Broadstreet Hollow Stream Restoration Project

IMPLEMENTATION & MONITORING REPORT

Broadstreet Hollow
Town of Lexington, Greene County, NY

UPDATED
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Greene County Soil & Water Conservation District
Catskill Mountain Chapter Trout Unlimited
Ulster County Soil & Water Conservation District
US Army Corps. of Engineers
Project Landowners

For Additional Information
http://www.gcswcd.com/stream/broadstreet

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1.0 Project Background

The Broadstreet Hollow stream, located in the Catskill Mountains, is a tributary to the Esopus Creek, and a contributing sub-basin to the Ashokan Reservoir. On January 19, 1996, the Catskills experienced a heavy mid-winter rain and unseasonably warm temperatures causing rapid snowmelt, extreme runoff, and extensive flooding. During the flood event, an isolated area of the Broadstreet Hollow stream experienced severe instability, resulting in more than thirty feet of lateral erosion. The erosion caused structural damage to one home and threatened several other structures in the area.

The Natural Resources Conservation Service (NRCS), in partnership with the Town of Lexington, provided assistance under the Emergency Watershed Protection Program (EWP). The emergency project rebuilt the streambank, to the pre-flood position, using stream channel sediment, and provided stabilization of 475 feet of streambank using heavy rock riprap. During the EWP project, the contractor and town highway department experienced significant difficulties with clay deposits that had become exposed in the stream channel. The final cost of the stabilization project was $45,597.

The EWP measures resulted in a straightened, over-widened stream channel and hardening of the outside meander bend. Additionally, the emergency action resulted in the loss of streambed armor, as the coarse cobble and small boulder material was used to restore the eroded streambank. Removal of the streambed armor material exposed deep deposits of glacial, lacustrine clay in the valley floor. The stream channel became more susceptible to increased levels of instability due to the combination of bank hardening, loss of streambed cover and the increased channel slope. Between early 1996 and the fall of 1999, the stream reach experienced severe degradation, leading to the de-stabilization of the high slope adjacent to the channel. The slope experienced a rotational failure, causing mass wasting and a bulging mass of lacustrine clay in the stream channel.

In the fall of 1999, flood conditions associated with Tropical Storm Floyd further degraded the stream channel. Rapid incision of the channel, paired with saturation of the adjacent hill slope, accelerated the rotational failure of the adjoining slope. This resulted in the development of an artesian formation, which created a constant upwelling of highly turbid groundwater. The turbid condition prevailed during both low and high flow conditions, with the stream remaining turbid from the project site to the confluence with the Esopus Creek.

The project area required mitigative action, which focused on reach restoration, in order to balance multi-objective project benefits with the immediate threat to water quality and erosion. The Broadstreet Hollow Stream Restoration Project was initiated, and represents a cooperative effort between the Greene County Soil and Water Conservation District (GCSWCD), the Ulster County Soil and Water Conservation District (UCSWCD) and the New York City Department of Environmental Protection Stream Management Program (NYCDEP SMP).

In the sections that follow, the coordination, design, construction and monitoring components of the Broadstreet Hollow Stream Restoration Project will be described. It is the intent of this document to be a working report displaying the status and performance of the Broadstreet Hollow project as it progresses.

2.0 Project Location

The project site is located along 1,100 feet of the Broadstreet Hollow stream channel, adjacent to Broadstreet Hollow Road in the Town of Lexington, Greene County. Broadstreet Hollow Road is located approximately 2 miles west of Phoenicia and 1/4 mile East of the NYC portal exit of the Shandaken Tunnel. The project reach is located between Jay Hand Hollow Road (entrance road to Camp Timberlake) and the next county bridge upstream along Broadstreet Hollow Road.

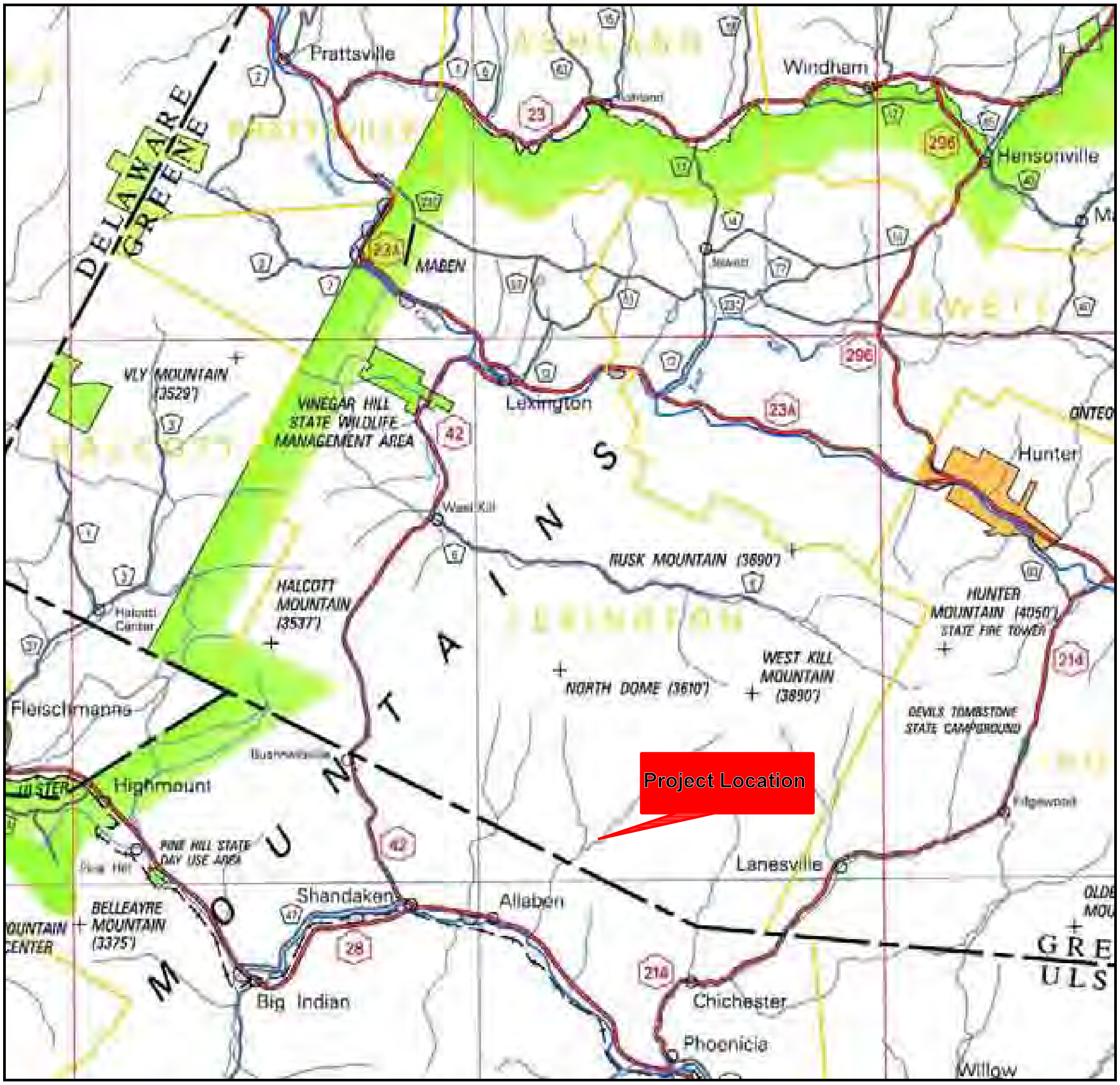

Figure 1. Project location map

3.0 Reach Stability Assessment

The severe conditions of the instability generated an immediate priority for the mitigation of the site's water quality impacts and assessment of the stability. Numerous assessments of the reach's physical stability were performed by various project partners prior to mitigation. The following general reach characteristics were documented and are summarized as follows:

- The reach was experiencing substantial streambank and bed erosion. In 1999, the project reach was characterized as having 600 linear feet of eroded streambank. The majority of the lower streambank and streambed contained fine clay material, amplifying turbidity of the flows through the reach.

- In addition to the lateral migration experienced during the 1996 flood event, the stream channel also experienced degradation. The degradation process was compounded by grading activities during the emergency repairs, which removed the little remaining cobble armor on the channel bottom. The channel incision further exposed deep, highly erodible lacustrine clay deposits.

- The degradation of the channel continued between 1996 and 1998, causing the adjacent high bank in the middle of the project reach to experience a geotechnical slope failure. Monitoring of the site revealed repeated sliding of a deep seated rotational plane, resulting in mass wasting and a bulging mass of lacustrine clay in the stream channel. The exposed clay in the rotational plane, and the failing streambanks presented a persistent water quality problem, due to a large supply of highly erodible colloidal soil materials.

- In September of 1999, Tropical Storm Floyd caused severe flooding and further down-cutting into lacustrine clays. An artesian formation appeared in the streambed creating a constant upwelling of highly turbid groundwater. A detailed geotechnical investigation was initiated which revealed a sand lens, approximately 4 - 5 inches thick, located under approximately 30 feet of glacial lacustrine clay. The artesian condition developed as the pressurized water in the sand lens pushed upwards through the clay material entraining clay particles. The formation amplified year round turbidity measurements taken in the stream channel, often averaging well over 60 NTU during base flow conditions.

- The evaluation of historic aerial photographs revealed substantial floodplain fill and straightening of the channel sometime after 1968. A pre-construction topographic survey of the project site and photographs taken after the January 1996 flood event were used to document the location of the eroded meander bend after the 1996 flood event. Historical aerial photographs were matched to the survey to document historical changes in the channel plan form. The assessment revealed that the stream channel had eroded over 27ft arresting approximately five feet from its pre-development location.

- Compounding the constraints affecting the project reach is the relatively steep and narrow watershed contributing to the reach. The watershed drainage area to the project site is approximately 5 mi^2 with an average valley slope of nearly 8%. The existing roadway, multiple bridge structures and adjacent homes also provide further confinement of the floodplain.

4.0 Restoration Project Goals and Objectives

As the GCSWCD and NYCDEP reviewed the condition of the reach, and its potential for restoration, numerous additional objectives were identified. Water quality was negatively affected by the existing site conditions. The partners proposed that restoration of the reach presented the opportunity to reduce this impact while meeting a wide range of objectives and providing a number of environmental benefits. The goals and objectives of the project were separated into two main categories and are outlined below.

4.1 Primary Goal

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

> ***To mitigate existing turbidity and TSS related water quality impacts associated with: lateral and vertical erosion, impacts from the artesian formation, and rotational failure in the project area.***

4.2 Secondary Objectives and Benefits

- Provide long term channel stabilization, to reduce property and structural damage, 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 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. These physical constraints were manmade and natural, and were inventoried, and incorporated into the 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 final project design needed to incorporate techniques for completing the project construction in areas containing large volumes of saturated lacustrine clay. Additional project constraints included the close proximity of the stream channel to the adjacent homes, which limited the style of construction and increased the staging time and costs of the project. Access to the project site was limited and would required the construction of several temporary access roads.

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 in Landowner Project Agreements, which is a temporary agreement between the landowner allowing for the project construction, maintenance and monitoring.

The restoration of the Broadstreet Hollow 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). The restoration project was authorized under Article 15 of ECL by the NYSDEC and Nationwide 27 by the ACOE.

5.0 Restoration Methodology and Strategy

Alternative strategies, that best reflected the project objectives, were evaluated to reach a common consensus between stakeholders and financial partners. The reach was highly unstable and it was believed that current channel processes would continue to impact the Broadstreet Hollow resource. To meet the numerous goals, set forth by project stakeholders, a restoration strategy focusing on the geomorphic form of the channel was chosen. This required classification of the current condition and the development of a preferred physical morphology for the restored channel. Through further refinement of goals, identification of project constraints and alternative analysis, the following strategy was developed for restoration:

- Develop a channel geometry and profile that will provide stability, maintain equilibrium (form), and maximize the stream's natural potential.

- Develop a new channel plan form which will result in a meander radius and geometry more consistent with a stable stream morphology, while reducing the existing threat to the adjacent structures.

- 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 clay material would reduce the potential for the future entrainment of clay particles.

- Re-elevate portions of the incised stream channel, to utilize the active floodplain, in order to reduce the potential for further channel incision.

- Construct the appropriate “geomorphic style” structures, to provide grade control consistent with the proposed stream channel, in order to mitigate degradation of the stream channel into the clay layer, re-establish a natural step-pool bed configuration, and provide for bank stability.
- Install multiple groundwater relief wells along the rotational failure in order to provide pressure relief to the artesian formation and assist in mitigating the upwelling of turbid groundwater.

- Re-establish an effective riparian buffer of trees, shrubs and deep rooted grasses.

- Provide habitat, recreation and aesthetic enhancements concurrent with the creation of a naturally functioning step-pool morphology and re-vegetated riparian area.

In 1998, the GCSWCD initiated the development of a restoration design for the project reach. Topographical surveys were conducted by a licensed surveyor and supplemented with geomorphic assessments and surveys performed by the GCSWCD and NYCDEP. Reference reach data, from a site located approximately 1/4 mile upstream of the project reach, was collected for use in the project design. The reference reach was a B3a stream type, with the streambed characterized by well imbricated cobbles and boulders. The moderately steep channel was typical of a stable step-pool channel morphology within this particular valley setting, and provided pertinent data for application to the project reach.

The project design incorporated a number of data sources including the reference reach data, regime analysis and analytical methods. The data was documented and evaluated against the available resources for the proposed restoration strategy. It was determined that the assessment and design would utilize data collected from various reference reaches within the region, typical values developed by Dave Rosgen and others, as well as published regional and provisional curves developed for the Catskills by the GCSWCD and NYCDEP. Analytical methods including HEC RAS modeling for flood flow analysis as well as various geotechnical stability models were utilized in the design process.

5.1 Channel Morphology

The dimensions and scale of the proposed stream channel were designed to be applicable through a full range of flows and to meet considerations for sediment transport and channel boundary conditions. Regime, tractive force and analytical type analyses were utilized in order to develop an appropriate reconfiguration.

The final design incorporated a channel cross section which would partially reduce stream entrenchment. This was accomplished partially, by re-elevating the channel profile to allow for re-connection with the adjoining floodplain, and by developing a multi-stage channel. The design cross section included a lower bankfull channel and a higher flood prone channel, which provided floodplain relief. HEC-RAS analysis was used to model flood flow to ensure that the restoration project would not further impact the residential structures during large flow events. The bankfull and floodplain dimensions were iterated using the model to provide for optimal flow conditions and effective sediment transport.

The channel alignment was created using regime and reference conditions paired with the analysis of historical aerial photography. The final plan form included modifications to account for valley slope, landform constraints, adjacent homes and the two existing bridge structures. Residential structures along the left bank and steep upland slopes on the right bank presented severe limitations to the available stream belt width through the project reach. Limited alternatives were available to mitigate the previous loss of channel sinuosity and resulting increase in slope. The final plan form included shifting the upper meander toward the west and slightly changing the radius of both meanders. Extensive effort was made to minimize disturbance, to the existing vegetation, caused by the meander adjustments. Table 1 summarizes average bankfull channel variables of the pre-restoration channel, reference reach and design channel.

The channel profile was created by utilizing slope characteristics of the valley, stream channel and existing floodplain terraces. The channel slope was constrained, vertically through the reach, by clay layers that would be in close proximity to the channel invert. The profile design included consideration for channel sinuosity, valley slope, channel dimension, sediment characteristics and flood conveyance. The design slope also considered the volume of cut and fill material, associated cost, and feasibility for construction.

The final design profile includes bed form variations typical of a step-pool morphology. The addition of cross vane structures provides an effective method to ensure profile stability while maintaining a step-pool morphology. Scour pools were created downstream of the cross vane structures in order to provide energy dissipation and to mimic the natural bed form characteristics. In total, thirteen cross vane structures were added through the project reach to provide grade control, to assist in providing lateral stability and to maintain a natural step-pool configuration for fisheries habitat.

Table 1: Comparison of average morphological values

Variables	Existing Channel	Proposed Reach	Reference Reach
Stream Type	F3b	B3	B3a
Drainage Area (mi^2)	4.55	4.55	4.03
Bankfull Width (ft)	39.0	28.2	26.4
Bankfull Mean Depth (ft)	1.89	1.45	1.35
Width / Depth Ratio	21.0	19.5	19.5
Bankfull Cross Sectional Area (ft^2)	72.5	41.0	35.1
Bankfull Mean Velocity (ft/sec)	-----	5.0	5.2
Bankfull Discharge (cfs)	-----	205	177
Bankfull Maximum Depth (ft)	2.58	2.60	2.42
Width of Flood Prone Area	50.8	45.1	42.3
Entrenchment Ratio	1.3	1.6	1.6
Meander Length (ft)	733	733	698
Meander Length/Bankfull Width	18.7	26.0	26.5
Radius of Curvature (ft)	419, 280	310, 280	260
Radius of Curvature / Bankfull Width	10.7, 7.2	11, 9.9	9.9
Belt Width (ft)	134.6	161.0	150.5
Meander Width Ratio	3.5	4.9	5.7
Sinuosity	1.10	1.10	1.10
Valley slope	0.06	0.06	0.06
Average Slope	0.03	0.03	0.05

5.2 Slope Failure & Artesian Formation

The rotational slope failure, occurring along the wooded area on the north bank of the project reach, was documented and surveyed by NYCDEP SMP staff and subsequently analyzed by Daniel G. Loucks, P.E., for incorporation into the project design.

- Soil borings revealed an upper layer of gravel and silt that extends between seven to nine feet in depth with a layered silt and clay layer extending an additional thirteen to thirty feet.
- A thin layer of clean sand was encountered between 26 and 30 feet.
- A single observation well was installed into the sand layer to monitor the groundwater levels. The level of the groundwater increased in the well to approximately 2.1 feet below the existing ground surface. This condition would presumably cause the artesian condition in the stream.
- A computer-aided stability analysis was used to analyze the failure slope and to assist in determining possible ways of improving the stability of the failure. Existing conditions verified a factor of safety less than 1.0.

The analysis indicated that the slope failure and resulting artesian formation were likely caused by excess water pressure that existed in the sand layer below the bottom of the stream. The water pressure would cause the sloping area to move toward the stream when the pressure increased and/or the stream bottom eroded enough to cause an instability on the slope.

In order to mitigate the effects of the rotational failure and the artesian formation several techniques were incorporated into the design and construction. The final design included re-grading the riparian area, along portions of the slope failure, in order to remove excess weight from the slide and to prepare the area for the installation of three groundwater relief wells. The relief wells were to be spaced along the failure and were to be installed 35' - 40' deep in order to relieve the pressure associated with the artesian condition below the streambed.

Construction of relief wells involved drilling a 14" diameter boring with a steel casing into which a 6" slotted PVC well point was placed. The casing was filled with a coarse gravel drainage envelope and then the casing was removed leaving the PVC well. The drainage envelope was capped with bentonite to maintain the artesian condition in the relief well. Each relief well included a solid PVC connecter pipe in order to allow the clear groundwater to gravity feed from the relief well into the adjacent stream channel.

5.3 Clay Materials

The project reach was characterized by extensive exposures of glacial clay material. To mitigate the water quality impacts of the clays, 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 3 - 4 feet of clay material, below the finish grade of the project design. The over-excavation of clay material would reduce the potential for the future entrainment of clay particles. The additional weight provided by the exchange in material would also assist with providing counterbalance to the rotational failure.

