Brandywine Restoration Project
- Batavia Kill -

IMPLEMENTATION & MONITORING REPORT

Brandywine Project - Batavia Kill
Town of Ashland, Greene County, NY

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Brandywine Restoration Project

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Town of Windham
Project Landowners

For Additional Information
www.gcswcd.com/stream/bataviakill/Maier

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1.0 Project Background

A regional study of water quality was initiated by the New York City Department of Environmental Protection (NYCDEP) in the spring of 1993. The study focused on sub-basins in the West of Hudson (WOH) watershed and included identifying areas of concern and developing a comprehensive understanding of the sources and fate of materials contributing to turbidity and total suspended solids (TSS). The results of the study ranked the Batavia Kill sub-basin as producing the highest levels of turbidity and TSS. In 1996, a pilot project was initiated between the NYCDEP and the Greene County Soil & Water Conservation District (GCSWCD) in the Batavia Kill watershed. The Batavia Kill Stream Corridor Pilot Project focused on using fluvial geomorphic based stream classification, assessment and restoration principles in an attempt to reduce turbidity and TSS loading in the Batavia Kill.

Prior to the cooperative effort between NYCDEP and GCSWCD, geomorphic restoration principles had not been extensively tested and used in the Northeast. The NYCDEP and GCSWCD believed that stream restoration based on geomorphic and natural channel design principles would provide multiple benefits including, improved fisheries habitat, flood protection, streambank stabilization and improved aesthetics, in addition to reducing sediment loading and turbidity from in-stream sources.

1.1 Batavia Kill Pilot Project Goals and Objectives

The primary goal of the Batavia Kill Pilot Project was to demonstrate the effectiveness of using fluvial geomorphic restoration techniques for reducing turbidity & TSS loading from in-stream sources. The fundamental goals of the pilot project were further developed and refined throughout the progression of the pilot project, and are summarized below:

- Evaluate and improve the effectiveness of natural channel design techniques in the Catskills based on assessments of the physical and biological characteristics of the restoration sites paired with water quality monitoring.

- Evaluate and improve the effectiveness of geomorphic assessment indices and techniques for the identification of stability problems for use in multi-objective restoration and planning.

- Evaluate the effectiveness of using stable reference reaches and regional relationships in the development of restoration designs.

- Conduct performance evaluations of the restoration projects, through monitoring and inspection, to document the status and stability of the demonstration projects. The results of performance evaluations can then be used to improve the future use of the design techniques.

- Develop design standards, typical details, construction specifications, construction sequencing procedures, and operation and maintenance protocols for geomorphic based NCD restoration projects.

1.2 Brandywine Restoration Project

Three demonstration projects were initiated during the first phase of the Batavia Kill Pilot Project.

The restoration of the Brandywine project reach is the second large scale effort implemented in the Batavia Kill stream corridor. The Brandywine Stream Restoration Project is located in the center of the Batavia Kill mainstem in the Town of Ashland. The project reach drainage is modified due to its location below the Batavia Kill's three flood control structures. The Brandywine project reach is approximately 3800 feet in length and runs parallel with State Highway 23. The reach begins below Valley View Farm and ends at property operated by VanEtten Trucking. The reach ranges in drainage area from $43.1mi^2$ to $50.8mi^2$ with the convergence of North Settlement creek and one small unnamed tributary.

The project represents a cooperative effort between NYCDEP, GCSWCD, and several other stakeholders in the Batavia Kill watershed. In the sections that follow, planning and coordination, assessment, design, construction and monitoring components, of the project will be described. Further, it is our intention to make this report a working document, displaying the status and performance of the Maier Farm Stream Restoration Project as it progresses.

2.0 Watershed Setting

The Batavia Kill watershed is a 72 square mile sub-basin of the Schoharie drainage. The Maier Farm project reach has the flattest valley slope of the drainage system, at 0.3%. This reach of the Batavia Kill, having multiple river terraces positioned laterally along a broad alluvial valley, is classified as a valley type VII. Alluvial terraces and floodplains are the predominant depositional landforms occurring along this reach. The valley is very broad with extensive belt width available for stream channel migration. Historically, the stream channel alignment has been heavily manipulated, resulting in the current irregular and distorted meander pattern. Historic management of the watershed, including alignment modifications, have resulted in numerous channel responses including increased sediment supply, over-widened channels, rapid lateral migration and impacted habitat through the valley segment.

Field assessments, coupled with the analysis of aerial photography, were used to characterize stability and inventory historic stream response through the reach. An initial stream corridor inventory and assessment in 1997 included an erosion inventory to prioritize reaches for future monitoring efforts. From these assessments, it was determined that the stream segment encompassing the project area, had the highest level of erosion, per unit stream length, in comparison to the five other corridor segments. More than 45% of this segment's streambanks were experiencing active erosion and bank failure, averaging more than $4ft^2$ of exposure on streambanks for every foot of stream length. These soils were being lost to both hydraulic and geotechnical streambank failures, or a combination of both.

The predominant soil type found in the reaches streambanks is gravelly loam. Typically, this soil is a deep stratified soil found on the sides of terraces and convex portions of outwash plains. These soils are loose in structure with little rock content, corresponding to a high susceptibility to erosion and entrainment of the reaches streambanks. Review of the soil characteristics of the segment determined the corridor was highly susceptible to accelerated bank erosion due to the thick unconsolidated layers of glacial soils. The composition of the streambank material and soil structure, within this segment, are generally finer than the channel pavement material. Further, the assessment in 1997 inventoried lacustrine clay in the bottom of pool features in several areas. Erosion of the clay severely impacts water quality, which is a primary concern for project partners.

Riparian buffers are crucial in maintaining stream stability within stream type and valley setting. The review of aerial photography and field investigation determined that the riparian buffer provided minimal streambank protection throughout the segment. The existing riparian vegetation primarily consisted grasses along the top of the streambank, with sparse areas of shrubs and deciduous trees. The invasive species Japanese knotweed (Polygonum cuspidatum) heavily colonized the entire segment and appeared to be actively progressing through the low lying floodplain areas. It is believed that the dominant characteristics of the knotweed severely limits the reestablishment of native plant species, essential for an effective riparian buffer.

Anthropogenic impacts have contributed to the degradation of riparian areas and flow and sediment regimes in the stream channel. Historically, the land directly adjacent to the channel has been used for agriculture. Cultivation by farmers to the edge of the streambank has had the greatest impact on riparian areas. The riparian buffer has been left extremely thin and heavily fragmented through the segment. The lack of a mature riparian buffer is the primary cause of streambank instability within the segment. Further, the construction of three flood control structures within the last 30 years has modified the natural water and sediment regimes through the segment. These structures have caused increases in flow duration and available energy that impacts the streambanks and channel bottom. These structures also retain sediment which prevents sediment transport to downstream reaches and subsequently has impacted channel morphology downstream.

In summary, these watershed and corridor modifications are the likely cause for the increase of streambank erosion through the segment. Historic management, flood events and associated mitigative work had left this section of the Batavia Kill highly susceptible to increased environmental degradation from reduced stream stability.

3.0 Reach Stability Assessment

The Phase I inventory and assessment, conducted in 1997, was used to delineate this segment of the Batavia Kill into six independent monitoring reaches. The Brandywine reach was identified as one of the most unstable reaches along the Batavia Kill stream corridor, with over 2500 feet of eroded bank, representing nearly 70 percent of the reach's banks. Therefore, Brandywine reach was a priority site for comprehensive monitoring. The following sections further summarize the state of the reach before restoration between 1997 and 1999.

3.1 Existing Channel Morphology

Field assessment and monitoring of the Brandywine reach began in 1997 and continues presently. The site has undergone Phase I-IV assessments which included several monitored cross sections, a monitored longitudinal profile, inventories of channel and point bar substrate, as well as a number of stability analyses. These measures were monitored annually before construction and used in the evaluation of the reach. The location of the preconstruction monitoring cross sections and corresponding data are displayed in Appendix B.

A corridor walkover and aerial photograph progression were initially used in the evaluations of the reach. These assessments determined the reach averaged 3.2 square feet of erosion per foot of streambank with 45% of the reach experiencing erosion. The upper half of the reach was noted as generally stable with the majority of erosion occurring in the lower half. A progression of historical aerial photographs confirmed that severe channel migration has occurred historically in the lower half of the reach with the upper half remaining relatively stable.

The upper portion of the reach was surveyed in July of 1997 including four cross sections and 700 feet of longitudinal profile. The upper sections of the reach were classified as a B4c stream type changing to a C4 stream type, with a decrease in entrenchment due to the position of a floodplain terrace, in the lower section of the reach. This section of the reach appeared stable but significant colonizations of Japanese knotweed were present along the left stream bank.

Figure1 Historic Aerial Progression of the Brandywine Reach

A historical aerial photograph progression was performed which characterized the lower reach as exhibiting unstable planform behavior and excessive channel migration (Figure 1). This was particularly apparent in the area downstream of the confluence with North Settlement Creek in which channel migration and several channel avulsions had resulted in oxbow and oxbow cutoffs formations (Figure 4). Measurements determined 980 feet of channel migration between the years of 1959 and 1997.

Further evaluation of the physical condition of the lower portion of the reach determined the area was a substantial contributor of excessive sediment into the system and thus deemed a priority within the corridor. Field assessment and monitoring in the lower section of the reach, referred to as the Brandywine site, began in the summer of 1997. The site has undergone several levels of assessment including, two monitored cross sections, 3350 feet of monitored longitudinal profile, and an assessment of channel and point bar substrate. The monitoring cross sections documented 52 square feet (Figure 2) and 80 square feet (Figure 3) of erosion (Red Hatch) between 1997 and 1999. A topographic survey was completed for the entire site in November of 1997 covering an area of approximately 32 acres.

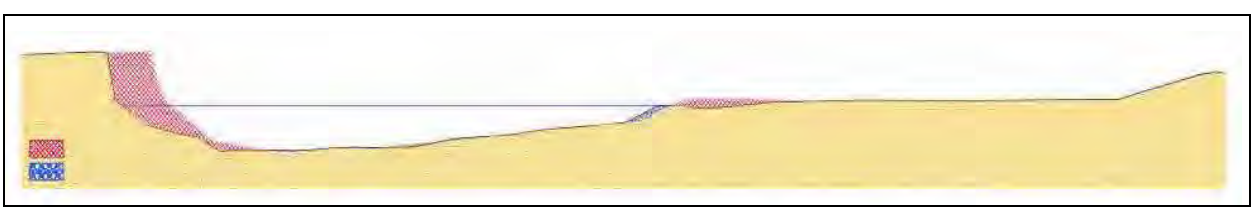


Figure 2 Overlay of cross section #1 on the Brandy Wine site, 1997 - 1999.

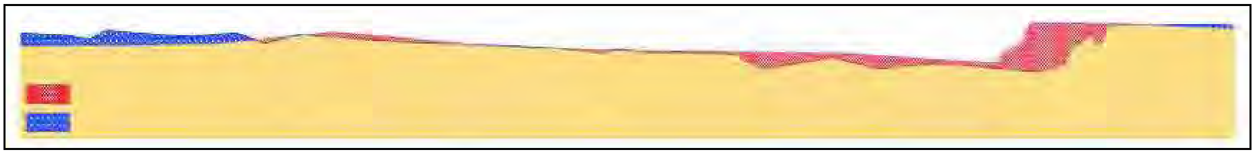


Figure 3 Overlay of cross section #2 on the Brandy Wine site, 1997 - 1999.

The Brandywine site was classified as a Rosgen C4 stream type with channel sediment dominated by very coarse gravel. In general, the assessment determined a over-widened channel condition and high width/depth ratios. The principal channel erosional processes were lateral migration and avulsions during extreme events and inefficiency to transport the sediment regime.

3.2 Soils and Geology

In the summer of 1998, a project was initiated to inventory and map clay exposures in the Batavia Kill corridor, in partnership with NYCDEP. The geologic mapping through the reach found glacial lacustrine clay in the bottom of several pool features. The presence of lacustrine clay denotes a thin layer of armoring sediment and susceptibility to scour resulting in water quality impairment. Additionally, the stratigraphic column of the eroding streambank was inventoried including three distinct layers. The upper horizon consisted of 2 foot thick layer of sandy clay loam over a horizon of small gravel material. The base material and channel bottom consisted of unconsolidated till.

3.3 Riparian Vegetation

The riparian vegetation located through the reach is characterized as low density deciduous overstory with large areas of grasses along bordering farm fields. The existing condition provides minimal streambank protection and is compounded by the invasive species Japanese Knotweed (Polygonum cuspidatum). This species has colonized significant portions of the streambanks and floodplain throughout the entire reach. The dominance of the species through the reach creates little potential for self recovery of the natural riparian vegetation. The poor vegetative condition of the reach has historically been compounded by the farming practices along the adjacent fields. Farming to the top of the stream bank and removal of all riparian vegetation along the fields has limited the development and function of the riparian community as a filter to sediment and nutrients.

Figure 4 Historic channel meanders and avulsions.

4.0 Project Goals and Objectives

As the GCSWCD and NYCDEP reviewed the condition of the reach and its potential for restoration, a number of issues were identified. Water quality was negatively affected by streambank erosion. The partners proposed that restoration of the reach presented the opportunity to minimize erosion while meeting a wide range of objectives and providing a number of environmental benefits.

4.1 Primary Goal

The primary goal of the restoration project can be summarized as follows:

> **To mitigate excessive turbidity and total suspended solids impact on water quality by addressing excessive lateral erosion.**

4.2 Secondary Objectives and Benefits

- Provide long term channel stabilization, to reduce property damage and while maintaining the integrity and benefit of a naturally functioning channel and floodplain.

- Reduce and/or avoid further impacts on aquatic and riparian habitat within the project area, and upstream and downstream reaches, while maintaining the aesthetic values of a natural stream channel.

4.3 Project Constraints

During the planning process, project partners assisted in identifying numerous project criteria constraints. These include, physical site constraints, landowner approval and access, data needs and limitations, and project permitting.

The project design needed to address channel stability and processes, and work within the existing physical site constraints. The physical constraints included manmade and natural limitations which were inventoried, and incorporated into the final design. The pre-construction monitoring identified several distinct instabilities and associated problems through the project reach. Ultimately, the restoration design needed to correct channel plan form, profile and cross section parameters in order to meet the goals and objectives of the project and to provide for potential long-term channel stability.

The project design needed to incorporate additional techniques for completing the project construction through isolated areas containing lacustrine clay as well as accounting for vast areas of riparian vegetation consisting primarily of Japanese knotweed (Polygonum cuspidatum) and its potential for further dispersal.

The acceptance of the project by the landowners had substantial bearing on the success of the restoration. Landowner approval and access to the project area was identified as a critical project constraint. The need for approval by multiple primary and secondary landowners within the project area generated the need to educate the owners about stream instability and the apparent need for mitigative action. The planning and design process required utilizing the landowners knowledge of the site and incorporating owner concerns into the project when practical. The provision of landowner approval was set forth using Landowner Project Agreements, which is a temporary agreement between the landowner allowing for the project construction, maintenance and monitoring.

The restoration of the Maier Farm site required permits to be issued by the Army Corps of Engineers (ACOE), the New York State Department of Environmental Conservation (NYSDEC), and the New York City Department of Environmental Protection (NYCDEP).

5.0 Restoration Methodology and Strategy

Alternative restoration strategies, that best reflected the project objectives, were evaluated by landowners and project partners until a consensus was reached. The project reach was unstable and it was believed that current channel processes would continue to impact the adjacent landowner and the Batavia Kill resource. To meet the numerous goals, set forth by project stakeholders, a restoration strategy focusing on the geomorphic channel form was chosen. This required classification of the current condition and the development of a preferred physical morphology for the restored channel. The following strategy for restoration was developed after refinement of project goals and constraints*:*

- Develop a channel geometry and profile that will provide stability, maintain equilibrium (form), and maximize the streams natural potential while appropriately conveying the sediment supply.

- Develop a new channel planform which will result in a meander geometry more consistent with the available valley features.

- Remove the existing, exposed lacustrine clay material found within the channel boundary to a determined scour depth below the finished grade of the project design. The over-excavation of the clay material would reduce the potential for the future entrainment of clay particles.

- Maintain and/or increase the ability of the stream channel to utilize the active floodplain, during flow events which meet or exceed bankfull stage.

- Utilize a combination of geomorphic structures paired with bioengineering techniques to reduce and protect against bank erosion, provide grade control, and promote increased physical habitat.

- Obtain needed fill materials from on-site sources, where possible, using a combination of floodplain re-contouring, borrow areas, and floodplain ponds.

- Create a single defined channel through the braided area capable of transporting a range a flow and providing for increased sediment transport.

- Establish an effective riparian buffer consisting of trees, shrubs and deep rooted grasses to assist in providing long-term stability of the stream channel and floodplain.

- Provide habitat, recreation, and aesthetic enhancements concurrent with the creation of a naturally functioning stream morphology and floodplain area*.*

In 1997, the GCSWCD initiated the development of a restoration design for the project reach. A topographic survey was conducted and supplemented with geomorphic assessments and monitoring surveys. Since a typical stable reference reach for the appropriate stream type could not be found, it was determined that the assessment and design would utilize data collected from adjacent stream reaches, aerial photography, regime analysis and analytical methods.

5.1 Channel Morphology

The dimensions and scale of the proposed stream channel were designed to accommodate a full range of flows and to meet considerations for sediment transport and channel boundary conditions. Regime and tractive force analyses and other analytical tools were utilized in order to develop an appropriate reconfiguration. Unlike traditional channel sizing, the design channel continually transforms between channel features, changing in shape, length, and spacing as the channel meanders through the reach.

After reviewing the historic trends of channel migration, it was determined that the channel was expanding its available belt width and increasing overall sinuosity by laterally eroding the streambanks within the reach. The goal for the channel realignment was to develop a stable plan form, in order to accelerate the channels evolution toward a more stable form. The final design included the partial realignment of 2,750 feet of stream channel. The channel alignment was created using regime and reference conditions paired with the analysis of historical aerial photography. Modifications to the proposed planform were made to provide the best applicable alignment through the bridge structure. The planform dimensions were carried upstream from the bridge to a point above the project where the new geometry could be matched into the existing conditions. The slight increase in channel meandering would provide for a reduction in local channel slope and allow for better local floodplain interaction near the bridge structure. The cut and fill quantities and feasibility of construction were also considered during the design for realignment.

The channel profile was created using valley slope characteristics, the existing channel and floodplain terraces, as well as regime and reference conditions. The channel profile was constrained vertically through the reach by underlying glacial clay layers that existed in close proximity to the channel invert, requiring over-excavation in several pool areas. The channel profile was also designed to provide for bed feature variation, simulating a more natural riffle/pool complex, in order to provide for increased channel habitat and energy dissipation. These variations are common in natural riffle-pool complexes. The channel profile was enhanced using grade control devices in order to promote natural erosion and deposition characteristics through the reach.

The cross sectional dimensions of the channel were altered to promote proper sediment and flow transport through the reach during a range of flow events. A multi-staged channel was created through the reach in order to provide for a defined bankfull channel, physical habitat during low flow, and increased floodplain function for large flow events. Improving the width-depth dimensions through the over-widened sections, and creating a single channel in the braided area of the reach provide for more efficient sediment conveyance. Further, the channel dimensions of the base flow channel were enhanced by the creation of pools at the outside of meanders and behind in-stream structures throughout the entire reach. A summary of channel design and reach parameters characteristics has been described in Table 1.

Table 1: Comparison of channel morphological ranges.

Variables	Existing Channel	Proposed
Stream Type (Reach)	C4	C4
Bankfull Width (ft.)	69-121.13	63.7-78
Bankfull Mean Depth (ft.)	3.06-2.37	3.4-3.6
Width/Depth Ratio	22.5-51.2	18.6-21.6
Bankfull Cross Sectional Area (sq. ft.)	211.3-286.7	218-281
Bankfull Maximum Depth (ft.)	4.21-5.41	4.2-8.5
Width of Flood Prone Area (ft.)	218-378	>304
Entrenchment Ratio	3.15- 3.12	4.8
Sediment D50 (mm)	45	-------
Sediment D84 (mm)	120	-------
Sinuosity	1.04	1.12
Average Channel Slope (ft./ft.)	0.003	0.006

5.2 In-stream Structures

The design incorporated four general types of in-stream structures to promote channel stabilization. A combination of rock vanes, cross vanes and root wads were used to achieve multiple benefits including channel grade control, streambank stabilization, improved physical habitat, efficiency of sediment conveyance, dissipation of excess channel energy, and maintaining bed form variation.

Thirteen rock vanes were incorporated along four meander bends in the project to assist in reducing shear stress and bank erosion, while allowing for the long term establishment of vegetation. Additionally, rock vanes provide bed form variation by maintaining scour pools downstream of the vane arms. The design incorporated three cross vane structures at the top of channel cross over segments and a single w-weir at the bottom of the project reach. These structures provide grade control, impede head ward erosion, and reduce shear stress and bank erosion. Material for the construction of the rock structures was obtained from local quarries and transported to the project reach.

Root wads were proposed for habitat enhancement and to provide increased bank stabilization in high stress areas. Available root wads were to be used in combination with rock vane structures. Large trees remaining from previous flood events and trees obtained during the clearing and grubbing of the project area were used to construct the root wads.

5.3 Riparian Vegetation

The project design planned for the use of traditional bioengineering practices to provide increased streambank stability and to initiate riparian vegetation growth in disturbed areas. Live fascines, native sod mats, and large willow transplants were combined with the installation of live stakes, posts, and bare root transplants. The design proposed installation of more than 2,578 feet of live fascines, installed in a double row, on the outside of all meander bends and high stress areas. Locally harvested willow and alder species provided materials for the bioengineering efforts. A seed and mulch mixture was used to provide short term stabilization of disturbed areas.

The design proposed the placement of large transplanted willow clumps along significant areas of potential high stress (i.e. along bank keys where rock structures tie into the streambank). Secondary benefits of the transplants included accelerated re-vegetation and stream channel shading. The willow clumps were harvested from an on-site borrow area, located along the western side of the of the project.

Native sod mats were installed along the top of the streambanks to accelerate streambank re-vegetation. Sod mats were also used to reduce sediment runoff from construction activities in the floodplain, to the channel, until complete ground cover was established. Upon completion of bioengineering applications a conservation seed and mulch was applied to the entire project area.

A substantial effort was put forth to mechanically remove the existing knotweed stands and to minimize the disturbance to the existing native floodplain vegetation. Areas containing knotweed were excavated below the rooting depth, collected, and disposed of in deep trenches excavated throughout the project site.

5.4 Clay Material

The project reach contained isolated exposures of glacial clay material located in existing scour areas. To mitigate the water quality impacts of the clay, the restoration design provided specifications for removal of the clay materials by over-excavation and replacement with clean gravel/cobble material. Specifications called for the removal of a minimum of three feet of clay material, below the finished grade of the project design. Excavated clay material was disposed in designated areas located in the adjacent floodplain away from the active channel.

5.5 Fill Material

A large quantity of fill material was required through sections of the project reach in order to implement the proposed channel and floodplain modifications. The acquisition and transport of this quantity of fill from off-site sources would be relatively expensive, therefore the selection on-site fill sources were included within the project planning and design stage.

6.0 Project Implementation

The restoration project was authorized by NYSDEC under Article 15 of ECL, and approved by the USACOE pursuant to Section 404 of the Clean Water Act, in August of 1998. A Stormwater Pollution Prevention Plan was submitted to the New York City Department of Environmental Protection and accepted in July of 1998. Due to the probability of high water and inclement weather at the time of anticipated construction, project construction was postponed until the summer of 1999. Permit extensions were granted by all reviewing agencies.

6.1 Project Bidding

A project bid package was developed to include drawings and specifications for the proposed project. The project was publically bid in July of 1999 using a competitive bid process. A mandatory site showing was attended by several contractors, and three bids were submitted for the construction. The final accepted project bid is summarized in Table 2.

6.2 Project Construction Time Line

Project construction was initiated on 1999, beginning with clearing/grubbing and dewatering. Construction of the new stream channel and in-stream structures required approximately calendar days. Bioengineering components were initiated immediately following the channel reconstruction and continued until the middle of August.

Table 2: Final Project Bid

Bid Item	Estimated Quantities	Contractor - Bid Price.	
		Unit Bid Price	Total Price
Mobilization	----------	----------	$8,739.00
Clearing/ Grubbing	----------	----------	$15,160.00
De-watering	----------	----------	$31,000.00
S.C. Excavation	----------	-----------	$37,000.00
Surveys	----------	----------	$3,000.00
Rock Vanes	13	$2,127.00	$27,646.32
W-W eir	1	$7,371.00	$7,371.00
Cross vanes	4	$3,598.00	$14,392.48
Root Wads	3	$634.00	$1,902.00
Live Material Transplants - Sod Mats	1225	$10.00	$12,250.00
Live Material Transplants - Trees	47	$50.00	$2,350.00
Fascines	2578'	$5.00	$12,231.25
Seeding & Mulching- Permanent	----------	$8,000	$8,000.00
Seeding & Mulching - Temporary	----------	$3,500	$3,500.00
		Total	$184,542.05

6.3 Project Construction Details

Construction details and specifications were created within the project bid package and can be obtained from the GCSWCD. Detailed construction drawings can be found in Appendix C , photographs highlighting project construction are in Appendix B. A summary of project construction details is provided below.

- A temporary access road was created along the floodplain to provide entry to the project area. The access road utilized an existing driveway and an agricultural utility road. The areas were modified to allow for access by heavy equipment and transported material into the project area.

- Clearing and grubbing of the borrow areas and the proposed meander bends was initiated in phases prior to beginning the excavation. Cleared vegetation was buried in areas requiring fill material. Areas containing knotweed were excavated below the rooting depth, collected, and disposed of in deep trenches excavated throughout the project site.

- An inflatable water barrier structure was installed above the project reach to dam stream flow while the active work zone was de-watered by pumping all upstream flow around the work area. Stream flow was pumped using a 12" diesel pump into a sealed pipeline.

A controlled geotextile outlet was used to discharge the flow into the Batavia Kill below the bridge structure.

- De-watering of the site will be accomplished in two stages by pumping areas retained with water structures into detention ponds and directing pond overflow into off channel diversions and existing high flow channels.

- The first stage of de-watering includes pumping flows from North Settlement Creek and Batavia Kill onto the south flood plain. This will gravity feed into an existing high flow channel and will enter the Batavia Kill below the project area. Construction will begin at the lower end of the project and continue upstream working toward the proposed crossing.

- The second stage of de-watering includes placing a water structure at the upstream end of the work reach and pumping the Batavia Kill into an existing diversion on the north side of the project area. This diversion will enter North Settlement Creek and then flow into constructed reach on the lower half of the project.

- Stream channel excavation of the new meander bends was initiated in the lower portion of the project reach and progressed upstream. Material generated during the excavation of the meander bends was used to fill portions of the existing channel.

- Native sod mats were obtained from the proposed pond footprint and placed along finished streambank areas.

- Clay material were excavated from the stream channel and replaced with adequate fill material. The excavated clay material was used in designated fill areas in the adjacent floodplain and located away from the active channel.

- The installation of rock structures was initiated at the bottom of the reach and continued upstream following the final grading of stream channel. The project included the installation of rock structures, which required rock to be hauled from a local quarry in Lexington to the project site.

- Root wads were acquired during the clearing and grubbing of the project site. Root wads were installed in the project area to provide habitat and added bank protection in high stress areas.

- Final grading was completed in the stream channel after the installation of the rock structures, and continued in the floodplain areas as fill material was generated. Upon completion of the finished grading, exposed areas were seeded and mulched to provide temporary stabilization.

- Large willow transplants and sod mats were installed along with the progression of the final grading. Additional bioengineering and plantings, to include live willow fascines, live stakes and posts, and bare root seedlings, were installed in phases by the contractor, District staff and a group of local Trout Unlimited volunteers when the plant material entered dormancy.

6.4 Project Constructability

Access to the project area, through private property, was acquired through landowner agreements prior to the start of construction. Mobilization of construction equipment to the work area was achieved through the adjacent landowners driveways. Site conditions were generally considered favorable for equipment mobilization.

Groundwater infiltration into the work area became a general problem during the channel excavation and rock structure installation. General stream flow up to 10cfs was diverted around the project area using a pump and pipeline system. Provisions were made to pump relatively small amounts of infiltration water to adjacent vegetated floodplain areas, but were inadequate to handle the influx of groundwater into the site. Additional pumps were added to reduce the volume of water present in the work area. However, the majority of the rock structures, especially ones located in pool areas, required installation to commence below water level. Several problems were generated by the turbid conditions limiting visibility during the installation and inspection process.

6.5 Project Construction Modifications

Modifications that were made throughout both phases of construction and implementation of the project were included within post-construction topographic surveys of the entire project site. The as-built surveys were initiated in the fall of 1999 and 2000. Drawings of the as-built and monitoring surveys are provided in Appendix F.

6.6 Project Construction Cost

A summary of final construction costs is included in Table 3.

7.0 Project Monitoring and Performance

In order to document the stability and performance of the restoration project and to provide baseline conditions for comparison against pre-construction conditions, regular inspections and annual monitoring surveys are conducted. Project inspections include photographic documentation of the project reach and a visual inspection of the rock structures, channel stability, bioengineering and riparian vegetation. The inspections are conducted annually during the project site survey as well as during and after significant flow events. The project monitoring surveys include both physical channel and structural stability assessments. Long term monitoring of water quality is being performed by NYCDEP, which includes measurements of total suspended solids (TSS) and turbidity. Specific project inspections and monitoring reports are summarized in Appendix F.

7.1 Project Physical Performance

Restoration projects, using geomorphic and natural channel design techniques, incorporate principles that seek to re-establish the dynamic equilibrium of the stream channel. This includes the channel's ability to make minor adjustments over time as the project experiences a range of flow events. A channel in dynamic equilibrium typically experiences minor variations in channel shape and form, which are natural and considered stable morphology. In order to document the changes in morphology and project stability, monitoring surveys have been initiated in the project reach.

Table 3: Final project construction costs.

Item #	Bid Item Description	Final Quantity	Final Cost
1	Mobilization	----------	$8,739.00
2	Clearing/ Grubbing	----------	$15,160.00
3	De-watering	----------	$31,000.00
4	S.C. Excavation	----------	$37,000.00
5	Surveys	----------	$0.00
6	Rock Vanes	15 vanes @ $2,127/vane	$29,778.00
7	W-Weir	1 weir @ $7,371/weir	$7,371.00
8	Cross vanes	4 vanes @ $3,598/vane	$14,392.48
9	Root Wads	1 root wads @ $634/root wad	$634.00
10	Live Material Transplants - Sod	1206yd^2 @ $10/yd^2	$12,060.00
11	Live Material Transplants - Trees	44 transplants @ $50/each	$2,200.00
12	Fascines	0ft. @ $5/ft.	$0.00
13	Seeding & Mulching - Permanent	----------	$6,000.00
14	Seeding & Mulching - Temporary	---------	$0.00
		Total Main Contract	**$164,334.48**
Project Change Orders			
Item #	**Description**	**Quantity**	**Final Cost**
1	Rock Vanes	1	$2,127.00
2	Additional Sediment Control Pump (at 24hr/day rate)	----------	$9,200.00
3	Cross Vane(2 on NS)	3	$3,598.00
4	Clay Excavation	----------	$6,265.00
		Total Change Orders and Deletions	**$21,190.00**
		Total Payment Including Change Orders	**$185,524.48**

The monitoring of the project includes pre-construction surveys, an as-built survey, and multiple sets of post-construction monitoring. The physical performance of the channel is monitored using surveys which minimally include a longitudinal profile, multiple monumented cross sections and sediment analysis. The relationship of channel morphology “at-a-station”, and general morphology trends through the reach will be analyzed using the collected data. These physical measures will be further refined by stream feature specific quantities. The comparison of time intervals and change in physical parameters will be determined, as well as the characterization of hydrologic inputs from storm events.

These quantities can be further developed by comparisons within the reach, against regional values, stream channel classification indexes, and reference reach data. The channel parameters can be applied to channel evolution models to review the effectiveness of treatment in halting or accelerating a channel process.

In the case of long term monitoring data, the individual treatments can be compared, quantified and delineated. As the project monitoring progresses, future analyses will be used to determine the effectiveness, in terms of worth of the project at multiple scales, in comparison to other natural channel design projects and treatments in the watershed. Specific project inspections and monitoring reports are summarized in Appendix F.

7.2 Habitat Assessment

The NYCDEP in cooperation with the GCSWCD, inventoried macroinvertebrate communities in the project reach prior to the commencement of the restoration. Additionally, areas upstream and downstream, as well as stable reaches located within other areas of the Batavia Kill were inventoried for use in baseline comparisons. Major objectives of the macroinvertebrate monitoring efforts were to determine:

- If macroinvertebrate populations and communities differ between neighboring, stable (reference), and unstable (project) stream reaches

- If improved stability of the restored reach is reflected by improvements in macroinvertebrate populations and communities.

Habitat assessments were completed before restoration of the unstable project commenced. Inventories were completed at project/treatment and reference reaches in the summer of 1999. Preliminary findings from these surveys are summarized in Appendix E.

8.0 Operation and Maintenance

Proper operation and maintenance is a critical element for the success of restoration projects, which use geomorphic and natural channel design techniques. Based upon experience with local conditions, the GCSWCD and NYCDEP SMP believe that attaining acceptable channel stability requires an extended period for the project to become established. While site conditions and hydrological conditions strongly influence the amount of time a project needs to become established, it appears that at least a two-year establishment period must be considered. This establishment period must include allowances for revegetation and adjustments/repairs to rock structures. It is critical to have a clear understanding that typically, restoration goals are not achieved the day the excavation is completed, and the evaluation of project success must be based on performance over a longer period of time.

During the initial years after establishment, as the restoration site experiences a range of flows and the sediment regime becomes “naturalized”, projects usually require modifications and design enhancements. Project sponsors must be prepared to undertake adjustments in the channel form and/or rock structures as indicated by the project monitoring. It is believed that as project vegetation becomes established the overall operation and maintenance of the project will decrease.

A management plan and strategy has been developed for the Batavia Kill stream corridor by the GCSWCD. The plan provides a working document to assist with resource management in the watershed, which will also assist in the operation and maintenance of the project reach.

8.1 Rock Structures

In-stream rock structures may require some modification and enhancement. The monitoring and inspections performed by project partners will assist in prescribing the modification of rocks to ensure structural integrity, intended functions of the vane, and debris and sediment maintenance considerations. The annual project status reports will document these needs and modifications.

8.2 Vegetation

Vegetative establishment in the project area is a critical component to the project's long term stability. General site constraints and gravelly soil conditions limit the success and establishment of the designated vegetative element of the project. Careful planning, monitoring and maintenance is required for all of the installed vegetation. Increased browsing pressure from mammals, potential for disease, and extreme weather conditions can reduce the success of the plant materials. Inspection and monitoring of the plant materials throughout the initial stage of development will assist in ensuring plant viability.

Supplemental installation of plant material, as needed, in the form of bioengineering and riparian planting will ensure effective riparian establishment. During supplemental planting, a variety of bio-engineering techniques will be used to increase woody vegetation at the site. These plantings will require maintenance to ensure proper moisture at critical times. The development of the monitoring plan for vegetation is in Appendix D.

Appendix A

Project Location Maps

Location: County of Greene, Town of Ashland

The “Bandy Wine” site is located off State Highway 23 in the Town of Ashland, between County Highway 19 and County Highway 17 at the confluence of Batavia Kill and North Settlement Creek. Access to the site is acquired by entering the parking lot at the Brandy Wine Restaurant and walking down the access road towards the Batavia Kill. The center of the project area is located at the confluence of North settlement Creek And the Batavia Kill and stems approximately 1000 feet upstream and downstream. (Figure 1.1)

(Figure 1.1)

Property Boundaries:

A list of adjacent property owners was compiled using local tax maps for the town of Ashland (Figure 2.1)

Note: Primary properties, as listed, are those that border the Batavia Kill and are located within the project area. Secondary properties, as listed, include those that are located near or adjacent to the project area.

Primary Properties

94.0-2-38	Caracciolo, Louis & Corinne
94.0-2-16.2	Caracciolo, Louis & Corinne
94.0-2-18	Tuttle, Howard B.
94.0-2-12.1	Makely, Richard & Joanne
94.0-2-36.2	Petrou, Milton
94.0-2-15	White, Ann A.

Secondary Properties

94.0-2-12.2	Tompkins, Gary L. & Joanne E
94.0-2-36.1	Lawrence, Betram & Helen
94.0-2-13	Episcopal Church
94.0-2-14	Tompkins, Gary L. & Joanne E
94.0-2-37	Lawrence, Betram & Helen

Aerial Photograph:

The “Brandy Wine” project was surveyed and classified by Greene County Soil & Water Conservation District Technicians in October of 1997. The approximate beginning and ending points of the survey are noted on the May 1995 aerial photograph (Figure 3.1) by red bars, and the eroded sections of the bank are highlighted in yellow.

(Figure 3.1)

Appendix B

Photographs and Descriptions

B.1 Pre-construction1996-1999

B.2 Project Construction 1999

B.1 Pre-construction 1996-1999

Photograph 1: Aerial view taken in 1999 looking upstream through the project reach. The abandoned meander scroll is in the foreground, and the Van Etten trucking company can be seen in the top left.

Photograph 2: Bankfull flow event taken before restoration. The extreme turbidity can be seen in the image.

Photograph 3: View of lower left floodplain and the abandoned channel.

Photograph 4:The first meander bend at the top of the project at or near bankfull flow. The streambank in the image is completely raw and cut.

Photograph 5: The lower project area. Apparent are the bar features and the C type stream morphology. Cut streambanks are apparent and all the smaller, lighter colored vegetation in the image is Japanese knotweed. The dominance of the invasive can be easily seen.

Photograph 6:Project area during a storm event.

B.2 Project Construction 1999

Photograph 7: Aerial view of clearing and grubbing activities in the project area.

Photograph 8: Floodplain during grubbing of Japanese knotweed.

Photograph 9: Channel after de-watering, water in image is from groundwater flow that was collected in secondary pump.

Photograph 10: Cleared floodplain in middle of project area.

Photograph 11:Floodplain grading and channel realignment by dozer equipment.

Photograph 12:Example of the delivery of rock used to construct middle cross vane. Apparent is the massive size of material used in the construction of the structures.

Photograph 13: Grading operations of central point bar. Image shows grade stakes used in construction stakeout activities performed by GCSWCD staff.

Photograph 14: Graded channel and vane construction activities. The image shows the trucking equipment used to haul rock for in stream structures.

Photograph 15: Bar grading and bank shaping in the middle of project area.

Photograph 16: W-weir construction near end of project length.

Photograph 17: Example of earth work with multiple dozers performed in the channel realignment and grading.

Photograph 18: First meander bend on top of project.

Photograph 19:Completed channel, and vanes before water was back in channel.

Photograph 20: Lower third of first meander bend newly seeded and mulched.

Photograph 21: Rainfall event early in project vegetation establishment period.

Photograph 22:Middle point bar with some vegetation grass establishment.

