

# CROWNS WEST STREAM RESTORATION PROJECT

## ANNUAL MONITORING REPORT FOR 2007 (YEAR 1)

Contract Number D06003-2

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**Submitted to:** NCDENR - Ecosystem Enhancement Program  
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December 2007

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December 2007

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## 1.0 EXECUTIVE SUMMARY

This Annual Report details the monitoring activities during the 2007 growing season (Monitoring Year 1) on the Crowns West Stream Restoration Site (“Site”). As per the approved Restoration Plan for the Site, this Annual Monitoring Report presents data on stream geometry, stem count data from vegetation monitoring stations, and discusses any observed tendencies relating to stream stability and vegetation survival success.

Crowns West Branch had been channelized and riparian vegetation had been cleared in the lower half of the Site. The upstream area had a degraded, early successional buffer that included several exotic species. Prior to restoration, Crowns West Branch was incised along its length and lacked bedform diversity. As a result, channel degradation was widespread throughout the Site. After construction, it was determined that 3,835 linear feet (LF) of stream were restored.

A total of 11 monitoring plots 100 square meters (m<sup>2</sup>) (10m x 10m) in size were used to predict survivability of the woody vegetation planted on-site. The Year 1 vegetation monitoring indicated an average survivability of 738 stems per acre. The data shows that the Site is on track for meeting the minimum success interim criteria of 320 trees per acre by the end of Year 3 and the final success criteria of 260 trees per acre by the end of Year 5.

During Year 1 monitoring, kudzu (*Pueraria montana*) and privet (*Ligustrum L.*) were observed on the Site. The kudzu is located east of Haw Branch Road and is present in the NC Division of Highways (NCDOT) right-of-way and also occurs within the project easement. The privet is located along the southern easement boundary, west of Haw Branch Road or along the right side of the restored channel west, of Haw Branch Road. These areas are scheduled to be treated during Year 2 of monitoring.

Dimension, pattern, profile and in-stream structures remained stable during Year 1. The on-site crest gauge documented the occurrence of at least one bankfull flow event during Year 1 of the post-construction monitoring period. Inspection of conditions during a site visit revealed visual evidence of out-of-bank flow, confirming the crest gauge reading of 0.40 feet (4.8 inches) above the bankfull stage. During Year 1 monitoring, no repairs have been necessary. Year 1 monitoring revealed no problem areas within the boundaries of the Site.

The restoration plan for the Site did not include wetland areas. Therefore, no groundwater monitoring stations or rain gauges were installed on the Site.

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

## **2.0 PROJECT BACKGROUND**

The project involved the proposed restoration of 3,835 linear feet of stream. Table 1 summarizes the restoration areas on the Site. Selected site photographs are shown in Appendix A and B. A total of 10.8 acres of stream and riparian buffer are protected through a conservation easement.

### **2.1 Project Objectives**

The specific goals for the Crowns West Site Restoration Project were as follows:

- Restore 3,904 LF of channel dimension, pattern and profile
- Improve floodplain function by matching floodplain elevation with bankfull stage
- Establish native stream bank and floodplain vegetation in the 10.8-acre permanent conservation easement
- Improve water quality in the Crowns West and New River watershed by reducing sediment and nutrient inputs
- Improve aquatic and riparian habitat by creating deeper pools and areas of re-aeration, planting a riparian buffer, and reducing bank erosion.

### **2.2 Project Structure, Restoration Type and Approach**

For analysis and design purposes, Baker Engineering divided on-site streams into reaches. The reaches were numbered sequentially from west to east, with a “M” designation for “mainstem.” M1 begins on the upstream portion of the project, and flows east, ending at Haw Branch Road. M2 begins at Haw Branch Road and flows east, to the end of the wood line at the downstream end of the project. One unnamed tributary (UT1) flowing from Haw Branch Road to the confluence with Crowns West Branch was originally proposed for restoration and was included in the 3,904 LF of stream restoration proposed for the Site. The landowner withdrew this short section of UT1 in exchange for additional property and stream length at the upstream section of M1 on Crowns West Branch. UT1 was to be tied into the project and the tie-in point was stabilized.

The restoration design allows stream flows larger than bankfull flows to spread onto the floodplain, dissipating flow energies and reducing stress on streambanks. In-stream structures were used to control streambed grade, reduce streambank stress, and promote bedform sequences and habitat diversity. The in-stream structures consisted of root wads, log vanes, log weirs, and constructed riffles which promote a diversity of habitat features in the restored channel. Where grade control was a consideration, constructed riffles were installed to provide long-term stability. Streambanks were stabilized using a combination of erosion control matting, temporary and permanent seeding, bare-root planting, and transplants. Transplants provide living root mass to increase streambank stability and create holding areas for fish and aquatic biota. Native vegetation was planted across the Site, and the entire restoration site is protected through a permanent conservation easement.

**Table 1. Design Approach for the Crowns West Restoration Site**

Crowns West Restoration Site: Project No. D06003-2				
Project Segment or Reach ID	Mitigation Type *	Approach**	Linear Footage	Stationing
M1	R	P1, P2	2,320	10+46 - 24+37
M2	R	P1, P2	1,515	24+09 - 36+13
<b>Total linear feet of channel restored:</b>			3,835	

\* R = Restoration

\*\*P1 = Priority I  
P2 = Priority II

### 2.3 Location and Setting

The Site is located in Onslow County, NC (Figure 1), approximately six miles northwest of the town of Richlands. The Site lies in the White Oak River Basin within North Carolina Division of Water Quality sub-basin 03-05-02 and NCEEP targeted local watershed 03030001010010.

### 2.4 Project History and Background

Land use on the Site consisted primarily of row crop agriculture with adjacent woodlands. Crowns West Branch had been channelized and riparian vegetation had been cleared in the lower half of the Site. The upstream area had a degraded, early successional buffer that included several exotic species. Prior to restoration, Crowns West Branch was incised and lacked bedform diversity. As a result, channel degradation was widespread throughout the Site.

The chronology of the Crowns West Project is presented in Table 2. The contact information for all designers, contractors, and relevant suppliers is presented in Table 3. Relevant project background information is presented in Table 4.

### 2.5 Project Plan

Plans depicting the as-built conditions of the major project elements, locations of permanent monitoring cross-sections, and locations of permanent vegetation monitoring plots are presented in Figures 2A, 2B, 2C, 2D, 2E, 2F and 2G of this report.

**Table 2. Project Activity and Reporting History**

<b>Crowns West Restoration Site: Project No. D06003-2</b>			
<b>Activity or Report</b>	<b>Scheduled Completion</b>	<b>Data Collection Complete</b>	<b>Actual Completion or Delivery</b>
Restoration Plan Prepared	N/A	N/A	Jul-06
Restoration Plan Amended	N/A	N/A	N/A
Restoration Plan Approved	N/A	N/A	Aug-06
Final Design – (at least 90% complete)	N/A	N/A	Oct-06
Construction Begins	Nov-06	N/A	Nov-06
Temporary S&E mix applied to entire project area	N/A	N/A	Mar-07
Permanent seed mix applied to entire project area	Mar-07	N/A	Mar-07
Planting of live stakes	Mar-07	N/A	Mar-07
Planting of bare root trees	Mar-07	N/A	Mar-07
End of Construction	Mar-07	N/A	Mar-07
Survey of As-built conditions (Year 0 Monitoring-baseline)	Mar-07	Mar-07	Mar-07
Year 1 Monitoring	Dec-07	Oct-07	Dec-07
Year 2 Monitoring	Scheduled Dec-08	Scheduled Oct-08	N/A
Year 3 Monitoring	Scheduled Dec-09	Scheduled Oct-09	N/A
Year 4 Monitoring	Scheduled Dec-10	Scheduled Oct-10	N/A
Year 5 Monitoring	Scheduled Dec-11	Scheduled Oct-11	N/A

**Table 3. Project Contacts**

<b>Crowns West Restoration Site: Project No. D06003-2</b>	
<b>Designer</b>	
Baker Engineering NY, Inc.	8000 Regency Parkway, Suite 200 Cary, NC 27518 <u>Contact:</u> Kevin Tweedy, Tel. 919-463-5488
<b>Construction Contractor</b>	
River Works, Inc.	8000 Regency Parkway, Suite 200 Cary, NC 27518 <u>Contact:</u> Will Pedersen, Tel. 919-459-9001
<b>Planting Contractor</b>	
River Works, Inc.	8000 Regency Parkway, Suite 200 Cary, NC 27518 <u>Contact:</u> Will Pedersen, Tel. 919-459-9001
<b>Seeding Contractor</b>	
River Works, Inc.	8000 Regency Parkway, Suite 200 Cary, NC 27518 <u>Contact:</u> Will Pedersen, Tel. 919-459-9001
Seed Mix Sources	Mellow Marsh Farm, 919-742-1200
Nursery Stock Suppliers	International Paper, 1-888-888-7159
<b>Monitoring Performers</b>	
Baker Engineering NY, Inc.	8000 Regency Parkway, Suite 200 Cary, NC 27518
Stream Monitoring Point of Contact:	Dwayne Huneycutt, Tel. 919-463-5488
Vegetation Monitoring Point of Contact:	Dwayne Huneycutt, Tel. 919-463-5488



**Table 4. Project Background**

<b>Crowns West Restoration Site: Project No. D06003-2</b>	
Project County:	Onslow County, NC
Drainage Area:	
Reach: M1	0.65 mi <sup>2</sup>
Reach: M2	0.98 mi <sup>2</sup>
Estimated Drainage % Impervious Cover:	
M1	>5%
M2	>5%
Stream Order:	
M1	1
M2	2
Physiographic Region	Coastal Plain
Ecoregion	Carolina Flatwoods
Rosgen Classification of As-Built	C5
Cowardin Classification	Riverine, Upper Perennial, Unconsolidated Bottom, Sand
Dominant Soil Types	
M1	Mk,CrB
M2	Mk,CrB, AuB
Reference site ID	Beaverdam Branch
USGS HUC for Project and Reference sites	03030001010010
NCDWQ Sub-basin for Project and Reference	03-05-02
NCDWQ classification for Project and Reference	C5c
Any portion of any project segment 303d listed?	No
Any portion of any project segment upstream of a 303d listed segment?	No
Reasons for 303d listing or stressor?	N/A
% of project easement fenced	0%

### 3.0 PROJECT CONDITION AND MONITORING RESULTS

#### 3.1 Vegetation Assessment

##### 3.1.1 Description of Vegetative Monitoring

As a final stage of construction, the stream margins and riparian area of the Site were planted with bare root trees, live stakes, and a seed mixture of temporary and permanent ground cover herbaceous vegetation. The woody vegetation was planted randomly six to eight feet apart from the top of the stream banks to the outer edge of the project’s re-vegetation limits. In general, bare-root vegetation was planted at a target density of 680 stems per acre, in an 8-foot by 8-foot grid pattern. The tree species planted at the Site are shown in Table 5. The permanent seed mix of herbaceous species applied to the project’s riparian area included soft rush (*Juncus effuses*), redtop (*Agrostis alba*), virginia wild rye (*Elymus virginicus*), switchgrass (*Panicum virgatum*), smartweed (*Polygonum pennsylvanicum*), tick seed (*Bidens frondosa*), lance leaf coreopsis (*Coreopsis lanceolata*), fox sedge (*Carex vulpinoidea*), hop sedge (*Carex lupulina*), and shallow sedge (*Carex lurida*). This seed mixture was broadcast on the Site at a rate of 15 pounds per acre. All planting was completed in March 2007.

At the time of planting, eleven vegetation plots – labeled 1 through 11 - were delineated on-site to monitor survival of the planted woody vegetation. Each vegetation plot is 0.025 acre in size, or 10 meters x 10 meters. All of the planted stems inside the plot were flagged to distinguish them from any colonizing individuals and to facilitate locating them in the future. The trees also were marked with aluminum metal tags to ensure that the correct identification is made during future monitoring of the vegetation plots.

On a designated corner within each of the eleven vegetation plots, one herbaceous plot was also delineated. The herbaceous plots measure 1 meter x 1meter in size. These plots are photographed throughout the growing season. The locations of the eleven vegetation plots are presented in Figures 2A through 2G.

##### 3.1.2 Vegetative Success Criteria

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

Table 5. Vegetation Species Planted Across the Restoration Site			
Crowns West Restoration Site: Project No. D06003-2			
Scientific Name	Common Name	Percent Planted by Species	Total Number of Stems
Bare Root Trees Species			
<i>Betula nigra</i>	River Birch	15%	1,110
<i>Celtis laevigata</i>	Sugarberry	5%	370
<i>Fraxinus</i>	Green Ash	7.50%	555

<b>Table 5. Vegetation Species Planted Across the Restoration Site</b>			
<b>Crowns West Restoration Site: Project No. D06003-2</b>			
<b>Scientific Name</b>	<b>Common Name</b>	<b>Percent Planted by Species</b>	<b>Total Number of Stems</b>
<i>pennsylvanica</i>			
<i>Juglans nigra</i>	Black Walnut	5%	370
<i>Nyssa sylvatica</i> <i>var. biflora</i>	Swamp Tupelo	10%	740
<i>Platanus occidentalis</i>	Sycamore	20%	1,480
<i>Quercus lyrata</i>	Overcup Oak	10%	740
<i>Quercus michauxii</i>	Swamp Chestnut Oak	10%	740
<i>Quercus phellos</i>	Willow Oak	7.50%	555
<i>Taxodium distichum</i>	Bald Cypress	10%	740
<b>Native Herbaceous Species</b>			
<i>Elymus virginicus</i>	Virginia wildrye	15%	NA
<i>Panicum virgatum</i>	Switchgrass	15%	NA
<i>Carex vulpinoidea</i>	Fox sedge	5%	NA
<i>Polygonum pennsylvanicum</i>	Smart Weed	5%	NA
<i>Juncus effusus</i>	Soft rush	10%	NA
<i>Carex lupulina</i>	Hop sedge	10%	NA
<i>Agrostis alba</i>	Redtop	10%	NA
<i>Bidens frondosa</i>	Tick seed	10%	NA
<i>Coreopsis lanceolata</i>	Lance leaf coreopsis	10%	NA
<i>Carex lurida</i>	Shallow sedge	10%	NA
<b>Woody Vegetation for Live Stakes</b>			
<i>Salix sericia</i>	Silky Willow	40%	1,040
<i>Cornus amomum</i>	Silky Dogwood	40%	1,040
<i>Sambucus canadensis</i>	Elderberry	20%	520

### 3.1.3 Vegetative Observations and Results

The permanent ground cover seed mixture broadcast on the Site after construction was present during Year 1 monitoring of the Site.

Tables A.1. through A.6. in Appendix A present vegetation metadata, vegetation vigor, vegetation damage and stem count data of the monitoring stations at the end of the Year 1 monitoring period. Data from the Year 1 monitoring event of the eleven vegetation plots showed a range of 560 to 960 stems per acre. The data showed that the plots had an average of 738 stems per acre. Based on these results, all plots are on track to meet the success criteria of 320 stems per acre at the end of monitoring Year 3.

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

No significant volunteer woody species were observed in any of the vegetation plots. The plots will also be assessed during Year 2 monitoring for volunteer species.

### **3.1.4 Vegetative Problem Areas**

There are quite a few weedy species occurring on the Site, though none seem to be posing any problems for the woody or herbaceous hydrophytic vegetation. The weedy species are mostly annuals and seem to pose very little threat to survivability on site.