5.4 Riparian Vegetation

The project design includes the use of traditional bioengineering practices to provide for increased streambank stability and to initiate riparian vegetation growth in the disturbed areas. Over 1,000 feet of live willow fascines and over 200 willow stakes were incorporated through the project reach for installation along high stress streambank areas. Short term stabilization of the disturbed areas are seeded and hydro-mulched using a conservation seed mixture. Additional planting will be accomplished in the riparian areas as needed using various native trees and shrubs.

5.5 Special Considerations

The project design included relocating the stream channel closer, from 26ft. to 13ft., toward one of the homes on the lower portion of the project reach. A retaining wall was proposed for installation behind the residence and further evaluated by project engineers. It was determined that a lateral soil pressure between 20 and 40 psf per foot could be used for the retaining wall design, depending on backfill conditions. The resulting design included a stacked and pinned rock wall for installation behind the residence. The wall included large block shaped boulders stacked nearly vertical with steel pins drilled and inserted through the rock to join the wall. The addition of the stacked rock retaining wall would provide an economical alternative while providing adequate protection to the structure during high flow events.

6.0 Project Implementation

6.1 Project Bidding

A project bid package was developed to include drawings and specifications for the proposed project. The project was publically bid using a competitive bid process to select a contractor. Due to the relatively short time between the public bid and the proposed commencement of construction, as well as the extreme site conditions, only two bids were submitted for the project. The final accepted project bid is summarized in Table 2.

6.2 Project Construction Time Line

Construction of the new stream channel and cross vane structures required approximately 45 calendar days. Project construction was initiated on September 15, 2000, beginning with channel excavation and relief well installation. Completion of the primary channel construction ended on October 31, 2000. Bioengineering components were initiated immediately following the channel reconstruction and continued into November of 2000.

6.3 Project Construction Details

Table 2: Final Project Bid

Bid Item	Estimated Quantities	Contractor - Bid Price	
		Unit Bid Price	Total Price
Mobilization	----------	----------	$13,500.00
Clearing/Grubbing G	----------	----------	$6,500.00
De-watering	----------	----------	$25,000.00
S.C. Excavation	----------	----------	$7,500.00
Cross Vanes	1500 tons	$39.00	$58,500.00
Clay Removal	2000 yd^3	$20.00	$40,000.00
Coarse Gravel	3000 yd^3	$17.90	$53,700.00
Fine Gravel	2000 yd^3	$16.50	$33,000.00
Stacked Rip Rap (wall)	100 ft	$112.00	$11,200.00
Steel Pins	250	$30.00	$7,500.00
Live Fascines	1000 ft	$4.25	$4,250.00
Live Posts	200	$8.00	$1,600.00
Relief Wells	105 ft	$460.00	$48,300.00
		Total Bid Price	$310,550.00

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 B along with photographs highlighting project construction in Appendix A.2 and A.3. A summary list of project construction details are provided below.

- A temporary access road was created along the right bank floodplain to allow for equipment to access and grade the area along the rotational failure. A temporary bridge was installed across the stream channel to allow for access by the drill rig to begin the installation of the three relief wells.

- The active work zone was de-watered by pumping all upstream flow around the work area. Due to the close proximity of homes around the project site, a two stage de-watering plan was required. Stream flow was pumped using a 10" submersible electric pump and piped through sealed pipeline through adjacent properties.

- Stream channel excavation began at the top of the project area and continued downstream. Over-excavated clay material was hauled from the project site, rock cross vanes were installed and fill material was added to re-grade the final channel bottom.

- The final project required the movement of over 8,000 cubic yards of material and the excavation and replacement of approximately 2,720 cubic yards of clay material from the streambed and streambanks. The excavated clay material was hauled to a safe, upland disposal area. The replacement material consisted of a coarse cobble/gravel material in the streambed and a finer bank-run material on the banks and flood prone areas.

- The saturated clay condition through the project area made construction extremely difficult and provided minimal stability for the equipment. Channel excavation and rock structure installation was accomplished primarily using excavators and working from construction mats made from large timbers.

- Sediment and erosion control was accomplished by collecting turbid water at the bottom of the reach, prohibiting its release to downstream reaches and pumping the turbid water to grassy areas for natural filtration.

- The project included the installation of 13 rock cross vane structures utilizing approximately 940 tons of rock. Rock was obtained from a local quarry, and contained individual pieces hauled to the project site ranging from 2 -10 tons each.

- After the stream channel work was completed, a steel sheet pile wall was installed behind the residence on the lower portion of the reach. The sheet pile wall was substituted for the stacked rock wall after further investigations by the project engineer. It was determined that the structural foundation of the residence was not suitable for withstanding the necessary excavation near the home for the installation of the stacked wall.

- Final grade work was completed in the floodplain and the bioengineering was installed. The bioengineering included native willow fascines and stakes obtained from a local source. Conservation seed mix was used to provide temporary stabilization to the disturbed project areas. Live material transplants and bare root seedlings were installed in the floodplain areas.

6.4 Project Constructability

The project area encompassed two county bridges as well as several private structures in close proximity to the channel. Access to the project area through private property was necessary and permitted using landowner agreements, prior to the start of construction. The temporary access points were limited and provided minimal space for mobility and project staging, requiring the use of specific equipment for implementation.

Construction of the new channel and floodplain was performed, nearly completely, using excavators working from the upper banks. The excavators were required to have a hydraulic thumb apparatus capable of handling the boulders used for the construction of the cross vane structures. Further, the glacial clays presented a stability problem for construction equipment due to clay liquefying from the machine vibration. Timber construction matting was used to prevent the heavy equipment from sinking into the clay and rock structures were forced to be expeditiously installed in order to prevent further instability.

6.5 Project Construction Modifications

The initial project plans included the installation of a stacked rock retaining wall to protect a single residence located along the left bank of the project reach. The proposed stacked rock retaining wall was modified to a steel sheet pile wall after the determination that the house foundation was inadequate to withstand the necessary excavation. The detail was modified during construction after an initial inspection revealed the house was located on stacked block and did not rest on adequate footing.

6.6 Project Construction Cost

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

Table 3. Summary of final construction costs.

Bid Item	Item Description	Final Quantity	Final Cost
1	Mobilization/Demobilization	----------	$13,500.00
2	Clearing/Grubbing	----------	$6,500.00
3	De-watering	----------	$25,000.00
4	S.C. Excavation	----------	$7,500.00
5	Cross Vanes	938.56 tons @ $39/ton	$36,603.84
6	Clay Removal	2,718 yd^3 @ $20/$yd^3$	$54,360.00
7	Coarse Gravel	4,292 yd^3 @ $17.90/$yd^3$	$76,826.80
8	Fine Gravel	440 yd^3 @ $16.50/$yd^3$	$7,260.00
9	Sheet Pile	1998 ft^2 @ $28.50/$ft^2$	$56,943.00
10	Live Fascines	1000 ft @ $4.25/ft	$4,250.00
11	Live Posts	200 @ $8.00/post	$1,600.00
12	Relief Wells	123ft @ $460/ft	$56,580.00
		Total Contract Cost	**$346,923.64**
Change Orders (not including the substitution of steel sheet pil for stacked rock wall)			
CO1	Well Lid	replacement of well lid	$236.25
CO2	Water	provide water to shallow wells	$1,796.55
CO3	Sheet Pile Wall	excess rock drilling and bracing	$4,960.00
CO4	Waste Disposal	old fuel tank found during excavation	$150.00
		Total Change Orders	**$7,142.80**
		Complete Project Total	**$354,066.44**

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, sheet pile wall, relief wells, 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 as well as fisheries 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 necessary for the maintenance of a stable morphology. In order to document the changes in morphology and project stability, monitoring surveys have been initiated in the project reach.

The monitoring of the project includes pre-construction surveys, an as-built survey, and multiple post-construction monitoring. The physical performance of the channel is monitored using surveys to minimally include 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 association to hydrologic inputs associated with storm events and sediment transport.

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 NCD projects and treatments in the watershed. Specific project inspections and monitoring reports are summarized in Appendix F.

7.2 Fisheries Assessment

The USGS, in cooperation with the NYCDEP SMP and the GCSWCD, inventoried fish communities in stable, unstable, and control reaches from several streams in southeastern New York State as part of a stream restoration demonstration program. Major objectives of the fishery monitoring effort are to determine:

- If fish populations and communities differ between stable (reference) and unstable (control and project) stream reaches

- If improved stability of restored reaches is reflected by improvements in affected fish populations and communities.

Fishery surveys in the Broad Street Hollow Basin were completed before restoration of the unstable project (treatment) reach was done. Inventories were completed at project/treatment and reference reaches in the summer of 1999 and at all 3 reaches in 2000 and 2002. 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 on experience with local conditions, and the five NCD projects completed to date, 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 reestablishment of vegetation and adjustments/repairs to rock structures. It is critical to have a clear understanding that typically, restoration goals are not achieved the day the contractor leaves the project area, 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. The Broadstreet Hollow Operation and Maintenance Plan is included, in draft form, in Appendix C.

A management plan and strategy is currently being developed for the Broadstreet Hollow watershed by the NYCDEP SMP and the Ulster County SWCD. The plan will provide a working document to assist with resource management in the watershed, which will ultimately assist in the operation and maintenance of the project reach.

A Landowner Guide for the adjacent property owners is included in Appendix D. The focus of the Landowners Guide is to support and educate the landowners around the project area regarding the physical components of the stream channel, floodplain, and project vegetation. Additionally, the Landowner Guide incorporates distinct actions the landowners will need to follow in order to maximize the benefits from the restored project reach. These actions include, defining the roles of the project stakeholders, techniques for managing riparian vegetation, accessing the stream, modification of the plan, general advice, as well as project contacts and general information.

8.1 Rock Structures

In stream rock structures may require some modification and enhancement. This is detailed in the Operation and Maintenance Plan for the site, which addresses the replacement of rocks to ensure structural integrity, intended functions of the vanes, and debris and sediment maintenance considerations. The Operation and Maintenance Plan also outlines the modification and repair, as well as monitoring schemes.

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 addressed in the monitoring component of the Operation and Maintenance Plan and the Landowners Guide found in the attached appendices.

Appendix A

Photographs and Descriptions

A.1 Preconstruction 1996 - 2000

A.2 Project Construction 2000

A.3 Project Construction 2000

A.4 Completed Project Construction 2000

A.5 Flood Event: December 2000

A.6 Post Flood Inspections: 2000 - 2001

A.7 Project Repair & Maintenance - 2001

A.8 Project Inspection - October 2002

A.9 Project Inspection - June 2003

A.10 High Flow Event - September 2003

A.11 Project Inspection - May 2004

A.12 Project Inspection High Flow Event - April 2005

A.13 Project Inspection - May 2005

A.1 Preconstructing 1996-2000

Photograph 1: Structural and property damage at the Torregrossa residence resulting from the 1996 flood event.

Photograph 2: Structural and property damage at the Torregrossa residence resulting from the 1996 flood event. The close proximity of the residential structures along the left floodplain are prone to future threats by erosion and bank failure caused by the channel instability.

Photograph 3: Channel degradation occurring through glacial clay at the base of the adjacent rotational failure. The rotational failure is denoted by the erosion and angled vegetation along the left portion of the photograph, as well as the bulging formation of clay in the center of the stream channel. The artesian formation is present in the right portion of the image contributing high turbidity during low flow periods.

Photograph 4: The EWP stabilization utilized natural channel armor (boulder & cobble) material for fill to replace the eroded streambank which exposed the underlying glacial clay. Extreme difficulty resulted in the completion of EWP construction and the instability of the channel increased.

Photograph 5: A 1999 aerial photograph showing the extreme turbidity produced from the from the artesian formation during base flow conditions. The rotational bank failure is present in the left of the photograph.

Photograph 6: The artesian formation producing highly turbid flow during base flow conditions.

A.2 Project Construction 2000

Photograph 7: Drilling the first of three artesian relief wells which were designed to alleviate groundwater pressure. Substantial vegetation and earth were removed from the area prior to the well installation in order to provide access for the drill rig, as well as remove weight from the rotational failure.

Photograph 8: De-watering of the construction area was achieved using a 10" submersible electric pump located behind an inflatable water barrier. Stream flow was pumped through adjacent properties in two stages, using a sealed pipeline.

Photograph 9: Excavators were used as the primary equipment for completing the rough grading of the channel due the relatively narrow floodplain. Excavators worked primarily from construction mats due to the underlying clay material liquefying from the vibration of the equipment.

Photograph 10: Large quarry rock is delivered to the project site for use in the construction of the rock cross vanes. Layout of the project design was accomplished using survey equipment to stake out channel grades and rock structures.

Photograph 11: Over-excavated clay is removed from the channel bottom, while the excavator worked from construction mats. The construction of the stream channel and structures through the project reach was extremely difficult due to the limited site access, proximity of nearby homes, and clay content.

Photograph 12: Installation of a horizontal drain pipe into the adjoining relief well in order to reduce groundwater pressure. The horizontal drain pipes for each well were discharged through the arm of a nearby cross vane for aesthetic considerations and to provide cold water release into downstream scour pools.

A.3 Project Construction 2000

Photograph 13: Construction of rock cross vanes in the over-excavated channel bottom.

Photograph 14: Earthen coffer dams were used throughout the de-watered project reach to prevent turbid ground water and rain water from entering the construction areas.

Photograph 15: Wooden construction mats were used to provide a stable base for the heavy equipment to work from. Water is pumped from the excavation area while over-excavating clay material.

Photograph 16: The presence of lacustrine clay made construction extremely difficult. Clay was removed from the channel bottom and replaced with cobble/gravel mix to provide stability to the constructed channel bottom and reduce the stream contact.

Photograph 17: A steel sheet pile wall was installed along a 90ft. section of the channel to protect an adjacent home from future flood damage. The steel sheet pile wall was substituted for a stacked rock wall after the stability of the homes foundation was assessed and found to be unstable.

Photograph 18: Completed rock cross vanes before the final channel grading and scour pools were finished.

A.4 Completed Project Construction 2000

Photograph 19: Floodplain excavation and grading were completed using excavators after the installation of the rock structures and grading of the channel bottom.

Photograph 20: A mixture of cobble and gravel was used to replace the over-excavated clay material and raise the streambed to final grade. Finer material was imported to rebuilt sections of the floodplain.

Photograph 21: Floodplain excavation and grading were completed using excavators after the stream had been released into the constructed channel.

Photograph 22: The completed stream channel and floodplain were hydroseeded using a conservation mix and cellulose fiber mulch.

Photograph 23: Initial bioengineering was installed to include willow fascines. Fascines were placed along both streambanks and bankfull benches.

Photograph 24: The photograph represents the newly re-vegetated channel looking downstream through the lower portion of the construction area. The completed sheet pile wall can also be seen along the left streambank.

A.5 Flood Event: December 2000

Photograph 25: Cross Vane #1 actively redirecting stream flow during the December 17, 2000 flood event. This section of channel is located in the upper project area taken from the upper bridge looking downstream.

Photograph 26: The stream flow appears slightly above bankfull stage, between the second and third cross vanes. The constructed bankfull bench along the left bank is slightly underwater with stakes used in the fascine installation are noted in the center of the photograph.

Photograph 27: The extreme energy of the flood flow is displayed as well as the cross vanes effectiveness at dissipating energy and focusing flow toward the center of the channel.

Photograph 28: The image displays same cross vane in Photo 27 looking downstream through the reach.

Photograph 29: Flood flow through the area of the project reach where the erosion and damage from the January 1996 flood event occurred. Displayed is the proximity of the homes to flood flow are noted near the center of the photograph is the sheet pile wall nearly inundated.

Photograph 30: The image displays the bottom of the site looking upstream from the Timber Lake Bridge.

A.6 Post-Flood Inspections: 2000 - 2001

Photograph 31: The image displays the channel condition looking upstream through the project reach the day after the December 17th flood event. Minor erosion was noted through this portion of the reach and two cross vanes were noted with structural damage.

Photograph 32: The photograph shows the channel condition looking downstream from the same point as photo 31. Vegetation had not been established through the project reach before the flood event.

Photograph 33: A spring photograph taken prior to the development of vegetation. Note the comparison in water clarity to the preconstruction photographs.

Photograph 34: The image displays the channel from the uppermost bridge looking downstream in April of 2001. Cross vane structures appear to be functioning properly despite several problems caused by the December 2000 flood event.

Photograph 35: The image displays some minor bank scour near station 3+50 resulting from the flood event. The erosion is attributed to large voids which were located between the top rocks and footer rocks of the cross vane prohibiting deposition which should occur in this area.

Photograph 36: The image displays the void created at cross vane #1 from the undermining of the structures footer rock during the flood event. The depth of the scour hole behind the structure exceeded the placement depth of the footer rocks, causing rocks within the structure to shift.

A.7 Project Repair & Maintenance: 2001

Photograph 37: Repair and maintenance was made to the project in October 2002. The stream channel was de-watered and repairs were made to the structures show in the photograph.

Photograph 38: Excavators were used from the top of the streambank to make repairs and modifications. The area receiving the most damage during the flood event is shown in the photograph.

Photograph 39: Repair work to cross vane was completed by resetting several of the top rocks and filling the voids between the top rocks and footers. Additionally, coarser boulder material was placed below the scour pool to roughen the stream bed and provide additional stability.

Photograph 40: Cross vane #1 after the completion of repair and modifications.

Photograph 41: Cross vane #5 prior to the repair and modifications. Noted on the right of the photograph is a large boulder dislodged from the upstream cross vane and transported during the flood event.

Photograph 42: De-watering for project repair and modification was accomplished using a 10" submersible pump and sealed pipeline.

A.8 Project Inspection October 2002

Photograph 43: Cross vane #1, taken from the upper bridge during a storm event in October 2002. Note the change in water clarity from the preconstruction photographs.

Photograph 44: Repaired cross vanes structures functioning during a moderate flow event on October 12, 2002. This area received the most damage in the December 2000 event and a majority repair work in 2001. Apparent is the continued vegetative growth and properly functioning structures.

Photograph 45: The image shows the middle and lower portion of the project reach through the area where the artesian formation existed.

Photograph 46: After the recession of the October 12, 2002 flow, cross section #1 appears to be functioning properly during normal flow. (Reference image #43)

Photograph 47: After the recession of the October 12, 2002 flow, the middle and lower portion of the project appears to be functioning properly during normal flow. (Reference image #45)

Photograph 48: The lower portion of the project appears to be functioning properly under normal flow conditions.

A.9 Project Inspection June 2003

Photograph 49: The upper portion of the reach looking upstream through cross vane #1.

Photograph 50: The installed vegetation along the right bank continues increase establishment through the upper section of the project.

Photograph 51: Variation in stream profile, maintained by the cross vane structures, continues to provide physical habitat during low flow periods.

Photograph 52: A deep scour hole, located below cross vane # 7.

Photograph 53: The vegetation is slowly increasing establishment along the right bank area, along the face of the former rotational failure.

Photograph 54: The lower portion of the project reach, behind the Torregrossa residence, has remained stable.

A.10 Project Inspection September 2003

Photograph 55: Multiple storm events in August and September resulted in increased base flow through the project area.

Photograph 56: Vegetation growth in the upper reach of the project is increasingly adding to the bank stability.

Photograph 57: Looking upstream along the upper meander bend, the rock structures continue to redirect stream flow toward the central portion of the channel.