Photograph 23: Contractor hydro seeding project area

Photograph 24: Contractor hydro seeding project area

1

2

3

4

5

6

Brandywine Stream Restoration Project
Pre-Construction


7


8


9


10


11


12

Brandywine Stream Restoration Project
Project Construction 1999

13

14

15

16

17

18

Brandywine Stream Restoration Project
Project Construction 1999


19


20

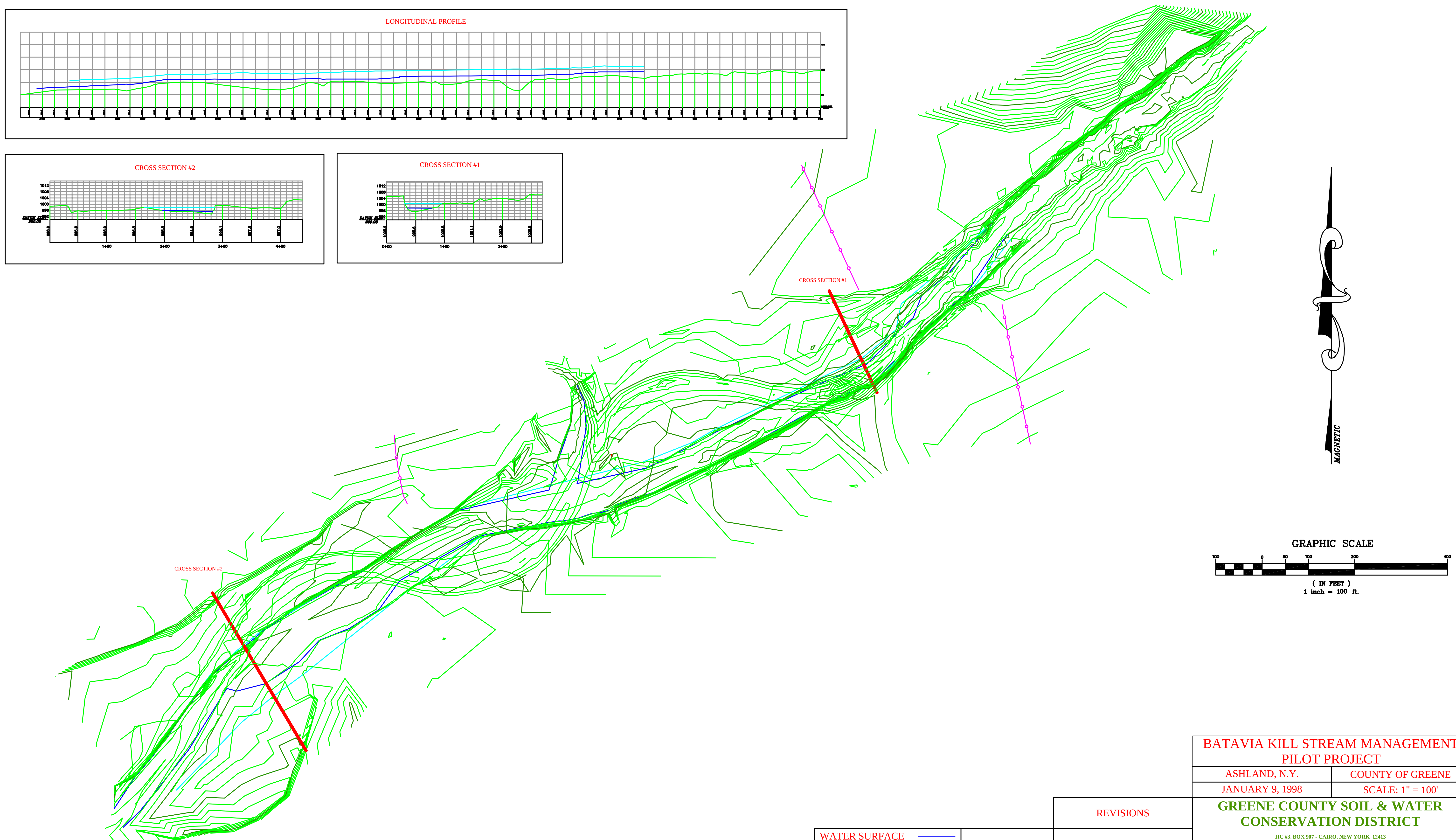

21


22


23


24

Brandywine Stream Restoration Project
Completed Project Construction 1999



WATER SURFACE	
BANKFULL	
FENCELINE	
CROSS SECTIONS	
SURFACE	

REVISIONS

BATAVIA KILL STREAM MANAGEMENT PILOT PROJECT

ASHLAND, N.Y.	COUNTY OF GREENE
JANUARY 9, 1998	SCALE: 1" = 100'

GREENE COUNTY SOIL & WATER CONSERVATION DISTRICT

HC #3, BOX 907 - CAIRO, NEW YORK 12413
PHONE (518) 622-3620
FAX (518) 622-0344

"BRANDY WINE" STREAM RESTORATION

PROJECT #: BSP-98.01	CHECKED BY:
DRAWING #: 1A	PRECONSTRUCTION MONITORING SECTION LOCATIONS
DRAWN BY: DOUGLAS DEKOSKIE	

Appendix C

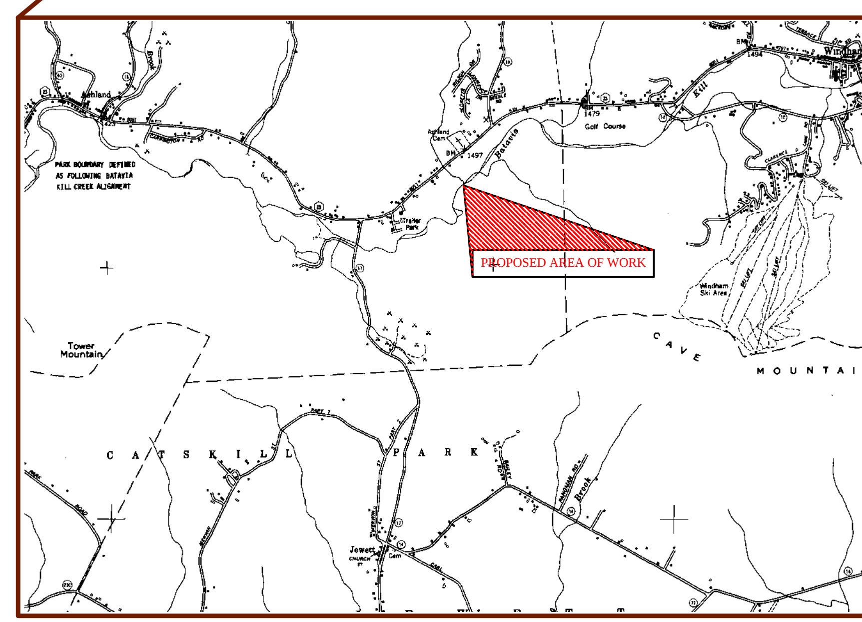
Project Design

GREENE COUNTY SOIL & WATER CONSERVATION DISTRICT

BATAVIA KILL STREAM MANAGEMENT PILOT PROJECT

"BRANDY WINE" STREAM RESTORATION PROJECT

INDEX OF DRAWINGS

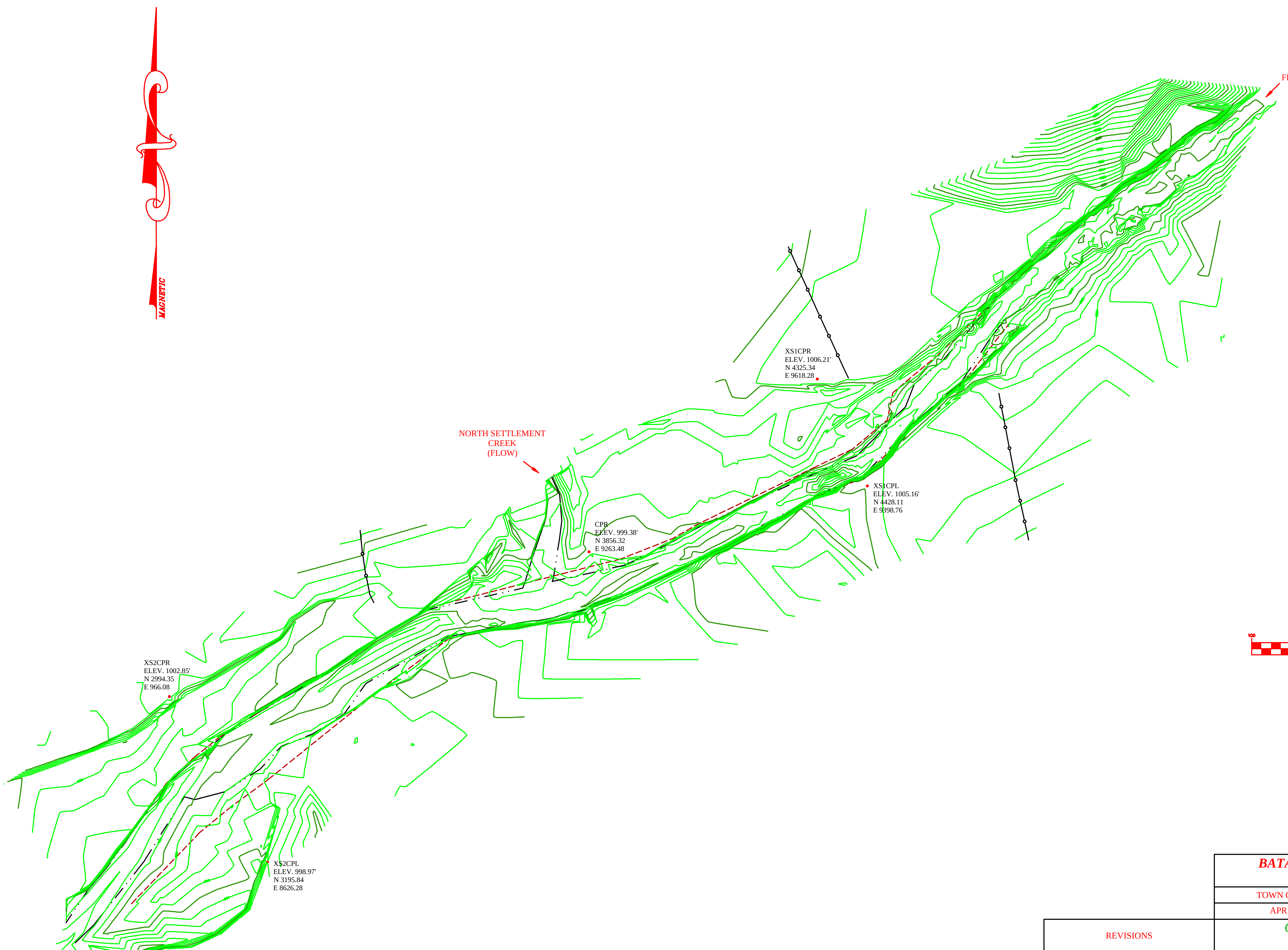


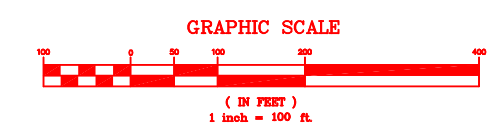
SITE LOCATION MAP
(NOT TO SCALE)

BATAVIA KILL STREAM MANAGEMENT PILOT PROJECT	
TOWN OF ASHLAND	COUNTY OF GREENE
APRIL 30, 1999	NOT TO SCALE
GREENE COUNTY SOIL & WATER CONSERVATION DISTRICT BOX 907 GREENE COUNTY OFFICE BUILDING, CAIRO, NY 12414 PHONE (518) 622-3620 FAX (518) 622-0344	
"BRANDY WINE" STREAM RESTORATION PROJECT	
CHECKED BY:	PROJECT #: BSP-98.01
DRAWN BY: DOUG DEKOSKIE	DRAWING #: 98.01
SHEET 1 OF 13	TITLE PAGE

REVISIONS

LEGEND





NOTE

Existing topographic survey was performed on November 20, 1997.

NOTE

Initial elevation, northing, and easting was assumed. The entire survey is based upon these assumptions.

LEGEND	
EXISTING WATER SURFACE	— · · — · · —
EXISTING BANKFULL SURFACE	— — — — —
FENCE	—o—o—o—
CONTROL POINT	•

REVISIONS

BATAVIA KILL STREAM MANAGEMENT PILOT PROJECT

TOWN OF ASHLAND	COUNTY OF GREENE
APRIL 30, 1999	SCALE: 1" = 100'

GREENE COUNTY SOIL & WATER CONSERVATION DISTRICT

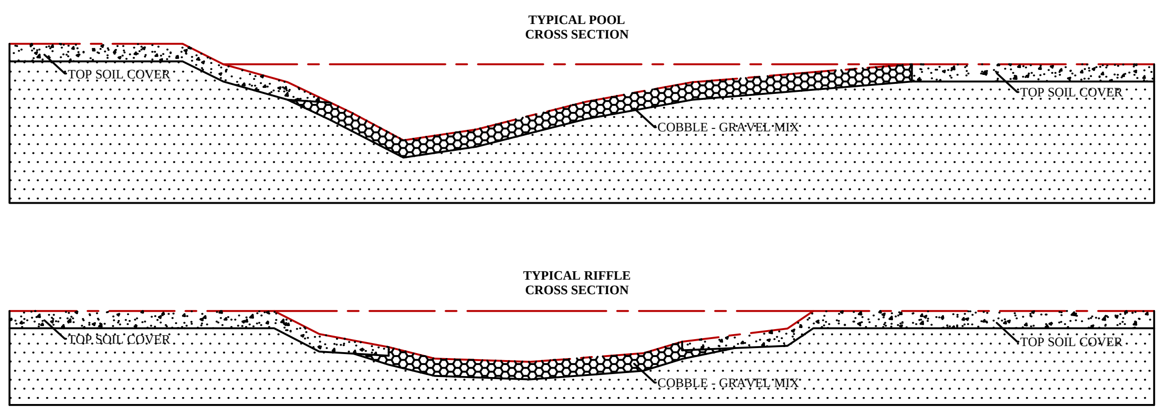
BOX 907 GREENE COUNTY OFFICE BUILDING, CAIRO, NY 12414
PHONE (518) 622-3620
FAX (518) 622-0344

"BRANDY WINE" STREAM RESTORATION PROJECT

CHECKED BY:	PROJECT #: BSP-98.01
DRAWN BY: DOUG DEKOSKIE	DRAWING #: 98.01
SHEET 2 OF 13	EXISTING TOPOGRAPHIC SURVEY
1' CONTOUR INTERVAL	

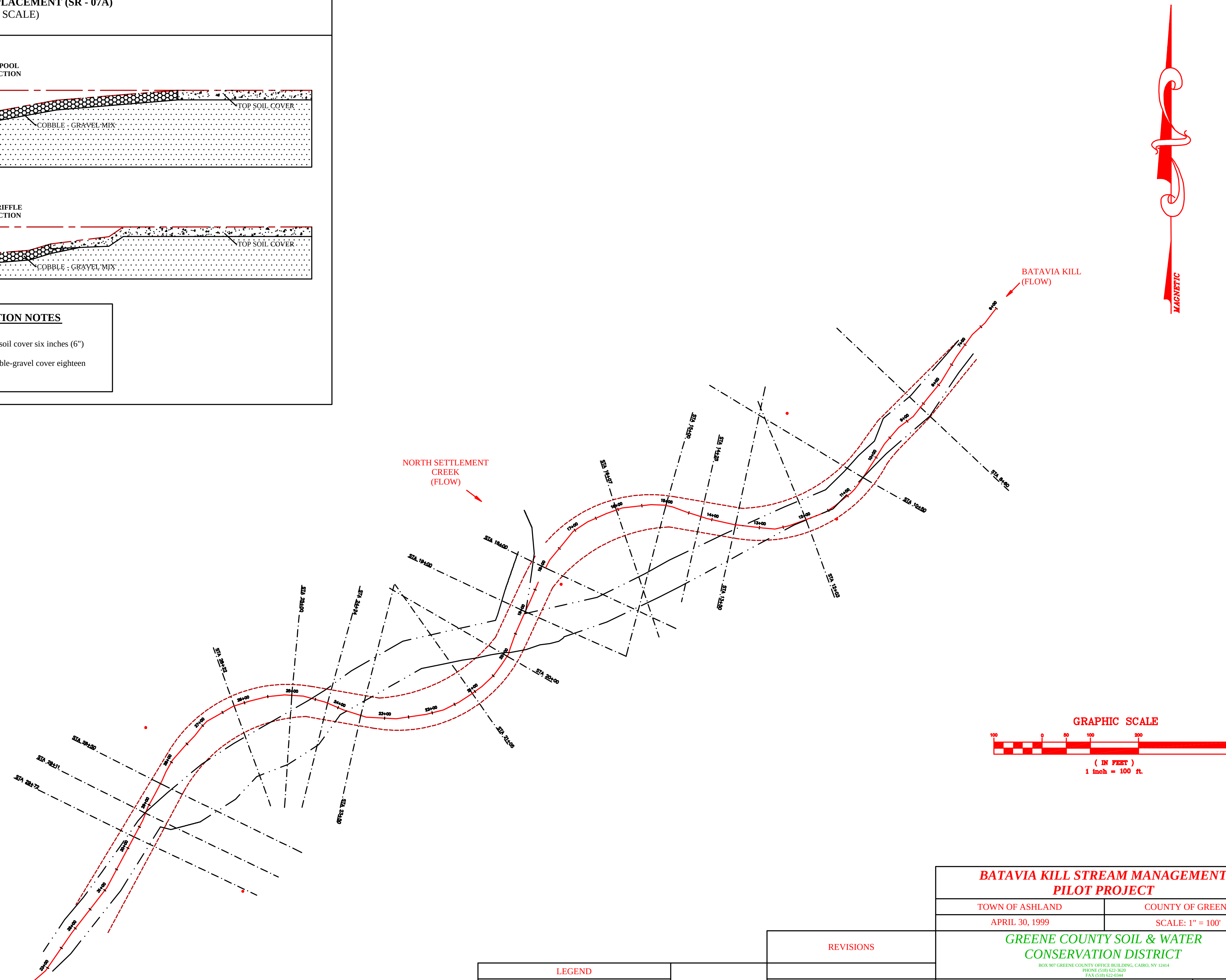
TYPICAL MATERIAL PLACEMENT (SR - 07A)

(NOT TO SCALE)



CONSTRUCTION NOTES

1. Minimum thickness of top soil cover six inches (6")
2. Minimum thickness of cobble-gravel cover eighteen inches (18")



NOTE

Existing cross sections were taken from a topographic survey performed on November 20, 1997.

LEGEND	
PROPOSED BANKFULL CHANNEL	— — —
EXISTING WATER SURFACE	— · · — · · —
CONTROL POINT	•
CROSS SECTION	—— · ——

REVISIONS

BATAVIA KILL STREAM MANAGEMENT PILOT PROJECT

TOWN OF ASHLAND	COUNTY OF GREENE
APRIL 30, 1999	SCALE: 1" = 100'

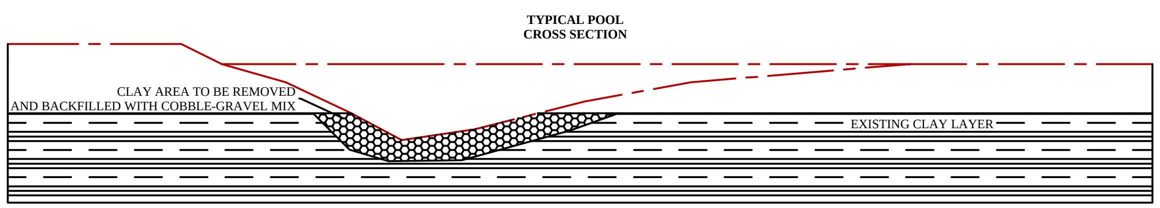
GREENE COUNTY SOIL & WATER CONSERVATION DISTRICT

BOX 907 GREENE COUNTY OFFICE BUILDING, CAIRO, NY 12414
PHONE (518) 622-3620
FAX (518) 622-0344

"BRANDY WINE" STREAM RESTORATION PROJECT

CHECKED BY:	PROJECT #: BSP-98.01
DRAWN BY: DOUG DEKOSKIE	DRAWING #: 98.01
SHEET 3 OF 13	PROPOSED PLAN VIEW (W/ EXISTING CONDITIONS)

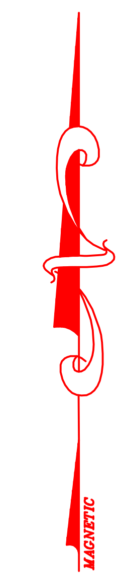
TYPICAL CLAY OVER-EXCAVATION
(NOT TO SCALE)

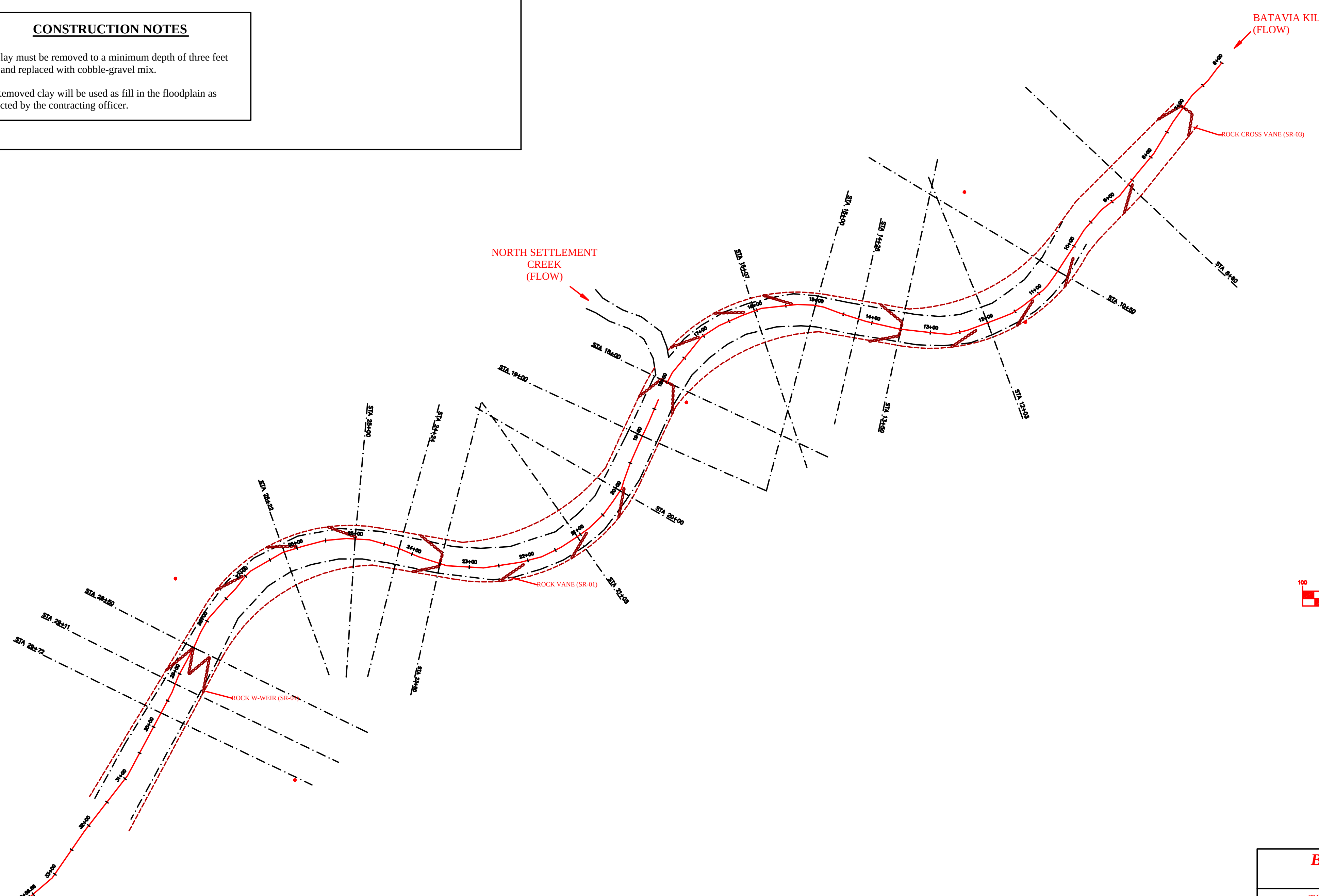


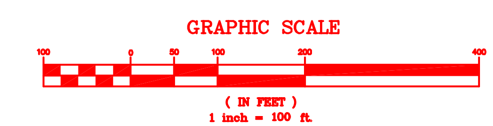
CONSTRUCTION NOTES

1. Clay must be removed to a minimum depth of three feet (3') and replaced with cobble-gravel mix.

2. Removed clay will be used as fill in the floodplain as directed by the contracting officer.







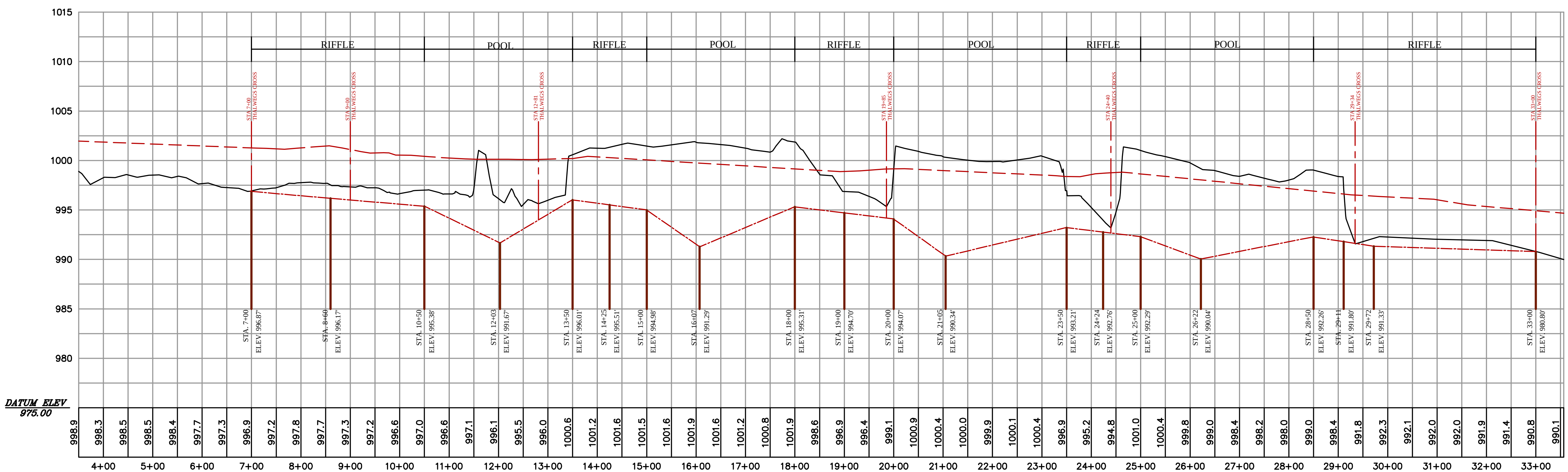
NOTE
Existing cross sections were taken from a topographic survey performed on November 20, 1997.

NOTE
Proposed structures are shown for placement only and are not drawn to scale. See Construction Details.

LEGEND	
PROPOSED WATER SURFACE	— · —
PROPOSED BANKFULL CHANNEL	— — — —
CONTROL POINT	•
CROSS SECTION	— · —
STRUCTURE	oooooooooooo

REVISIONS

BATAVIA KILL STREAM MANAGEMENT PILOT PROJECT	
TOWN OF ASHLAND	COUNTY OF GREENE
APRIL 30, 1999	SCALE: 1" = 100'
GREENE COUNTY SOIL & WATER CONSERVATION DISTRICT BOX 907 GREENE COUNTY OFFICE BUILDING, CAIRO, NY 12414 PHONE (518) 622-3620 FAX (518) 622-0344	
"BRANDY WINE" STREAM RESTORATION PROJECT	
CHECKED BY:	PROJECT #: BSP-98.01
DRAWN BY: DOUG DEKOSKIE	DRAWING #: 98.01
SHEET 4 OF 13	PROPOSED PLAN VIEW



NOTE
Existing profile was taken from a topographic survey performed on November 20, 1997.

LEGEND	
EXISTING GROUND	————
BANKFULL SURFACE	— — — —
PROPOSED THALWEG	——— - ———

REVISIONS

BATAVIA KILL STREAM MANAGEMENT PILOT PROJECT

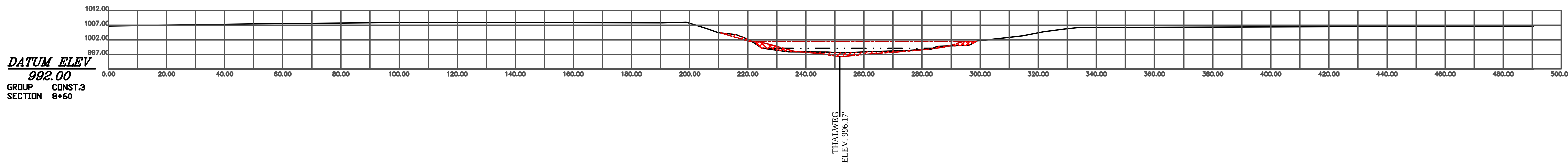
TOWN OF ASHLAND	COUNTY OF GREENE
APRIL 30, 1999	SCALE: 1" = 100'H, 1" = 5'V

GREENE COUNTY SOIL & WATER CONSERVATION DISTRICT

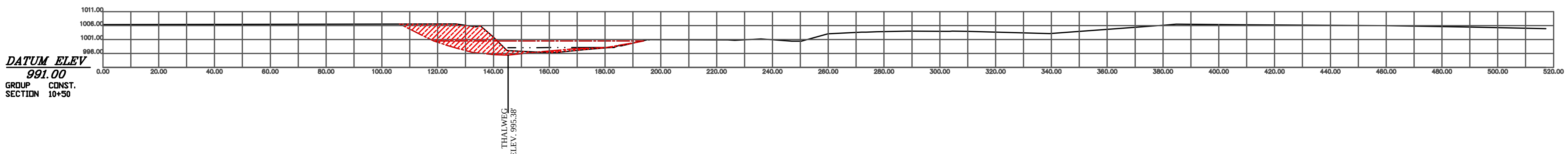
"BRANDY WINE" STREAM RESTORATION PROJECT

CHECKED BY:	PROJECT #: BSP-98.01
DRAWN BY: DOUG DEKOSKIE	DRAWING #: 98.01
SHEET 5 OF 13	PROPOSED LONGITUDINAL PROFILE

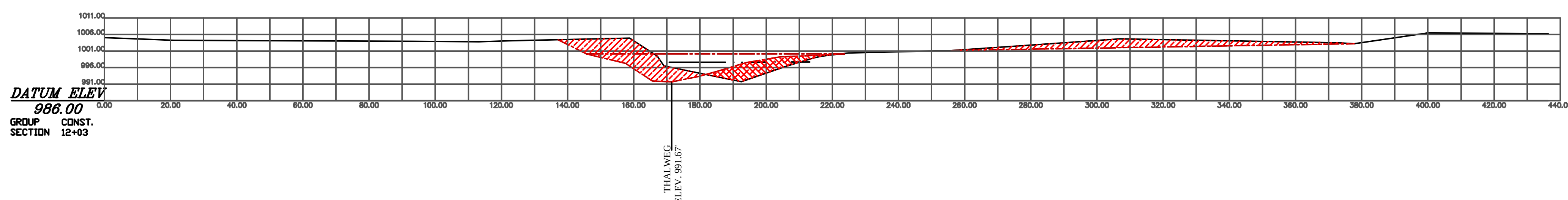
SECTION 8+60



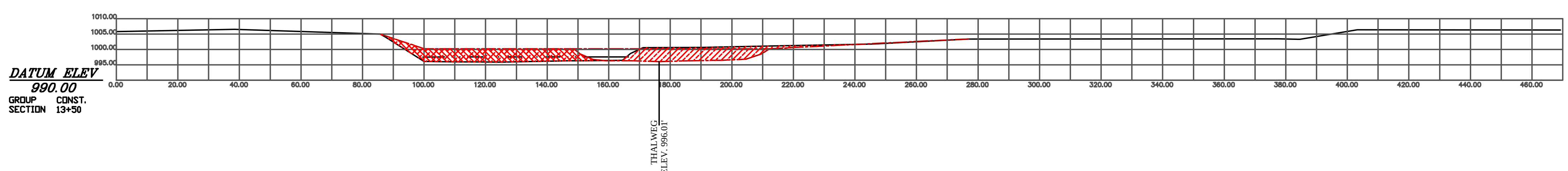
SECTION 10+50



SECTION 12+03



SECTION 13+50



NOTE
Existing cross sections were taken from a topographic survey performed on November 20, 1997.

LEGEND	
AREA TO FILL	
PROPOSED BANKFULL CHANNEL	
AREA TO CUT	
EXISTING GROUND	

REVISIONS

BATAVIA KILL STREAM MANAGEMENT PILOT PROJECT

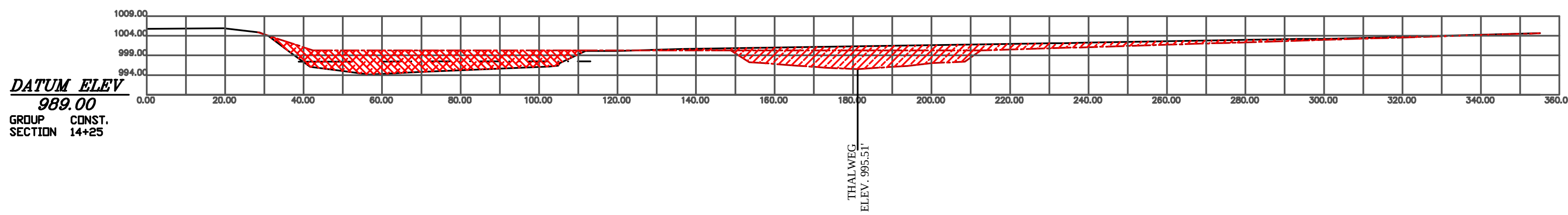
TOWN OF ASHLAND	COUNTY OF GREENE
APRIL 30, 1999	SCALE: 1" = 20'

GREENE COUNTY SOIL & WATER CONSERVATION DISTRICT

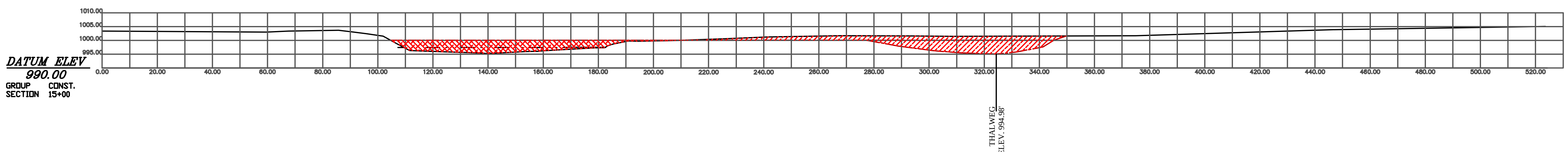
"BRANDY WINE" STREAM RESTORATION PROJECT

CHECKED BY:	PROJECT #: BSP-98.01
DRAWN BY: DOUG DEKOSKIE	DRAWING #: 98.01
SHEET 6 OF 13	CROSS SECTIONS (8+60 - 13+50)

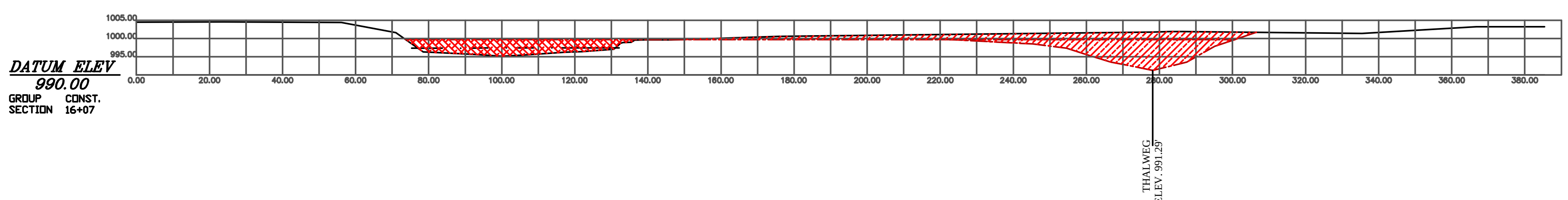
SECTION 14+25



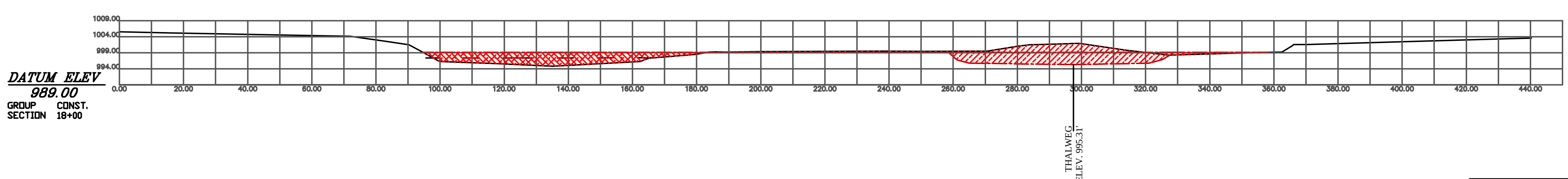
SECTION 15+00



SECTION 16+07



SECTION 18+00



NOTE
Existing cross sections were taken from a topographic survey performed on November 20, 1997.

LEGEND

AREA TO FILL
PROPOSED BANKFULL CHANNEL
AREA TO CUT
EXISTING GROUND

REVISIONS

BATAVIA KILL STREAM MANAGEMENT PILOT PROJECT

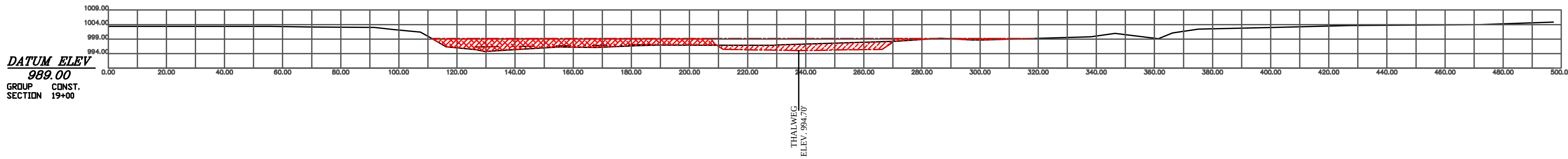
TOWN OF ASHLAND	COUNTY OF GREENE
APRIL 30, 1999	SCALE: 1" = 20'

GREENE COUNTY SOIL & WATER CONSERVATION DISTRICT
BOX 907 GREENE COUNTY OFFICE BUILDING, CAIRO, NY 12414
PHONE (518) 622-3620
FAX (518) 622-0344

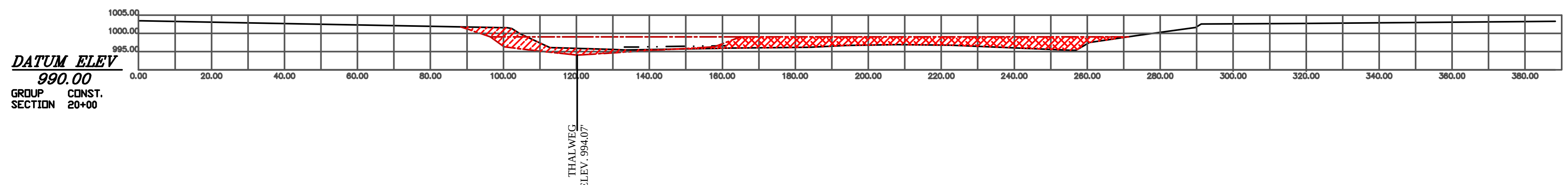
"BRANDY WINE" STREAM RESTORATION PROJECT

CHECKED BY:	PROJECT #: BSP-98.01
DRAWN BY: DOUG DEKOSKIE	DRAWING #: 98.01
SHEET 7 OF 13	CROSS SECTIONS (14+25 - 18+00)

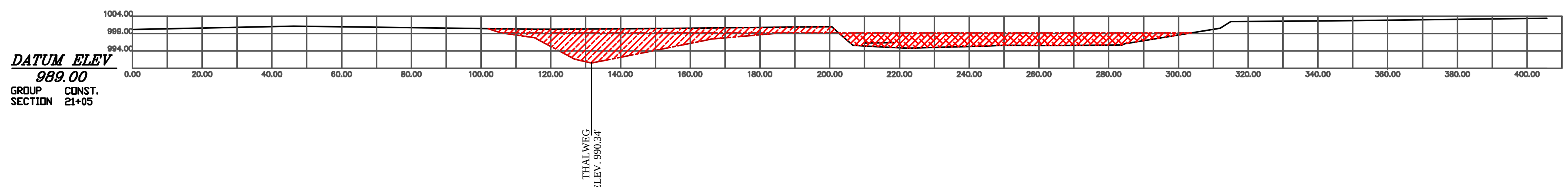
SECTION 19+00



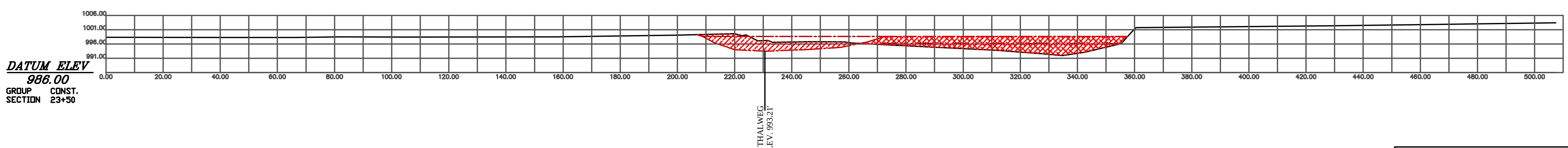
SECTION 20+00



SECTION 21+05



SECTION 23+50



NOTE
Existing cross sections were taken from a topographic survey performed on November 20, 1997.

