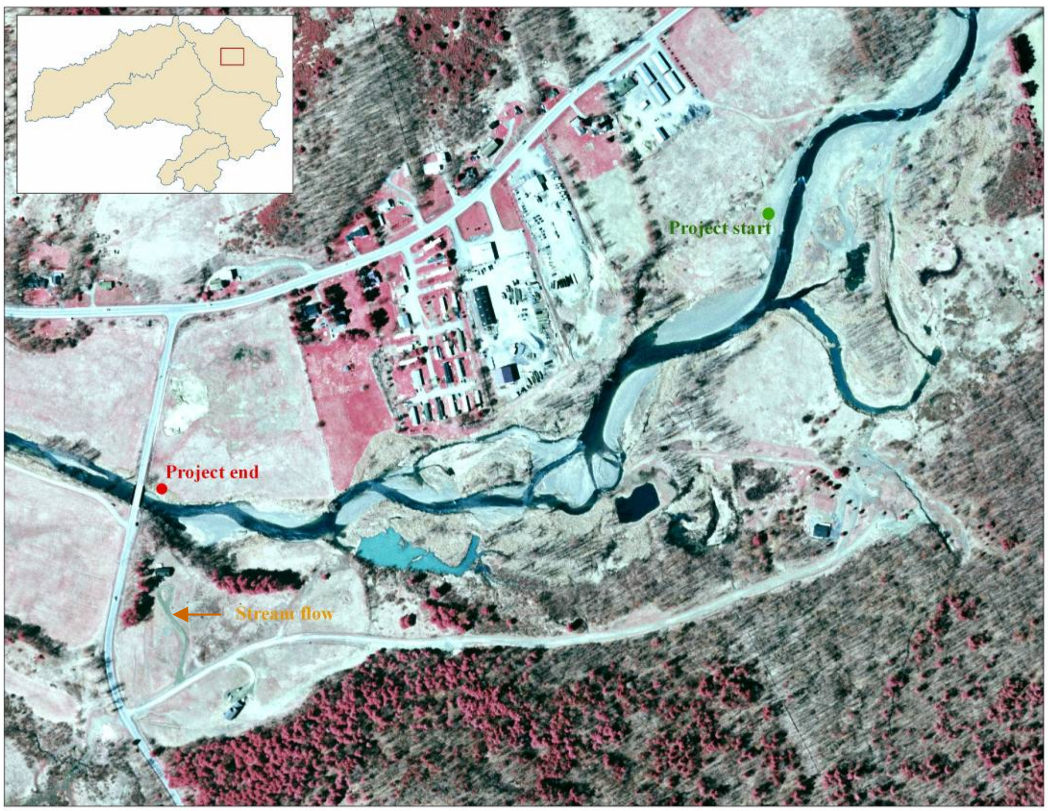
Ashland Connector Stream Restoration Project

Project Implementation Report

Town of Ashland, Greene County, New York



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Project Information:

Project Name and Location

Ashland Connector Stream Restoration Project
Town of Ashland
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Project Description:

Background

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

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

Batavia Kill Pilot Project Goals and Objectives

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

- Evaluate and improve the effectiveness of natural channel design techniques in the Catskills, based on assessments of the physical and biological characteristics of the restoration sites paired with water quality monitoring at the outlet of the Batavia Kill and above and below the Conine restoration project site (scheduled for 2007 construction).

