

CROWNS WEST STREAM RESTORATION PROJECT

ANNUAL MONITORING REPORT FOR 2008 (YEAR 2)

Contract Number D06003-2



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1.0 EXECUTIVE SUMMARY

This Annual Report details the monitoring activities during the 2008 growing season (Monitoring Year 2) 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 (m²) (10m x 10m) in size were used to predict survivability of the woody vegetation planted on-site. The Year 2 vegetation monitoring indicated an average survivability of 725 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 2 monitoring, kudzu (*Pueraria spp.*) 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.

According to the cross-section survey, stream dimension remained stable during Year 2. Overall in-stream structures also remained stable during Year 2. The longitudinal profile for Year 2 showed that the in-stream structures and features are remaining stable. However, the upstream portion of reach M2 demonstrated slight aggradation below the Haw Branch Road culvert. This area will be monitored closely during the coming year.

The on-site crest gauge documented the occurrence of at least one bankfull flow event during Year 2 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 1.91 feet (22.92 inches) above the bankfull stage.

The total length of stream channel restored on the Site was 3,835 LF. This entire length was inspected during Year 2 of the monitoring period (2008) to assess stream performance. During Year 2 monitoring, the Site did experience several problem areas related to root wad installations. All problem areas were located in the pools and involved erosion around rootwads that were installed in sandy soil areas. These problems were repaired in November 2008 and are currently functioning properly.

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 LF 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 watersheds 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 originally 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. The entire restoration project 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
Total linear feet of channel restored:			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

Crowns West Restoration Site: Project No. D06003-2			
Activity or Report	Scheduled Completion	Data Collection Complete	Actual Completion or Delivery
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	Dec-08	Oct-08	Dec-08
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

Crowns West Restoration Site: Project No. D06003-2	
Designer	
Michael Baker Engineering, Inc.	8000 Regency Parkway, Suite 200 Cary, NC 27518 <u>Contact:</u> Kevin Tweedy, Tel. 919-463-5488
Construction Contractor	
River Works, Inc.	8000 Regency Parkway, Suite 200 Cary, NC 27518 <u>Contact:</u> Will Pedersen, Tel. 919-459-9001
Planting Contractor	
River Works, Inc.	8000 Regency Parkway, Suite 200 Cary, NC 27518 <u>Contact:</u> Will Pedersen, Tel. 919-459-9001
Seeding Contractor	
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
Monitoring Performers	
Michael Baker Engineering, 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

Crowns West Restoration Site: Project No. D06003-2	
Project County:	Onslow County, NC
Drainage Area:	
Reach: M1	0.65 mi ²
Reach: M2	0.98 mi ²
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	C5c
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	C
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*), reedtop (*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 1 meter in size. These plots are photographed at the end of 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

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
<i>Fraxinus pennsylvanica</i>	Green Ash	7.50%	555
<i>Juglans nigra</i>	Black Walnut	5%	370
<i>Nyssa sylvatica</i> var. <i>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
Native Herbaceous Species			
<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
Woody Vegetation for Live Stakes			
<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 species that were planted as part of the permanent ground cover seed mixture broadcast on the Site after construction were present during Year 2 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 2 monitoring period. Data from the Year 2 monitoring event of the eleven vegetation plots showed a range of 567 to 971 stems per acre. The data showed that the plots had an average of 725 stems per acre. Based on these results, all plots are on track to meet the interim 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 and identification 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 be assessed during Year 3 monitoring for significant 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 2 monitoring, kudzu (*Pueraria spp.*) 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.

Privet (*Ligustrum L.*) was also observed on the Site, during Year 2 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.

These areas have been treated previously with herbicides and are scheduled to be treated again in the spring of 2009. The privet in the area will be treated by the cut and paint method. The areas will continue to be monitored and treated with herbicides to control the spread of invasives.

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.

As directed by EEP guidelines, longitudinal profiles will be completed in all five years of the monitoring period. 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 2 cross-section monitoring data for stream stability were collected during August 2008. 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 2. 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 1, 3, 4, 7 and 8 are located across riffles found between meander bends. Cross-section 1 has aggraded since the as-built survey, however, it has remained stable since monitoring during Year 1. The channels in cross-sections 3, 7 and 8 have remained relatively stable since the as-built survey. However, the floodplains of cross-sections 7 and 8 have experienced sediment deposition on the floodplain, composed mostly of fine sand. Visual on-site observations of areas east of Haw Branch Road have documented the deposition of sediment on the floodplain, which occurred during a large out-of-bank flow event during the year. This is considered to be a natural system response and no areas of concern have been noted due to the deposition.

Cross-sections 2, 5, 6, and 9 are located across pools found at the apex of meander bends. Based on the cross-section data, the pools at cross-sections 2 and 6 have filled some since Year 1 monitoring. Cross-sections 5 and 9 have remained relatively stable since Year 1. The pool cross-sections are showing slow development of point bar features on the inside bank of the meander bends.

The longitudinal profile for Year 2 was surveyed in December 2008 and was compared to data collected during the as-built condition survey and Year 1 monitoring.

The results of the Year 2 longitudinal profile show that the pools and riffles in M1 have maintained elevations and pool depths similar to those documented during the as-built survey and Year 1 monitoring. The longitudinal profile shows that the riffles and in-stream structures throughout the reach M1 are stable.

The Year 2 profile for M2 shows that the riffles at the beginning of the reach, (stations 33+95 to 45+05) have slightly aggraded since Year 1. The aggradation in these riffle areas was found to be generally 0.1 – 0.3 feet in depth. The Year 2 profile for M2 shows that the pools between stations 33+95 to 38+75 have also aggraded slightly since Year 1. The maximum measurement recorded in the pool areas is 2 feet in depth. It is noted that this area of concern is downstream of the Haw Branch Road culvert. The longitudinal profile for reach M2 shows that the riffles and in-stream structures are stable on the downstream portion of the reach. The longitudinal profile for the upstream portion of reach M2 will be closely monitored during Year 3.

The longitudinal profiles of reaches M1 and M2 are presented in Appendix B.

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 that 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 2 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 2 of monitoring was approximately 1.91 feet (22.92 inches) above the bankfull stage and was the result of overbank flooding of M2.

Table 6. Verification of Bankfull Events

Crowns West Restoration Site: EEP Contract No. D06003-2			
Date of Data Collection	Date of Occurrence of Bankfull Event	Method of Data Collection	Photo # or Measurement
3/24/2008	Unknown	Crest Gage on M2	1.91
5/29/2008	Unknown	Crest Gage on M2	0.18
8/20/2008	Unknown	Crest Gage on M2	0.17
10/2/2008	Unknown	Crest Gage on M2	0.33

3.2.5 Stream Problem Areas

During Year 2 monitoring, the Site experienced several stream restoration-related problems. These problems were repaired in November 2008 and are currently functioning properly. The stream problem areas were located on reaches M1 and M2. All problem areas were located in pools where erosion occurred around root wads that were installed in sandy soils. The areas were repaired during November 2008 and will be monitored closely during the coming years.

Photographs of the problem areas prior to repairs are presented in Appendix B.

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 in October 2008 at the end of the monitoring season. 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

A summary of the results obtained from the visual inspection of in-stream structures performed during Year 2 of post-construction monitoring is presented in Table B.1. 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 2 monitoring, all features except the pools described in Section 3.2.5 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.

3.2.9 Benthic Macroinvertebrate Sampling

Benthic macroinvertebrate monitoring was conducted in accordance with the Crowns West Restoration Plan. Because of seasonal fluctuations in populations, macroinvertebrate sampling must be consistently conducted in the same season. Benthic sampling for the Site was conducted during February 2008. This report summarizes the benthic samples collected following Year 1 of the post-construction monitoring phase. Year 2 data will be collected in February 2009.

The sampling methodology followed the Qual 4 method listed in NCDWQ's Standard Operating Procedures for Benthic Macroinvertebrates (2006). Field sampling was conducted by Baker Engineering. Laboratory identification of collected species was conducted by Wendell Pennington, of Pennington and Associates, Inc.

Benthic macroinvertebrate samples were collected at one location on the Site (Site 1) and one location at the Beaverdam Branch reference site in Jones County (Site 2). Site 1 was located within the restoration area of M1 on the Site.

Benthic macroinvertebrates were collected to assess quantity and quality of life in the streams. In particular, specimens belonging to the insect orders Ephemeroptera (mayflies), Plecoptera (stoneflies) and Trichoptera (caddisflies) (EPT species) are useful as an index of water quality. These groups are generally the least tolerant to water pollution and therefore are very useful indicators of water quality. Sampling for these three orders is referred to as EPT sampling.

Habitat assessments using NCDWQ's protocols were also conducted at each site. Physical and chemical measurements including water temperature, percent dissolved oxygen, dissolved oxygen concentration, pH, and specific conductivity were recorded at each site. The habitat assessment field data sheets and photos are presented in Appendix B.

3.2.10 Benthic Macroinvertebrate Sampling Results and Discussion

A comparison between the pre- and post-construction monitoring results is presented in Table 7 with complete laboratory results presented in Appendix B.

At Site 2, the undisturbed reference site, the Year 1 community structure and ecological habitat appears to be similar to that observed during the pre-construction monitoring period. Site 2 showed a slight increase in both overall and EPT taxa richness as well as a slight increase in EPT biotic indices. However, the data showed a lower total biotic index for Site 2 than was observed during pre-construction sampling.

Site 1, which underwent complete restoration, exhibited decreased total and EPT taxa richness, as well as decreased total and EPT biotic indices in the post-construction sample. It is anticipated that, as the project matures, populations will increase as more habitat in the form of snags, logs, and leaf packs become available.

Currently Site 1 has 18 percent Dominance in Common (DIC) compared to the reference site, which indicates that 18 percent of the dominant communities at the reference site are dominant at Site 1. In pre-construction conditions, Site 1 had a DIC of 41 percent. This indicates that post-construction recolonization from refugia upstream or downstream (represented at Site 2) has begun. It is anticipated that improvements in biotic indices and an increase in DIC will be seen in future monitoring reports as communities begin to re-colonize.

Table 7. Summary of Pre-Restoration vs. Post-Restoration Benthic Macroinvertebrate Sampling Data				
Crowns West Restoration Site: EEP Contract No. D06003-2				
	Site 1		Site 2	
	M1 Crowns West (Restoration)		Beaverdam Branch (Reference)	
	Pre	Post	Pre	Post
	3/3/2006	2/28/2008	1/5/2006	2/28/2008
Total Taxa Richness	24	14	28	35
EPT Taxa Richness	4	0	3	6
Total Biotic Index	6.75	3.99	7.78	6.73
EPT Biotic Index	5.78	NA	4.05	5.28
Dominance in Common (%)	41	18	N/A	N/A
EPT Abundance	-	0	-	29
Habitat Assessment Rating	42	88	89	70
Water Temperature (°C)	Not Collected	10.5	Not Collected	7.9
DO Concentration (mg/l)	Not Collected	5.05	Not Collected	9
pH	Not Collected	6.63	Not Collected	7.24
Conductivity (µmhos/cm)	Not Collected	110	Not Collected	320

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 2 of the monitoring period (2008) to assess stream performance. During Year 2 monitoring, the Site experienced several areas of bank erosion around rootwads that were installed within sandy soils. These problems were repaired in November 2008 and currently appear to be functioning properly.

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 at least one bankfull flow event during the Year 2 of the post-construction monitoring period. Inspection of site conditions during a site visit revealed visual evidence of out-of-bank flow.

Overall, the site is on track to achieve the stream morphology success criteria specified in the Restoration Plan for the Site.

Macroinvertebrate data at the Site, exhibited a decrease in total and EPT taxa richness, as well as a decrease in total and EPT biotic indices in the post-construction sample. It is anticipated that, as the project matures, populations will increase as more habitat in the form of snags, logs, and leaf packs become available. The Site has 18 percent Dominance in Common (DIC) compared to the reference site, which indicates that 18 percent of the dominant communities at the reference site are dominant at Site 1. In pre-construction conditions, Site 1 had a DIC of 41 percent. This indicates that post-construction recolonization from refugia upstream or downstream has begun.

Vegetation Monitoring - For the 11 monitoring plots, vegetation monitoring indicated a survivability range of 567 stems per acre to 971 stems per acre with an overall average of 728 stems per acre. The data shows that the Site is on track for meeting the success interim criteria of 260 trees per acre at the end of Year 5.