LEGEND	
AREA TO FILL	(cross-hatched)
PROPOSED BANKFULL CHANNEL	— - —
AREA TO CUT	(hatched)
EXISTING GROUND	——

REVISIONS

BATAVIA KILL STREAM MANAGEMENT PILOT PROJECT

TOWN OF ASHLAND	COUNTY OF GREENE
APRIL 30, 1999	SCALE: 1" = 20'

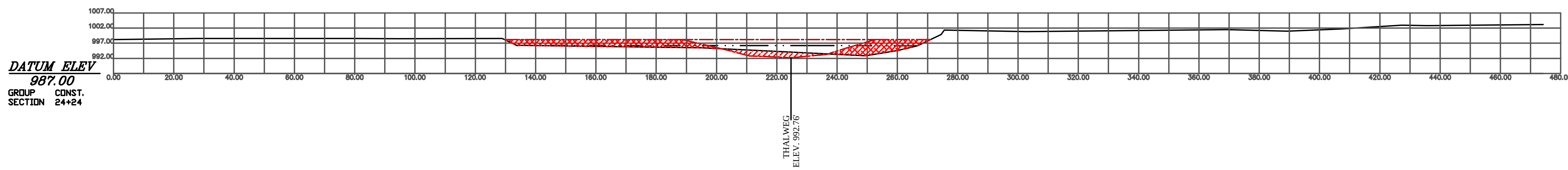
GREENE COUNTY SOIL & WATER CONSERVATION DISTRICT

BOX 907 GREENE COUNTY OFFICE BUILDING, CAIRO, NY 12414
PHONE (518) 622-3620
FAX (518) 622-0344

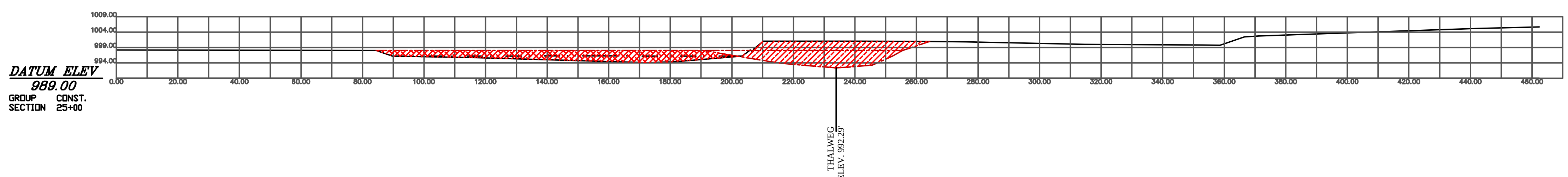
"BRANDY WINE" STREAM RESTORATION PROJECT

CHECKED BY:	PROJECT #: BSP-98.01
DRAWN BY: DOUG DEKOSKIE	DRAWING #: 98.01
SHEET 8 OF 13	CROSS SECTIONS (19+00 - 23+50)

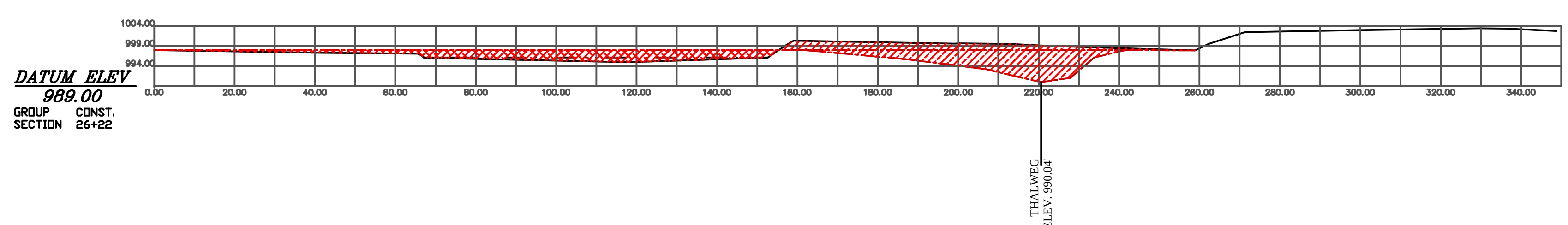
SECTION 24+24



SECTION 25+00



SECTION 26+22



NOTE
Existing cross sections were taken from a topographic survey performed on November 20, 1997.

LEGEND

- AREA TO FILL
- PROPOSED BANKFULL CHANNEL
- AREA TO CUT
- EXISTING GROUND

REVISIONS

BATAVIA KILL STREAM MANAGEMENT PILOT PROJECT

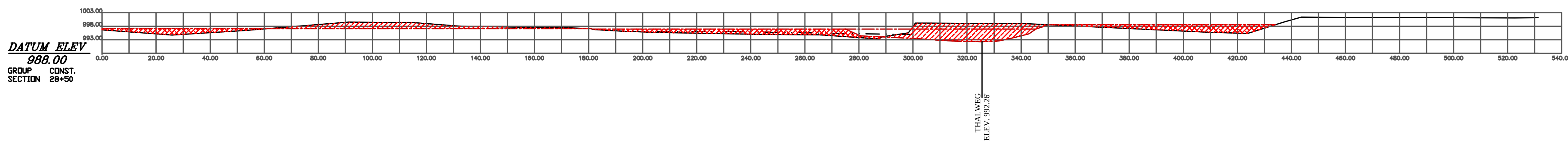
TOWN OF ASHLAND	COUNTY OF GREENE
APRIL 30, 1999	SCALE: 1" = 20'

GREENE COUNTY SOIL & WATER CONSERVATION DISTRICT
BOX 907 GREENE COUNTY OFFICE BUILDING, CAIRO, NY 12414
PHONE (518) 622-3620
FAX (518) 622-0344

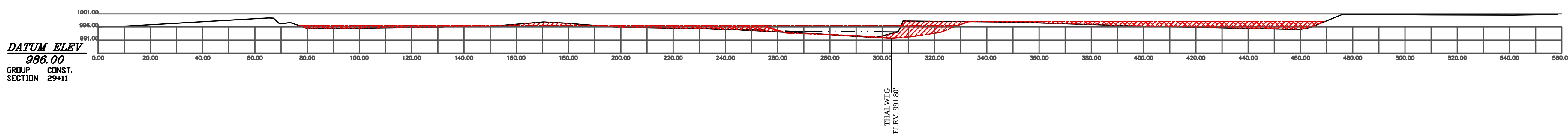
"BRANDY WINE" STREAM RESTORATION PROJECT

CHECKED BY:	PROJECT #: BSP-98.01
DRAWN BY: DOUG DEKOSKIE	DRAWING #: 98.01
SHEET 9 OF 13	CROSS SECTIONS (24+24 - 26+22)

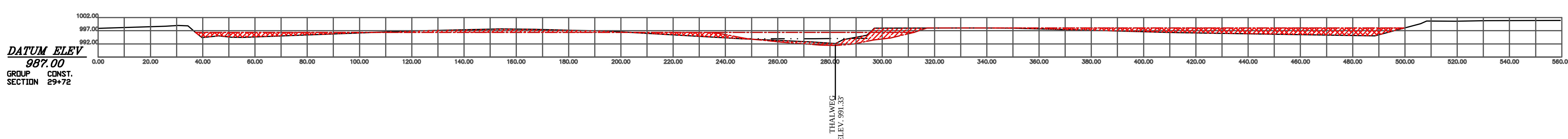
SECTION 28+50



SECTION 29+11



SECTION 29+72



NOTE

Existing cross sections were taken from a topographic survey performed on November 20, 1997.

LEGEND	
AREA TO FILL	
PROPOSED BANKFULL CHANNEL	
AREA TO CUT	
EXISTING GROUND	

REVISIONS

BATAVIA KILL STREAM MANAGEMENT PILOT PROJECT

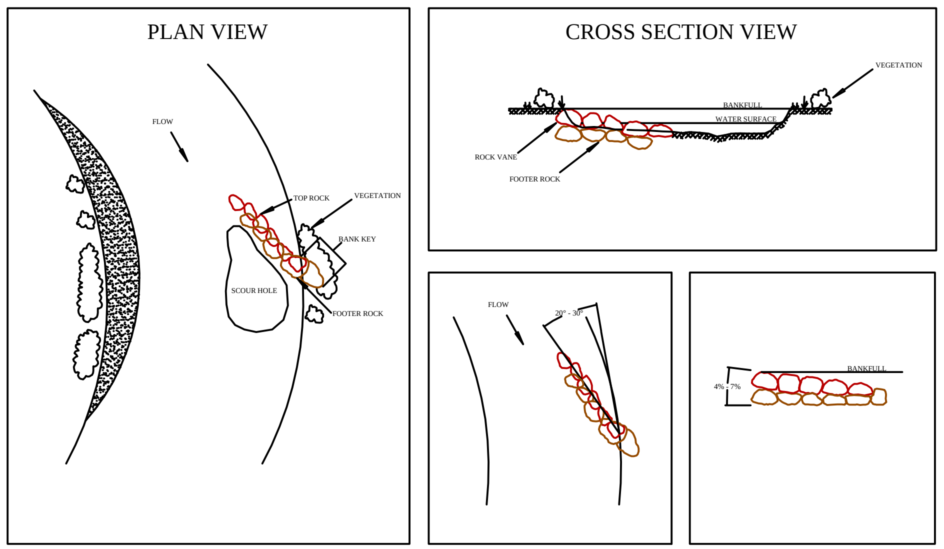
TOWN OF ASHLAND	COUNTY OF GREENE
APRIL 30, 1999	SCALE: 1" = 20'

GREENE COUNTY SOIL & WATER CONSERVATION DISTRICT
BOX 907 GREENE COUNTY OFFICE BUILDING, CAIRO, NY 12414
PHONE (518) 622-3620
FAX (518) 622-0344

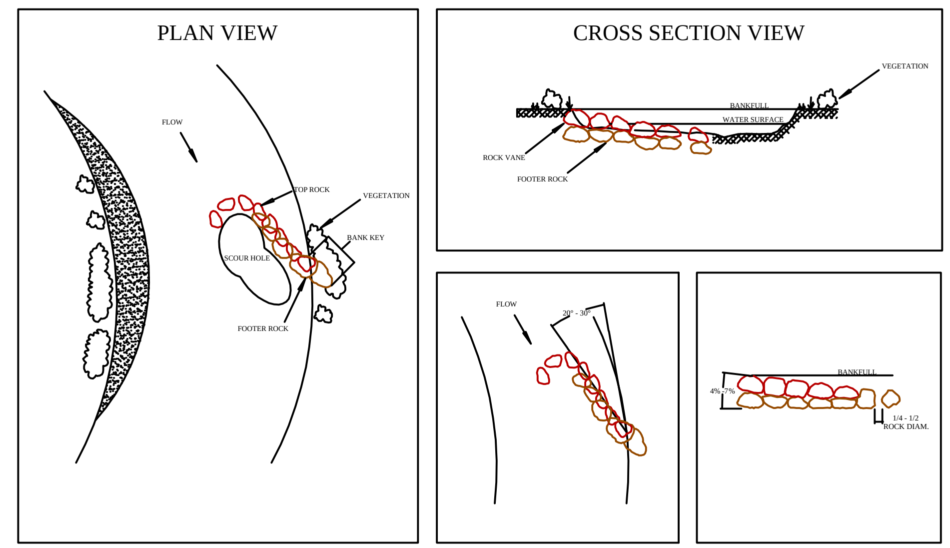
"BRANDY WINE" STREAM RESTORATION PROJECT

CHECKED BY:	PROJECT #: BSP-98.01
DRAWN BY: DOUG DEKOSKIE	DRAWING #: 98.01
SHEET 10 OF 13	CROSS SECTIONS (28+50 - 29+72)

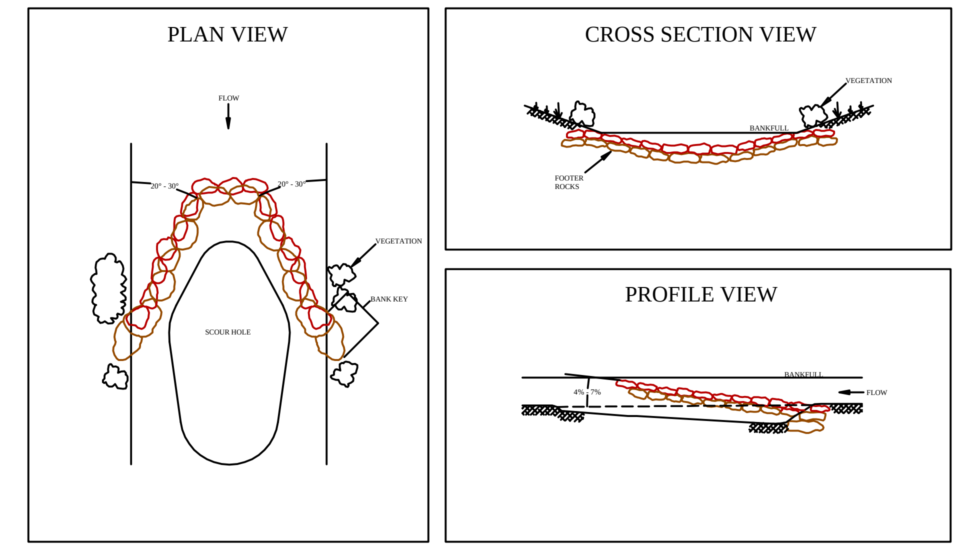
ROCK VANE (SR-01)



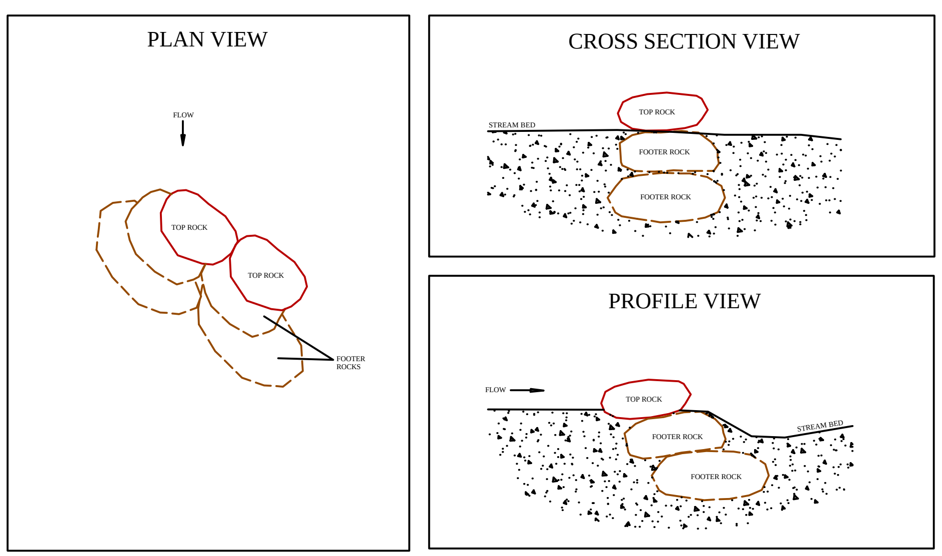
J-HOOK VANE (SR-02)



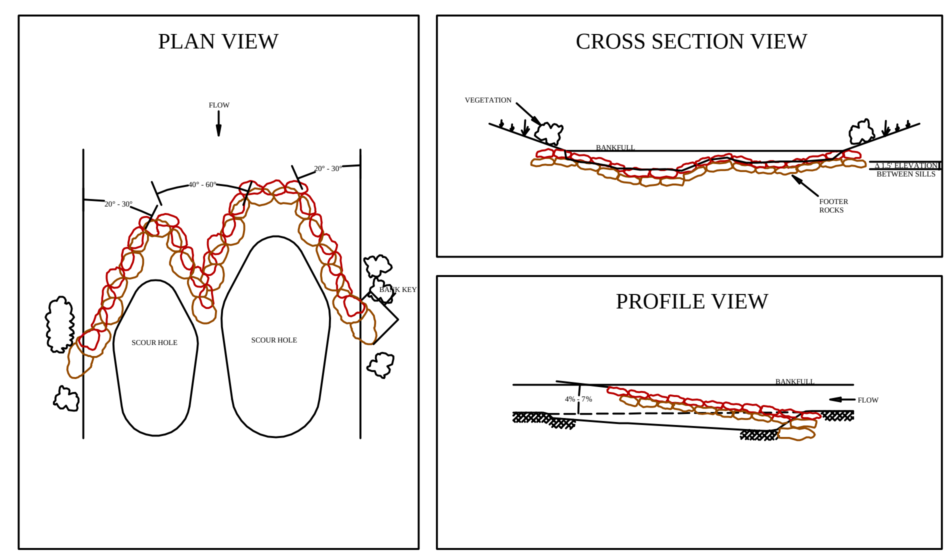
ROCK CROSS VANE (SR-03)



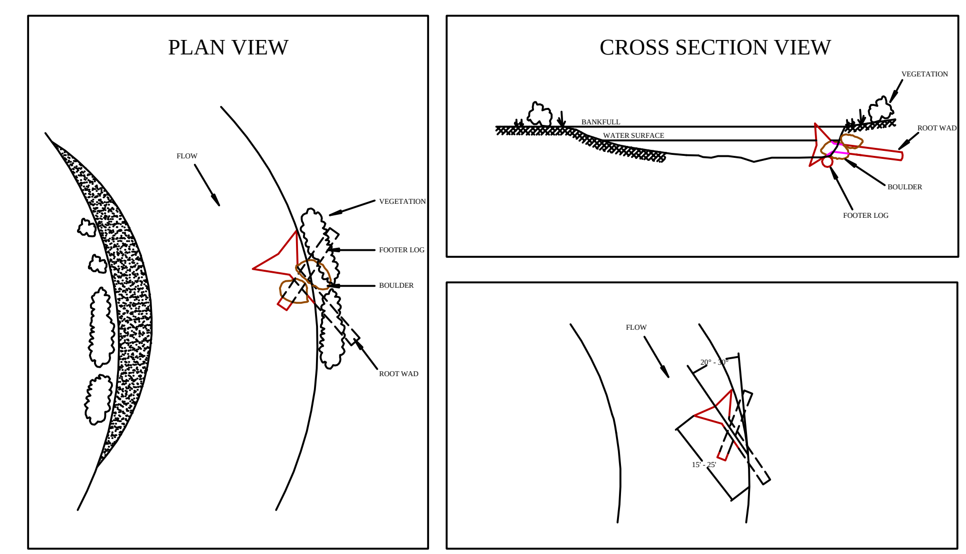
FOOTER ROCK PLACEMENT



ROCK W-WEIR (SR-04)



ROOT WAD (SR-06)



CONSTRUCTION NOTES

1. The construction of all structures will done in the presence of a designated contracting officer.

2. The size and placement of scour holes will be determined by the contracting officer. See construction specifications.

3. The bank key for all rock structures will be a minimum of eight feet (8') in length.

4. Vegetative transplants are to be placed in the immediate area upstream and downstream of the installed structure as designated by the contracting officer.

MATERIAL SPECIFICATIONS

1. Rock Size

	A-axis	B-axis	C-axis
Minimum Size	4'	3'	2'
Maximum Size	8'	6'	5'

2. Root wads and footer logs will be identified and flagged by the contracting officer.

3. Root wads should have a minimum root diameter of four feet (4') with a minimum length of fifteen feet (15') and a trunk diameter of at least eighteen inches (18").

LEGEND

REVISIONS

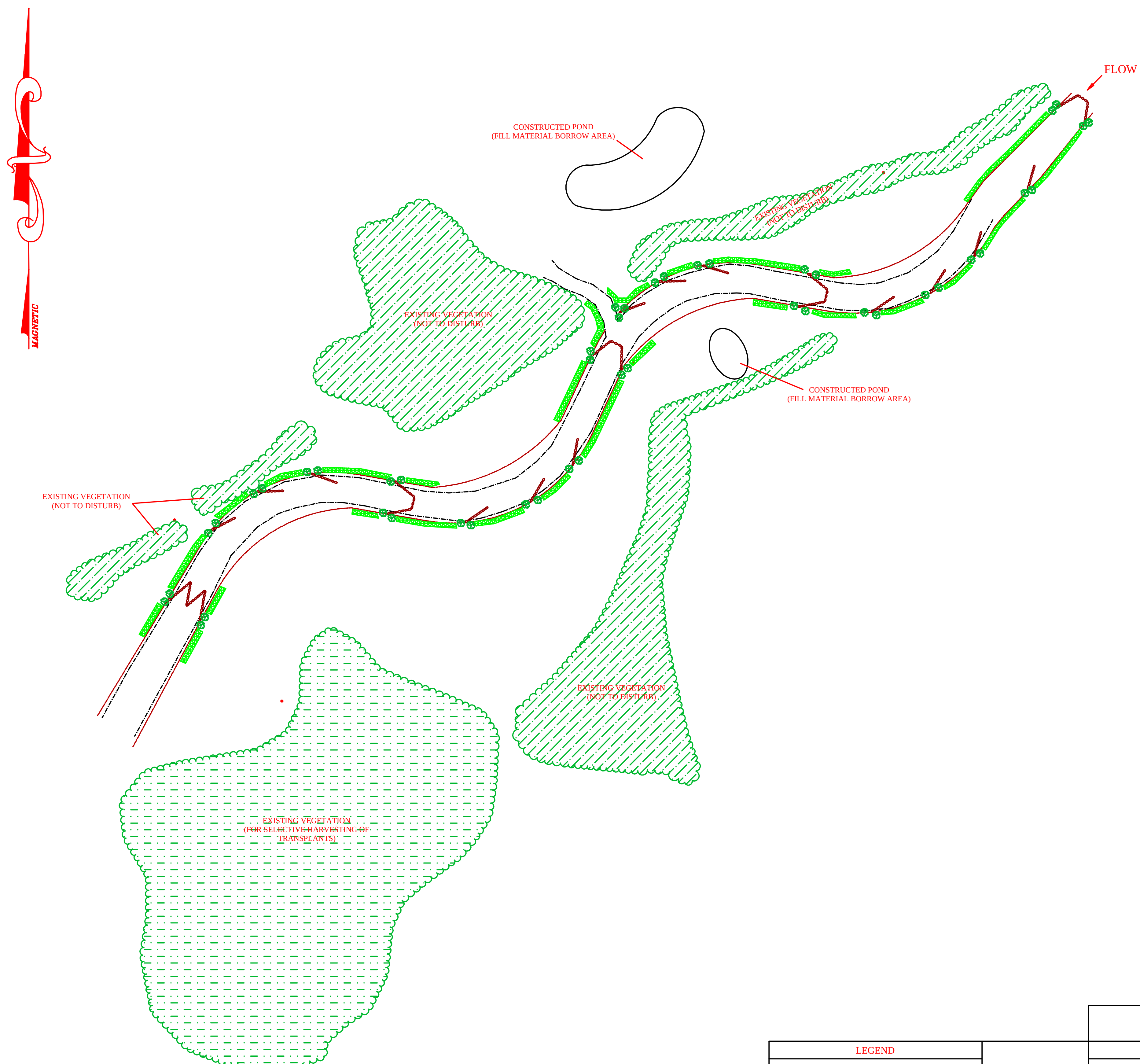
BATAVIA KILL STREAM MANAGEMENT PILOT PROJECT

TOWN OF ASHLAND	COUNTY OF GREENE
APRIL 30, 1999	SCALE (PER DRAWING)

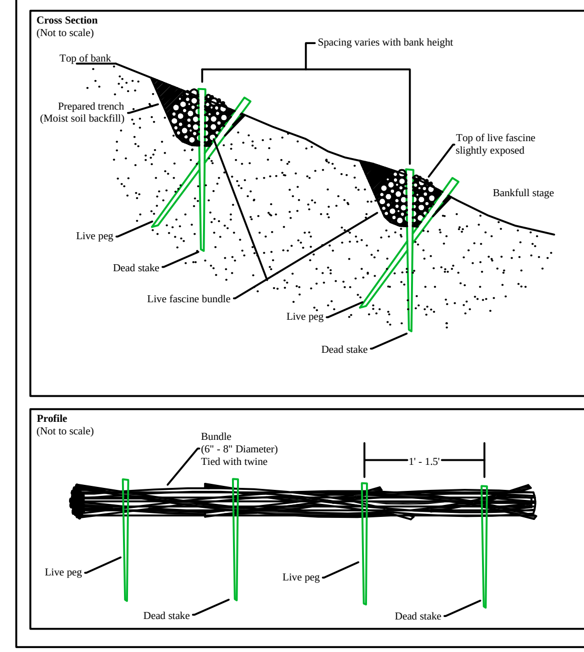
GREENE COUNTY SOIL & WATER CONSERVATION DISTRICT
BOX 907 GREENE COUNTY OFFICE BUILDING, CAIRO, NY 12414
PHONE (518) 622-3620
FAX (518) 622-0344

"BRANDY WINE" STREAM RESTORATION PROJECT

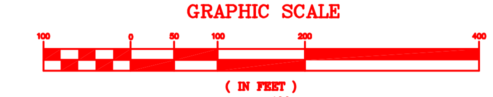
CHECKED BY:	PROJECT #: BSP-98.01
DRAWN BY: DOUG DEKOSKIE	DRAWING #: 98.01
SHEET 11 OF 13	CONSTRUCTION DETAILS



LIVE FASCINE DETAIL (VS-01)



GRAPHIC SCALE

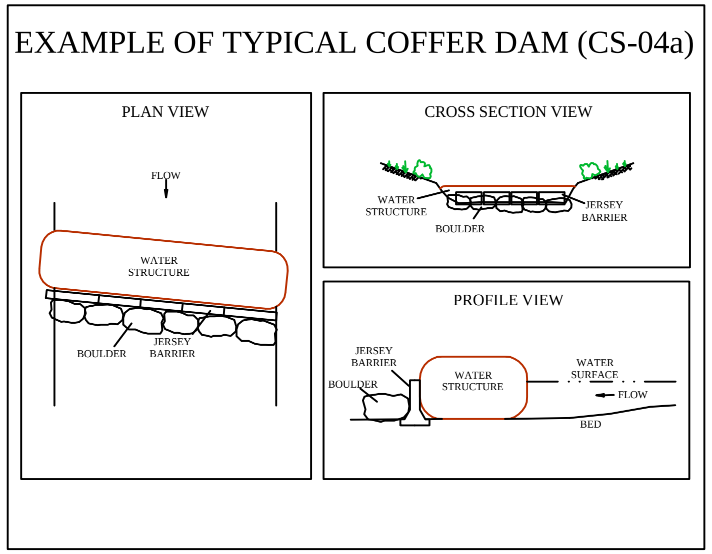


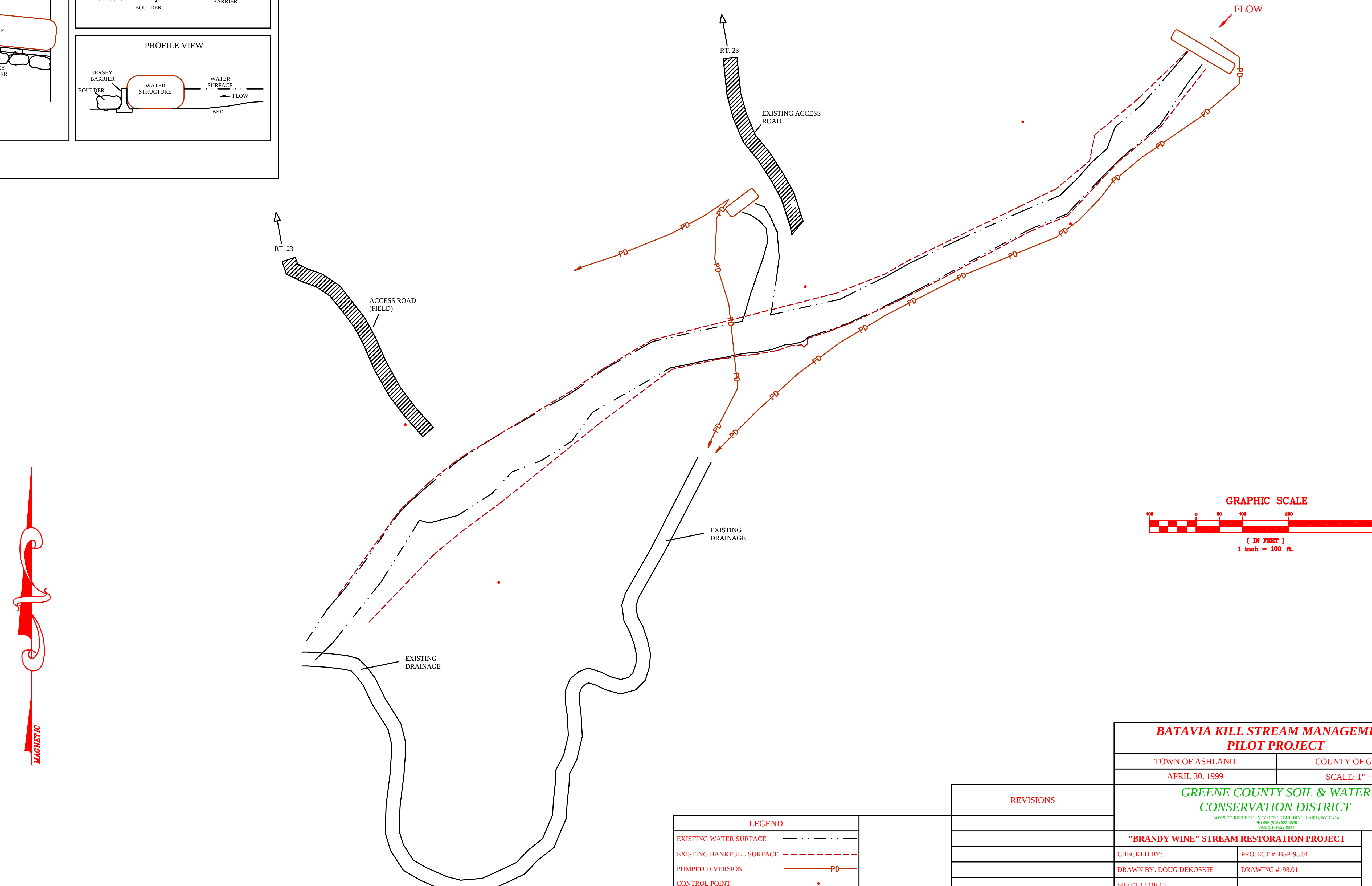
(IN FEET)
1 inch = 100 ft.

LEGEND	
PROPOSED WATER SURFACE	— · — · —
PROPOSED BANKFULL CHANNEL	— — — — —
CONTROL POINT	•
LIVE FASCINE PLANTING AREA	
STRUCTURE	

REVISIONS

BATAVIA KILL STREAM MANAGEMENT PILOT PROJECT	
TOWN OF ASHLAND	COUNTY OF GREENE
APRIL 30, 1999	SCALE: 1" = 100'
GREENE COUNTY SOIL & WATER CONSERVATION DISTRICT BOX 907 GREENE COUNTY OFFICE BUILDING, CAIRO, NY 12414 PHONE (518) 622-3620 FAX (518) 622-0344	
"BRANDY WINE" STREAM RESTORATION PROJECT	
CHECKED BY:	PROJECT #: BSP-98.01
DRAWN BY: DOUG DEKOSKIE	DRAWING #: 98.01
SHEET 12 OF 13	PLANTING DETAILS





LEGEND	
EXISTING WATER SURFACE	— · · — · · —
EXISTING BANKFULL SURFACE	– – – – –
PUMPED DIVERSION	——PD——
CONTROL POINT	•

REVISIONS

BATAVIA KILL STREAM MANAGEMENT PILOT PROJECT

TOWN OF ASHLAND	COUNTY OF GREENE
APRIL 30, 1999	SCALE: 1" = 100'

GREENE COUNTY SOIL & WATER CONSERVATION DISTRICT
BOX 907 GREENE COUNTY OFFICE BUILDING, CAIRO, NY 12414
PHONE (518) 622-3620
FAX (518) 622-0344

"BRANDY WINE" STREAM RESTORATION PROJECT

CHECKED BY:	PROJECT #: BSP-98.01
DRAWN BY: DOUG DEKOSKIE	DRAWING #: 98.01
SHEET 13 OF 13	DEWATERING PLAN

Appendix D

Project Physical Monitoring Plan

Brandywine Restoration Project
Project Monitoring Plan

1.0 Introduction

In recent years, there has been increasing focus on the use of fluvial geomorphic restoration techniques to provide channel stabilization while targeting a range of additional multi-objective project goals. The techniques, generally referred to as natural stream channel design, typically include the development of an appropriate channel geometry, which mimics a natural stable form of the channel. Combinations of rock and log structures and various bioengineering practices are typically used to promote increased, long term bank and channel stability, promote fisheries habitat, and facilitate flood and sediment transport.

A natural channel maintains it's stability while making continual adjustments in geometry over time as a result of changes in stream flow and sediment load. Restoration projects that are constructed to imitate the natural equilibrium of stable channels are subject to these adjustments and remain particularly vulnerable prior to the establishment of vegetation.

A critical element to the long term success of these projects is in monitoring the restoration site to provide for baseline conditions and to verify results of the restoration effort. Monitoring the restoration project can be used to meet permit requirements, measure the performance and success, and provide increased knowledge in the design and construction procedures.

The following document describes the proposed physical monitoring plan for the Brandywine Restoration Project.

2.0 Permit Requirements - Monitoring

A condition of the permit, issued by the Army Corps of Engineers for the Brandywine Restoration Project, requires the Greene County Soil & Water Conservation District to submit annual reports documenting the status of the project, for three years following the completion of construction. The report to the New York District of the Army Corps must include:

- the current stream type of the reach
- the condition of the planted vegetation
- the condition of upstream and downstream reaches
- color photographs taken during normal low flow, and following an annual or bankfull event to include:
    - the reconfigured channel
    - the re-vegetated areas
    - upstream and downstream reaches

3.0 General Monitoring Strategy

The physical monitoring of the project will include pre-construction, as-built, and post-construction surveys to include a complete longitudinal profile, multiple cross sections, and sediment sampling. Additionally, the project reach will be inspected on a routine basis and will have a detailed inspection after each flow event that meets or exceeds bankfull discharge. Photo documentation of the project site will be used to monitor change over time, as well as to meet the project permit requirements. A five year monitoring program will be initiated in order to fulfill the permit requirements as well as provide a longer period for data collection and comparison given the uncertainty of flow events and vegetative establishment.

4.0 Surveys and Sampling Locations

The following surveys will be performed to document physical performance:

4.1 Topographic Survey (As-built)

The completed restoration projects are surveyed immediately after construction to document the “as-built” condition of the new channel and the adjoining floodplain area. The as-built survey includes:

- topographic ground surface
- location of structures
- longitudinal profile along the thalweg
- multiple cross sections
- bankfull stage
- water surface
- locations of installed bioengineering components.

4.2 Cross Sections

At the time of the as-built survey, monumented cross sections will be installed for use in detailed monitoring efforts. Cross sections are monumented using capped rebar pins, which are located in the topographic survey and recorded using GPS.

Cross sections are placed in various locations along the completed project reach to monitor stream process. These include sections through potential high stress areas and across varying stream features (pools, riffles, etc.) in order to document stability, stream classification, and potential erosion and scour. Additional cross sections will be established across or near stabilization structures (rock vanes, cross vanes, etc.) in order to monitor performance.

4.3 Longitudinal Profile

Longitudinal profile surveys include the sampling of ground surface point at slope breaks along the thalweg of the channel to document physical channel dimensions. The profile survey also includes the daily water surface slope as well as the elevation of bankfull indicators along the channel. The sampling is tied to the project datum so future modeling efforts can be initiated. The profile survey can be used to indicate channel vertical stability and channel efficiency, as well as correlate morphological channel parameters such as feature characteristics, increase in channel storage, and riffle-pool measurements.

4.4 Sediment Samples

Sediment sampling is used to provide indicators of channel process, as well as for stream classification and monitoring. The primary sediment analysis is based on the Wolman pebble count. Pebble counts are conducted using composite methods for classification, as well as detailed sampling at designated cross sections for hydraulic analysis and to monitor shifts in particle size. Additional pebble counts may be conducted in specific features (i.e. pools) to monitor changes in the sediment stratification as the project adjusts to the natural bed load supply in the system.

The Greene County Soil & Water Conservation District also intends to conduct bar sample analyses within the project reach. Bar sample analyses are not recommended for a period of time after construction, and will not be completed until such time that the GCSWCD feels that the channel has reached a natural sediment regime. As a minimum, bar sampling analysis of the restoration reach should not be conducted until the reach has experienced at least one, preferably more, bankfull flows.

5.0 Assessment Procedures

The monitoring data will be analyzed using two general scales. Relationships will be made to annually to determine general morphological trends occurring through the project reach as well as comparisons made "at-a-station" using direct comparisons between monitored stations. Monitoring data can additionally be correlated to flow events which occur between monitoring intervals.

Surveys will be matched and analyzed in order to review the change in channel dimensions and geometry of individual surveys. This technique will assist in quantifying physical change at a station and used to review processes through the reach. The assessment can be conducted at multiple scales at various time increments in order to provide annual performance data as well as after significant flow events.

A simple comparison between surveys (annual or storm) can indicate channel progression, changes in channel efficiency, and deviation of channel morphology from the design channel parameters. Analysis of the physical data may also determine the appropriateness of a channel design technique and may show the sensitivity of certain techniques to channel processes. In terms of management (operation and maintenance), the overlays provide indicators of the trajectory of the rebuilt channel, therefore the analysis can be used to quantify further modification of the channel. The assessment can be further developed using comparisons within the reach, against regional values, stream channel classification indexes, and reference reach data. The channel parameters can be applied to channel evolution models to review the effectiveness of a treatment in halting or accelerating a channel process.

6.0 Reporting

Several project status reports will be generated in order to document the specific type and timing of the project monitoring and assessment. Status reporting will include a combination of various site inspection reports, annual status reports, a post-construction report, and a final assessment report. A brief summary of each report is listed as follows:

6.1 Post-construction Report

The as-built survey report will include the following:

- Field adjustments made during the project construction
- Project construction implementation
- Location of post-construction monitoring stations (sections, profile)
- Location and placement of installed structures

- Photographs taken throughout construction and immediately following construction

6.2 Periodic Site Inspections

Periodic site inspections will include the following:

- General site inspection
- Inspection of structures
- Inspection of vegetation
- General channel stability
- Representative photographs through the reach and adjacent areas
- General notes and recommendations

6.3 Annual Status Reports

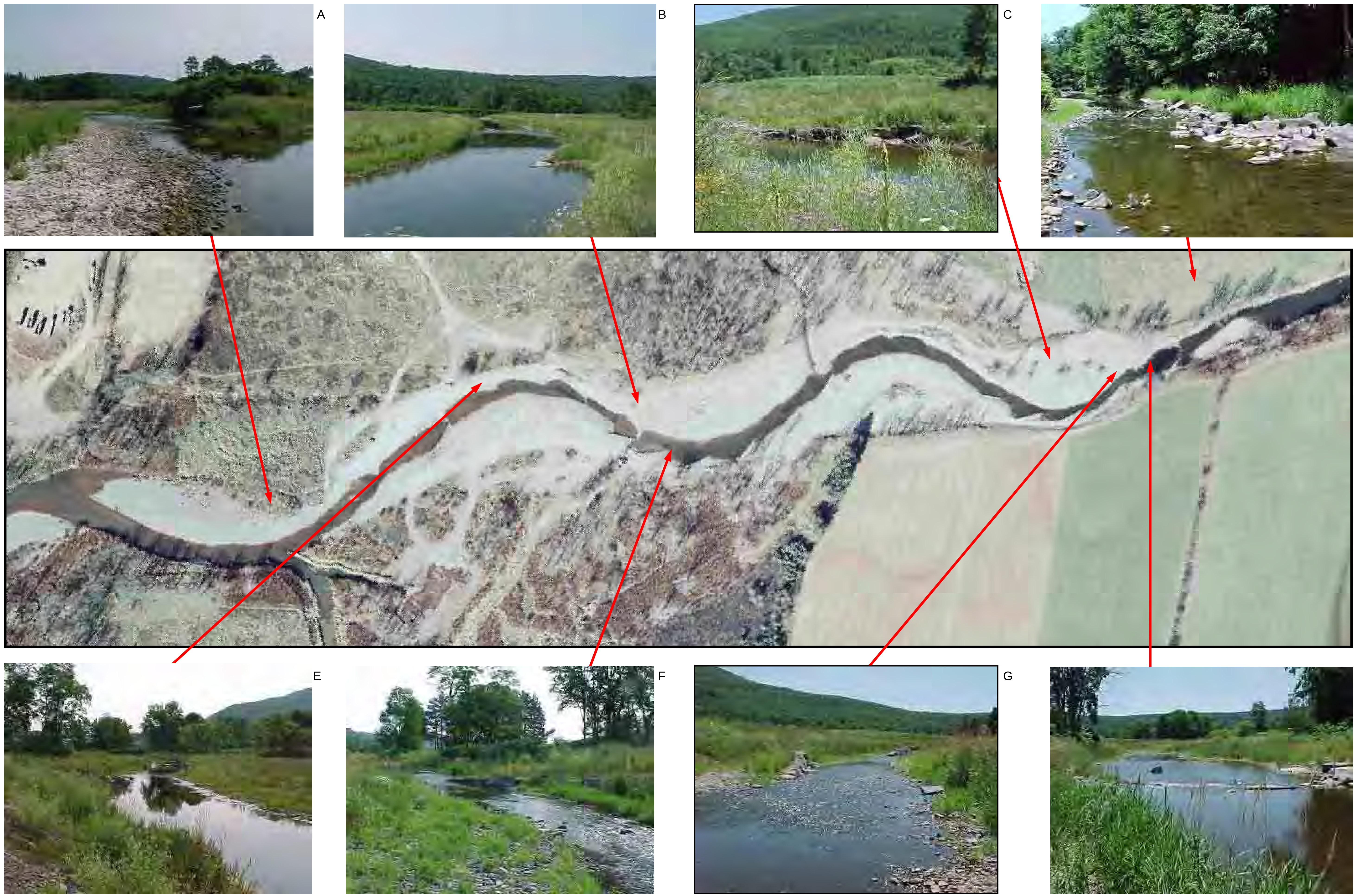
The annual status reports will include the following:

- General site inspection
- Inspection of structures
- Inspection of vegetation
- General channel stability
- Monitoring surveys and assessment
- Representative photographs through the reach and adjacent areas
- General notes and recommendations

6.4 Assessment Reports

The assessment report will include the following:

- Summary of the overall project stability
- Analysis of monitoring surveys and assessments
- Representative photographs through the reach and adjacent areas
- General notes and recommendations


A
B
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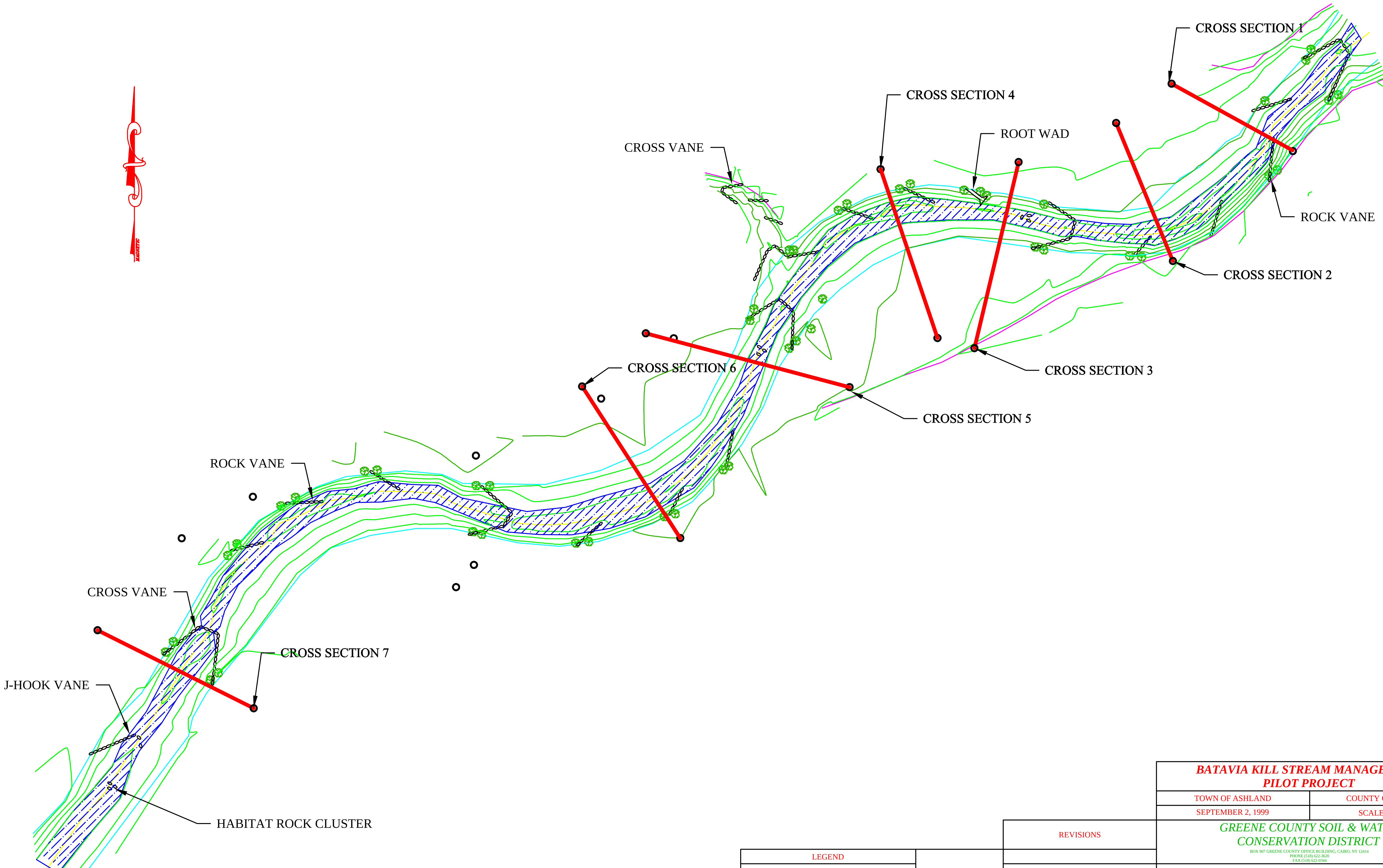

AS-BUILT SURVEY PERFORMED ON SEPTEMBER 2, 1999.

