/acre.

Development of planted and volunteer herbaceous species is excellent, with percent cover averaging 81.3%. In plots 1,2, and 3, the herbaceous component is comprised of planted grasses, perennial dicotoledons, sedges (*Carex*, *Scirpus*, and *Cyperinus*), rushes (*Juncus*), spikerushes (*Eleochraris*), and cattails (*Typha latifolia*). It is evident that the facultative herbaceous component is doing well in wetter regions of the site, but in some dryer regions (such as on the island, Plot 5) invasive species, namely lespedeza (*Lespedeza cuneata*) and frost aster (*Aster pilosus*), have developed dense cover to the detriment of more desirable species.

Reasons for poor survivorship of planted tree species are contributed to three factors: First, surface soils are waste soils and are nutrient poor. Due to cost constraints, there was no effort made to overlay a more suitable topsoil layer prior to planting. Secondly, whitetail dear and other wildlife browsed many of the planted trees before they could become well-established. Lastly, permanent inundation within the low area of Zone 1 resulted in poor survivorship of planted species and no recruitment of volunteers in Plot 4.

2.2 Wetland Hydrology

One data logger was installed on the wetland "island" at an elevation of 263 feet (ground water gauge B), one on the levee at an elevation of 261 feet (ground water gauge A), and the final two were both placed at an elevation of 262 feet, one in the reference wetland (ground water gauge D) and one to right of the entrance road traveling towards the "island" in the restoration site (ground water gauge C). For the intermittently exposed and semi-permanently flooded regions (262 feet and less), the criteria to meet soil conditions is having ponded, flooded, or saturated soils within 12 inches of the surface for 12.5% of the growing season during years of normal precipitation. For the temporarily folded region (262.1 to 263.5 feet), hydrologic restoration will be considered successful if the soil is ponded, flooded, or saturated within 12-inches of the surface for at least 5% for the growing season during years with normal precipitation.

2.2.1 Results and Discussion

The second monitoring of groundwater gauges commenced from early October, 2003 to October 31, 2004. The growing season is considered to be 213 days (April 5 – November 3). Gauge locations are depicted in Plan Sheet 1 of 5 and gauge monitoring results along with rainfall amounts for this time period are shown in Figures 3 through 6. Analysis of the three groundwater gauges (A, C, and D), in the intermittently exposed and semi-permanently flooded regions shows that in 2004, groundwater levels were less than 12 inches below the soil surface for more than 12.5% of the growing season (27 consecutive days). Gauge B is at the top of the temporarily flooded region and Gauge C at the bottom. Gauge C was saturated for 15% of the growing season while Gauge B was saturated for 4.2% of the growing season, which falls just short of the minimum 5%. However, it can be assumed that the temporarily flooded region between these two gauges is meeting the hydrologic criteria of 5-12%. Comparison of rainfall data with groundwater level trends indicates that groundwater levels do fluctuate in correspondence with rainfall events, and that reference gauge D indicates water levels within 12 inches of the soil surface for 71 consecutive days (33%) of the growing season. Saturated soil levels (within 12 inches of the soil surface) for the three monitoring gauges during the growing season are as follows: Gauge A: 138 consecutive days (64.8%); Gauge B: 9 consecutive days (4.2%); Gauge C: 32 consecutive days (15%).

Results from gauge monitoring data suggest that restored wetland regions do meet the hydrologic success criteria. This is further evidenced by the continual presence of saturated soils, ponding, drainage patterns, water stained leaves, sediment deposits, and prevalence of hydrophytic vegetation. Groundwater levels are slightly lower than expected in the "island" region of Zone 3 (saturated for 4.2% of the growing season), but this area was intended to be an upper landscape region exhibiting saturation between 5 and 12.5% of the growing season, and wetland plants are supported.

Zone 1 which surrounds the "island" was designed to remain semi-permanently flooded, which is defined as surface water persisting throughout the growing season in most years and when surface water is absent, the water table is usually at or very near the land surface. However, during the past year, the site hydrology in the low areas surrounding the "island", or Zone 1, did not fluctuate as anticipated, but maintained a maximum depth of approximately 1.6 feet. This is more reflective of a permanently flooded wetland as opposed to the targeted semi-permanently flooded wetland. This has in turn caused poor planted tree survivorship in Plot 4. This failure is in part due to elevations that were established too low and in part the lack of water table fluctuation.

2.3 Stream Enhancements

The log vanes in Sandy Creek were observed to evaluate any breaching of the structures. The water should flow over the log vane or the rocks placed at the end of the vane. The structures should not show any erosion along the arms or evidence of water bypassing the structure. The stream banks should show evidence of vegetation stabilization. The banks disturbed by the installation of the log vane should not show any signs of erosion. The stream will be monitored yearly at a permanent cross section along with a pebble count to evaluate the stream stability.

2.3.1 Results and Discussion

All thirteen structures were inspected for stabilization and function. The banks adjacent to the structures are stable and showed no evidence of erosion. The vegetation is establishing slowly in these areas. The log structures have soil deposits near the bank and pools forming in the streambed. Because this is a sand bed stream the pools vary with each storm event. The logs and rocks in each feature are stable and show no evidence of any breaching. The log vanes are performing their function of bank stabilization and the creation of additional bed form features in Sandy Creek. The permanent cross section and pebble counts show no significant changes.

2.4 Areas of Concern & Site Recommendations

The major concern is the permanently flooded conditions of Zone 1. However, wetland sites, specifically creation sites, must be given time for vegetation to become established and soils to begin to develop. These two functions compliment each other and are self-promoting. This is likely the reason that even though the reference gauge D and site gauge C are installed at the same elevation, the reference gauge experienced saturated conditions within 12 inches of the soil surface for more that twice the number of days experienced at gauge C. Therefore, as the site surrounding Zone 1 develops, more fluctuation of the water table is anticipated. In addition, natural deposition from organic matter and sediment from overbank flooding events will slowly fill the lower areas of Zone 1.

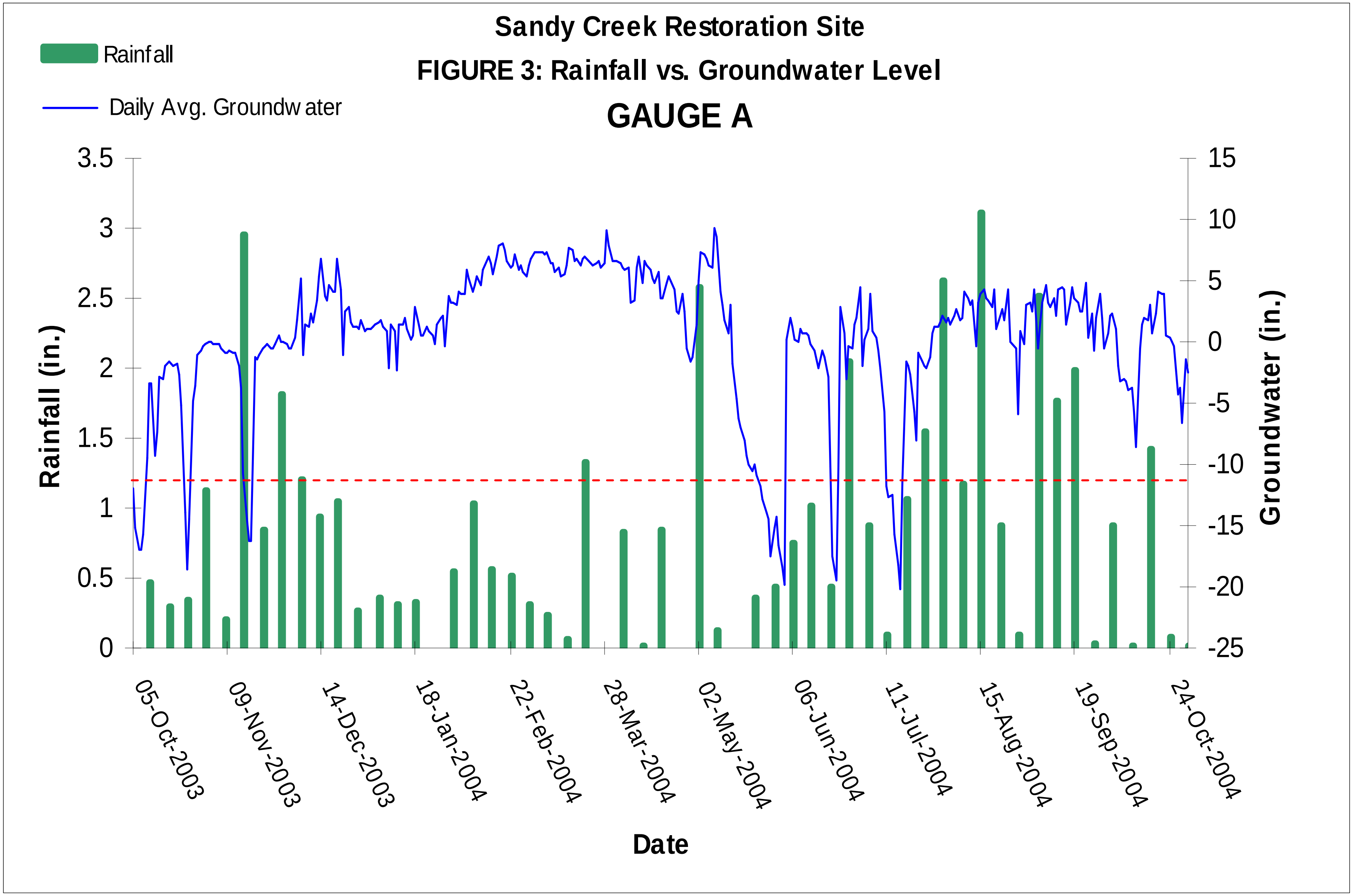
The speed at which a creation site develops is impossible to predict. Eventually, Zone 1 will experience the seasonal fluctuations consistent with a semi-permanently flooded wetland. However, realizing that monitoring of the site is costly, it would e possible to partially fill the lower areas of Zone 1 to an elevation of 261.5. In the short term, this would increase the chance of survivorship in the planted vegetation. It has been estimated that approximately 1,300 cubic yards of soil would be required to raise the elevation. The soils could be obtained on site by excavating the eastern bank within the buffer and moving these soils into the adjacent Zone 1 as shown on Plan Sheet 1 of 5. This additional excavation would result in increasing the restored wetland acreage by 0.5 to 0.8 acres. However, it is recommended that a second year of monitoring be conducted and analyzed before attempting any site reconfigurations.