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

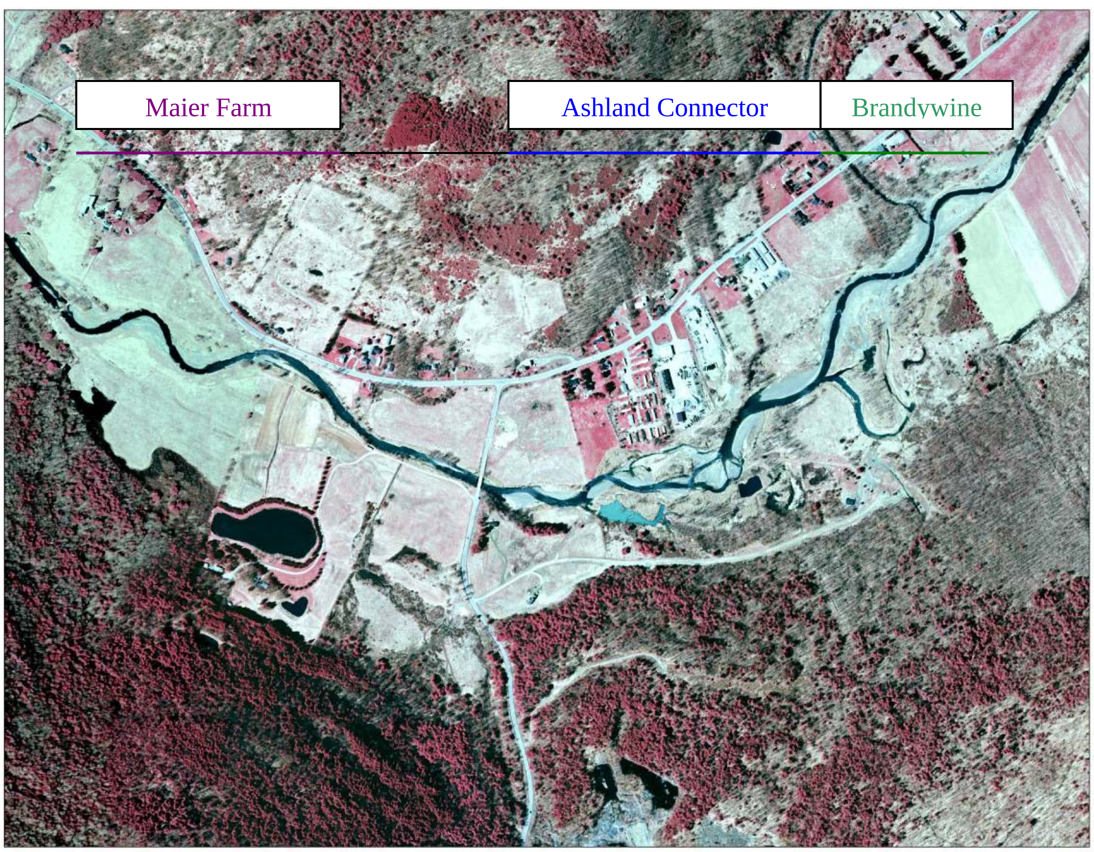
- Evaluate the effectiveness of using stable reference reaches and regional relationships in the development of restoration designs.

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

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

Batavia Kill Restoration Projects

Three demonstration projects were installed during the first phase of the Batavia Kill Pilot Project including the Big Hollow, Brandywine and Maier Farm Stream Restoration Projects. The proposed restoration of the Ashland Connector Reach is the first project within the second phase of the program, and will serve to connect the Brandywine and Maier Farm Projects, resulting in over two miles of restored stream channel. The project reach is located near the middle of the Batavia Kill main stem, in the Town of Ashland, upstream of the County Route 17 Bridge. After the completion of the last of the planned projects – Conine – the combined total of restored stream length will be over three miles.



2001 Digital Ortho Quarter Quad imagery displaying Maier Farm on the left, Brandywine on the right and the pre-restoration condition in the Ashland Connector project reach

Goals and Constraints of Project

This project, as set forth in this design document, involved the stabilization of a severely aggraded and eroded stream reach on the Batavia Kill. The project was an EPA mandated deliverable under the 2002 NYC Filtration Avoidance Determination (FAD) and was undertaken with a primary objective of water quality protection.

Goals

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

To mitigate excessive turbidity and total suspended solids impact on water quality by addressing excessive lateral erosion in areas with glacial lake clay and clay rich lodgment till exposures by restoring a self sustaining stream form and function through the reach.

As proposed, this goal was to be accomplished through the use of Natural Channel Design (NCD) concepts to reconstruct a new stream channel, which would reduce environmental, property and structure damage. This approach will assist in maintaining the integrity and benefit of a naturally functioning channel and floodplain. Additionally, use of NCD to guide stream restoration activities may help to avoid further impacts on aquatic and riparian habitat within the project area and on upstream and downstream reaches. The aesthetic value of the impaired reach will improve with the implementation of NCD techniques in place of traditional techniques.