LEGEND

- BANKFULL SURFACE
- WATER SURFACE
- STRUCTURE
- TRANSPLANT

REVISIONS

BATAVIA KILL STREAM MANAGEMENT PILOT PROJECT

TOWN OF ASHLAND	COUNTY OF GREENE
SEPTEMBER 2, 1999	SCALE: 1" = 60'

GREENE COUNTY SOIL & WATER CONSERVATION DISTRICT

BOX 907 GREENE COUNTY OFFICE BUILDING, CAIRO, NY 12414
PHONE (518) 622-3620
FAX (518) 622-0344

"BRANDY WINE" STREAM RESTORATION PROJECT

CHECKED BY:	PROJECT #: BSP-98.01
DRAWN BY: JB/MM	DRAWING #:
SHEET 1 OF 1	MONITORING LOCATIONS

Appendix E

Fish & Habitat Monitoring Plan

NOT COMPLETE

Appendix F

Project Status Reports

F.1 Project Status: Flood Event Inspection (September 1999)

F.2 Project Status: Repairs (2000)

F.3 Project Status: Asbuilt (2000)

F.4 Project Status: 2001 Inspection - Survey

F.5 Project Status: 2002 Inspection - Survey

F.6 Project Status: 2003 Inspection - Survey

F.7 Project Status: 2004 Inspection - Survey

F.8 Project Status: Flood Event Inspection (April 2005)

F.9 Project Status: 2005 Inspection - Survey

F.10 Project Status 2007 Inspection - Survey

F.1 Demonstration Project Status September 16,1999 -Storm Event Inspection

On September 16, 1999, the Batavia Kill watershed experienced several inches of rain resulting in flood flow through the Brandywine Demonstration Project. To show project status, field inspections were conducted during and immediately after the flood event. Damage to project components and observations of the functioning structures were documented and described. Based on the inspections and site assessments, recommendations were developed for future modification of the project and for the general use of NCD techniques. Images of the site functioning during the flood event and following the flood event can be found at the end of this section.

Rainfall and Stream Flow

In the Northeastern Catskills, the most significant impact of tropical storm Floyd was the intensive surface runoff caused by the concentrated rainfalls. A comparison of tropical storm Floyd to the previous hurricanes, Connie and Donna (Table 1), shows that Floyd produced the highest rainfall amount in the shortest duration within the Batavia Kill Basin.

Table1: Rainfall Comparisons of Hurricane Related Flood Events in Batavia Kill

Storm Event	Total Rainfall	Duration	Flood RI (at Hensonville)
Connie (Aug 1955)	7.75"	40 hours	25
Donna (Sep 1960)	7.9"	96 hours	20
Floyd (Sep 1999)	9.36" measured 12" reported	24 hours	30 provisional (USGS)

To evaluate the impact of tropical storm Floyd, on Batavia Kill stream flow, stream gage data was examined and the findings were summarized in Table 2. The real time gage at Ashland is located approximately 2,000 downstream of the project reach. This data indicates that the flood flow, produced by tropical storm Floyd, was greater than both the April 1987 event and the January 1996 events which had substantial impact in a number of drainage systems in the Catskills.

Table 2: Stream Flow Comparison of Major Flood Events

Gage Location	Schoharie Creek @ Prattsville	Batavia Kill near Ashland	Batavia Kill @ Hensonville
USGS Gage No.	01350000	01349900	01349850
Drainage Area	237 sq.mi.	51.2 sq.mi.	13.5 sq.mi
Gage Type	Real time	Daily (tape)	Crest gage
Period of Record	95 years	12 years	40 years
10/16/55	51,600 cfs	no record	no record
9/12/60	49,900 cfs	no record	no record
4/4/87	47,600 cfs	11,500 cfs	2,390 cfs
1/18/96	52,800 cfs	14,300 cfs	2,000 cfs
9/17/99	42.800 cfs	15,300 cfs	2,170 cfs

Field Observations During the Storm Event

At 6:50 PM VanSchaack arrived at the lower end of the Brandywine site and observed that the stage was above bankfull. The flow was over the gravel bar on the left bank. The lower most cross vane was identified by two, then later a third, standing wave in the vicinity of the center of the cross vane. Walking the lower most constructed meander, the structures appeared to be working on the upper end of the pool but were less obvious at the lower end. At this point, the water surface was observed as extending as far as could be seen on the opposite side of the creek.

Relocating to the access point at the North Settlement Creek (behind Brandywine Restaurant), at 7:10 VanSchaack observed that the North Settlement Creek was high, violent and out of its banks as it neared the confluence with the Batavia Kill. Walking East along the right bank, VanSchaack observed that the water was just cresting on the high bank (right bank), and there appeared to be several feet of flow across the opposite flood plain. Larger woody debris was noted floating in the floodway on the opposite bank. The in-stream structures located in the pool area just above North Settlement Creek appeared to be working and a distinct slack water was noted along the edge of the stream flow.

Continuing upstream, observations were made at the second cross vane from the top but the water was too deep to note any activity. Observations were limited to this point as the raising stream had topped the high bank, and the observer had to wade back to the access point through 6-8 inches of water. Conditions were unsafe at this point and the observer was forced to leave the site.

Impact to Brandywine Demonstration Project

During initial observations, on September 17, 1999, the stream stage was just below bankfull and most structures were not visible due to highly turbid water. A thorough examination of the project site was conducted once the stream flow had receded, a week following the flood. The more significant damages that were recorded during observations are discussed below. The features discussed are there relative position along the project reach, starting from the top of the project and proceeding downstream.

The project exhibited a greater level of damage than the Maier Farm site but can be attributed to generally the same causes. The Brandywine Project had been completed only 10 days before the flood event. The site had virtually no vegetation, with only a faint hint of germinating seed. The project had been completed during intermittent days of rain, the first significant precipitation since the projects started in the beginning of August.

Like the Maier site, the primary failure occurred on the lower section of the meander bends, and was attributed to the failure of the vanes to maintain an effective depositional feature. Several rock vanes and cross vanes had reduced or no deposition occurring on the upstream side of the structure arm. The absence of deposition was primarily noted in the middle of the vane, with the structure generally still keyed in on the upper end, and buried in sediment on the lowest area. As pointed out in the Maier summary, this depositional feature is a desired effect that is necessary in reducing stress on the structure. It is noted that if the void in the structure is larger that the available natural sediment to the site the depositional feature will scour during high flow events and make the structure vulnerable to damage.

The second major contributing factor in structural problems was the lack of protection around the bank key on the structures located on the lower 1/3 of the meander bends. In this area the rock vane and cross vane bank keys were constructed into the streambanks at an average linear distance of 12'. This key was designed in conjunction with the bioengineering to reduce scour and velocity around the back of the structure during over bank flow. Without the protection of the bioengineering (live fascines, transplants, willow stakes and posts, sod mats, and conservation grasses), the 12' bank key became vulnerable to high velocities and shear stresses, causing scour around the structure.

On the Brandywine project the channel pattern experienced relatively minor changes considering the scale of the earth work recently completed and the magnitude of the flood event. While some erosion had occurred on the meanders bends, the meander radius remained basically unchanged and the changes in cross sectional area appeared to be within acceptable limits of the constructed channel.

The exception to this response was the lower 1/3 of the bottom meander on the project. In this area, a section of the stream experienced a very significant channel shift (right bank) of approximately fifty feet (50').

In the area of the 2nd and 4th cross vanes, the stream was partially diverted around the structures on the left bank (both). The stream flow was concentrated, and cut shallow channels across the point bar face just down stream. When the vanes had become compromised by the diverted flow, they presented a central obstruction and promoted increased flow diverted toward the streambank. The plan form response was a minor shift towards the left bank and a lesser migration of the left bank in a down valley direction. In spite of these shifts, the District felt the resulting channel pattern was still consistent with the design form.

Cross vane #1 on the upper project was relatively unchanged, while cross vane #3 (just below North Settlement Creek) was in place but with the right key buried under the sediment from the tributary. Cross vane #4 (lowest) was a complete loss due to the channel shift noted above.

In the projects construction, the District had addressed the North Settlement Creek tributary and Batavia Kill confluence by directing the tributary flow to enter the Batavia Kill at a point just above the right arm of Cross vane #3. On NSC, three rock vanes had been used on the lower meander and cross vanes, at the top and bottom, to direct the flow to enter at cross vane #3 in the Batavia Kill.

On reviewing the site after the flood recession, the first thing noted by observers was the excessive deposition of fairly course bedload at the confluence. After the flood, the depositional outwash was approximately three feet (3') higher in elevation than the surrounding flood plain, and a presented a direct and unnatural obstruction to the main stream. All structures on North Settlement Creek (NSC) were completely buried under sediment but remained fully intact. There was no evidence that the Batavia Kill had any problem effectively transporting the sediment supply from NSC once it had reached the main channel of the BK.

In addition to the deposition at the confluence, the NSC channel had experienced significant aggradation for a distance as far as 500 feet upstream. Since post flood surveys were not conducted, the extent of this deposition was not documented, but the impact was easily visible. After noting the amount and size of the bedload, the District moved upstream to look for any additional sources of sediment which may have impacted the channel. Approximately ½ mile upstream, a large streambank failure was noted, with banks as high as 40 - 50 feet with evidence of a sizable failure during the storm.

The increased deposition in NSC was a direct result of the change in stream velocity and power as it entered the Batavia Kills flood water. As velocity was reduced, NSC would not be able to effectively transport its larger bedload into the Batavia Kill and as a result deposited its larger bedload causing a “delta” area extending upstream into North Settlement Creek. This would cause the constructed channel to fill with sediment and overflow into its floodplain. It is believed that upon recession of the Batavia Kill flood waters NSC had head cut back through this depositional feature in an attempt to re-gain a stable slope and meander pattern.

After reviewing the NSC impacts, the GCSWCD proposes that a short section of the lower tributary may require additional measures to harden the meander. This would aid in supporting the higher velocities and shear stresses needed to transport the sediment load to the main channel of the BK, with the understanding that extreme flood events like this one could cause a similar depositional feature to form.

Summary of Flood Damages and Recommendations

After review of the available data and site observations, as well as discussions with numerous stream professionals, the impacts on the demonstration projects were summarized as follows:

> [1] Due to voids in the structures, small particle size and the power of the stream flows, the upstream depositional feature did not properly form on many of the rock vanes.
>
> [3] The areas that experienced the greatest damage (the lower 1/3 of the outside bank) were designed to aid in the re-direction of damaging velocities, but required the presence of strong riparian vegetation to maintain an effective system. At the time of the flood, the vegetation had not been fully established, therefore, the site lacked adequate vegetative control. It is felt that vegetation is as critical a design component as channel sizing and bank protection(vanes).

[4] While difficult to determine for certain, the over excavation of clay deposits from the channel bottom may have contributed to some of the damage. During construction, the fill material was placed wet and loose and the streambed did not benefit from several gentler flow events which may have promoted effective sorting and compaction.

Future Recommendations

Based on the pre and post-flood assessments, several recommendations for repair of the damaged structures and for future use of the NCD techniques. These recommendations can be summarized as follows:

[1] Stream Geomorphology

Based on post flood observations by the GCSWCD and an evaluation conducted by Clear Creeks it was concluded that the channel morphology design was appropriate.

[2] Vegetation Establishment

There is a period between construction and vegetation establishment, when streams are more susceptible to damage associated with high and flood flow, therefore, establishing vegetation is critical for successful project implementation. Planting should be a priority, however significant effort should also focus on improving the rate of vegetation establishment through techniques such as irrigation.

Seeding and mulching of disturbed areas, even if temporary, is critical for controlling environmental impacts of project construction and to prevent slow, cumulative erosion of the streambanks.

[3] Rock Structure Construction

To mitigate the problems associated with the absence of deposition on the structures, hand chinking of voids is advised, and when the bedload is finer in nature larger cobble should be brought to the site and used as a base for the deposition area.

The problem with diversion around the top of structures in critical areas may be eliminated by the use of floodplain sills extending from the top of the structures. In many cases suitable large logs will not be present, therefore, it may be necessary to use additional rocks to construct the sill. The sill would only be required in areas where stresses are predicted to be highest.

[4] De-watering Operations

Groundwater inflow in the project area was substantial, causing work to be completed in the wet. When such conditions exist, additional de-watering resources should be considered to allow for proper chinking of voids during construction of the rock structures. For example, a third pump may be used in addition to a pump at the upper end of the project to divert the stream flow coming into the project site, and a pump at the bottom of the project to handle turbid water.

F.1 1999 Inspection: Photographs and Descriptions-Flood Event September 16, 1999

Photograph 1: Beginning of storm event looking downstream through fourth meander bend.

Photograph 2: Vane beginning to work during beginning of event. Obvious is the minimal vegetative cover.

Photograph 3: View looking upstream at second meander. North Settlement tributary entering on left side of image.

Photograph 4: North Settlement tributary in the beginning stages of storm event.

Photograph 5: Bankfull flow through project area on September 16, 1999.

Photograph 6: North Settlement Creek above bankfull flow.

Photograph 7: Second meander during high flow. Stage above bankfull and almost entering floodplain.

Photograph 8: Flood flow through second meander.

Photograph 9: Top of second meander.

Photograph 10: First meander completely inundated

Photograph 11: Storm flow before entering old terrace.

Photograph 12: First meander vanes completely submerged.

Photograph 13: GCSWCD staff investigating project area September 17 after peak had receeded.

Photograph 14: The confluence of North Settlement and the Batavia Kill. Evident is the large pile of gravel that had been left from the event.

Photograph 15: Looking upstream from second meander at below bankfull stage. Apparent is the extreme turbidity levels entering the project site.

Photograph 16: Project area on storm recession.

Photograph 17:New vegetation (grasses) had been stripped and deposited over on bar.

Photograph 18:Middle project area.

Photograph 19:Aerial View looking downstream from second meander. The image displays the loss of vegetative cover on bars but the installed channel planform features (sinuosity) remained.

Photograph 20:Lower project bend displaying some cutting and erosion.

Photograph 21: The entrance of North Settlement Creek.

Photograph 22:Looking upstream at planform of channel. Areas disturbed and re-seeded during construction were lost. Also the a number of vanes were substantially damaged. The cross vane in center picture shows evidence of missing rocks.

Photograph 23:The downstream extent of the project area was also substantially damaged from the event.

Photograph 24: The image shows the bank erosion on the first meander bend. The lower third of meander bends through the entire project were damaged the most in the event.

Photograph 25: Large cobble material was deposited along the inside of several meander bends

Photograph 26: Further documentation of erosion on the lower third of a meander bend.

Photograph 27: Large cobble material in the vicinity of the North Settlement Creek confluence.

Photograph 28: Further documentation of erosion on the lower third of a meander bend.

Photograph 29: A functioning cross vane at the lower end of the project site.

Photograph 30: Further documentation of erosion on the lower third of a meander bend as well as evidence of out of bank flow.

Brandywine Stream Restoration Project
Flood Event September 16, 1999


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Brandywine Stream Restoration Project
Flood Event September 16,1999

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Brandywine Stream Restoration Project
Flood Event September 17, 999

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Brandywine Stream Restoration Project
Post Flood Damage September 24, 1999


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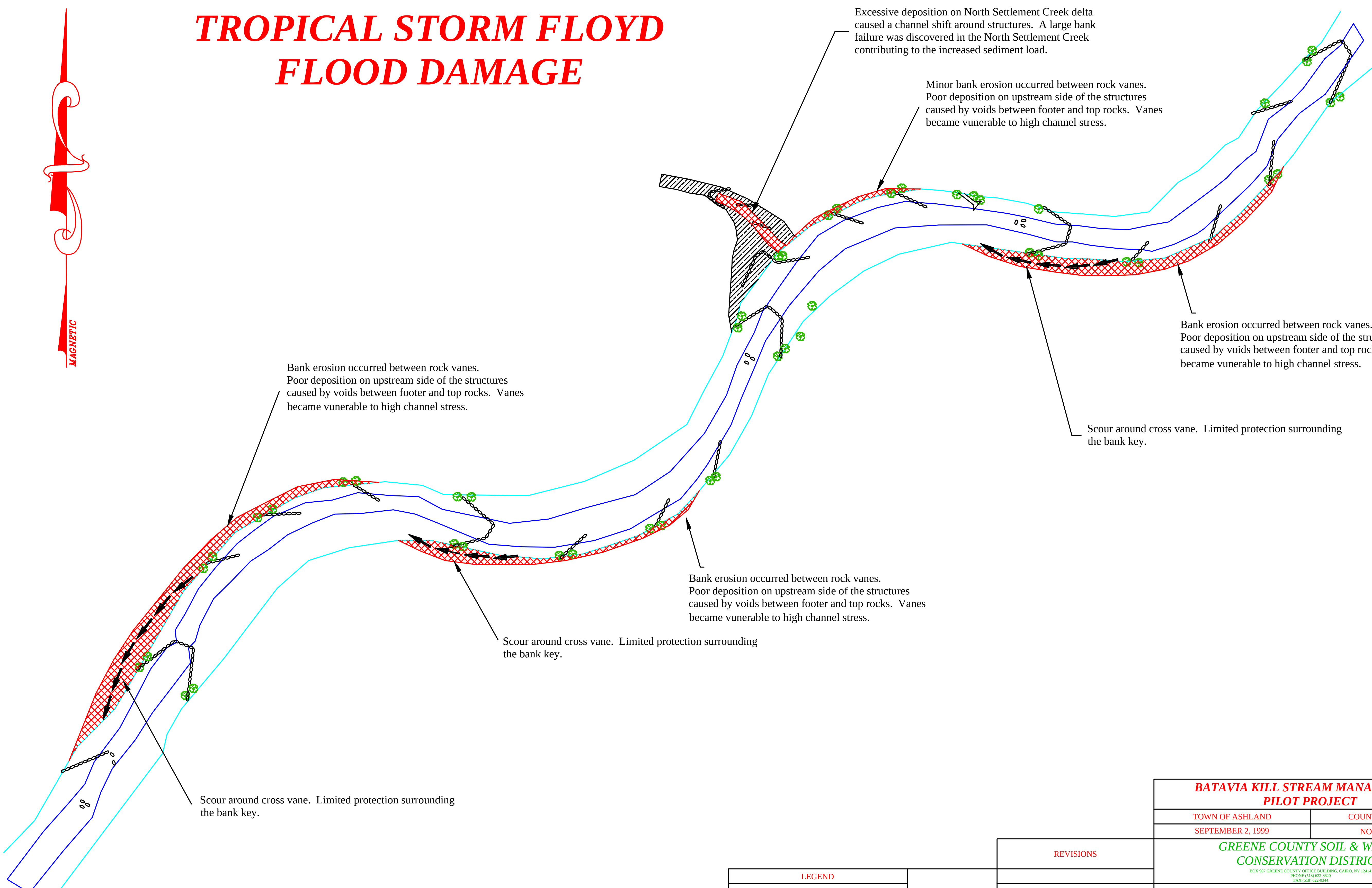
Brandywine Stream Restoration Project
Post Flood Damage December 1999

TROPICAL STORM FLOYD FLOOD DAMAGE



AS-BUILT SURVEY PERFORMED ON SEPTEMBER 2, 1999.

LEGEND

- BANKFULL SURFACE
- WATER SURFACE
- STRUCTURE
- TRANSPLANT

REVISIONS

BATAVIA KILL STREAM MANAGEMENT PILOT PROJECT	
TOWN OF ASHLAND	COUNTY OF GREENE
SEPTEMBER 2, 1999	NOT TO SCALE

GREENE COUNTY SOIL & WATER CONSERVATION DISTRICT

BOX 907 GREENE COUNTY OFFICE BUILDING, CAIRO, NY 12414
PHONE (518) 622-3620
FAX (518) 622-0344

"BRANDY WINE" STREAM RESTORATION PROJECT	
CHECKED BY:	PROJECT #: BSP-98.01
DRAWN BY: DOUG DEKOSKIE	DRAWING #:
SHEET ? OF ?	PROJECT AS-BUILT SURVEY

F.2 Demonstration Project Status 2000-Brandywine Project Repair

Background

Asa result of tropical Storm Floyd which struck the Batavia Kill watershed on September 16, 1999, the Brandywine project reach required reconstruction and modification of several components. While the projects overall design/constructed dimension, pattern and profile were not impacted during the flood, erosion did occur in areas of inadequate vegetation and several of the rock structures experienced damage similar to that seen at the Maier Farm Site. Due to the fact that the storm hit late in the season, a decision was made to postpone repairs until the 2000 construction season. The purpose of this document is to describe the specific project modifications, details and costs associated with the repair and modifications of the Brandywine Project.

Project Modification Time line

Repairs to the project were initiated late in August 2000, with the work completed by September 15th. The total repair period was approximately 14 days. Planting was commenced in October, requiring approximately 5-7 days to complete.

Project Repair Details

The following is a summary of the repair activities.

[1] To expedite the reconstruction/repairs, the GCSWCD/ Fastracs Inc. used a passive de-watering system which included constructing a by-pass channel on the flooplain and a gravel cofferdam upstream of the project to divert flow through the by-pass channel and around the work areas.

[2] On all damaged structures, additional rocks were placed to strengthen the vanes and to chink any voids between the rocks. Larger cobble (6"-18") was obtained from a local gravel bank, and was used as backfill behind the structure arms to fill the voids and to create the upstream depositional area on each structure.

[3] On most structures, an extended flooplain sill was constructed for a distance of approximately twenty (20') from the top of the vane. The sills were completely buried below the bankfull or flooplain level and should eliminate future erosion around the head of the vanes. In recent applications completed by Dave Rosgen, he has incorporated large (>24" diameter) logs buried just below the surface. The log sills run from the top of the vane arm and perpendicular to the fall of the valley. On the Phase I demonstration projects, these sills were not used due to the lack of suitable logs on site and the added cost of using stone for sill construction. Rosgen does not use them in all situations, but considers them "cheap insurance" when the logs are available on site.

[4] Between the rock vanes, the top of the streambank was repaired by using medium size stone as a toe for replacement fill and by slightly lowering the slope on the upper bank. The material was compacted with an excavator bucket and prepared for planting live fascines.

[5] On the lower cross vane, coarse materials were used as back fill for the vane arm to promote deposition. Several top rocks were reoriented to slightly steepen the slope on the left arm and to repair a flat spot on the right arm.

[6] At the confluence of North Settlement Creek, the rock structure was modified to provide grade control at the end of the tributary. North settlement creek was also slightly realigned over the last

75 feet to line the channel up with the modified rock structure. Additionally, large rock riprap was placed in several high energy areas on the left bank of the tributary over the last 100-150 feet of the tributary just before it met the Batavia Kill.

[7] Live fascines and willow posts were installed as originally planned later in the fall when plant materials had gone dormant. .

[8] The entire site was re-seeded and mulched.

Project Constructability

Landowner access was achieved through the continuance of the landowner agreements. The ACOE and DEC project permits were extended from their original project permits.

Project Repair Cost

Total repair costs were approximately $75,000 to include vendor and materials. Additional expenses for machine rental and repair and seeding and mulch totaled $7,855.71.

MaterialsPurpose/ Placement	Cost
Equipment, Operators, De-watering, Sediment control	$ 53,142.25
Cobble materials	$ 862.10
Trucking Heavy Rock and Cobble	$ 2,663.32
Trucking Rock and Cobble	$ 2,544.76
Loader Rental	$ 500.00
Trucking	$ 1,012.50
Rock	$ 2,252.47
Rock	$ 4,273.48
Greene SWCD	$ 7,855.71
Total Cost Materials and Labor and Equipment	**$ 75,106.59**

Future Monitoring

In the fall of 2000, the the GCSWCD will re-surveyed the Brandywine site and installed monitoring cross sections. The GCSWCD will continue annual monitoring in 2001.

F.2 2000 Inspection: Photographs and Descriptions-Repair/ Inspection

Photograph 1: An aerial image of the entire Brandywine site

Photograph 2: An aerial image of the second meander showing a damaged rock vane

Photograph 3: A second photo of 2 above.

Photograph 4: A gravel bar is being formed along with evidence on bank erosion on the opposite bank.

Photograph 5: Another gravel bar is being formed.

Photograph 6: A damaged rock vane and a forming gravel bar.

Photograph 7: The constructed settling basin for the repair work.

Photograph 8: Repair of the lower third of the second meander bend.

Photograph 9: Repair of the lower third of the third meander bend and the cross vane.

Photograph 10: Stockpile of fill material used to backfill a damaged rock vane.

Photograph 11: Construction equipment used to repair and reset rock vanes.

Photograph 12: Construction equipment being used to repair the channel at the end of the project site.

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Brandywine Stream Restoration Project
Post Flood Damage May 2000

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Brandywine Stream Restoration Project
Project Repair & Bioengineering September 2000

F.3 Brandywine 2000 - Repair As-Built

In 2000, the GCSWCD staff performed the as-built survey to document channel alterations and survey benchmarks for future monitoring, and to show the modifications that were made to the project design during construction and the repairs that were initiated following the high flows in April of 1999. The survey encompassed the as-built condition of the constructed channel and the adjoining floodplain area to a 1' contour finish grade topography. The survey also included rock structures, thalweg and water surface profile, location of monumented cross section pins, and installed bioengineering components. Although original construction was completed in 1999, flows associated with Hurricane Floyd necessitated repair work that were not be completed until August of 2000, therefore, an asbuilt survey was not completed immediately following original project completion.

Cross Section Survey

During the as-built survey, seven cross sections were installed for use in future detailed monitoring efforts. Cross sections were monumented using capped rebar pins, which are inventoried within the topographic survey and the locations are recorded using GPS. Cross sections were stationed at various locations along the channel profile in order to provide monitoring for stream process and stability. The cross sections were installed through various stream features (pools, riffles, etc.) and structures to document stream classification, potential erosion and scour, and to document the overall channel stability.

Table 1 Channel Geometry of existing, proposed, and as-built conditions.

Variables	Existing Channel	Proposed Reach	As-Built
Stream Type	C4	C4	C4
Bankfull Width (ft.)	121.1	63.7	72.6
Bankfull Mean Depth (ft.)	2.4	3.5	3.1
Bankfull Max. Depth (ft.)	4.2	4.2	5.1
Riffle Bankfull Cross Sectional Area (sq. ft.)	286.7	225.0	221.9
Pool Bankfull Cross Sectional Area (sq. ft.)			223.2
Maximum Pool Depth (ft.)	5.4	8.5	5.4
Pool Width (ft.)	69.0	79.3	78.5

The values presented in Table 1 are the averages of measurements taken through specified features in the project reach. Values for riffle comparisons were obtained from cross section #2 pre-construction, and cross section # 1, 3, and 7 for as-built. Values for pool comparisons were obtained from cross section #1 pre-construction, and cross section # 2, 4 6 and 5 for as-built. The average bankfull channel parameters for the proposed reach design are also shown.

Table 2 displays the bankfull channel measures at each cross section performed during the as-built survey. These values will be used to review trends in channel adjustment at-a-station and through the entire reach. The planned monitoring surveys will assist in evaluating the need for further channel modification and future performance evaluations. The lack of sufficient bankfull identifiers may skew these data and one may expect to see more accurate results in the following years after several large flows have more clearly defined the channel.

Table 2 Brandywine cross section as-built bankfull geometry data.

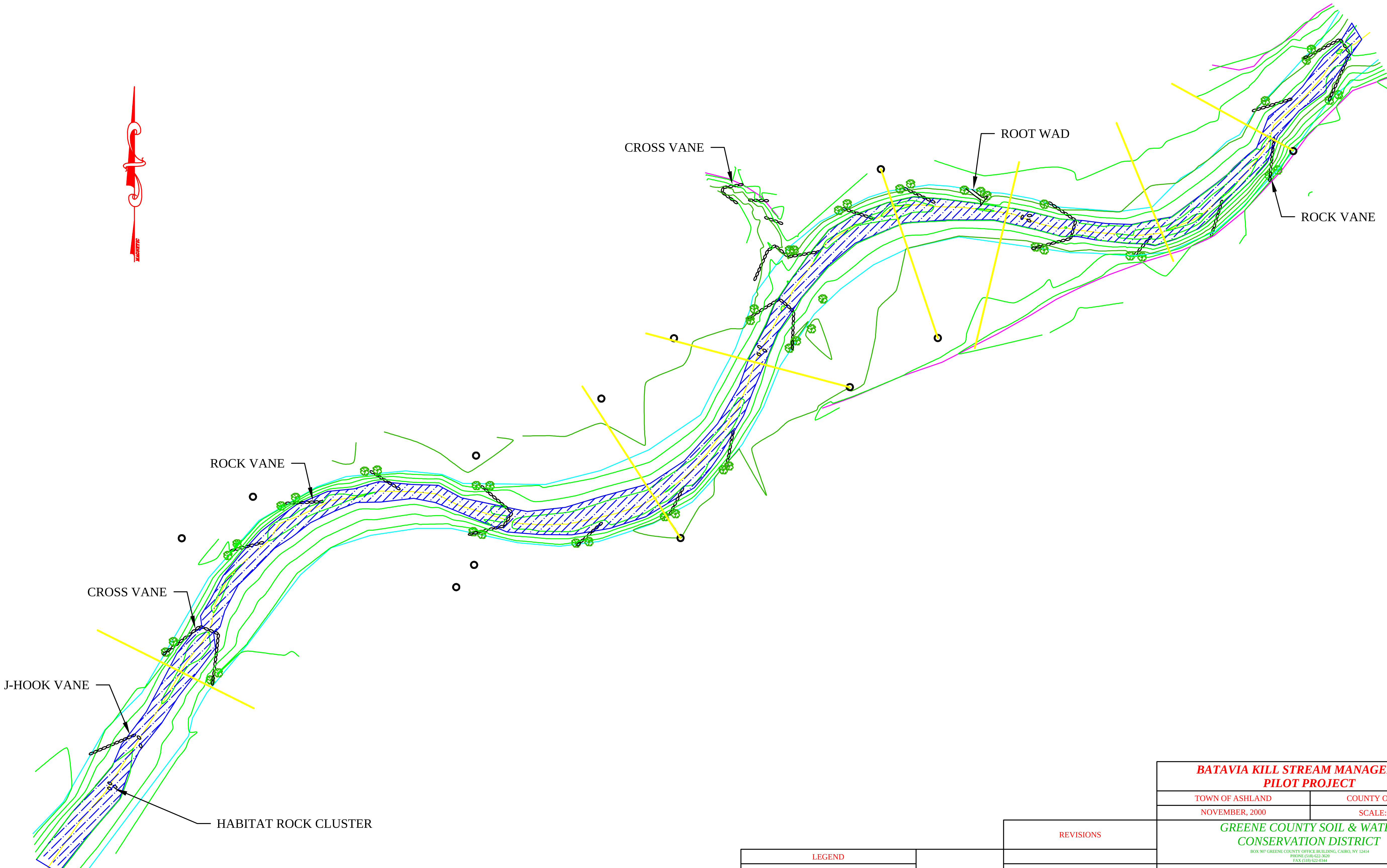
Cross Section	Station	Feature	BF Area	Width	Max Depth	Mean Depth
1	2+95.59	Riffle	171.54	80.45	3.84	2.13
2	5+00.28	Pool	142.88	63.12	4.76	2.26
3	7+20.18	Riffle	229.53	67.16	5.97	3.42
4	8+79.92	Pool	146.19	58.60	4.68	2.49
5	11+77.1	pool	240.77	98.62	4.80	2.44
6	14+18.6	Pool	363.03	93.54	7.30	3.88
7	22+07.53	Riffle	264.49	70.30	5.45	3.76
Average Riffles			221.85	72.64	5.09	3.10
Average Pools			223.22	78.47	5.39	2.77

Longitudinal Profile

Physical channel dimensions were determined through longitudinal profile surveys, which included the sampling of the ground surface at slope breaks along the thalweg of the channel. The profile survey also sampled the water surface and bankfull indicators along the channel. The sampling was tied to the original pre-restoration datum and topographic survey. The profile plot was sampled from a (TIN) surface, created from the post-construction topographic survey of the site.

Summary

The as-built survey data shows that the proposed stream type was built in 1999 and repaired in 2000 and the bankfull parameters met the construction specifications detailed by GCSWCD. The as-built survey was reviewed by GCSWCD staff and the project was documented as-built within acceptable tolerances.



AS-BUILT SURVEY PERFORMED ON SEPTEMBER 2, 1999.

LEGEND	
BANKFULL SURFACE	(cyan line)
WATER SURFACE	(blue line)
STRUCTURE	(chain line)
TRANSPLANT	(symbol)

REVISIONS

BATAVIA KILL STREAM MANAGEMENT PILOT PROJECT

TOWN OF ASHLAND	COUNTY OF GREENE
NOVEMBER, 2000	SCALE: 1" = 60'

GREENE COUNTY SOIL & WATER CONSERVATION DISTRICT

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"BRANDY WINE" STREAM RESTORATION PROJECT

CHECKED BY:	PROJECT #: BSP-98.01
DRAWN BY: DOUG DEKOSKIE	DRAWING #:
SHEET 1 OF 1	PROJECT AS-BUILT SURVEY

F.4 Project Status: Summer 2001 Inspection - Survey

Site Inspection and Monitoring Survey

In August of 2001 the project site was inspected and surveyed by GCSWCD staff in order to review the project status and to document the physical condition and stability of the stream channel. The inspection included a review of the overall stability, rock structures, and riparian vegetation. The monitoring survey included surveying the monumented cross sections and complete longitudinal profile, stream pavement sampling, and a bar sample. A summary of the inspection results and recommendations is provided below. Photographs taken during various site visits in 2001 are included following this appendix.

In stream Structures:

Inspection of the cross vanes revealed no visual damage, erosion, or problems associated with the structures. Minor voids in the vane arms and sills were noted, allowing small volumes of water to penetrate the structures during low flow periods, but do not seem to pose any significant problems with the structural integrity or vane function. Regular deposition along the upstream portions of the vane arms appears normal and the vanes all appear to be functioning properly during various flow stages. The cross vanes appear to be effective at reducing the erosion and scour which potentially would have resulted prior to the installation of the project. The repaired rock vanes seem to be working effectively with no visually apparent structural changes.

Riparian Vegetation:

The bioengineering was installed during the project repair in the fall of 2000 by GCSWCD and a number of volunteers. The vegetation included willow fascines and stakes posts transplants and seedlings. The plants were placed along the streambanks and in the adjacent floodplain areas and conservation grasses were applied with hydro-mulch in all disturbed areas.

The bioengineering and planting's appear to be establishing appropriately despite heavy browsing by deer. It is expected that mild browsing will result in increased generation of plant rooting and subsequent plant top growth once the plants become established. The extent of the browsing should be monitored and mitigated if necessary until the planting become established.

Recommendations include:

- Enhancing bioengineering and riparian planting's as needed.
- Continued monitoring and inspection for signs of willow blight and over browsing.

Channel Stability:

The channel showed no evidence of large-scale deposition (aggradation) or incision (degradation) through the reach. Minor bank erosion was visible on the right bank near station 24+00. Further, no glacial clays were visibly present in the channel bottom.

Visual inspection of the reaches located upstream and downstream of the project area indicates no evidence of significant apparent erosion, deposition, or accelerated lateral migration. The inspections have not shown any visual indication of turbidity in the adjacent reaches.

Recommendations include:

- Continue to monitor erosion along right stream bank at station 24+00.

Project Reach Survey:

A monitoring survey was initiated in August of 2001 to document the annual project status and physical condition of the stream channel. The monitoring included surveying the 7 monumented cross sections and complete longitudinal profile, performing composite pebble counts, and writing a summary of conditions. The dimensions presented represent changes occurring during the monitoring period as well as modifications made during the project modifications and repair in 2000.

Cross Section Survey

At the time of the as-built survey, seven monumented cross sections were installed for use in future detailed monitoring efforts. Cross sections were monumented using capped rebar pins which were located during the topographic survey and were recorded using GPS. Cross sections were stationed at various locations along the channel profile in order to provide monitoring for stream process and stability. The cross sections were installed through various stream features (pools, riffles, etc.) and structures in order to document stream classification, potential erosion and scour, and to document the overall channel stability.

The values presented in Table 1 for the 2001 survey are averages taken from multiple cross sections. Values for riffle comparisons were obtained from cross sections 1, 3, 6 and 7 while values for pool comparisons were obtained from cross sections 2, 4, and 5.

Table 2 represents the measurements taken at the seven sections in the August survey. Also provided are feature specific averages and averages including all sections (pool and riffles).

Table 1 Average bankfull channel dimensions.

Variables	As-Built	2001
Stream Type	C4	C4
Bankfull Width (ft.)	72.6	51.7
Bankfull Mean Depth (ft.)	3.1	1.9
Bankfull Max. Depth (ft.)	5.1	2.9
Bankfull Cross Sectional Area (sq. ft.)	221.9	99.9
Pool Bankfull Cross Sectional Area (sq. ft.)	223.2	143.9
Maximum Pool Depth (ft.)	5.4	4.8
Pool Width (ft.)	78.5	53.2

Table 2 Cross section bankfull channel dimensions Survey 2001.

Cross Section	Station	Feature	BF Area	Width	Max Depth	Mean Depth
1	2+95.59	Riffle	153.95	70.01	3.37	2.20
2	5+00.28	Pool	144.21	55.84	4.71	2.45
3	7+20.18	Riffle	121.51	48.53	3.64	2.50
4	8+79.92	Pool	169.15	58.97	5.11	2.87
5	11+77.41	Pool	118.34	45.57	4.61	2.49
6	14+18.60	Riffle	67.91	44.05	2.48	1.54
7	22+07.53	Riffle	56.04	44.20	2.15	1.27
Average Riffles			99.85	51.70	2.91	1.88
Average Pools			143.90	55.13	4.81	2.60
Reach Average			118.76	53.17	3.72	2.19

Longitudinal Profile

The longitudinal profile survey included the sampling of ground and water surface elevations along the slope breaks of the thalweg. The 2001 survey included a detailed profile beginning and ending at the top and bottom of the project reach. Bankfull elevations were added by reviewing cross sectional data and transposing the bankfulll elevation and station to the longitudinal profile.

The stationing along the thalweg of each channel varies between the two years resulting from the selection of features by the field staff and minor changes in thalweg plan form.

Channel Pattern

Channel alignment changes were analyzed by reviewing the cross sections and lateral alignment of the thalweg of the stream profile. Although minor erosion and deposition were noted through isolated areas of the project reach there appears to be no evidence of unstable lateral migration or plan form change of meander radius, meander length, or sinuosity.