Photograph 58: The visual clarity of the water through the entire project area has remained high during moderate increases in stage and stream flow. The photograph views downstream through the area of the previous artesian formation and rotational failure. An inspection of the groundwater relief wells showed that the wells were working properly.

Photograph 59: Streamflow crested to the bankfull stage on September 28, 2003 leaving a well-defined debris line along the bankfull benches.

Photograph 60: The structures appeared to be functioning properly throughout the recession of the flow event.

A.11 Project Inspection May 2004

Photograph 61: View upstream at bridge at top of project reach.

Photograph 62: Looking downstream from bridge at upper bridge.

Photograph 63: First meander with establishing willow vegetation in foreground.

Photograph 64: Looking downstream through middle of reach, noting minor erosion at end of cross vane arm.

Photograph 65: View of sheet pile wall and vegetation establishment along right floodplain.

Photograph 66: Image looking downstream at lower bridge noting absence of turbid condition during normal flow.

A.12 Project Inspection April 4, 2005 Storm Event

Photograph 67: Looking upstream from Timberlake Bridge. Note the erosion on the left bank downstream from the sheet pile wall.

Photograph 68: A close up of the erosion as described in 67.

Photograph 69: A close up of the erosion as described in 67.

Photograph 70: The left bank of the stream near station 6+50.

Photograph 71: A wide angle view of the erosion as described in 70.

Photograph 72: The right bank near station 5+25. Note the location of the relief well and the erosion surrounding it.

Photograph 73: A close up of the well described in 72. Note that the lower pipe is disconnected from its outlet.

Photograph 74: Erosion on the left bank near station 5+75. Also in the photo is a nearby cross vane.

Photograph 75: The right bank near the cross vane at approximately station 4+60.

Photograph 76: The left keyway to the cross vane at approximately station 3+90.

Photograph 77: The possible high water mark of the storm on the left bank near station 3+50.

Photograph 78: View from the bridge at the top of the project site, looking downstream, specifically at the erosion along the right bank.

A.13 Project Inspection May 11, 2005

Photograph 79: View looking upstream at upper bridge noting minor right bank scour.

Photograph 80: Image looking downstream through middle of reach displaying right and left bank erosion and damaged well.

Photograph 81: Left bank erosion near cross section 4, at fourth downstream cross vane with exposed keyway.

Photograph 82: Right bank erosion near cross section 5 and exposed well casing.

Photograph 83: Left bank erosion near cross section 8.

Photograph 84: Right bank erosion near cross section 8 .

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Appendix A.1 Broadstreet Hollow Stream Restoration Project
Pre-Construction 1996 - 2000

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Appendix A.2 Broadstreet Hollow Stream Restoration Project
Project Construction 2000

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Appendix A.3 Broadstreet Hollow Stream Restoration Project
Project Construction 2000


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Appendix A.4 Broadstreet Hollow Stream Restoration Project
Completed Project Construction 2000

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Appendix A.5 Broadstreet Hollow Stream Restoration Project
Flood Event: December 2000

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December 18, 2000

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December 18, 2000

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April 12, 2001

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April 12, 2001

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July 18, 2001

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July 18, 2001

Appendix A.6 Broadstreet Hollow Stream Restoration Project
Post Flood Inspections: 2000 - 2001

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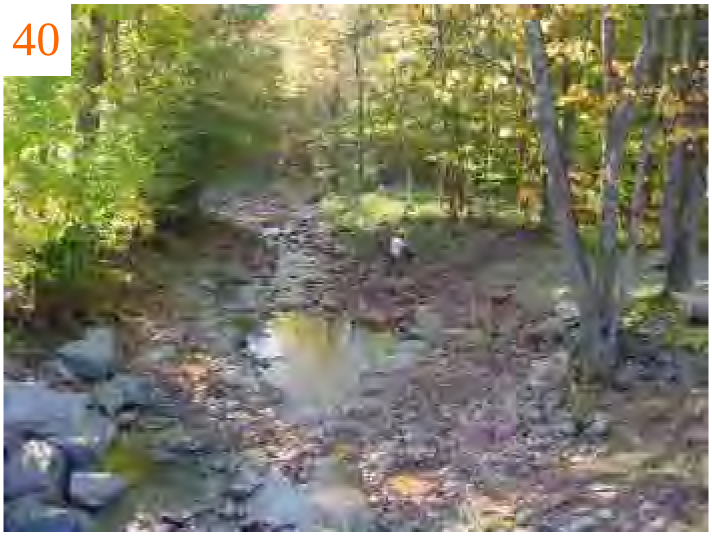

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42

Appendix A.7 Broadstreet Hollow Stream Restoration Project
Project Repair & Maintenance 2001

October 12, 2002

October 12, 2002

October 12, 2002

October 14, 2002

October 14, 2002

October 14, 2002

Appendix A.8 Broadstreet Hollow Stream Restoration Project
Project Inspection—October 2002

June 6, 2003

June 6, 2003

June 6, 2003

June 6, 2003

June 6, 2003

June 6, 2003

September 2, 2003

September 2, 2003

September 23, 2003

September 23, 2003

September 28, 2003

September 28, 2003

Appendix A.10 Broadstreet Hollow Stream Restoration Project
Project Inspection—September 2003

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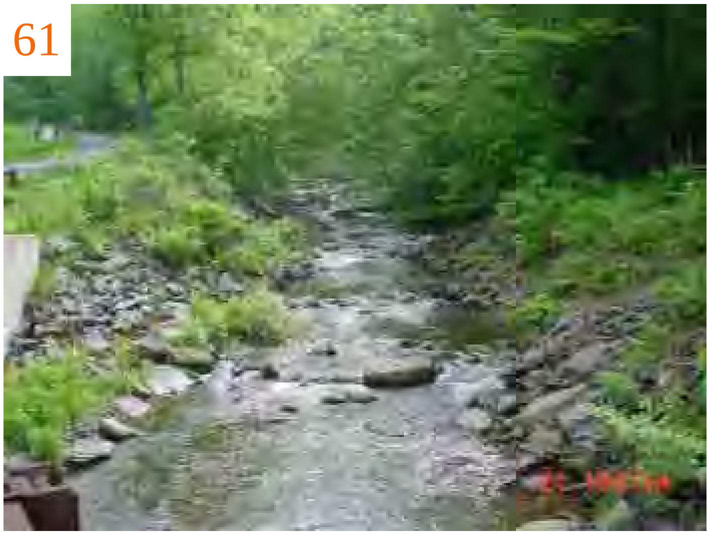

May 5, 2004

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May 5, 2004

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May 5, 2004

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May 5, 2004

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May 5, 2004

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May 5, 2004

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April 2, 2005

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April 2, 2005

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April 2, 2005

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April 2, 2005

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April 2, 2005

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April 2, 2005

Appendix A.12 Broadstreet Hollow Stream Restoration Project
Project Storm Event Inspection —April 2, 2005

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April 2, 2005

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April 2, 2005

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April 2, 2005

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April 2, 2005

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April 2, 2005

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April 2, 2005

Appendix A.12 Broadstreet Hollow Stream Restoration Project
Project Storm Event Inspection —April 2, 2005

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May 11, 2005

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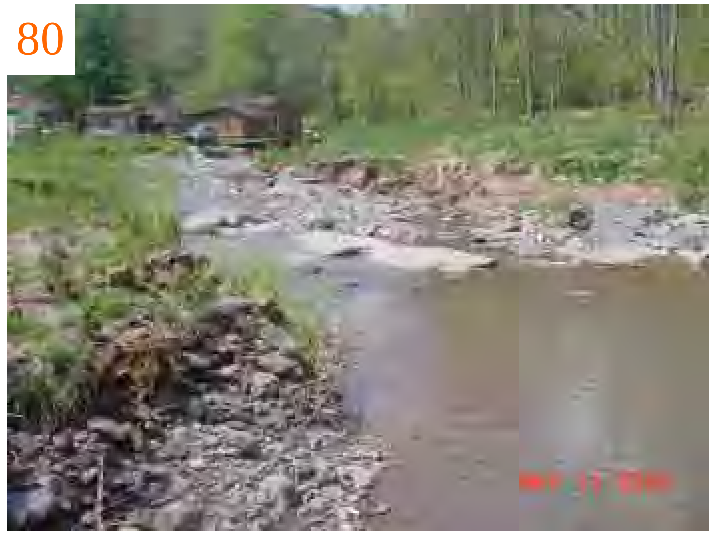

May 11, 2005

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May 11, 2005

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May 11, 2005

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May 11, 2005

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May 11, 2005

Appendix A.13 Broadstreet Hollow Stream Restoration Project
Project Inspection—May 11, 2005

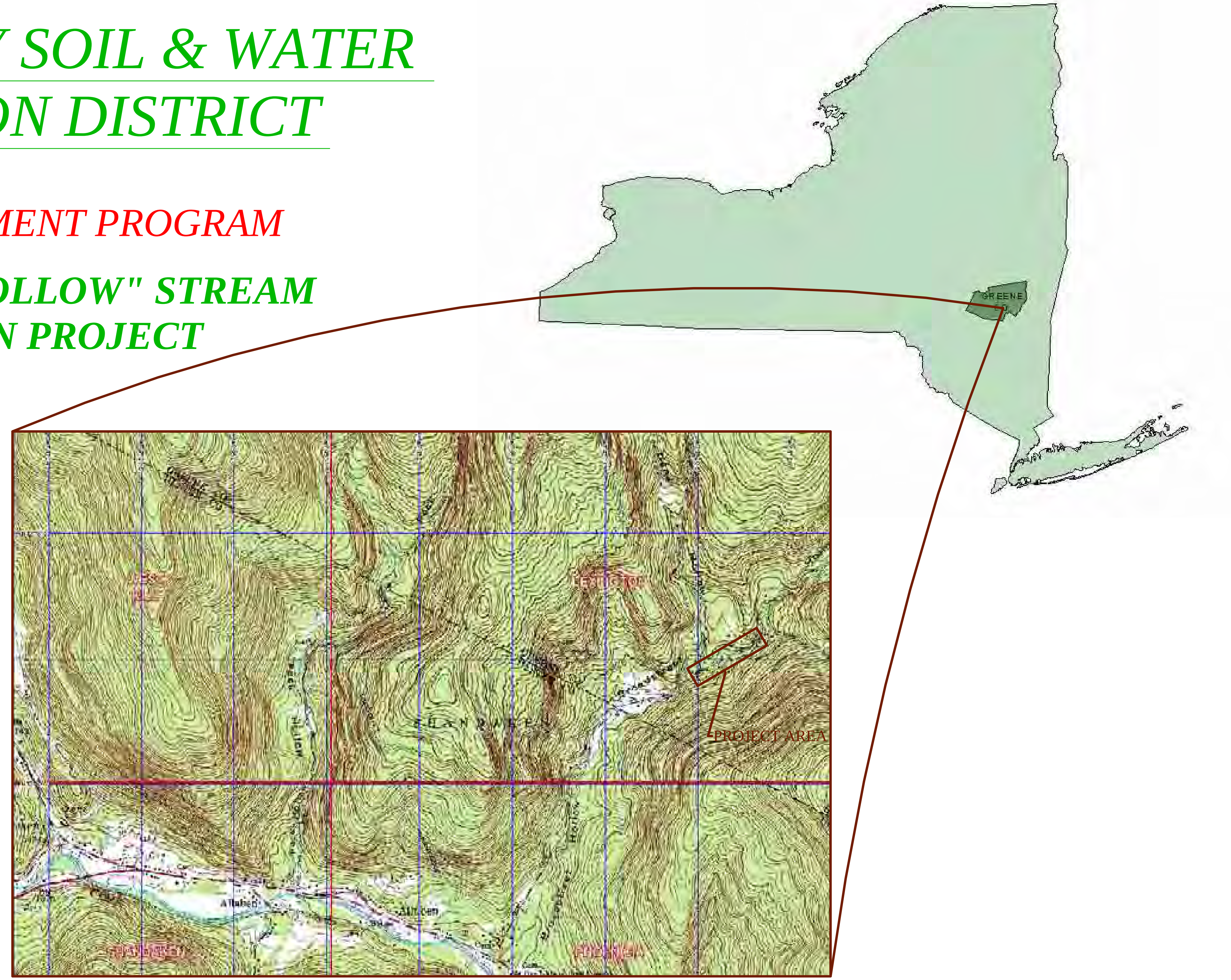
Appendix B

Project Design

GREENE COUNTY SOIL & WATER CONSERVATION DISTRICT

STREAM MANAGEMENT PROGRAM

"BROAD STREET HOLLOW" STREAM RESTORATION PROJECT



SITE LOCATION MAP
(NOT TO SCALE)

INDEX OF DRAWINGS

CALL (2) FULL WORKING DAYS BEFORE YOU DIG

1-800-962-7962

UPFO

IT'S THE LAW

KEA

KAATERSKILL ENGINEERING ASSOCIATES, PC

CAIRO, NY 518-622-9667 TANNERSVILLE, NY 518-589-3034

LEGEND

REVISIONS

BROAD STREET HOLLOW STREAM RESTORATION PROJECT

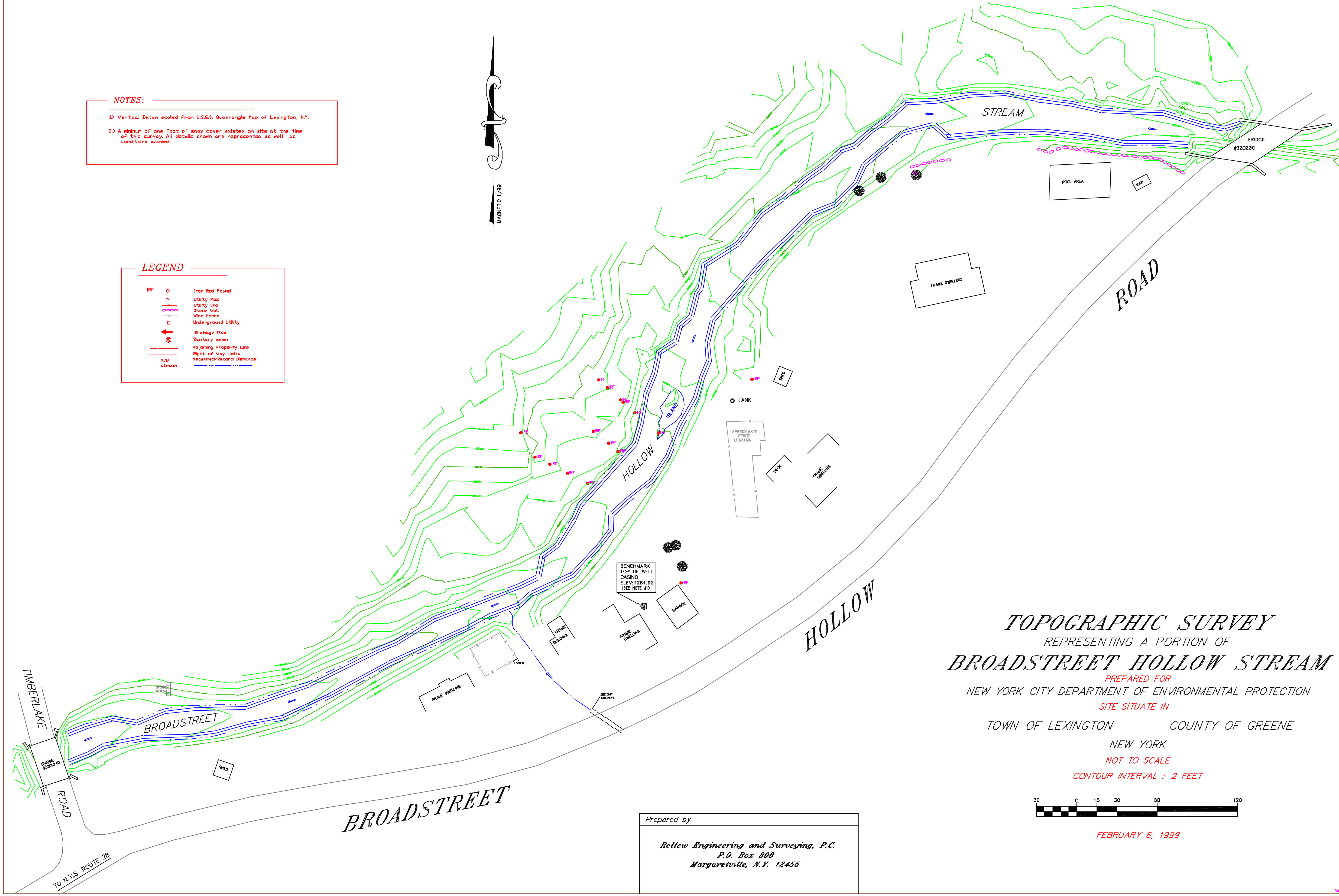
TOWN OF LEXINGTON	COUNTY OF GREENE
APRIL 28, 2000	NOT TO SCALE

GREENE COUNTY SOIL & WATER CONSERVATION DISTRICT

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

PREPARED FOR NEW YORK CITY DEPARTMENT OF ENVIRONMENTAL PROTECTION

CHECKED BY:	PROJECT #: BSH - 00.01
DRAWN BY: DOUG DEKOSKIE	DRAWING #: BSH - 00.01
SHEET 1 OF 10	TITLE PAGE



NOTES:

1.) Vertical Datum scaled from U.S.G.S. Quadrangle Map of Lexington, N.Y.

2.) A minimum of one foot of snow cover existed on site at the time of this survey. All details shown are represented as well as conditions allowed.