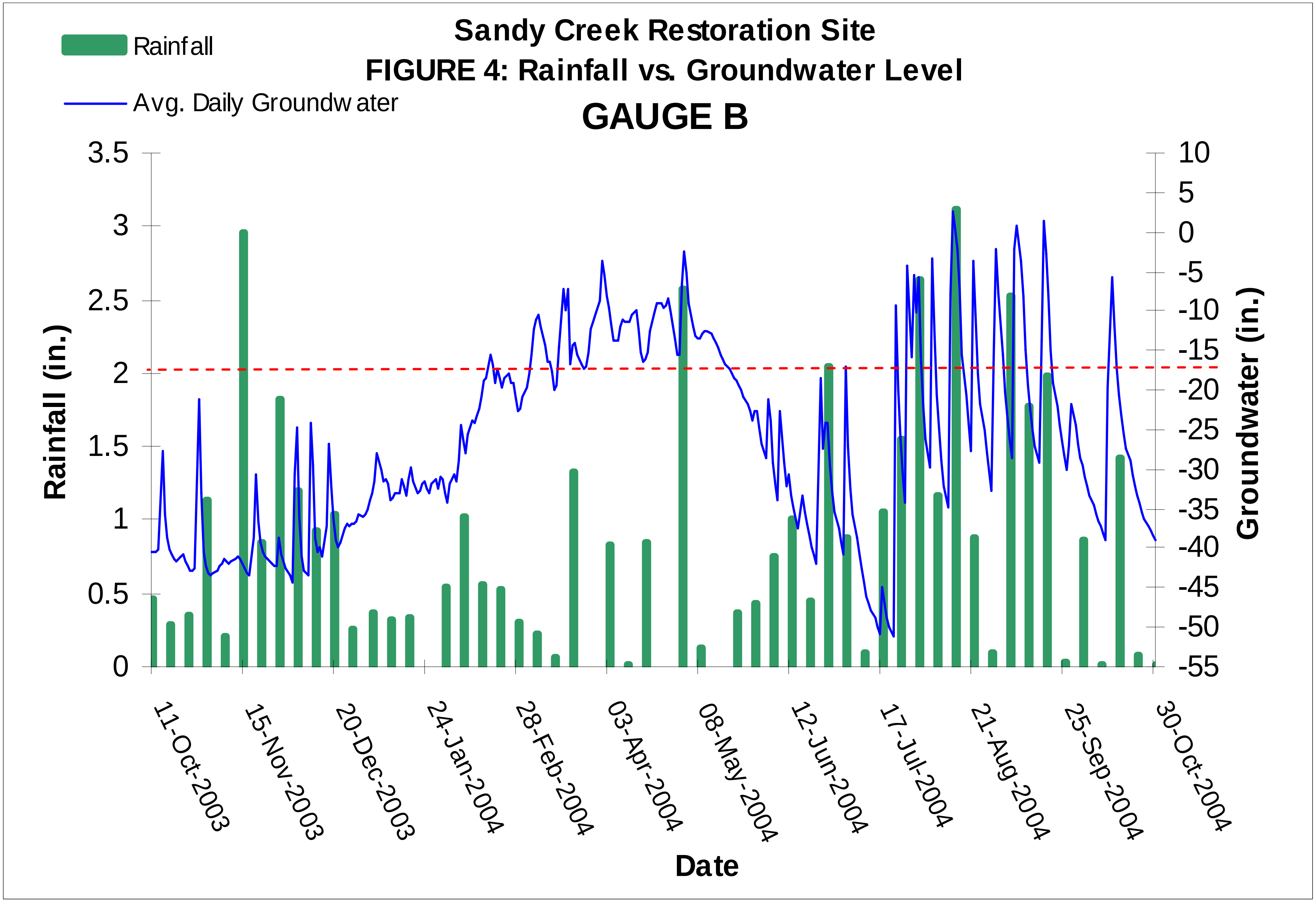
Prior to construction of the site, there was little diversity in the vegetation. This was undoubtedly due to the majority of the site being waste soil with some remaining rock debris resulting in extremely poor soil conditions. Even after construction, the majority of the site was still this composite. This is the main reason for the high mortality rate in the planted stock. However, certain volunteer species that are tolerant of the poor soil conditions have successfully rooted and, combined with the planted species that have survived, resulted in the majority of the site meeting the vegetation success criteria. As the site develops, better soil conditions will evolve which will eventually support a greater variety of species. However until that time, efforts to diversify the vegetation will likely produce similar results.

As for the vegetation of Zone 1, additional plantings at this time would not be practical. For the same reasons noted for the hydrological alterations, the site must be allowed to further develop before considering additional plantings. In summary, no vegetation alterations are recommended at this time unless the option to raise the elevation of Zone 1 is pursued and replanting in construction areas are necessary.

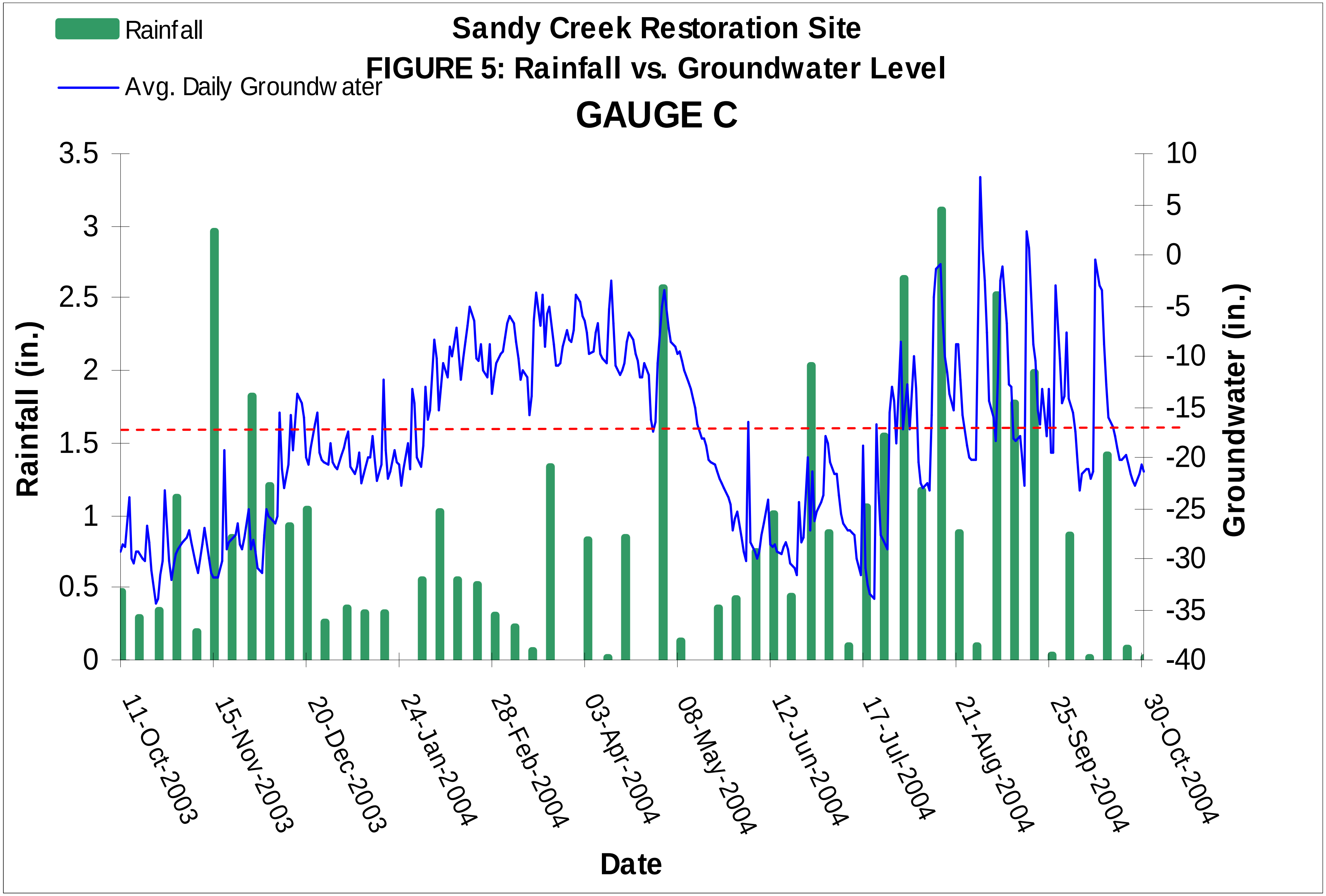
The following computer data files are attached with this report.