Sediment Characteristics

Pavement samples within the bankfull channel were collected during the survey of the reach. Samples were taken at cross sections(features) and along sections of the channel. The inventory included the sampling at cross section 1(riffle) and 5 (pool) feature. Sampling using a *zig zag* techniques along the channel between cross sections was also performed. Table 3 displays the samples stratified into common percentiles, and classes in millimeters.

Table 3: Common percentiles of sampled sediment

	XS 1	XS 5
D95 =	78	173
D84 =	46	97
D50 =	15.2	49
D35 =	8	34
D15 =	1.4	10.5

F.4 2001 Project Inspection: Photographs and Descriptions

Photograph 1: The first cross vane (background) and rock vane (foreground) of the project site.

Photograph 2: The left bankfull bench at the top of the project site with establishing vegetation.

Photograph 3: A view of the third rock vane

Photograph 4: The confluence of North Settlement Creek and the installed sill.

Photograph 5: An installed rock vane near monitoring cross section 6.

Photograph 6: A functioning cross vane along the second meander

Photograph 7: A structure rock that has rotate off of the vane arm

Photograph 8: A view of the cross vane along the third meander

Photograph 9: A cross vane and the scour pool downstream

Photograph 10: Three functioning rock vanes placed in sequence to protect each other.

Photograph 11: The final cross vane of the site; functioning as designed.

Photograph 12: Establishing willow fascines along a cross vane arm.

Brandywine Stream Restoration Project
Project Inspection— 2001


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Brandywine Stream Restoration Project
Project Inspection— 2001

GREENE COUNTY SOIL & WATER CONSERVATION DISTRICT

NYCDEP STREAM MANAGEMENT PROGRAM

"BRANDYWINE" STREAM RESTORATION PROJECT

2001 MONITORING SURVEY

INDEX OF DRAWINGS

REV	DATE	DESCRIPTION	APP.

REVISIONS

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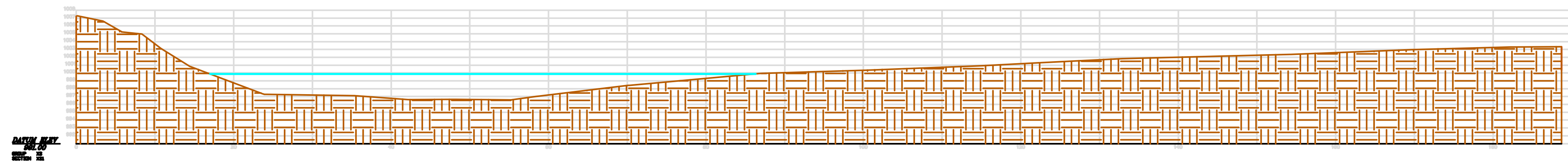
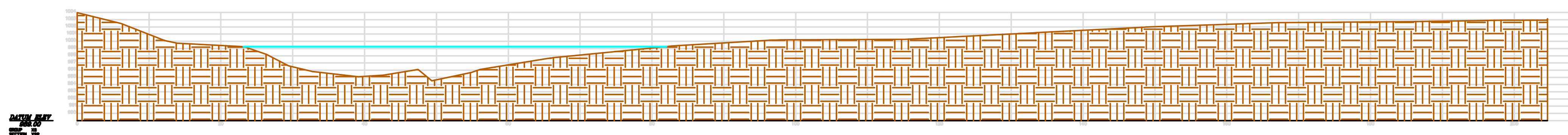
BRANDYWINE
FOR
ACOE
STATE ROUTE 23A
TOWN OF ASHLAND GREENE COUNTY, NY
TITLE SHEET

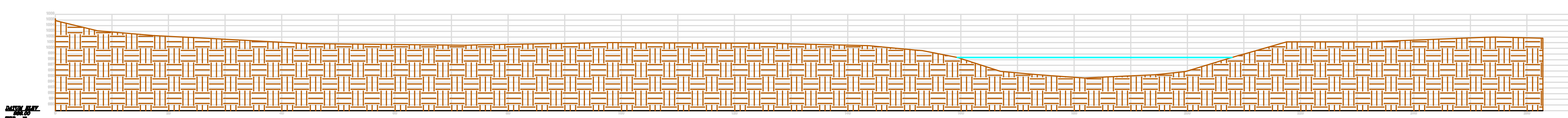
PROJECT:
DATE: 3/10/06
SCALE: AS NOTED
DRAWN BY: JRB/MM
DESIGN BY:

DRAWING: BW-1

SHEET 1 OF 4







REV	DATE	DESCRIPTION	APP.

REVISIONS

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FAX (518) 622-0344

BRANDYWINE

FOR

ACOE

STATE ROUTE 23A

TOWN OF ASHLAND

GREENE COUNTY, NY

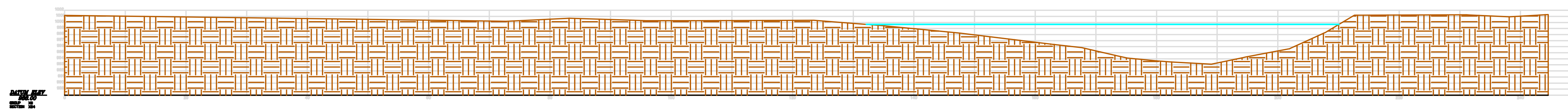
CROSS SECTIONS 1-3

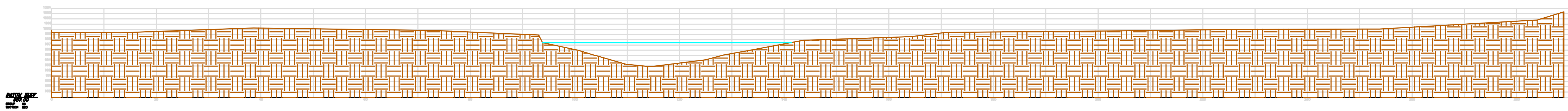
PROJECT:
DATE: 3/10/06
SCALE: 1"=20'
DRAWN BY: JRB/MM
DESIGN BY:

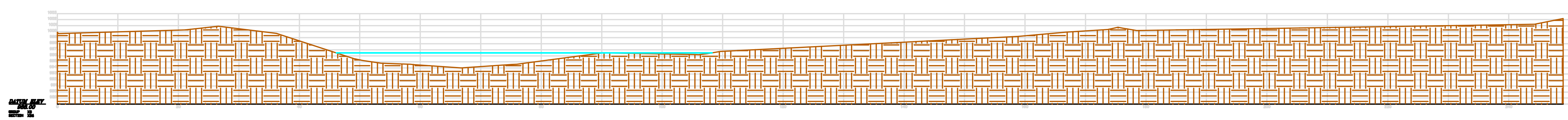
DRAWING:

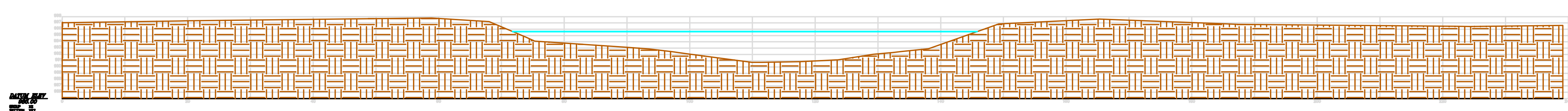
BW-2

SHEET 2 OF 4









REV	DATE	DESCRIPTION	APP.

REVISIONS

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BRANDYWINE

FOR

ACOE

STATE ROUTE 23A

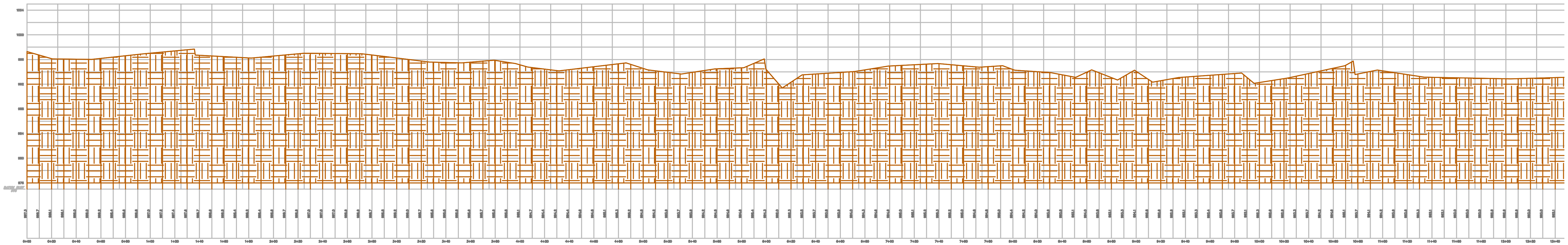
TOWN OF ASHLAND — GREENE COUNTY, NY

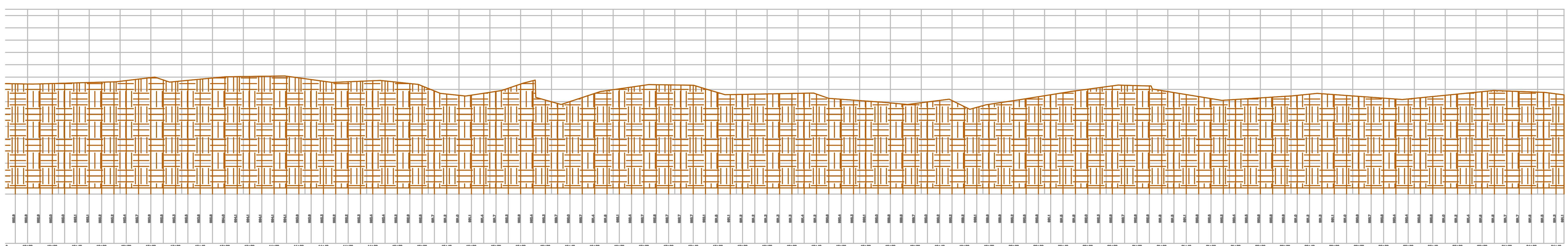
CROSS SECTIONS 4-7

PROJECT:
DATE: 3/10/06
SCALE: 1"=20'
DRAWN BY: JRB/MM
DESIGN BY:

DRAWING: **BW-3**

SHEET 3 OF 4





REV	DATE	DESCRIPTION	APP.

REVISIONS

GREENE COUNTY SOIL & WATER CONSERVATION DISTRICT

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BRANDYWINE
FOR
ACOE
STATE ROUTE 23A

TOWN OF ASHLAND — GREENE COUNTY, NY

CROSS SECTIONS 4-7

PROJECT:
DATE: 3/10/06
SCALE: 1"=20'
DRAWN BY: JRB/MM
DESIGN BY:

DRAWING: **BW-3**

SHEET 3 OF 4

F.5 Project Status: Summer 2002 Inspection - Survey

Site Inspection and Monitoring Survey

In August of 2002 the project site was inspected and surveyed by GCSWCD staff in order to review the project status and to document the physical condition and stability of the stream channel. The inspection included a review of the overall stability, rock structures, and riparian vegetation. The monitoring survey included surveying the monumented cross sections and complete longitudinal profile, performing pebble counts, and a bar sample. A summary of the inspection results and recommendations is provided below. Photographs taken during various site visits in 2002 are included at the end of this appendix.

In stream Structures:

Inspection of the cross vanes revealed no visual damage, erosion, or problems associated with the structures. Minor voids in the vane arms and sills were noted, allowing small volumes of water to penetrate the structures during low flow periods but do not seem to pose any significant problems with the structural integrity or vane function. Regular deposition along the upstream portions of the vane arms appears normal and the vanes all appear to be functioning properly during various flow stages. The cross vanes appear to be effective at reducing the erosion and scour which potentially would have resulted prior to the installation of the project. The repaired rock vanes seem to be working effectively with no visually apparent structural changes.

Riparian Vegetation:

Additional bioengineering was installed during the project repair in the fall of 2000 by GCSWCD and a number of volunteers. The vegetation included willow fascines and stakes posts, transplants and thousands of seedlings. The plants were placed along the streambanks and in the adjacent floodplain areas and conservation grasses were applied with hydro-mulch in all disturbed areas.

The bioengineering and planting's appear to be establishing appropriately despite heavy browsing by deer. It is expected that mild browsing will result in increased generation of plant rooting and subsequent plant top growth once the plants become established. The extent of the browsing should be monitored and mitigated if necessary until the planting become established.

Recommendations include:

- Enhancing bioengineering and riparian planting's as needed.
- Continued monitoring and inspection for signs of willow blight and over browsing.

Channel Stability:

The channel showed no evidence of large-scale deposition (aggradation) or incision (degradation) through the reach. Some stream bank cutting and erosion occurring at station 24+00 (middle meander). It is felt that this erosion is minimal and localized between the two effective rock vanes. Further no glacial clays are visibly present in the channel bottom.

Visual inspection of the reaches located upstream and downstream of the project area indicates no evidence of apparent erosion, deposition, or accelerated lateral migration. The inspections have not shown any visual indication of turbidity in the adjacent reaches.

Recommendations include:

- Evaluate erosion from stream bank at station 24+00.

Project Reach Survey:

A monitoring survey was initiated in August of 2002 to document the annual project status and physical condition of the stream channel. The monitoring included surveying the seven monumented cross sections and complete longitudinal profile, performing composite pebble counts, and a summary of conditions. The dimensions presented represent changes occurring during the monitoring period as well as modifications made during the project modifications and repair in 2000.

Cross Section Survey

At the time of the as-built survey, seven monumented cross sections were installed for use in future detailed monitoring efforts. Cross sections were monumented using capped rebar pins which were located in the topographic survey as well as recorded using GPS. Cross sections were stationed at various locations along the channel profile in order to provide monitoring for stream process and stability. The cross sections were installed through various stream features (pools, riffles, etc.) and structures in order to document stream classification, potential erosion and scour, and to document the overall channel stability.

The values presented in Table 1 for the 2002 survey are averages taken from multiple cross sections. Values for riffle comparisons were obtained from cross sections 1, 3, 6 and 7 while values for pool comparisons were obtained from cross sections 2, 4, and 5.

Table 2 represents the measurements taken at the seven sections during the August survey. Also provided are feature specific averages and averages including all sections (pool and riffles).

Table 1: Cross-section variables and measurements.

Average Bankfull Variables	2000	2001	2002
Stream Type	C4	C4	C4
Cross Sectional Area (ft^2)	221.85	99.85	91.73
Width (ft)	72.64	51.70	49.72
Mean Depth(ft)	3.10	1.88	1.80
Width/Depth	25.36	28.67	29.95
Max Depth (ft)	5.09	2.91	2.82
Max Pool Depth (ft)	5.39	4.81	5.40
Pool Width (ft)	78.47	55.13	65.38

Table 2: Cross sectional dimensions 2002 survey.

Cross Section	Station	Feature	BF Area	Width	Max Depth	Mean Depth	W/D
1	2+95.59	riffle	118.56	58.0969	2.839	2.04	28.47
2	5+00.28	pool	130.44	57.8488	4.0637	2.25	25.66
3	7+20.18	riffle	133.63	51.0233	3.7174	2.62	19.48
4	8+79.92	pool	296.68	86.4661	6.8328	3.43	25.20
5	11+77.41	pool	151.29	51.8195	5.3177	2.92	17.75
6	14+18.60	riffle	46.9	43.4036	2.2772	1.08	40.17
7	22+07.53	riffle	67.84	46.3723	2.4476	1.46	31.70
Average Riffles			91.73	49.72	2.82	1.80	29.95
Average Pools			192.80	65.38	5.40	2.87	22.87
Total Average			135.05	56.43	3.93	2.26	26.92

Longitudinal Profile

The longitudinal profile survey included the sampling of ground and water surface elevations along the slope breaks of the thalweg. The 2002 survey included a detailed profile beginning and ending at the top and bottom of the project reach. Bankfull elevations were added by reviewing cross sectional data and transposing the bankfull elevation and station to the longitudinal profile.

The stationing along the thalweg of each channel varies between the years resulting from the selection of features by the field staff and minor changes in thalweg plan form.

Channel Pattern

Channel alignment changes were analyzed by reviewing the cross sections and lateral alignment of the thalweg of the stream profile. Although minor erosion and deposition were noted through isolated areas of the project reach there appears to be no evidence of unstable lateral migration or plan form change of meander radius, meander length, or sinuosity.

Sediment Characteristics

Pavement samples within the bankfull channel were collected during the survey of the reach. Samples were taken at cross sections(features) and along sections of the channel. The inventory included the sampling at cross section 1(riffle) and 5 (pool) feature. Sampling using a *zig zag* techniques along the channel between cross sections was also performed. Table 3 displays the samples stratified into common percentiles, and classes in millimeters.

Table 3: Sediment samples and common percentiles.

	xs 1	xs 2
D95=	207.97	122.96
D84 =	77.89	99.57
D50 =	45	61.41
D35 =	35.25	51.9
D15=	17.99	33.88

F.5 2002 Project Inspection: Photographs and Descriptions

Photograph 1: A rock vane at the bottom of the last meander on the project site.

Photograph 2: The last cross vane of the project site.

Photograph 3: Receding high flow waters at the bottom of the project site.

Photograph 4: Receding high flow waters at the top of the first meander near adjacent to a farm field

Photograph 5: A functioning cross vane along the second meander

Photograph 6: The confluence of North Settlement Creek over the constructed sill.

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Brandywine Stream Restoration Project
Project Inspection— 2002

GREENE COUNTY SOIL & WATER CONSERVATION DISTRICT

NYCDEP STREAM MANAGEMENT PROGRAM

"BRANDYWINE" STREAM RESTORATION PROJECT

2002 MONITORING SURVEY

INDEX OF DRAWINGS

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2. 2002 MONITORED CROSS SECTIONS
3. 2002 MONITORED CROSS SECTIONS
4. 2002 MONITORED LONGITUDINAL PROFILE

REV	DATE	DESCRIPTION	APP.

REVISIONS

GREENE COUNTY SOIL & WATER CONSERVATION DISTRICT
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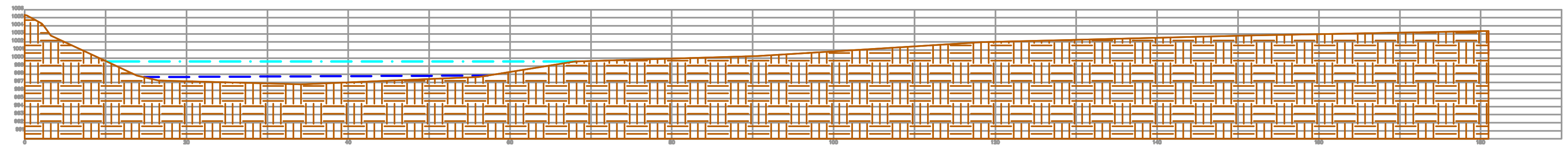
PHONE (518) 622-3620
FAX (518) 622-0344

BRANDYWINE
FOR
ACOE
STATE ROUTE 23A
TOWN OF ASHLAND GREENE COUNTY, NY
TITLE SHEET

PROJECT:
DATE: 3/10/06
SCALE: AS NOTED
DRAWN BY: JRB/MM
DESIGN BY:

DRAWING: BW-1



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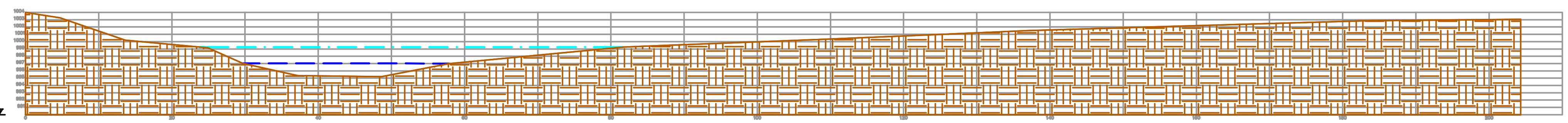
GROUP XS
SECTION 1



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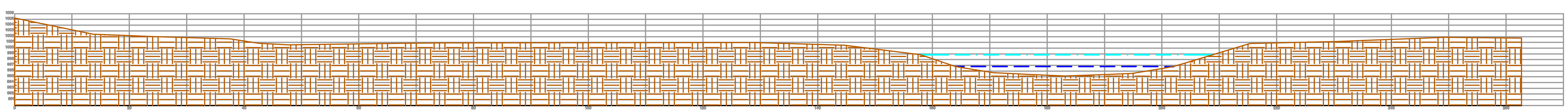

DATUM ELEV.
990.00
GROUP XS
SECTION 3

REV	DATE	DESCRIPTION	APP.

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BRANDYWINE

FOR

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STATE ROUTE 23A

TOWN OF ASHLAND GREENE COUNTY, NY

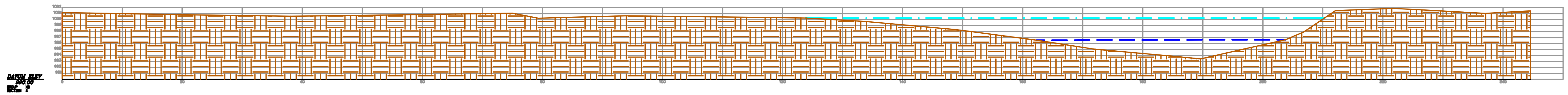
CROSS SECTIONS 1-3

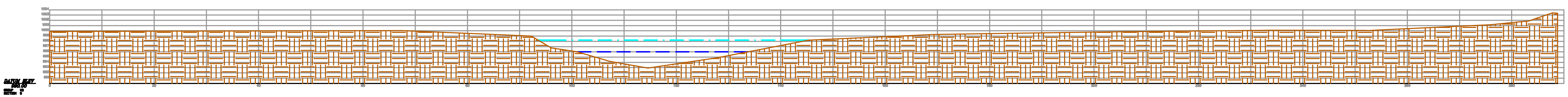
PROJECT:
DATE: 3/10/06
SCALE: AS NOTED
DRAWN BY: JRB/MM
DESIGN BY:

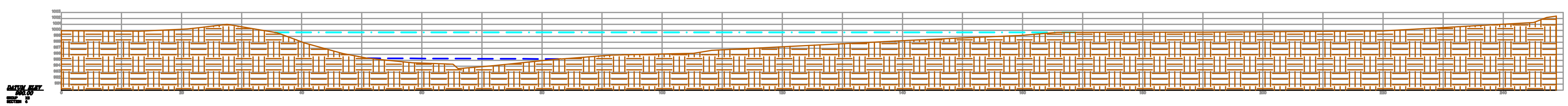
DRAWING:

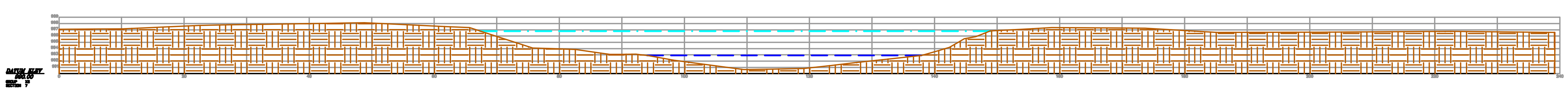
BW-2

SHEET 2 OF 4









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FOR

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STATE ROUTE 23A

TOWN OF ASHLAND — GREENE COUNTY, NY

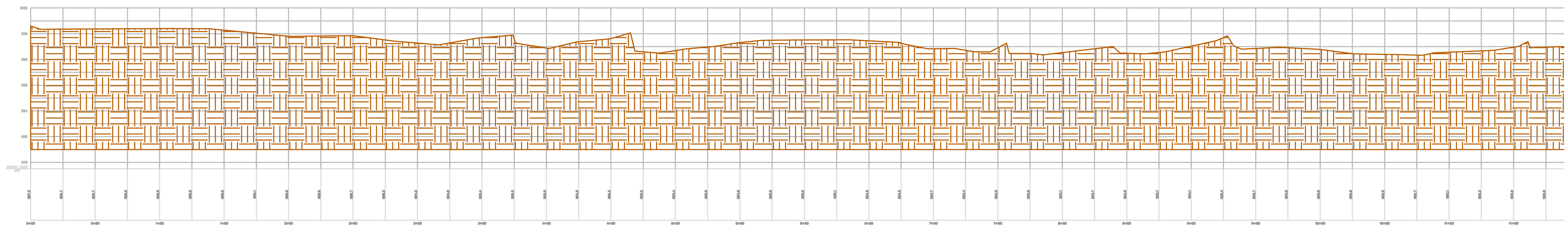
CROSS SECTIONS 4-7

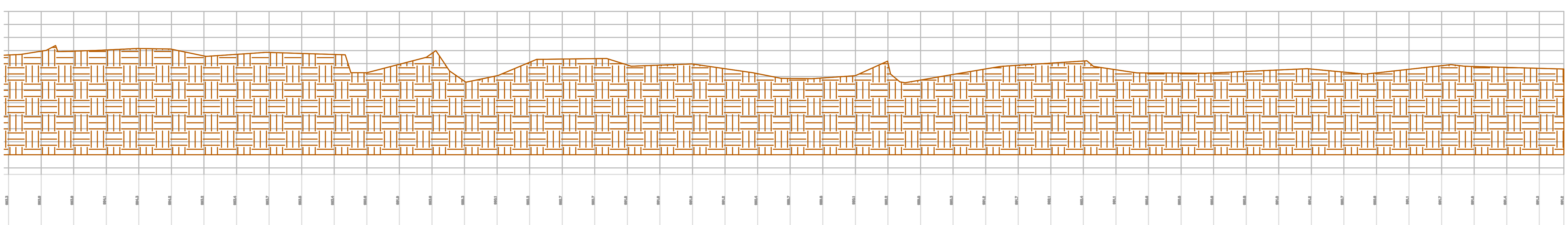
PROJECT:
DATE: 3/10/06
SCALE: AS NOTED
DRAWN BY: JRB/MM
DESIGN BY:

DRAWING:

BW-3

SHEET 3 OF 4





REV	DATE	DESCRIPTION	APP.

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BRANDYWINE
FOR
ACOE
STATE ROUTE 23A
TOWN OF ASHLAND
GREENE COUNTY, NY

PROFILE

PROJECT:
DATE: 3/10/06
SCALE: AS NOTED
DRAWN BY: JRB/MM
DESIGN BY:

DRAWING:
BW-4
SHEET 4 OF 4

F.6 Project Status: Summer 2003 Inspection - Survey

Site Inspection and Monitoring Survey

In August of 2003 the project site was inspected and surveyed by GCSWCD staff in order to review the project status and to document the physical condition and stability of the stream channel. The inspection included a review of the overall stability, rock structures, and riparian vegetation. The monitoring survey included surveying the monumented cross sections and complete longitudinal profile, performing pebble counts, and a bar sample. A summary of the inspection results and recommendations is provided below. Photographs taken during various site visits in 2003 are included at the end of this appendix.

In stream Structures:

Inspection of the cross vanes revealed no visual damage, erosion, or problems associated with the structures. Minor voids in the vane arms and sills were noted, allowing small volumes of water to penetrate the structures during low flow periods, but do not seem to pose any significant problems with the structural integrity or vane function. Three rock vanes have had one large rock rotate off of the structure and settle downstream. These large voids may potentially limit the effectiveness of these structures. Regular deposition along the upstream portions of the vane arms appears normal and the remaining vanes appear to be functioning properly during various flow stages. The cross vanes appear to be effective at reducing the erosion and scour which potentially would have resulted prior to the installation of the project. The repaired rock vanes seem to be working effectively with no visually apparent structural changes.

Recommendations include:

- Continue to monitor rock vanes and determine applicability of repair.

Riparian Vegetation:

Additional bioengineering was installed during the project repair in the fall of 2000 by GCSWCD and a number of volunteers. The vegetation included willow fascines and stakes posts, transplants and thousands of seedlings. The plants were placed along the streambanks and in the adjacent floodplain areas and conservation grasses were applied with hydro-mulch in all disturbed areas.

The bioengineering and planting's appear to be establishing appropriately despite heavy browsing by deer. It is expected that mild browsing will result in increased generation of plant rooting and subsequent plant top growth. The extent of the browsing should be monitored and mitigated if necessary until the planting become established. Further study effort may be needed to determine a strategy to encourage vegetative establishment on sites such as these.

Recommendations include:

- Enhancing bioengineering and riparian planting's as needed.
- Continued monitoring and inspection for signs of willow blight and over browsing.

Channel Stability:

The channel showed no evidence of large-scale deposition (aggradation) or incision (degradation) through the reach. Some stream bank cutting and erosion occurring at station 24+00 (middle meander). It is felt that this erosion is minimal and localized between the two effective rock vanes. Further, no glacial clays are visibly present in the channel bottom.

Visual inspection of the reaches located upstream and downstream of the project area indicates no evidence of apparent erosion, deposition, or accelerated lateral migration. The inspections have not shown any visual indication of turbidity in the adjacent reaches.

Recommendations include:

- Evaluate erosion from stream bank at station 24+00.

Project Reach Survey:

A monitoring survey was initiated in August of 2003 to document the annual project status and physical condition of the stream channel. The monitoring included surveying the seven monumented cross sections and complete longitudinal profile, performing composite pebble counts, and a summary of conditions. The dimensions presented represent changes occurring during the monitoring period as well as modifications made during the project modifications and repair in 2000.

Cross Section Survey

At the time of the as-built survey, seven monumented cross sections were installed for use in future detailed monitoring efforts. Cross sections were monumented using capped rebar pins which were located in the topographic survey as well as recorded using GPS. Cross sections were stationed at various locations along the channel profile in order to provide monitoring for stream process and stability. The cross sections were installed through various stream features (pools, riffles, etc.) and structures in order to document stream classification, potential erosion and scour, and to document the overall channel stability.

The values presented in Table 1 for the 2003 survey are averages taken from multiple cross sections. Values for riffle comparisons were obtained from cross sections 1, 3, 6 and 7 while values for pool comparisons were obtained from cross sections 2, 4, and 5.

Table 2 represents the measurements taken at the seven sections during the August survey. Also provided are feature specific averages and averages including all sections (pool and riffles).

Table 1: Cross-section variables

Average Bankfull Variables	2000	2001	2002	2003
Stream Type	C4	C4	C4	C4
Cross Sectional Area (ft^2)	221.9	99.9	91.7	113.7
Width (ft)	72.6	51.7	49.7	57.9
Mean Depth (ft)	3.1	1.9	1.8	2.0
Width/depth	25.4	28.7	30.0	30.2
Max Depth (ft)	5.1	2.9	2.8	8.3
Max Pool Depth (ft)	5.4	4.8	5.4	4.7
Pool Width (ft)	78.5	55.1	65.4	54.4

Table 2: Cross sectional dimensions 2003 survey

Cross Section	Station	Feature	BF Area	Width	Max Depth	Mean Depth	W/D
1	2+95.59	riffle	134.5	63.8	3.3	2.1	30.2
2	5+00.28	pool	146.9	62.0	4.9	2.4	26.1
3	7+20.18	riffle	125.4	52.4	3.6	2.4	21.9
4	8+79.92	pool	169.7	59.8	5.0	2.8	21.1
5	11+77.41	pool	99.3	41.5	4.2	2.4	17.4
6	14+18.60	riffle	108.4	67.9	3.9	1.6	42.5
7	22+07.53	riffle	86.4	47.5	22.2	1.8	26.1
Average Riffles			113.7	57.9	8.3	2.0	30.2
Average Pools			138.6	54.4	4.7	2.5	21.5
Total Average			124.4	56.4	6.7	2.2	26.5

Longitudinal Profile

The longitudinal profile survey included the sampling of ground and water surface elevations along the slope breaks of the thalweg. The 2003 survey included a detailed profile beginning and ending at the top and bottom of the project reach. Bankfull elevations were added by reviewing cross sectional data and transposing the bankfull elevation and station to the longitudinal profile.

The stationing along the thalweg of each channel varies between the years resulting from the selection of features by the field staff and minor changes in thalweg plan form.

Channel Pattern

Channel alignment changes were analyzed by reviewing the cross sections and lateral alignment of the thalweg of the stream profile. Although minor erosion and deposition were noted through isolated areas of the project reach there appears to be no evidence of unstable lateral migration or plan form change of meander radius, meander length, or sinuosity.

Sediment Characteristics

Pavement samples within the bankfull channel were collected during the survey of the reach. Samples were taken at cross sections(features) and along sections of the channel. The inventory included the sampling at cross section 1(riffle) and 5 (pool) feature. Sampling using a *zig zag* techniques along the channel between cross sections was also performed. Table 3 displays the samples stratified into common percentiles, and classes in millimeters.

Table 3: Sediment samples and common percentiles.

	xs 1	xs 2
D95=	146	175
D84 =	95	121
D50 =	46	65
D35 =	30	48
D15=	1	18

F.6 2003 Project Inspection: Photographs and Descriptions

Photograph 1: The top of the project site with encouraging knotweed on the left bank

Photograph 2: The inside of the first meander with a rock vane in the background.

Photograph 3: The second rock vane of the project and a scour pool that is forming downstream.

Photograph 4:The third rock vane of the project site with vegetated stream banks

Photograph 5: A rock vane near monitoring cross section 4 and a downstream pool.

Photograph 6: A rock vane near monitoring cross section 4 and a downstream pool.

Photograph 7: A rock vane just upstream of North Settlement Creek.

Photograph 8: The pool downstream of monitoring cross section 4 and above the confluence of North Settlement Creek

Photograph 9: A rock vane downstream of monitoring cross section 5.

Photograph 10: Three rock vanes at the top of the third meander.

Photograph 11: The last cross vane on the project site and the downstream scour pool.

Photograph 12: The end of the project site.

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Brandywine Stream Restoration Project
Project Inspection— 2003

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Brandywine Stream Restoration Project
Project Inspection— 2003

GREENE COUNTY SOIL & WATER CONSERVATION DISTRICT

NYCDEP STREAM MANAGEMENT PROGRAM

"BRANDYWINE" STREAM RESTORATION PROJECT

2003 MONITORING SURVEY

INDEX OF DRAWINGS

REV	DATE	DESCRIPTION	APP.

REVISIONS

GREENE COUNTY SOIL & WATER CONSERVATION DISTRICT
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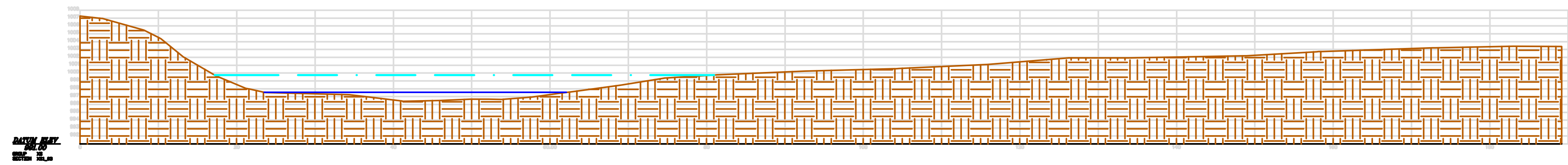
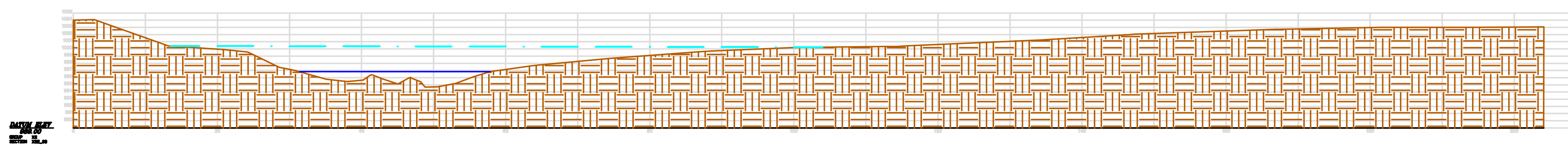
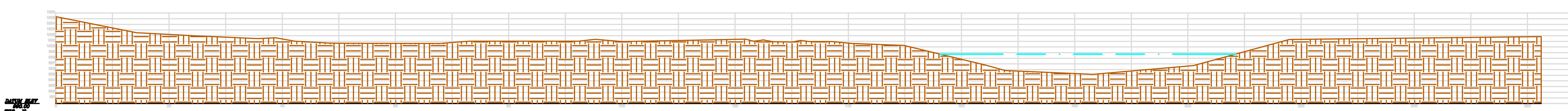
BRANDYWINE
FOR
ACOE
STATE ROUTE 23A
TOWN OF ASHLAND GREENE COUNTY, NY
TITLE SHEET

PROJECT:
DATE: 3/10/06
SCALE: AS NOTED
DRAWN BY: JRB/MM
DESIGN BY:

DRAWING: BW-1







REV	DATE	DESCRIPTION	APP.

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BRANDYWINE

FOR

ACOE

STATE ROUTE 23A

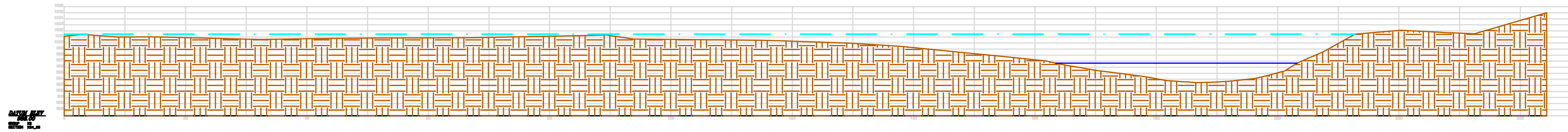
TOWN OF ASHLAND — GREENE COUNTY, NY

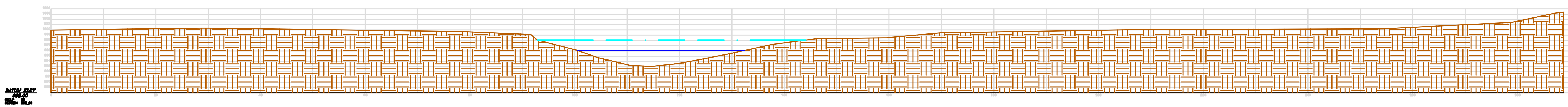
CROSS SECTION 1-3

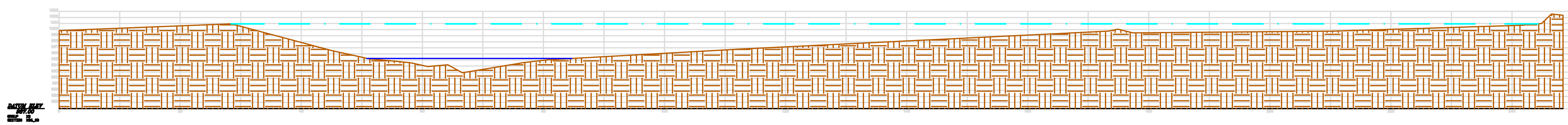
PROJECT:
DATE: 3/14/06
SCALE: 1"=20'
DRAWN BY: JRB/MM
DESIGN BY:

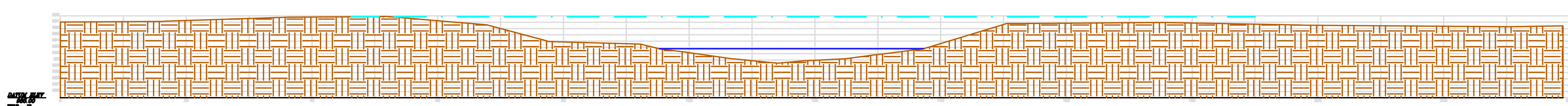
DRAWING: **BW-2**

SHEET 2 OF 4









REV	DATE	DESCRIPTION	APP.

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BRANDYWINE
FOR
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STATE ROUTE 23A

TOWN OF ASHLAND — GREENE COUNTY, NY

TITLE SHEET

PROJECT:
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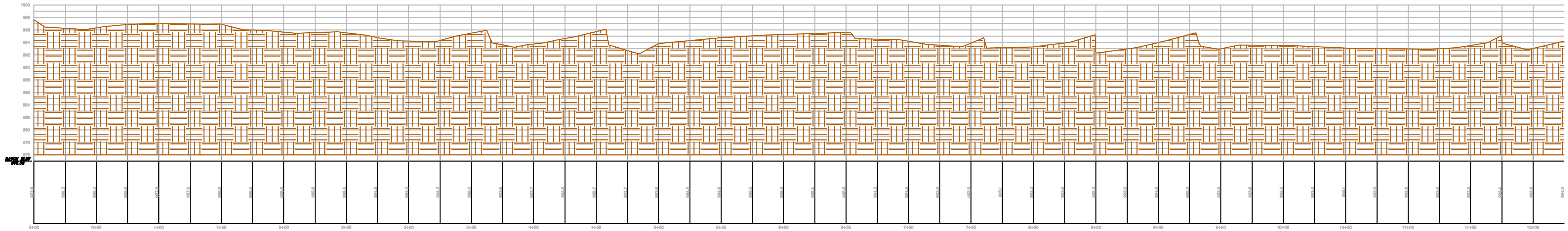
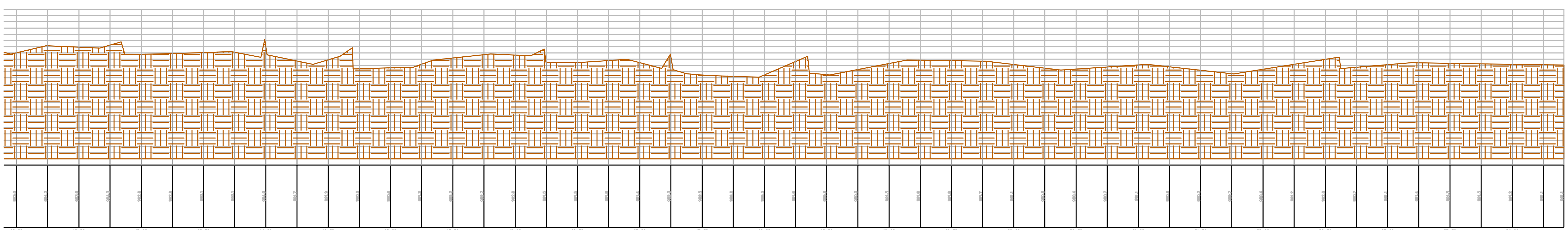
SCALE: 1"=20'
DRAWN BY: JRB/MM
DESIGN BY:

DRAWING: **BW-3**

SHEET 3 OF 4





REV	DATE	DESCRIPTION	APP.