When designing the project, the results of the initial physical assessments and the partner and stakeholder objectives were considered. After careful review, we determined that the following criteria would be part of the project design:

- Channel Stability
- Sediment Transport
- Flood Conveyance
- Fisheries Habitat
- Riparian Functions
- Aquatic and Wildlife Habitat
- Aesthetic Value
- Stream Recreation

Constraints

A number of potential limitations and constraints for the project were identified, refined and quantified. The potential constraints were considered at the appropriate stage in the development of the restoration design for the Ashland Connector reach. These potential issues included physical site constraints, landowner approval and access, project permitting and data needs and limitations. The following is a brief description of the primary constraints of the project.

Physical Site Constraints

The project design addressed channel stability and processes while working within the existing physical site constraints. The restoration design corrected planform, channel profile and cross sectional parameters in order to meet the goals and objectives of the project, and to achieve long-term channel stability. Therefore, GCSWCD inventoried the physical features that could affect restoration, while taking into consideration the risk of failure if alternatives were used.

Landowner Approval and Access

Landowner acceptance of the project has substantial bearing on the future success of the project. Therefore, landowner approval and access to the project area were identified as critical design constraints. The required approval of multiple primary and secondary landowners within the project area generated the need to educate these owners about stream instability and the apparent need for action. The planning and design utilized landowner knowledge of the site and incorporated owner concerns when practical. The provision of landowner approval was set forth via a Landowner Project Agreement, which is a 10 year license between the landowner and the GCSWCD.

Data Needs and Limitations

Channel assessment and design incorporated a number of data sources including; reference reach, regime and analytical methods. These needs were 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 reference sections within the corridor, typical values developed by Dave Rosgen and others, as well as provisional curves developed by project partners.

Project Permitting

The restoration project required ACOE, NYSDEC and NYCDEP permits. These permits could have potentially delayed project implementation. Working in close coordination with the ACOE, NYSDEC ensured that permits were not delayed, technical resources from these agencies could be utilized, and overall project requirements and needs could be efficiently incorporated into the restoration strategy. The NYSDEC authorized the project under Article 15 of ECL, while the ACOE utilized Nationwide 27 to approve the project.

Existing Site Conditions

Project Location

The project is located in the Town of Ashland, near the intersection of State Route 23 and County Route 17. The project starts approximately 3400 ft. upstream of the County Route 17 Bridge over the Batavia Kill.

Watershed Setting

The Batavia Kill watershed is a 72 square mile sub-basin of the Schoharie drainage. The project reach storm flow is modified due to its location below the Batavia Kill's three flood control structures. The project reach is located within the flattest valley slope of the drainage system, at 0.3% containing multiple river terraces, positioned laterally along a broad alluvial valley classified as a valley type VII. Alluvial terraces and flood plains are the predominant depositional land form occurring along this section of the drainage. The valley is very broad with extensive belt width available for stream channel migration. Historically, the stream channel alignment has been heavily manipulated, resulting in its current irregular and distorted meander pattern. Alignment modifications and the subsequent channel responses have had negative impacts on stream stability in this valley segment.

Field assessments, coupled with the analysis of aerial photography, were used to characterize stability and inventory historic stream response through the valley segment in which the reach is located. The initial field assessment in 1997 by GCSWCD included an erosion inventory within the Batavia Kill Stream corridor to prioritize reaches for future monitoring efforts and restoration. Through data analysis, it was determined that the corridor segment, which extended from County Route 12 to the Vogatz property west of Ashland, had the highest level of erosion, per unit stream length, in comparison to the four other corridor segments. More than 45% of this segment's streambanks were experiencing active erosion and bank failure, averaging more than $4ft^2$ of exposure on streambanks for every foot of stream length. The inventory determined extensive soil loss to both hydraulic and geotechnical streambank failures, or combinations of both.

Review of the general soils characteristics of the segment revealed that the segment was highly susceptible to bank erosion due to the thick unconsolidated layers of glacial soils. Gravelly loams, which are loose in structure with little rock content, are the predominate soil types of the segment's streambanks, corresponding to a natural susceptibility to erosion and entrainment. The composition of the banks and structure of soils within this segment are generally finer than the channel pavement material.

Healthy riparian buffers are critical in maintaining stability in this valley setting and for this stream type. The review of aerial photography and field investigation determined the riparian buffer provided limited streambank protection throughout the segment. The invasive species Japanese knotweed (*Fallopia japonica*) had colonized the entire segment and appeared to be proliferating in the low lying floodplain areas. It is believed the invasive species was limiting the re-establishment of any effective natural species and effective buffer through the segment due to the dominant characteristics of the species.