Pebble count.xls
Permanent Sections.xls
Data groundwater & rainfall.xls
Ab-creek1.dwg


Sandy Creek Restoration Site
FIGURE 3: Rainfall vs. Groundwater Level
GAUGE A
Rainfall
Daily Avg. Groundwater
Rainfall (in.)
Groundwater (in.)
Date
3.5
3
2.5
2
1.5
1
0.5
0
15
10
5
0
-5
-10
-15
-20
-25
05-Oct-2003
09-Nov-2003
14-Dec-2003
18-Jan-2004
22-Feb-2004
28-Mar-2004
02-May-2004
06-Jun-2004
11-Jul-2004
15-Aug-2004
19-Sep-2004
24-Oct-2004



Sandy Creek Restoration Site
FIGURE 4: Rainfall vs. Groundwater Level
GAUGE B
Rainfall
Avg. Daily Groundwater
Rainfall (in.)
Groundwater (in.)
Date
3.5
3
2.5
2
1.5
1
0.5
0
10
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
-55
11-Oct-2003
15-Nov-2003
20-Dec-2003
24-Jan-2004
28-Feb-2004
03-Apr-2004
08-May-2004
12-Jun-2004
17-Jul-2004
21-Aug-2004
25-Sep-2004
30-Oct-2004



Rainfall
Avg. Daily Groundwater
Sandy Creek Restoration Site
FIGURE 5: Rainfall vs. Groundwater Level
GAUGE C
Rainfall (in.)
Groundwater (in.)
3.5
3
2.5
2
1.5
1
0.5
0
10
5
0
-5
-10
-15
-20
-25
-30
-35
-40
11-Oct-2003
15-Nov-2003
20-Dec-2003
24-Jan-2004
28-Feb-2004
03-Apr-2004
08-May-2004
12-Jun-2004
17-Jul-2004
21-Aug-2004
25-Sep-2004
30-Oct-2004
Date

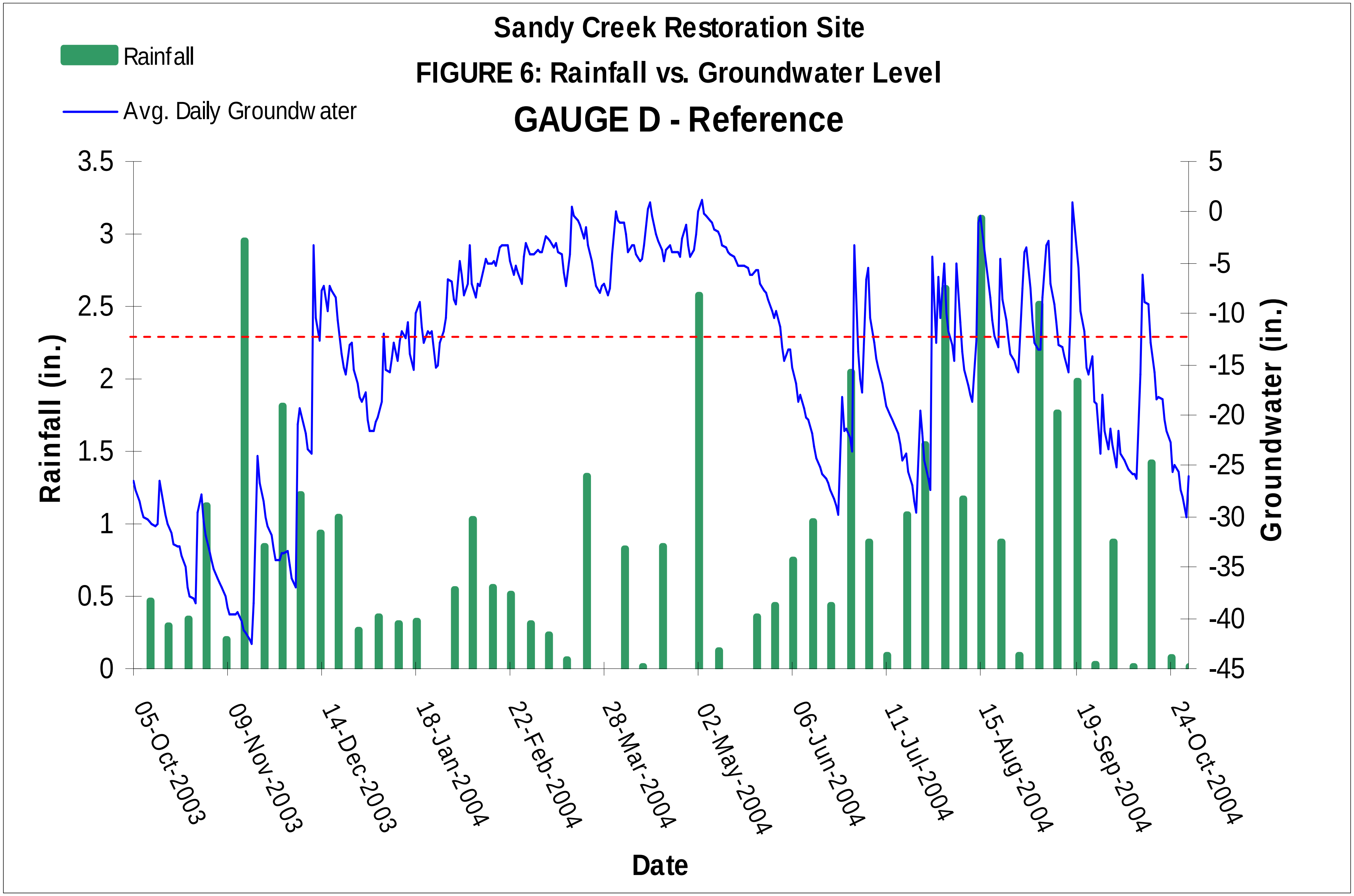

Sandy Creek Restoration Site
FIGURE 6: Rainfall vs. Groundwater Level
GAUGE D - Reference
Rainfall
Avg. Daily Groundwater
Rainfall (in.)
Groundwater (in.)
Date
3.5
3
2.5
2
1.5
1
0.5
0
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
05-Oct-2003
09-Nov-2003
14-Dec-2003
18-Jan-2004
22-Feb-2004
28-Mar-2004
02-May-2004
06-Jun-2004
11-Jul-2004
15-Aug-2004
19-Sep-2004
24-Oct-2004

Table 1 Summary of Vegetation Plot Data

Plot 1: In Zone 2, closer to flooded timber area along southern edge of site

Species	#Stems 06/28/03	# Stems 09/29/04
Quercus phellos	6	2
Fraxinus pennsylvanica	***10***	61
Populus deltoides		2
Salix nigra		55
Viburnum nudum	***2***	
Sambucus canadensis	***7***	

Plot 2: In Zone 3, closer to flooded timber area along southern edge of site

Species	#Stems 06/28/03	# Stems 05/28/04 Contractor Replanted	# Stems 09/29/04
Quercus lyrata		1	1
Liriodendron tulipifera		1	1
Betula nigra		2	3
Fraxinus pennsylvanica			35
Platanus occidentalis			1
Acer rubrum		30	2
Salix nigra		5	6
Viburnum nudum			1
Acer negundo	2		
Nyssa sylvatica	2		