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BRANDYWINE
FOR
ACOE
STATE ROUTE 23A

TOWN OF ASHLAND
GREENE COUNTY, NY

TITLE SHEET

PROJECT:
DATE: 3/14/06
SCALE: AS NOTED
DRAWN BY: JRB/MM
DESIGN BY:

DRAWING:
BW-4
SHEET 4 OF 4

F.7 Project Status: Summer 2004 Inspection - Survey

Site Inspection and Monitoring Survey

In August of 2004 the project site was inspected and surveyed by GCSWCD staff in order to review the project status and to document the physical condition and stability of the stream channel. The inspection included a review of the overall stability, rock structures, and riparian vegetation. The monitoring survey included surveying the monumented cross sections and complete longitudinal profile, performing pebble counts, and a bar sample. A summary of the inspection results and recommendations is provided below. Photographs taken during various site visits in 2004 are included at the end of this appendix.

In stream Structures:

Inspection of the cross vanes revealed no substantial visual damage, erosion, or problems associated with the structures on all but one cross vane. The cross vane at station 15+25 had several large rock rotate off of the structure and settle downstream. Minor voids in the vane arms and sills were noted, allowing small volumes of water to penetrate the structures during low flow periods, but do not seem to pose any significant problems with the structural integrity or vane function. Three rock vanes have had one large rock rotate off of the structure and settle downstream. These large voids may potentially limit the effectiveness of these structures. Regular deposition along the upstream portions of the vane arms appears normal and the remaining vanes appear to be functioning properly during various flow stages. The cross vanes appear to be effective at reducing the erosion and scour which potentially would have resulted prior to the installation of the project. The repaired rock vanes seem to be working effectively with no visually apparent structural changes.

Recommendations include:

- Continue to monitor rock vanes and determine applicability of repair.

Riparian Vegetation:

Additional bioengineering was installed during the project repair in the fall of 2000 by GCSWCD and a number of volunteers. The vegetation included willow fascines and stakes posts, transplants and thousands of seedlings. The plants were placed along the streambanks and in the adjacent floodplain areas and conservation grasses were applied with hydro-mulch in all disturbed areas.

The bioengineering and planting's appear to be establishing appropriately despite heavy browsing by deer. It is expected that mild browsing will result in increased generation of plant rooting and subsequent plant top growth. The extent of the browsing should be monitored and mitigated if necessary until the planting become established. Further study effort may be needed to determine a strategy to encourage vegetative establishment on sites such as these.

Recommendations include:

- Enhancing bioengineering and riparian planting's as needed.
- Continued monitoring and inspection for signs of willow blight and over browsing.

Channel Stability:

The channel showed no evidence of large-scale deposition (aggradation) or incision (degradation) through the reach. Some stream bank cutting and erosion occurring at station 24+00 (middle meander). It is felt that this erosion is minimal and localized between the two effective rock vanes. Further, no glacial clays are visibly present in the channel bottom.

Visual inspection of the reaches located upstream and downstream of the project area indicates no evidence of apparent erosion, deposition, or accelerated lateral migration. The inspections have not shown any visual indication of turbidity in the adjacent reaches.

Recommendations include:

- Evaluate erosion from stream bank at station 24+00.

Project Reach Survey:

A monitoring survey was initiated in August of 2004 to document the annual project status and physical condition of the stream channel. The monitoring included surveying the seven monumented cross sections and complete longitudinal profile, performing composite pebble counts, and a summary of conditions. The dimensions presented represent changes occurring during the monitoring period as well as modifications made during the project modifications and repair in 2000.

Cross Section Survey

At the time of the as-built survey, seven monumented cross sections were installed for use in future detailed monitoring efforts. Cross sections were monumented using capped rebar pins which were located in the topographic survey as well as recorded using G.P.S.. Cross sections were stationed at various locations along the channel profile in order to provide monitoring for stream process and stability. The cross sections were installed through various stream features (pools, riffles, etc.) and structures in order to document stream classification, potential erosion and scour, and to document the overall channel stability.

The values presented in Table 1 for the 2004 survey are averages taken from multiple cross sections. Values for riffle comparisons were obtained from cross sections 1, 3, 6 and 7 while values for pool comparisons were obtained from cross sections 2, 4, and 5.

Table 2 represents the measurements taken at the seven sections during the August survey. Also provided are feature specific averages and averages including all sections (pool and riffles).

Table 1: Cross-section variables.

Average Bankfull Variables	2000	2001	2002	2003	2004
Stream Type	C4	C4	C4	C4	C4
Cross Sectional Area (ft^2)	221.9	99.9	91.7	113.7	116.6
Width (ft)	72.6	51.7	49.7	57.9	55.5
Mean Depth (ft)	3.1	1.9	1.8	2.0	2.1
Width/depth	25.4	28.7	30.0	30.2	26.8
Max Depth (ft)	5.1	2.9	2.8	8.3	3.3
Max Pool Depth (ft)	5.4	4.8	5.4	4.7	5.8
Pool Width (ft)	78.5	55.1	65.4	54.4	74.3

Table 2: Cross sectional dimensions 2004 survey.

Cross Section	Station	Feature	BF Area	Width	Max Depth	Mean Depth	W/d
1	2+95.59	riffle	128.9	58.8	3.3	2.2	26.9
2	5+00.28	pool	174.5	72.3	5.5	2.4	30.0
3	7+20.18	riffle	110.6	46.7	3.3	2.4	19.7
4	8+79.92	pool	262.7	76.6	6.3	3.4	22.3
5	11+77.41	pool	195.4	73.9	5.7	2.6	28.0
6	14+18.60	riffle	123.1	68.9	3.6	1.8	38.6
7	22+07.53	riffle	103.7	47.7	3.1	2.2	22.0
Average Riffles			116.6	55.5	3.3	2.1	26.8
Average Pools			210.8	74.3	5.8	2.8	26.8
Total Average			157.0	63.6	4.4	2.4	26.8

Longitudinal Profile

The longitudinal profile survey included the sampling of ground and water surface elevations along the slope breaks of the thalweg. The 2004 survey included a detailed profile beginning and ending at the top and bottom of the project reach. Bankfull elevations were added by reviewing cross sectional data and transposing the bankfull elevation and station to the longitudinal profile.

The stationing along the thalweg of each channel varies between the years resulting from the selection of features by the field staff and minor changes in thalweg plan form.

Channel Pattern

Channel alignment changes were analyzed by reviewing the cross sections and lateral alignment of the thalweg of the stream profile. Although minor erosion and deposition were noted through isolated areas of the project reach there appears to be no evidence of unstable lateral migration or plan form change of meander radius, meander length, or sinuosity.

Sediment Characteristics

Pavement samples within the bankfull channel were collected during the survey of the reach. Samples were taken at cross sections(features) and along sections of the channel. The inventory included the sampling at cross section 1(riffle) and 5 (pool) feature. Sampling using a zig zag techniques along the channel between cross sections was also performed. Table 3 displays the samples stratified into common percentiles, and classes in millimeters.

Table 3: Sediment samples and common percentiles.

	xs 1	xs 2
D95=	224	163
D84 =	112	114
D50 =	43	55
D35 =	27	31
D15=	6	6

F.7 2004 Project Inspection: Photographs and Descriptions

Photograph 1: The first cross vane of the project site.

Photograph 2: A downstream view from the first rock vane.

Photograph 3: The second cross vane of the project site.

Photograph 4: Vegetated banks near the apex of the second meander

Photograph 5: Encroaching knotweed along the second meander

Photograph 6: The cross vane and sill structure at the confluence of North Settlement Creek.

Photograph 7: The sill structure at the confluence of North Settlement Creek.

Photograph 8: A rock vane near monitoring cross section 5.

Photograph 9: A rock vane at the top of the third meander.

Photograph 10: Bank erosion near station 24+00 downstream from a rock vane

Photograph 11: The last cross vane on the project site.

Photograph 12: The bottom of the project site with minor aggradation along the left bank.

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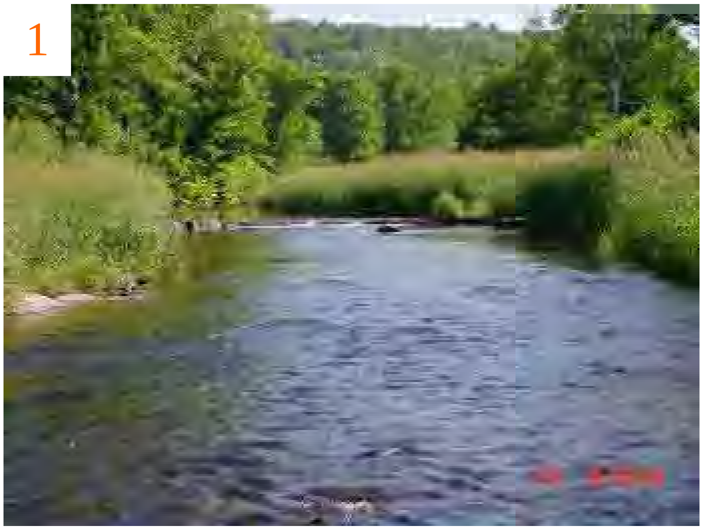

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Brandywine Stream Restoration Project
Project Inspection— 2004


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GREENE COUNTY SOIL & WATER CONSERVATION DISTRICT

NYCDEP STREAM MANAGEMENT PROGRAM

"BRANDYWINE" STREAM RESTORATION PROJECT

2004 MONITORING SURVEY

INDEX OF DRAWINGS

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REVISIONS

GREENE COUNTY SOIL & WATER CONSERVATION DISTRICT

BOX 907 GREENE COUNTY OFFICE BUILDING, CAIRO, NY 12413
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FAX (518) 622-0344

BRANDYWINE
FOR
ACOE
STATE ROUTE 23A
TOWN OF ASHLAND — GREENE COUNTY, NY

TITLE SHEET

PROJECT:
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SCALE: AS NOTED
DRAWN BY: JRB
DESIGN BY:

DRAWING: **BW-1**

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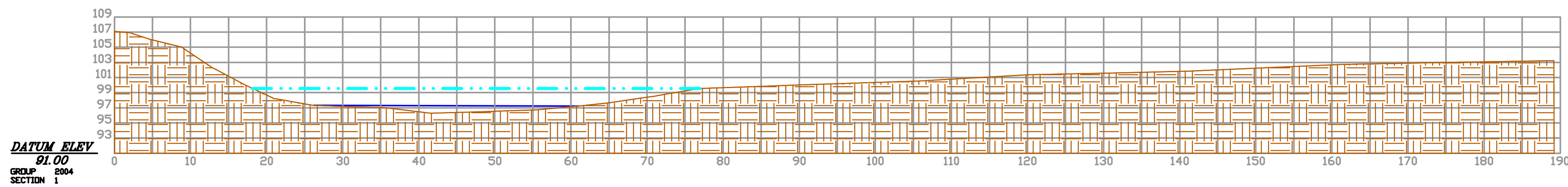

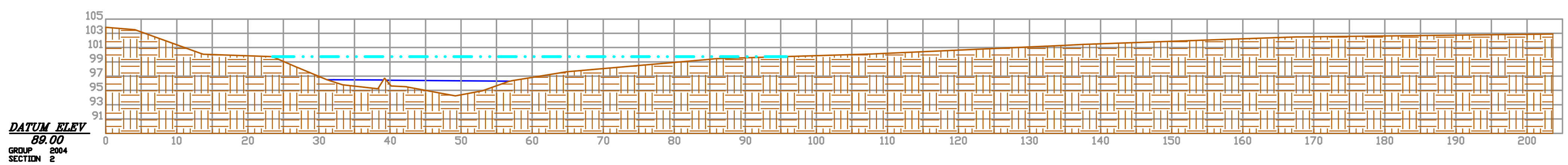

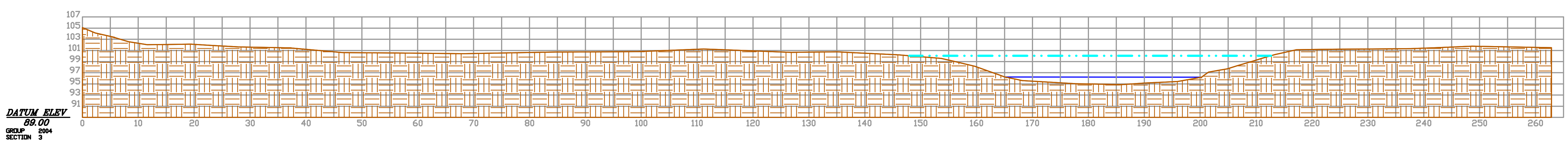

REV	DATE	DESCRIPTION	APP.

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BRANDYWINE
FOR
ACOE
STATE ROUTE 23A

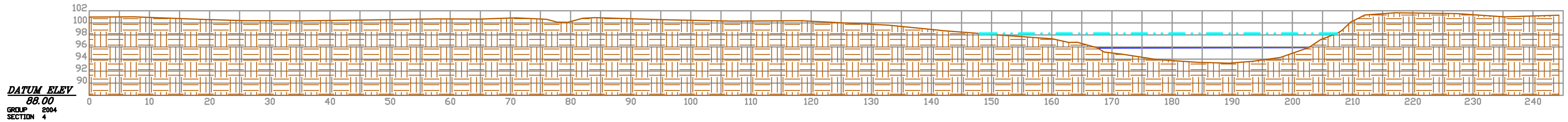
TOWN OF ASHLAND — GREENE COUNTY, NY

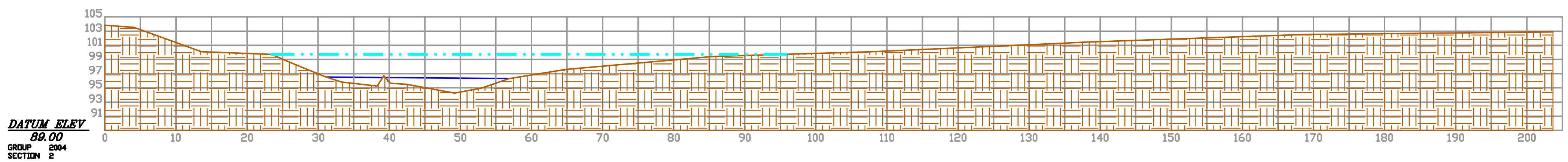
CROSS SECTIONS 1-3

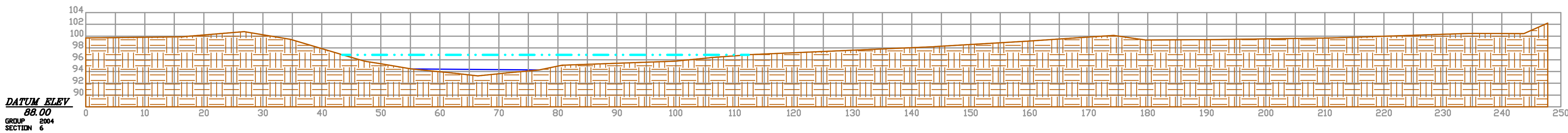
PROJECT:
DATE: 3/10/06
SCALE: 1"=20'
DRAWN BY: JRB/MM
DESIGN BY:

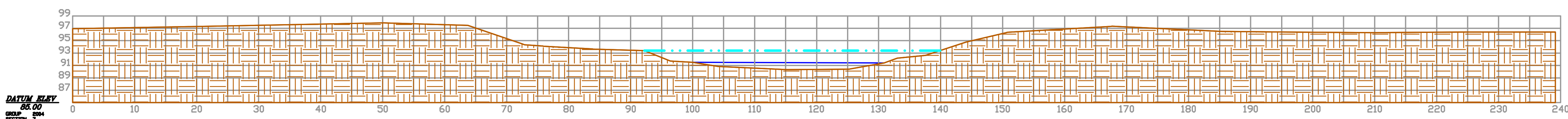
DRAWING: **BW-2**

SHEET 2 OF 4









REV	DATE	DESCRIPTION	APP.

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BRANDYWINE
FOR
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STATE ROUTE 23A

TOWN OF ASHLAND GREENE COUNTY, NY

CROSS SECTION 4-7

PROJECT:
DATE: 3/10/06
SCALE: 1"=20'
DRAWN BY: JRB/MM
DESIGN BY:

DRAWING:
BW-3
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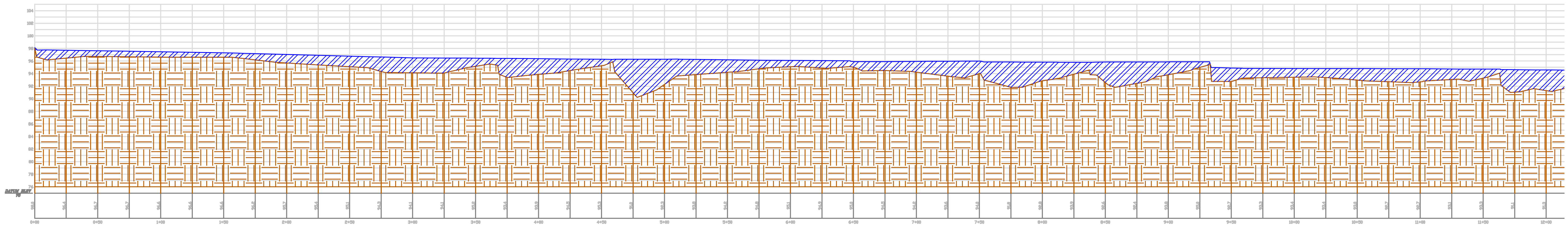

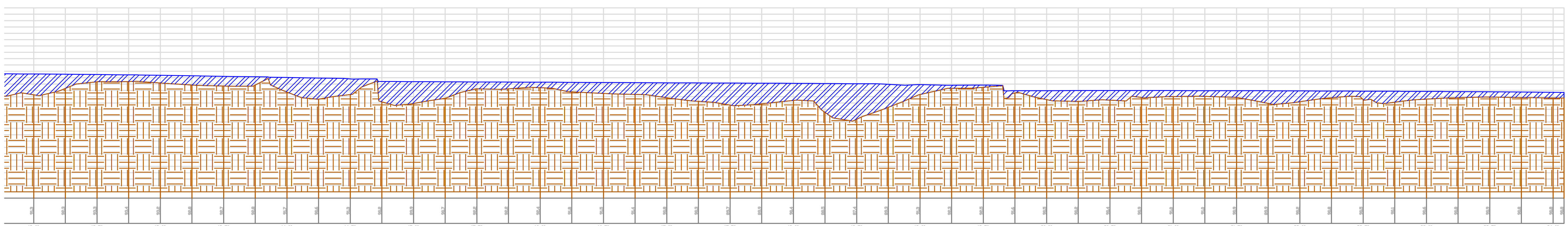

REV	DATE	DESCRIPTION	APP.

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BRANDYWINE
FOR
ACOE
STATE ROUTE 23A
TOWN OF ASHLAND
GREENE COUNTY, NY

PROFILE

PROJECT:
DATE: 3/10/06
SCALE: NTS
DRAWN BY: JRB/MM
DESIGN BY:

DRAWING:
BW-4

SHEET 4 OF 4

F.8 Project Status: Flood Event Inspection (April 21, 2005)

On April 3, 2005, the Batavia Kill watershed experienced several inches of rain on snow resulting in a peak flow through the stream channel exceeding the bankfull flood stage. The peak flow recorded at the USGS Gage Station (#01349950) at Red Falls equaled or exceeded 14,000cfs. The Brandy Wine Restoration Project was inspected several times during and after the flow event to document the flow conditions and project performance. The following written description is a summary of the inspected project components. Attached are images of the site taken after the flood event.

Rock Structures:

Four of the nineteen rock structures experienced continued damage as a result of the flood flow. All four structures originally sustained damage during previous high flow events and have been scheduled for repair/modification for several years. The damaged structures include one cross vane at Station 15+25 and three rock vanes located at Stations 14+00, 18+00, and 19+00.

Previous damage to the cross vane structure includes rotational collapse and movement of top rocks along the left arm and sill. The primary cause of the rotational collapse is attributed to excess scour of the plunge pool immediately downstream of the structure. The scour exceeded the maximum installation depth of the footer rocks, which resulted in a partially collapse into the scour pool area. Several top rocks along the left arm and sill were dislodged during previous flow events and were further displaced during the recent flood event.

Previous damage to the rock vane structures included rotational collapse and movement of top rocks along the vane arm. Problems associated with the structure included undesirable scour in areas where voids occurred between the top and footer rocks. Voids in the structures, larger that the available channel sediment, lead to increased scour caused by the convergence of flow through areas of the structure. Proper deposition of sediment, along the upstream face of the vane arm scoured as a result of the flow concentration through the voids.

Although isolated problems occurred at four of the nineteen structures, the remaining structures appeared to function properly during the flood flow. The cross vanes and rock vanes were effective at reducing the erosion and scour which potentially would have resulted prior to the installation of the project. Grass vegetation remained along the majority of the streambanks to the base water surface elevation.

Channel Stability:

The channel showed no evidence of large-scale deposition (aggradation) or incision (degradation) through the reach. Bank erosion was present in areas surrounding the damaged rock structures and primarily limited to the lower meander bend. Two isolated areas of erosion were noted upstream of the rock vanes near Stations 4+00 and 12+00. It is presumed that the bank erosion would have been partially if not entirely mitigated if the vegetation had been able to establish prior to the increased stresses caused by the flood event.

Fine sand deposition was noted on the outer streambank along the first meander bend as well as along the upstream portions of several rock vane and cross vane arms.

Riparian Vegetation:

The installed vegetation included willow fascines and stakes, which were placed along the streambanks and in the adjacent floodplain areas, as well as conservation grass which was applied with hay mulch. Various bare-root stock was planted in the floodplain in the summer of 2000.

Establishment of vegetation appears poor considering the amount and density of the installed material. It is felt that the lack of established vegetation exacerbated the damage through the project site. It is presumed that if the vegetation had become more established the damages would have been limited and in some areas avoided.

Large stands of Japanese knotweed have re-colonized in the floodplain and along the streambank in the project area. Maintenance and/or methods of eradication should be initiated in the project area to guarantee the success of the planted vegetation.

Recommendations and proposed repair/modification:

- Monitoring of the entire site should be completed prior to the initiation of any modification or repair. Additionally, the monitoring should be completed again immediately after the modification/repair is completed.
- Monitoring of the site should include surveying all monumented cross sections, flood stage profile through the entire site, as well as a composite pebble count. Thought should be given to surveying a longitudinal profile along the channel invert to document pool depth and possible local scour and deposition. Also to document feature slopes and max depths, as well as lengths/spacing as compared to design.
- Repair to the project site should follow recommendations outlined in the previous permit applications and include:
- Rebuilding the damaged rock vanes (Stations 14+00, 18+00, and 19+00) to include updated design dimensions for slope and interior acute angle.
- Rebuilding portions of the damaged cross vane (Station 15+25) to include the left arm and sill. To prevent the problem of increased scour below the structures it is proposed that the top sill rocks be shifted to sit upstream, instead of being placed directly on top of the footer rock. The placement will also reduce the rotational moment of the top sill rock and provide for a more "cascade-like" entrance over the lip into the pool behind the structures. This modification will deviate from the sharp plunge pool that was originally built. Further this modification will assist in limiting the scour depth near the footer rocks by dissipating energy away from the foundation of the rock structures. The sill and footer rock construction should include a minimum batter of 3:1.
- Extending the bank key of the cross vane located at the confluence with North Settlement Creek.

- Rocks must abut one another and should contain minimal void space between the rocks. Cobble fill should be used along the upstream side of the vane arm and bank key. The vane arms should be rebuilt to ¾ bankfull elevation.

- Re-grade banks, seed, and vegetate all exposed areas after completion of project repair/modifications. An attempt should be made to harvest native sod matting from the floodplain area downstream from the final meander bend. The sod mat should be applied to critical areas surrounding the repaired vane structures, and be installed between the base water surface and bankfull elevations. Sod harvest areas should be reseeded and mulched following sod removal.

- Bioengineering should be reinstalled along all outer bank areas and other defined high stress areas.

F.8 2005 Project Inspection: Photographs and Descriptions

Photos taken April 5th

Photograph 1: Confluence of Mitchell hollow tributary and the Batavia Kill.

Photograph 2: Upstream from Mitchell hollow confluence.

Photograph 3: Downstream from Mitchell hollow confluence.

Photograph 4: Channel erosion along the right bank.

Photograph 5: Upstream from existing cross vane representing stable channel.

Photograph 6: Bank stability from planted willow fascine.

Photograph 7: Downstream channel with minor bank erosion.

Photograph 8: Channel erosion along right bank of outside meander.

Photograph 9: Downstream channel with minor erosion along the right bank.

Photograph 10: Upstream channel with minor erosion along the right bank.

Photos taken April 8th

Photograph 1a. Sta. 1+25 Upstream cross vane in stable condition.

Photograph 2a. Sta. 1+25 Downstream stable channel.

Photograph 3a. Sta. 4+00 Downstream channel erosion on left bank.

Photograph 4a. Sta. 6+00 Downstream channel in stable condition.

Photograph 5a. Sta. 10+25 Confluence of Mitchell hollow tributary and the Batavia Kill.

Photograph 6a. Sta. 10+25 Upstream sediment deposition on bar.

Photograph 7a. Sta. 12+50 Bank erosion upstream from rock vane.

Photograph 8a. Sta. 14+00 Erosion with missing rocks within cross vane structure.

Photograph 9a. Sta. 14+00 Missing rocks within cross vane structure.

Photograph 10a. Sta. 19+00 Upstream damaged rock vane.

Photograph 11a. Sta. 20+00 Downstream stable cross vane.

BATAVIA KILL RESTORATION PROJECT
BRANDYWINE STORM ASSESSMENT
APRIL 2-3, 2005

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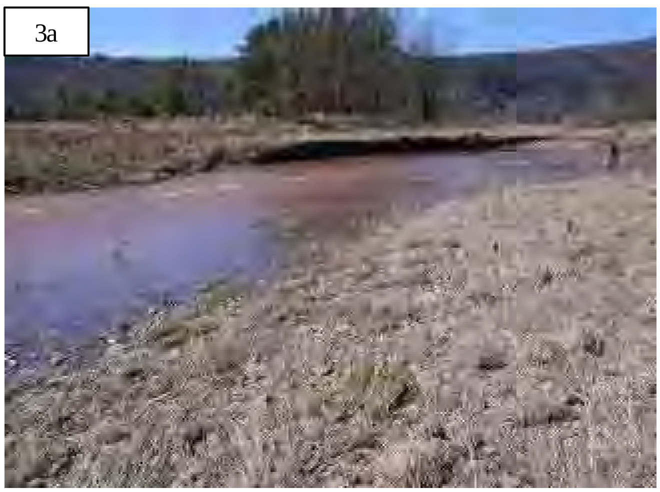
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F.9 Project Status: Summer 2005 Inspection - Survey

Site Inspection and Monitoring Survey

In August of 2005 the project site was inspected and surveyed by GCSWCD staff in order to review the project status and to document the physical condition and stability of the stream channel. The inspection included a review of the overall stability, rock structures, and riparian vegetation. The monitoring survey included surveying the monumented cross sections and complete longitudinal profile, performing pebble counts, and a bar sample. A summary of the inspection results and recommendations is provided below. Photographs taken during various site visits in 2005 are included at the end of this appendix.

In stream Structures:

Please refer to Appendix F.8 for a description of in stream structures.

Riparian Vegetation:

Please refer to Appendix F.8 for a description of riparian vegetation.

Channel Stability:

Please refer to Appendix F.8 for a description of channel stability.

Project Reach Survey:

A monitoring survey was initiated in August of 2005 to document the annual project status and physical condition of the stream channel. The monitoring included surveying the seven monumented cross sections and complete longitudinal profile, performing composite pebble counts, and a summary of conditions. The dimensions presented represent changes occurring during the monitoring period as well as modifications made during the project modifications and repair in 2000.

Cross Section Survey

At the time of the as-built survey, seven monumented cross sections were installed for use in future detailed monitoring efforts. Cross sections were monumented using capped rebar pins which were located in the topographic survey as well as recorded using G.P.S.. Cross sections were stationed at various locations along the channel profile in order to provide monitoring for stream process and stability. The cross sections were installed through various stream features (pools, riffles, etc.) and structures in order to document stream classification, potential erosion and scour, and to document the overall channel stability.

The values presented in Table 1 for the 2005 survey are averages taken from multiple cross sections. Values for riffle comparisons were obtained from cross sections 1, 3, and 7 while values for pool comparisons were obtained from cross sections 2, 4, 5 and 6.

Table 2 represents the measurements taken at the seven sections during the August survey. Also provided are feature specific averages and averages including all sections (pool and riffles). Large differences between values may be attributed to the large flow event that occurred in April 2005. This flow event not only potentially changed the channel dimensions but also altered evidence of the bankfull elevation. This caused difficulties with the identification of bankfull, potentially skewing these results. A standard system is currently being developed to take this bias out of these measurements.

Table 1: Cross-section variables

Average Bankfull Variables	2000	2001	2002	2003	2004	2005
Stream Type	C4	C4	C4	C4	C4	C4
Cross Sectional Area (ft^2)	221.9	99.9	91.7	113.7	116.6	278.4
Width (ft)	72.6	51.7	49.7	57.9	55.5	86.0
Mean Depth (ft)	3.1	1.9	1.8	2.0	2.1	3.3
Width/depth	25.4	28.7	30.0	30.2	26.8	27.2
Max Depth (ft)	5.1	2.9	2.8	8.3	3.3	5.4
Max Pool Depth (ft)	5.4	4.8	5.4	4.7	5.8	5.7
Pool Width (ft)	78.5	55.1	65.4	54.4	74.3	91.0

Table 2: Cross sectional dimensions 2005 survey

Cross Section	Station	Feature	BF Area	Width	Max Depth	Mean Depth	W/d
1	2+95.59	riffle	308.1	110.5	4.8	2.8	39.6
2	5+00.28	pool	145.1	60.9	4.2	2.4	25.6
3	7+20.18	riffle	196.2	64.4	4.6	3.1	21.1
4	8+79.92	pool	376.3	118.1	7.5	3.2	37.1
5	11+77.41	pool	267.1	86.8	4.7	3.1	28.2
6	14+18.60	pool	361.4	98.0	6.5	3.7	26.6
7	22+07.53	riffle	330.8	83.1	6.9	4.0	20.9
Average Riffles			278.4	86.0	5.4	3.3	27.2
Average Pools			287.5	91.0	5.7	3.1	29.4
Total Average			283.6	88.8	5.6	3.2	28.4

Longitudinal Profile

The longitudinal profile survey included the sampling of ground and water surface elevations along the slope breaks of the thalweg. The 2005 survey included a detailed profile beginning and ending at the top and bottom of the project reach. Bankfull elevations were added by reviewing cross sectional data and transposing the bankfull elevation and station to the longitudinal profile.

The stationing along the thalweg of each channel varies between the years resulting from the selection of features by the field staff and minor changes in thalweg plan form.

Channel Pattern

Channel alignment changes were analyzed by reviewing the cross sections and lateral alignment of the thalweg of the stream profile. Although minor erosion and deposition were noted through isolated areas of the project reach there appears to be no evidence of unstable lateral migration or plan form change of meander radius, meander length, or sinuosity.

Sediment Characteristics

Pavement samples within the bankfull channel were collected during the survey of the reach. Samples were taken at cross sections(features) and along sections of the channel. The inventory included the sampling at cross section 1(riffle) and 5 (pool) feature. Sampling using a zig zag techniques along the channel between cross sections was also performed. Table 3 displays the samples stratified into common percentiles, and classes in millimeters.

Table 3: Sediment samples and common percentiles

	xs 1	xs 5
D95=	123	109
D84 =	61	61
D50 =	28	27
D35 =	15	13
D15=	0	4

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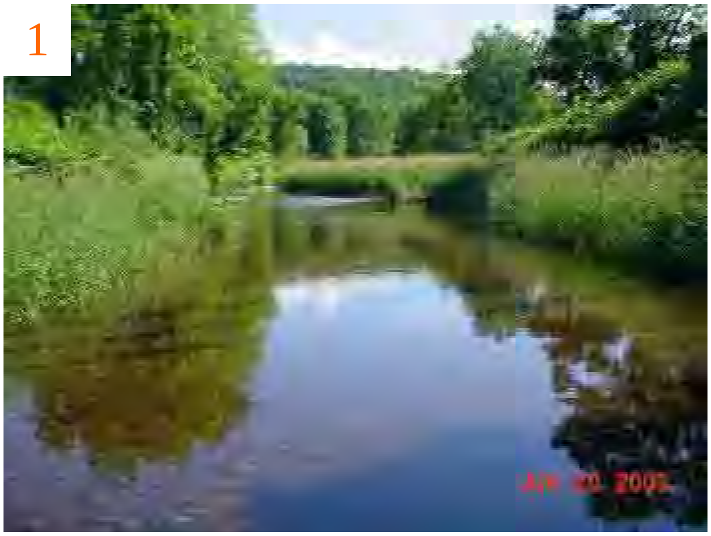

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Brandywine Stream Restoration Project
Project Inspection— 2005

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GREENE COUNTY SOIL & WATER CONSERVATION DISTRICT

NYCDEP STREAM MANAGEMENT PROGRAM

"BRANDYWINE" STREAM RESTORATION PROJECT

2005 MONITORING SURVEY

INDEX OF DRAWINGS

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2. 2005 MONITORED CROSS SECTIONS
3. 2005 MONITORED CROSS SECTIONS
4. 2005 MONITORED LONGITUDINAL PROFILE

REV	DATE	DESCRIPTION	APP.

REVISIONS

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BRANDYWINE
FOR
ACOE
STATE ROUTE 23A
TOWN OF ASHLAND GREENE COUNTY, NY
TITLE SHEET

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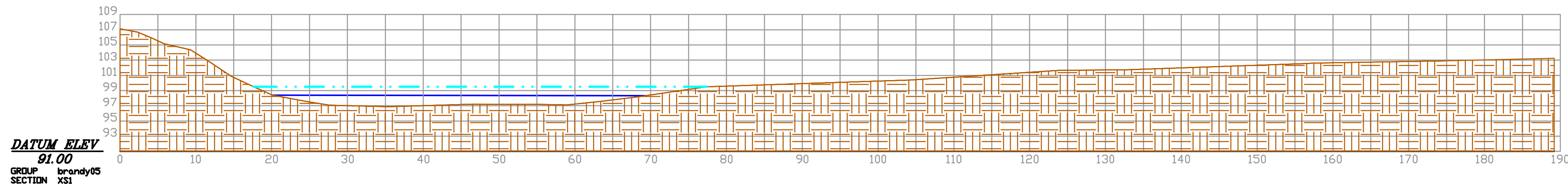
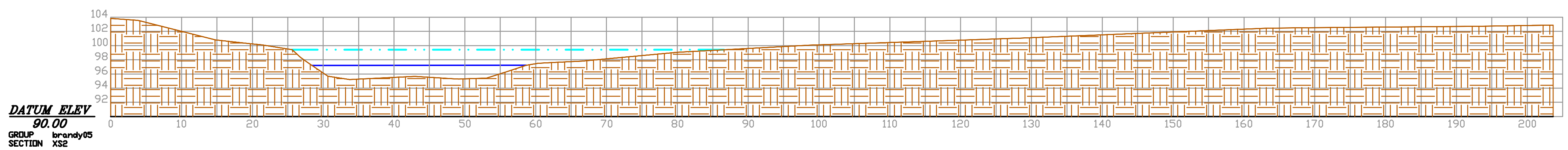
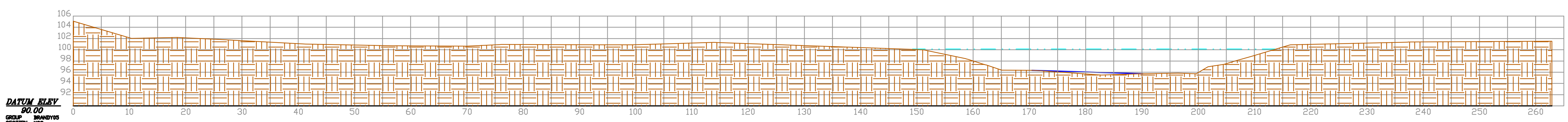
SCALE: AS NOTED
DRAWN BY: JRB/MM
DESIGN BY:

DRAWING: BW-1

SHEET 1 OF 4







REV	DATE	DESCRIPTION	APP.

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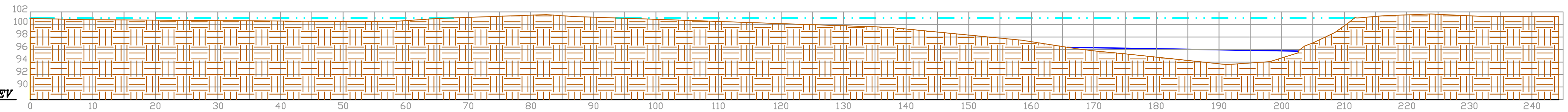
BRANDYWINE
FOR
ACOE
STATE ROUTE 23A
TOWN OF ASHLAND GREENE COUNTY, NY

CROSS SECTION 1-3

PROJECT:
DATE: 3/14/06
SCALE: AS NOTED
DRAWN BY: JRB/MM
DESIGN BY:

DRAWING:
BW-2
SHEET 2 OF 4



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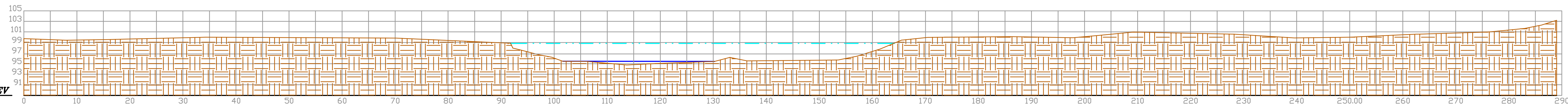

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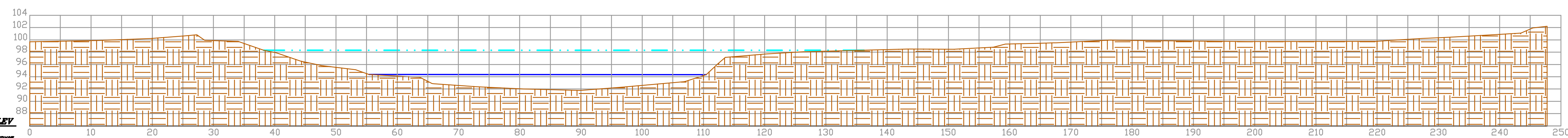

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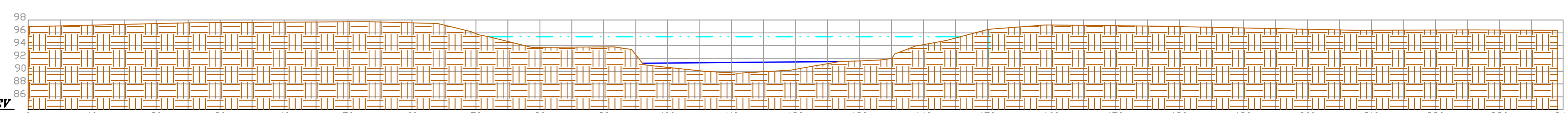

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SECTION XS7

REV	DATE	DESCRIPTION	APP.

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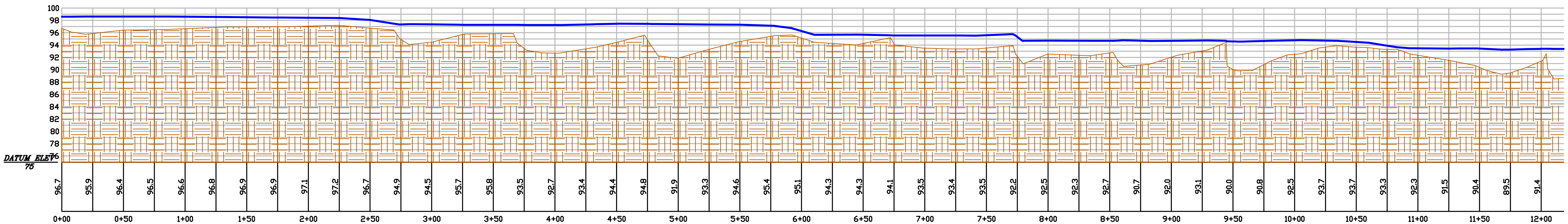
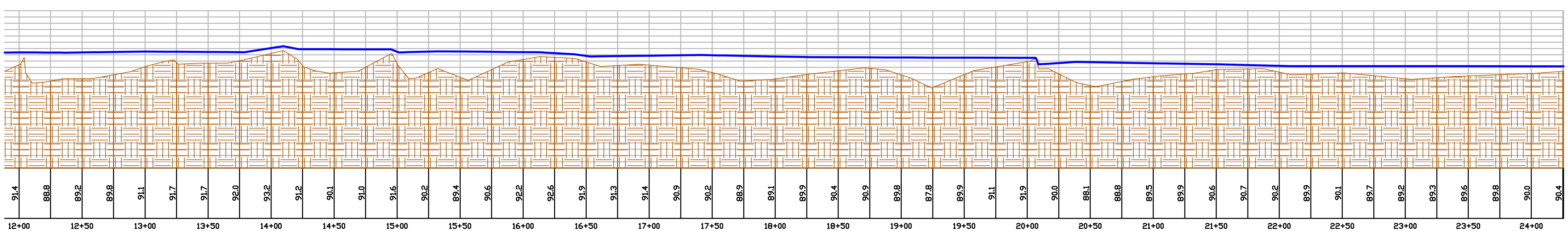
BRANDYWINE
FOR
ACOE
STATE ROUTE 23A
TOWN OF ASHLAND GREENE COUNTY, NY

CROSS SECTION 4-7

PROJECT:
DATE: 3/14/06
SCALE: AS NOTED
DRAWN BY: JRB/MM
DESIGN BY:

DRAWING:
BW-3
SHEET 3 OF 4





REV	DATE	DESCRIPTION	APP.