The construction of three flood control structures, in the last 30 years, has modified the natural water and sediment regimes through the segment. The structures have caused increases in flow duration and available energy that impacts streambanks and the channel bottom. These structures also prevent sediment transport through them, which is suspected to have an impact on channel morphology downstream.

In summary, these watershed and corridor modifications were the likely cause for the increase of natural streambank erosion rates through the segment. Further, the impaired state assessed in 1997 of this stream segment was, in part, due to the major flood event in 1996, and compounded by the emergency repair work that followed. The historic flooding and mitigation work left this section of the Batavia Kill highly susceptible to increased environmental degradation and reduced stream stability.

Existing Land Use and Cover

Land use within the project area is characterized by vacant riparian lands and floodplain. Adjacent land uses are variable with low density residential and forest cover on the south side of the corridor and high density residential and commercial use on the north side along State Route 23. Significant land uses adjacent to the project area include a Greene County Highway facility, a small mobile home park and a construction company's supply yard.

The project area land cover consisted of mixed vegetation types dominated by gravel alluvium and water. No impervious surface existed within the project area. The northern portion of the corridor outside the active stream corridor was dominated by Japanese knotweed, isolated wetland and meadow. The southern floodplain was dominated by forest cover along the adjacent high terrace. Several wetland areas were delineated and mapped as a component of the USACOE wetland Jurisdictional Determination. The Request for Jurisdictional Determination is on file and available for review at the GCSWCD office.

Water Resources

Water resources on the parcel consist of the Batavia Kill, which is classified by the New York State Department of Environmental Conservation (NYS DEC) as A(T) which means that the resource is used as a drinking water supply and that it may support a trout population. It is listed on the 2002 NYS DEC Priority Waterbodies List (PWL) under HUC 02020005/020 Batavia Kill, middle and tributaries (1202-0058) as Habitat/hydrology known to be stressed, minor impacts with a known problem species (knotweed) and silt/sediment as suspected pollutants. Sources of pollutants are listed as; Known - streambank erosion and habitat modification, and Possible - construction, and failing onsite systems. The project area is located entirely in the FEMA 100-year floodplain with several unnamed channels out-letting to the Batavia Kill.

Cultural Resources

A Phase 1A Literature Review and Phase 1B Archeological Field Reconnaissance of the project site was performed by Hartgen Archeological Associates, Inc. The archeological study recommended no sites for Phase II evaluation or avoidance during construction, concluding that no significant archeological features exist within the project boundaries.

Soils

Five soil types are located within the project area; Barbour loam 0-3 % slopes (Ba), Basher silt loam 0-3 % slopes (Bs), Fluvaquents-udifluvaquents complex 0- 3%(Fu) / Ochrepts, frequently flooded 0-8%(Oc), Tunkhannock gravelly loam, rolling 5-16 % slopes (TuC), and Tunkhannock gravelly loam, hilly 10-30% (TuD). These soil types are presented in Table 1 below.

Soil Type	Area (sq. ft)	Acres	Percent of Total	Hydrologic Soil Group
Ba	276,643	6.35	24.78%	B
Bs	355,734	8.17	31.86%	B
Fu/Oc	309,511	7.11	27.72%	Unclassified
TuC	16,897	0.39	1.51%	A
TuD	1,802	0.04	0.16%	A
W	155,997	3.58	13.97%	Water

Table 1: Soil types within Ashland project area

The Hydrologic Soil Group (HSG) for Fu soils is listed in the USDA Soil Survey for Greene County as Unclassified. Under the soil description in the Soil Survey it is stated that these (Fu) soils are "nearly level, very poorly drained to well-drained formed in recent alluvial deposits on flood plains." The Soil Survey further states, "This unit has a wide range of properties, depending on the type of alluvium." For planning purposes, the soil type with the project area was assumed to be well-drained B soil type.