LEGEND

IRF	○	Iron Rod Found
		Utility Pole
		Utility line
		Stone Wall
		Wire Fence
	□	Underground Utility
	←	Drainage Flow
	Ⓢ	Sanitary sewer
		Adjoining Property Line
		Right of Way Limits
	M/R	Measured/Record Distance
	stream	

TOPOGRAPHIC SURVEY

REPRESENTING A PORTION OF

BROADSTREET HOLLOW STREAM

PREPARED FOR

NEW YORK CITY DEPARTMENT OF ENVIRONMENTAL PROTECTION

SITE SITUATE IN

TOWN OF LEXINGTON COUNTY OF GREENE

NEW YORK

NOT TO SCALE

CONTOUR INTERVAL : 2 FEET

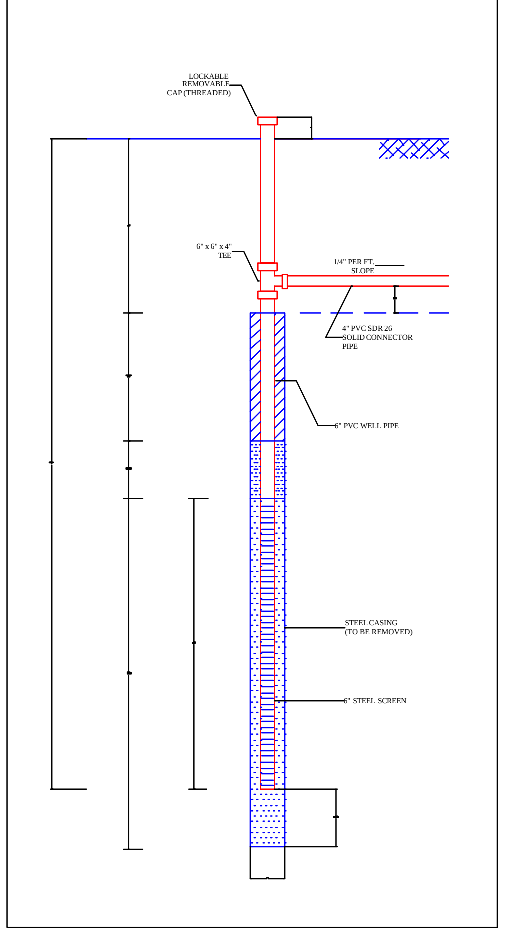
30 0 15 30 60 120

FEBRUARY 6, 1999

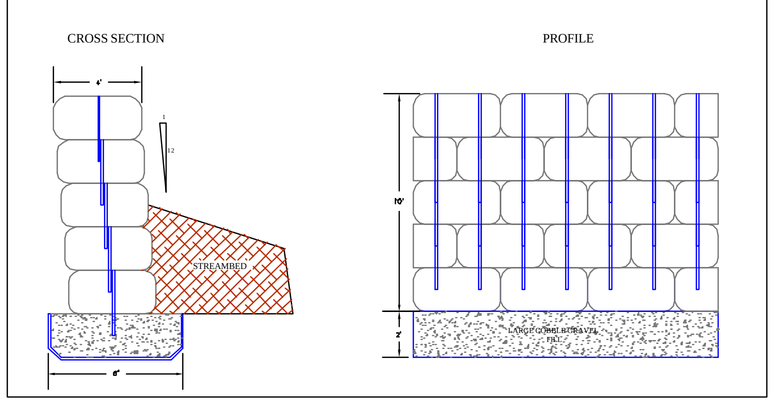
Prepared by

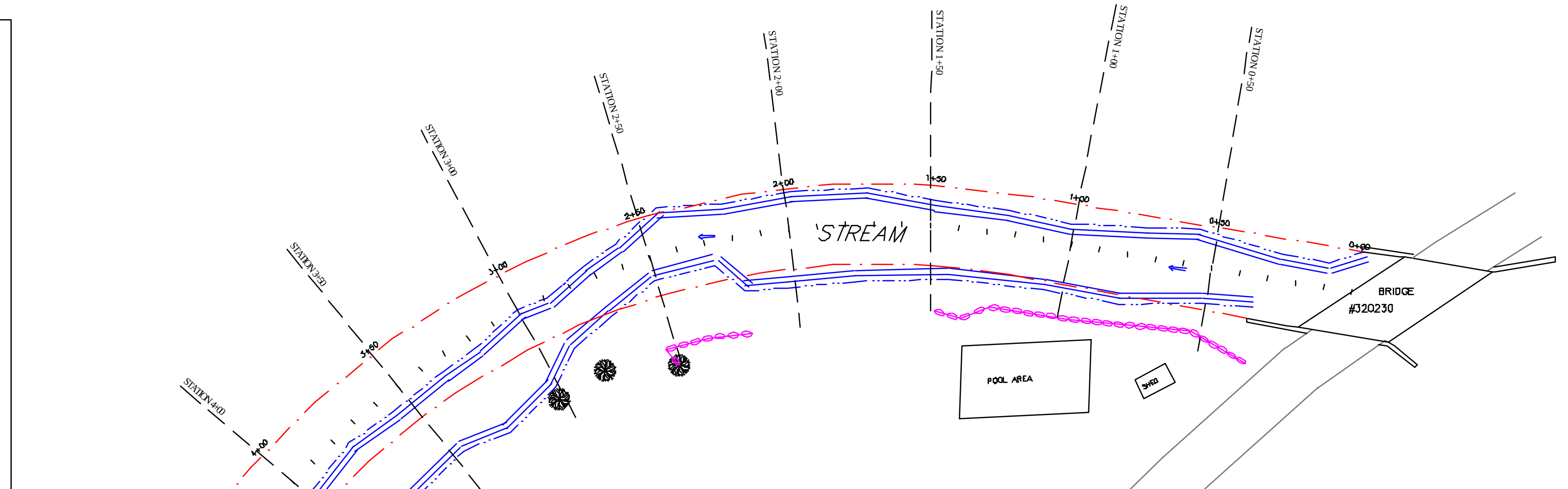
Rettew Engineering and Surveying, P.C.
P.O. Box 808
Margaretville, N.Y. 12455

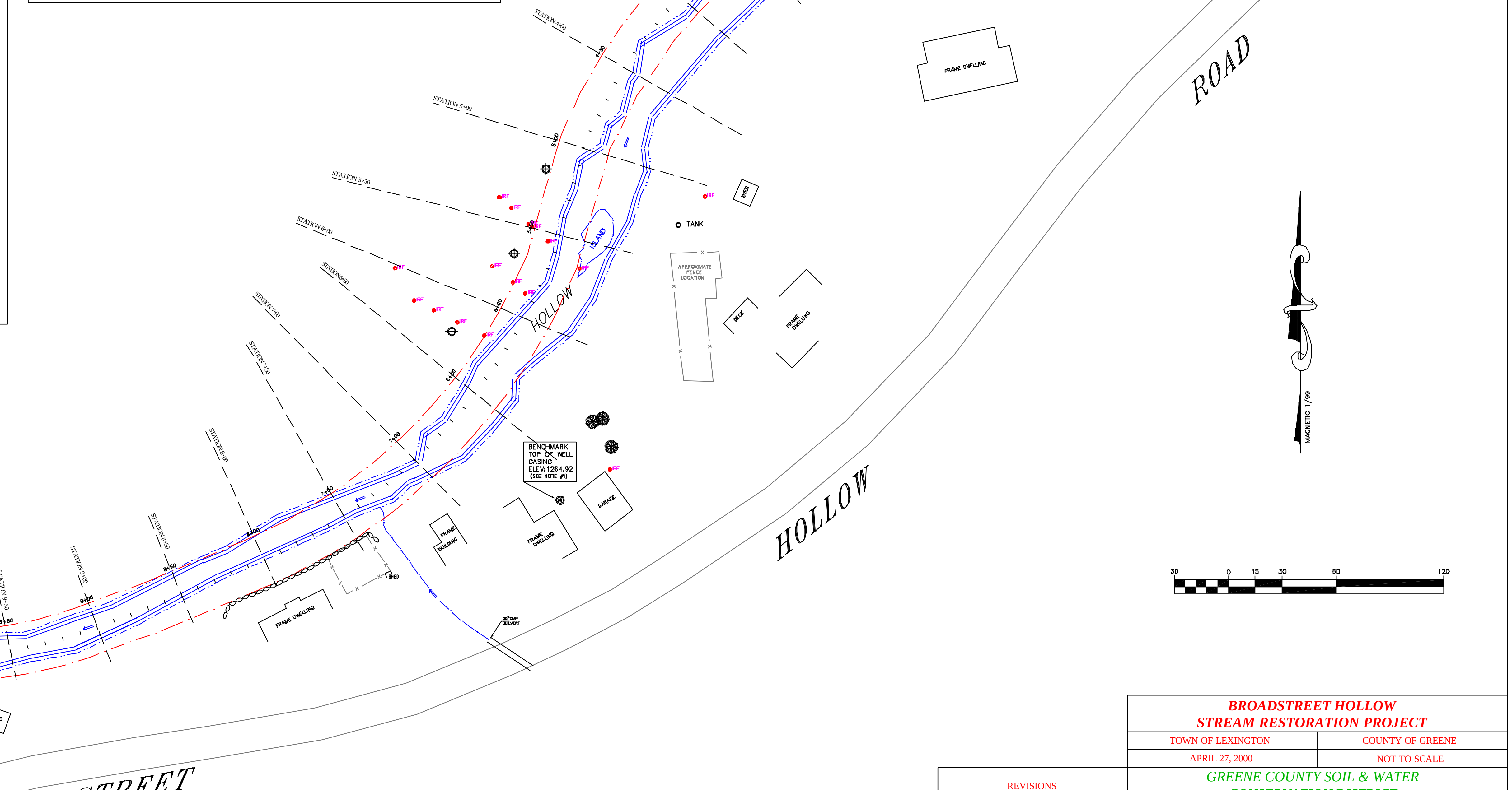
TYPICAL RELIEF WELL



TYPICAL RETAINING WALL (SR-08) (STACKED ROCK)







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CAIRO, NY 518-622-9667 — TANNERSVILLE, NY 518-589-3034

LEGEND

- PROPOSED BANKFULL CHANNEL
- EXISTING CHANNEL
- EXISTING STONE WALL
- IRON ROD FOUND — IRF
- PROPOSED RETAINING WALL
- RELIEF WELL

REVISIONS

BROADSTREET HOLLOW STREAM RESTORATION PROJECT

TOWN OF LEXINGTON	COUNTY OF GREENE
APRIL 27, 2000	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

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CHECKED BY:	PROJECT #: BSH - 00.01
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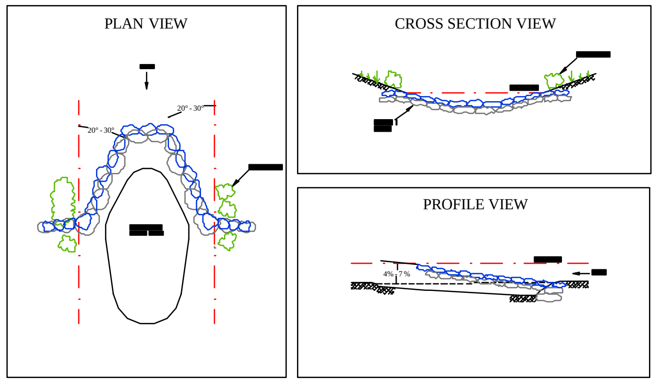
SHEET 3 OF 10	PROPOSED PLAN VIEW (W/ EXISTING CONDITIONS)

TYPICAL ROCK CROSS VANE (SR-03)



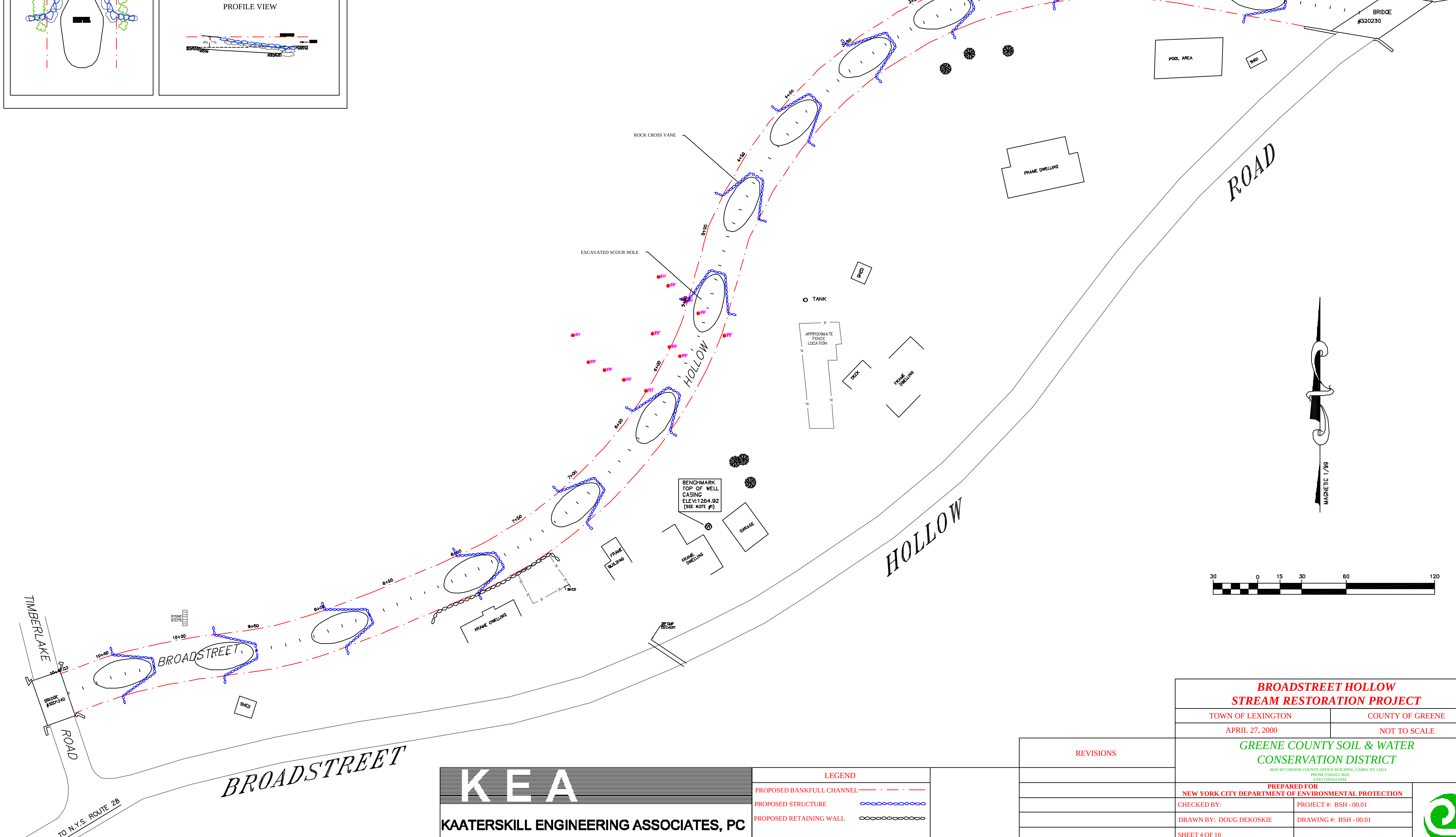
CONSTRUCTION NOTES

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	6'	4'	3'



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CAIRO, NY 518-622-9667 TANNERSVILLE, NY 518-589-3034

LEGEND

- PROPOSED BANKFULL CHANNEL
- PROPOSED STRUCTURE
- PROPOSED RETAINING WALL

REVISIONS

BROADSTREET HOLLOW STREAM RESTORATION PROJECT

TOWN OF LEXINGTON	COUNTY OF GREENE
APRIL 27, 2000	NOT TO SCALE

GREENE COUNTY SOIL & WATER CONSERVATION DISTRICT

BOX 907 GREENE COUNTY OFFICE BUILDING, CAIRO, NY 12414
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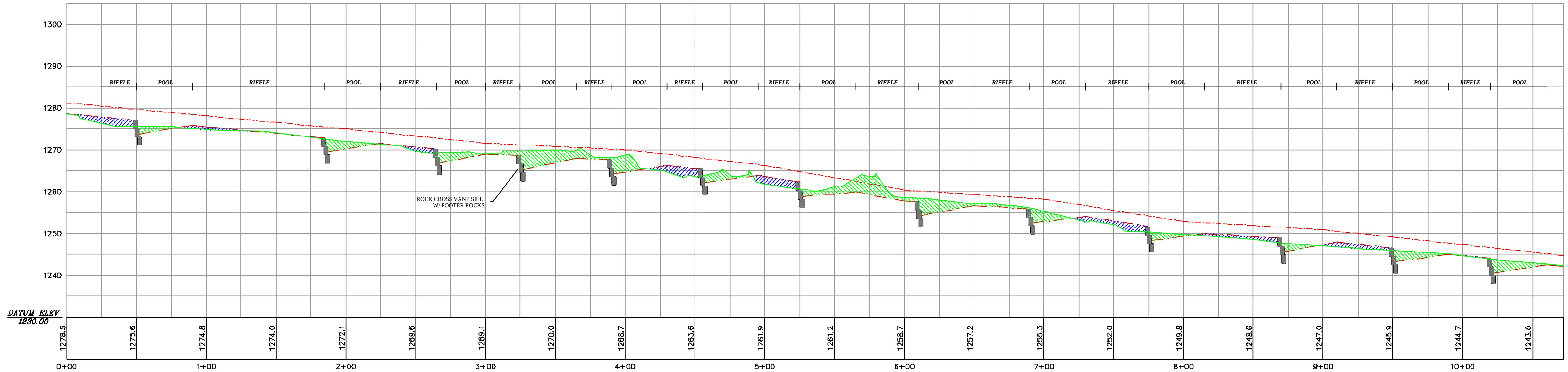
SHEET 4 OF 10	PROPOSED PLAN VIEW



TYPICAL MATERIAL PLACEMENT (SR - 07A)

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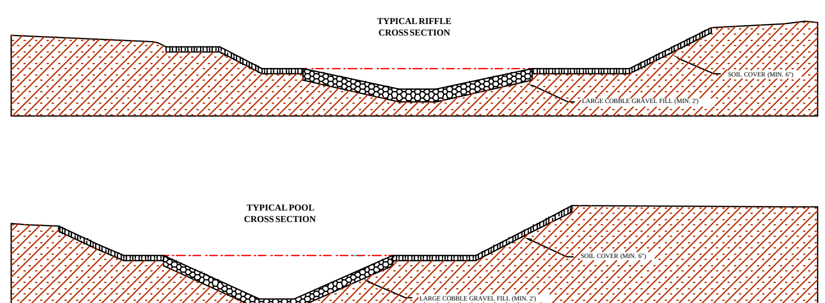
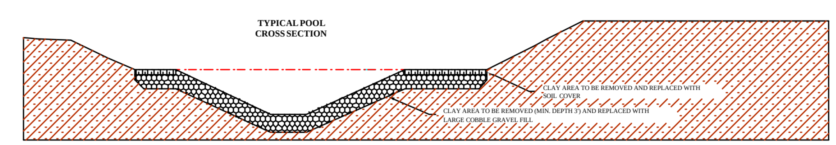


CONSTRUCTION NOTES

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

TYPICAL CLAY OVER-EXCAVATION (SR-07)

(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. Excavated clay will be removed from the project area as set forth in the construction specifications.

NOTE:

EXISTING PROFILE SAMPLED FROM FEBRUARY 5, 1999 SURVEY PERFORMED BY RETTEW ENGINEERING AND SURVEYING, P.C., P.O. BOX 808, MARGRETVILLE, NY 12455.