During Year 2 monitoring, kudzu (*Pueraria spp.*) 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 the spring of 2009.

Overall, the site is on track to achieve the stream morphology success criteria specified in the Restoration Plan for the Site.

5.0 WILDLIFE OBSERVATIONS

Observations of deer and raccoon tracks are common on the Site. During certain times of the year, frogs, snakes and crawfish and have been periodically observed. The macroinvertebrates sample in February 2008 revealed that an American eel (*Anguilla rostrata*) was present on the Site. The eel was captured and released by use of a kick net on reach M1.

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.

NCDWQ, Standard Operating Procedures for Benthic Macroinvertebrates. (2006).

FIGURES

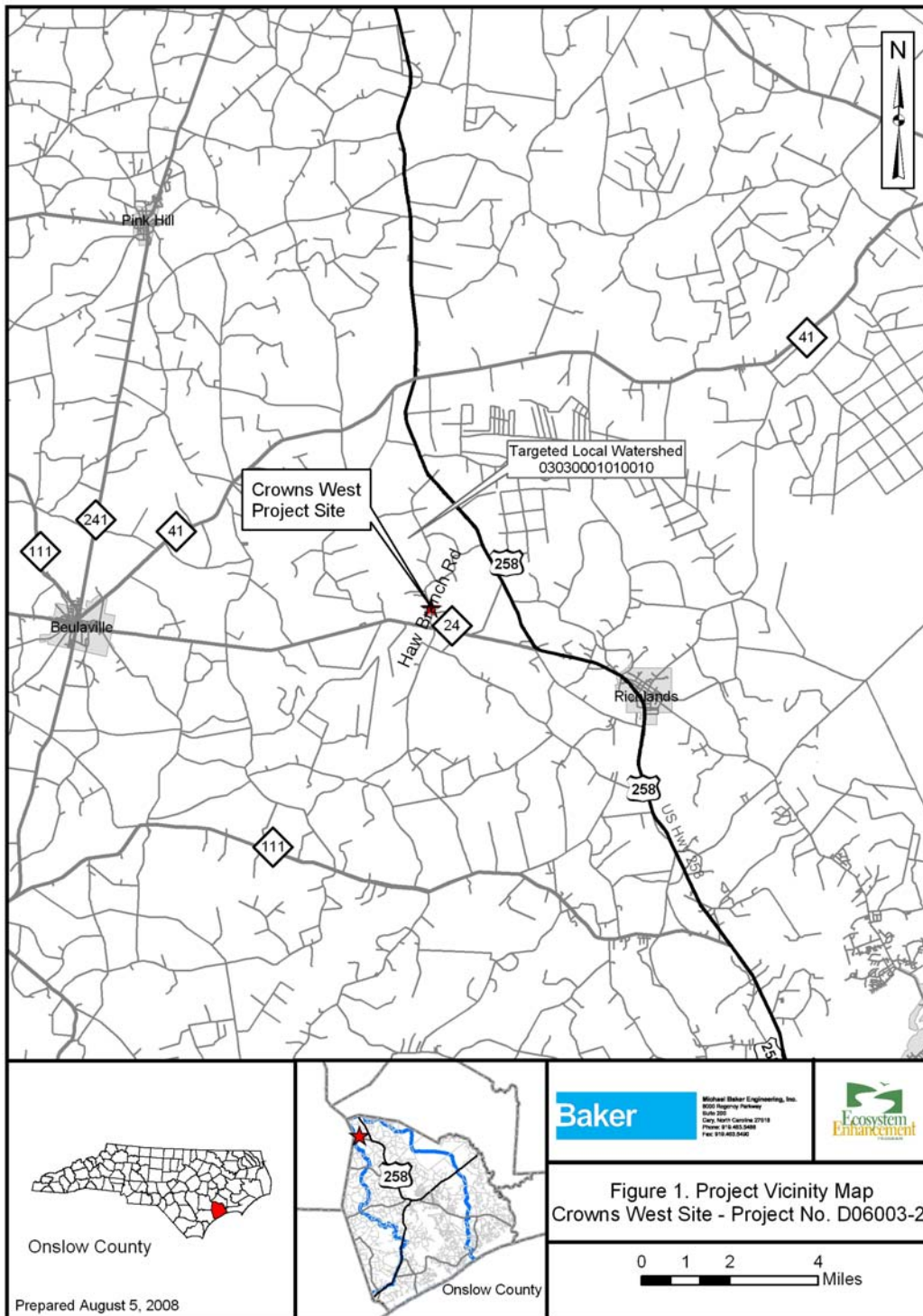


Figure 1. Location of Crowns West Stream Restoration Site.

PROJECT: D06003 - 2 CROWNS WEST

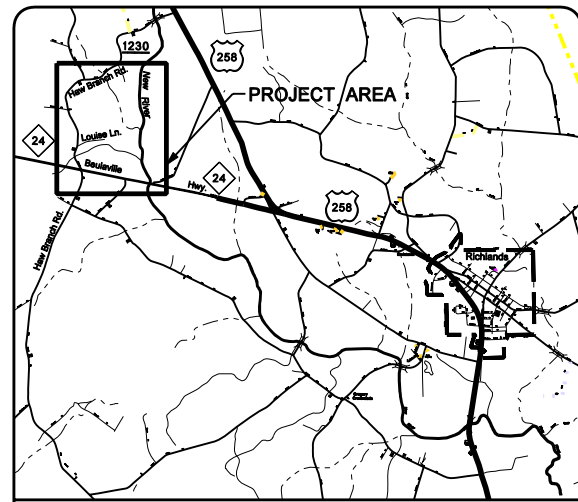
CROWNS WEST STREAM RESTORATION PROJECT
PROJECT # - D06003-2

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

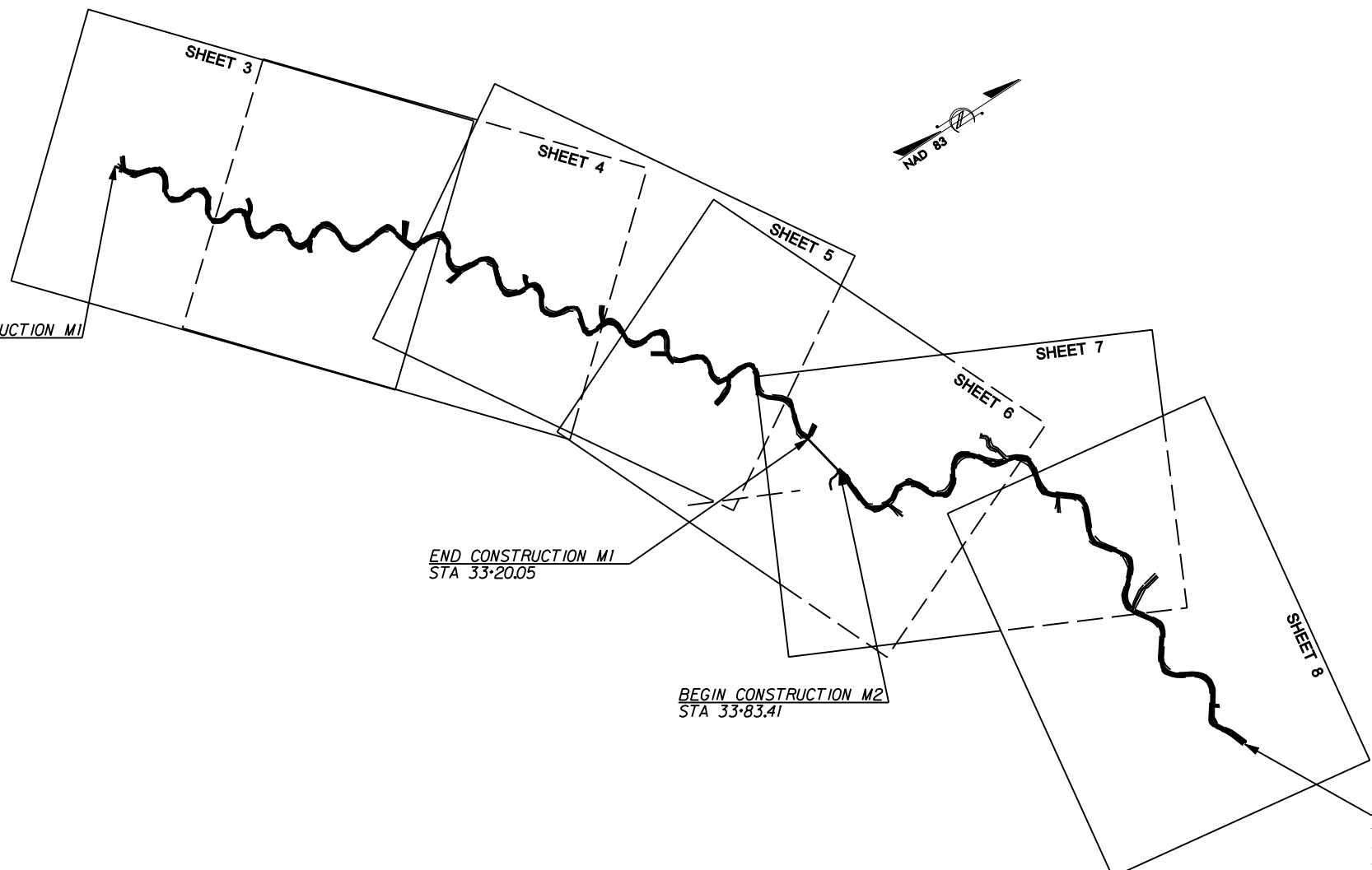
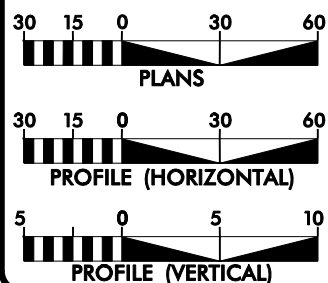


FIGURE 2A

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
 8020 Research Parkway
 Suite 200
 Cary, NORTH CAROLINA 27518
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MARCH 2007
 COMPLETION DATE:

KEVIN TWEEDY, PE
 PROJECT ENGINEER

JOSHUA WHITE
 PROJECT DESIGNER

PROJECT ENGINEER

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KEVIN L. TWEEDY
 027337
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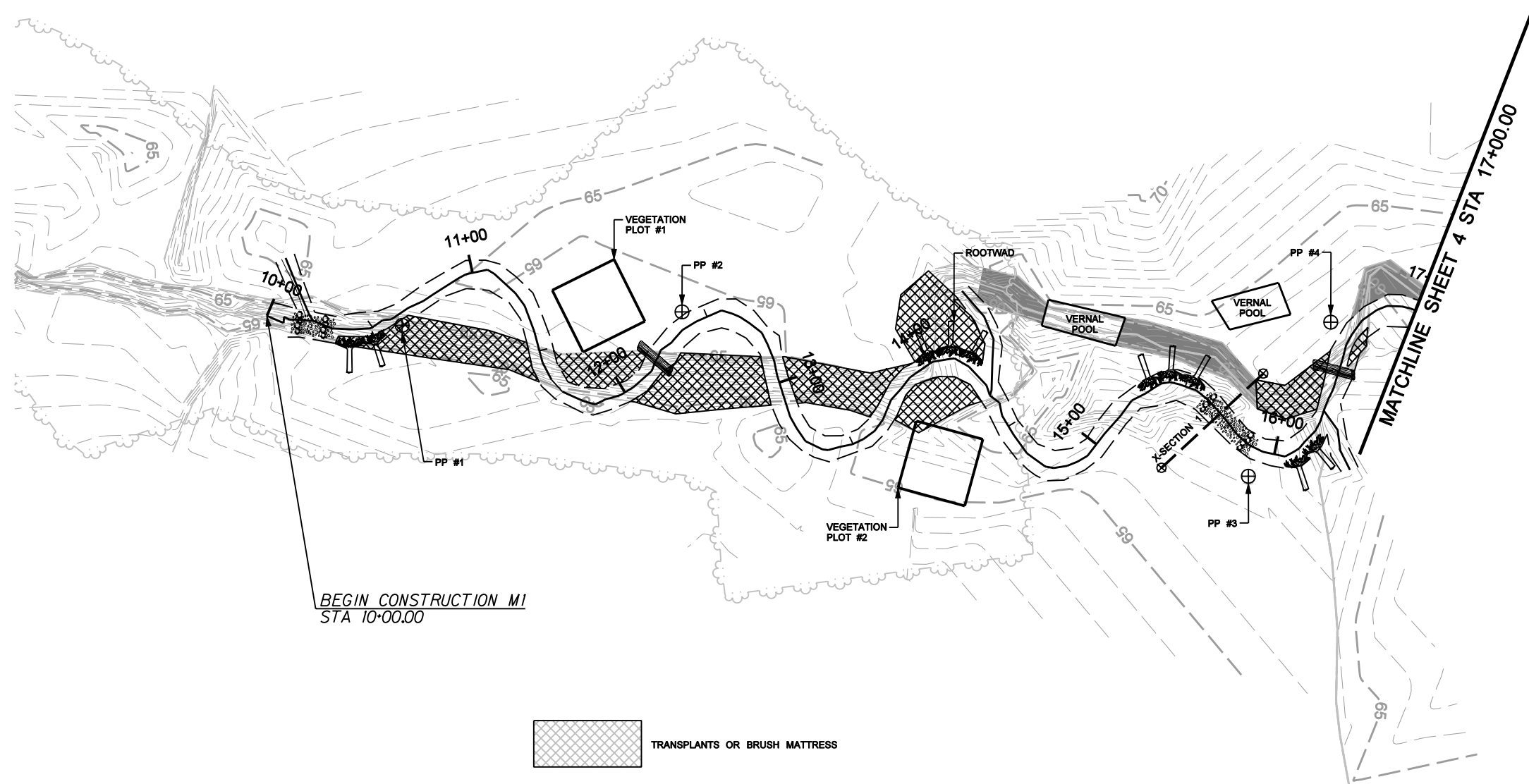
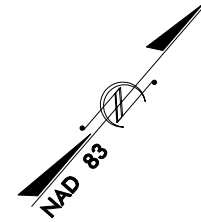
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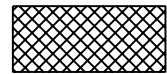