Plot 3: In Zone 2, farthest from Sandy Creek, along western side of site

Species	#Stems 06/28/03	# Stems 09/29/04
Quercus phellos	7	1
Fraxinus pennsylvanica	6	8
Betula nigra		1
Ulmus americana		1
Acer rubrum		7
Sambucus canadensis	3	1
Salix nigra		12
Viburnum nudum	4	

Plot 4: In Zone 1, lower flooded area around island

Species	#Stems 06/28/03	# Stems 09/29/04
Quercus lyrata	5	2
Quercus phellos	1	
Alnus serrulata	1	
Viburnum nudum	2	2
Carya ovata	4	
Cephalanthus occidentalis	2	
Salix nigra	3	
Sambucus canadensis	1	

Plot 5: In Zone 3, on "Island"

Species	#Stems 06/28/03	# Stems 09/29/04
Liquidambar styraciflua		1
Quercus sp.		1
Platanus occidentalis		2
Betula nigra		1
Liriodendron tulipifera	9	1
Acer rubrum		3
Nyssa sylvatica	3	
Salix nigra	1	
Gleditsia triacanthos		1

Table 2 Vegetation Density

VEGETATION	Zone 1		Zone 2		Zone 3	
	Plot 4		Plots 1 & 3		Plots 2 & 5	
	Observed	Planted	Observed	Planted	Observed	Planted
Tree Stratum (trees/acre)	97.2	420	3473	800	2259	1200
Shrub Stratum (%cover)	0	-	0	-	0	-
Herb Stratum (%cover)	0	-	72.5	-	90	-

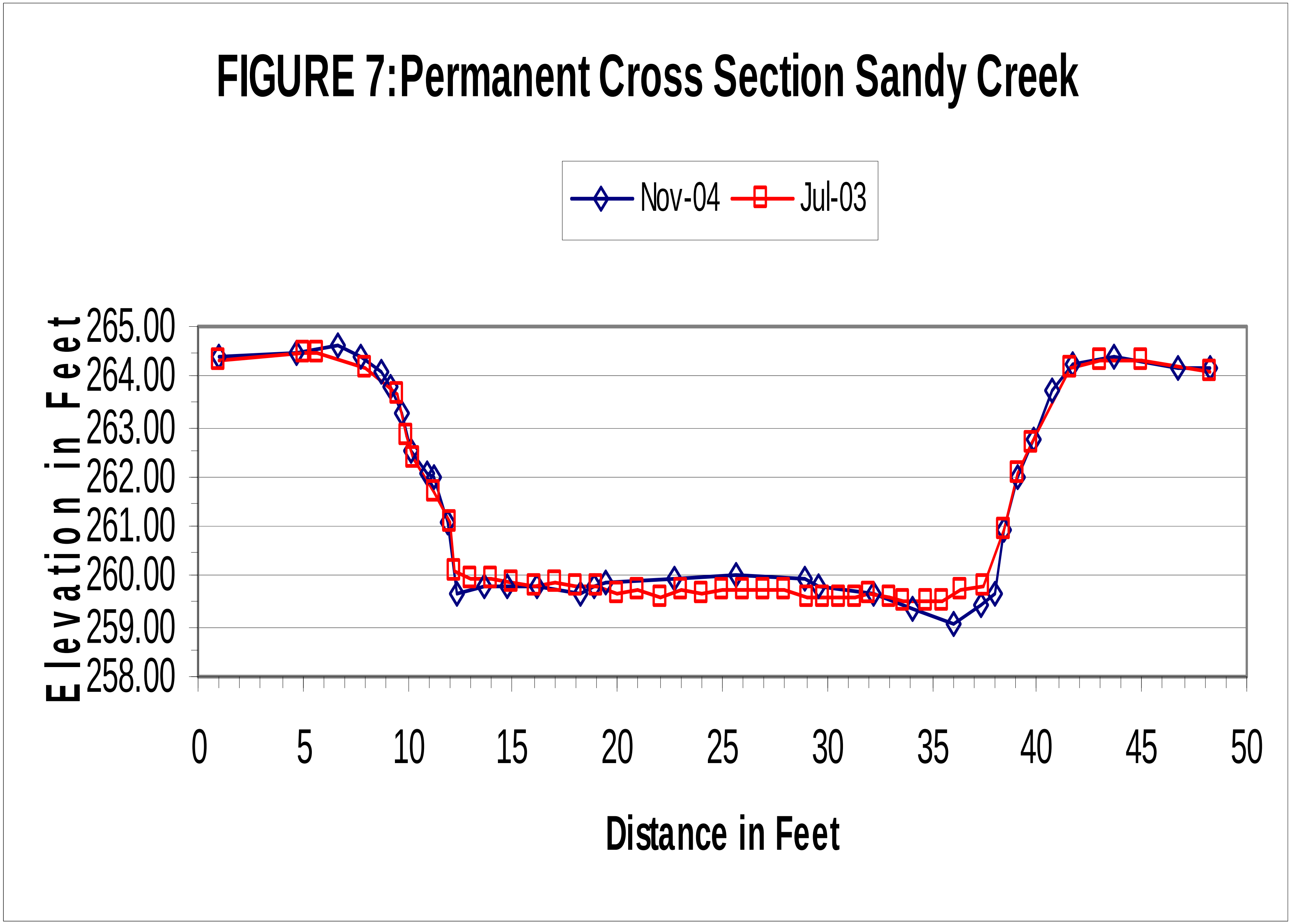
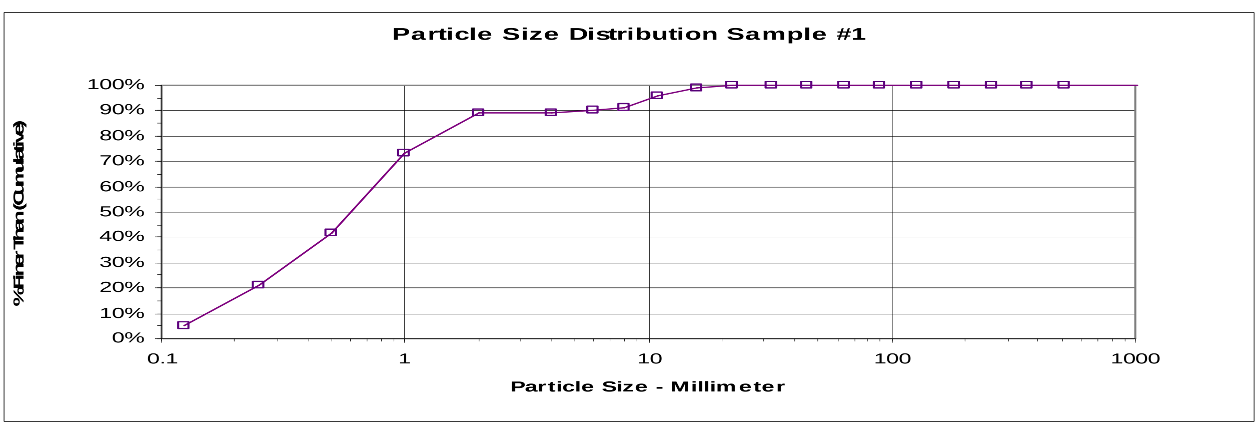


FIGURE 7:Permanent Cross Section Sandy Creek
Nov-04
Jul-03
Elevation in Feet
265.00
264.00
263.00
262.00
261.00
260.00
259.00
258.00
0
5
10
15
20
25
30
35
40
45
50
Distance in Feet

PEBBLE COUNT								
Project:	Sandy Creek 1st year monitoring				**Date:**	11/29/04		
Location:	At Permanenet cross Section station 18+50, Ripple							
				Particle Counts				
Inches	Particle	Millimeter		Riffles	Pools	Total No.	Item %	% Cumulative
	Silt/Clay	< 0.062	S/C	0		0	0%	0%
	Very Fine	.062 - .125	S	5		5	5%	5%
	Fine	.125 - .25	A	16		16	16%	21%
	Medium	.25 - .50	N	21		21	21%	42%
	Coarse	.50 - 1.0	D	31		31	31%	73%
.04 -.08	Very Coarse	1.0 - 2.0	S	16		16	16%	89%
.08 - .16	Very Fine	2.0 - 4.0		0		0	0%	89%
.16 - .22	Fine	4.0 - 5.7	G	1		1	1%	90%
.22 - .31	Fine	5.7 - 8.0	R	1		1	1%	91%
.31 - .44	Medium	8.0 - 11.3	A	5		5	5%	96%
.44 - .63	Medium	11.3 - 16.0	V	3		3	3%	99%
.63 - .89	Coarse	16.0 - 22.6	E	1		1	1%	100%
.89 - 1.26	Coarse	22.6 - 32.0	L	0		0	0%	100%
1.26 - 1.77	Very Coarse	32.0 - 45.0	S	0		0	0%	100%
1.77 - 2.5	Very Coarse	45.0 - 64.0		0		0	0%	100%
2.5 - 3.5	Small	64 - 90	C	0	0	0	0%	100%
3.5 - 5.0	Small	90 - 128	O	0	0	0	0%	100%
5.0 - 7.1	Large	128 - 180	B	0	0	0	0%	100%
7.1 - 10.1	Large	180 - 256	L	0	0	0	0%	100%
10.1 - 14.3	Small	256 - 362	B	0	0	0	0%	100%
14.3 - 20	Small	362 - 512	L	0	0	0	0%	100%
20 - 40	Medium	512 - 1024	D	0	0	0	0%	100%
40 - 80	Lrg- Very Lrg	1024 - 2048	R	0	0	0	0%	100%
	Bedrock		BDRK	0	0	0	0%	100%
			Totals	**100**	**0**	**100**	**100%**	**100%**