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CAIRO, NY 518-622-9667 TANNERSVILLE, NY 518-589-3034

LEGEND

PROPOSED BANKFULL SURFACE	— · — · —
PROPOSED THALWEG	— · — · —
AREA TO CUT	(green hatch)
AREA TO FILL	(blue hatch)

REVISIONS

BROADSTREET HOLLOW STREAM RESTORATION PROJECT

TOWN OF LEXINGTON	COUNTY OF GREENE
APRIL 28, 2000	NOT TO SCALE

GREENE COUNTY SOIL & WATER CONSERVATION DISTRICT
BOX 907 GREENE COUNTY OFFICE BUILDING, CAIRO, NY 12414
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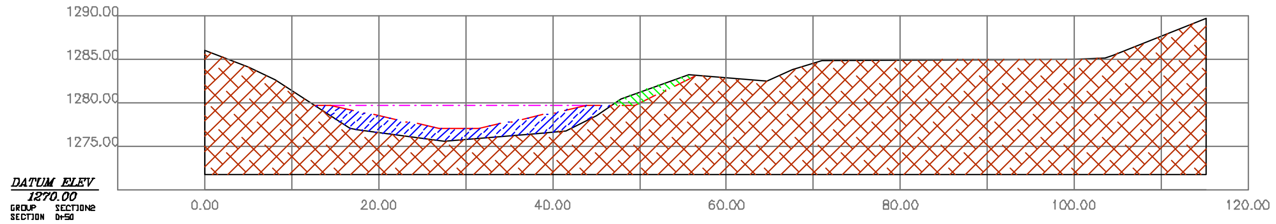
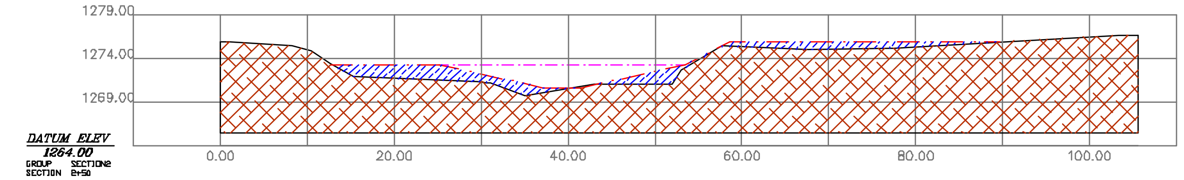
SHEET 5 OF 10	EXISTING AND PROPOSED LONGITUDIAL PROFILE

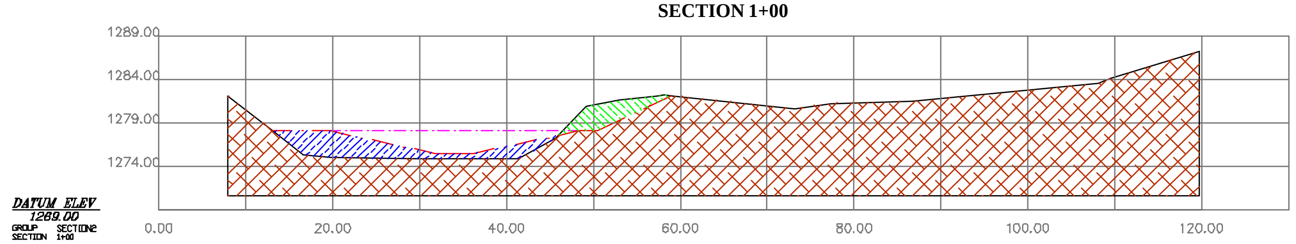
SECTION 0+50



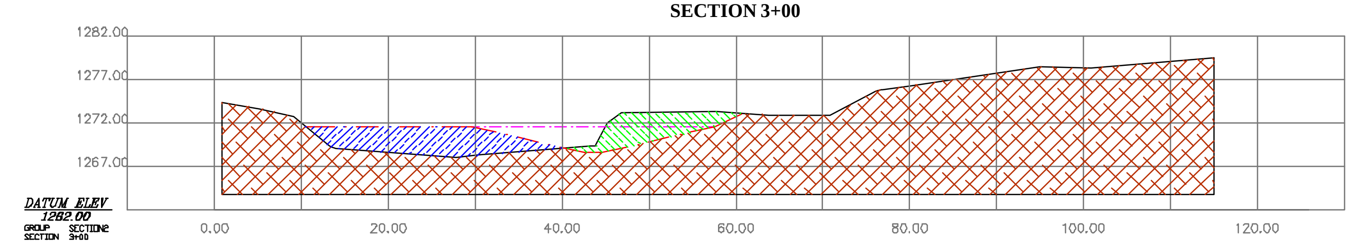
SECTION 2+50



SECTION 1+00



SECTION 3+00



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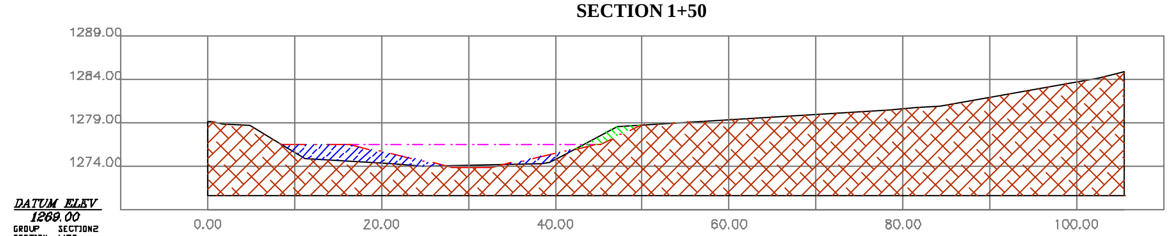

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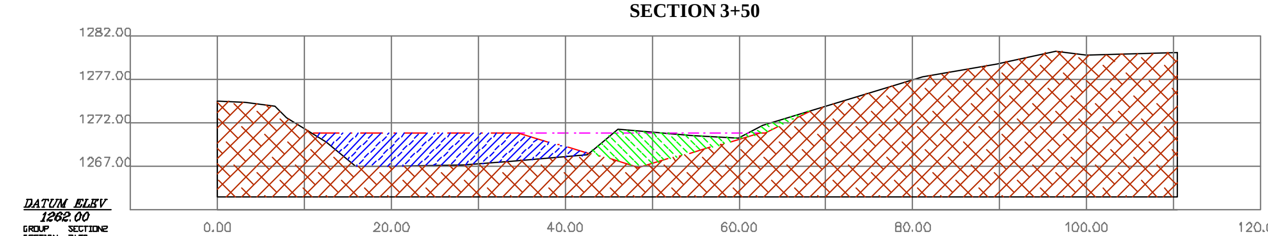

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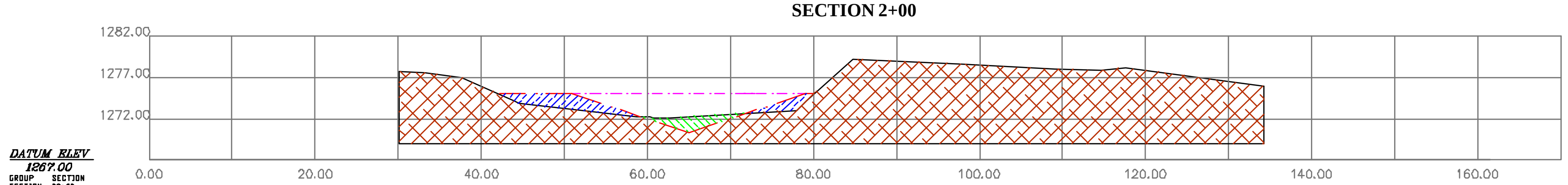

NOTE:

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KEA

KAATERSKILL ENGINEERING ASSOCIATES, PC

CAIRO, NY 518-622-9667 TANNERSVILLE, NY 518-589-3034

LEGEND	
PROPOSED GROUND	— · — · —
BANKFULL SURFACE	- · - · -
EXISTING GROUND	———
AREA TO CUT	(green hatch)
AREA TO FILL	(blue hatch)

REVISIONS

BROADSTREET HOLLOW STREAM RESTORATION PROJECT

TOWN OF LEXINGTON	COUNTY OF GREENE
APRIL 27, 2000	NOT TO SCALE

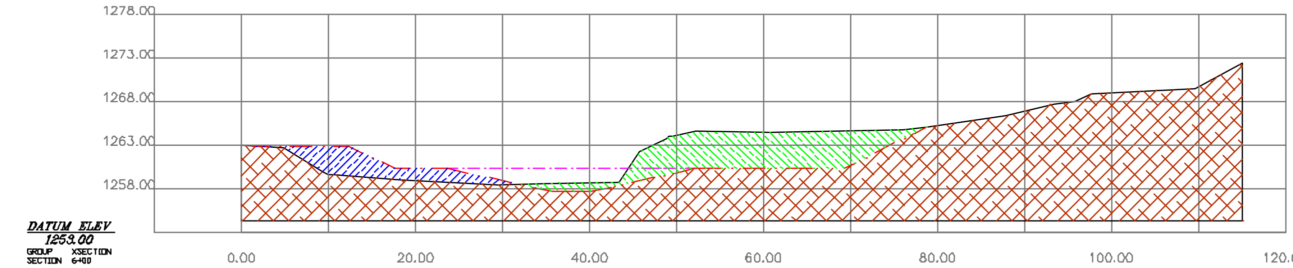
GREENE COUNTY SOIL & WATER CONSERVATION DISTRICT

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

PREPARED FOR
NEW YORK CITY DEPARTMENT OF ENVIRONMENTAL PROTECTION

CHECKED BY:	PROJECT #: BSH - 00.01
DRAWN BY: DOUG DEKOSKIE	DRAWING #: BSH - 00.01
SHEET 6 OF 10	PROPOSED CROSS SECTIONS (0+50 - 3+50)

SECTION 6+00



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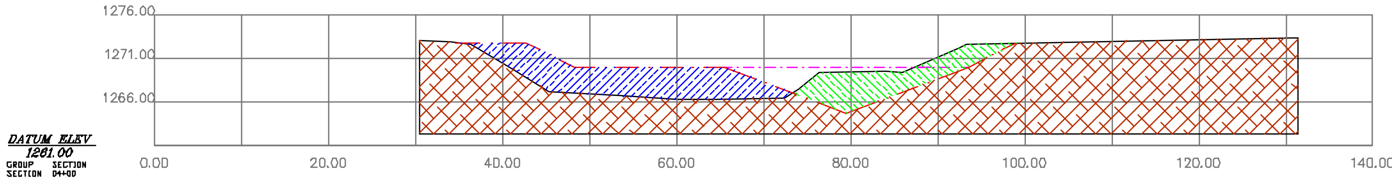

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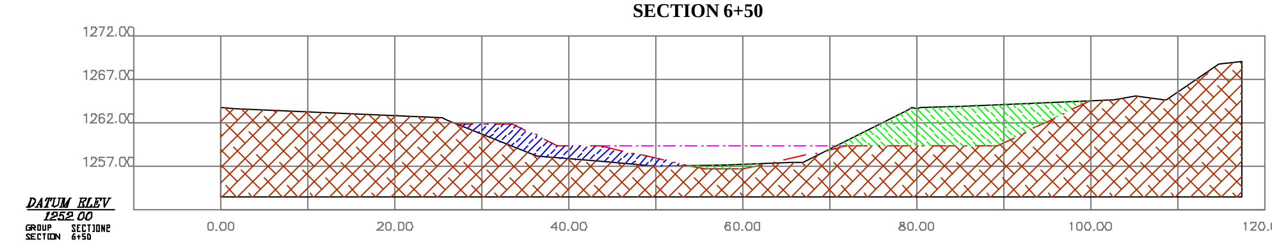

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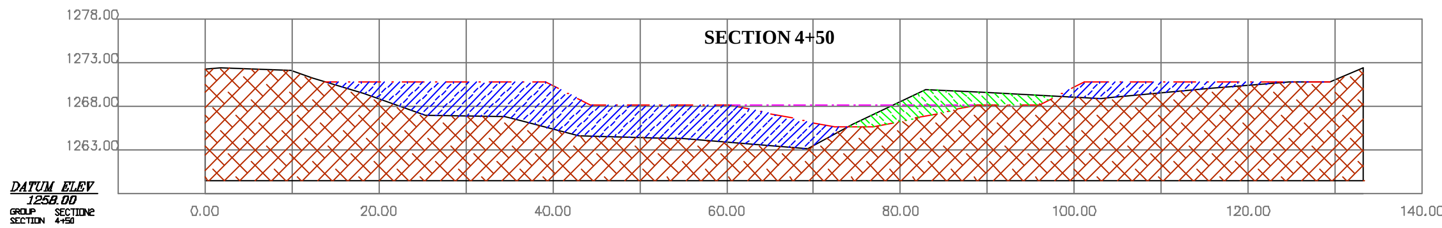
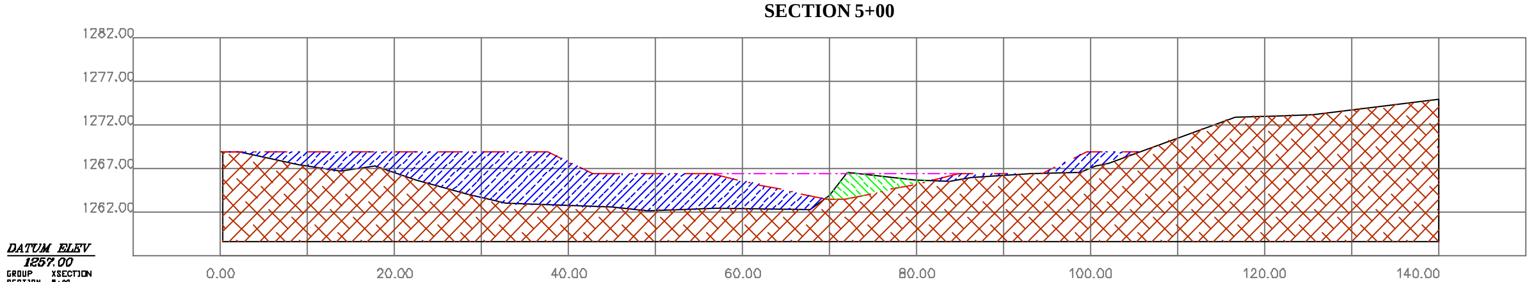


SECTION 5+00



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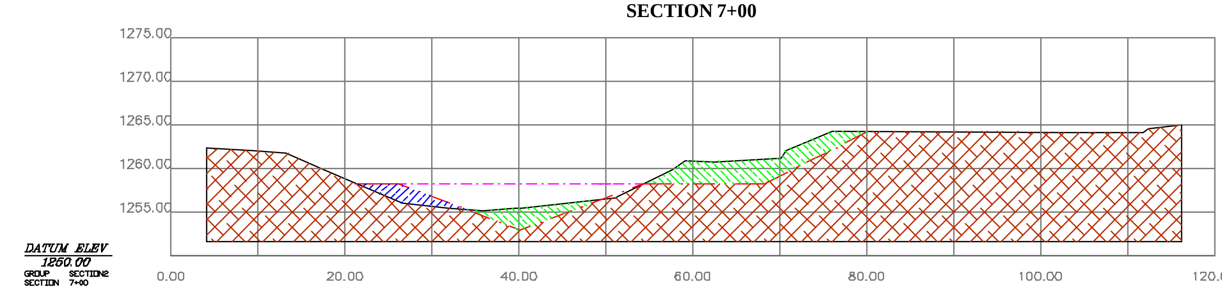

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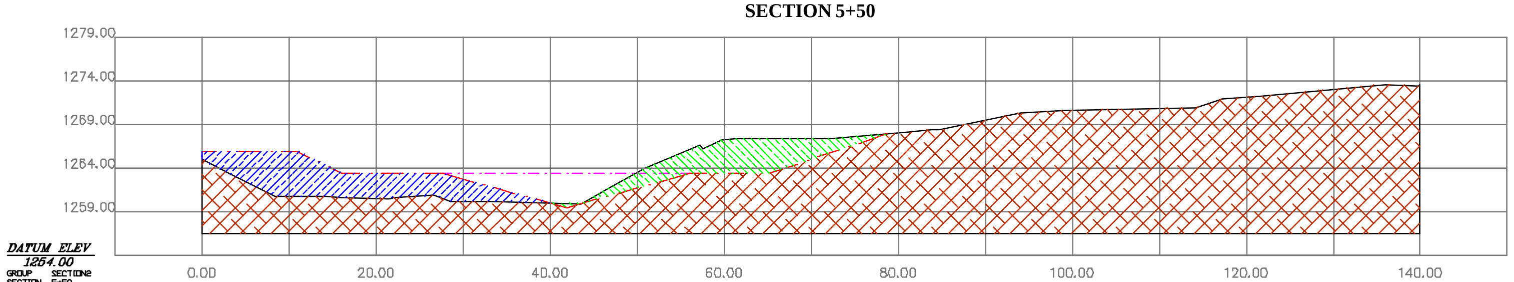

NOTE:

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KAATERSKILL ENGINEERING ASSOCIATES, PC

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LEGEND	
PROPOSED GROUND	— · — · —
BANKFULL SURFACE	— · · — · ·
EXISTING GROUND	———
AREA TO CUT	(green hatch)
AREA TO FILL	(blue hatch)

REVISIONS
MAY 8, 2000 - DD (XS 4+50 - XS 7+00)

BROADSTREET HOLLOW STREAM RESTORATION PROJECT

TOWN OF LEXINGTON	COUNTY OF GREENE
APRIL 27, 2000	NOT TO SCALE

GREENE COUNTY SOIL & WATER CONSERVATION DISTRICT

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NEW YORK CITY DEPARTMENT OF ENVIRONMENTAL PROTECTION

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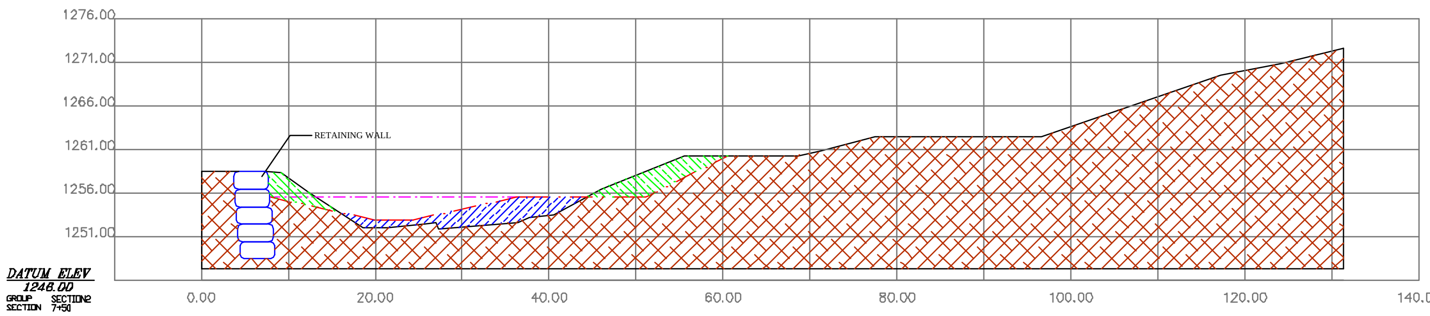
SHEET 7 OF 10	PROPOSED CROSS SECTIONS (4+00 - 7+00)

SECTION 7+50



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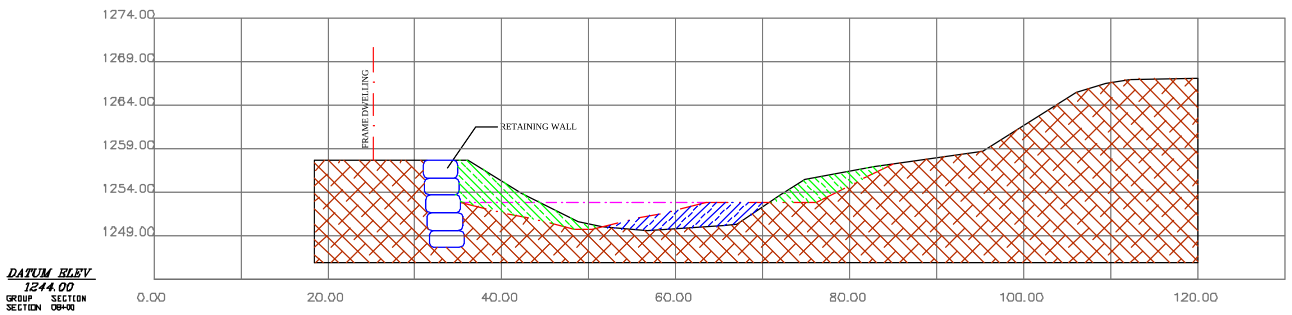