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Fax: 919.463.5490



-  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.

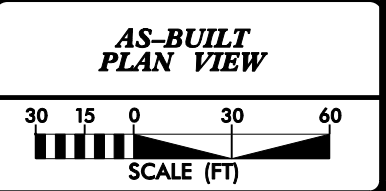


FIGURE 2B

2/26/03

11/27/2007
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PROJECT ENGINEER

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	Fax: 919.463.5490



NOTE:
CONTOURS SHOWN ARE PRE-RESTORATION CONDITIONS.

**AS-BUILT
PLAN VIEW**

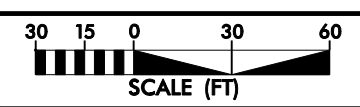
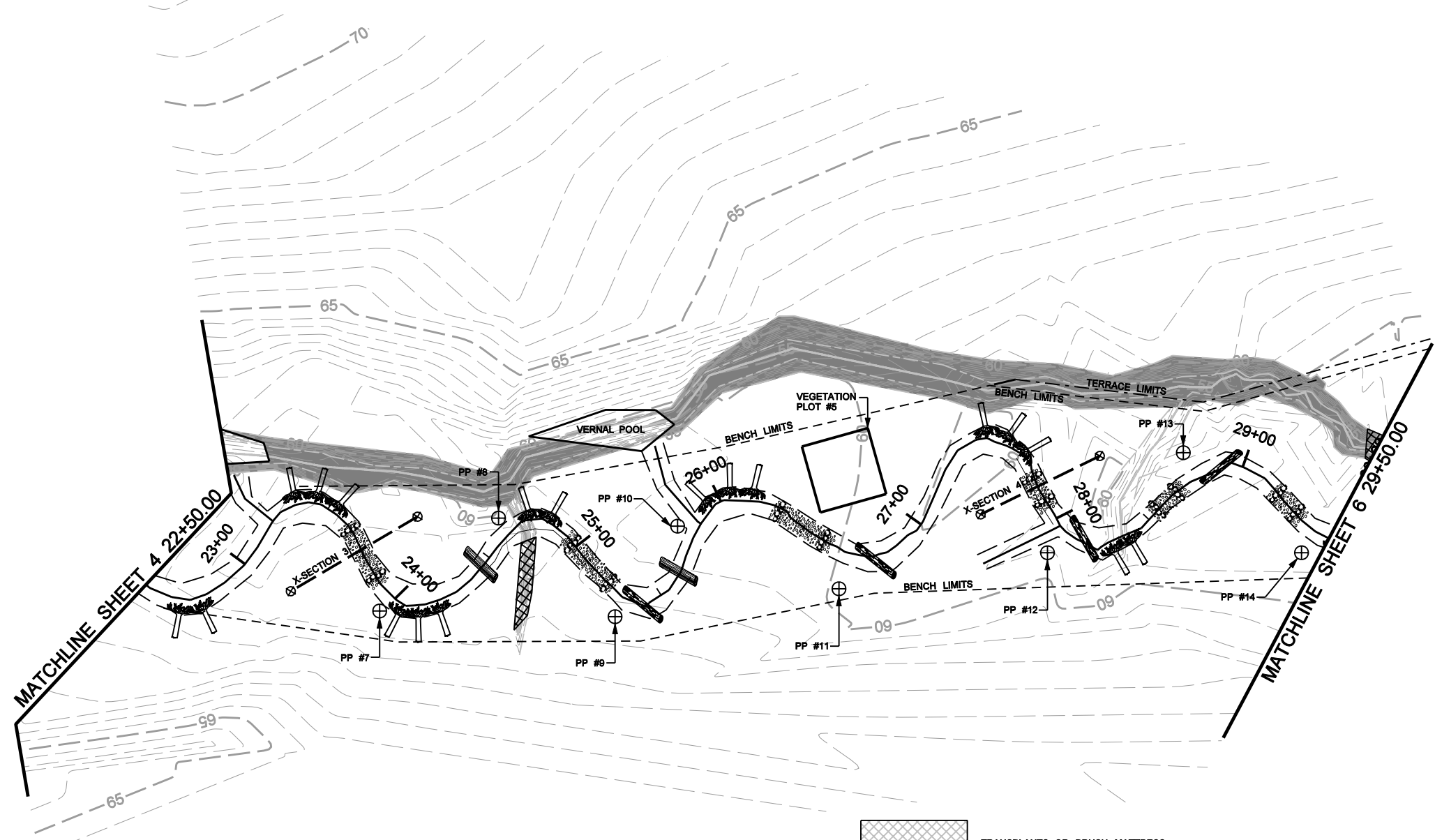
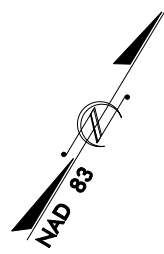





FIGURE 2C

2/26/03

 IV/27/2007
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-  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.

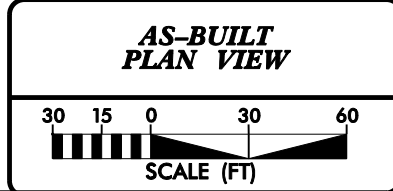
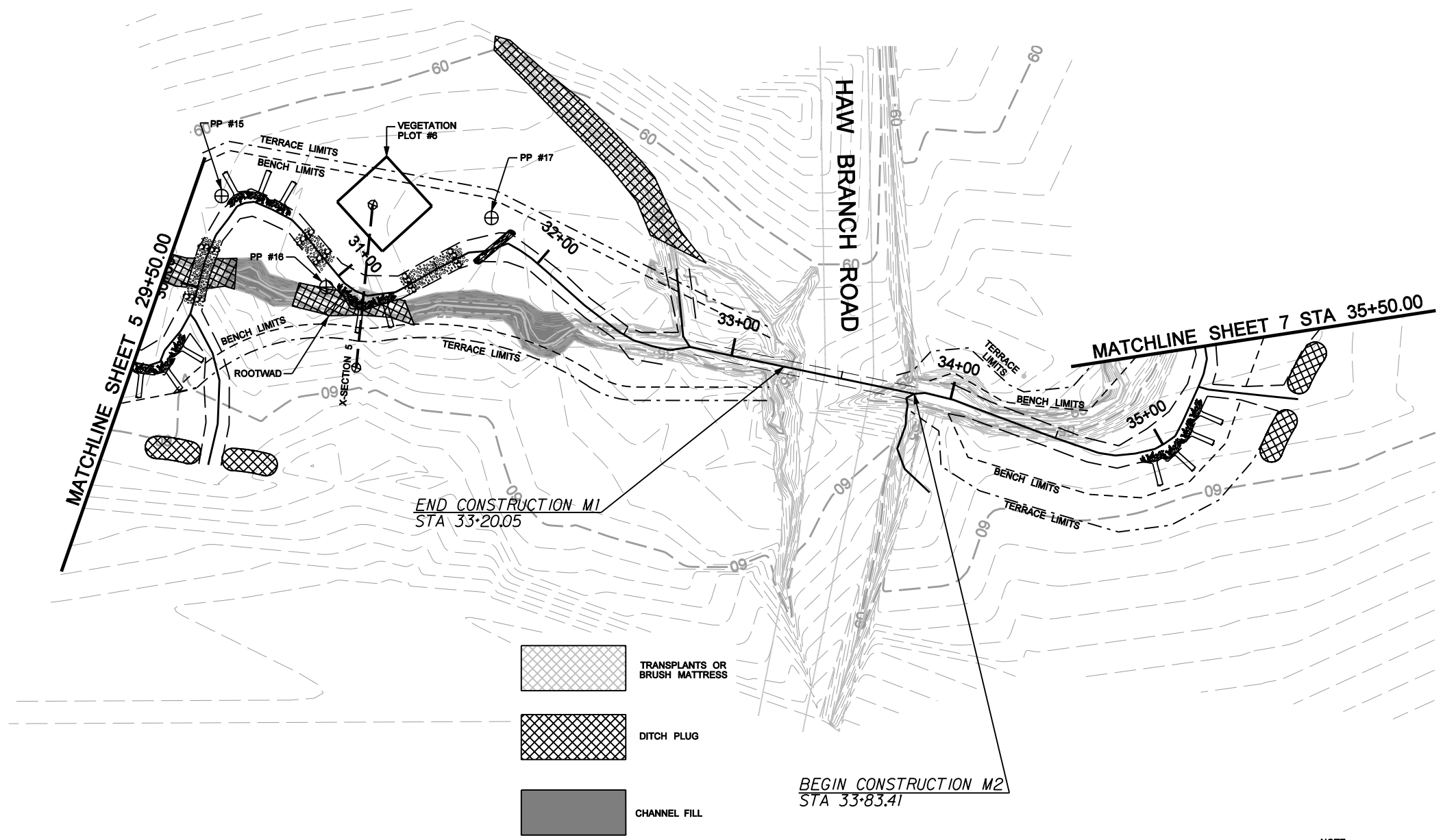
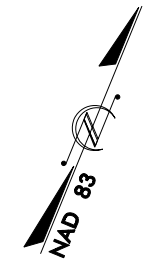