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BRANDYWINE
FOR
ACOE
STATE ROUTE 23A
TOWN OF ASHLAND GREENE COUNTY, NY
PROFILE

PROJECT:
DATE: 3/14/06
SCALE: AS NOTED
DRAWN BY: JRB/MM
DESIGN BY:

DRAWING: **BW-4**

SHEET 4 OF 4

F.10 Project Status: 2007 Inspection - Survey

Site Inspection and Monitoring Survey

In November of 2007 the project site was inspected and surveyed by GCSWCD staff in order to review the project status and to document the physical condition and stability of the stream channel. The inspection included a review of the overall stability, rock structures, and riparian vegetation. The monitoring survey included surveying the seven monumented cross sections and the complete longitudinal profile, performing pebble counts and a bar sample. A summary of the inspection results and recommendations is provided below.

Rock Structures:

Four of the nineteen rock structures remain damaged from previous flood flows. The damaged structures include one cross vane and three rock vanes. The damage to these structures includes rotational collapse and movement of top rocks along the vane arm. The primary cause for these failures was excess scour leading to collapse.

The remaining structures appear to be functioning properly during bankfull flows. Vegetation has established in the soil deposited on the tops of many of these structures. It is felt that vegetation growth in the regions where the structures tie into the floodplains should assist in dissipating energy during high flows, resulting in a decrease in the potential for damage to the structures.

Recommendations include:

- Continue monitoring structures for additional damage

Riparian Vegetation:

The installed vegetation included willow fascines and stakes which were placed along the streambanks and in the adjacent floodplain areas, as well as conservation grass which as applied with hay mulch. Various bare-root stock was planted in the floodplain in the summer of 2000.

The vegetation on the site appears to be well established in some areas and poorly established in others. Only a few willow fascines and stakes show signs that they are experiencing new growth, and the majority have died completely. Grasses and herbaceous plants are growing densely in some areas but have not populated the entire site.

Substantial amounts of Japanese Knotweed are present in the riparian areas of the project reach. Knotweed is an invasive species which can have negative impacts on the native riparian vegetation. The New York City Department of Environmental Protection is attempting to determine a method for controlling the growth and spread of knotweed. However, at present there is no simple way to eliminate knotweed from the site. The extent to which the knotweed spreads should be monitored to ensure it does not overwhelm existing native vegetation.

Recommendations include:

- Enhancing biodiversity of native plant species through follow up shrub and tree plantings
- Continued monitoring of Japanese knotweed
- Remediation of Japanese knotweed if a feasible method is discovered

Channel Stability:

The channel showed no evidence of large-scale deposition (aggradation) or incision (degradation) through the reach. Bank erosion was present in areas surrounding damaged structures and is primarily limited to the lower portion of the meander bends. Bank erosion is prevalent behind several vane arms. There is also substantial bank erosion present along stretches of the third and fourth (final) meander bends.

Fine sand deposition has been noted on the majority of the point bars in the project reach as well as along the upstream portions of many rock and cross vane arms.

Visual inspection of the reaches located upstream and downstream of the project area indicates no apparent evidence of erosion, deposition, or accelerated lateral migration. The inspections have not shown any visual indication of turbidity in the adjacent reaches.

Recommendations include:

- Evaluate erosion upstream of vane arms
- Evaluate erosion along outside bank of third and fourth meander bends

Project Reach Survey:

A monitoring survey was initiated in November of 2007 to document the annual project status and physical condition of the stream channel. The monitoring included surveying the seven monumented cross sections and the complete longitudinal profile, performing composite pebble counts, bar sample, and a summary of conditions.

Cross Section Survey

At the time of the as-built survey, seven monumented cross sections were installed for use in future detailed monitoring efforts. Cross sections were monumented using capped rebar pins which are located in the topographic survey as well as recorded using GPS. Cross sections were stationed at various locations along the channel profile in order to provide monitoring for stream process and stability. The cross sections were installed through various stream features (pools, riffles, etc.) and structures in order to document stream classification, potential erosion and scour, and to document the overall channel stability. A summary of cross sectional data is presented in Table 1.

Table 1: Summary of bankfull cross section dimensions, November 2007.

Cross Section	Feature	Area (ft.)	Width (ft.)	Max. Depth (ft.)	Mean Depth (ft.)
1	Riffle	206.10	93.16	3.82	2.21
2	Pool	123.23	54.59	3.82	2.26
3	Riffle	194.98	58.29	5.04	3.34
4	Pool	290.76	74.82	6.76	3.89
5	Pool	217.13	68.46	4.70	3.17
6	Pool	491.06	111.24	9.95	4.41
7	Riffle	428.51	105.14	6.31	4.08
Average Riffles		276.53	85.53	5.06	3.21
Average Pools		280.55	77.28	6.31	3.43
Reach Average		278.82	80.81	5.77	3.34

The values presented in Table 2 are averages taken from multiple cross sections. Values for riffle comparisons were obtained from cross sections 1, 3 and 5 while values for pool comparisons were obtained from cross sections 2, 4, and 6.

Table 2: Summary of bankfull cross sectional measurements.

Variable	Survey 2000	Survey 2001	Survey 2002	Survey 2003	Survey 2004	Survey 2005	Survey 2007
Stream Type	C4	C4	C4	C4	C4	C4	C4
Area (ft^2)	221.9	99.9	91.7	113.7	116.6	278.4	276.5
Width (ft)	72.6	51.7	49.7	57.9	55.5	86.0	85.5
Mean Depth (ft)	3.1	1.9	1.8	2.0	2.1	3.3	3.2
Width/Depth	25.4	28.7	30.0	30.2	26.8	27.2	28.4
Max Depth (ft)	5.1	2.9	2.8	8.3	3.3	5.4	5.1
Max Pool Depth (ft)	5.4	4.8	5.4	4.7	5.8	5.7	6.3
Pool Width (ft)	78.5	55.1	65.4	54.4	74.3	91.0	77.3

Longitudinal Profile

The longitudinal profile survey included the sampling of bankfull, ground, and water surface elevations along the slope breaks of the thalweg. The 2007 survey included a detailed profile beginning and ending at the top and bottom of the project reach. The stationing along the thalweg of the channel varies between years as a result of the selection of features by field staff and minor changes in thalweg plan form.

Channel Pattern

Channel alignment changes were analyzed by reviewing the cross sections and lateral alignment of the thalweg of the stream profile. Although minor erosion and deposition were noted through isolated areas of the project reach there appears to be no evidence of unstable lateral migration or plan form change of meander radius, meander length, or sinuosity.

Sediment Characteristics

Pavement samples within the bankfull channel were collected during the survey of the reach. Random sampling techniques were used through the entire reach to generate a composite sample, as well as samples obtained along independent cross sections (Table 3). The inventory included independent sampling at cross section #1 (riffle) and cross section #5 (pool).

Table 3: Sediment sample sizes taken November 2007 at selected cross sections.

Dominant Particle Size	Composite	Cross Section #1 (Riffle)	Cross Section #5 (Pool)
D_{95}			
D_{85}			
D_{50}			
D_{35}			
D_{15}			

A gravel bar sample was collected (Table 4) to be used as a surrogate for stream subpavement particle size. This sample was collected according to the procedure utilized for the “bottomless bucket method.” The procedure to this approach is as follows: locate the sampling site along the lower 1/3 of a meander bend at an elevation equal to the thalweg elevation plus one half the elevation difference between the thalweg and bankfull elevations, locate the two largest particles that may be mobile at bankfull flow in the vicinity and average their intermediate axis, excavate and collect all material from an area the size of the mouth of a standard five gallon pail to a depth equal to twice the average intermediate axis of the two aforementioned particles, finally, wet sieve the material to obtain the particle size distribution. This analysis produces values that are used in various classification equations and may be used in conjunction with the pebble counts to help determine particle size distributions of the stream pavement and sub-pavement.

Table 4: Gravel bar sample

Dominant Particle Size	Bar Sample
D_{95}	
D_{85}	
D_{50}	
D_{35}	
D_{15}	

Photographs and Descriptions

Photograph 1: View across stream from right bank at cross section 2.

Photograph 2: Rock vane on left bank near cross section 3 with bank erosion behind vane.

Photograph 3: Rock vane on right bank upstream of cross section 4.

Photograph 4: Rock vane on right bank downstream of cross section 4.

Photograph 5: Upstream view of North Settlement Creek at its confluence with Batavia Kill.

Photograph 6: Cross vane downstream of confluence with North Settlement Creek.

Photograph 7: View of knotweed in right floodplain looking downstream.

Photograph 8: View across stream from right bank at cross section 6.

Photograph 9: Cross vane with bank erosion behind left vane arm located downstream of cross section 6.

Photograph 10: Bank erosion on right bank exposing the sand and gravel soil.

Photograph 11: Rock vane with bank erosion behind vane arm.

Photograph 12: Cross vane near cross section 6 with substantial bank erosion behind right vane arm.

Brandywine Stream Restoration Project
Project Inspection - November 2007

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GREENE COUNTY SOIL & WATER CONSERVATION DISTRICT

NYCDEP STREAM MANAGEMENT PROGRAM

"BRANDYWINE" STREAM RESTORATION PROJECT

2007 MONITORING SURVEY

INDEX OF DRAWINGS

REV	DATE	DESCRIPTION	APP.

REVISIONS

GREENE COUNTY SOIL & WATER CONSERVATION DISTRICT
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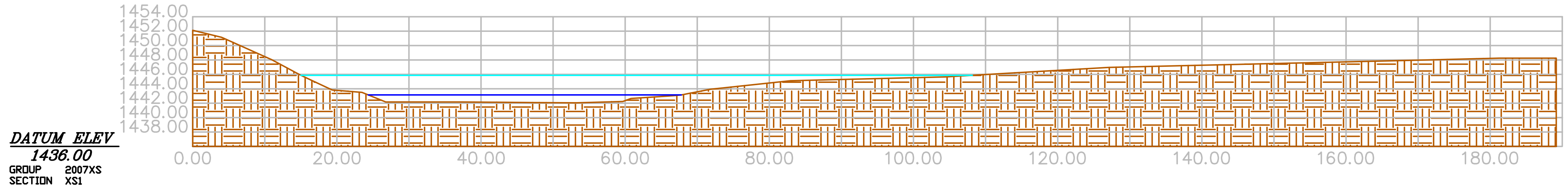
BRANDYWINE
FOR
ACOE
STATE ROUTE 23A
TOWN OF ASHLAND — GREENE COUNTY, NY

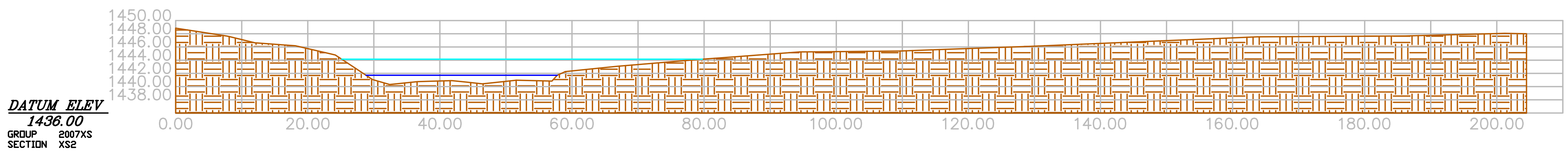
TITLE SHEET

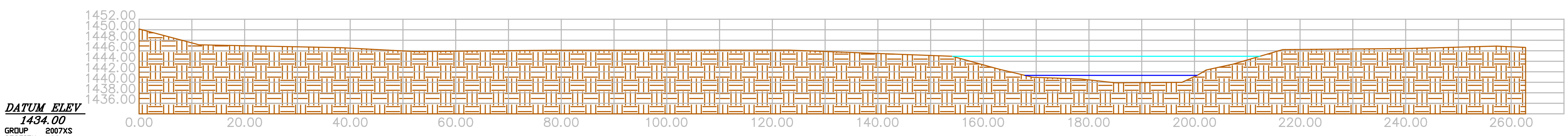
PROJECT:
DATE: 01/11/08
SCALE: AS NOTED
DRAWN BY: NSH
DESIGN BY:

DRAWING: **BW-1**

SHEET 1 OF 4







REV	DATE	DESCRIPTION	APP.

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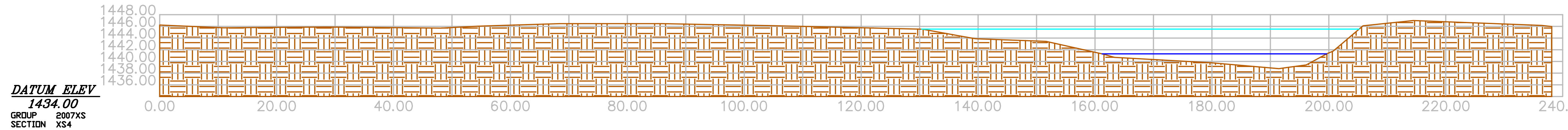
BRANDYWINE
FOR
ACOE
STATE ROUTE 23A
TOWN OF ASHLAND GREENE COUNTY, NY

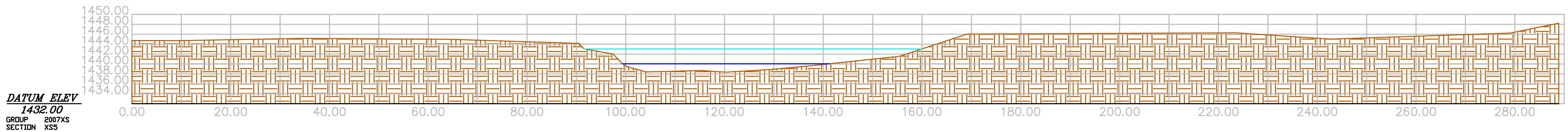
2007 - CROSS SECTIONS 1-3

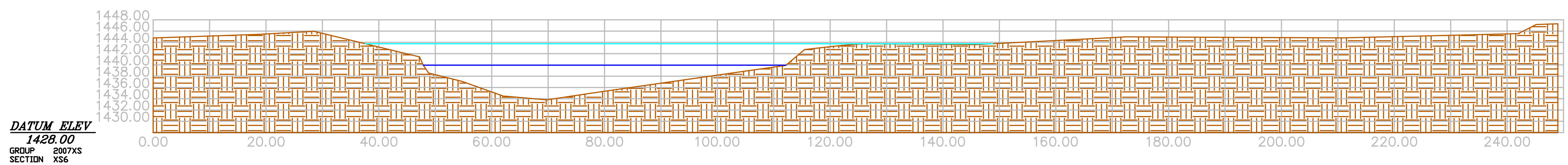
PROJECT:
DATE: 01/11/08
SCALE: 1:20
DRAWN BY: NSH
DESIGN BY:

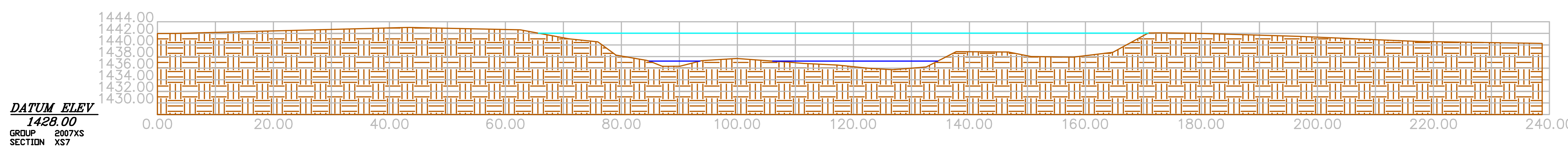
DRAWING: **BW-2**

SHEET 2 OF 4









REV	DATE	DESCRIPTION	APP.

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STATE ROUTE 23A

TOWN OF ASHLAND GREENE COUNTY, NY

2007 - CROSS SECTIONS 4-7

PROJECT:
DATE: 01/11/08
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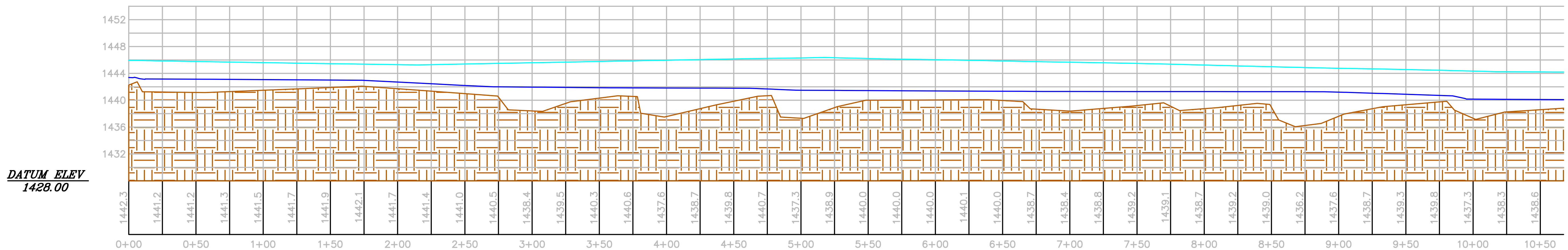
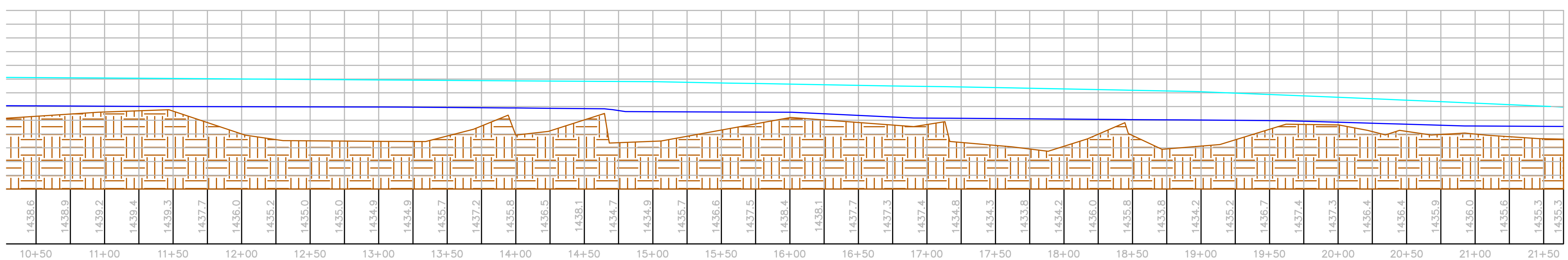
DESIGN BY:

DRAWING:

BW-3

SHEET 3 OF 4





REV	DATE	DESCRIPTION	APP.

REVISIONS

Legend

- Bankfull
- Thalweg
- Water Surface

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TOWN OF ASHLAND — GREENE COUNTY, NY

2007 - PROFILE

PROJECT:
DATE: 01/11/08
SCALE: AS NOTED
DRAWN BY: NSH
DESIGN BY:

DRAWING: **BW-4**

SHEET 4 OF 4

Brandywine Project Site
Summary of Survey Data
Updated: Jan.31, 2008

Brandywine 2007 Survey
Cross Section Data

Cross Section	Station	Feature	Area (ft^2)	Width (ft)	Max Depth (ft)	Mean Depth (ft)	Width to Depth Ratio (W/D)	Riffle Max Depth Ratio (D_{max}/D)	Pool Max Depth Ratio (D_{max}/D)	Bank Height (ft)	Bank Height Ratio (D_{top}/D_{max})	Pool Width Ratio (W_{pool}/W_{bkf})
1	1+64	Riffle	206.10	93.16	3.82	2.21	42.11	1.73		10.07	2.64	
2	3+64	Pool	123.23	54.59	3.82	2.26	24.18		1.69	5.99	1.57	0.68
3	5+90	Riffle	194.98	58.29	5.04	3.34	17.43	1.51		6.31	1.25	
4	7+46	Pool	290.76	74.82	6.76	3.89	19.25		1.74	8.22	1.22	0.93
5	10+39	Pool	217.13	68.46	4.70	3.17	21.59		1.48	7.68	1.63	0.85
6	12+87	Pool	491.06	111.24	9.95	4.41	25.20		2.25	12.16	1.22	1.38
7	20+59	Riffle	428.51	105.14	6.31	4.08	25.80	1.55		7.29	1.16	
Average for Riffles			276.53	85.53	5.06	3.21	28.44	1.59			1.68	
Average for Pools			280.55	77.28	6.31	3.43	22.56		1.79		1.41	0.96
Reach Averages			278.82	80.81	5.77	3.34	25.08				1.53	

Cross Section	Width	Flood-Prone Width	Entrenchment
3	58.29	367.61	6.31
Reach Averages			6.31

Brandywine Project Site
Summary of Survey Data
Updated: Jan.31, 2008

Brandywine 2007 Survey
Stream Pattern Data

Attribute	Sample Number												Average
	1	2	3	4	5	6	7	8	9	10	11	12	
Meander Length (ft)	841.69	889.11											865
Radius of Curvature (ft)	207.57	320.85	150.24	206.9									221
Meander Width (ft)	254.35	209.13	267.51										244
Pool to Pool Length (ft)	100.93	14.62	0	116.49	78.98	0	0	0	0	113.39	0		39

Meander Length Ratio (L_m/W_{bkf})	10.12	Valley Length	1896
Radius of Curvature Ratio (R_c/W_{bkf})	2.59	Channel Length	2173
Meander Width Ratio (W_{blt}/W_{bkf})	2.85	Sinuosity	1.15
Pool to Pool Spacing Ratio	0.45	Bankfull Width (W_{bkf})	85.53

Brandywine Project Site
Summary of Survey Data
Updated: Jan.31, 2008

Brandywine 2007 Survey
Profile Data

Attribute	Sample Number												Totals
	1	2	3	4	5	6	7	8	9	10	11	12	
Glide Length	50.29	13.73	10.17	10.72	12.17	23.78	51.58	12.64	10.18	25.65	13.65	12.03	246.59
Glide Drop	-0.43	-0.35	-0.10	-0.48	-0.25	-0.41	-0.36	-1.03	-0.65	-0.93	-1.18	-0.74	-6.91
Glide Slope	-0.009	-0.026	-0.010	-0.045	-0.021	-0.017	-0.007	-0.081	-0.064	-0.036	-0.086	-0.061	-0.028
Pool Length	123.14	75.64	89.55	59.76	92.62	107.86	114.79	235.02	60.10	110.25	116.77	105.54	1291.04
Pool Drop	0.59	0.30	-0.05	1.17	0.43	-0.07	0.67	1.81	0.41	1.51	0.63	0.96	8.34
Pool Slope	0.005	0.004	-0.001	0.020	0.005	-0.001	0.006	0.008	0.007	0.014	0.005	0.009	0.006
Riffle-Run Length	100.93	14.62	116.49	78.98	113.39	202.47							626.88
Riffle-Run Drop	1.48	0.12	0.23	0.24	1.32	2.17							5.55
Riffle-Run Slope	0.015	0.008	0.002	0.003	0.012	0.011							0.009

Overall Riffle-Run Length	626.88	Overall Pool-Glide Length	1537.63	Riffle-Run Slope Ratio (S_{rif}/S_{chan})	2.746
Overall Riffle-Run Drop	5.55	Overall Pool-Glide Drop	1.43	Pool-Glide Slope Ratio (S_{pool}/S_{chan})	0.288
Overall Riffle-Run Slope	0.0089	Overall Pool-Glide Slope	0.0009	Percent Riffle	29.0%
Overall Channel Slope	0.0032	Valley Slope (ft/ft)	0.0037	Percent Pool	71.0%

Appendix G

Other Project Reports

G.1 Evaluation of the Effectiveness of Stream Restoration in Batavia Kill Watershed

G.2 Effectiveness of Stream Restoration in Reducing Stream Bank Erosion: The Case of Batavia Kill Stream Restoration Projects, New York

Evaluation of the Effectiveness of Stream Restoration in Batavia Kill Watershed

By Yanwei Chen[1], S. K. Bhatia[2], James Buchanan[3], Doug DeKoskie[4]

ABSTRACT

The number of stream restoration projects has increased dramatically during the last decade, especially in the New York City watershed region, where stream management to improve water quality is a high priority, and where NYC Department of Environmental Protection and the Greene County Soil and Water Conservation District have partnered to develop a set of restoration demonstration projects. In this paper, post-project evaluation is conducted on the Maier Farm project, the first demonstration project in the Batavia Kill watershed (Greene County, New York). This evaluation focuses on the changes of morphological characteristics and erosion rates. The pre-project and post-project morphological characteristics such as width/depth ratio, bankfull width, bankfull area, bankfull mean depth, and bankfull maximum depth at the Maier Farm project reach are compared, and the trends in these characteristics are then analyzed. The post-project erosion rates at the Maier Farm reach are compared to the pre-project values as well as to those of other untreated reaches. It is found that the morphological characteristics tend to be stable three years after the completion of the project, and the restoration project contributed to the improvement of the bank stability and the reduction of the stream erosion rates.

Key Words: Stream restoration, Stream management, Post-project evaluation, Morphological characteristics, Erosion rates, Bank stability, Greene County SWCD, New York City Watershed, NYC Department of Environmental Protection

INTRODUCTION

With increasingly awareness of the negative impact of human activities on the watershed system, growing numbers of stream restoration projects are being carried out to improve water quality, stabilize the stream banks, and enhance the integrity of aquatic ecosystems (FISRWG, 1998). Stream restoration means to return an ecosystem to a close approximation of its condition prior to disturbance (Kondolf 1995, FISRWG 1998). However, the uncertainties in certain aspects of stream channel restoration, such as the bankfull elevation, meander dimensions, bankfull discharge, slope, and cross-sectional shape make the accurate prediction of the consequence of stream restoration projects extremely intricate (Johnson and Rinaldi 1998). Thus the post-project evaluation becomes critical to assess the performance of any restoration project.

In 1995, Kondolf and Micheli proposed an approach to evaluating stream restoration projects by emphasizing the measurement of the geomorphic characteristics of the restoration reach. Their emphasis of the geomorphic characteristics is based on the understanding that interactions between the stream channel, floodplain, and stream flows provide the framework supporting aquatic and riparian structures and functions (Kondolf and Micheli 1995). Since then, growing studies have been undertaken to evaluate the stream restoration projects by comparing the pre-project and post-project geomorphic characteristics.

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[3] Stream Restoration Specialist, Greene County Soil & Water Conservation District, Cairo, NY, 12413
[4] Stream Program Leader, Greene County Soil & Water Conservation District, Cairo, NY, 12413

Smith (1997) conducted a post-project evaluation on a 300-meter reach of Deep Run (Maryland) with a goal of assessing the change in stability over a two-year period. The Deep Run project was reconstructed into a meandering channel in August 1995 as mitigation for highway construction. Smith found that the cross-section dimensions increased over the monitoring period, and the absence of floodplain vegetation allowed high flow velocities which encouraged scour on the floodplain. He concluded that the reconfiguration was ineffective at enhancing channel stability.

In another study, Kurz and Rosgen (2002) compared the pre-project and post-project morphological characteristics of an 1800-meter demonstration project reach on the Lower Rio Blanco River (Colorado), which was restored in fall 1999. They found that even with 33% less flow, the maximum depths and the mean depth of the 2001 cross-sections were greater than the average values of 5 wildlife pre-restoration cross-sections. From the post-project monitoring data, they also noticed that there was an increasing trend in bankfull mean depth and bankfull maximum depth as well as a decreasing trend in width/depth ratio. Their analysis showed that the restoration was successful in improving the channel stability.

Although many studies have been conducted to evaluate stream restoration projects, little or no quantitative analyses were carried out on the change of the erosion rates. One possible reason for the absence of such studies might be the unavailability of pre-project erosion rates data. This paper evaluates the effectiveness of the first major stream restoration project in New York State – the Maier Farm Project in Batavia Kill watershed. This evaluation is based on the changes of morphological characteristics and erosion rates.

BATAVIA KILL WATERSHED STREAM RESTORATION

The Batavia Kill watershed is located in the Catskill Mountains in southeastern New York State (Figure 1). The watershed has an area of 186 km^2 and its mainstream, the Batavia Kill, runs for a distance of 34 km to its confluence with the Schoharie Creek, which is a major water resource for New York City's daily water supply.

The Batavia Kill watershed is characterized by steep slopes with unconsolidated glacial till, glacial lacustrine clays, and fine silts. The New York City Department of Environmental Protection (NYCDEP) had identified the watershed as having one of the highest turbidity conditions of all the NYC water supply systems. In 1997, the United States Environmental Protection Agency (USEPA) required NYCDEP to either improve the surface water quality to a certain level or to spend $8 billion to build a filtration plant. The NYCDEP has responded by developing a watershed protection program instead of the filtration plant. As part of the watershed protection program, the Greene County Soil & Water Conservation District (GCSWCD) has initiated the use of a geomorphic-based classification, assessment, and restoration strategy for addressing degraded stream reaches in the Batavia Kill Watershed.

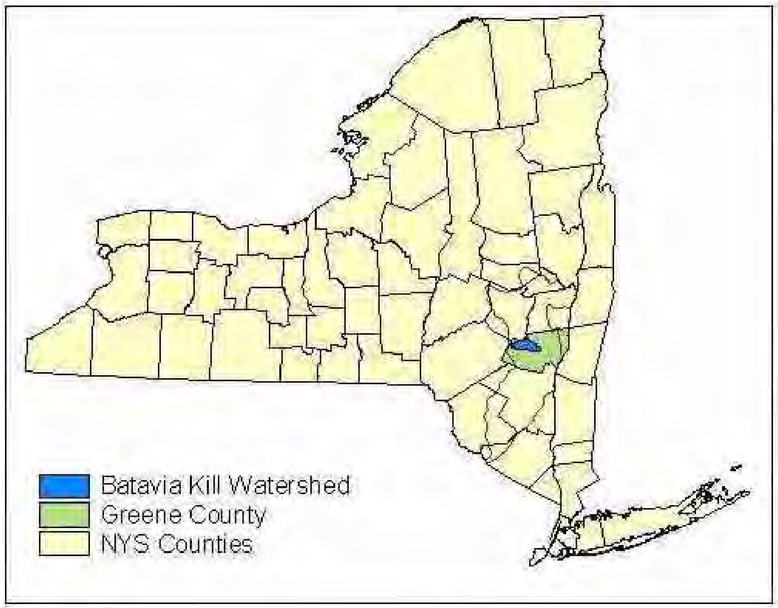


Figure 1: Batavia Kill Watershed Location Map

Three separate reaches were chosen as demonstration projects based on the consideration of the instabilities, funding, water quality, accessibility, and other factors. The first two projects were located in the middle of the stream corridor and are referred to as the Maier Farm project and the Brandywine project. The third demonstration project is located at the top of the watershed and is referred to as the Big Hollow project. Figure 2 shows the locations and the restoration periods of demonstration projects. Table 1 gives the design features of the demonstration projects.

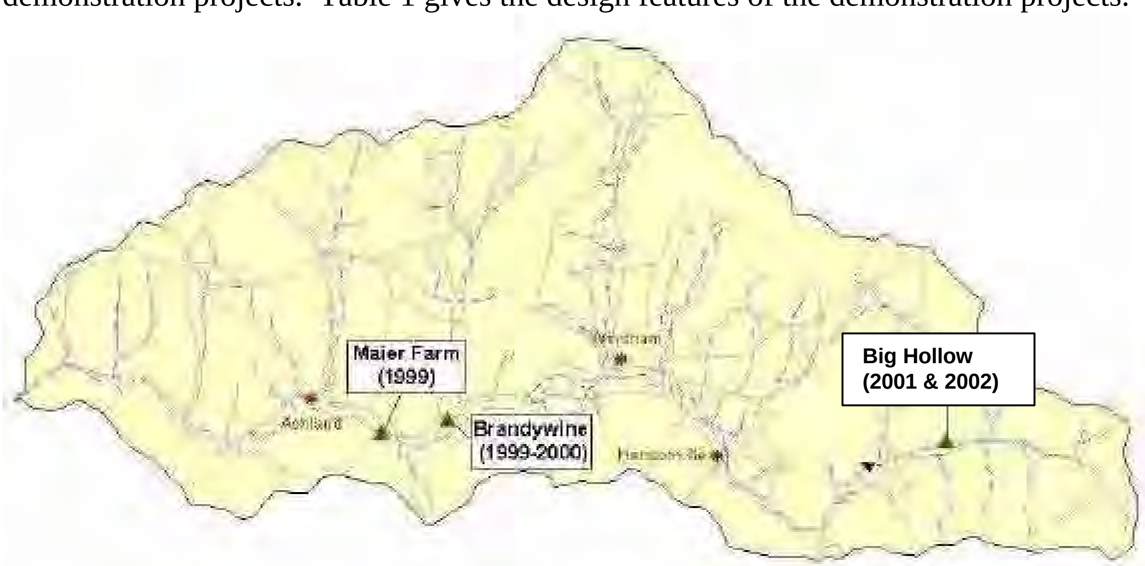


Figure 2: Locations and Construction Periods of Demonstration Projects in Batavia Kill Watershed

The Primary objective of the restoration projects is to mitigate excessive turbidity and total suspended solids impact on water quality by addressing excessive stream bank erosion (GCSWCD Management Plan, 2003). To achieve this goal, a stable Rosgen C4 stream type (Rosgen 1996) with typical meandering riffle-pool morphology was selected as the restoration strategy for the demonstration projects. Channel form and meander pattern was derived from historical aerial photographs, regime equations, and reference reach analyses.

Table 1: The Design Features of the Demonstration Projects

Projects	Maier Farm	Brandywine	Big Hollow
Drainage Area (km^2)	134	111	23
Bankfull X-section Area (m^2)	22	21	9
Bankfull Mean Depth (m)	1.2	2	0.67
Design Stream Type	C4	C4	C4
Slope	.0021	.0005-.0006	0.016
Project Length (m)	500	1100	> 490
No. of Rock Vanes	10	14	60
No. of Cross Vanes	3	6	10
No. of W-Weirs	1	-	-
No. of Root-wads	2	1	-

To date, the monitoring data at Maier Farm reach from 1997 to 2002 were provided by GCSWCD, and monitoring data at other project sites are under organization. It is for this reason that this paper will focus on the Maier Farm project, the first restoration project in the Batavia Kill watershed. The annual mean flow at the Maier Farm reach is about 2.8 m^3/s (USGS 01349900). During the monitoring period from 1997 to 2002, the biggest storm event was the tropical storm Floyd, estimated to be a 30-year storm event, which hit the watershed in September 1999 with the peak flow at 420 m^3/s. Other big storm events were the May 1998 flood which peaked at 65 m^3/s, the June 2000 flood with a peak flow of 136 m^3/s, and the December 2000 flow which peaked at 70 m^3/s.

MORPHOLOGICAL ANALYSIS

Morphological characteristics can be categorized into cross-section dimension, longitudinal profile, and bed material (Rosgen 1996). The cross-section survey, longitudinal profile measurement, and pebble count at the Maier Farm reach started in 1997. Two monitoring cross-sections (Refer to Harrelson et al. 1994) were installed in that year to serve as the pre-project survey baseline. The pre-project monitoring survey was conducted in 1997, 1998, and 1999. After the completion of the projects in August 1999, six permanent cross-sections were established on the Maier Farm project reach and as-built survey was conducted. Three weeks later, on September 16, 1999, the Batavia Kill basin was hit by tropical storm Floyd. After the flood event, six cross-sections were surveyed again. The monitoring survey was then conducted in 2000 and 2002.

Table 2 compares the post-project and pre-project morphological characteristics. The post-project value is the mean of post-project monitoring data, and the pre-project value is the mean of pre-project monitoring data. The proposed value is the average of the riffle and pool suggested in the design (GCSWCD, 2002).

Table 2: Changes in Morphological Characteristics at Maier Farm Project Reach

	W/D Ratio	BKF Mean Depth (m)	BKF Max. Depth (m)	BKF Width (m)	BKF Area (m^2)
Post-project	24.89	1	1.77	24.62	24.87
Pre-project	75.44	0.56	1.58	42	23.65
Proposed	19.1	1.13	2.10	21.5	24.2

The restored reach has much lower width/depth ratio and higher depth than the pre-restoration reach. The width/depth ratio is a very sensitive indicator in channel instability (Rosgen 1996). High width/depth ratio indicates a sharp reduction in the channel's capacity to transport sediment. The average post-project width/depth ratio (24.89) at the Maier Farm project reach is close to the average value (29.28) provided by Rosgen (1996) for the stable C4 stream type.

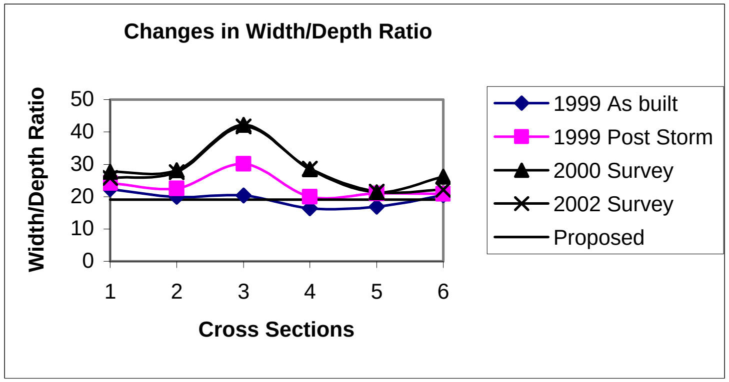
The changes of morphological characters from 1999 to 2002 at six cross-sections are given in Figure 3. The width/depth ratio has an increasing trend in 1999 and 2000 and then tends to be stable. The bankfull mean depth has a decreasing trend in 1999 and 2000 and then tends to be stable. No clear pattern was captured in the bankfull area and bankfull width changes. Notice that the changes in morphological characters between 1999 as-built survey and 1999 post-storm survey are obvious. These obvious changes were mainly due to the 1999 flood event. The Maier Farm site's construction was completed only three weeks before the storm hit. The site was vulnerable, with little to no vegetative cover, which is very essential in providing the bank stability, especially for the C4 type reach, on the stream bank. Although there were some damages on individual structures, the whole project still held its constructed planform and profile (GCSWCD, 2003). The project survived well compared to other untreated reaches (GCSWCD, 2003). Although the time period covered in this study is not long enough to assess a stable condition, Figure 3 shows that the project reach tends to be stable especially over 2000-2002 seasons.

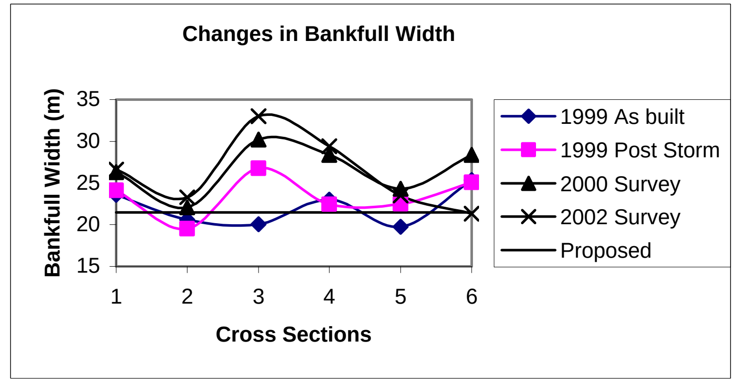
Figure 3 demonstrates that cross-section 3 has higher bankfull width and width/depth ratio than those of the other cross-sections. The field investigation showed that some in-stream structures nearby cross-section 3 were damaged during the 1999 storm event. This damage might be the reason why cross-section 3 has different morphological characteristics from the other cross-sections.

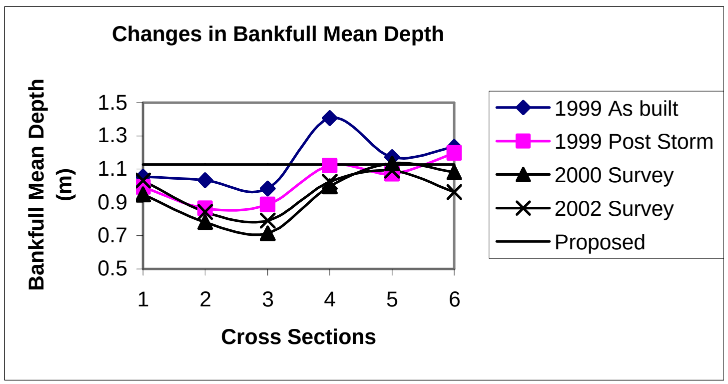
EROSION RATES ANALYSIS

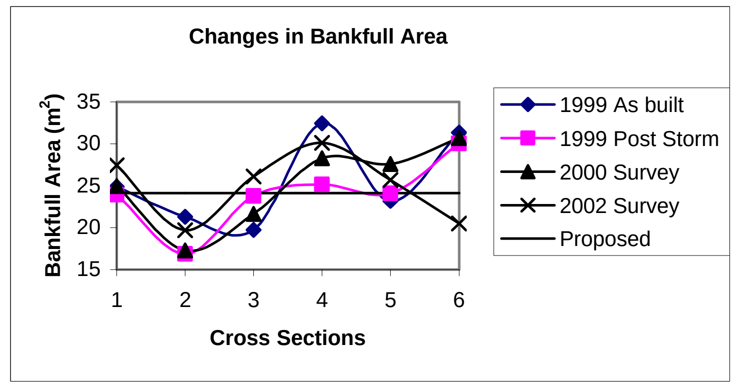
The primary stability problems observed at the pre-restoration reach were associated with meander migration and stream bank erosion, which were mainly due to poor riparian buffers and the unconsolidated layers of glacial soils. Since the primary objective of the stream restoration is to improve the water quality by reducing stream bank erosion, it is essential to evaluate the effectiveness of stream restoration on erosion rates.