During Year 1 monitoring, kudzu (*Pueraria montana*) was observed on the Site. The kudzu is located south of Haw Branch Road and is present in the NCDOT right-of-way and also occurs within the project easement. Treatment for the kudzu within the project easement is scheduled for late spring to early summer of 2008.

Privet (*Ligustrum L.*) was also observed on the Site, during Year 1 monitoring. The privet is located along the southern easement boundary, west of Haw Branch Road or along the right side of the restored channel, west of Haw Branch Road. This area is scheduled to be treated before spring of 2008. The privet in this area will be treated by the cut and paint method.

### **3.1.5 Vegetation Photographs**

Photographs are used to visually document vegetation plot success. A total of 11 reference stations were established to document tree conditions at each vegetation plot across the Site. Additional photo stations were also established at each of the 11 vegetation plots for herbaceous vegetation monitoring. Reference photos of both tree conditions and herbaceous conditions are taken at least once per year. Photos of the tree plots showing the on-site vegetation are included in Appendix A of this report. Photos of the herbaceous plots are also included in Appendix A.

## **3.2 Stream Assessment**

### **3.2.1 Morphometric Success Criteria**

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

*Cross-sections:* Two permanent cross-sections were installed per 1,000 LF of stream restoration work, with one of the locations being a riffle cross-section and one location being a pool cross-section. A total of nine permanent cross-sections were established across the

Site. Each cross-section was marked on both banks with permanent pins to establish the exact transect used. The permanent cross-section pins are surveyed and located relative to a common benchmark to facilitate easy comparison of year-to-year data. The annual cross-section surveys include points measured at all breaks in slope, including top of bank, bankfull, inner berm, edge of water, and thalweg.

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

*Longitudinal Profiles:* A complete longitudinal profile was surveyed following construction completion to record as-built conditions. The profile was conducted for the entire length of the restored channels (M1 and M2). Measurements included thalweg, water surface, bankfull, and top of low bank. Each of these measurements was taken at the head of each feature (e.g., riffle, pool, and glide). In addition, maximum pool depth was recorded. All surveys were tied to a single, permanent benchmark.

The approved Restoration Plan requires the following criteria be met to achieve stream restoration success. The longitudinal profiles should show that the bedform features are remaining stable; i.e., they are not aggrading or degrading. The pools should remain deep, with flat water surface slopes, and the riffles should remain steeper and shallower than the pools. Bedforms observed should be consistent with those observed for channels of the design stream type.

### **3.2.2 Morphometric Results**

Year 1 cross-section monitoring data for stream stability were collected during August 2007. The nine permanent cross-sections along the restored channels (five located across riffles and four located across pools) were re-surveyed to document stream dimension at the end of monitoring Year 1. Data from each of these cross-sections are summarized in Appendix B. The cross-sections show that there has been very little adjustment to stream dimension since construction.

Cross-sections 2, 5, 6, and 9 are located across pools found at the apex of meander bends. Based on the cross-section data, none of these sections show the development of point bar features on the inside bank of the meander bend. Due to below average rainfall for 2007 the pools on the project site did not experience enough sustained water and flow in the channel to develop point bar features. Cross-section 2 did not experience significant change during Year 1. However, cross-sections 5 and 6 exhibited shallower pools, while cross-section 9 showed a deeper pool than was measured in the as-built condition.

The longitudinal profile for Year 1 was surveyed in August 2007 and was compared to the data collected during the as-built condition survey. The longitudinal profile is presented in Appendix B. The results of longitudinal profile show that the pools in M1 and M2 have maintained elevations and pool depths similar to those documented during the as-built

survey. The longitudinal profile also showed that the riffles and in-stream structures are stable.

In-stream structures installed within the restored stream included constructed riffles, log vanes, log weirs, and root wads. Visual observations of these structures throughout the Year 1 growing season have indicated that all structures are functioning as designed and holding their elevation grade. Log vanes placed in meander pool areas have provided scour to keep pools deep and provide cover for fish. Log weirs placed in riffle areas have maintained riffle elevations and provided a downstream scour hole which provides habitat. Root wads placed on the outside of meander bends have provided bank stability and in-stream cover for fish and other aquatic organisms.

### 3.2.3 Hydrologic Criteria

One crest gauge was installed on the Site to document bankfull events. The gauge is checked regularly and records the highest out-of-bank flow between site visits. The gauge is located on the downstream portion of reach M2, which is presented in Figure 2G.

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

### 3.2.4 Hydrologic Monitoring Results

The on-site crest gauge documented the occurrence of at least one bankfull flow event during Year 1 of the post-construction monitoring period, as shown in Table 6. Inspection of conditions during a site visit revealed visual evidence of out-of-bank flow, confirming the crest gauge reading. The largest on-site stream flow documented by the crest gauge during Year 1 of monitoring was approximately 0.40 feet (4.8 inches) above the bankfull stage and was the result of overbank flooding of M2.

**Table 6. Verification of Bankfull Events**

<b>Crowns West Restoration Site: EEP Contract No. D06003-2</b>			
<b>Date of Data Collection</b>	<b>Date of Occurrence of Bankfull Event</b>	<b>Method of Data Collection</b>	<b>Photo # or Measurement</b>
7/6/2007	Unknown	Crest Gage on M2	0.40

### 3.2.5 Stream Problem Areas

During Year 1 monitoring, the Site did not experience any restoration-related problems. The Site received below normal rainfall during the 2007 growing season. Therefore, site visits revealed periods of a dry, exposed streambed. As a result, no stream problem areas were documented during Year 1 monitoring.

### **3.2.6 Stream Photographs**

Photographs are used to visually document restoration success. A total of 23 reference stations were established to document conditions at the constructed grade control structures across the Site, and additional photo stations were established at each of the 9 permanent cross-sections. The GPS coordinates of each grade control structure photo station have been noted as additional reference to ensure the same photo location is used throughout the monitoring period. Reference photos are taken at least once per year.

Each stream bank is photographed at each permanent cross-section photo station. For each stream bank photo, the photo view line follows a survey tape placed across the channel, perpendicular to flow (representing the cross-section line). The photograph is framed so that the survey tape is centered in the photo (appears as a vertical line at the center of the photograph), keeping the channel water surface line horizontal and near the lower edge of the frame.

Photographs will be used to document restoration success visually. Reference stations were photographed before construction and will be photographed for at least five years following construction. Reference photos will be taken once per year, from a height of approximately five to six feet. Permanent markers are established to ensure that the same locations (and view directions) on the Site are monitored during each monitoring event.

A photo log of the restored channel is presented in Appendix B of this report. Data for each of the nine permanent cross-sections are also included in Appendix B.

Photographs of the restored channel were taken at the end of the monitoring season to document the evolution of the stream geometry. Herbaceous vegetation is dense along the edges of the restored stream, making the photography of some of the stream channel areas difficult.

### **3.2.7 Stream Stability Assessment**

Table B.1. presents a summary of the results obtained from the visual inspection of in-stream structures performed during Year 1 of post-construction monitoring. The percentages noted are a general, overall field evaluation of the how the features were performing at the time of the photo point survey. According to the visual stability assessment, during Year 1 monitoring, all features on the Site are performing as designed.

### **3.2.8 Quantitative Measures Summary Tables**

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

The Year 1 cross-section data are compared to baseline stream geometry data collected in April 2007 (as-built conditions) and Year 1 data collected in October 2007 in Appendix B.

#### **4.0 OVERALL CONCLUSIONS AND RECOMMENDATIONS**

*Stream Monitoring* - The total length of stream channel restored on the Site was 3,835 LF. This entire length was inspected during Year 1 of the monitoring period (2007) to assess stream performance. Based on the data collected, all riffles, pools, and other constructed features along the restored channel are stable and functioning as designed.

The on-site crest gauge documented the occurrence of one bankfull flow event during the Year 1 of the post-construction monitoring period. Inspection of site conditions during a site visit revealed visual evidence of out-of-bank flow.

*Vegetation Monitoring* - For the 11 monitoring plots, vegetation monitoring indicated a survivability range of 560 stems per acre to 960 stems per acre with an overall average of 738 stems per acre. The data shows that the Site is on track for meeting the success interim criteria of 320 trees per acre by the end of Year 3.

During Year 1 monitoring, kudzu (*Pueraria montana*) and privet (*Ligustrum L.*) were observed on the Site. The kudzu is located east of Haw Branch Road and is present within the NCDOT right-of-way and also occurs within the project easement. The privet is located along the southern easement boundary west, of Haw Branch Road or along the right side of the restored channel west, of Haw Branch Road. These areas are scheduled to be treated during Year 2 of monitoring.

#### **5.0 WILDLIFE OBSERVATIONS**

Observations of deer and raccoon tracks are common on the Site. During certain times of the year, frogs and crawfish have been periodically observed.

#### **6.0 REFERENCES**

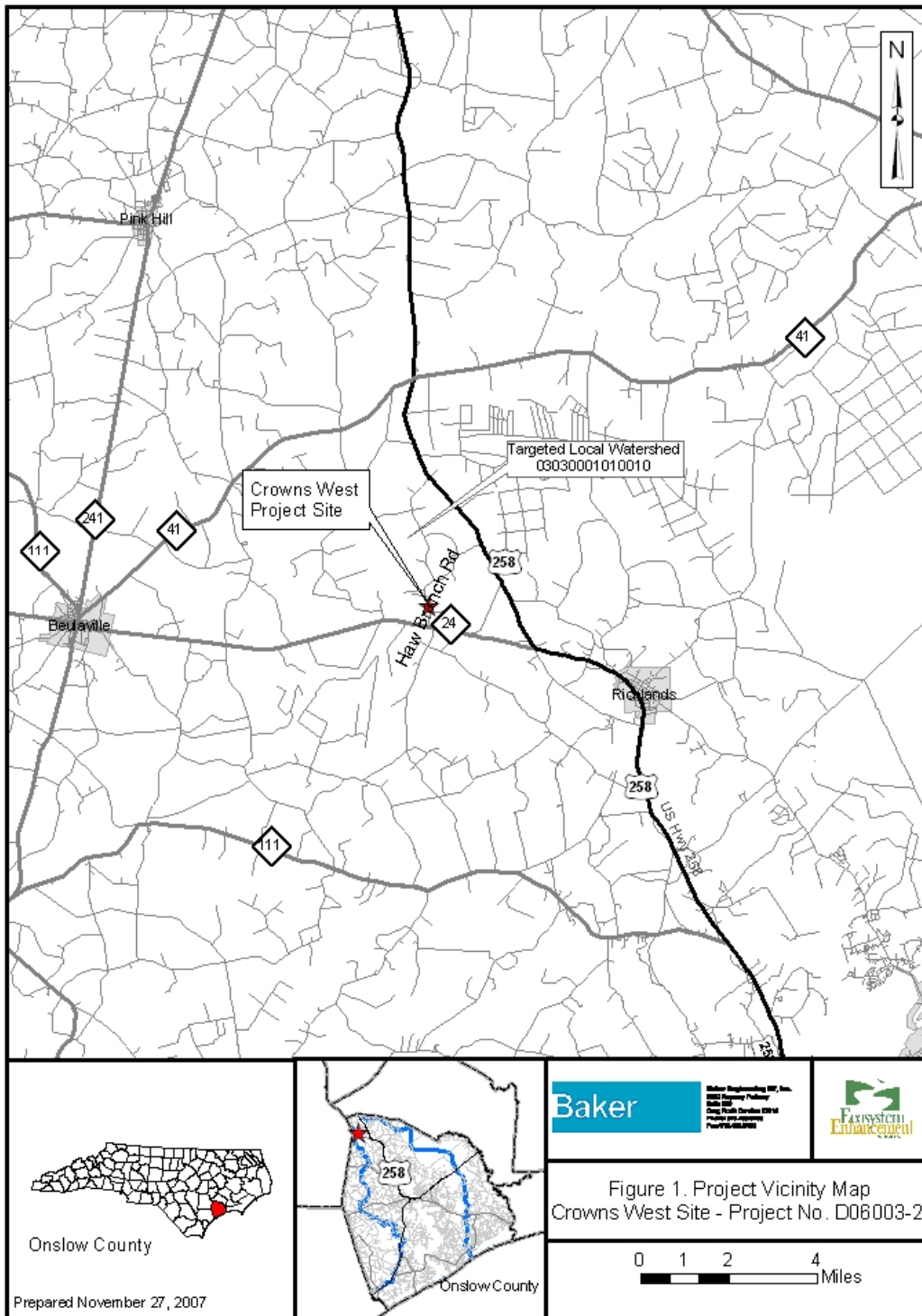
Rosgen, D. L. 1994. *A Classification of Natural Rivers*. Catena 22: 169-199.

Schafale, M. P., and A. S. Weakley. 1990. *Classification of the Natural Communities of North Carolina, Third Approximation*. North Carolina Natural Heritage Program, Division of Parks and Recreation. NCDENR. Raleigh, NC.

USDA, NC Agricultural Experiment Station, *Soil Survey of Onslow County, North Carolina*, 1992.



# **FIGURES**



**Figure 1. Location of Crowns West Stream Restoration Site.**

**PROJECT: D06003 - 2 CROWNS WEST**

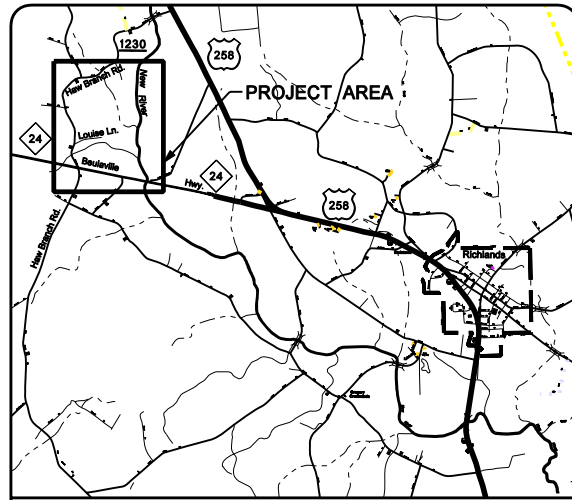
**CROWNS WEST STREAM RESTORATION PROJECT**  
**PROJECT # - D06003-2**

**ONSLOW COUNTY**

**LOCATION: OFF HAW BRANCH ROAD SR 1230  
 NORTHWEST OF RICHLANDS**

**TYPE OF WORK: AS-BUILT FOR STREAM RESTORATION**

STATE	BUCK PROJECT REFERENCE NO.	SHEET NO.	TOTAL SHEETS
NC	0290R	1	13
NO.	DATE	CHECKED BY	APPROVED BY
1	04/09/07	JOSHUA WHITE	KEVIN TWEEDY
2	04/30/07	JOSHUA WHITE	KEVIN TWEEDY