FIGURE 2D

2/26/03

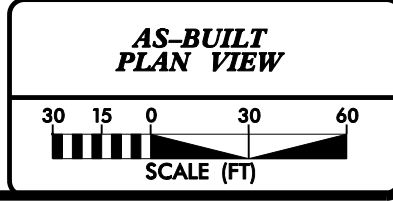
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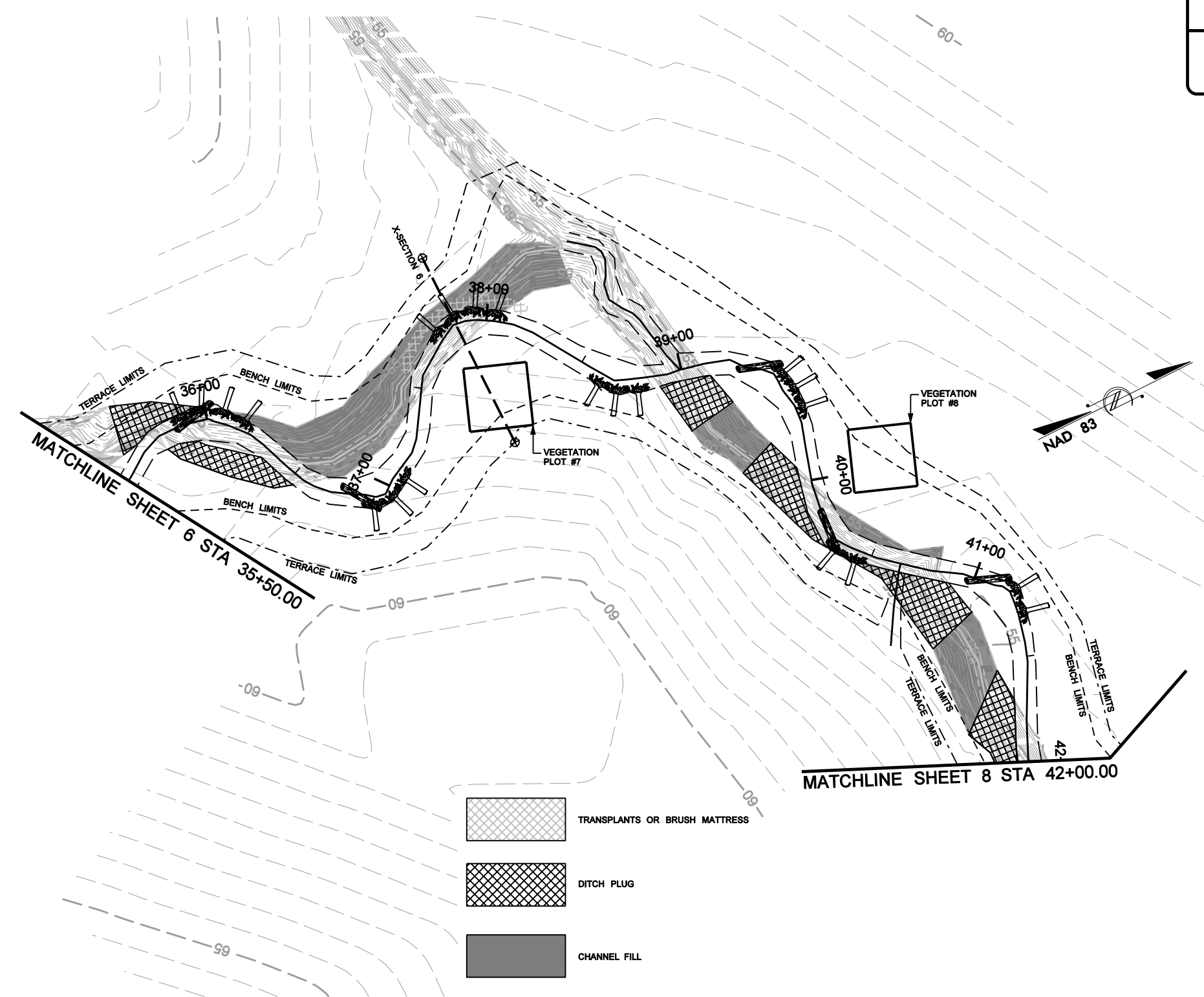
NOTE:
PRESERVED TREES WHERE POSSIBLE BETWEEN STATIONS 10+00 TO 33+66.

NOTE:
CONTOURS SHOWN ARE PRE-RESTORATION CONDITIONS.

FIGURE 2E



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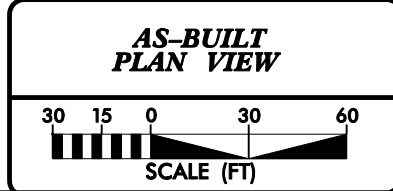


FIGURE 2F

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 11/27/2007
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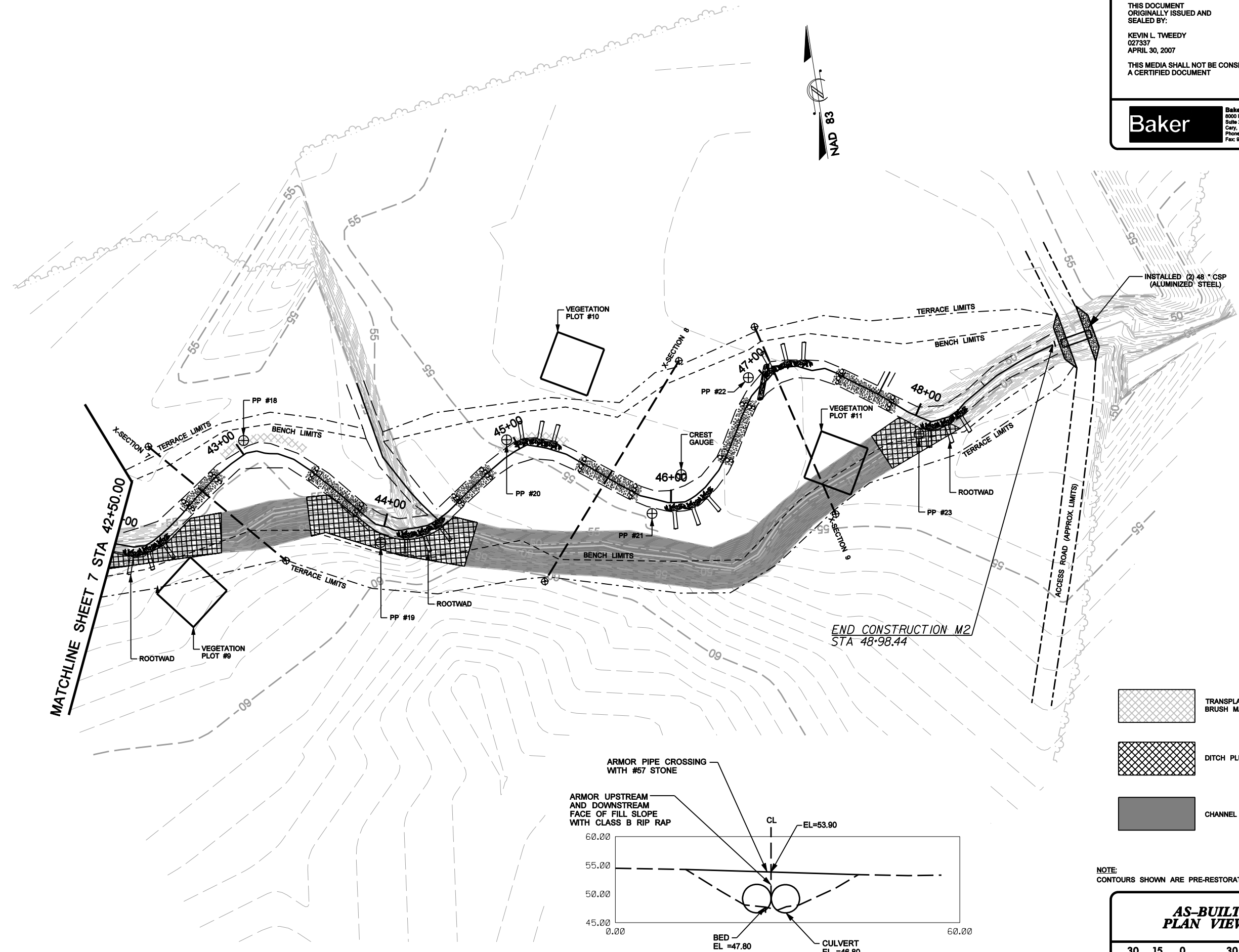
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-  TRANSPLANTS OR BRUSH MATTRESS
-  DITCH PLUG
-  CHANNEL FILL

NOTE:
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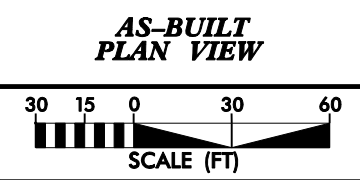
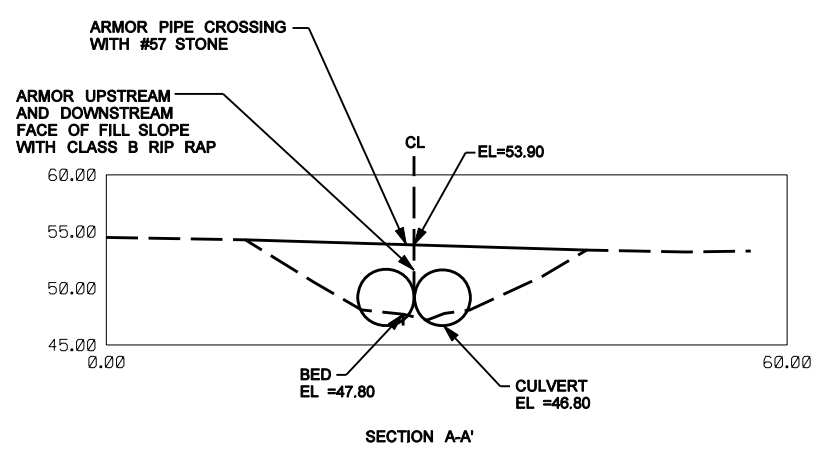


FIGURE 2G

2/26/03
11/27/2007
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APPENDIX A

VEGETATION RAW DATA

VEGETATION TABLES

Table A.1. Vegetation Metadata

Crowns West Restoration Site: Project No. D06003-2	
Report Prepared By	Dwayne Huneycutt
Date Prepared	11/4/2008 12:51
database name	Baker-2008-ResamplingCrownsWestD060032-EntryTool-v2.2.5.mdb
database location	L:\Monitoring\Veg Plot Info\CVS Data Tool
computer name	DHUNEYCUTT-2
DESCRIPTION OF WORKSHEETS IN THIS DOCUMENT-----	
Metadata	Description of database file, the report worksheets, and a summary of project(s) and project data.
Proj, planted	Each project is listed with its PLANTED stems per acre, for each year. This excludes live stakes.
Proj, total stems	Each project is listed with its TOTAL stems per acre, for each year. This includes live stakes, all planted stems, and all natural/volunteer stems.
Plots	List of plots surveyed with location and summary data (live stems, dead stems, missing, etc.).
Vigor	Frequency distribution of vigor classes for stems for all plots.
Vigor by Spp	Frequency distribution of vigor classes listed by species.
Damage	List of most frequent damage classes with number of occurrences and percent of total stems impacted by each.
Damage by Spp	Damage values tallied by type for each species.
Damage by Plot	Damage values tallied by type for each plot.
Planted Stems by Plot and Spp	A matrix of the count of PLANTED living stems of each species for each plot; dead and missing stems are excluded.
PROJECT SUMMARY-----	
Project Code	D060032
project Name	Crowns West
Description	Stream Restoration Project
River Basin	White Oak
length(ft)	3835
stream-to-edge width (ft)	50
area (sq m)	35624.71
Required Plots (calculated)	10
Sampled Plots	0

Table A.2. Vegetation Vigor by Species

Crowns West Restoration Site: Project No. D06003-2								
	Species	4	3	2	1	0	Missing	Unknown
	Betula nigra	3	9	5		2		
	Celtis laevigata			4				
	Fraxinus pennsylvanica	5	5	8				
	Juglans nigra		2	5	4	2		
	Nyssa biflora	2	12	16				
	Quercus lyrata	4	10	6				
	Quercus michauxii	2	4	6				
	Quercus nigra	1						
	Quercus phellos		7	5				1
	Taxodium distichum	4	11	7				
	Platanus occidentalis	3	18	29		1		1
	Unknown					20		
TOT:	12	24	78	91	4	25	2	

Table A.3. Vegetation Damage by Species

Crowns West Restoration Site: Project No. D06003-2						
	Species	All Damage Categories	No Damage	Human Trampled	Unknown	Vine Strangulation
	Betula nigra	19	17			2
	Celtis laevigata	4	4			
	Fraxinus pennsylvanica	18	18			
	Juglans nigra	13	11		2	
	Nyssa biflora	30	29	1		
	Platanus occidentalis	52	50		2	
	Quercus lyrata	20	20			
	Quercus michauxii	12	12			
	Quercus nigra	1	1			
	Quercus phellos	13	12		1	
	Taxodium distichum	22	21			1
	Unknown	20			19	1
TOT:	12	224	195	1	24	4

Table A.4. Vegetation Damage by Plot

Crowns West Restoration Site: Project No. D06003-2						
Plot	All Damage Categories	No damage	Human Trampled	Unknown	Vine Strangulation	
D060032-DH-0001-year:2	18	14		4		
D060032-DH-0002-year:2	18	17		1		
D060032-DH-0003-year:2	15	14		1		
D060032-DH-0004-year:2	16	14		2		
D060032-DH-0005-year:2	24	19		1	4	
D060032-DH-0006-year:2	19	19				
D060032-DH-0007-year:2	16	16				
D060032-DH-0008-year:2	26	22		4		
D060032-DH-0009-year:2	21	17		4		
D060032-DH-0010-year:2	27	24		3		
D060032-DH-0011-year:2	24	19	1	4		
TOT:	11	224	195	1	24	4