3.0 PHOTO LOG

Log Vanes

July 12, 2003

Log Vane #1, Station 2+04

November 3, 2004

July 12, 2003

Log Vane #2, Station 4+12

November 3, 2004

Log # 3, Station 6 + 55

July 12, 2003

November 3, 2004

Log # 4, Station 8 + 88

July 12, 2003

November 3, 2004
Sandy Creek Stream Enhancement
Log Vanes

Log Vane # 5, Station 10 + 99

November 3, 2004

Log Vane # 6, Station 13 + 83

July 12, 2003

November 3, 2004

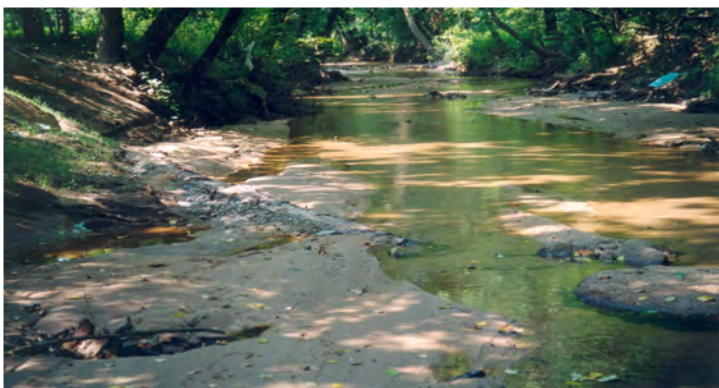
Sandy Creek Stream Enhancement

Log Vanes

Log Vane #7, Station 15 + 39
July 12, 2003

November 3, 2004

Log Vane # 8, Station 17 + 45



July 12, 2003

November 3, 2004

Sandy Creek Stream
Enhancement Log Vanes

Log Vane # 9, Station 19 +72

July 12, 2003

November 3, 2004

Log Vane #10, Station 20 + 91

July 12, 2003

November 3, 2004

Sandy Creek Stream
Enhancement Log Vanes

Log Vane # 11, Station 22 + 66

July 12, 2003

November 3, 2004

Log Vane #12, Station 24 + 20

July 12, 2003

November 3, 2004

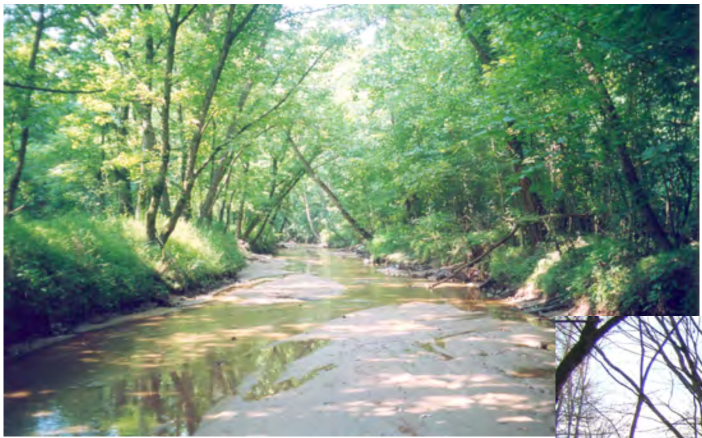
Sandy Creek Stream Enhancement Log Vane & Permanent Cross Section

Log Vane # 13,
Station 26 +12

July 12, 2003

November 3, 2004

Permanent Cross-Section, Station 18 + 25, Viewed Looking Downstream



July 12, 2003

November 29, 2004

Vegetation Plot 1 – Sandy Creek Wetland Site

Picture 1

Picture 1A

Above pictures taken after construction July 12, 2003. Picture below was taken November 3, 2004 after one growing season.

Vegetation Plot 2 – Sandy Creek Wetland Site

Picture 2

Picture 2A

The above pictures were included in the original as-built report for the project. The pictures were taken on July 12, 2003. The photograph at the bottom of the picture was taken on November3, 2004 after one growing season.

Vegetation Plot 3 – Sandy Creek Wetland Site

Picture 3

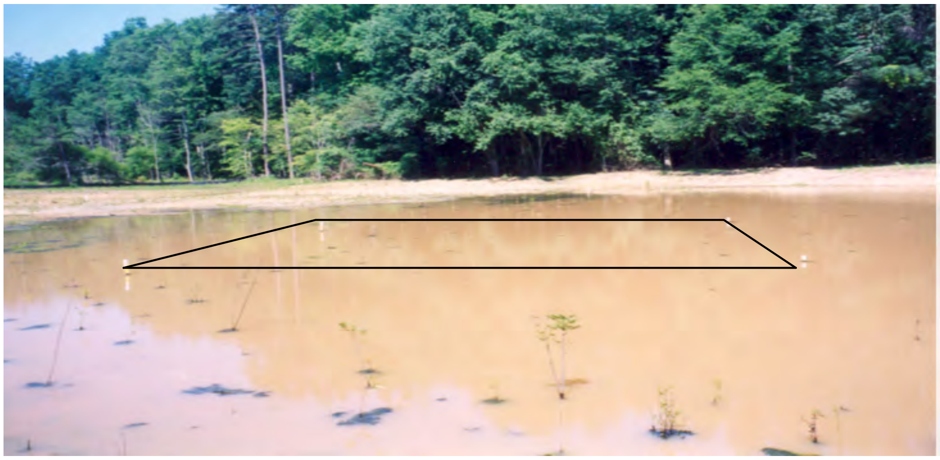
Picture 3A

Ground

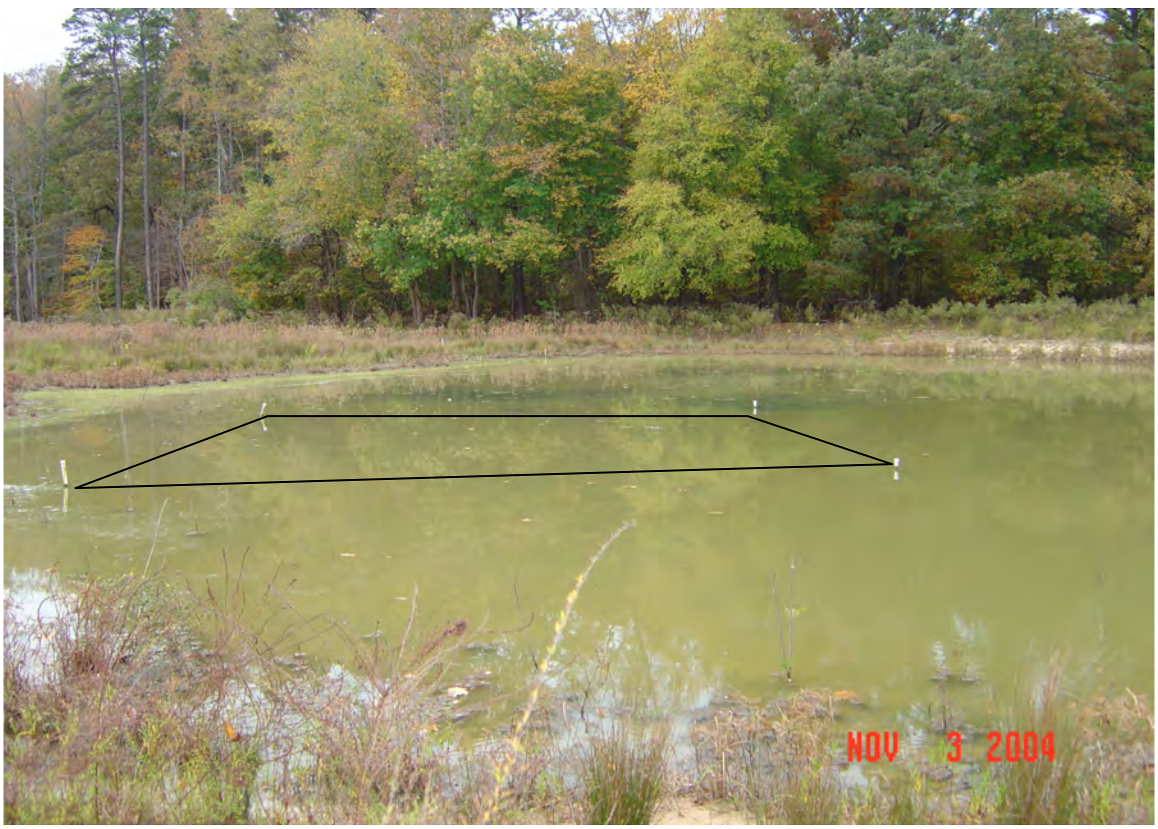
The pictures above were taken July 12, 2003 after construction. The picture below was taken on November 3, 2004 after one year of growing season.