**VICINITY MAP**

**INDEX OF SHEETS**

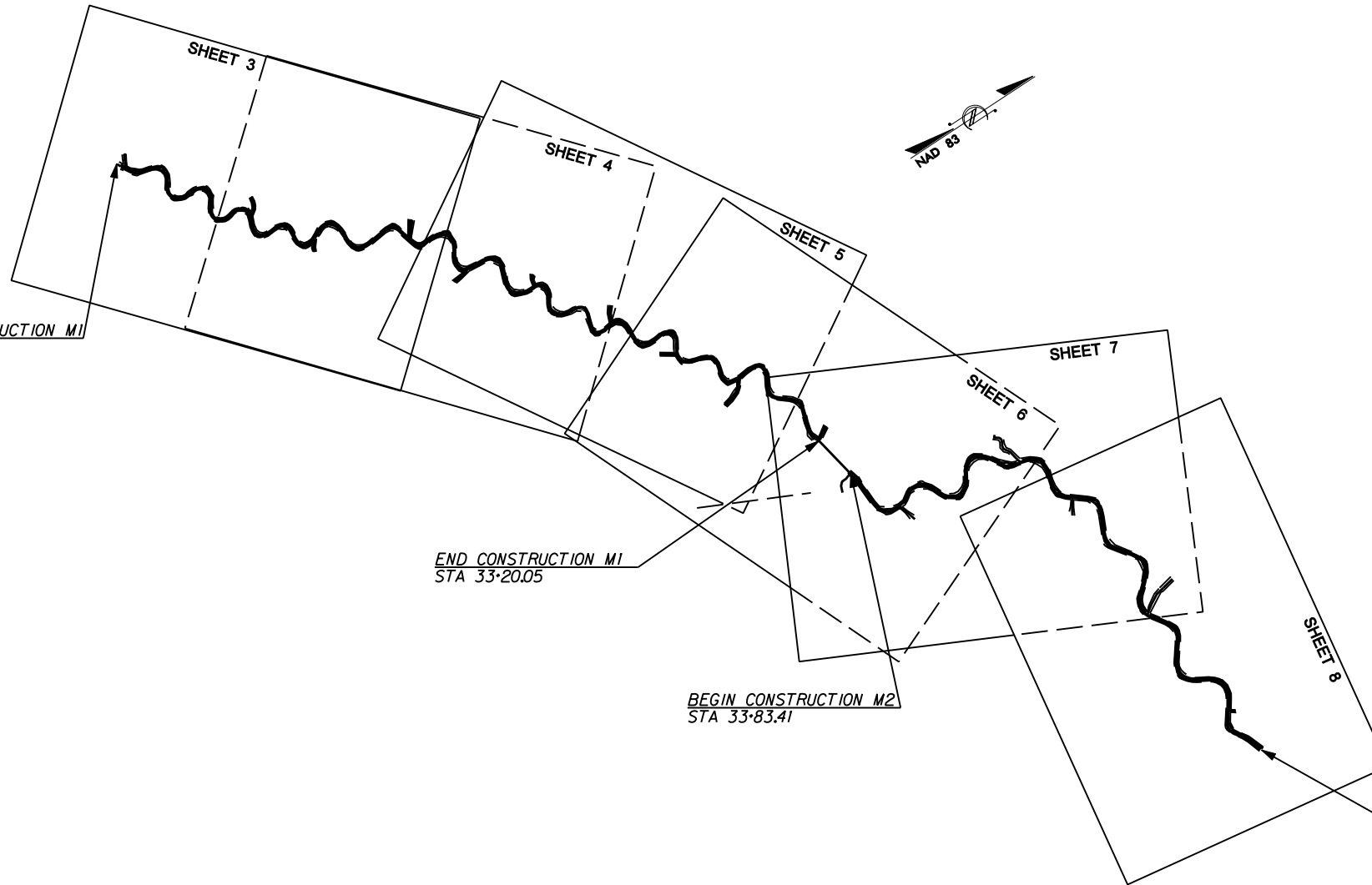
- 1 TITLE SHEET
- 1-A STREAM CONVENTIONAL SYMBOLS  
GENERAL NOTES, STANDARD SPECIFICATIONS, AND VEGETATION SELECTION
- 1-B CONVENTIONAL SYMBOLS
- 2 TO 2-C TYPICAL POOL AND RIFFLE CROSS SECTIONS, STRUCTURE DETAILS
- 3 TO 8 AS-BUILT PLAN VIEWS

*BEGIN CONSTRUCTION M1*  
 STA 10+00.00  
 77.6368° W  
 34.9254° N

*END CONSTRUCTION M1*  
 STA 33+20.05

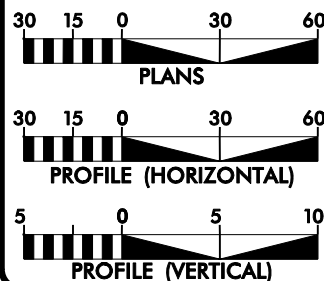
*BEGIN CONSTRUCTION M2*  
 STA 33+83.41

*END CONSTRUCTION M2*  
 STA 48+98.44  
 77.6285° W  
 34.9290° N



**FIGURE 2A**

**GRAPHIC SCALES**



**DESIGN DATA**

EXISTING STREAM LENGTH = 3334 FT  
 AS-BUILT STREAM LENGTH = 3835 FT

PROJECT REACH	EXISTING	AS-BUILT
M1	1819 FT	2320 FT
M2	1515 FT	1515 FT

**PREPARED FOR THE OFFICE OF:**  
 NCDENR - ECOSYSTEM ENHANCEMENT PROGRAM  
 2728 CAPITAL BLVD, SUITE 1H 103  
 RALEIGH, NC 27604



**CONTACT:** GUY PEARCE  
 REP FULL DELIVERY COORDINATOR

**PREPARED IN THE OFFICE OF:**

**Baker**  
Baker Engineering  
 6020 Research Parkway  
 Suite 200  
 Cary, NORTH CAROLINA 27518  
 Phone: 919.483.6400  
 Fax: 919.483.6490

MARCH 2007  
 COMPLETION DATE:

KEVIN TWEEDY, PE  
 PROJECT ENGINEER

JOSHUA WHITE  
 PROJECT DESIGNER

**PROJECT ENGINEER**

THIS DOCUMENT  
 ORIGINALLY ISSUED AND  
 SEALED BY:

KEVIN L. TWEEDY  
 027337  
 APRIL 30, 2007

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SIGNATURE: \_\_\_\_\_ P.E.

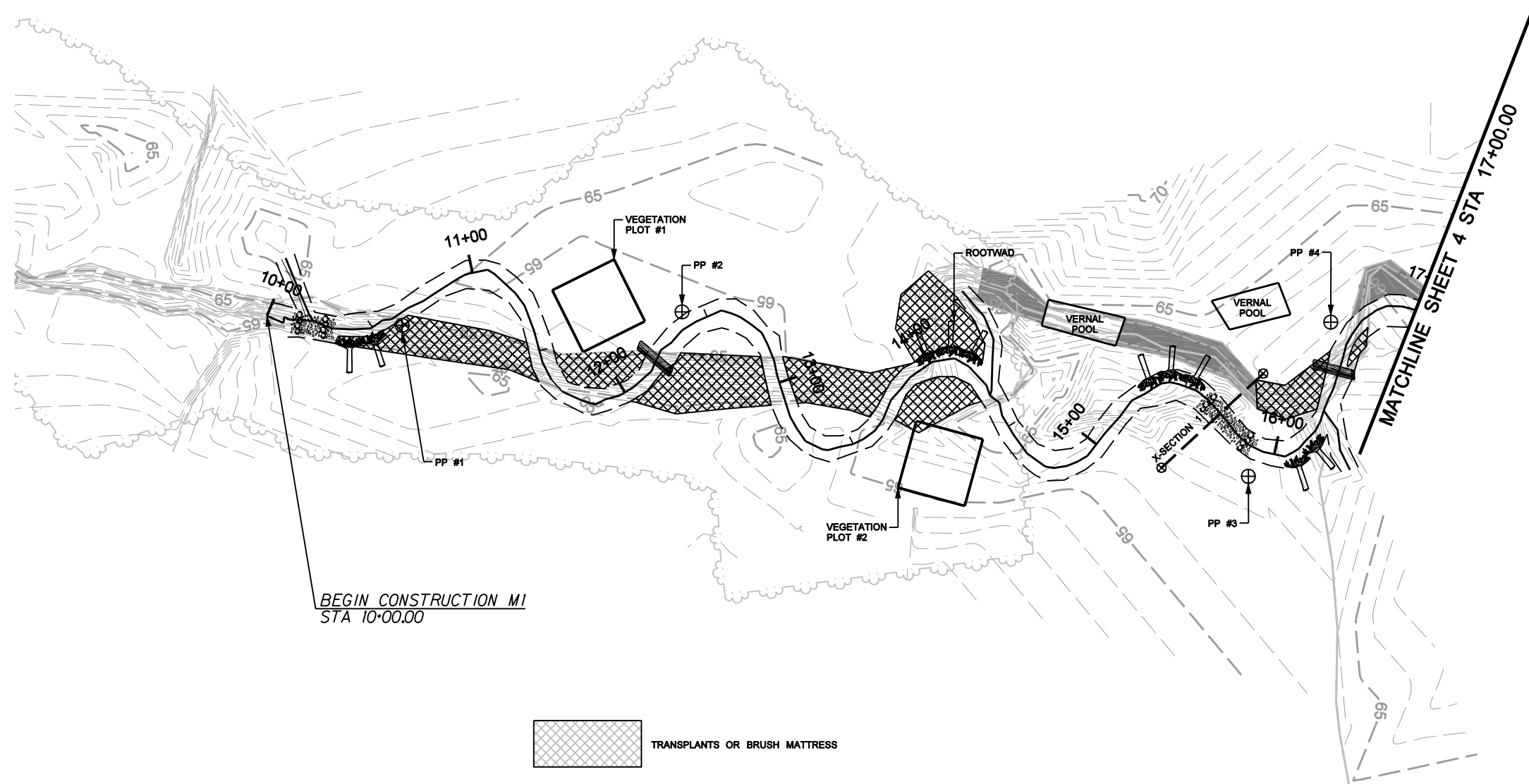
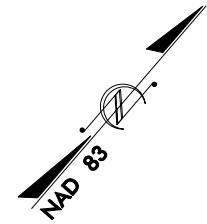
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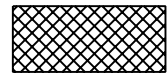

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5000 Regency Parkway  
Suite 200  
Cary, NORTH CAROLINA 27518  
Phone: 919.463.5488  
Fax: 919.463.5490



BEGIN CONSTRUCTION MI  
STA 10+00.00

-  TRANSPLANTS OR BRUSH MATTRESS
-  DITCH PLUG
-  CHANNEL FILL

NOTE:  
PRESERVED TREES WHERE POSSIBLE BETWEEN STATIONS 10+00 TO 33+66.

NOTE:  
CONTOURS SHOWN ARE PRE-RESTORATION CONDITIONS.

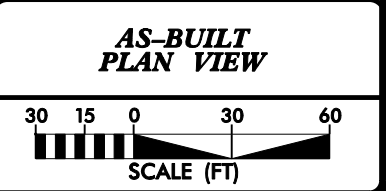


FIGURE 2B

2/26/03

11/27/2007  
F:\0290R\design\as-built\0290R\_Buck\_ASB\_04.dgn

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Phone: 919.463.5488  
Fax: 919.463.5490



NOTE:  
CONTOURS SHOWN ARE PRE-RESTORATION CONDITIONS.

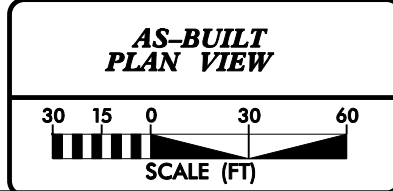


FIGURE 2C

IV/27/2007  
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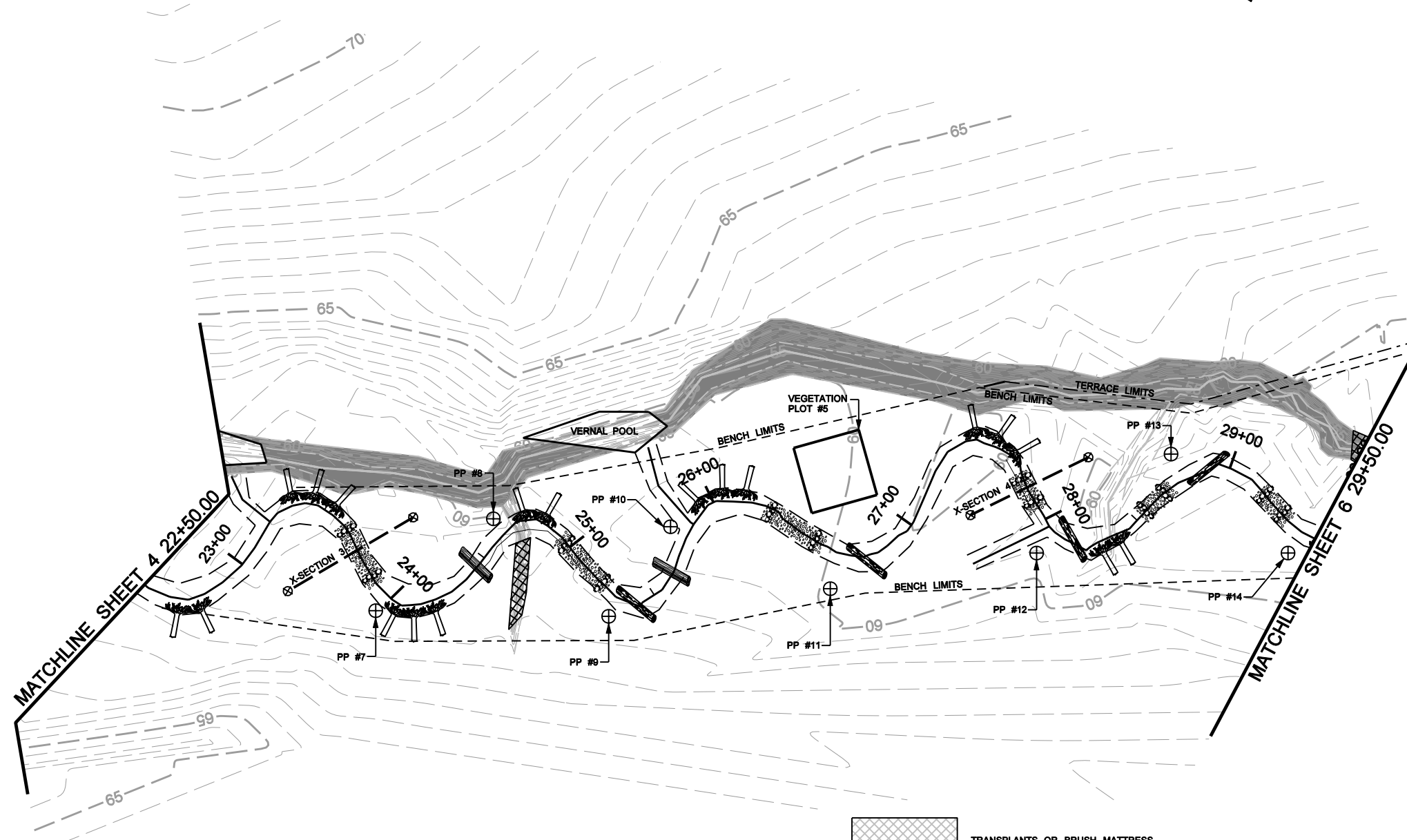
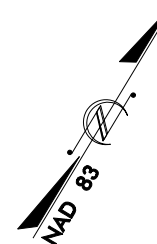
THIS DOCUMENT  
ORIGINALLY ISSUED AND  
SEALED BY:


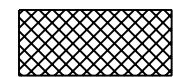

KEVIN L. TWEEDY  
027337  
APRIL 30, 2007

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Phone: 919.463.5488  
Fax: 919.463.5490



-  TRANSPLANTS OR BRUSH MATTRESS
-  DITCH PLUG
-  CHANNEL FILL

NOTE:  
PRESERVED TREES WHERE POSSIBLE BETWEEN STATIONS 10+00 TO 33+66.