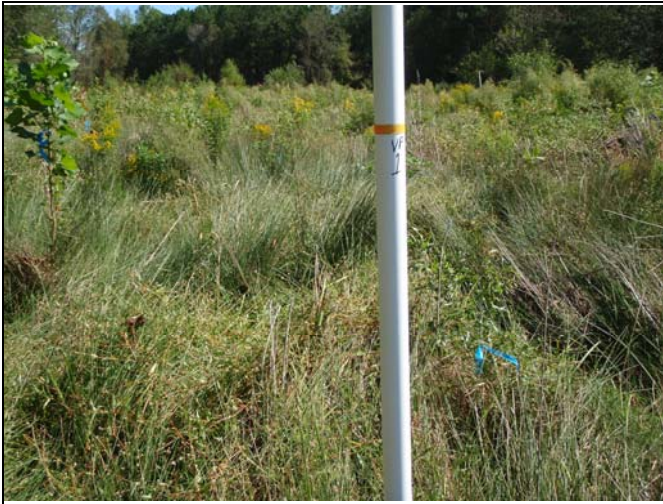
Table A.5. Stem Count by Plot and Species

Crowns West Restoration Site: Project No. D06003-2															
Species	Total Planted Stems	Number of plots	Average Number of Stems	Plot D060032-DH-0001-Year:2	Plot D060032-DH-0002-Year:2	Plot D060032-DH-0003-Year:2	Plot D060032-DH-0004-Year:2	Plot D060032-DH-0005-Year:2	Plot D060032-DH-0006-Year:2	Plot D060032-DH-0007-Year:2	Plot D060032-DH-0008-Year:2	Plot D060032-DH-0009-Year:2	Plot D060032-DH-0010-Year:2	Plot D060032-DH-0011-Year:2	
Betula nigra	17	8	2.12	3	1			5	1				4	1	1
Celtis laevigata	4	3	1.33				2				1	1			
Fraxinus pennsylvanica	18	6	3		2	2				7	1		2	4	
Juglans nigra	11	5	2.2						3	1	1	1			5
Nyssa biflora	30	9	3.33	1	4	2	3	4	1		4		4	7	
Platanus occidentalis	50	11	4.55	6	8	7	3	1	6	1	6	5	6	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 nigra	1	1	1											1	
Quercus phellos	12	5	2.4	3		2				1	2		4		
Taxodium distichum	22	6	3.67		3	1		10	1	1	6				
TOT:	11	197	11	14	17	14	14	20	19	16	22	17	24	20	

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

Tree Species	Plots											Year 2 Totals	Average Stems/acre
	1	2	3	4	5	6	7	8	9	10	11		
<i>Betula nigra</i>	3	1		1	5	1			4	1	1	17	N/A
<i>Celtis laevigata</i>				2				1	1			4	
<i>Fraxinus pennsylvanica</i>			2	2			7	1		2	4	18	
<i>Juglans nigra</i>						3	1	1	1		5	11	
<i>Nyssa biflora</i>	1	4	2	3	4	1		4		4	7	30	
<i>Platanus occidentalis</i>	6	8	7	3	1	6	1	6	5	6	1	50	
<i>Quercus lyrata</i>	1	1				5	3		5	5		20	
<i>Quercus michauxii</i>				3		2	2	1	1	2	1	12	
<i>Quercus nigra</i>											1	1	
<i>Quercus phellos</i>	3		2				1	2		4		12	
<i>Taxodium distichum</i>		3	1		10	1	1	6				22	
Stems/plot	14	17	14	14	20	19	16	22	17	24	20	197	
Stems/acre Year 2	567	688	567	567	809	769	647	890	688	971	809	N/A	
Stems/acre Initial	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



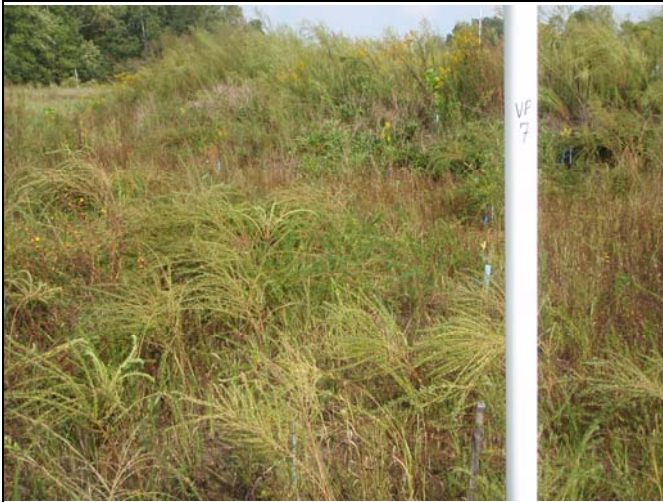
Herbaceous Vegetation Plot 5



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



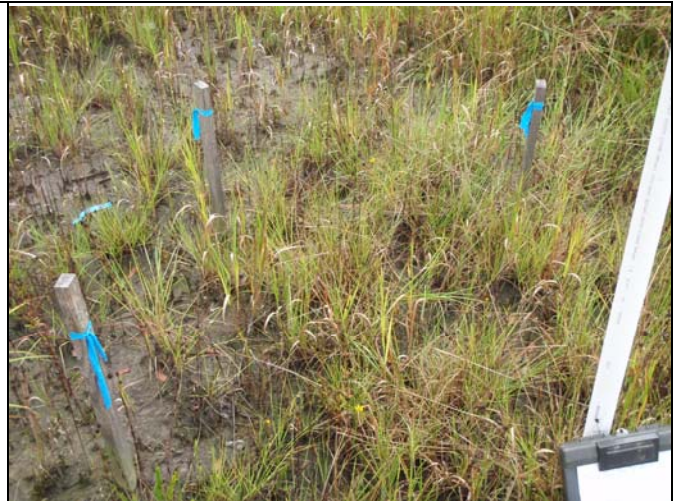
Vegetation Plot 10



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

Crowns Wet Restoration Site: Project No. D06003-2						
Feature	Performance Percentage					
	Initial	MY-01	MY-02	MY-03	MY-04	MY-05
A. Riffles	100%	100%	95%			
B. Pools	100%	100%	90%			
C. Thalweg	100%	100%	NA			
D. Meanders	100%	100%	100%			
E. Bed General	100%	100%	100%			
F. Bank Condition	100%	100%	95%			
G. Wads	100%	100%	75%			

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
Dimension - Riffle																	
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	-----	-----	-----
Pattern																	
Channel Beltwidth (ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	45	58.5	72	-----	-----	-----
Radius of Curvature (ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	18	27	36	-----	-----	-----
Meander Wavelength (ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Meander Width Ratio	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	5	6.5	8	-----	-----	-----
Profile																	
Riffle Length (ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Riffle Slope (ft/ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Pool Length (ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Pool Spacing (ft)	-----	-----	-----	-----	-----	-----	-----	-----	2.5	-----	3.4	23	34	45	-----	-----	-----
Substrate and Transport Parameters																	
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	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Additional Reach Parameters																	
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
Dimension - Riffle																	
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	-----	-----	-----
Pattern																	
Channel Beltwidth (ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	50	65	80	-----	-----	-----
Radius of Curvature (ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	20	30	40	-----	-----	-----
Meander Wavelength (ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Meander Width Ratio	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	5	6.5	8	-----	-----	-----
Profile																	
Riffle Length (ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Riffle Slope (ft/ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Pool Length (ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Pool Spacing (ft)	-----	-----	-----	-----	-----	-----	-----	-----	2.5	-----	3.4	25	38	50	-----	-----	-----
Substrate and Transport Parameters																	
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	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Additional Reach Parameters																	
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	-----

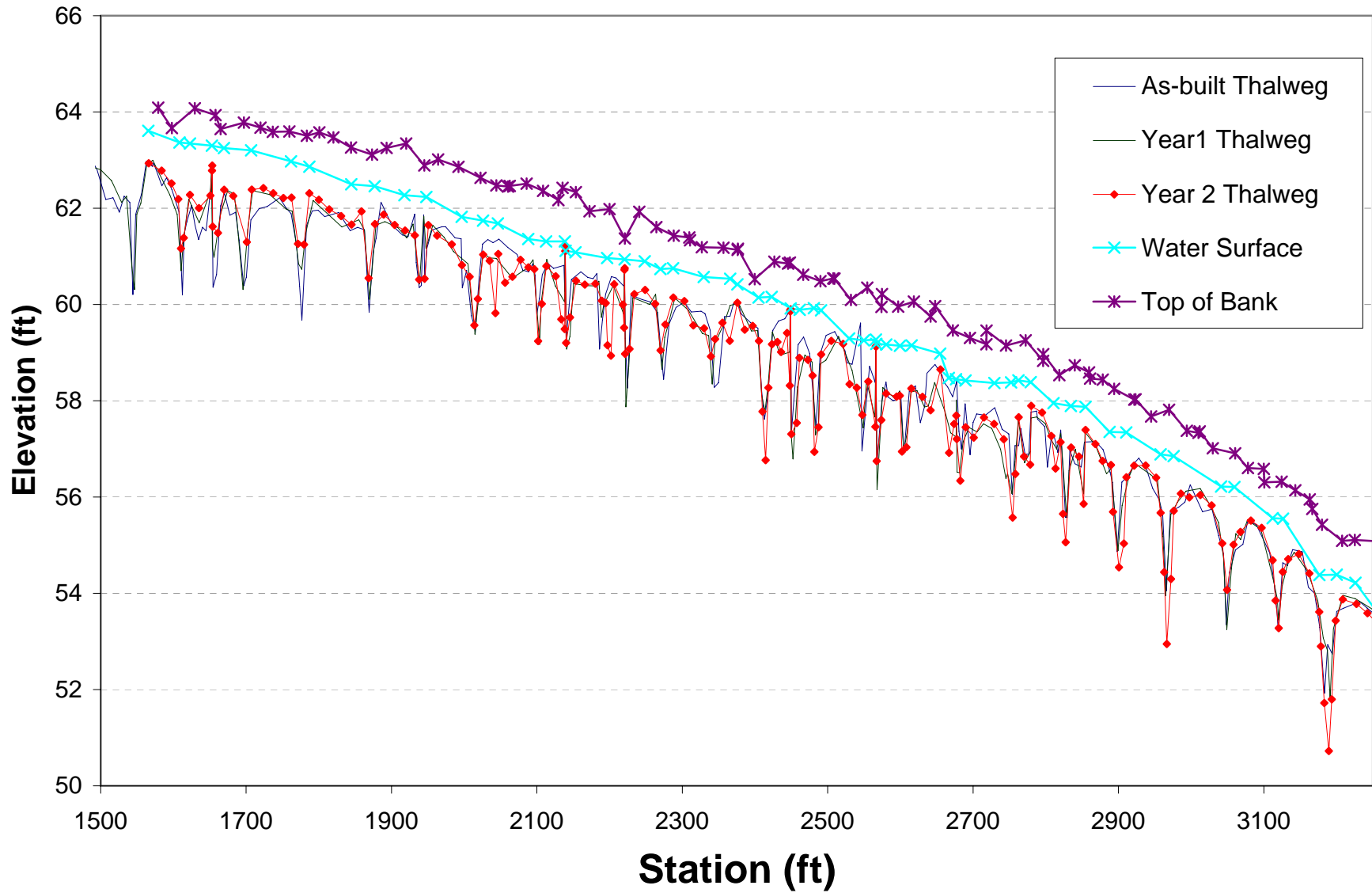
Table B.3. Morphology and Hydraulic Monitoring Summary