Reach Stability Assessment

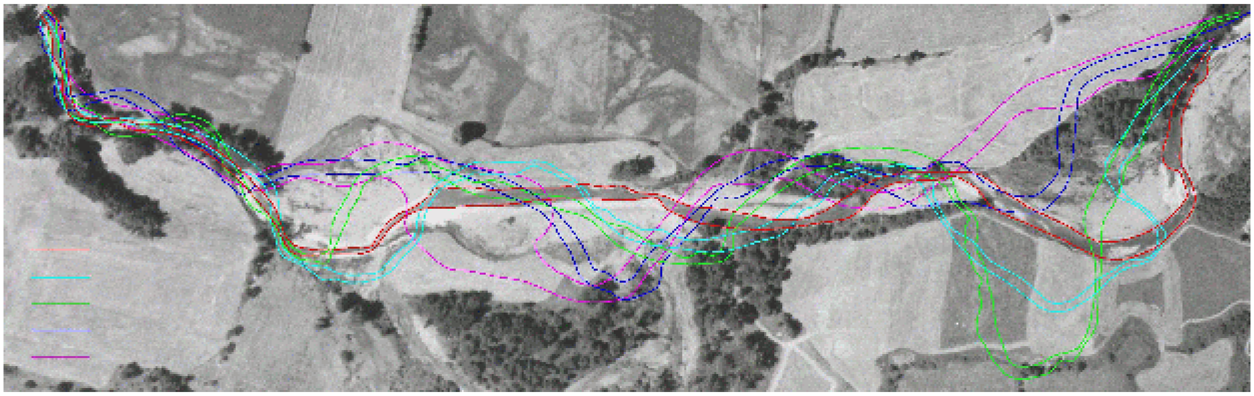
The Ashland Connector Reach begins behind the Greene County Highway Department Ashland Facility and runs 3,400 feet downstream to the bridge at County Route 17. The drainage area of the reach ranges from $50.8mi^2$ to $51.2mi^2$, with a single unnamed intermittent tributary entering the reach. The reach has an average valley slope of 0.3%, moderate to broad in width, with an unconfined landform contributing to frequent stream migration. Current land use in the reach is variable, with low density residential and forest cover on the south side of the stream, and institutional, high density residential, and commercial use on the north side. Significant land uses within the reach include the county highway facility and a small trailer park.

Stream Morphology

An inventory of the project reach in 1997 revealed that 38% of the streambanks exhibited signs of active erosion, with nearly 1,050 feet of exposed streambank along its length. An average of 2 ft^2 of exposed streambank surface per linear foot of stream length was inventoried. An additional inventory on the reach in 2003 revealed that nearly 70% of the streambanks exhibited signs of active erosion, with nearly 1,895 feet of exposed streambank along its length. An average of 4.5 ft^2 of exposed streambank surface per linear foot of stream length was inventoried. The resulting 30% increase of affected stream length and the 125% increase of exposed streambank per linear foot of stream length clearly demonstrated the need for restoration activities. The predominant stream type in the reach was C4, with sections of braided channel characteristic of a D stream type (Rosgen 1996) present at the upper end. Overall, stream morphology was characterized by significant areas of aggradation, channel over widening, and an increase in the channel’s width to depth ratio.

Typical of over-widened channels, the reach was characterized by lateral streambank erosion and frequent channel shifts and avulsion.

Historically, the channel has been inefficient at carrying its sediment load, leading to extensive deposition and point bar formations. In the image below, a 1959 aerial photograph is overlain with the stream channel pattern from 1969, 1980, 1997 and 2000.



1959 Aerial photograph of reach with 1968, 1980, 1997 and 2000 channel planform locations overlaid. Note extreme channel migration on former farmlands in lower right corner

A side by side comparison of the reach is shown below in aerial photographs from 1959, 1967, 1997 and 2000.

1959 Aerial photograph of reach 4c with 1968, 1980, 1997 and 2000 channel planform locations overlaid. Note extreme channel migration on former farmlands in lower left corner

Lateral channel migration through the period of record had averaged between 150 feet and 475 feet, with major shifts most likely associated with channel avulsions during the larger flood events. Both figures show the major shifts in the stream channel location during the period of record. The floodplain in this reach was characterized by numerous oxbows created by meander cutoff, several of which have filled with sediment. The presence of older, revegetated oxbow cutoffs evident in the 1959 photography suggests that extreme channel migrations may actually pre-date available aerial photography. The stream alignment was irregular, with multiple channels and numerous remnant channel avulsions. A fairly large manmade pond on the left floodplain had been historically threatened by migration of the channel, and might have been breached if the meander had continued to erode.