NOTE:  
CONTOURS SHOWN ARE PRE-RESTORATION CONDITIONS.

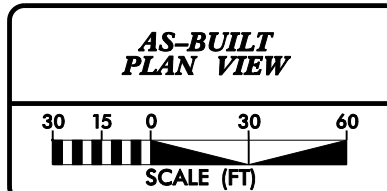
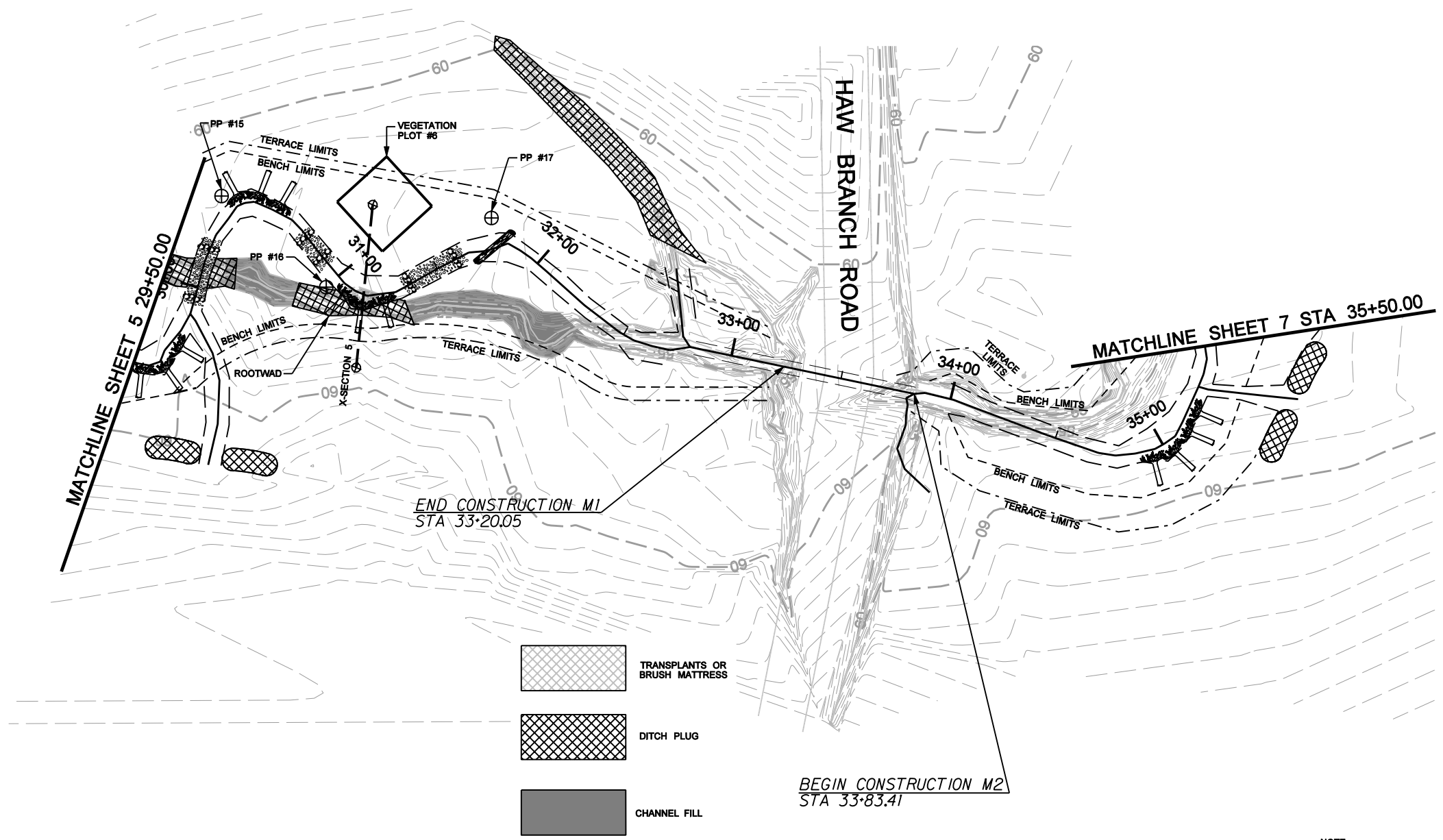
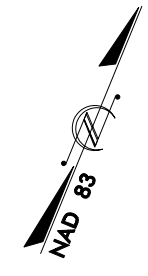


FIGURE 2D

2/26/03

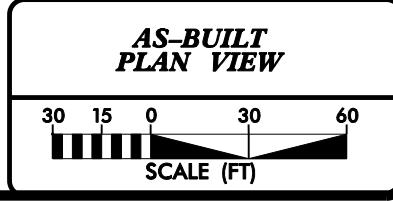
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F:\0290R\design\as-built\0290R\_Buck\_ASB\_06.dgn



NOTE:  
PRESERVED TREES WHERE POSSIBLE BETWEEN STATIONS 10+00 TO 33+66.

NOTE:  
CONTOURS SHOWN ARE PRE-RESTORATION CONDITIONS.

FIGURE 2E



2/26/03  
 11/27/2007  
 F:\0290R\design\as-built\0290R\_Buck\_ASB\_07.dgn

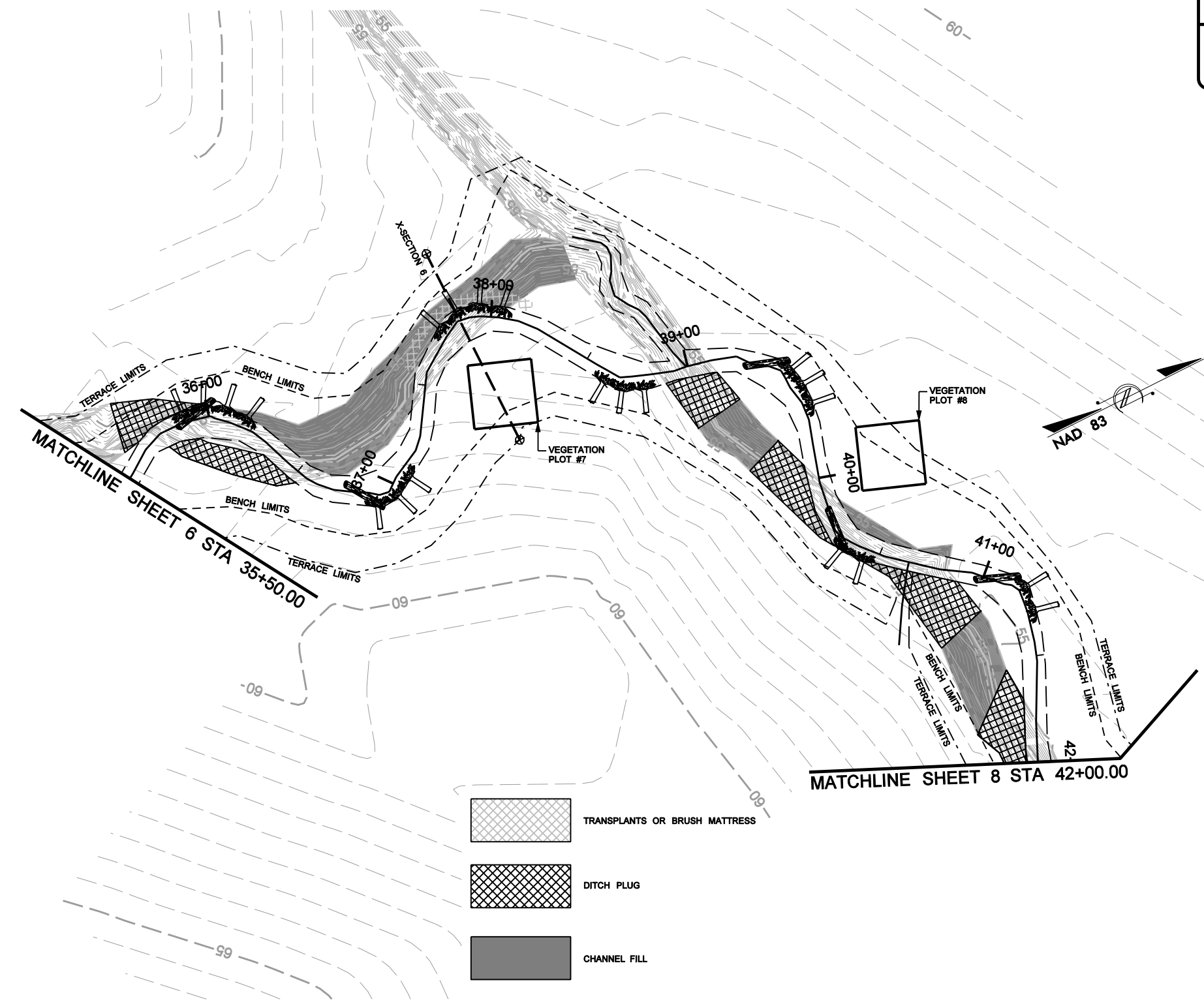
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Phone: 919.463.5488  
Fax: 919.463.5490



NOTE:  
CONTOURS SHOWN ARE PRE-RESTORATION CONDITIONS.

**AS-BUILT  
PLAN VIEW**

30 15 0 30 60  
SCALE (FT)

FIGURE 2F

2/26/03  
 11/27/2007  
 F:\0290R\design\as-built\0290R\_Buck\_ASB\_08.dgn



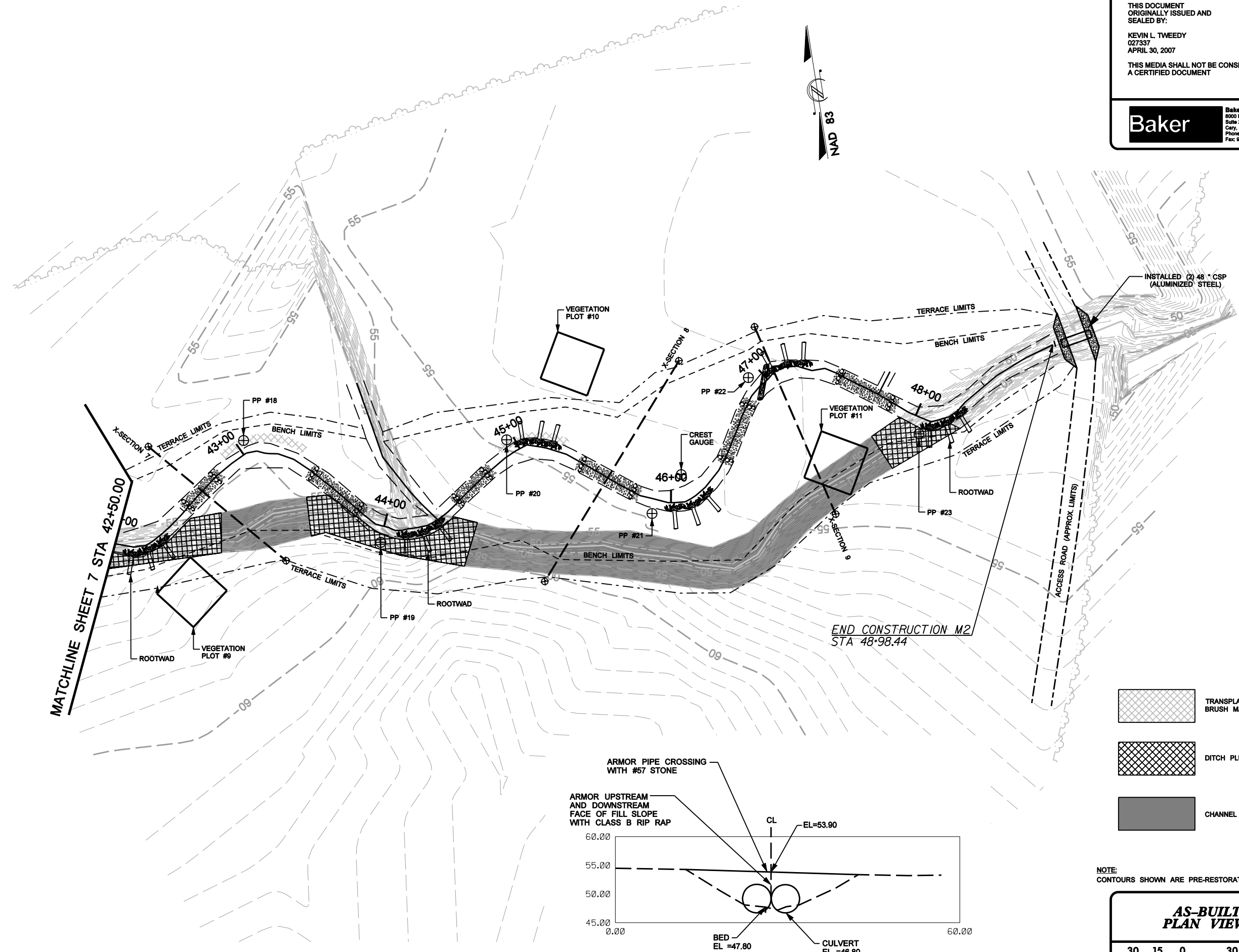
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Fax: 919.493.5490



-  TRANSPLANTS OR BRUSH MATTRESS
-  DITCH PLUG
-  CHANNEL FILL

NOTE:  
CONTOURS SHOWN ARE PRE-RESTORATION CONDITIONS.