Crowns West Restoration Site: Project No. D06003-2																				
Reach: M1 (2320 feet)																				
Parameter	Cross Section 1					Cross Section 2					Cross Section 3					Cross Section 4				
	Riffle					Pool					Riffle					Riffle				
	MY1	MY2	MY3	MY4	MY5	MY1	MY2	MY3	MY4	MY5	MY1	MY2	MY3	MY4	MY5	MY1	MY2	MY3	MY4	MY5
Dimension																				
BF Width (ft)	11.52	9.79				12.38	10.43				10.32	10.38				8.77	8.76			
BF Mean Depth (ft)	0.73	0.61				1.89	1.57				0.71	0.61				0.72	0.58			
Width/Depth Ratio	15.78	16.05				6.54	6.64				14.48	16.99				12.18	15.10			
BF Cross-Sectional Area (ft²)	8.41	6.00				23.46	16.40				7.35	6.30				6.31	5.10			
BF Max Depth (ft)	1.25	0.97				3.05	2.75				1.27	1.10				1.19	0.92			
Width of Floodprone Area (ft)	60.22	-				69.87	-				64.56	-				58.25	-			
Entrenchment Ratio	5.2	6.1				5.6	6.7				6.3	5.3				6.6	6.6			
Bank Height Ratio	1.0	1.0				1.2	1.2				1.0	1.1				1.0	1.1			
Wetted Perimeter (ft)	-	-				-	-				-	-				-	-			
Hydraulic Radius (ft)	-	-				-	-				-	-				-	-			
Substrate																				
d50 (mm)																				
d84 (mm)																				
Parameter	Cross Section 5																			
	Pool																			
	MY1	MY2	MY3	MY4	MY5															
Dimension																				
BF Width (ft)	12.83	11.19																		
BF Mean Depth (ft)	1.15	1.33																		
Width/Depth Ratio	11.2	8.4																		
BF Cross-Sectional Area (ft²)	14.70	14.9																		
BF Max Depth (ft)	2.63	2.69																		
Width of Floodprone Area (ft)	65.99	-																		
Entrenchment Ratio	5.1	6.1																		
Bank Height Ratio	1.0	1.1																		
Wetted Perimeter (ft)	-	-																		
Hydraulic Radius (ft)	-	-																		
Substrate																				
d50 (mm)																				
d84 (mm)																				

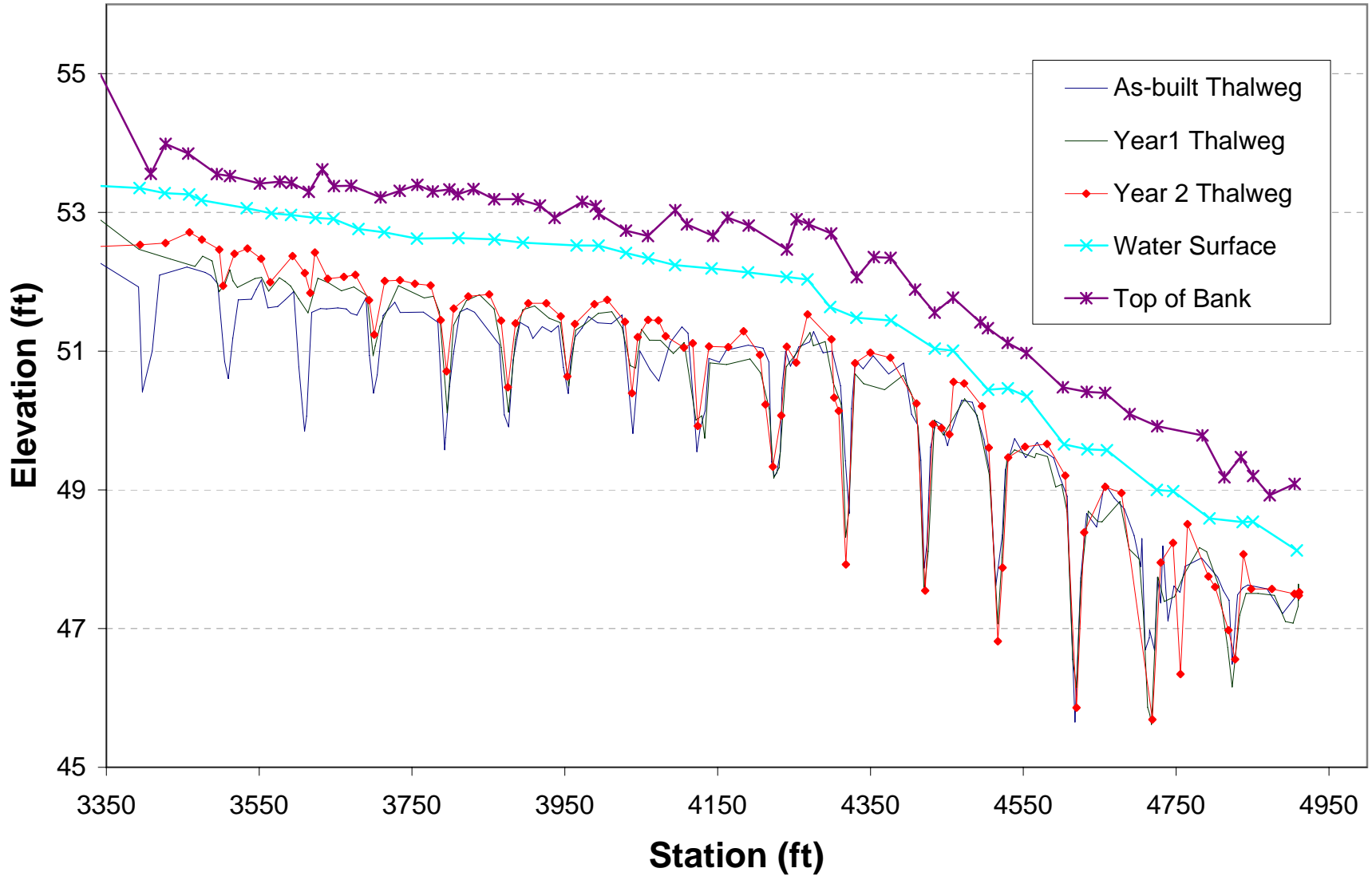
Parameter	MY-1 (2007)			MY-2 (2008)			MY-3 (2009)			MY-4 (2010)			MY-5 (2011)							
	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med					
Pattern																				
Channel Beltwidth (ft)			-																	
Radius of Curvature (ft)			-																	
Meander Wavelength (ft)			-																	
Meander Width Ratio			-																	
Profile																				
Riffle length (ft)			-																	
Riffle Slope (ft/ft)			-																	
Pool Length (ft)			-																	
Pool Spacing (ft)			-																	
Additional Reach Parameters																				
Valley Length (ft)																				
Channel Length (ft)			2320																	
Sinuosity			1.38																	
Water Surface Slope (ft/ft)			0.0041																	
BF Slope (ft/ft)																				
Rosgen Classification			C																	
Reach: M2 (1515 feet)																				
Parameter	Cross Section 6 Pool					Cross Section 7 Riffle					Cross Section 8 Riffle					Cross Section 9 Pool				
	MY1	MY2	MY3	MY4	MY5	MY1	MY2	MY3	MY4	MY5	MY1	MY2	MY3	MY4	MY5	MY1	MY2	MY3	MY4	MY5
Dimension																				
BF Width (ft)	14.00	13.13				10.60	9.12				9.46	9.24				12.31	14.44			
BF Mean Depth (ft)	1.70	1.26				0.94	0.88				1.12	0.98				1.75	1.79			
Width/Depth Ratio	8.24	10.40				11.25	10.41				8.46	9.46				7.03	8.06			
BF Cross-Sectional Area (ft ²)	23.77	16.60				9.98	8.00				10.57	9.00				21.55	25.90			
BF Max Depth (ft)	3.30	2.17				1.52	1.37				1.80	1.53				3.21	3.86			
Width of Floodprone Area (ft)	76.44	-				75.71	-				133.14	-				109.89	-			
Entrenchment Ratio	5.5	5.3				7.1	7.9				14.1	13.9				8.9	7.8			
Bank Height Ratio	1.0	1.1				1.0	1.1				1.0	1.1				1.0	1.1			
Wetted Perimeter (ft)	-	-				-	-				-	-				-	-			
Hydraulic Radius (ft)	-	-				-	-				-	-				-	-			
Substrate																				
d50 (mm)																				
d84 (mm)																				

**STREAM DATA
AND PHOTOS**

Crowns West Profile Station 15+00 to 32+50



Crowns West Profile Station 33+50 to 50+00



Permanent Cross-section 1
(Year 2 Data - Collected August 2008)

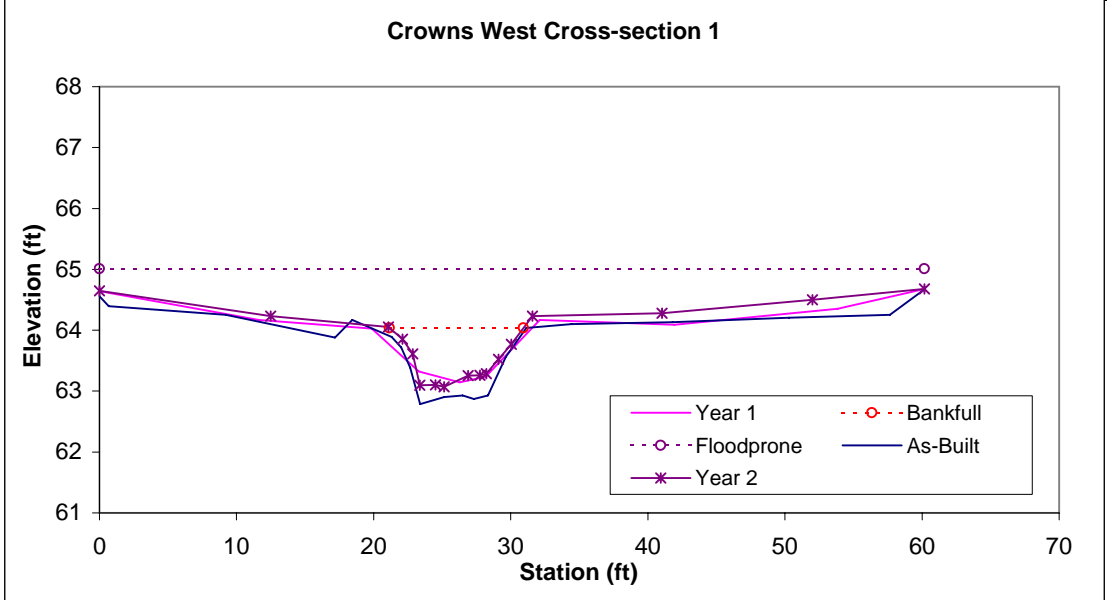


Looking at the Left Bank

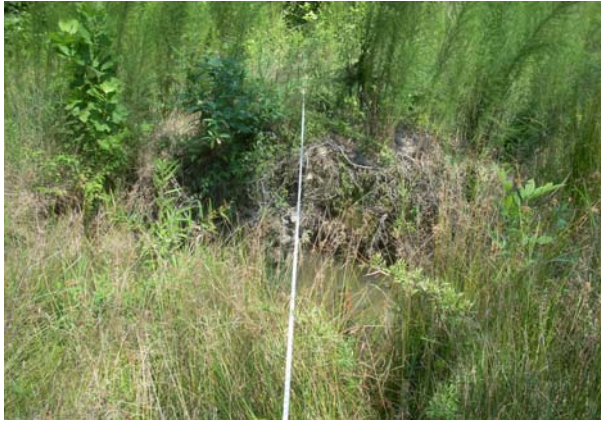


Looking at the Right Bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	Cc	6	9.79	0.61	0.97	16.05	1	6.1	64.04	64.05



Permanent Cross-section 2
(Year 2 Data - Collected August 2008)

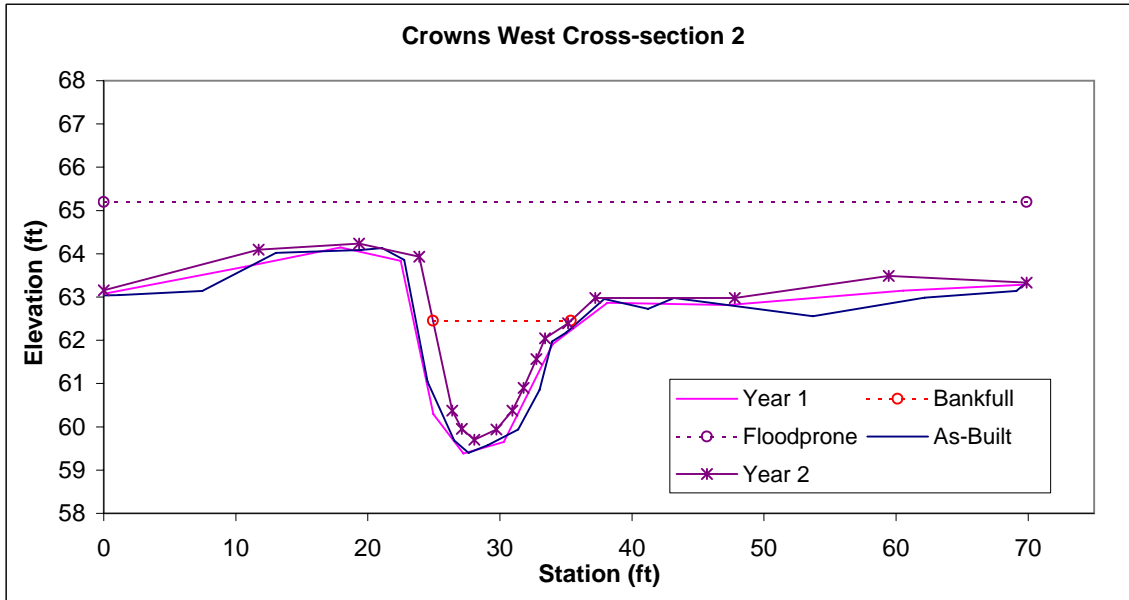


Looking at the Left Bank



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		16.4	10.43	1.57	2.75	6.64	1.2	6.7	62.45	62.98