Historically, minimal vegetation had been present along the channel margin and extensive bar formations confirmed excessive channel migration and apparent sediment conveyance inefficiencies. Observations made during the assessment period, as well as from historic aerial photographs, had also shown evidence of gravel bar and floodplain mining in the reach. While floodplain mining had been discontinued on the south side of the stream at the lower end of the reach, excavation for topsoil had been ongoing on the north floodplain. In general the reach was characterized as highly unstable, with a trend toward channel over-widening, with severe streambank erosion at the channel margins. Rapid channel shifts after flood events were common, and the channel clearly could not effectively transport sediment.

Riparian Vegetation

The project reach was characterized by a poor riparian condition, heavily dominated by Japanese knotweed. While woody vegetation was present on the adjacent high terrace, and several locations on the outer edges of the floodplain, the active stream corridor was almost completely covered by knotweed. At the top of the reach, active erosion of the south bank was occurring in spite of the presence of a moderately dense stand of locust trees. The entire north bank of the reach had essentially no riparian buffer other than knotweed.

Active channel migration has historically threatened this floodplain pond. Knotweed is a significant limiting factor to the likelihood of the reach regaining natural stability.

Numerous wetlands and a man-made pond are located on the south floodplain. The wetlands are contiguous with extensive wetland conditions in the reach, and in most cases were the result of channel adjustments that abandoned meander scrolls. The wetlands and pond contribute to the diverse habitat potential of the reach. The wetlands within the reach were considered a priority for protection or mitigation due to the scarcity of established riparian wetlands within the Batavia Kill watershed. The historic channel shifts had frequently impacted these wetlands by removing much of the wetland soils and vegetation. Insufficient sediment conveyance through the reach had also resulted in deposition (filling) in many low wetland areas in the reach.

Infrastructure

Infrastructure issues in the reach are limited to the County Route 17 crossing at the bottom of the reach. The bridge did not appear to have any problems associated with scour or downstream erosion, although aggradation upstream of the bridge may have been partially due to a back-water condition at the bridge. While the bridge is wide enough to span the expected bankfull width at this point in the watershed, extensive fill across the north floodplain between the bridge and NYS Route 23 may have contributed to aggradation during larger flood events. The bridge may have been threatened by historic trends of channel migration. As of 2002, the meander upstream of the bridge continued to move down valley, and could have potentially resulted in improper alignment with the bridge opening, and erosion around the abutment.

Reach Summary

Numerous assessments in the reach had revealed signs of extreme instability, with aggradation, channel widening and streambank erosion prevalent throughout most of its length. Channel planform adjustments had been active for at least 40 years, and the observed instability may have been initiated many years ago as the result of frequent attempts to manage the channel. Riparian conditions were poor, and continued instability of the reach would have breach the floodplain pond, as well as impacted the bridge at County Route 17.

Restoration Strategy:

A fundamental component of the pilot project was to demonstrate the use of NCD techniques and their effectiveness at meeting multiple goals of a stream restoration project. Assessment and project design incorporated NCD techniques into the evaluation of the reach and development of restoration alternatives. This methodology required classification of the current condition of the Ashland Connector reach and development of a preferred physical morphology. The strategy was consistent with the physical constraints of the landscape and gave consideration to social and political expectations. Alternative strategies for stabilization were evaluated to reach a common consensus between project stakeholders.

The restoration strategy, selected for the project reach, involved the proposed construction of a Rosgen C4 stream type with meandering riffle pool channel morphology. Channel form and meander pattern were derived from analysis of historical aerial photographs of the valley section, and the use of analytical, regime, and reference reach techniques. The position of the reach between the previously constructed Brandywine and Maier Farm Restoration Projects provided the opportunity to utilize several years of physical monitoring data to incorporate and enhance attributes of the design. The project design is attached at the end of this report.
The final restoration strategy focused primarily on the following objectives:

- Develop a stable stream planform with a meander pattern appropriate for the available belt width, slope and other valley features. The restoration designs provide for construction of a C4 stream type.

- Develop a stable stream channel profile (bedform), with a riffle pool complex appropriate for a C stream type. To promote the appropriate morphology, in stream rock structures (Cross Vanes) will be used to provide grade control. These structures will also be used to reduce in stream degradation into clay deposits.

- Develop an appropriate channel dimension (shape and cross sectional area), for a C stream type, that effectively conveys its sediment supply.

- Provide for streambank stability by using in stream rock structures (Rock Vanes) to reduce shear stress and velocity against the outside meander bends.

- Use root wads to provide additional streambank protection and supplemented fisheries habitat.