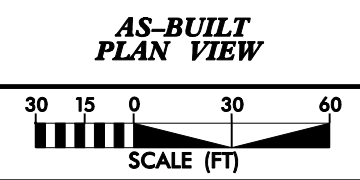
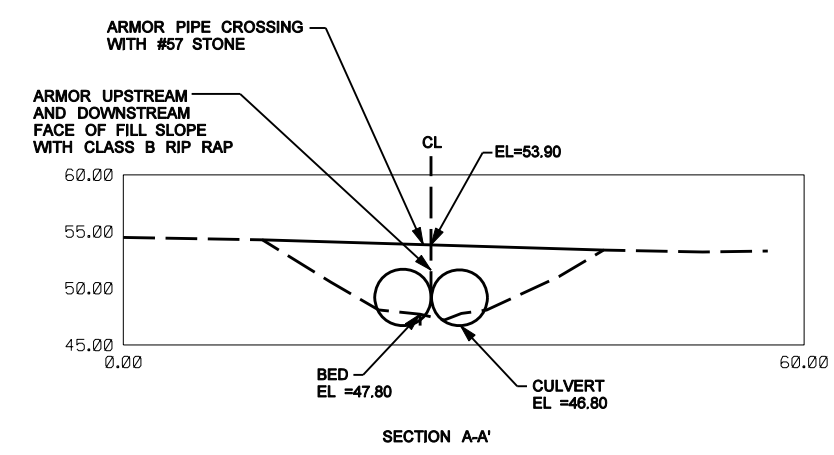


FIGURE 2G

2/26/03  
11/27/2007  
F:\0290R\design\as-built\0290R\_Buck\_ASB\_09.dgn

# **APPENDIX A**

## **VEGETATION RAW DATA**

# **VEGETATION TABLES**

**Table A.1. Vegetation Metadata**

<b>Crowns West Restoration Site: Project No. D06003-2</b>	
<b>Report Pr</b>	Dwayne Huneycutt
<b>Date Prep</b>	12/12/2007 14:20
<b>database</b>	CVS_EEP_EntryTool_v220.mdb
<b>database</b>	C:\Program Files\CVS Data Tool
<b>computer</b>	DHUNEYCUTT-2
<b>DESCRIPTION OF WORKSHEETS IN THIS DOCUMENT-----</b>	
<b>Metadata</b>	This worksheet, which is a summary of the project and the project data.
<b>Proj, plan</b>	Each project is listed with its PLANTED stems, for each year. This excludes live stakes and lists stems per acre.
<b>Proj, total</b>	Each project is listed with its TOTAL stems, for each year. This includes live stakes, all planted stems, and all natural/volunteer stems. Listed in stems per acre.
<b>Plots</b>	List of plots surveyed.
<b>Vigor</b>	Frequency distribution of vigor classes.
<b>Vigor by S</b>	Frequency distribution of vigor classes listed by species.
<b>Damage</b>	List of most frequent damage classes with number of occurrences and percent of total stems impacted by each.
<b>Damage b</b>	Damage values tallied by type for each species.
<b>Damage t</b>	Damage values tallied by type for each plot.
<b>Planted S</b>	Count of planted living stems of each species for each plot; dead and missing stems are excluded.
<b>PROJECT SUMMARY-----</b>	
<b>Project C</b>	D060032
<b>project N</b>	Crowns West
<b>Descriptio</b>	Stream Restoration Project
<b>River Bas</b>	White Oak
<b>length(ft)</b>	3835
<b>stream-to</b>	50
<b>area (sq n</b>	35624.71
<b>Required</b>	10
<b>Sampled l</b>	11

**Table A.2. Vegetation Vigor by Species**

<b>Crowns West Restoration Site: Project No. D06003-2</b>							
	<b>Species</b>	<b>4</b>	<b>3</b>	<b>2</b>	<b>1</b>	<b>0</b>	<b>Missing</b>
	Betula nigra	4	9	5			
	Celtis laevigata		4				
	Fraxinus pennsylvanica	3	13	1			
	Juglans nigra		8	5			
	Nyssa biflora	5	22	3			
	Quercus lyrata	7	12	1			
	Quercus michauxii	3	9				
	Quercus phellos		7	6			
	Taxodium distichum	11	11				
	Platanus occidentalis	8	29	13	1		
	Unknown	1	2	1		20	
<b>TOT:</b>	<b>11</b>	<b>42</b>	<b>126</b>	<b>35</b>	<b>1</b>	<b>20</b>	

**Table A.3. Vegetation Damage by Species**

<b>Crowns West Restoration Site: Project No. D06003-2</b>					
	<b>Species</b>	<b>All Damage Categories</b>	<b>(No damage)</b>	<b>Unknown</b>	<b>Vine Strangulation</b>
	Betula nigra	18	18		
	Celtis laevigata	4	4		
	Fraxinus pennsylvanica	17	17		
	Juglans nigra	13	13		
	Nyssa biflora	30	30		
	Platanus occidentalis	51	50		1
	Quercus lyrata	20	19	1	
	Quercus michauxii	12	12		
	Quercus phellos	13	13		
	Taxodium distichum	22	22		
	Unknown	24	4	17	3
<b>TOT:</b>	<b>11</b>	<b>224</b>	<b>202</b>	<b>18</b>	<b>4</b>

Table A.4. Vegetation Damage by Plot

Crowns West Restoration Site: Project No. D06003-2				
Plot	All Damage Categories	(No damage)	Unknown	Vine Strangulation
D060032-DH-0001-year:1	18	14		4
D060032-DH-0002-year:1	18	17	1	
D060032-DH-0003-year:1	15	14	1	
D060032-DH-0004-year:1	16	15	1	
D060032-DH-0005-year:1	24	23	1	
D060032-DH-0006-year:1	19	19		
D060032-DH-0007-year:1	16	16		
D060032-DH-0008-year:1	26	24	2	
D060032-DH-0009-year:1	21	16	5	
D060032-DH-0010-year:1	27	22	5	
D060032-DH-0011-year:1	24	22	2	
<b>TOT:</b>	<b>11</b>	<b>224</b>	<b>202</b>	<b>18</b>

Table A.5. Stem Count by Plot and Species

Crowns West Restoration Site: Project No. D06003-2															
Species	Total Planted Stems	# Plots	Avg# stems	Plot D060032-DH-0001-year:1	Plot D060032-DH-0002-year:1	Plot D060032-DH-0003-year:1	Plot D060032-DH-0004-year:1	Plot D060032-DH-0005-year:1	Plot D060032-DH-0006-year:1	Plot D060032-DH-0007-year:1	Plot D060032-DH-0008-year:1	Plot D060032-DH-0009-year:1	Plot D060032-DH-0010-year:1	Plot D060032-DH-0011-year:1	
Betula nigra	18	7	2.57	3	1		1	7	1				4	1	
Celtis laevigata	4	3	1.33				2				1	1			
Fraxinus pennsylvanica	17	6	2.83		2	2				7	1		1	4	
Juglans nigra	13	5	2.6						3	1	1	1		7	
Nyssa biflora	30	9	3.33	1	4	2	3	4	1		4		4	7	
Platanus occidentalis	51	11	4.64	7	8	7	4	1	6	1	6	5	5	1	
Quercus lyrata	20	6	3.33	1	1				5	3		5	5		
Quercus michauxii	12	7	1.71				3		2	2	1	1	2	1	
Quercus phellos	13	5	2.6	3		2				1	2		5		
Taxodium distichum	22	6	3.67		3	1		10	1	1	6				
Unknown	4	3	1.33					1					2	1	
<b>TOT:</b>	<b>11</b>	<b>204</b>		<b>15</b>	<b>17</b>	<b>14</b>	<b>15</b>	<b>23</b>	<b>19</b>	<b>16</b>	<b>24</b>	<b>17</b>	<b>22</b>	<b>22</b>	

**Table A.6. Stem Count for Each Species Arranged by Plot  
Crowns West Restoration Site**

Tree Species	Plots											Year 1 Totals	Average Stems/acre
	1	2	3	4	5	6	7	8	9	10	11		
<i>Betula nigra</i>	3	1	0	1	7	1	0	0	4	0	1	18	N/A
<i>Celtis laevigata</i>	0	0	0	2	0	0	0	1	1	0	0	4	
<i>Fraxinus pennsylvanica</i>	0	0	2	2	0	0	7	1	0	1	4	17	
<i>Juglans nigra</i>	0	0	0	0	1	3	1	3	1	0	7	16	
<i>Nyssa biflora</i>	1	4	2	3	4	1	0	4	0	4	7	30	
<i>Platanus occidentalis</i>	7	8	7	4	1	6	1	6	5	5	1	51	
<i>Quercus lyrata</i>	1	1	0	0	0	5	3	0	5	5	0	20	
<i>Quercus michauxii</i>	0	0	0	3	0	2	2	1	1	2	1	12	
<i>Quercus phellos</i>	3	0	2	0	0	0	1	2	0	5	0	13	
<i>Taxodium distichum</i>	0	3	1	0	10	1	1	6	0	0	0	22	
<b>Stems/plot</b>	15	17	14	15	23	19	16	24	17	22	21	18	
<b>Stems/acre Year 1</b>	600	680	560	600	920	760	640	960	680	880	840	N/A	738
<b>Stems/acre Initial</b>	729	729	607	648	972	760	640	1053	850	1093	931	N/A	819

# **VEGETATION PHOTOS**





Vegetation Plot 1



Herbaceous Vegetation Plot 1



Vegetation Plot 2



Herbaceous Vegetation Plot 2



Vegetation Plot 3



Herbaceous Vegetation Plot 3



Vegetation Plot 4



Herbaceous Vegetation Plot 4



Vegetation Plot 5



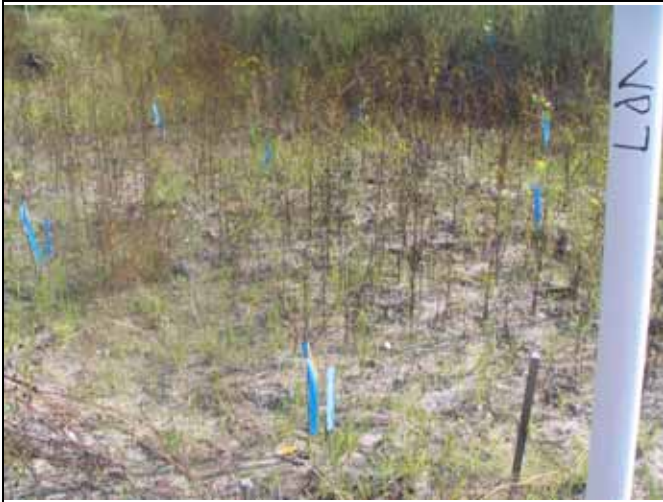
Herbaceous Vegetation Plot 5



Vegetation Plot 6



Herbaceous Vegetation Plot 6



Vegetation Plot 7



Herbaceous Vegetation Plot 7



Vegetation Plot 8



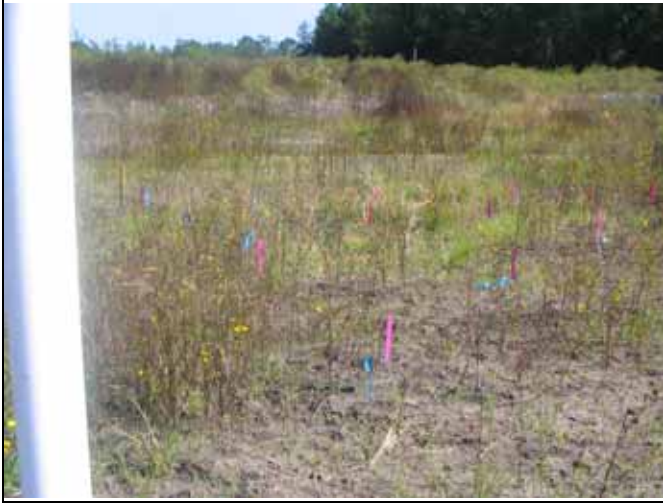
Herbaceous Vegetation Plot 8



Vegetation Plot 9



Herbaceous Vegetation Plot 9



Vegetation Plot 10



Herbaceous Vegetation Plot 10



Vegetation Plot 11



Herbaceous Vegetation Plot 11

# **APPENDIX B**

## **GEOMORPHIC RAW DATA**

# **STREAM TABLES**

**Table B.1. Categorical Stream Feature Visual Stability Assessment**

<b>Crowns Wet Restoration Site: Project No. D06003-2</b>						
<b>Feature</b>	<b>Performance Percentage</b>					
	<b>Initial</b>	<b>MY-01</b>	<b>MY-02</b>	<b>MY-03</b>	<b>MY-04</b>	<b>MY-05</b>
A. Riffles	100%	100%				
B. Pools	100%	100%				
C. Thalweg	100%	100%				
D. Meanders	100%	100%				
E. Bed General	100%	100%				
F. Bank Condition	100%	100%				
G. Wads	100%	100%				

Table B.2. Baseline Stream Summary

Crowns West Restoration Site: Project No. D06003-2

Crowns West - Reach M1

Parameter	USGS Gauge		Regional Curve Interval			Pre-Existing Condition			Reference Reach(es) Data			Design			As-built		
	-----	-----	LL	UL	Eq.	Min	Mean	Max	Min	Mean	Max	Min	Med	Max	Min	Mean	Max
<b>Dimension - Riffle</b>																	
BF Width (ft)	-----	-----	-----	-----	-----	5.6	5.9	6.2	-----	-----	-----	9	9.0	9.0	8.8	10.1	11.3
Floodprone Width (ft)	-----	-----	-----	-----	-----	8.0	10.5	13.0	-----	-----	-----	70.0	90.0	110.0	58.2	61	64.6
BF Mean Depth (ft)	-----	-----	-----	-----	-----	1.4	1.6	1.7	-----	-----	-----	0.9	0.9	0.9	0.72	0.73	0.74
BF Max Depth (ft)	-----	-----	-----	-----	-----	1.70	2.0	2.20	1.5	1.6	1.7	1.1	1.2	1.2	1.2	1.2	1.3
BF Cross Sectional Area (ft²)	-----	-----	-----	-----	-----	8.4	9.0	9.5	24	24.0	24	8.0	8.0	8.0	6.3	8.4	7.4
Width/Depth Ratio	-----	-----	-----	-----	-----	3.4	3.9	4.3	11.0	14.0	17.0	-----	10.0	-----	12.2	13.9	15.3
Entrenchment Ratio	-----	-----	-----	-----	-----	1.3	1.8	2.2	10.0	10.5	11.0	7.0	9.0	11.0	5.3	6.1	6.6
Bank Height Ratio	-----	-----	-----	-----	-----	2.7	2.8	2.9	1.0	1.2	1.3	1.0	1.1	1.2	1.0	1.0	1.0
BF Velocity (fps)	-----	-----	-----	-----	-----	-----	-----	-----	1.5	1.5	1.5	2.2	-----	2.2	-----	-----	-----
<b>Pattern</b>																	
Channel Beltwidth (ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	45	58.5	72	-----	-----	-----
Radius of Curvature (ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	18	27	36	-----	-----	-----
Meander Wavelength (ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Meander Width Ratio	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	5	6.5	8	-----	-----	-----
<b>Profile</b>																	
Riffle Length (ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Riffle Slope (ft/ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Pool Length (ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Pool Spacing (ft)	-----	-----	-----	-----	-----	-----	-----	-----	2.5	-----	3.4	23	34	45	-----	-----	-----
<b>Substrate and Transport Parameters</b>																	
d16 / d35 / d50 / d84 / d95	-----	-----	-----	-----	-----	.2/.29/.36/.68/.94			.3/.4/.5/.9/1.2			-----	-----	-----	-----	-----	-----
Reach Shear Stress (competency) lb/ft²	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Stream Power (transport capacity) W/m²	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
<b>Additional Reach Parameters</b>																	
Channel length (ft)	-----	-----	-----	-----	-----	-----	1,938	-----	-----	-----	-----	-----	2,372	-----	-----	2,275	-----
Drainage Area (SM)	-----	-----	-----	-----	-----	-----	0.7	-----	3	-----	3	-----	0.7	-----	-----	0.7	-----
Rosgen Classification	-----	-----	-----	-----	-----	-----	G5/E5	-----	-----	C5c	-----	-----	E5	-----	-----	E5	-----
BF Discharge (cfs)	-----	-----	-----	-----	-----	-----	-----	-----	37	37	37	-----	17.3	-----	-----	-----	-----
Sinuosity	-----	-----	-----	-----	-----	-----	1.27	-----	-----	1.66	-----	-----	1.4	-----	-----	1.4	-----
BF slope (ft/ft)	-----	-----	-----	-----	-----	-----	0.004	-----	-----	0.0004	-----	-----	0.0030	-----	-----	0.004	-----