Permanent Cross-section 3
(Year 2 Data - Collected August 2008)

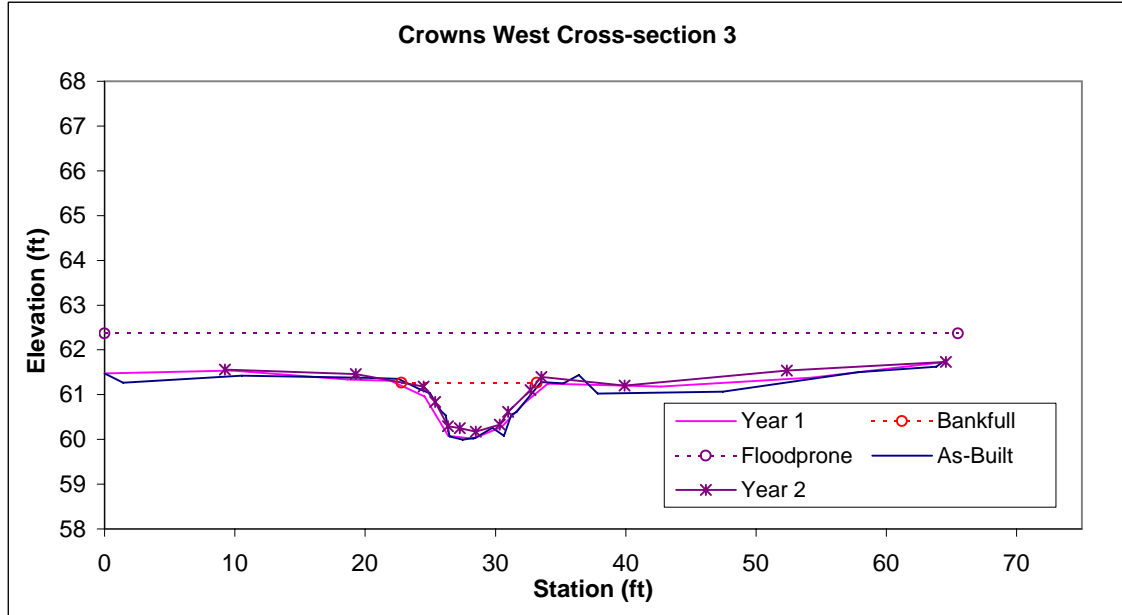


Looking at the Left Bank

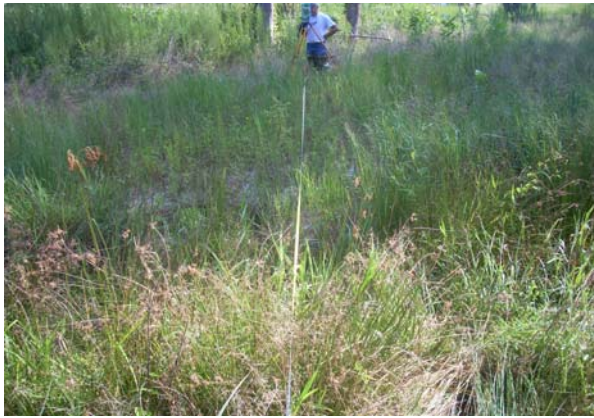


Looking at the Right Bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	Cc	6.3	10.38	0.61	1.1	16.99	1.1	5.3	61.27	61.4



Permanent Cross-section 4
(Year 2 Data - Collected August 2008)

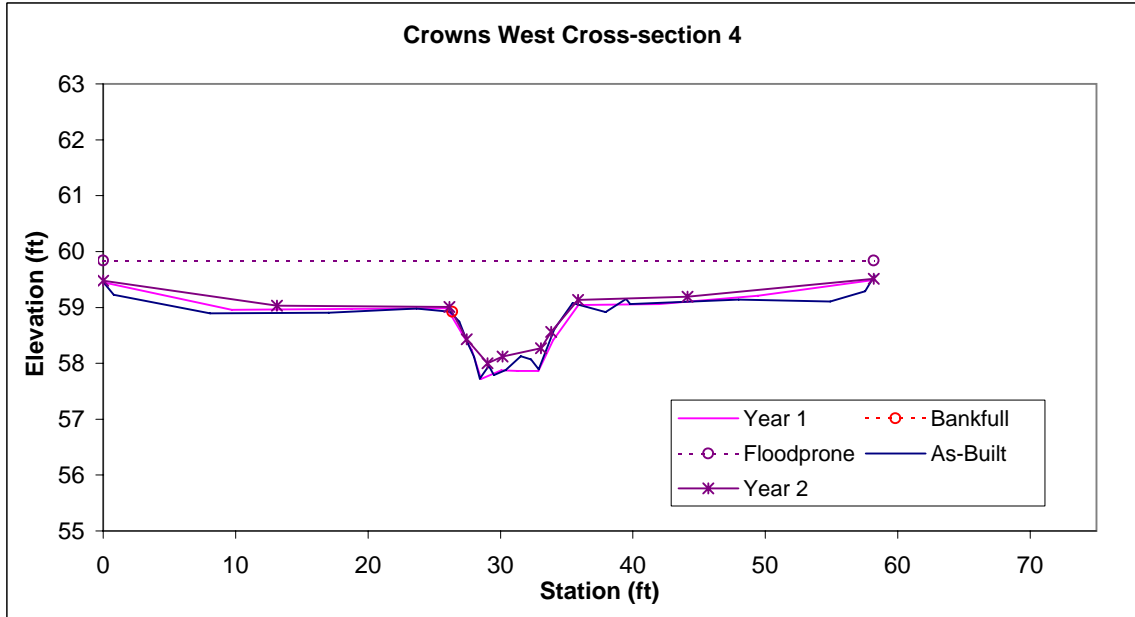


Looking at the Left Bank



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	5.1	8.76	0.58	0.92	15.1	1.1	6.6	58.92	59.01



Permanent Cross-section 5
(Year 2 Data - Collected August 2008)

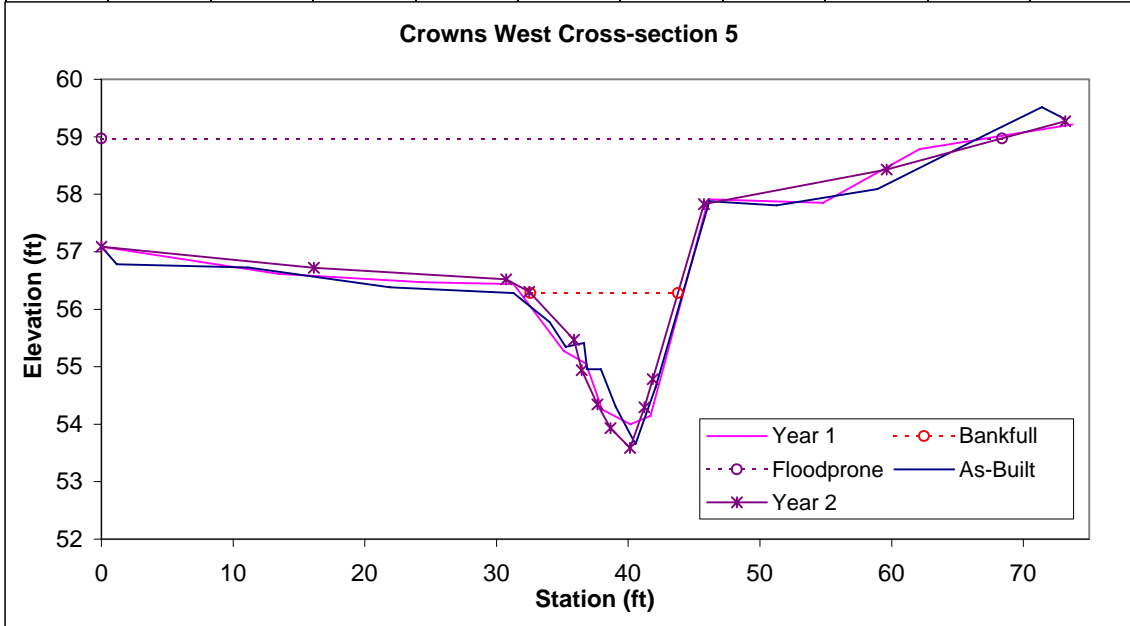


Looking at the Left Bank



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		14.9	11.19	1.33	2.69	8.42	1.1	6.1	56.28	56.52



Permanent Cross-section 6
(Year 2 Data - Collected August 2008)

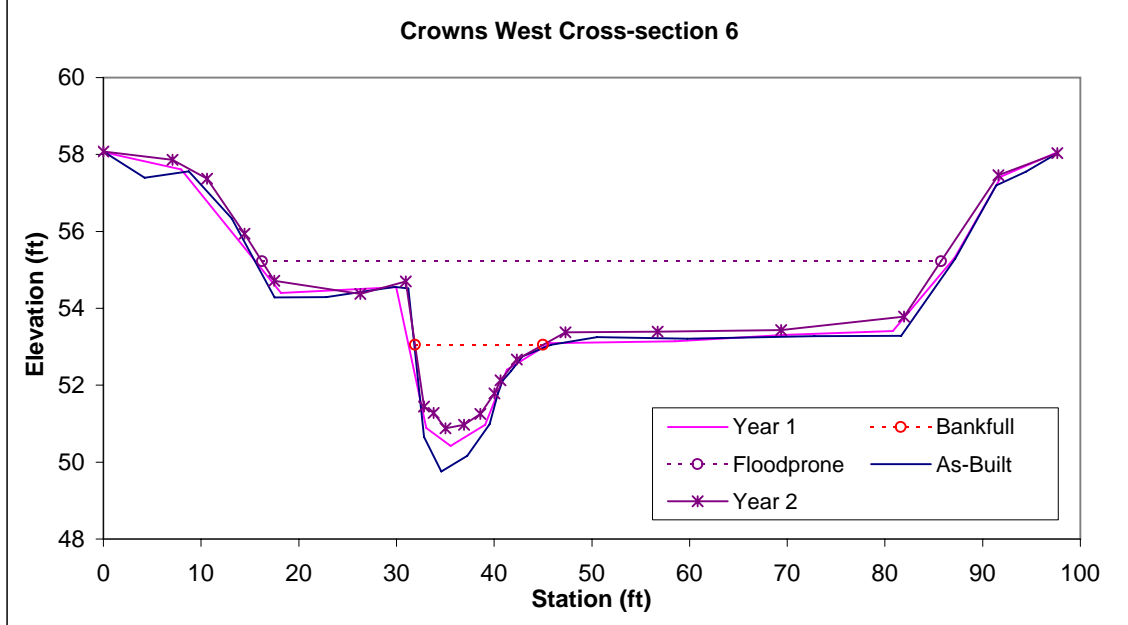


Looking at the Left Bank



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		16.6	13.13	1.26	2.17	10.4	1.1	5.3	53.05	53.37



Permanent Cross-section 7
(Year 2 Data - Collected August 2008)