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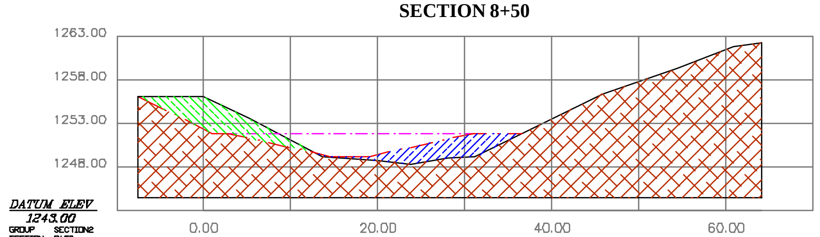
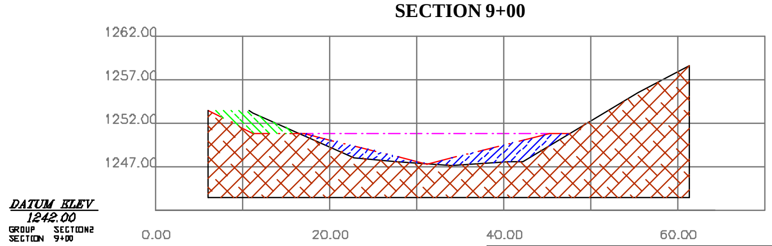


SECTION 9+00



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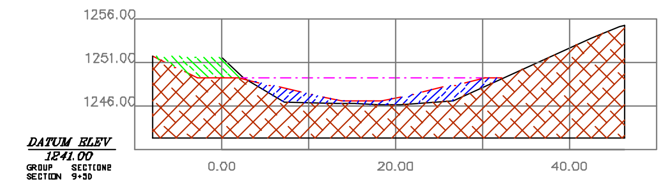

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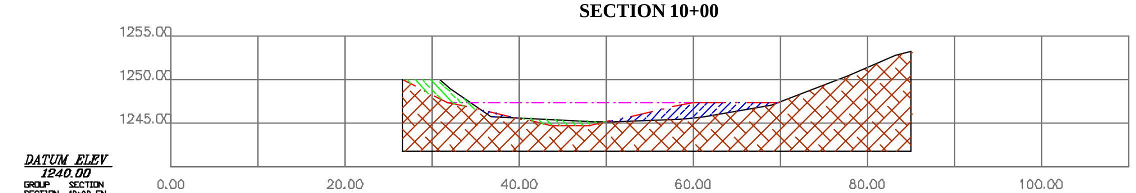

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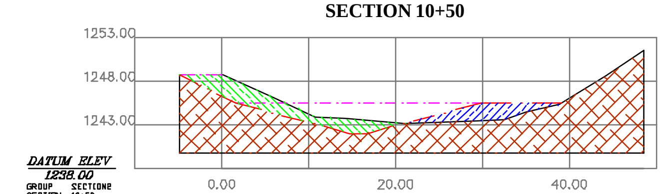

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LEGEND

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

REVISIONS

BROADSTREET HOLLOW
STREAM RESTORATION PROJECT

TOWN OF LEXINGTON	COUNTY OF GREENE
APRIL 27, 2000	NOT TO SCALE

GREENE COUNTY SOIL & WATER CONSERVATION DISTRICT

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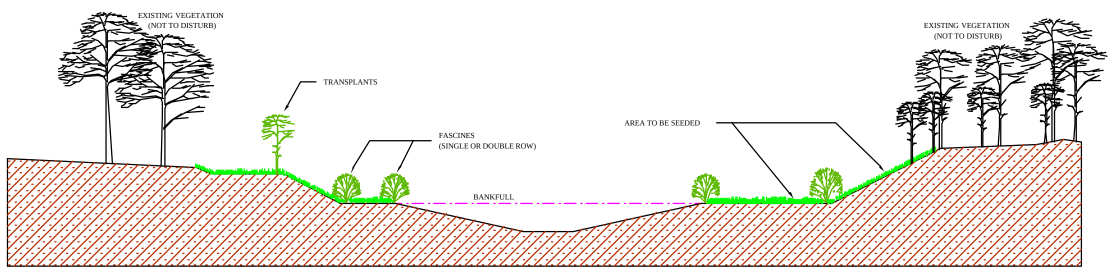
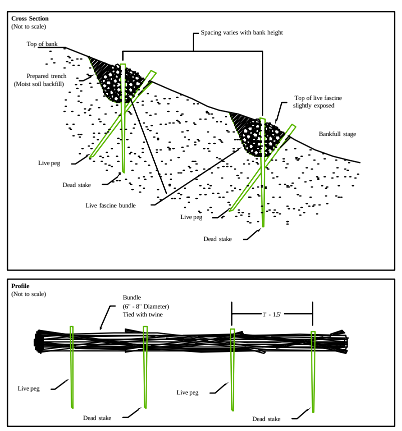
CHECKED BY:	PROJECT #: BSH - 00.01
DRAWN BY: DOUG DEKOSKIE	DRAWING #: BSH - 00.01
SHEET 8 OF 10	PROPOSED CROSS SECTIONS (7+50 - 10+50)

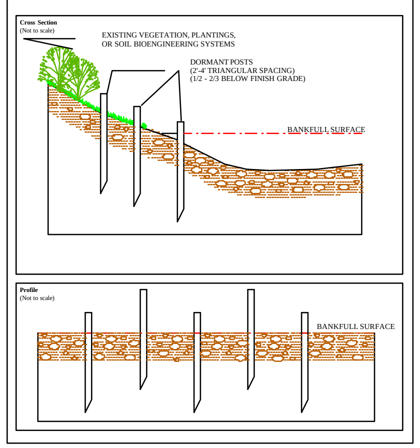
TYPICAL PLANTING DETAIL
(NOT TO SCALE)

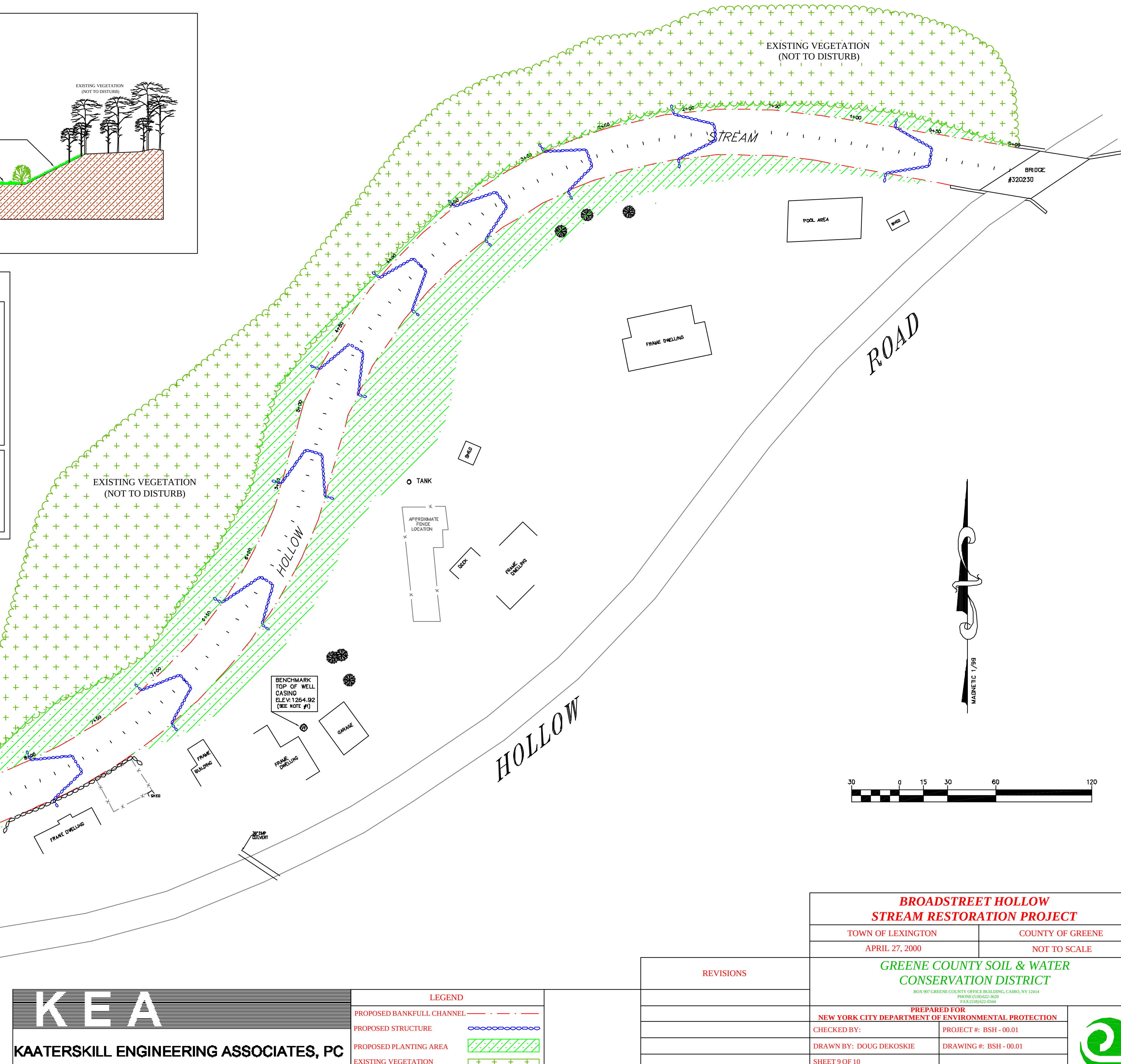


LIVE FASCINE DETAIL (VS-01)



DORMANT POST DETAIL (VS-03a)





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LEGEND	
PROPOSED BANKFULL CHANNEL	
PROPOSED STRUCTURE	
PROPOSED PLANTING AREA	
EXISTING VEGETATION (NOT TO DISTURB)	

REVISIONS

BROADSTREET HOLLOW STREAM RESTORATION PROJECT

TOWN OF LEXINGTON	COUNTY OF GREENE
APRIL 27, 2000	NOT TO SCALE

GREENE COUNTY SOIL & WATER CONSERVATION DISTRICT
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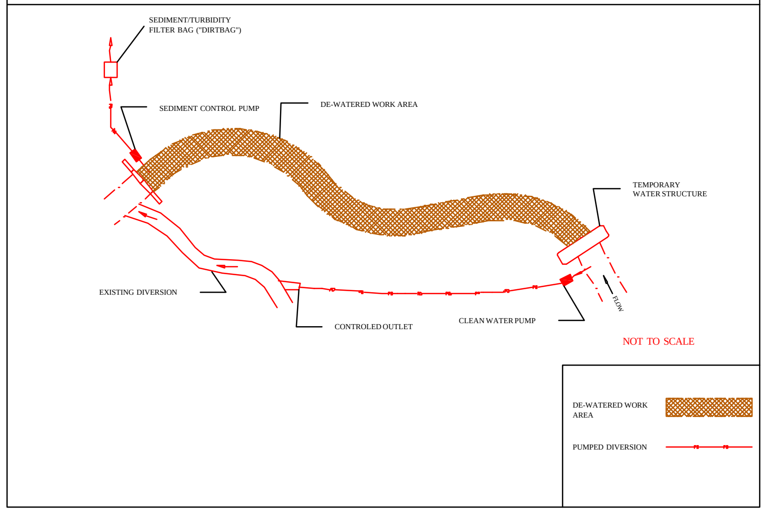
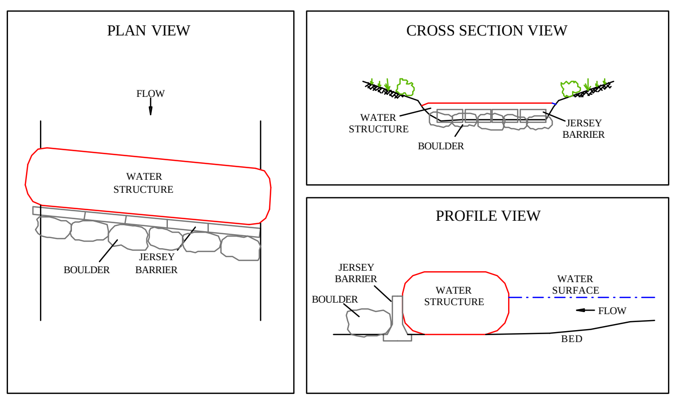
CHECKED BY:	PROJECT #: BSH - 00.01
DRAWN BY: DOUG DEKOSKIE	DRAWING #: BSH - 00.01
SHEET 9 OF 10	PLANTING DETAIL

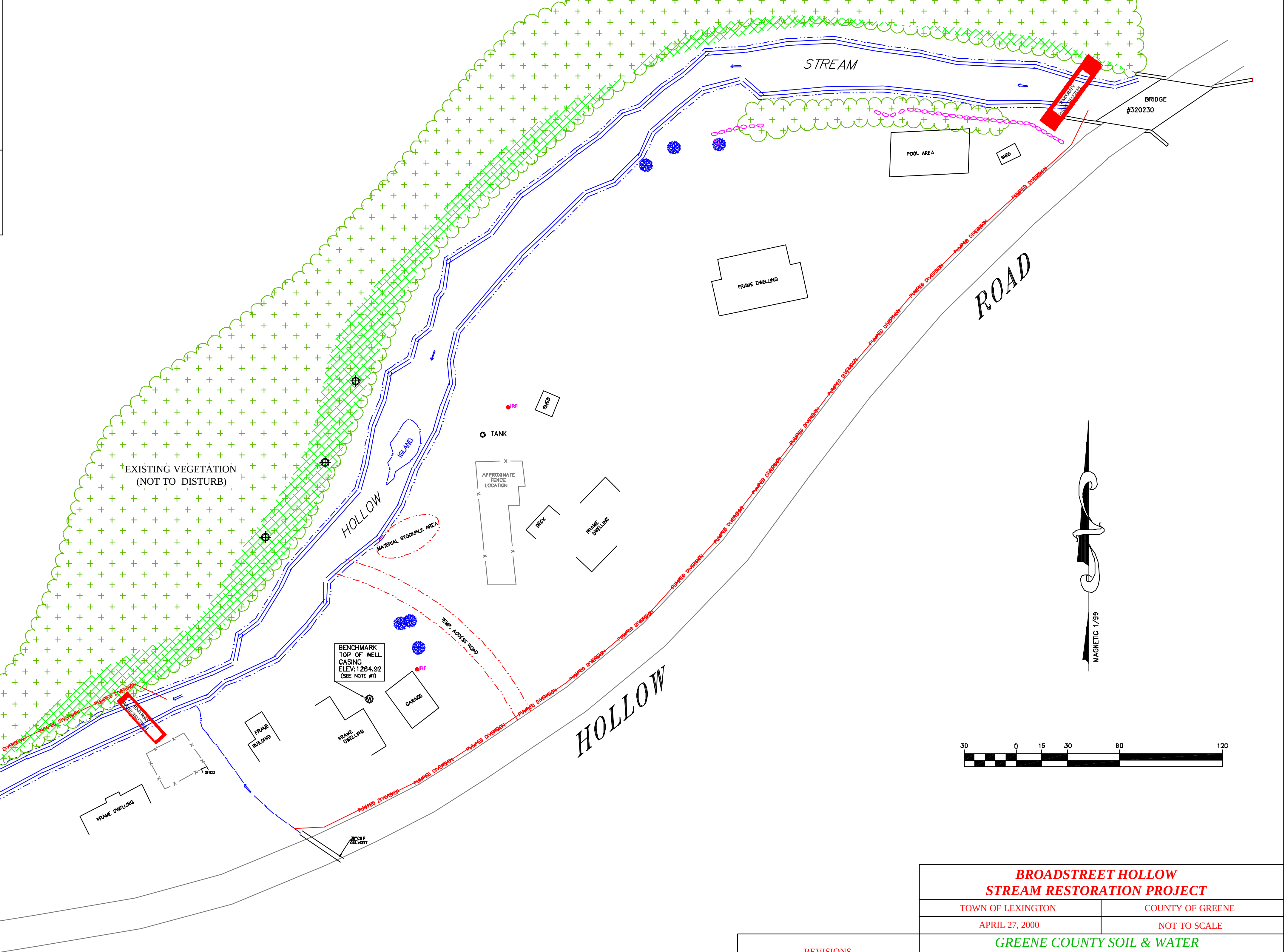
TYPICAL DEWATERING DETAIL



NOTE: Installation of the relief wells must be done prior to any stream channel construction. Drainage water from the relief wells must be piped and/or pumped below the work area during construction.

EXAMPLE OF TYPICAL COFFER DAM (CS-04a)





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LEGEND	
PUMPED DIVERSION	PUMPED DIVERSION
EXISTING VEGETATION (NOT TO DISTURB)	+ + + +
EXISTING VEGETATION (TO BE DISTURBED)	
RELIEF WELL	⊕

REVISIONS

BROADSTREET HOLLOW STREAM RESTORATION PROJECT

TOWN OF LEXINGTON	COUNTY OF GREENE
APRIL 27, 2000	NOT TO SCALE

GREENE COUNTY SOIL & WATER CONSERVATION DISTRICT

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SHEET 10 OF 10	DEWATERING PLAN

Appendix C

Broadstreet Hollow Operation and Maintenance Plan

OPERATION & MAINTENANCE PLAN
Broadstreet Hollow Stream Restoration Project #1

I. AUTHORITY

The Broadstreet Hollow Stream Restoration Project, located in the Town of Lexington, Greene County, New York (henceforth called "the project"), is sponsored by New York City Department of Environmental Protection (DEP), coordinated by Ulster County Soil and Water Conservation District (UCSWCD) with design and construction activities sub-contracted by UCSWCD to Greene County Soil and Water Conservation District (GCSWCD). Partial funding for the project has been provided by the US Army Corp of Engineers (USACOE) under the Water Resource Development Act. DEP is also a principal financial contributor to the project.

DEP is dedicated to protect its drinking water supply quality against contamination from excess turbidity and associated pathogens. DEP is under consent order to undertake this project (environmental benefit project number R4-1648-94-03). As principal local agency responsible for the project design, construction, maintenance and monitoring, GCSWCD is responsible conservation activities in the project area.

II. PROJECT OBJECTIVES

The purpose of this project is to reduce stream instability and resulting turbidity in the New York City Water Supply. The existing conditions are characterized by excessive turbidity during a full range of flow conditions. The turbidity has been identified as originating from a slope failure, which is exposing glacial lake clay deposits in the stream bed and banks along a 1100 linear foot reach of the Broadstreet Hollow stream. The turbidity problem is compounded by an artesian groundwater situation which is causing silt laden water to pipe from the stream bottom.

The plan for the restoration consists of stream realignment, stream bed grade control, and slope stabilization, to mitigate turbidity produced from glacial lake clay exposures. The project will also help protect local property and structures from on-going slope failures and stream instability. This project is not a flood control project.

1. Project Location

The project is located in the upper section of the Broadstreet Hollow stream. The project reach runs the entire length between Bridge # 320230 (upstream limit) and Bridge #3201240.

2. Project Description

As constructed, the work completed at this site is a self maintaining, full stream restoration project. The project design was based on measurements and observations taken at the project site, as well as a reference reach located upstream from the project reach. The design of the project focused on three (3) primary areas;

2-a. Stream Channel Geometry

To provide for stable stream features, the GCSWCD utilized measurements from aerial photos and topographic surveys of a project reference reach to develop the proper alignment, profile, and cross sectional area for the project reach.