**Crowns West - Reach M2**

Parameter	USGS Gauge		Regional Curve Interval			Pre-Existing Condition			Reference Reach(es) Data			Design			As-built		
	-----	-----	LL	UL	Eq.	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max
<b>Dimension - Riffle</b>																	
BF Width (ft)	-----	-----	-----	-----	-----	5.8	-----	12.0	-----	-----	-----	-----	10	-----	8.77	10.13	11.52
Floodprone Width (ft)	-----	-----	-----	-----	-----	17.0	-----	37.0	-----	-----	-----	60.0	70.0	80.0	58.2	78.4	133.1
BF Mean Depth (ft)	-----	-----	-----	-----	-----	1.4	-----	1.8	-----	-----	-----	1.0	1.0	1.0	0.71	0.84	1.12
BF Max Depth (ft)	-----	-----	-----	-----	-----	2.5	-----	3.0	1.5	-----	1.7	1.2	1.3	1.3	1.19	1.41	1.80
BF Cross Sectional Area (ft²)	-----	-----	-----	-----	-----	9.7	-----	16.8	24	24	24	10.0	10	10.0	6.3	8.5	10.6
Width/Depth Ratio	-----	-----	-----	-----	-----	3.4	-----	8.6	11.0	-----	17.0	-----	10.0	-----	8.5	12.4	15.8
Entrenchment Ratio	-----	-----	-----	-----	-----	1.5	-----	6.4	10.0	-----	11.0	6.0	7.0	8.0	5.2	7.9	14.1
Bank Height Ratio	-----	-----	-----	-----	-----	1.9	-----	2.3	1.0	-----	1.3	1.0	1.1	1.2	1.0	1.0	1.0
BF Velocity (fps)	-----	-----	-----	-----	-----	-----	-----	-----	1.5	-----	1.5	1.6	-----	1.6	-----	-----	-----
<b>Pattern</b>																	
Channel Beltwidth (ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	50	65	80	-----	-----	-----
Radius of Curvature (ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	20	30	40	-----	-----	-----
Meander Wavelength (ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Meander Width Ratio	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	5	6.5	8	-----	-----	-----
<b>Profile</b>																	
Riffle Length (ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Riffle Slope (ft/ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Pool Length (ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Pool Spacing (ft)	-----	-----	-----	-----	-----	-----	-----	-----	2.5	-----	3.4	25	38	50	-----	-----	-----
<b>Substrate and Transport Parameters</b>																	
d16 / d35 / d50 / d84 / d95	-----	-----	-----	-----	-----	.2/.29/.36/.68/.94			.3/.4/.5/.9/1.2			-----	-----	-----	-----	-----	-----
Reach Shear Stress (competency) lb/ft²	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Stream Power (transport capacity) W/m²	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
<b>Additional Reach Parameters</b>																	
Channel length (ft)	-----	-----	-----	-----	-----	-----	1396	-----	-----	-----	-----	-----	1528	-----	-----	1560	-----
Drainage Area (SM)	-----	-----	-----	-----	-----	-----	1	-----	3	-----	3	-----	1	-----	-----	1	-----
Rosgen Classification	-----	-----	-----	-----	-----	-----	G5/E5	-----	-----	C5c	-----	-----	E5	-----	-----	E5	-----
BF Discharge (cfs)	-----	-----	-----	-----	-----	-----	-----	-----	37	37	37	-----	16.2	-----	-----	-----	-----
Sinuosity	-----	-----	-----	-----	-----	-----	1.27	-----	-----	1.66	-----	-----	1.4	-----	-----	1.38	-----
BF slope (ft/ft)	-----	-----	-----	-----	-----	-----	0.004	-----	-----	0.0004	-----	-----	0.003	-----	-----	0.004	-----

**Table B.3. Morphology and Hydraulic Monitoring Summary**

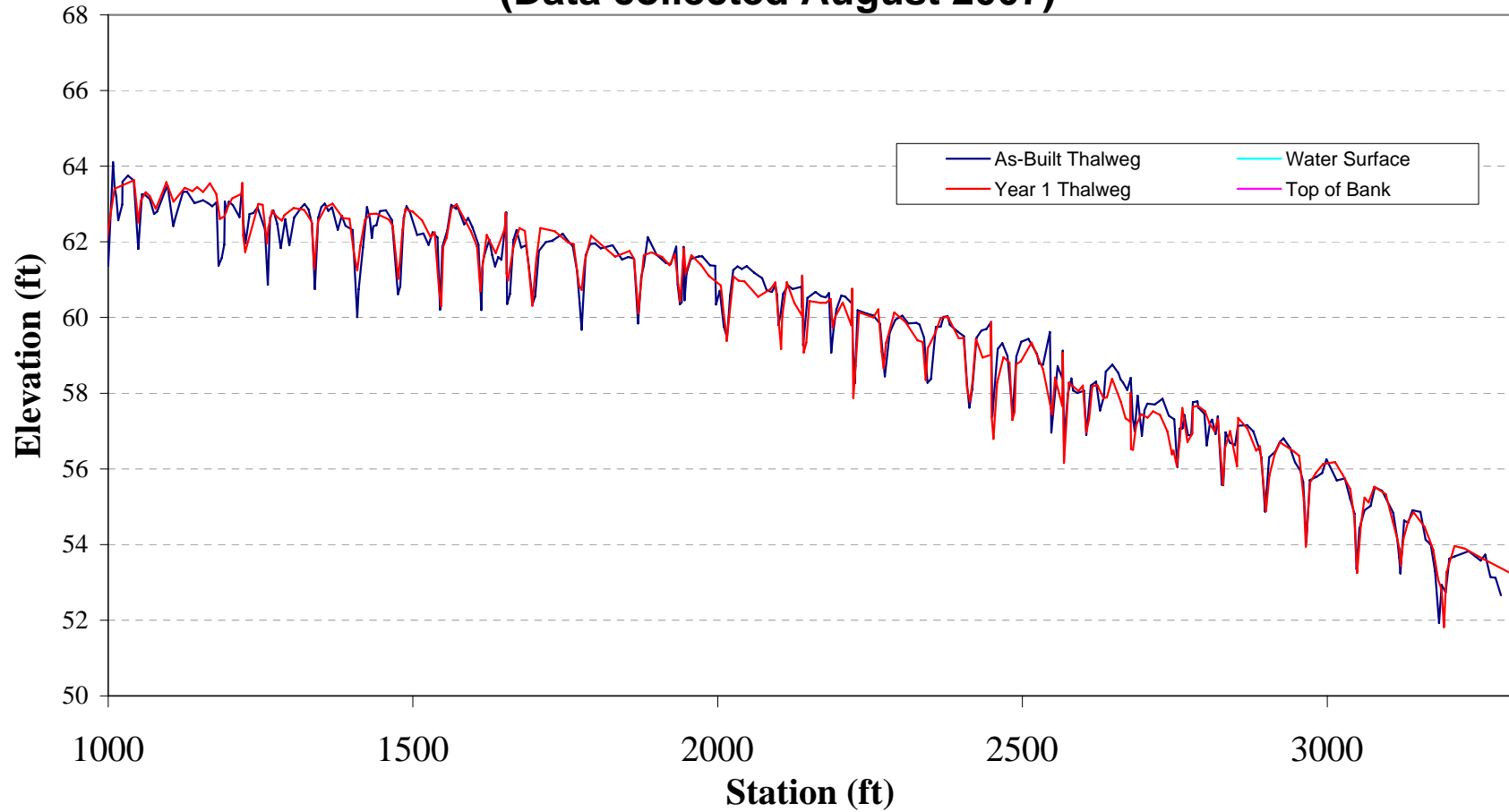
Crowns West Restoration Site: Project No. D06003-2																				
Reach: M1 (2320 feet)																				
Parameter	Cross Section 1 Riffle					Cross Section 2 Pool					Cross Section 3 Riffle					Cross Section 4 Riffle				
	MY1	MY2	MY3	MY4	MY5	MY1	MY2	MY3	MY4	MY5	MY1	MY2	MY3	MY4	MY5	MY1	MY2	MY3	MY4	MY5
<b>Dimension</b>																				
BF Width (ft)	11.52					12.38					10.32					8.77				
BF Mean Depth (ft)	0.73					1.89					0.71					0.72				
Width/Depth Ratio	15.8					6.5					14.5					12.18				
BF Cross-Sectional Area (ft <sup>2</sup> )	8.41					23.46					7.35					6.31				
BF Max Depth (ft)	1.25					3.05					1.27					1.19				
Width of Floodprone Area (ft)	60.22					69.87					64.56					58.25				
Entrenchment Ratio	5.23					5.64					6.26					6.64				
Bank Height Ratio	1					1.17					1.01					1				
Wetted Perimeter (ft)																				
Hydraulic Radius (ft)	-					-					-									
<b>Substrate</b>																				
d50 (mm)																				
d84 (mm)																				
<b>Parameter</b>	Cross Section 5 Pool																			
	MY1	MY2	MY3	MY4	MY5															
<b>Dimension</b>																				
BF Width (ft)	12.83																			
BF Mean Depth (ft)	1.15																			
Width/Depth Ratio	11.2																			
BF Cross-Sectional Area (ft <sup>2</sup> )	14.70																			
BF Max Depth (ft)	2.63																			
Width of Floodprone Area (ft)	65.99																			
Entrenchment Ratio	5.14																			
Bank Height Ratio	1																			
Wetted Perimeter (ft)																				
Hydraulic Radius (ft)	-																			
<b>Substrate</b>																				
d50 (mm)																				
d84 (mm)																				



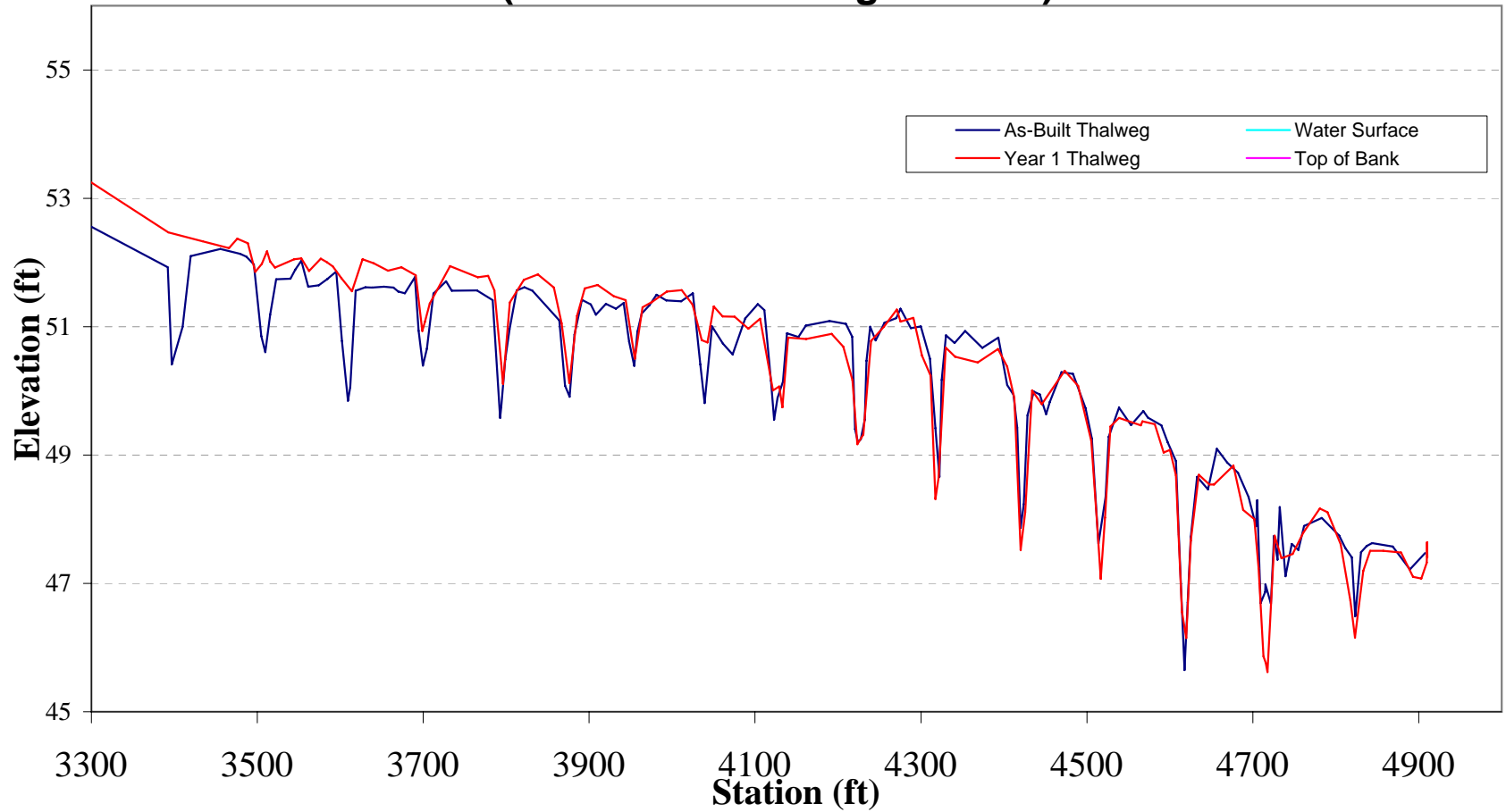


**STREAM DATA  
AND PHOTOS**

**Chart M1 - Year 1 - Station 10+00 to 33+00  
(Data collected August 2007)**



**Chart M2- Year 1 - Station 17+00 to 34+00  
(Data collected August 2007)**



**Permanent Cross-section 1**  
(Year 1 Data - Collected Aug. 2007)

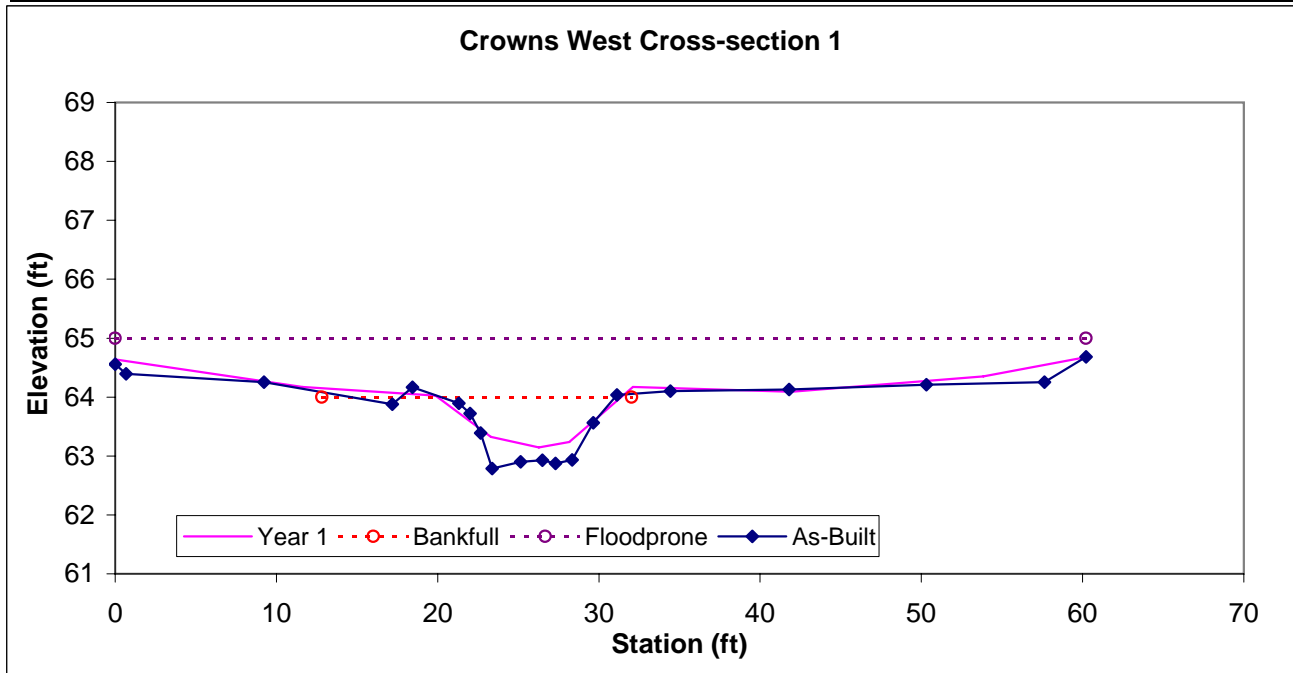


Looking at the Left Bank



Looking at the Right Bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	Cc	8.4	19.2	0.44	1	44.11	0.9	3.1	64	63.88