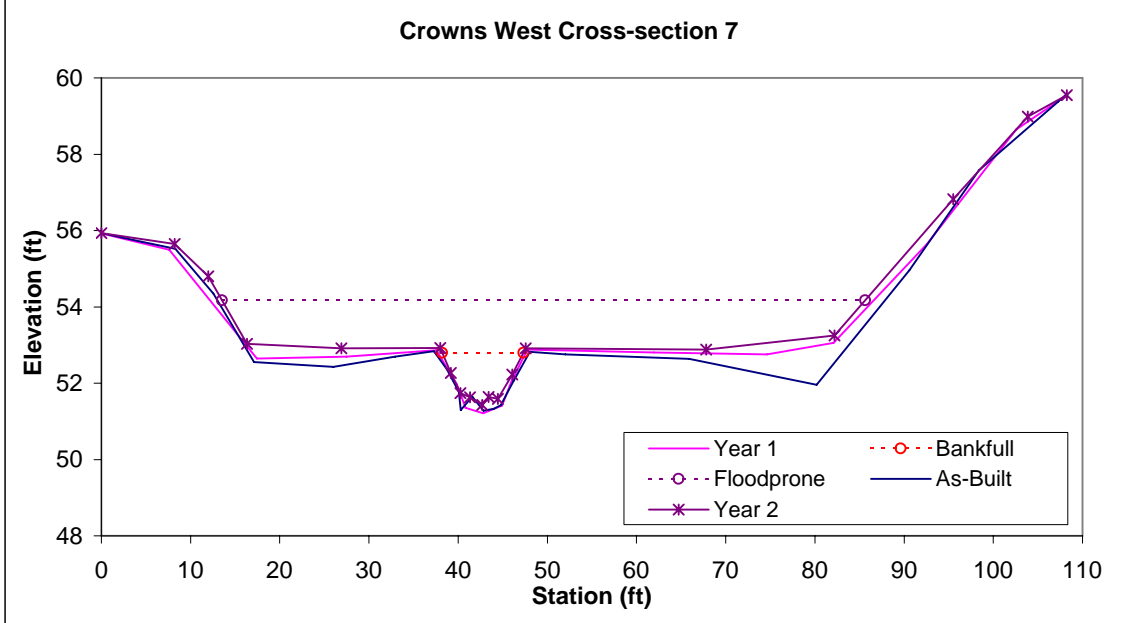


Looking at the Left Bank



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	8	9.12	0.88	1.37	10.41	1.1	7.9	52.8	52.91



Permanent Cross-section 8
(Year 2 Data - Collected August 2008)

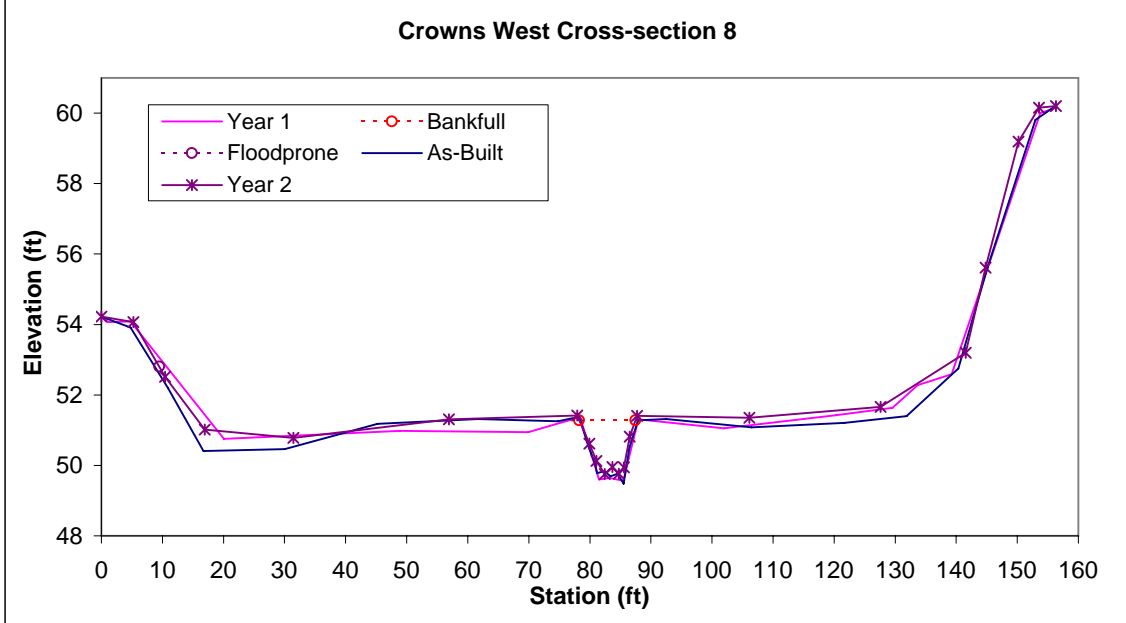


Looking at the Left Bank



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	9	9.24	0.98	1.53	9.46	1.1	13.9	51.28	51.41



Permanent Cross-section 9
(Year 2 Data - Collected August 2008)



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		25.9	14.44	1.79	3.86	8.06	1.1	7.8	49.83	50.09

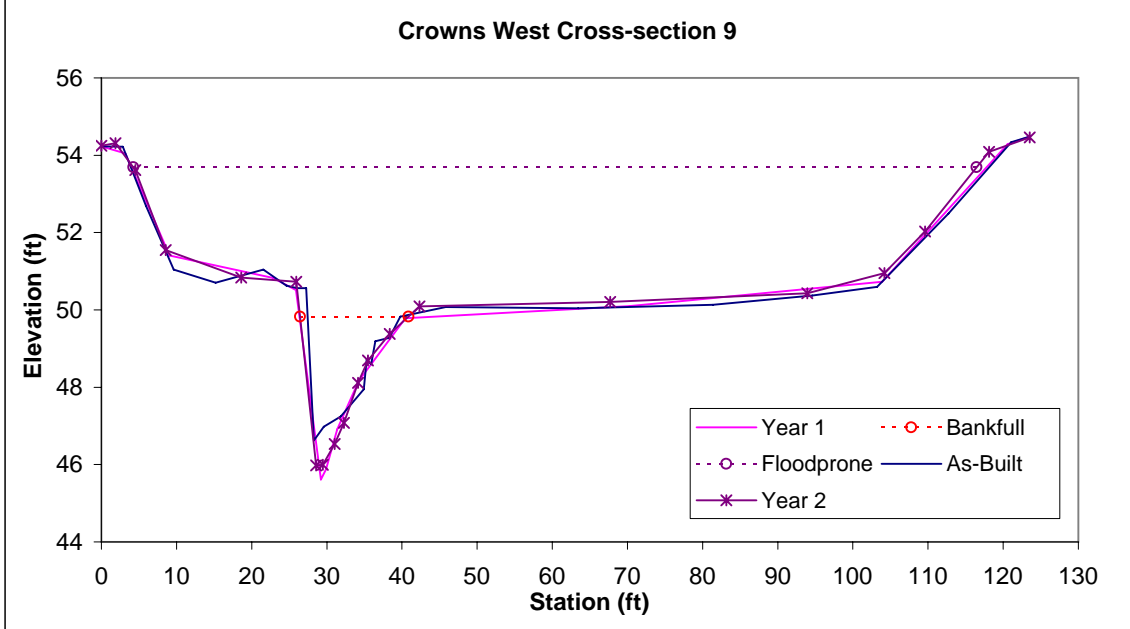




Photo Point 1 - Constructed Riffle 1



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



Problem Area 1, Station ~31+50



Problem Area 2, Station ~43+00



Problem Area 3, Station ~45+25



Problem Area 4, Station ~47+50



Crest gauge reading of 1.91 feet



Crest gauge reading of 0.33 feet

BENTHIC MACROINVERTEBRATES COLLECTED FROM CROWNS MANAGEMENT, ONSLOW CO., NC, FEBRUARY 2008.

SPECIES	T.V.	F.F.G.	Sta. 1	Sta. 2
PLATYHELMINTHES				
Turbellaria				
Tricladida				
Dugesiidae				
<i>Girardia (Dugesia) tigrina</i>	7.2		1	
MOLLUSCA				
Bivalvia				
Sphaeriidae				
	*8	FC		
<i>Pisidium sp.</i>	6.5	FC		2
Gastropoda				
Mesogastropoda				
Viviparidae				
<i>Campeloma decisum</i>	6.5	SC		2
Basommatophora				
Planorbidae				
	*6	SC		
<i>Menetus dilatatus</i>	8.2	SC	6	
Physidae				
<i>Physella sp.</i>	8.8	CG		4
Planorbidae				
	*6	SC		
<i>Planorbella sp.</i>	6.8			1
ANNELIDA				
Oligochaeta				
	*10	CG		
Tubificida				
Tubificidae w.o.h.c.				
	7.1	CG		1
ARTHROPODA				
Crustacea				
Isopoda				
Asellidae				
		SH		
<i>Caecidotea sp.</i>	9.1	CG		2
Amphipoda				
		CG		
Crangonyctidae				
<i>Crangonyx sp.</i>	7.9	CG	1	
Gammaridae				
<i>Gammarus sp.</i>	9.1	SH		37
Decapoda				
Cambaridae				
	7.5			
<i>Procambarus sp.</i>	7	SH		3
Insecta				
Ephemeroptera				
Baetidae				
		CG		
<i>Pseudocloeon sp.</i>	4	CG		1
Ephemerellidae				
		SC		
<i>Eurylophella sp.</i>	4.3	SC		2
Heptageniidae				
		SC		
<i>Maccaffertium (Stenonema) modestum</i>	5.5	SC		22
<i>Stenacron interpunctatum</i>	6.9	SC		2
Odonata				
Calopterygidae				
		P		
<i>Calopteryx dimidiata</i>	7.8	P		9
Cordulegastridae				
		P		

BENTHIC MACROINVERTEBRATES COLLECTED FROM CROWNS MANAGEMENT, ONSLOW CO., NC, FEBRUARY 2008.

SPECIES	T.V.	F.F.G.	Sta. 1	Sta. 2
<i>Cordulegaster maculata</i>	5.7			1
Megaloptera				
Corydalidae		P		
<i>Nigronia serricornis</i>	5	P		1
Sialidae		P		
<i>Sialis sp.</i>	7.2	P		1
Trichoptera				
Hydropsychidae		FC		
<i>Cheumatopsyche sp.</i>	6.2	FC		1
Philopotamidae		FC		
<i>Chimarra aterrima</i>	2.8	FC		1
Coleoptera				
Dryopidae				
<i>Helichus fastigiatus</i>	4.6	SC	1	1
Dytiscidae		P	1	
<i>Hydroporus sp.</i>	8.6	PI	4	3
Gyrinidae		P		
<i>Gyrinus sp.</i>	6.2	P		1
Haliplidae				
<i>Peltodytes sp.</i>	8.7	SH	1	
Diptera				
Chironomidae				
<i>Chaetocladius sp.</i>		CG	1	
<i>Conchapelopia sp.</i>	8.4	P		5
<i>Corynoneura sp.</i>	6	CG		8
<i>Cricotopus sp.</i>		CG	17	1
<i>Cricotopus bicinctus</i>	8.5	CG	5	
<i>Diplocladius cultriger</i>	7.4	CG	6	
<i>Orthocladius sp.</i>		CG	18	
<i>Microtendipes pedellus gp.</i>	5.5	CG		1
<i>Paralauterborniella nigrohalteralis</i>	4.8	CG		1
<i>Polypedilum flavum (convictum)</i>	4.9	SH		6
<i>Polypedilum fallax</i>	6.4	SH		1
<i>Rheotanytarsus exiguus gp.</i>	5.9			1
<i>Tanytarsus sp.</i>	6.8	FC		1
<i>Zavreliomyia sp.</i>	9.1	P	1	1
Simuliidae		FC		
<i>Simulium sp.</i>	6	FC	42	3
Tabanidae		PI		
<i>Chrysops sp.</i>	6.7	PI		3
Tipulidae		SH		
<i>Hexatoma sp.</i>	4.3	P		1
<i>Tipula sp.</i>	7.3	SH		1
TOTAL NO. OF ORGANISMS			105	132
TOTAL NO. OF TAXA			14	35
EPT INDEX			0	6
NC BIOTIC INDEX			6.76	7.17



Site 1 – Crowns West macroinvertebrate sampling site, view is upstream



Site 1 – Crowns West macroinvertebrate sampling site, view is downstream



Site 2 – Beaverdam Branch macroinvertebrate sampling site, view is upstream



Site 2 – Beaverdam Branch macroinvertebrate sampling site, view is downstream



Site 1 - American eel (*Anguilla rostrata*)