The restoration activities first focused on the channel alignment in the project area. The flood of January 19,1996 had caused significant adjustments in the sinuosity of the channel. The project design involved re-adjusting the channel alignment, especially at the center of the project reach; where post-flood repairs had caused additional adverse adjustments to the channel.

Emergency repairs made after the 1996 flood also resulted in adverse adjustments in the channels cross sectional area and slope. Over excavation of the channel to obtain materials for repairs to the damaged streambanks left an over widened channel, a long extended riffle (instead of a step pool complex). As a result, the stream became incised. The project has compensated for these changes by establishing a cross sectional area and stream profile consistent with the reference reach.

A sheet pile wall protects the lowest residential structure in the project reach and allows the meander pattern to fit within the narrow, residentially developed valley. The retaining wall is located at the outside of the meander to protect against erosional forces in this area. The layers of rock wall are pinned together and installed on footer rocks set below the stream bed elevation to protect against erosion, debris and frost heaving.

2-b. Grade Control and Current Deflecting Structures

To provide for long term stabilization of the stream profile, as well as to reduce velocities against the streambanks, the project includes thirteen (13) cross vane structures. These cross vanes provide effective grade control through the project reach and their spacing is consistent with the step-pool bedform complex measured at the reference reach. In addition, the vane arms will reduce boundary shear stress against the streambank, enable vegetation to become established, and maximize the effectiveness of the vegetative cover to provide bank stability.

2-c. Vegetation

The project includes a vegetation plan which addresses multiple objectives. On the right (far) side of the stream, willow fascines, posts and stakes are used on the streambanks, with larger trees transplanted to the riparian area. On the left side of the project, willows and other woody vegetation are limited to the lower elevations of the channel, and are of a species which would have a minimal impact on the limited space in the rear yards of the residential structures. To provide additional stabilization on the left bank, larger deciduous and evergreen trees are transplanted from off-site.

On the west right side and part of the left side of the project reach, a Conservation Seed Mix is used for stabilization of all disturbed areas. Behind residential structures on the left side, a standard lawn mix is used. Existing native vegetation is conserved wherever possible.

3. Project Performance

In recent years, there has been increasing focus on the use of restoration techniques to provide stabilization of stream systems in a more natural form. Generically known as Natural Channel Design, these techniques typically include the development of a stable channel geometry based on form and flow as determined from reference reaches, the construction of structures to reduce erosional forces on the streambanks, and the establishment of vegetative cover. In many settings, the critical element to the success of these projects over an extended period of time, as well as over a wide range of storm events, is the establishment of an effective vegetative community both on the immediate streambanks as well as in the adjoining riparian zone.

While the ultimate goal of these designs is to establish stream system stability which will remain stable under most flow conditions. The degree of stability obtained will be directly related to the extent of vegetative cover. In the period immediately after construction, the project is subject to minor damage as the under flows as small as the 1.5-2 year recurrence interval due to the lack of established vegetation. As woody vegetation is established and its root mass increases, the project becomes increasingly capable of handling bankfull flows without altering the stream’s planform geometry.

The stream bed and banks will adjust in the first few years of the project as hydraulic forces move and grade materials. These adjustments will be monitored and if found to be beyond an equilibrium geometry, will be maintained as described in Section V. The project is designed to be self maintaining, however, an act of nature can produce unforseen events such as debris flows which can alter the performance of in-channel structures and reduce their effectiveness. The performance of the structures will be monitored and the structures will be maintained as described in Section V.

The project is designed to provide adequate flood plain for conveyance of up to the 100 year event.

III. PROJECT INSPECTIONS

A. Project Surveys

The GCSWCD will conduct an "as built" survey within thirty (30) days following completion of the project's earthmoving operations. The survey will be to the same standard as the design survey and must include, but is not limited to; a topographic survey of the project site, location and elevations of the cross-vanes, location, elevation and vertical position of the retaining wall, all significant channel features, buildings, roads and utilities.

This survey will establish monumented cross sections for future project monitoring. A copy of the survey will be provided to the DEP as well as maintained on file by the GCSWCD for future reference.

B. Inspection Schedule

The GCSWCD is responsible for establishing an Inspection Schedule which will allow for routine, as well as episodic reviews of project status. The GCSWCD will conduct detailed annual inspections of the project as well as after significant flow events. Detailed annual inspections will include surveys of the channel cross section, profile and geometry, and the collection of other data necessary to document the project condition.

1. Routine Inspections.

Commencing one (1) year after the completion of the project, the GCSWCD will initiate detailed annual inspections of the project. Detailed annual inspections must be conducted in years one (1) through three (3) after completion of the earthmoving phase of the project. If the first three (3) annual inspections demonstrate stability in the stream reach, with no significant change in any of the projects features, the GCSWCD may reduce detailed inspections to a period of once every five (5) years. The GCSWCD will continue to make annual visual inspections of the project, and in the event a problem is noted, will schedule a detailed inspection to evaluate the observed changes. GCSWCD and DEP will jointly develop the protocol for Inspection surveys prior to conducting the first survey. Detailed Inspections will include, but are not limited to;

a. Longitudinal Profile, adequately document cross vane sills and pools

b. Channel Cross Sections (Monumented)

c. Pebble counts

d. Conditions of structures, note voids, missing rock or irregular erosional patterns.

e. Condition of vegetation, evaluate establishment rate, mortality, inspect for signs of disease and insect damage, review and clearing actions or other disturbances to the vegetation.

f. Photo documentation of structures, vegetation and other stream features.

g. Survey hillslope reference pins to monitor slope stability

2. Post Event Inspections

Commencing immediately after construction, the GCSWCD will conduct visual inspections of the project after significant runoff events. In the first two (2) years after construction, the GCSWCD will conduct visual inspections after each bankfull event. If significant impacts to the project are noted, the GCSWCD will conduct a detailed survey as set forth in the section above.

The GCSWCD will draft an inspection report, and complete photo documentation of the site. In the event of a larger flood event (> 50 year RI), the GCSWCD will conduct a detailed inspection to document channel morphological features, and any changes as the result of the flood event. If a post-event inspection occurs within six months prior to an annual inspection, the annual inspection is not required.

3. Reporting

Annually, the GCSWCD will draft an inspection report with attachments of any surveys or data collected. The Inspection Report shall include, but is not limited to;

a. The date of inspection

b. The person(s) conducting the inspection

c. Stream conditions at the time of the inspection

d. A description of the hydrological events experienced at the site since the previous inspection

e. Copies of cross section and profile surveys plotted over the previous or as-built survey as appropriate.

f. Copies of pebble counts, bar samples or other data collections as may be applicable.

g. Copies of any reports and recommendations as may be provided by outside consultants who review or evaluate the site. The Inspection Reports will be provided to DEP and UCSWCD and maintained on file at the GCSWCD for use by others.

IV. PROJECT EVALUATION

In projects utilizing Natural Channel Design techniques, it must be recognized that some changes can reasonably be expected as the channel makes final adjustments to pool depths and depositional patterns. While observed adjustments in the project which involve depositional features may not be indications of project function, continued impacts characterized by erosion of the streambanks or repetitive damage to the rock structures will require a detailed analysis of these problems.

Maintenance or repair, if determined to be required, will be performed as funds and staff are available. by GCSWCD for a period of one year following the completion of construction activities. GCSWCD will be responsible for the maintenance and repair of the project through the duration of the Broadstreet Hollow Stream Management Plan Contract. During this period, GCSWCD, in consultation with DEP and UCSWCD, will be responsible for determining whether maintenance or repair is required based on the guidelines provided in Section V.

Landowner observations of the project's function are valuable tools for assessing the effectiveness of the design. Landowners typically observe the project under the widest range of conditions, and their constant exposure to the work enables them to provide valuable information about its performance and condition. Landowners, suspecting that the stream restoration project or a feature of the project may not be performing as intended or, with knowledge of a specific problem, will contact the GCSWCD to report their observations and/or concerns. Landowners are encouraged to take pictures of the stream to demonstrate their concerns.

V. PROJECT MAINTENANCE

Since the project is designed to be self maintaining, routine maintenance of the various components is expected to be minimal.

1. Rock Structures

On this project, structures are limited to the thirteen (13) cross vanes constructed in this reach. Maintenance of the cross vanes structures is primarily associated with ensuring that the structures maintain their design standards with regard to the slope of the vane arms, spacing between the rocks and clearing of any snags which may be hung up on the vane arms or sill after significant flood events. The following items will be considered to be routine maintenance.

a. Replacement of any dislodged rocks will be priority maintenance item. In the event flood flows or debris cause any rock(s) to be dislodged from the cross vane, or should the placement of the rock be altered such that the vane does not function properly, the GCSWCD will replace and/or adjust the placement of the rock.

b. The GCSWCD will observe the function of the cross vanes with regard to maintenance of an effective depositional wedge on the upstream side of the vane arms. The GCSWCD will undertake chinking of any voids with rock of a suitable size or will adjust the placement of vane rocks to reduce voids which have been demonstrated to be impacting the function of the vane. The GCSWCD will replace any materials as funds are available.

c. If significant woody debris accumulates on any section of a cross vane, the GCSWCD will remove the debris from the vane. Debris will be removed from the immediate stream corridor when possible, but in the event the debris is large in size and inaccessible by equipment, the materials may be cut into small sections and left for removal during the next flood event. Landowners can notify GCSWCD of large debris accumulation. Landowners should only attempt to remove small woody debris by hand during periods of low flow.

2. Stacked Rock Sheet Pile Wall

During routine and event based inspections, the GCSWCD will inspect the stacked rock retaining wall for any signs of movement. The GCSWCD will establish monitoring points where the vertical face of the wall can be monitored for angle as well as observe any rocks part of the wall which may be dislodged by either stream action or frost heaving. In the event the wall exhibits signs of movement, the GCSWCD will consult with KEA Engineering, and will develop a Repair Plan as set forth in Section VI 1.

The GCSWCD will inspect and repair the wall when it is shown that the wall is leaning or if excessive drainfill material is being lost from behind the wall. The Landowner will make no adjustments to the wall without the express consent of GCSWCD.

3. Groundwater Relief Wells

The groundwater relief wells constructed during this project require little to no maintenance. The GCSWCD will routinely remove the well covers and inspect the well shaft for signs of failure and will inspect the drainage outfalls to insure that the pipe outlets are clear and free of obstructions.

4. Vegetation

The vegetation plan developed for this project was designed to accommodate stability requirements, as well as landowner issues related to space and aesthetics. During annual inspections, the GCSWCD will evaluate the growth rate and establishment density of the vegetative materials, as well as the general vigor of the plantings. All vegetation is to be maintained in a live and vigorous state, and the GCSWCD will replace or replant the project as required to meet the establishment rates set forth in the USACOE permit (85% survival by end of 2nd growing season following construction).

In the event that the plant material does not become established, or should disease and other stresses result in loss of vegetation, the GCSWCD will replant the materials. In regards to maintenance by the landowners, a Landowner's Vegetation Management Guide is provided as an attachment to this document with a map of project vegetation and instructions for the proper care and maintenance of the riparian vegetation.

Unless otherwise specified within the Landowner's Vegetation Management Guide, no vegetation shall be removed, trimmed or otherwise altered within forty (40) feet of the streambanks, without the review and approval of the GCSWCD. On the left bank, landowners may mow the grass to the top of the bank, but must take care to prevent damage to the trees and shrubs on the streambank. Limited pruning of the willows on the lower slope on the left bank can be undertaken by the landowners in accordance with instructions provided by the GCSWCD. Under no circumstances will any vegetation be dug out, transplanted, removed or intentionally destroyed by the landowners.

VI. REPAIR, MODIFICATION or RECONSTRUCTION

In the event that inspections conducted by the GCSWCD, DEP, NYS DEC, USACOE or others reveals that the project has been impacted by stream flows, landowners activities or design features, the GCSWCD will be responsible to undertake repairs, modifications or reconstruction of the project. The following activities will be associated with the repair work. The GCSWCD will be responsible to complete a Repair Plan for the work, as well as coordinate all activities with landowners in the project area as well as contractors whom may be used to undertake the repair activities. Additionally, the GCSWCD will be responsible to secure any NYSDEC, NYCDEP or USACOE permits as may be required to undertake the repair actions.

1. Repair Plan

When routine or post-event inspections indicate undesirable stream channel impacts, the GCSWCD will immediately develop a Repair Plan in consultation with the DEP, the landowners, and other interested parties. The repair plan will include an evaluation of the observed damage (or change in stream geometry), the potential causes, the design parameters for the repair and a schedule for completion of the work. In the case where repairs are routine (i.e. a rock is dislodged from a structure, the GCSWCD will undertake repairs without a formal Repair Plan, but will document all repair activities associated with the work. In all cases, the GCSWCD will review the Repair Plan with DEP and the Project Engineer whose approval will be required prior to undertaking all proposed work. All repairs will be documented in the annual inspection report.

2. Funding

In the event of the need to undertake repairs, modifications or reconstruction, the GCSWCD will work in cooperation with UCSWCD, DEP, NYS DEC, USACOE and the landowners to identify available funds for the work to be conducted. In the event damages occur as the result of a flood event which receives a federal disaster declaration, the GCSWCD will submit the damages to FEMA under the 406 Public Assistance Program. Due to the water quality objectives of this project, there is a clear and distinct public interest and responsibility in the project. To the extent possible, the GCSWCD will use its own equipment/resources and/or the assistance of local municipal in-kind services.

3. Access

The Landowners in the project area will provide access to the project site to GCSWCD for the purpose of performing surveys, assessments, maintenance, repairs, modifications or reconstruction. Specific access points are shown on the project “as-built” drawings.

4. Construction

The GCSWCD will serve as the contracting entity for any outside contractors as may be required to undertake the repairs, modifications or reconstruction of the project. The GCSWCD will utilize contractors capable of completing the work, and will procure contractual services in accordance with NYS General Municipal Law and with any agreements the GCSWCD may have in effect with the DEP, NYS DEC or USACOE.

5. Permits

The GCSWCD will be responsible for obtaining permits from NYS DEC, DEP and the USACOE as may be required to undertake the work.

VII. MONITORING AND REPORTING

To evaluate the long range effectiveness of the project, the GCSWCD and DEP will conduct a comprehensive monitoring plan. Monitoring of the project is divided into three (3) separate and distinct sections.

1. Stream Channel Geometry

The GCSWCD will monitor the project for a ten year period for changes in channel geometry, streambank erosion and the function of the rock structures. The GCSWCD will use a detailed “as-built” survey, as well as surveys of monumented cross sections and the stream profile to monitor the stability of the project. Monitoring is described in greater detail in the section on Project Inspections. The GCSWCD will provide copies of the monitoring reports to DEP, NYS DEC and the USACOE. The GCSWCD will also maintain copies of monitoring reports at the GCSWCD office in Cairo NY.

2. Water Quality Benefits

The DEP, through its routine water quality monitoring program, will continue to conduct monitoring of turbidity (and TSS levels) at the confluence with the Esopus Creek. Turbidity and TSS monitoring includes both storm event sampling as well as synoptic sampling at established sites. Data and reports associated with this monitoring shall be provided to the GCSWCD, and shall be maintained by the DEP at their offices in Kingston.

3. Fisheries Habitat

Fisheries and macroinvertebrate monitoring will be coordinated by the USGS under an agreement with the GCSWCD. The USGS, DEP, GCSWCD and others will utilize a monitoring program developed by the USGS. Baseline data collected prior to construction will be compared to post construction data over several years after construction. Copies of fisheries monitoring will be maintained by the USGS, with copies provided for archiving at the GCSWCD and DEP offices.

VIII. TRANSFER OF RESPONSIBILITY

The GCSWCD may transfer responsibilities for all, or part of the operation and maintenance activities to the landowners in the project area, to another agency with stream management experience, or to a third party entity which has been established specifically to provide management to a designated stream/watershed. In all cases, the GCSWCD ultimately is responsible to insure that the party to whom the responsibilities are transferred undertakes these responsibilities in a manner consistent with this Operations and Maintenance (O&M) plan.

Transfer of these responsibilities must be done in writing, and must include a copy of this Operations and Maintenance plan as an attachment to the written agreement transferring the defined responsibilities. The GCSWCD will review the proposed transfer of responsibilities with the DEP, USACOE, NYS DEC and obtain DEP approval prior to executing any sub-agreements. No sub-agreements between the GCSWCD and the Landowners (and /or another entity) for Operation and Maintenance tasks shall be considered as an agreement between the party and either the DEP or USACOE.

IX. PLAN MODIFICATIONS

In the event that modifications are required to this O&M plan based on observations noted during inspections, changes in the projects design in response to damage from flood events, or for any other reason, the GCSWCD will develop a revised O&M plan with these changes clearly indicated, as well as the justification of the need for the modifications.

The revisions shall be submitted to DEP, NYS DEC, landowners and USACOE for their review and approval, as well as to the Landowners. The revised O&M plan does not become effective until such time that all parties have provided their approval in writing to the GCSWCD. All revisions to this O&M plan shall additionally be reviewed and approved by the GCSWCD's consultant engineer.

X. COMPLIANCE

In the event that one or more parties to this plan, with responsibilities as outlined in this plan, fail to meet their responsibilities, the NYCDEP, NYSDEC and USACOE may take any actions, as may be available to them by law, regulations or contracts, to enforce the conditions of this Operations and Maintenance Plan.

XI.DEFINITIONS

bankfull - a water surface elevation on a stream bank where flow begins to leave the channel and spread out on the flood plain. A bankfull flow is thought to be responsible for shaping the channel and moving the greatest amount of sediment and bedload over time.

cross vane - a rock structure which consists of two sloping arms angled and tilted upstream from each stream bank and joining at the thalweg (center of the stream). A cross vane provides longitudinal grade control and controls the cross sectional location of the thalweg.

flood control project - a project designed to prevent flood waters from damaging property

reach - a section of stream length defined and described for the purpose of discussion and analysis by the consistency of its attributes.

recurrence interval - the statistical probability expressed as a frequency of the occurrence of a flow event of a given magnitude (stage) based upon the available records of previous stream flows. For example, if a stream flow of 1000 cubic feet per second has a 2 year recurrence interval, it can be expected that over a 100 years, 50 such events could be expected. It is not a prediction of when an event will occur.

reference reach - a section of stream found to be a stable and used as a example of the proper stream cross sectional area, slope and meander geometry for use in designing restoration plans

stream geometry - the measurable characteristics used to describe the stream's pattern, profile and dimension. Such characteristics include its slope, sinuosity, riffle to pool ratio, width to depth ratio, entrenchment ratio, etc.

XII. ATTACHMENTS

Provided as attachments to this O&M plan are the following items;

1. A copy of the "as built" survey showing final plan form, streambed profile and location and elevations of all rock structures.

2. A plan view map showing all vegetation established including the locations the material has been planted, the species and the form (i.e. transplants, posts, fascines etc) of the vegetative material when it was planted. A Landowner Vegetation Management Guide based and the vegetation map will be provided to assist landowners in the proper care of the riparian vegetation on their property.

3. A series of color photographs which clearly document the entire project length and the constructed features.

4. Copies of any NYS DEC, DEP or USACOE permits which contain provisions which require the applicant to complete repairs, maintenance, monitoring or other activities associated with management of the project after construction.