**Permanent Cross-section 2**  
(Year 1 Data - Collected Aug. 2007)

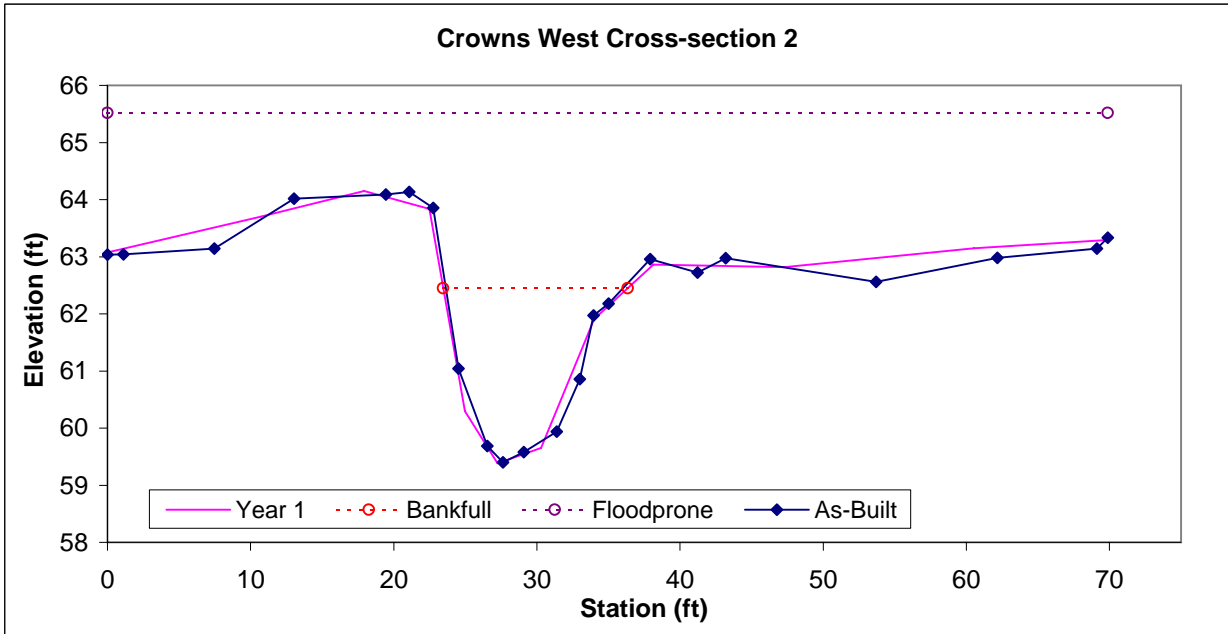


Looking at the Left Bank



Looking at the Right Bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Pool		23.3	12.88	1.81	3.07	7.11	1.1	5.4	62.45	62.86



**Permanent Cross-section 3**  
 (Year 1 Data - Collected Aug. 2007)

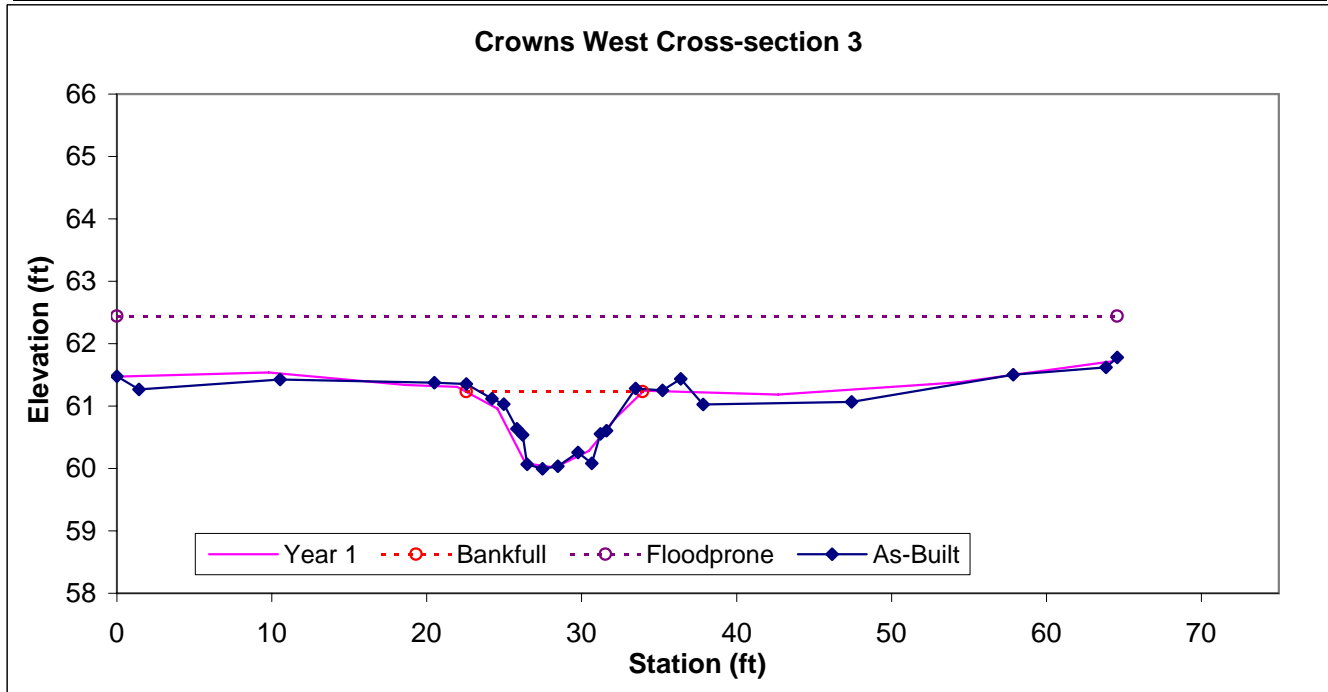


Looking at the Left Bank



Looking at the Right Bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	Cc	7.7	11.39	0.68	1.21	16.83	1	5.7	61.23	61.25



**Permanent Cross-section 4**  
 (Year 1 Data - Collected Aug. 2007)

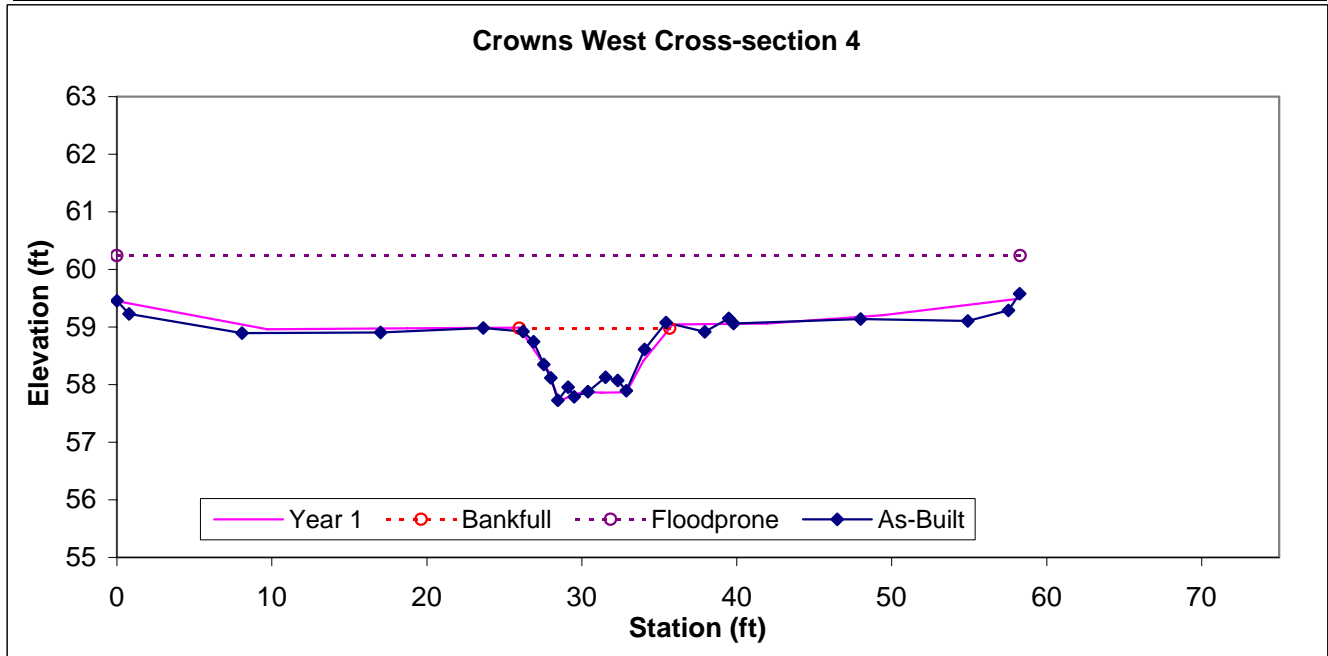


Looking at the Left Bank



Looking at the Right Bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	Cc	7.7	9.72	0.8	1.26	12.2	1	6	58.78	58.79



**Permanent Cross-section 5**  
(Year 1 Data - Collected Aug. 2007)

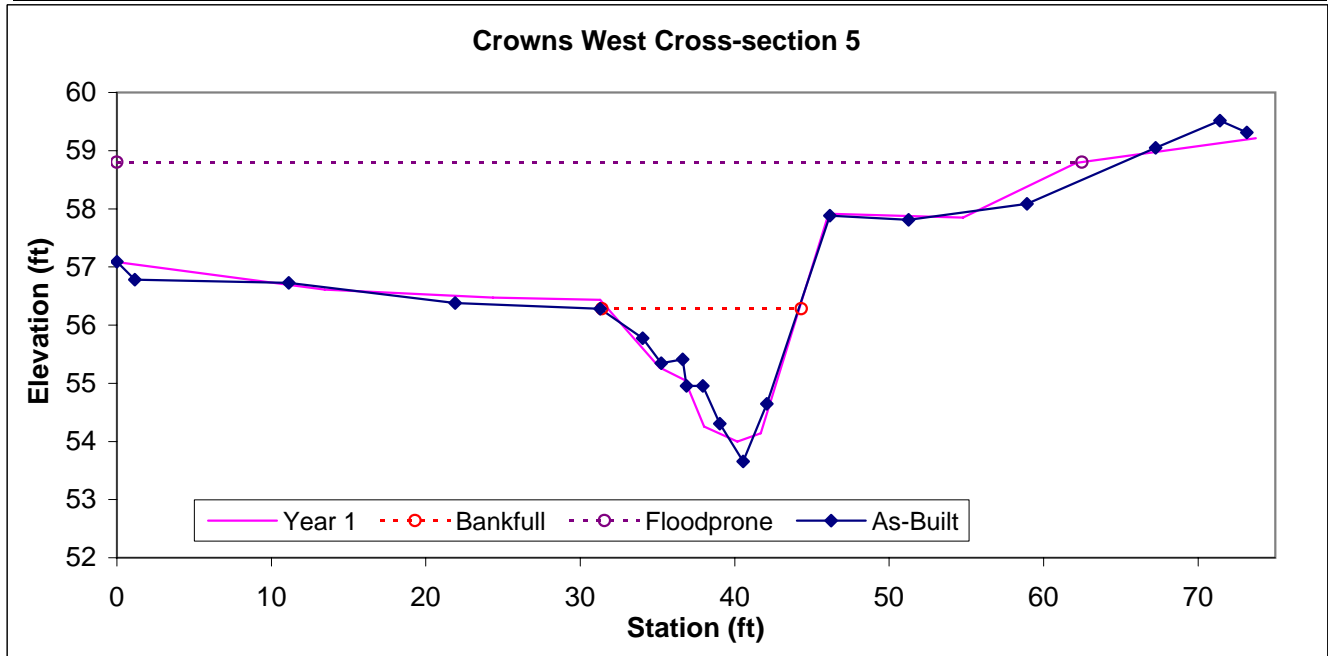


**Looking at the Left Bank**



**Looking at the Right Bank**

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Pool		17.7	12.92	1.37	2.4	9.42	1	4.8	56.28	56.32



**Permanent Cross-section 6**  
 (Year 1 Data - Collected Aug. 2007)

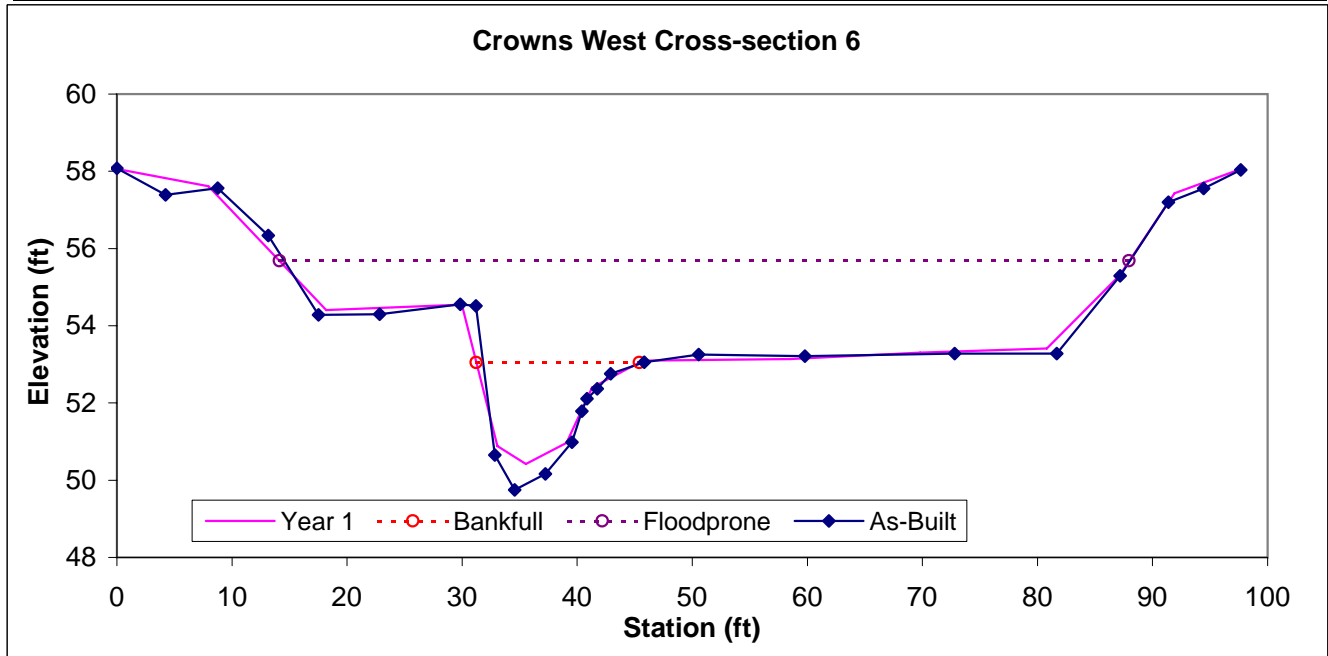


Looking at the Left Bank



Looking at the Right Bank

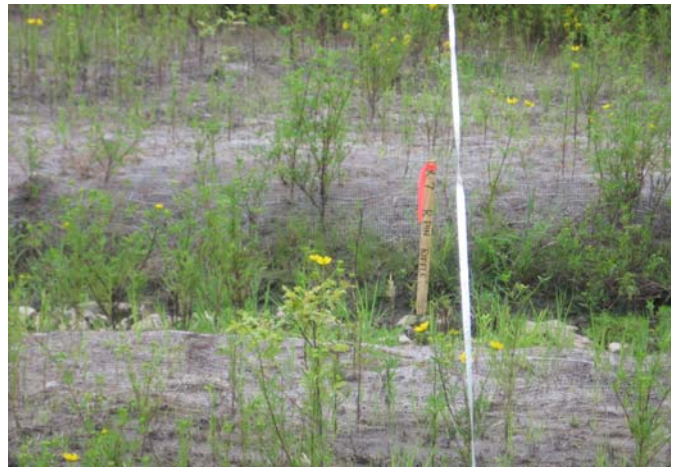
Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Pool		20.6	14.17	1.45	2.63	9.75	1	5.2	53.05	53.1