Vegetation Plot 4 – Sandy Creek Wetland Site

Picture 4



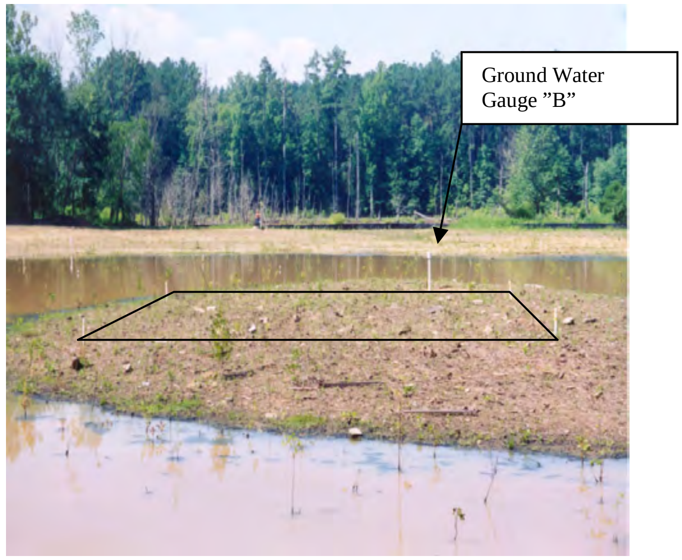
The above picture was taken on July 12, 2003 just after construction. The picture taken below was taken on November 3, 2004 after one growing season. The water remained in this area throughout the year.



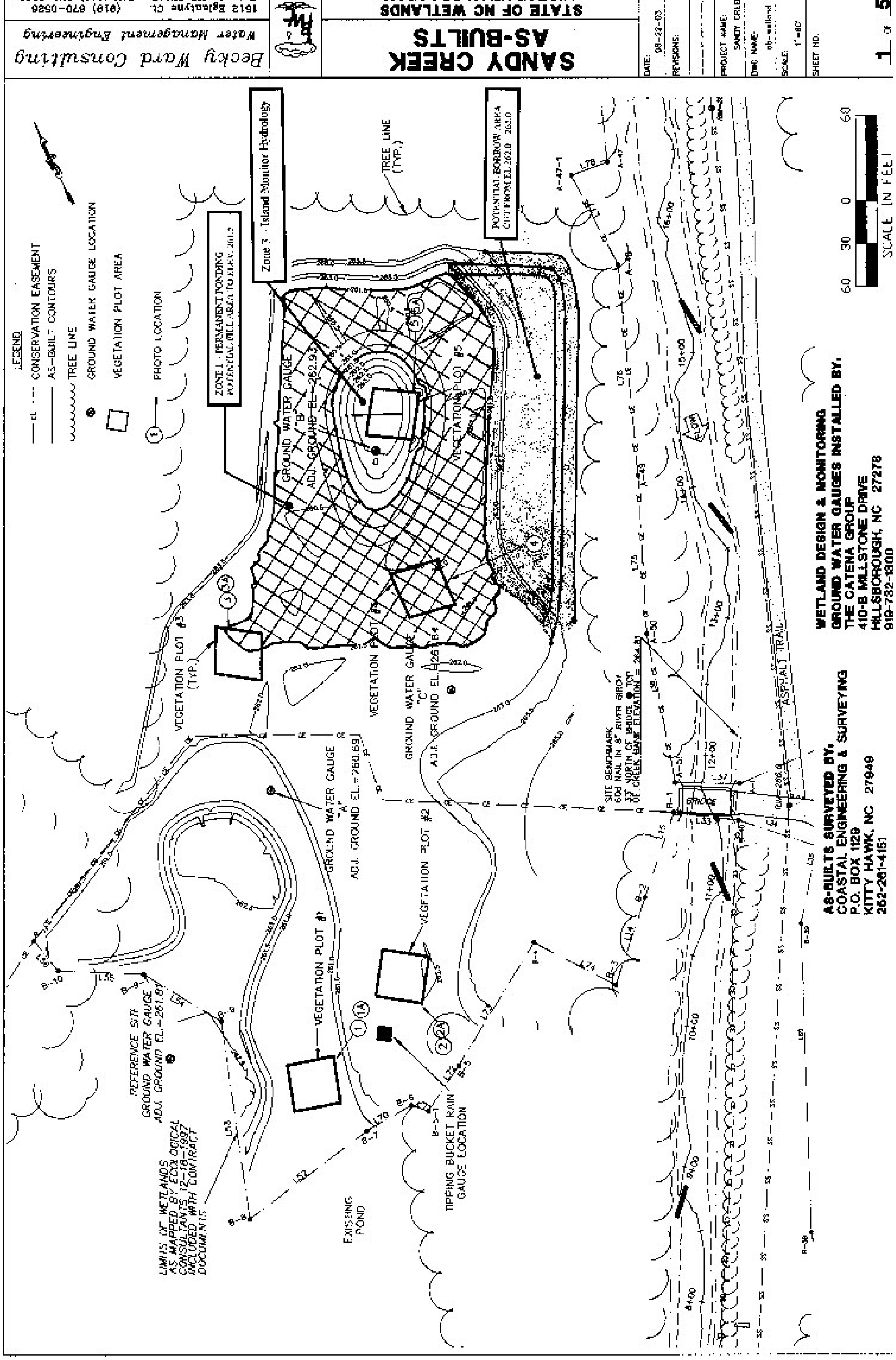
Vegetation Plot 5 – Sandy Creek Wetland Site