Appendix D

Broadstreet Hollow Landowner Guide

Landowner Guide
Broadstreet Hollow Stream Restoration Project



Prepared By
Greene County Soil & Water Conservation District
New York City Department of Environmental Protection Stream Management Program
January 2001

I. Purpose of the Guide

The purpose of this document is to provide you with information to guide you in the maintenance of the stream restoration project completed on your property. It will provide some basic information regarding the project design, how the restored stream is expected to function and what is required in the way of maintenance to achieve maximum benefit from the project. This includes a discussion of the purpose and performance of the rock structures, as well as guidance on how you can help establish and maintain vigorous streamside vegetation.

II. Introduction

In many areas of the watershed, the New York City Department of Environmental Protection Stream Management Program and local Soil & Water Conservation Districts are working as partners to pilot the use of new stream management strategies. Based on the principles of fluvial geomorphology, the study of a stream's function within a landscape, the focus of our work has been on restoring natural stream health while minimizing the need for repeated excavation and riprapping of channels. As a resident of the watershed, you may have noticed how some sections of stream withstand high storm flows with no significant signs of erosion or rock deposition. It is our goal to create such "stable" streams throughout Broadstreet Hollow beginning with your section of the stream.

As we have worked through the assessment and restoration project with the landowners, we have attempted to keep you informed not only of our progress but also of our project goals. We realize that as landowners, you will be our best advocates for this type of restoration and it is important to us that you have an understanding of the processes at work in your backyards. The following information is provided as general background on the development of the project design.

III. The Restoration Design

Prior to designing the restoration project as constructed on your property, the Greene County Soil and Water Conservation District (GCSWCD) and NYCDEP used a number of assessment tools to evaluate the stability of your stream reach and to determine the factors influencing its condition since the 1996 floods. During this assessment process, critical stream features such as the cross sectional area, pattern or alignment and the slope of the stream were surveyed and compared to the same measurements from a stable section of the stream. This stable section was located higher in the watershed and is referred to as a "reference reach" (Photo 1). Using historical aerial photographs and detailed measurements from the reference reach as a "blue print", a new channel was constructed in the project reach.

Photo 1. Survey of the reference reach located above project site

A. Stream Channel Design Features

As you look at the channel, you will notice there is a main channel area, with lower terraces on alternating sides of the stream. The lower channel is known as the "bankfull" channel, and it is designed to convey the runoff and sediment from smaller storm events which occur on a 1-2 year interval. The bankfull flow is often called the dominant flow or channel forming flow, as it is these smaller, more frequent storm events which exert the most influence on the stream's pattern, profile and dimension. Landowners should expect to see some minor erosion and deposition in this section of the channel as the stream makes some minor adjustments and sorts the loose materials.

In above the bankfull channel is the floodplain. The floodplain is designed to carry the runoff experienced in larger storm events. The GCSWCD and our engineers have run flood prediction models on the stream reach, and have designed the channel and floodplain to contain the flows associated with storms up to the 100 year flood event. Although the floodplain is far less active than the bankfull channel, it is still an important component of the stream and landowners should not place any fill or other obstructions in this area. The arrangement of this two stage channel can be seen in Figure 3.

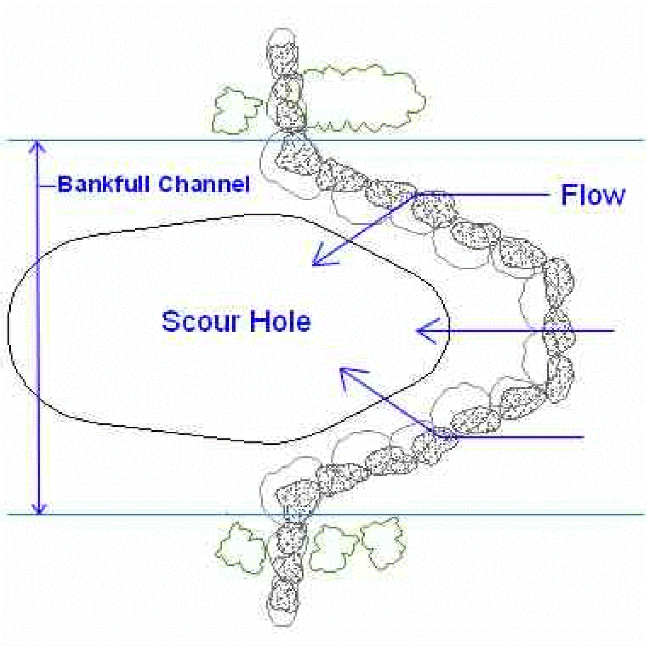
When we designed and built the project, we also made minor adjustments in the stream's alignment to help reduce the energy of the water as it moves down stream. Increasing the size and number of meanders in a stream reduces the slope and resulting energy. To further reduce energy, the stream's slope was designed as a series of steps with water flowing over boulder rock structures into energy dissipating pools.

B. Cross Vane Rock Structures

Once a stable stream channel alignment and slope was determined from the reference reach, the GCSWCD incorporated a number of rock structures to provide this slope and alignment control. These structures are referred to as cross vanes. As you will note in their construction, the cross vanes are two downward angled ramps extending from the bank in an upstream direction, with a solid, level sill of rock set at the elevation of the desired streambed (Photo 2 and Figure 1).

Photo 2. Note still water along banks , velocities in center of the stream channel

The flat sill located in the center of the stream channel provides the grade control, while the two ramps of the structure function to reduce the water surface slope along the streambank upstream of the structure. By reducing (flattening) the water surface slope, the erosive forces on the streambanks (known as shear stress) is also reduced to a point where vegetation can be used to provide bank stability. During higher flows, you should observe an area of flatter water on each side of the channel upstream of the structure with the faster velocities directed to the center of the channel. The cross vanes will maintain a pool just downstream of the sill area. This pool will further dissipate stream energy and help maintain stability in the reach.



C. Maintenance of the Stream Channel and the Cross Vanes

The GCSWCD will continue to monitor the stream channel bed and banks to insure that our design is stable. As the landowner, do not to attempt any excavation or adjustments to the channel. Maintenance of the channel bed, banks and rock structures are the responsibility of the GCSWCD. Maintenance of these structures is generally limited to the first few years when a few flood events may dislodge rocks from the cross vanes. The replacement and or adjustment of these rocks are the responsibility of the GCSWCD. Landowners can assist the GCSWCD by reporting damages to these structures. If large woody vegetation becomes trapped on the structures it can be removed, but you are requested to notify the GCSWCD in advance.

Figure 1. Overhead view of Rock Cross Vane

D. Groundwater Relief Wells

Across the stream from your homes, the project design called for the installation of several groundwater relief wells to mitigate the silt boil which had developed in the center of the channel. During test borings conducted by our geo-technical engineer, it was discovered that a layer of coarse sand 3' to 4' thick was present under the clays at a depth between 27' and 32'. The sand layer accumulated groundwater flow. Being confined between deep clay layers, enough pressure would build in the sand layer to create an artesian condition. Groundwater pressure in the sand layer was strong enough to push water up to the stream bottom through the overlaying clays. As the groundwater moved upwards, it eroded the clay layer and a highly turbid solution of groundwater and clay particles was entered the stream.

To mitigate this condition, the project installed three groundwater relief wells which basically provide pressure relief to the shallow confined aquifer, and which divert upwelling groundwater flow safely to the stream via a discharge pipe. As designed, the groundwater wells do not require any maintenance other than an occasional inspection to make sure the discharge outlets are clear of obstructions.

E. The Role of Vegetation

Vegetation plays three main roles in providing for stream quality. First, the vegetation plays a critical role in providing for stream bank stability. The roots of trees, shrubs and grasses help to secure the stream bank and keep it from eroding during high stream flows. When trees, shrubs, and grass are planted in combination, their roots form a mosaic capable of holding the soil at all levels. Vegetation in the riparian area also reduces the amount of erosion that can result from surface runoff as it finds its way to the stream. The second way that vegetation is helps is by slowing runoff. By allowing surface runoff more time to enter the soil, vegetation is reducing the amount of non-point source pollution -- road salts, excess fertilizers or

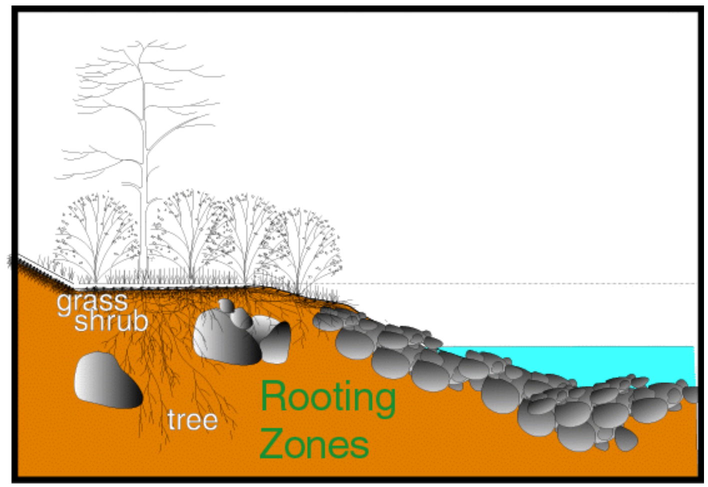


Figure 2. The riparian vegetation rooting zone

other chemicals – which otherwise might be carried into the stream. Finally, streamside vegetation provides cover for the stream. This reduces water temperatures and improves fisheries habitat by providing protection from predators. Organic material, in the form of leaf litter, provides essential nutrients to aquatic insects - a basic food of native fish.

IV. Vegetation Maintenance

The purpose of this section is to help landowners maintain the vigor of the streamside vegetation on the project reach. By keeping riparian vegetation healthy, the landowner is ensuring that the vegetation functions effectively to keep streambanks stable and enhance the quality of the aquatic habitat.

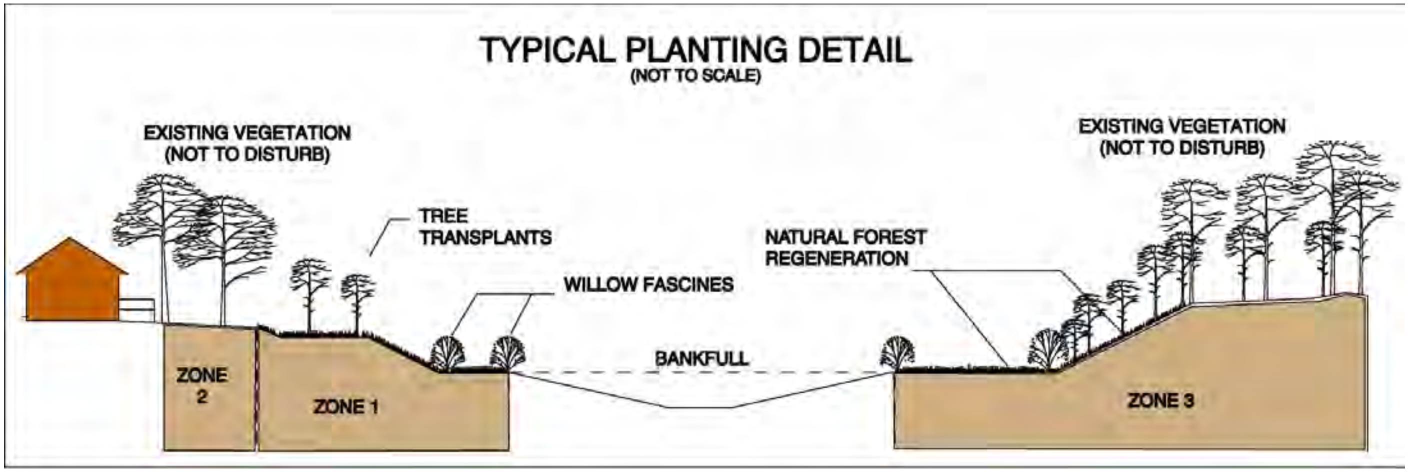
A. Riparian Vegetation Zones and their Management

The establishment of an effective vegetative riparian buffer is extremely critical to this project. Furthermore the success of that vegetation is dependant on your assistance.

This section describes the riparian vegetation zones that will be established following construction. Each zone differs in its assortment of plant species and the planting arrangement. The selections of specific plants and their arrangement is intended to maximize the function of the riparian vegetation based on the stresses and conditions expected in each zone. Correspondingly, each zone will have different management recommendations for the landowners to follow. These recommendations are based upon the experience gained from other conservation projects utilizing these plants, and the evaluation of their performance.

For the purpose of vegetation management, the riparian area of the Broadstreet Hollow Creek at the project site is broken into three zones. Each zone experiences differing levels of stress during storm events and high flow conditions. In general, the level of stress declines as distance from the stream increases. Concurrently, the plant selection and arrangement changes as the distance from the stream increases. A view of the limits of the zones is shown in Figure 3.

Zone 1:
This zone is a flood plain and subject to the greatest amount of stress. Here, nearest the stream, the vegetation is managed for maximum root development and occupation of the stream bank in an effort to reduce the effects of erosive stresses on the stream bank. This is accomplished primarily using closely spaced, low growing shrubs and trees. Cool climate perennial grasses are used in this area to provide immediate post-construction soil stability until the shrubs and trees become established. Management here is generally restricted to encouraging rapid growth by watering trees and shrubs and replacing dead plants. Fertilizer applications are generally unnecessary, and could mistakenly make their way into the waterway.



Zone 2:
As you move away from the stream, grasses and more widely spaced taller trees and shrubs become dominant. Here, the function is to provide soil stability, while creating habitat cover and allowing for the infiltration of surface runoff. Management is initially limited to watering, plant protection from deer browse, and plant replacement, with some pruning and mowing allowed outside of the flood prone area.

Zone 3:
On the right bank of the stream the vegetation will include primarily trees and shrubs native to New York forests in an effort to re-establish a natural riparian forest buffer. The upper slope area (above the bankfull floodplain) will be initially seeded with conservation seed mixture for surface erosion control. A number of bare root tree seedlings will be planted in the spring of 2001. This area will primarily be left to regenerate on its own, as there are adequate seed trees present and the area is out of the flood zone. In the first year of establishment,

Figure 3. The riparian vegetation zones

this zone may require some irrigation, but otherwise, will be left to grow without intensive management. Once established, the vegetation in this zone will not require maintenance. Protection against browsing wildlife will be provided by Greene County Soil and Water

Conservation District upon establishment and will be necessary until the trees are above the reach of deer.

B. Managing the Vegetation

As a participant in this project, it is the responsibility of each landowner to monitor the general condition of the vegetation and to report any potential problems to the Greene County Soil and Water Conservation District at (518) 622-3620.

Pruning

Landowners should recognize that most riparian vegetation, especially in Zone 1 and 3, is best left to grow without significant trimming or pruning. Top pruning or shearing of shrubs will promote lateral growth and is appropriate once the shrub has reached a height of 4 - 5 feet.

Mowing

Mowing grasses will reduce the rooting depth of individual grass plants and thereby will decrease their effectiveness in protecting the soil from erosive forces. Intensive mowing with lawn tractors can kill or severely damage young trees and natural regeneration, as well as compact the soil. Landowners should respect the suggestion not to mow grass or cut trees and shrubs in Zone 1. Mowing is allowed in Zone 2. Landowners are asked to cut the grass only at the highest settings and to maintain a three foot (3') buffer of grass at the very edge of the zone. This buffer strip should be cut only once each year. Landowners should avoid mowing in the hot summer months and during drought periods.

Mulching

The use of heavy mulches around new plantings, such as bark chips or shredded cypress bark should be avoided, as these will kill off the important grasses needed for soil surface protection. The use of straw as a mulch for preserving soil moisture around new plantings is recommended instead of heavy, less biodegradable mulches.

Unless otherwise approved by the Greene County Soil & Water Conservation District, landowners will not remove or move any trees or shrubs planted by the project. Landowners can supplement the trees and shrubs planted after construction, but should check with the Greene County Soil & Water Conservation District to ensure that the plant species is compatible with the site conditions as well as the designed planting strategy. Remember, it is important to maintain a mix of trees, shrubs, and grasses to provide the best protection against soil erosion.

Hardy, reliable plant material has been used in this project. It should not be necessary to use fertilizer, herbicides, or pesticides on any of the plantings. Any such applications should be made by the Soil and Water Conservation District. Owner application of these materials could complicate efforts to monitor the effectiveness of the project by reducing water quality, adversely affecting fish populations and damaging the vegetation. In addition, landowners are requested to avoid using Zone 1 for disposal of cuttings, grass clippings and other materials. While the GCSWCD recognizes the need for “compost” areas, placement of these materials in the immediate stream corridor inhibits plant growth and reduces stability. The GCSWCD will discuss on-site composting options with each individual landowner.

C. Access to The Stream

This project is not intended to limit landowner access to the stream. In fact, it is important to the success of the project that you continue to enjoy the experience and benefits of living on the stream. Your assessment of our work as stream management professionals is extremely important to us. We recognize that establishment of thick shrub vegetation along the stream may present an obstacle to your access. However, we have observed many other stream sites where “trails” to the water have become the primary source of stream bank instability. By the use of selective thinning of the shrubs, protection from concentrated surface runoff, and stabilization of the path with stones, a stable access point can be maintained. The Greene County Soil & Water Conservation District will work with each of you to establish safe and stable access points along your property.

D. Modifying the Plan

This guide contains recommendations to be followed by current and future residents of the project site. The recommendations are made in an effort to protect local property from the hazards that accompany unstable stream conditions. Should the Greene County Soil & Water Conservation District find that conditions warrant an alteration to the vegetation plan or the management strategy of this document, the District may act to correct the conditions.

E. Advice and information

Additional information or advice is available through the Greene County Soil and Water Conservation District at (518) 622-3620 or the NYC Department of Environmental Protection’s Stream Management Program at (845) 340-7518.

Table 1: Broadstreet Hollow Planting List and Stream Bank Management Recommendations

Shrubs		
Willow -Salix purpurea (Streamco cultivar)	Zone 1/3	Establishment - planted as live stakes, fascines, seedlings Benefit - bank stabilization, storm water run-off protection, wildlife habitat Needs/Management - Irrigation in first year during dry spells, browse control, can be top pruned after they reaches 4-5 feet to keep in bush form. Later years prune deadwood.
Red Osier Dogwood	1/2/3	
Button Bush	1/2/3	
Trees		
Cottonwood - Populus deltoides (male clones)	3	Establishment - Live stakes, stump sprout, natural repopulation, seedlings, balled & burlapped Benefit - deep rooting, selection based on soil conditions, stabilization, stream cover. Needs/Management - Irrigation during initial establishment, report dead, diseased or downed tress to GCSWCD
Grasses		
Conservation Seed Mixture 00% Fescue 00% Rye 00% Legume 00% ________	Zones All	Establishment - hydro-seeded Benefit - fast coverage, strong fiberous root mass provide protection from both stream flows and surface runoff. Needs/Management - Landowners may routinely mow the grass up to a point three feet (3') from the top of the floodplain bank (edge Zone 2/3) and may annually mow all the way to the edge of Zone 3 to prevent woody growth in this area. A narrow buffer of grass which is not routinely mowed will allow the grass to put energy into root development instead of regenerating top growth.

Appendix E

Fish and Habitat Monitoring Plan

NOT COMPLETE