**Permanent Cross-section 7**  
 (Year 1 Data - Collected Aug. 2007)

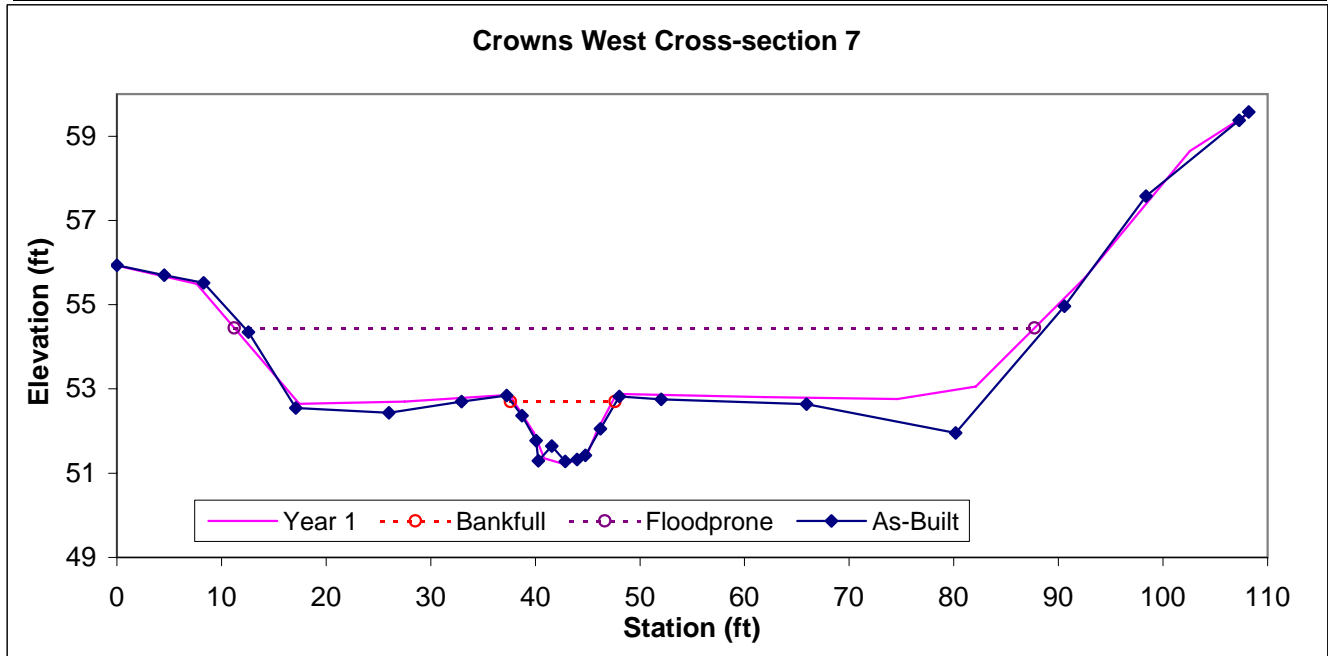


Looking at the Left Bank

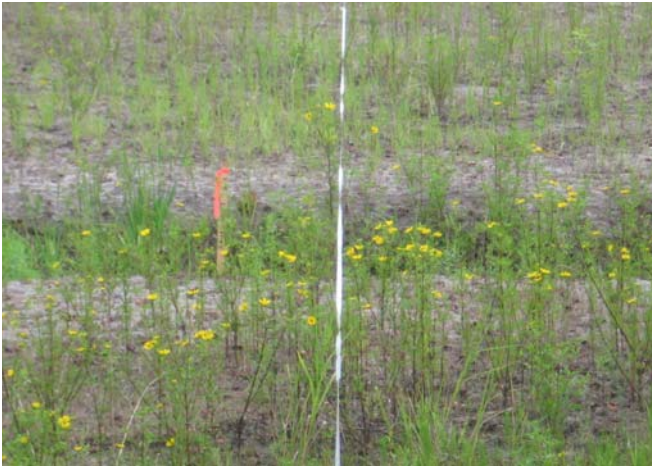


Looking at the Right Bank

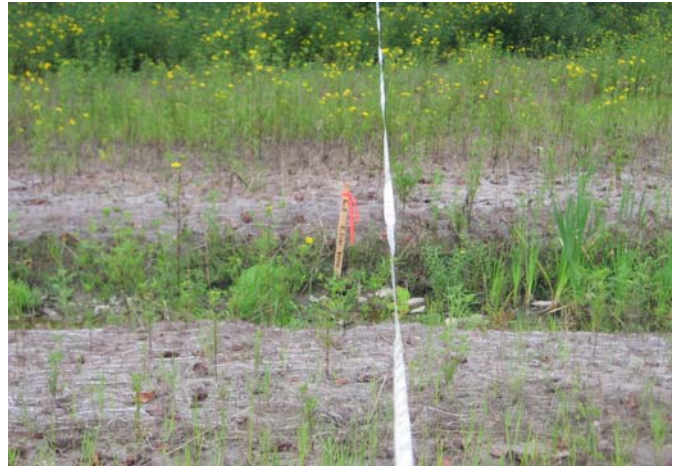
Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	E	10.2	10.01	1.02	1.62	9.86	1	7.6	52.7	52.73



**Permanent Cross-section 8**  
(Year 1 Data - Collected Aug. 2007)

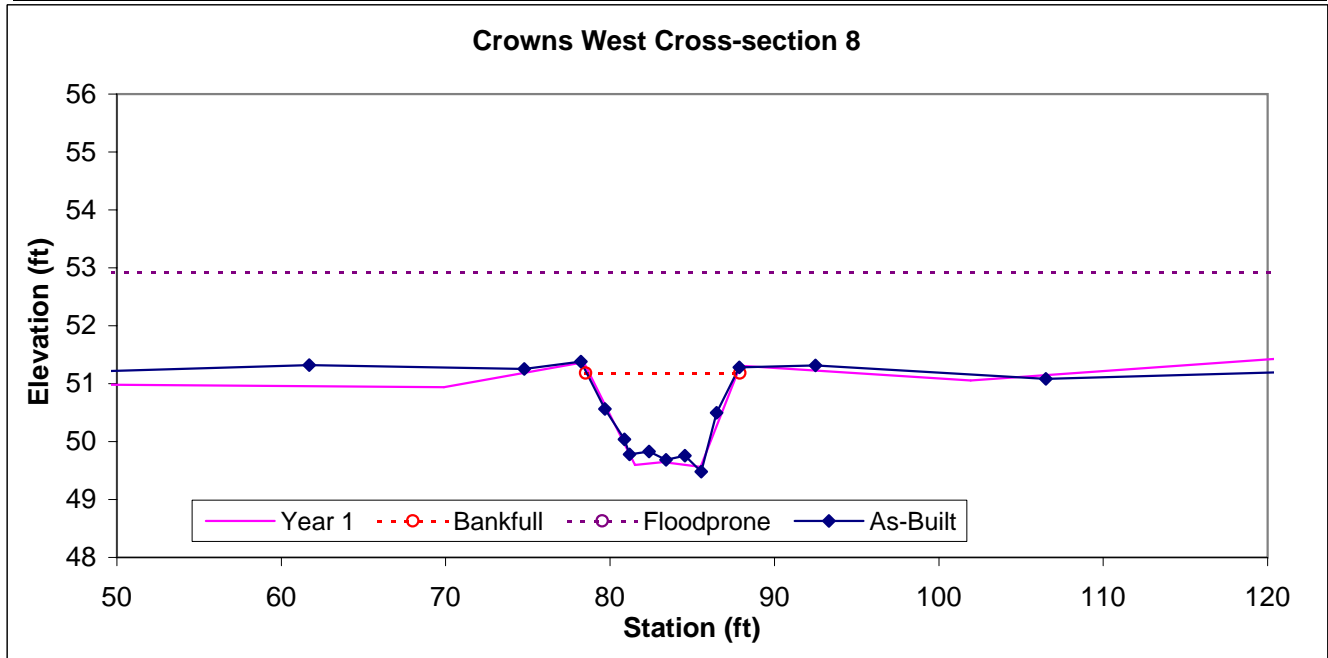


Looking at the Left Bank



Looking at the Right Bank

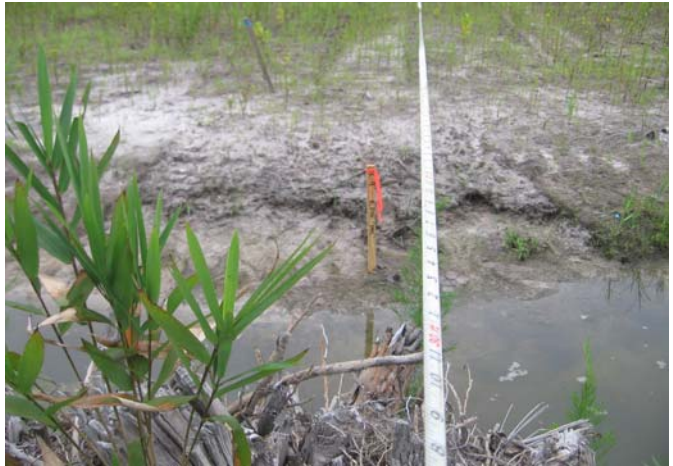
Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	E	11.4	9.38	1.21	1.74	7.74	1	13.9	51.18	51.19



**Permanent Cross-section 9**  
(Year 1 Data - Collected Aug. 2007)



**Looking at the Left Bank**



**Looking at the Right Bank**

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Pool		25.11	14.08	1.78	4.17	7.9	1	8.2	49.83	49.66

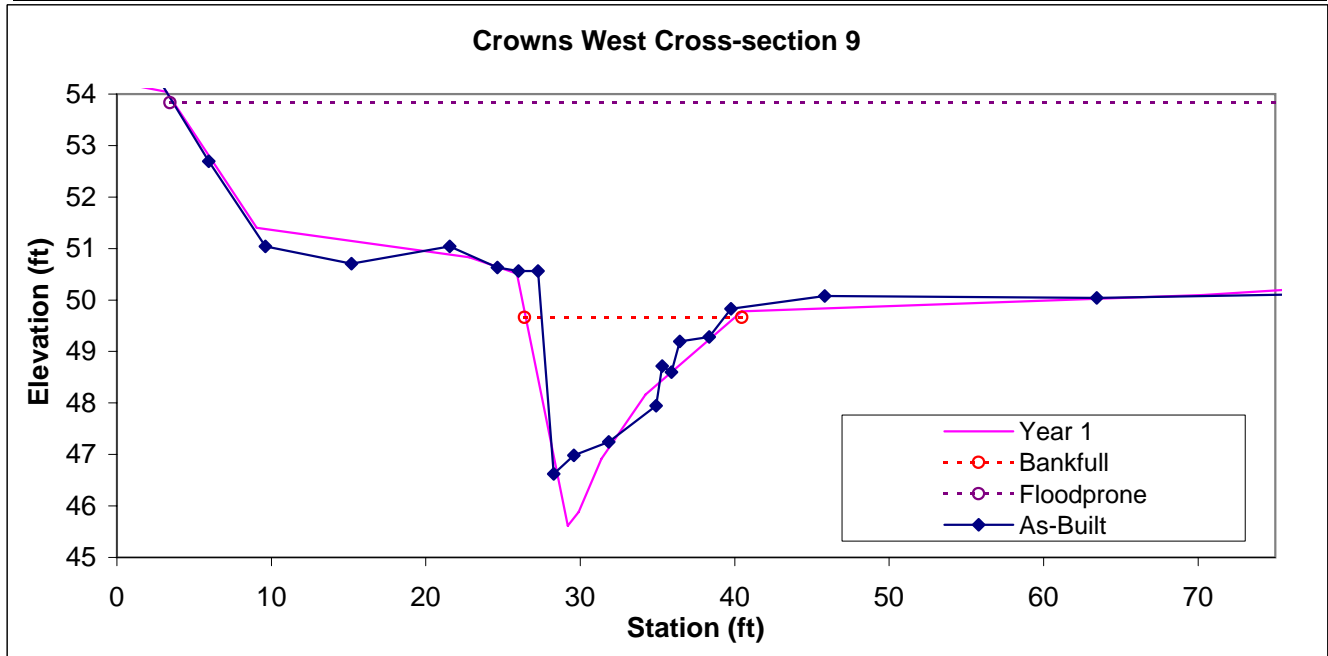






Photo Point 1 - Constructed Riffle 1



Photo Point 2 - Log Weir 1



Photo Point 3 - Constructed Riffle 2



Photo Point 4 - Log Weir 2



Photo Point 5 - Log Weir 3



Photo Point 6 - Log Weir 4



Photo Point 7 - Constructed Riffle 3



Photo Point 8 - Log Weir 5



Photo Point 9 - Constructed Riffle 4



Photo Point 10 - Log Weir 6



Photo Point 11 - Constructed Riffle 5



Photo Point 12 - Constructed Riffle 6



Photo Point 13 - Constructed Riffle 7



Photo Point 14 - Constructed Riffle 8



Photo Point 15 - Constructed Riffle 9



Photo Point 16 - Constructed Riffle 10



Photo Point 17 - Constructed Riffle 11



Photo Point 18 - Constructed Riffle 12



Photo Point 19 - Constructed Riffle 13



Photo Point 20 - Constructed Riffle 14



Photo Point 21 - Constructed Riffle 15



Photo Point 22 - Constructed Riffle 16



Photo Point 23 - Constructed Riffle 17



Crest gauge after bankfull event, 0.28 inches