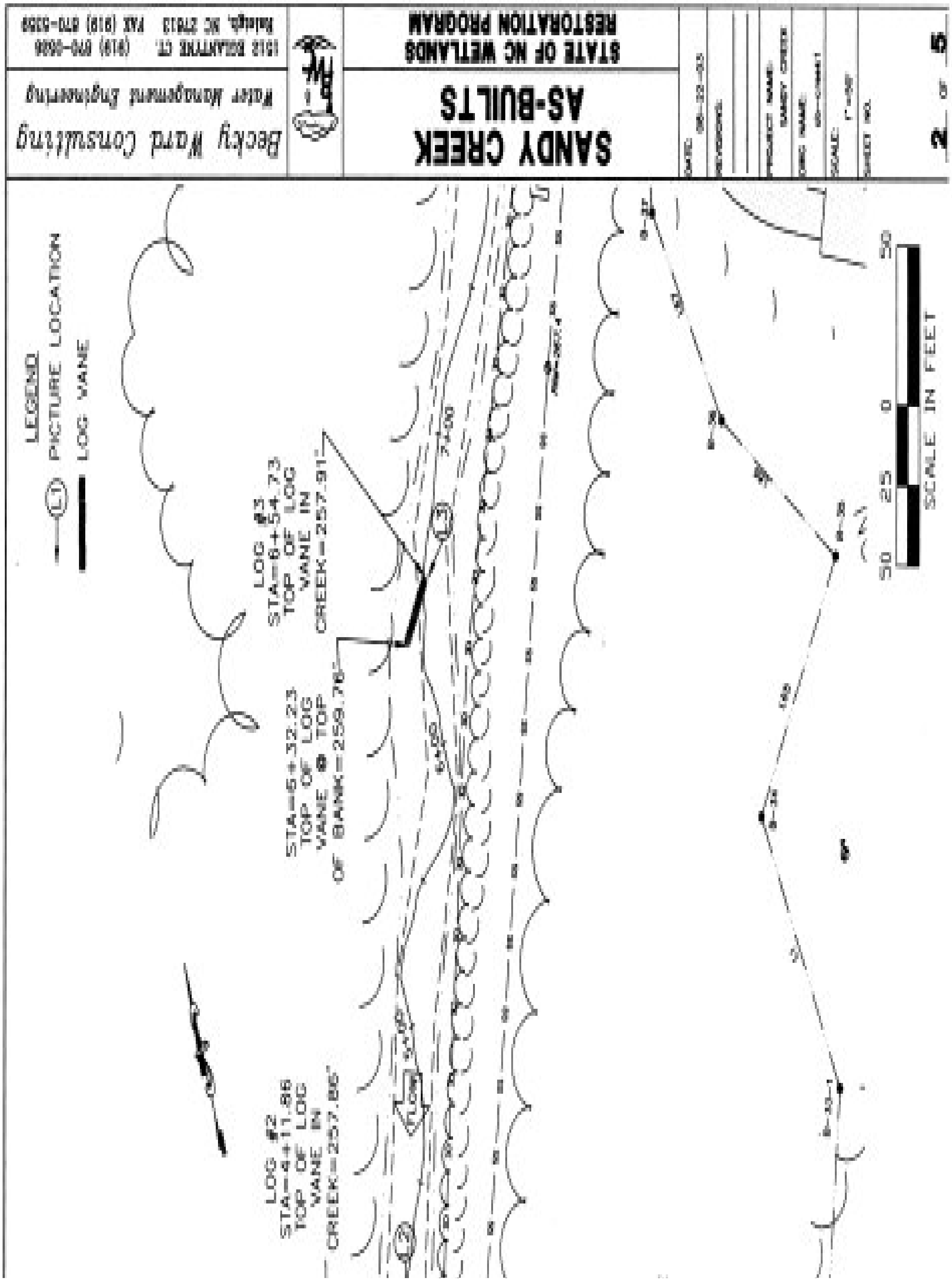
Picture 5

Picture 5A



The above pictures were taken on July 12, 2003. The picture below, taken November 3, 2004, shows one season of growth on the newly constructed site.


SANDY CREEK AS-BUILTS
STATE OF NC WETLANDS RESTORATION PROGRAM
Becky Ward Consulting
Water Management Engineering
1612 Eglantyne Ct. Raleigh, NC 27613
(919) 870-0526 FAX (919) 870-5969
LEGEND
CONSERVATION EASEMENT
AS-BUILT CONTOURS
TREE LINE
GROUND WATER GAUGE LOCATION
VEGETATION PLOT AREA
PHOTO LOCATION
WETLAND DESIGN & MONITORING
GROUND WATER GAUGES INSTALLED BY;
THE CATENA GROUP
410-B MILLSTONE DRIVE
HILLSBOROUGH, NC 27278
919-732-1300
AS-BUILTS SURVEYED BY;
COASTAL ENGINEERING & SURVEYING
P.O. BOX 1129
KITTY HAWK, NC 27949
252-261-4151
SCALE IN FEET
EXISTING POND
TIPPING BUCKET RAIN GAUGE LOCATION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STATE OF NC WETLANDS
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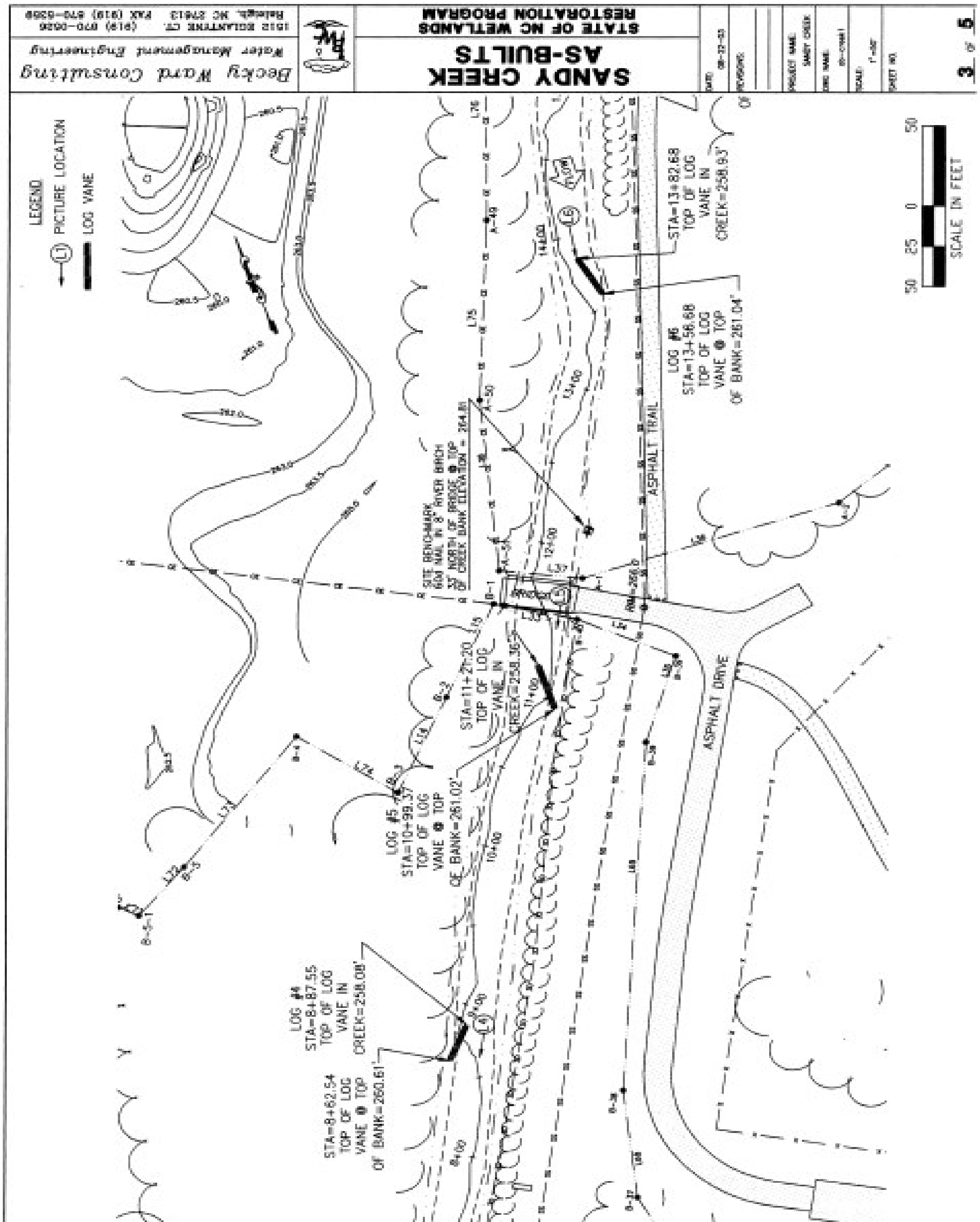
Water Management Engineering
2 of 5
LEGEND
PICTURE LOCATION
LOG VANE
LOG #3
STA=6+54.73
TOP OF LOG
VANE IN
CREEK=257.91'
STA=6+32.23
TOP OF LOG
VANE @ TOP
OF BANK=259.76'
LOG #2
STA=4+11.86
TOP OF LOG
VANE IN
CREEK=257.86'
50
25
0
50
SCALE IN FEET