Harrelson et al., (1994) suggested two ways to measure the bank erosion: the first method is the repeated cross-section survey; the second method is to insert erosion pins at regular intervals into a stream bank and to measure the exposure of the erosion pins over a certain period. Rosgen used erosion pins to measure the erosion rates in the Colorado fluvial sites study and the Yellowstone study (Rosgen 1996). The erosion rates ranged from 0.006 to 0.92 m/yr in the Colorado study and from 0.005 to 0.76 m/yr in the Yellowstone study. Most measured stream reaches in the Colorado study are A and B types.









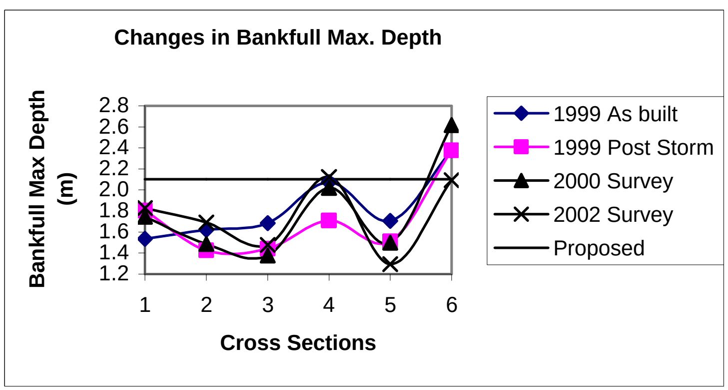


Figure 3: Changes of Post-project Morphological Characteristics from 1999 to 2002 at 6 Cross Sections on the Maier Farm Project Reach in the Batavia Kill watershed

The classification of the Yellowstone study reaches was not given. In another study, Harmel et al., (1999) measured the bank erosion rates on the Upper Illinois River in northeast Oklahoma using erosion pins. Most reaches they chose were the C4 type. The range of bank erosion measured in their study was quite different from Rosgen's results. The erosion ranged from –0.009 m to 8 m during the period from September 1996 to July 1997.

In this study, the erosion rate is measured by repeated cross-section surveys. For example, the pre-project erosion rate was determined by overlaying two different cross-sections surveyed on April 27, 1999 and on July 17, 1998. From this data, the mean erosion rates were calculated. The post-project erosion rate was obtained by surveying 6 different cross sections and overlaying that data surveyed at different times: on June 21, 2000 and the as-built cross-section on August 26, 1999. The eroded area of the six cross-sections was then averaged to determine the mean erosion rate. In this way, the eroded area at the whole cross-section was calculated, including the stream bank erosion and the channel bed erosion.

Table 3 summarizes the post-restoration erosion rate and pre-restoration erosion rate on the Maier Farm site. The first look at Table 3 shows that the difference between post-project and pre-project erosion rate is negligible. From these data, one might draw a conclusion that the restoration technique at this project site was not effective in reducing stream erosion. However, we should also take the hydrological aspect into consideration when comparing the erosion rate during different periods, because the stream flow is a very important factor that affects the erosion rate.

Table 3: Comparison of Post-project and Pre-project erosion rates

Monitoring Season	Mean Eroded Area (m^2/year)
Post-project (99-00)	4.7
Pre-project (98-99)	4.6

For the hydrological consideration, the daily mean stream flow data (Figure 4) is obtained from USGS gage 01349900 (Near Ashland), which is located upstream of the Maier Farm reach. From August 26, 1999 to June 21, 2000 (post-project period), eight storm events with the daily mean discharge higher than the mean peak flow (mean value of the flood events) were recorded. The highest daily mean stream flow, which occurred on September 17, 1999, exceeded 65 m^3/s (Notice that this is the daily mean flow, not the peak flow; the peak flow exceeded 420 m^3/s). It was followed by another major flood event on June 7, 2000, with a daily mean stream flow higher than 56 m^3/s. However, during the pre-project monitoring season (from July 17, 1998 to April 27, 1999) only three storm events exceeded the mean peak flow, while the highest daily mean stream flow is 30 m^3/s. Apparently, the post-project monitoring season experienced more storm events and higher flow than the pre-project monitoring season, but the erosion is almost the same (Table 3) during these two monitoring seasons. Therefore, one can conclude that the stream restoration project did contribute to the stream stability.

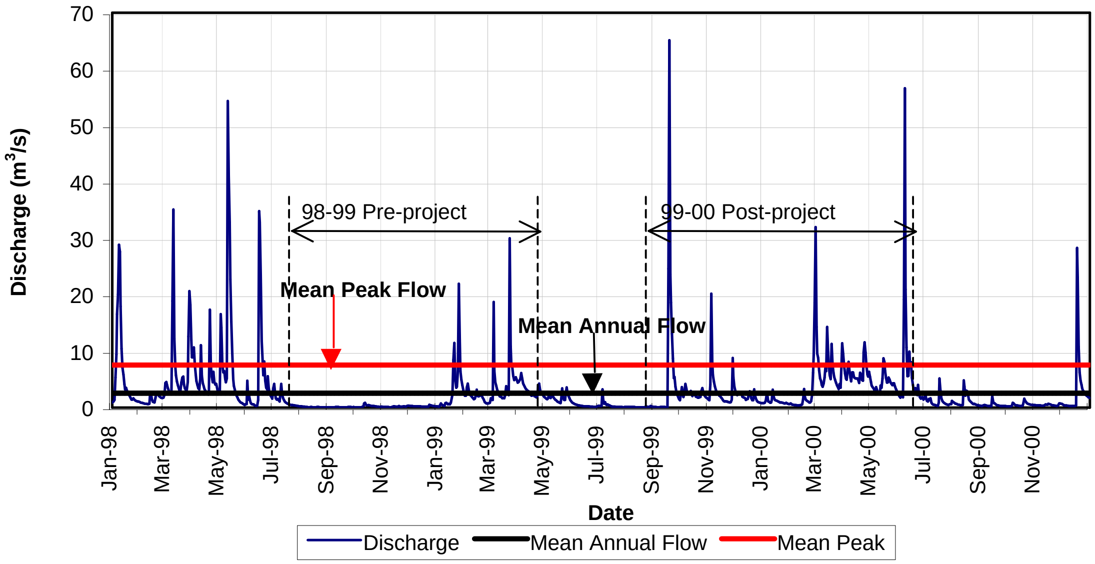


Figure 4: Daily Mean Stream Flow at Batavia Kill Near Ashland NY (USGS 01349900)

Another way to evaluate the effectiveness of the restoration project on stabilizing the stream bank is to compare the erosion rate at project reach to that of untreated stream reaches (unstable reaches). Since the project reach is a C4 type, it is interesting to compare the erosion rate between it and the untreated C-type stream reaches. There are 95 monitoring cross-sections on the Batavia Kill stream. Among them, 25 are set up on untreated C-type stream reaches. The erosion rate during 1999-2000 monitoring season can be determined by overlaying surveyed cross-sections in 1999 and 2000 to measure the eroded area. The 25 untreated C-type reaches are located from the headwaters to the mouth of the watershed, and the drainage area ranges from 13 km^2 to 182 km^2. The results are summarized in Figure 5. The mean erosion rate of 25 cross-sections on untreated C-type reaches is 7.58 m^2/year, and the mean erosion rate of 6 project cross-sections on the Maier Farm site is 4.7 m^2/year. The average erosion rate at untreated reaches is 61% higher than that of the project reach.

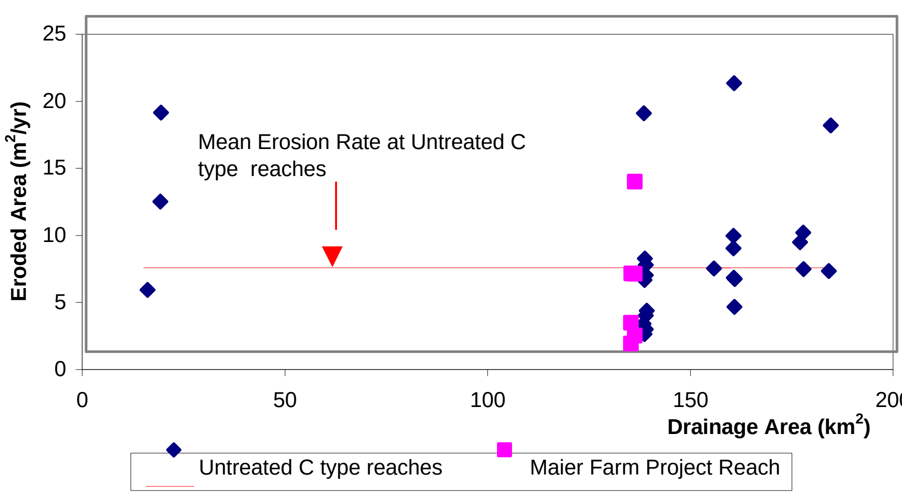


Figure 5: Comparison Erosion Rate between the Project Reach and Untreated C type Reaches in the Batavia Kill watershed

The project reach has different drainage area from other untreated reaches. To compare the erosion rate among reaches with different drainage areas, the eroded area/drainage area ratio is also calculated to normalize the erosion rate. The mean erosion area/drainage area ratio is 3.2 for untreated C-type reaches, and it is 0.97 for the project reach. The average eroded area/drainage area ratio at untreated reaches is 230% higher than that of the project reach.

It is important to note that the post-project erosion rate is calculated by using the monitoring data measured only one year after construction. At that time, the vegetative cover was not established and there was no root network on the stream bank. Since riparian vegetation can significantly improve bank stability and prevent bank erosion (Rosgen 1996), it is reasonable to assume that the post-project erosion rate would be even smaller if the vegetation cover were established on the project reach.

Stream bank erosion is the major source of the total sediment supply (Rosgen 2001). From the above analysis, one can reasonably assume that the effective reduction of erosion by the restoration project will lower the total sediment supply and thus improve the water quality, which is the primary objective of the stream restoration. However, there is no water quality data such as total suspended solids and turbidity available at the Maier Farm project reach to test that assumption. The water-quality monitoring plan should be integrated into future stream restoration projects to quantify the effect on the improvement of water quality.

CONCLUSION

The comparison of post-project and pre-project morphological characteristics shows that the restoration significantly reduced the width/depth ratio and increased the mean depth of the Maier Farm reach. The analysis of the post-project morphological data demonstrates that the width/depth ratio increased and that the mean depth decreased during 1999-2000 survey period due to the 1999 storm event, but, there are clear signs that those morphological characteristics tend to be stable during the 2000-2002 monitoring season.

Although experiencing more storm events and much higher stream flow during the post-project period (1999-2000), the Maier Farm project reach had almost the same erosion rate as that of the pre-project monitoring season (1998-1999). This fact provided excellent evidence of the restoration stability of the Maier Farm project. Moreover, compared to the project reach, the average untreated C-type reach has a 61% higher erosion rate and a 230% higher eroded area/drainage area ratio.

Overall, the Maier Farm project in the Batavia Kill watershed is successful in improving the stream channel stability and reducing the erosion rate.

ACKNOWLEDGMENT

We would like to acknowledge data support for this study from Greene County Soil and Water Conservation District and the U.S. Geological Survey. We would also like to thank Sarah J. Miller and Corri Zoli for their helpful comments.

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Effectiveness of Stream Restoration in Reducing Stream Bank Erosion: The Case of Batavia Kill Stream Restoration Projects, New York

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ABSTRACT: The number of stream restoration projects has increased dramatically during the last decade, especially in the New York City watershed region, where stream management to improve water quality is a high priority, and where the NYC Department of Environmental Protection and the Greene County Soil and Water Conservation District have partnered to develop a set of restoration demonstration projects. In this paper, the effectiveness of stream restoration projects in reducing stream bank erosion in the Batavia Kill watershed (Greene County, New York) is evaluated. This evaluation is based on a multivariate regression model to relate stream bank erosion rates to various explanatory variables including instruments representing geomorphological characteristics, flow conditions, rainfall conditions, temperature, the vegetation index, soil erodibility, and sediment characteristics. The general to specific approach is used to specify the regression model. A range of statistical tests is applied to check the model accuracy and the validity of the regression model. The results of these tests show that the stepwise regression model accurately predicts stream bank erosion rates on the Batavia Kill stream. The regression model is then applied on the project reaches, assuming there was no stream restoration to predict the stream bank erosion. It is found that the measured erosion on the restored reaches is much smaller than predicted erosion in the "without restoration" case, which means that the effectiveness of stream restoration in reducing bank erosion in the Batavia Kill watershed is significant.

Key Words: Stream restoration, Stream bank erosion, Erosion rates, Multivariate regression model, Model specification, Bank stability, Greene County SWCD, New York City Watershed, NYC Department of Environmental Protection

INTRODUCTION

Stream bank erosion and its associated sediment yield have tremendous negative impacts on water quality. Studies have shown, for instance, that stream bank erosion accounts for the majority of sediment load in some urban watersheds in the United States (Rosgen 1996; Trimble 1997). Sediment loads increase turbidity, alter aquatic habitats, and introduce pollutants, such as trace metals, in surface water. It is reported that an estimated 220,000 kilometers of stream bank are in need of erosion protection in the United States (U.S. Army Corps of Engineers 1983). Therefore, it is important to find out effective ways to minimize bank erosion and improve water quality.

In the 1960's, stream restoration was recognized for the first time as important – an occurrence that resulted from the negative impact of human activities on the watershed system. One can define stream restoration as "returning an ecosystem to a close approximation of its condition prior to disturbance" (Kondolf and Micheli 1995, FISRWG 1998). One primary purpose of the stream restoration is to stabilize stream banks and thus mitigate stream bank erosion. Therefore, the effectiveness of stream restoration in reducing stream bank erosion is critical in evaluating the success of a stream restoration project.

Extensive research has been carried out to analyze and predict stream bank erosion (Hooke 1979; Lawler 1986; Rosgen 1996; Simon and Darby 2002). Most of these studies estimate stream bank erosion rates based on the factors which are likely to control erosion. However, none of these approaches focuses on evaluating the effectiveness of stream restoration in reducing stream bank erosion. This scarcity is partially due to the relative short history of stream restoration projects and the lack of consistent monitoring of pre-project and post-project morphological and hydraulic characteristics, which are considered to be major elements controlling stream erosion. Therefore, a procedure based on stream monitoring data for the purpose of evaluating the effectiveness of stream restoration in reducing stream bank erosion needs to be developed. In this study, pre-project and post-project monitoring data in the Batavia Kill Watershed stream restoration projects have served as the basis of performance evaluation.

BATAVIA KILL WATERSHED STREAM RESTORATION PROJECTS

The Batavia Kill watershed is located in the Catskill Mountains in southeastern New York State (Figure 1). The watershed has an area of 186 km^2 and its mainstream, the Batavia Kill, runs for a distance of 34 km to its confluence with the Schoharie Creek, which is a major water resource for New York City's daily water supply. The New York City Department of Environmental Protection (NYCDEP) had identified the Batavia Kill watershed as having one of the highest turbidity conditions of all the NYC water supply systems. In 1997, the United States Environmental Protection Agency (USEPA) required NYCDEP to either improve the surface water quality to a certain level or to spend $8 billion to build a filtration plant. The NYCDEP has responded by developing a watershed protection program instead of the filtration plant. As part of the watershed protection program, the Greene County Soil & Water Conservation District (GCSWCD) has initiated the use of a geomorphic-based classification, assessment, and restoration strategy for addressing degraded stream reaches in the Batavia Kill watershed.

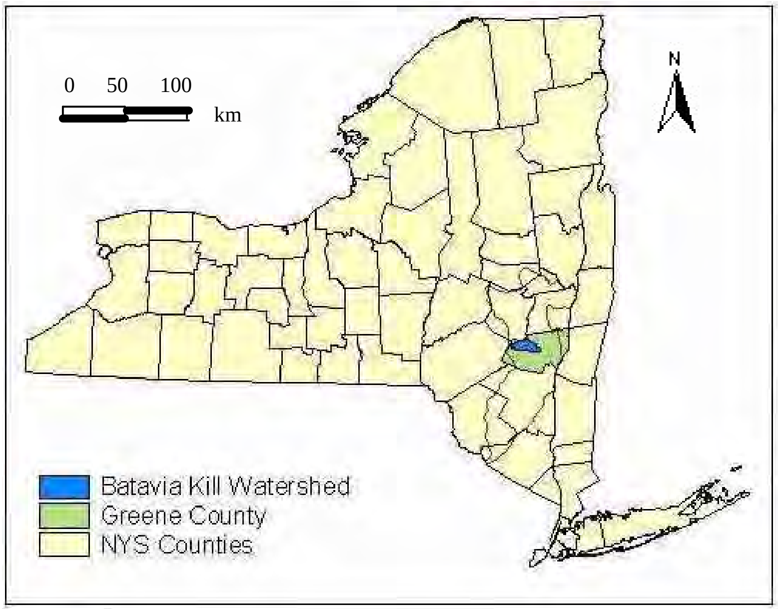

Figure 1: Batavia Kill Watershed Location Map

To date, three stream restoration projects have been accomplished in the Batavia Kill watershed. The first two projects were located in the middle of the stream corridor and are referred to as the Maier Farm project and the Brandywine project. The third project is located at the top of the watershed and is referred to as the Big Hollow project. Figure 2 shows the locations and the restoration periods of each restoration project. The Primary objective of the restoration projects was to mitigate excessive turbidity and the impact of Total Suspended Solids (TSS) on water quality by addressing excessive stream bank erosion (GCSWCD 2003). To achieve this goal, a stable Rosgen C4 stream type (Rosgen 1996) with typical meandering riffle-pool morphology was selected as the restoration strategy for the projects. Channel form and meander pattern was derived from historical aerial photographs, regime equations, and reference reach analyses.

The Batavia Kill watershed monitoring activities have been conducted annually since 1997. The monitoring activities include cross-section and profile survey, pebble counts, and the Bank Erosion Hazard Index (BEHI) measurement. To date, more than 100 cross sections have been established on the Batavia Kill stream. The channel geometry, channel bed materials distribution, and the vegetation information can be derived from the monitoring data.

STREAM BANK EROSION MONITORING AND MEASUREMENT

Sites with apparent erosion on stream banks are selected to conduct erosion monitoring since these sites are likely to show the erosion process more frequently and clearly. These sites are also important from the stream management point of view because they produce considerable amount of sediments, which are the major source of TSS and cause high turbidity. The description of erosion monitoring sites is given in Table 1. In total, eight erosion-monitoring sites were chosen on the Batavia Kill stream: these sites are Head Water, Big Hollow (pre-restoration), Brandywine (pre-restoration), Maier Farm (pre-restoration), Kastanis, Holdens, Red Falls, and Conine. The relative locations of erosion-monitoring sites are given in Figure 2. The drainage area at these sites ranges from 2.8 km^2 to 182.3 km^2. Each site was further divided into several sections based on the morphological characteristics such as sinuosity and the radius of curvature as well as soil erodibility. The subdivision of each monitoring site enables the investigation of the erosion variation under similar climatic and hydrological conditions. Altogether 33 separate sections were obtained by this approach (Table 1).

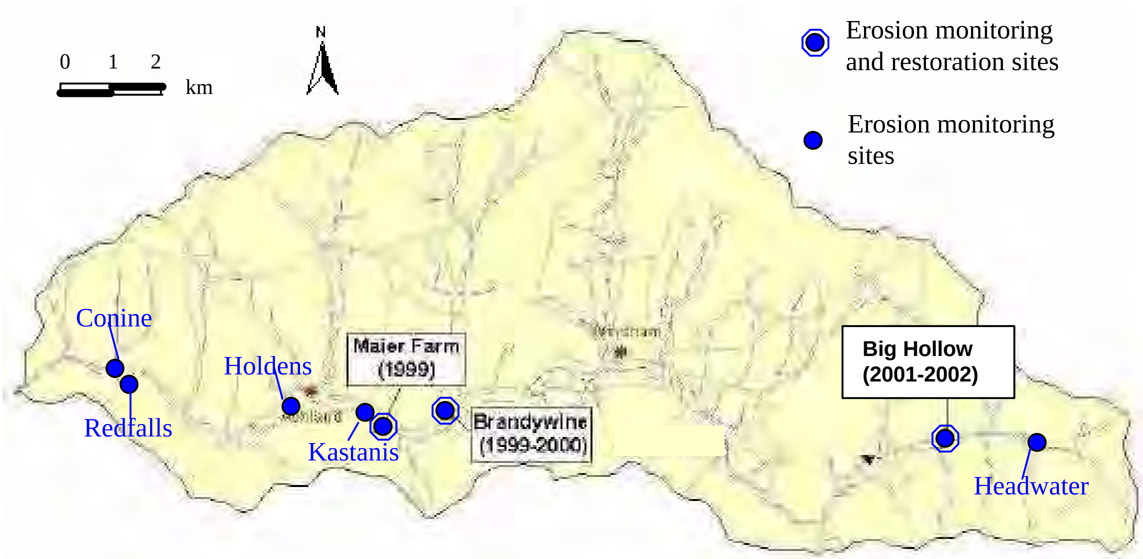

Figure 2: Demonstration Projects and Erosion Monitoring Sites in the Batavia Kill Watershed

The stream bank erosion is determined by overlaying cross-sections surveyed annually over the period from 1997 to 2003 on the Batavia Kill stream, and then measuring the eroded bank area or distance over a monitoring season. This method is believed to have the advantage of minimal disturbance on the stream bank, while covering the erosion measurement on the whole stream cross-section under investigation.

STREAM BANK EROSION PREDICTION

As one of major modeling techniques, multivariate regression is frequently used in the stream bank erosion prediction to establish the relationship between the bank erosion rates and various explanatory variables (Lawler 1986; Rosgen 1996). In this study, the stream bank erosion on the erosion monitoring sections determined from the cross-section surveys is regressed on a set of explanatory variables, and the erosion prediction model derived from the regression has been employed on out of sample data to predict stream bank erosion.

Table 1: Bank Erosion Monitoring Sites

Site	Section	No. of Cross-sections	No. of Observations	Average Drainage Area (km^2)	Description
Head Water	A	2	1	2.8	Upper portion of the reach is relatively stable, but lower portion of the reach exhibits severe erosion. Land cover is dominated by forest. Steep valley slope, narrow channel
	B	2	2	9.3	
	C	1	3	13.8	
Big Hollow	A	2	1	14.1	The reach was restored in 2001 and 2002. Prior to the restoration, the reach was highly unstable with extreme bank erosion. Very little vegetation coverage on the bank. Land use is open space with limited residential usage. Gravel bed channel. Bank materials consist of the mixture of clay/silt, sand and gravel.
	B	1	2	15.0	
	C	5	2	15.1	
	D	1	2	15.5	
	E	2	2	15.5	
	F	2	2	17.0	
	G	1	1	18.2	
	H	1	2	18.3	
Brandywine	A	1	2	108.2	The reach was restored in 1999 and 2000. The reach exhibited extreme bank erosion prior to the restoration.
	B	1	2	108.2	
Maier Farm	A	1	2	133.3	The reach was restored in 1999. The reach was extremely unstable prior to the restoration.
	B	1	2	133.4	
Kastanis	A	1	3	135.2	Experiencing large amount of bank erosion. Some portion of the stream bank has no vegetation cover. Forest and pasture land coverage, low density of residential housing. Gravel bed channel. Bank materials consist of the mixture of clay/silt, sand and gravel.
	B	3	3	136.5	
	C	1	3	136.7	
	D	4	3	136.8	
	E	3	3	137.0	
	F	2	3	137.2	
	G	2	3	137.6	
Holdens	A	2	1	158.5	Average valley slope is 0.3%, broad floodplain. Unstable reach and severe channel migration. Stream bank consists of non-cohesive materials. Farm and pasture land use.
	B	2	1	158.6	
	C	4	1	158.7	
Red Falls	A	2	2	174.7	Average valley slope is 1.2%, steep bank slope. Forest land coverage. Extremely unstable reach and highly negative impacts on water quality. High eroding banks, large clay exposure, active channel lateral migration.
	B	3	2	175.2	
	C	2	2	175.5	
	D	2	2	175.5	
Conine	E	2	2	175.5	Average valley slope is 1.2%, narrow flood plain. Extremely instable, accelerated bank erosion. Poor riparian vegetation.
	A	2	1	181.8	
	B	4	2	182.1	
	C	2	1	182.3	
Sum	33 sections	67	66		

Choices of Explanatory Variables

A number of factors have been identified as having influences on the stream bank erosion rates (Wolman 1959; Knighton 1998). These factors can be categorized into several groups: (1) cross-sectional and longitudinal characteristics; (2) parameters of flow conditions; (3) rainfall conditions; (4) temperature conditions, primarily the influence of frost; (5) vegetation and soil erodibility; and (6) sediment characteristics. Each group of influencing factors contains variables that may affect stream bank erosion rates. These variables have been considered in the regression to test their relationships with the steam bank erosion rates. Table 2 lists the explanatory variables examined in this study.

Table 2: Independent Variables used in the Bank Erosion Prediction

Factor	Variables	Source and method of measurement
(1) Cross-sectional and longitudinal characteristics	Drainage Area	USGS topographic maps measurements
	Cross-section area	Field survey of cross-sections
	Bankfull width	Field survey of cross-sections
	Cross-section maximum depth	Field survey of cross-sections
	Cross-section mean depth	Field survey of cross-sections
	Width/depth ratio	Field survey of cross-sections
	Bank height and Bank angle	Field survey of cross-sections
	Radius of curvature	GIS map measurement
	Radius of curvature/Bankfull depth	GIS map and field survey of cross-sections
	Sinuosity	GIS map measurement
	Channel slope	Field survey of longitudinal profile
(2) Flow conditions	Product of real time stream discharge and flow duration during a monitoring season	United States Geological Survey (USGS) gage stations nearby the bank erosion monitoring sites
(3) Rainfall Condition	Amount of rainfull per season Duration of rainfull per season	National Climatic Data Center (NCDC) station nearby the erosion monitoring sites
(4) Temperature	Froze-thaw circles per season Frozen days per season	NCDC station nearby the bank erosion monitoring sites
(5) Vegetation	Vegetation coverage index	GIS vegetation coverage, field pictures, field surveys, aerial photos, and BEHI.
(6) Bank and Bed Materials	Soil erodibility k, Bed materials size distribution D_{50}	GIS soil coverage, soil survey of Greene County, pebble counts, and bar samples

To quantify the influence of storm events on the stream bank erosion, the hydrograph method (McCuen 1998) is employed to account for the magnitude and duration of stream flows. In this method, volume of flow during a storm event is calculated by integrating the stream discharge with its duration. Since it is the medium to large events that contribute the most to stream bank erosion (Knighton 1998), events with flows higher than the mean peak flow, which is the average of all discharges above the mean annual flow, are taken into consideration. The volume of flows with discharge above the mean peak flow during an erosion-monitoring season at a particular site is selected as an explanatory variable to account for the impact of flows on stream bank erosion. Real time discharge data (recorded every 15 minutes) at each erosion-monitoring site are obtained from the nearby USGS gages in the Batavia Kill watershed to retrieve the flow magnitude and duration. Most erosion-monitoring sties are within several kilometers distance from the nearest USGS gage.

To investigate the influences of vegetation on bank erosion on the Batavia Kill stream, the historical vegetation information on each bank erosion-monitoring site are gathered from BEHI data, field surveys, field pictures, aerial photos as well as the GIS map. The vegetation conditions vary largely from site to site. Some sites have been fully covered by various vegetation, however others are exposed by barren soils. Meanwhile, there are also some banks partially covered by the vegetation. The vegetation condition on each site is categorized into one of these three groups, and is indexed as an explanatory variable in the bank erosion prediction model (full coverage =1, partial coverage =0.5, and barren soil =0).

Multivariate Regression Modeling

The average bank erosion area on cross-sections on an erosion-monitoring section over a monitoring season is selected as the dependent variable. Since the erosion measurement is made only on sections showing apparent bank erosion, whereas restored reaches generally exhibit little or no erosion, the project sites after stream restoration are excluded from the regression model. This strategy results in 66 observations on 33 erosion-monitoring sections. The bank erosion area – the dependent variable – has a mean value of 2.8 m^2 and a standard deviation of 3.3 m^2. There are 20 explanatory variables being considered in the regression analysis. These explanatory variables and their statistics are provided in Table 3.

Table 3: The Statistics of Explanatory Variables

Number	Variables	Abbreviation	Mean	Standard Deviation
1	Drainage area (km^2)	drain.area	107.19	64.65
2	Cross-section area (m^2)	xs.area	19.347	8.815
3	Bankfull width (m)	bkf.width	23.187	8.88
4	Cross-section maximum depth (m)	xs.maxdep	1.443	0.444
5	Cross-section mean depth (m)	xs.meandep	0.824	0.294
6	Width depth ratio	width.dep	32.335	18.837
7	Bank height (m)	bk.ht	3.916	3.248
8	Bank angle (°)	bk.angl	33.913	13.077
9	Radius of curvature	radius.curv	147.462	87.526
10	Radius of curvature/Bankfull width	rc.bkf	2.302	1.912
11	Sinuosity	sinu	1.192	0.288
12	Channel slope	chnl.slop	0.00829	0.00863
13	Erodibility K	erod	0.261	0.045
14	Stream flow ($10^6 m^3$)	streamflow	33.9	33.294
15	Precipitation days	precp.day	129.602	74.967
16	Precipitation (mm)	precp	1252.1	653.7
17	Froze-thaw circles	froze.thaw	134.136	74.300
18	Frozen days	froze.day	175.000	101.091
19	Bed material size (mm)	bed.mat	59.364	26.919
20	Vegetation index	veg	0.379	0.430

An analysis of multicollinearity among explanatory variables shows that a high degree of multicollinearity exists among regressors. The high multicollinearity makes it very difficult to interpret the effect of each independent variable on the response. Therefore, a specified model should be derived to best predict the stream bank erosion. The general to specific approach is used to specify the model. This algorithm starts with the full model, which incorporates all explanatory variables, and then deletes one variable from the model at a time. The variable to be removed from the model is the one that makes the smallest contribution. To determine a variable's contribution, the absolute value of that variable's t-ratio is considered. To be removed, the t-value must be less than a critical t-value in absolute value. This algorithm takes into account the joint effect of independent variables. In this study, the t-value corresponding to 95% significance level is used as the critical t-value.

After one variable is removed, the dependent variable is regressed on the rest of the explanatory variables to determine the next variable to be eliminated from the regression model until all variables are statistically significant. The final model selected by this approach has 7 explanatory variables: they are cross-section area, cross-section mean depth, width/depth ratio, bank angle, sinuosity, stream flow, and the vegetation index.

The final model has a R^2 of 0.7553, indicating that more than 75% bank erosion can be explained by the erosion prediction model. The F-statistic is 25.57, which is much higher than the critical F value of 2.172. The explanatory variables are therefore statistically significant in explaining the stream bank erosion. The t-statistic shows that all explanatory variables are statistically significant at a 90% confidence level, except for the bank angle (Table 4). Actually, the bank angle is statistically significant at a 77% confidence level. A variable at this significance level should be retained in the model to avoid screening out variables that may be important (Frees 1996). This choice is motivated by an algebraic result that when a variable enters a model, the standard error of the estimates will decrease if the t-ratio of that variable exceeds one in absolute value (Frees 1996). In addition, from the geotechnical point of view, the bank angle is an important variable contributing to stream bank erosion (Simon 2002). The level of multicollinearity among the explanatory variables in the final model is checked, and the results show that the degree of multicollinearity is not severe. The stream bank erosion estimated by the final model is plotted against the measured bank erosion in Figure 3.

The final model indicates that bank angle, sinuosity, and stream flow are directly related to stream bank erosion, while the vegetation index has an inverse relationship to bank erosion. Actually, field observations in the Batavia Kill watershed support the above model's interpretation. A large amount of bank erosion is observed at reaches where the banks are steep and the channels are sinuous, such as Kastanis and Red Falls. High flow events generally produce more bank erosion, and this is consistent with observations made by many researchers (Hooke 1979; Knighton 1998). At bank-erosion monitoring sections on the Batavia Kill stream, banks with high vegetation coverage in general have much less erosion than banks with little or no vegetation coverage. Table 4 also shows that bank erosion is directly related to the cross-section area while inversely related to the cross-section mean depth and width depth ratio. However, since width depth ratio can be computed as the cross-section area divided by the square of the cross-section mean depth, the relationship between the bank erosion and the cross-section area, mean depth and width depth ratio becomes intricate. The first order derivative analysis revealed that for most reaches on the Batavia Kill stream, bank erosion is indeed directly related to the cross-section area and inversely related to the cross-section mean depth, which means that wide and shallow reaches have the potential to incur more bank erosion.

Table 4: Summary of the Final Model

	Coefficients	Standard Error	t value	Pr(>|t|)	Significant codes
(Intercept)	-35.029	24.1438	-1.451	0.15221	
xs.area	0.131	0.0693	1.891	0.06367	.
xs.meandep	-18.654	7.672	-2.431	0.01815	*
width.depth	-0.43	0.251	-1.714	0.09185	.
bk.angl	0.241	0.198	1.214	0.22969	
sinu	75.814	9.045	8.382	1.41E-11	***
streamflow	0.00897	0.00265	3.391	0.00126	**
veg	-18.364	6.875	-2.671	0.00979	**

Significant codes: 0 `***' 0.001 `**' 0.01 `*' 0.05 `.' 0.1 ` ' 1

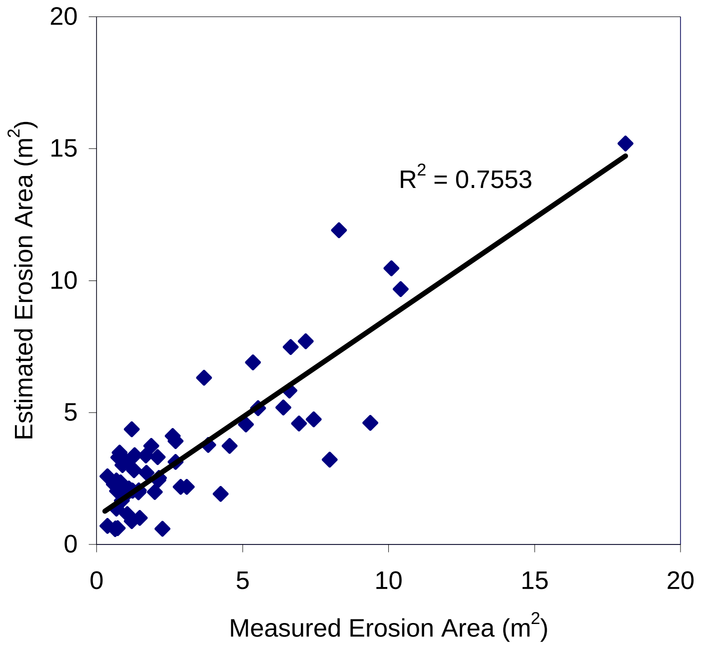

Figure 3: Estimated Bank Erosion by the Final Model vs. Measured Erosion

Model Validation

To validate the methodology being applied to the model specification, the 66 observations are split into two data sets. Each data set consists of 33 observations.

One data set is used to develop a prediction model, and the other data set containing out of sample data is used to validate the prediction model. The same general to specific method is used to specify the prediction model, and the predicted values are compared with the measured erosions (Figure 4). The R^2 between the predicted erosions and the measured erosions is 0.7084, which means that more than 70% of the measured bank erosions could be explained by the regression model. The methodology used in the model specification well predicts the characteristics of stream bank erosion. Notice that the relevant explanatory variables in the regression model generated from the validation process are not necessary the same as those in the final model specified using all observations because those two models are specified using a different number of observations.

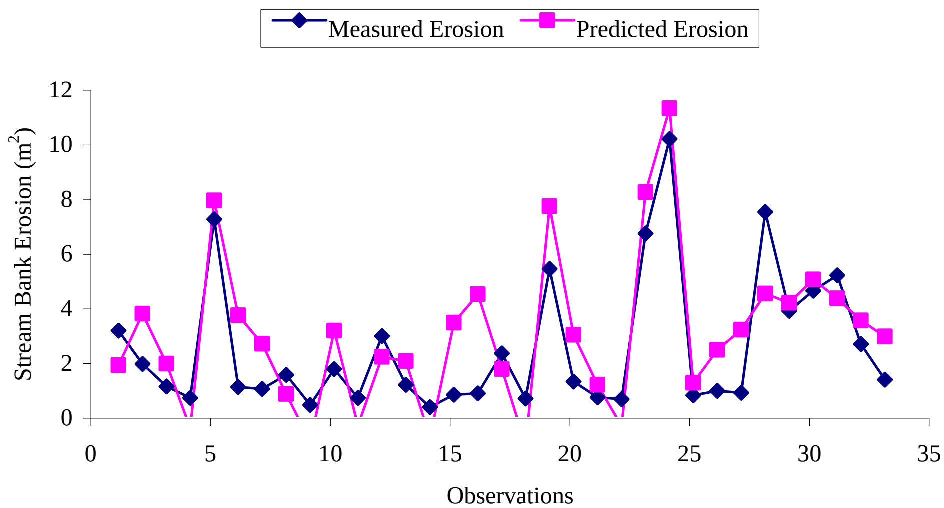

Figure 4: Comparison between the Predicted Erosion and Measured Erosion

Model Comparison

To further evaluate its predictability, the regression model developed in this study is compared with two existing bank erosion prediction models: Rosgen's Streambank Erosion Prediction Model (1996) and the Bank Stability and Toe Erosion Model developed by the United States Department of Agriculture, Agriculture Research Service (http://msa.ars.usda.gov/ms/oxford/nsl/cwp_unit/bank.html). The accuracy of prediction is measured by using three statistics: Mean Square Error (MSE), Mean Error (ME), and Mean Absolute Error (MAE) (Frees 1996). The results show that the regression model predicts the stream bank erosion in the Batavia Kill watershed more accurately than the other two models (Chen 2005). The MSE, ME, and MAE computed from the regression model are always smaller than those calculated from the other two models in absolute value.

EVALUATE STREAM RESTORATION IN REDUCING BANK EROSION

The stream bank erosion prediction model specified using all observations is applied on the Batavia Kill stream to evaluate the effectiveness of stream restoration projects in reducing bank erosion. Suppose there were no stream restoration, the bank erosion at project sites can be estimated using the prediction model given the pre-restoration conditions. The hypothetical bank erosion ("without restoration" case) is compared with the measured bank erosion at restored reaches ("with restoration" case). If the bank erosion estimated in the "without restoration" case is much greater than the erosion measured in the "with restoration" case, the stream restoration is said to be effective in reducing bank erosion. Otherwise, the stream restoration is ineffective in reducing bank erosion.

Table 5 compares the stream bank erosion measured at the restored reaches on the Batavia Kill stream from the completion of each project to the summer of 2003 with the erosion estimated by the prediction model over the same time period assuming no stream restoration. The total volume of measured stream bank erosion at the project sites is 2,685 m^3, and the total volume of bank erosion estimated by the prediction model in the "without restoration" scenario is 10,145 m^3. The "without restoration" case would produce 3.8 times more bank erosion than the "with restoration" case. The volume of reduced bank erosion by stream restoration is 7,460 m^3, which could fill about 1,000 dump trucks. The effectiveness of stream restoration in reducing stream bank erosion is significant.

Table 5: Comparison of Measured Erosion and Predicted Erosion

Project Reaches	Time Period	Reach Length (m)	Measured Erosion Volume at Restored Project Reaches (m^3)	Predicted Erosion Volume Assuming No Stream Restoration (m^3)
Maier Farm	09/99 -06/03	500	1,743	2,465
Brandywine	07/00 -06/03	1,100	226	5,048
Big Hollow	06/02-07/03	1,430	716	2,632
Sum		3,030	**2,685**	**10,145**

CONCLUSION

In this study, multivariate regression is used to relate stream bank erosion to various explanatory variables. These variables include instruments representing geomorphological characteristics, flow conditions, rainfall conditions, temperature, the vegetation index, soil erodibility, and sediment characteristics. The general to specific approach is used to derive a best-fit model to predict the stream bank erosion. The final model selected by this specification procedure shows that the higher the bank angle, sinuosity, and stream flow, the greater the amount of stream bank erosion; contrarily, the higher the vegetation coverage on the stream bank, the less the amount of bank erosion. The first order derivative analysis shows that for most reaches on the Batavia Kill stream, bank erosion is directly related to the cross-section area and inversely related to the cross-section mean depth, which means that wide and shallow reaches on the Batavia Kill stream have the potential to incur more bank erosion.

A set of tests has been applied on the bank erosion prediction model to test the model precision and to validate the methodology used to specify the model. These tests show that the stepwise regression model well predicts the stream bank erosions on the Batavia Kill stream. The regression model is then employed to predict stream bank erosion on the project reaches, assuming there was no stream restoration. The results show that from the completion of each project to the summer of 2003, the restoration projects reduced the stream bank erosion by 7,460 m^3. The effectiveness of stream restoration in reducing stream bank erosion in the Batavia Kill watershed is significant.

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