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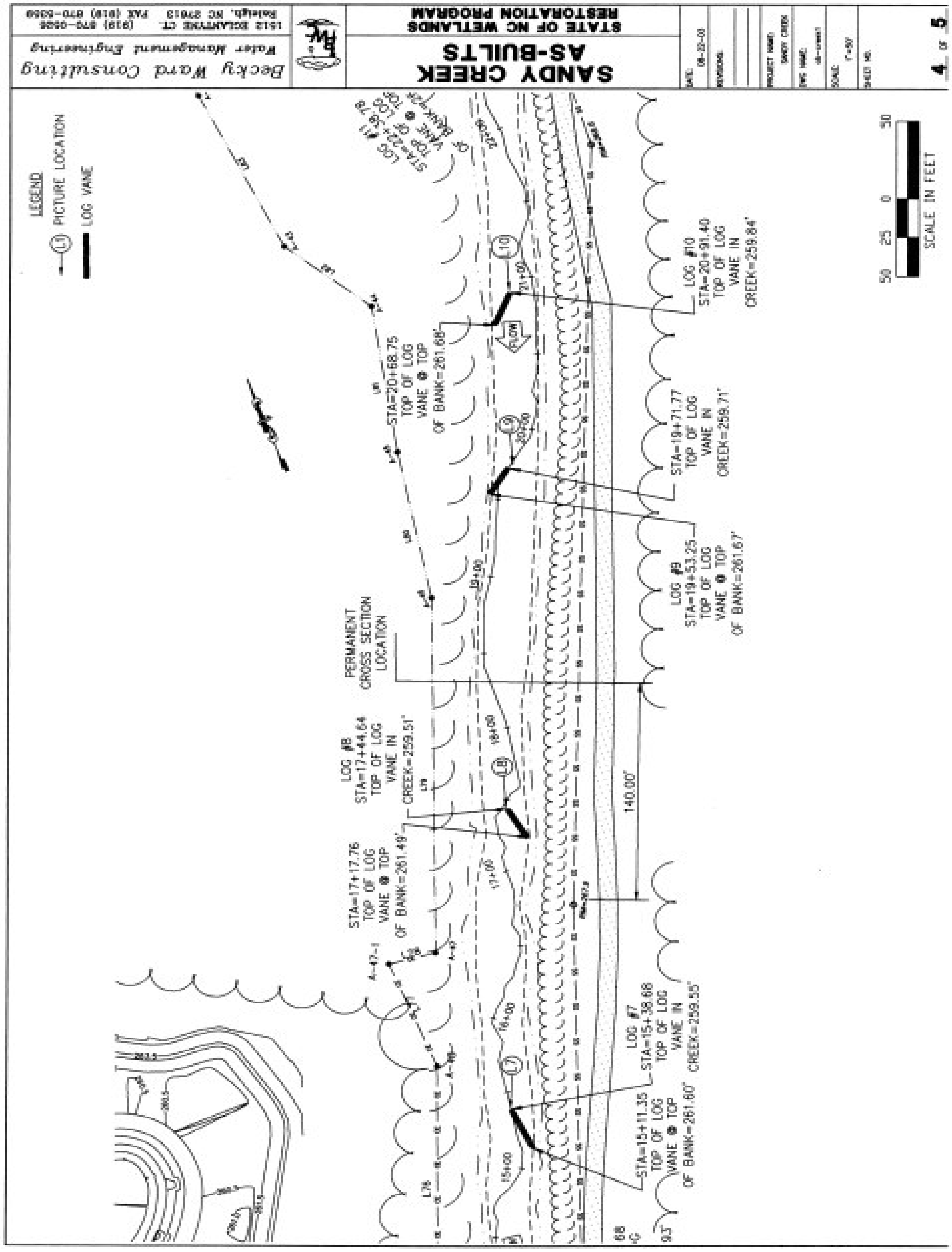
Water Management Engineering
1512 EGLANTINE CT. (919) 870-0526
Raleigh, NC 27613 FAX (919) 870-5359
LEGEND
PICTURE LOCATION
LOG VANE
SCALE IN FEET
STA=13+82.68
TOP OF LOG
VANE IN
CREEK=258.93'
LOG #6
STA=13+56.68
TOP OF LOG
VANE @ TOP
OF BANK=261.04'
ASPHALT TRAIL
ASPHALT DRIVE
STA=11+21.20
TOP OF LOG
VANE IN
CREEK=258.36'
LOG #5
STA=10+99.37
TOP OF LOG
VANE @ TOP
OF BANK=261.02'
LOG #4
STA=8+87.55
TOP OF LOG
VANE IN
CREEK=258.08'
STA=8+62.54
TOP OF LOG
VANE @ TOP
OF BANK=260.61'



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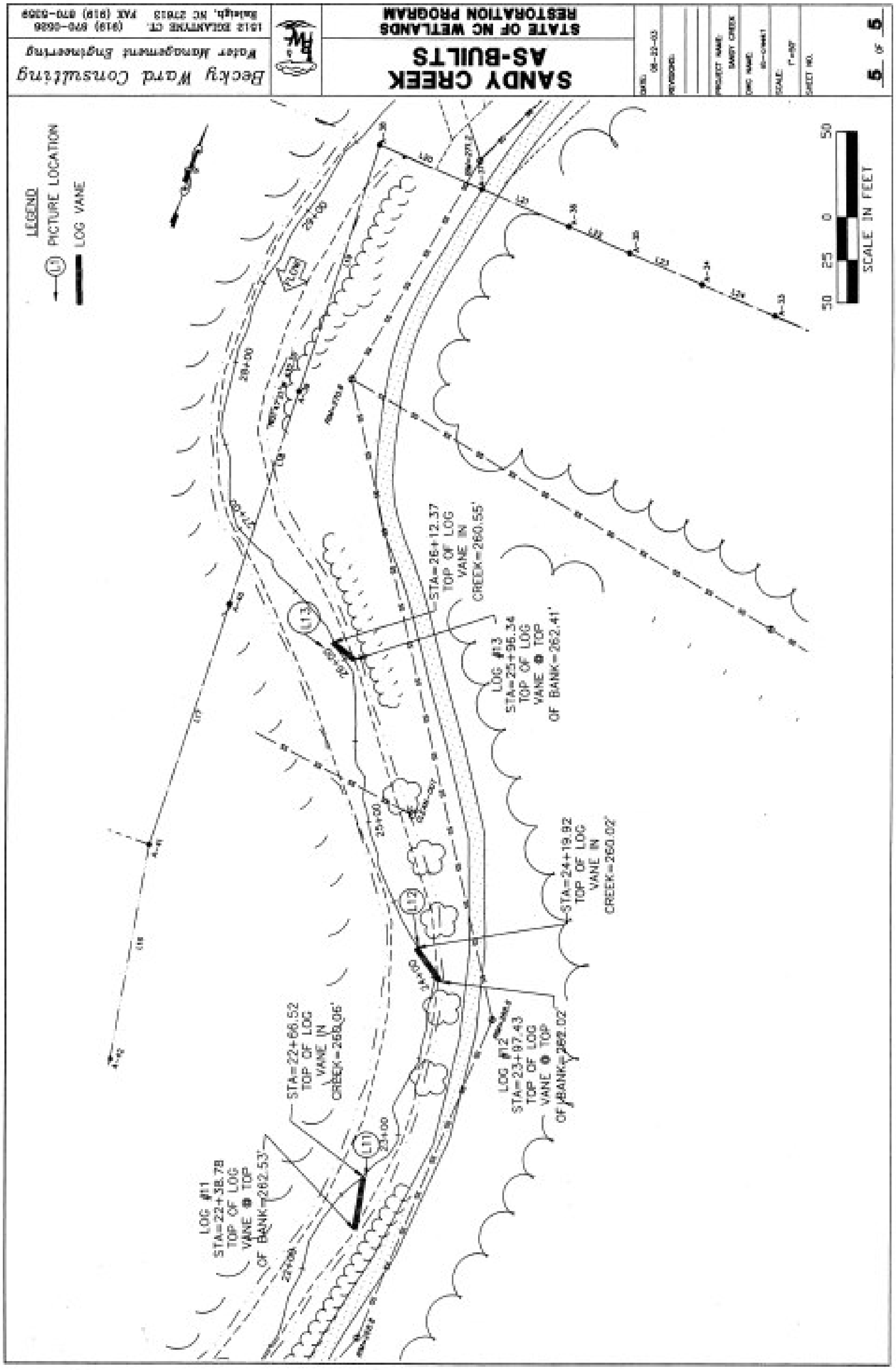
LEGEND
PICTURE LOCATION
LOG VANE
SCALE IN FEET
LOG #10 STA=20+91.40 TOP OF LOG VANE IN CREEK=259.84'
STA=20+68.75 TOP OF LOG VANE @ TOP OF BANK=261.68'
STA=19+71.77 TOP OF LOG VANE IN CREEK=259.71'
LOG #9 STA=19+53.25 TOP OF LOG VANE @ TOP OF BANK=261.67'
PERMANENT CROSS SECTION LOCATION
LOG #8 STA=17+44.64 TOP OF LOG VANE IN CREEK=259.51'
STA=17+17.76 TOP OF LOG VANE @ TOP OF BANK=261.49'
140.00'
LOG #7 STA=15+38.68 TOP OF LOG VANE IN CREEK=259.55'
STA=15+11.35 TOP OF LOG VANE @ TOP OF BANK=261.60'


Becky Ward Consulting
Water Management Engineering
1512 EGLANTYNE CT. Raleigh, NC 27613
(919) 870-0686 FAX (919) 870-5359
SANDY CREEK
AS-BUILTS
STATE OF NC WETLANDS
RESTORATION PROGRAM
5 of 5
LEGEND
PICTURE LOCATION
LOG VANE
SCALE IN FEET
FLOW
STA=26+12.37 TOP OF LOG VANE IN CREEK=260.55'
LOG #13 STA=25+95.34 TOP OF LOG VANE @ TOP OF BANK=262.41'
STA=24+19.92 TOP OF LOG VANE IN CREEK=260.02'
LOG #12 STA=23+97.43 TOP OF LOG VANE @ TOP OF BANK=262.02
STA=22+66.52 TOP OF LOG VANE IN CREEK=260.06'
LOG #11 STA=22+38.78 TOP OF LOG VANE @ TOP OF BANK=262.53'
L11
L12
L13