- Use extensive woody and herbaceous live material to provide for the long-term stability of streambanks and the floodplain.

Bankfull Discharge Calculations

Determination of the discharge (stream flow) associated with the bankfull flow is essential to natural channel design concepts. The bankfull channel design was based on the expected bankfull discharge at the specific location in the watershed and was determined using the following methodologies. Table 4 on page 16 gives the final values chosen for each design variable.

1.)From: Bankfull Discharge as a function of Drainage Area for several regions of the United States **<u>The Reference Reach Field Book</u>** using the Southeast Pennsylvania data (Rosgen 2005)

Drainage Area (50.8 mi^2)=> Bankfull Q= 1250 cfs
Drainage Area (51.2 mi^2)=> Bankfull Q= 1300 cfs

2.)From: Bankfull Discharge and Hydraulic Geometry Regional Relationships for 18 USGS Stream Gages in The Catskill Mountains, NY (Published AWRA 2003 International Congress)

Drainage Area (50.8 mi^2)⇒ Bankfull Q = 1919 cfs
Drainage Area (51.2 mi^2)⇒ Bankfull Q = 1933 cfs

3.)From: Regional Relationships for 18 USGS Stream Gages in The Catskill Mountains, NY, Stratified by Hydrologic Region for Hydrologic Region 4 for bankfull discharge and cross-sectional area (Published AWRA 2003 International Congress)

Drainage Area (50.8 mi^2)⇒ Bankfull Q = 2510 cfs
Drainage Area (51.2 mi^2)⇒ Bankfull Q = 2525 cfs

4.)From: Regional Relationships for 18 USGS Stream Gages in The Catskill Mountains, NY, Stratified by Mean Annual Runoff (MAR> 2.3) for bankfull discharge and cross-sectional area (Published AWRA 2003 International Congress)

Drainage Area (50.8 mi^2)⇒ Bankfull Q =3342 cfs
Drainage Area (51.2 mi^2)⇒ Bankfull Q =3361 cfs

5.)From: USGS (90-4197, Lumia) Short Regression Equation for 2-year flow event region 4

$$Q_2 = 68.3(A)^{.914}$$

Where:
Q_2 = Peak discharge with 2 year return interval
A = Drainage area (mi^2)

Drainage Area (50.8 mi^2)⇒ Q_2 = 2475 cfs
Drainage Area (51.2 mi^2)⇒ Q_2 = 2493 cfs

	Discharge(cfs)	
Method	50.8 mi^2	51.2 mi^2
1	1250	1300
2	1919	1933
3	2510	2525
4	3342	3361
5	2475	2493

Table 2: Summary of Discharge Values

Channel Dimension

During the design process, channel sizing was used to promote channel equilibrium and to provide long-term self-sustainability. This was designed using hydraulic techniques including tractive, regime, reference and other analytical techniques for boundary considerations. The channel was also designed to provide for sediment transport and passage of the base, bankfull and flood flows, with considerations for future channel boundary conditions. Unlike traditional channel sizing, the design channel continually transforms between riffle and pool features which change in shape, length and spacing as the channel meanders through the reach.

Channel Dimensions			
Method	Bankfull		
	Width (ft)	Depth (ft)	Area (ft^2)
Rosgen Graph	66	4.9	305
No Stratification	93	3	306
Stratified by Hydraulic Region 4	104	4	385
Stratified by Mean Annual Runoff (>2.3cfsm)	107	4	416
Stratified by Stream Type (C)	78	3	264

Table 3: Summary of Conceptual Channel Dimensions

In general the existing channel is considered inefficient and sediment deposition had amplified bank erosion and channel instability. Improving the width-depth dimensions of the over-widened section and creating a single channel in the braided area of the reach provided for proper transport of sediment. Further, the channel dimensions of the base flow channel were enhanced by the creation of pools at the outside of meanders and behind in-stream structures throughout the entire reach. These designed pools will improve base flow conditions by increasing storage, and by helping to re-attach floodplain access during larger storm events.

Channel dimensions are a function of the bankfull discharge that is expected to be passing through the reach. These dimensions were roughly associated with drainage area using the following methods:

> As determined by Sarah Miller and Dan Davis, Optimizing Catskill Mountain Regional Bankfull Discharge and Hydraulic Geometry Relationships, AWRA International Congress (2003)

Drainage Area (Average 51 mi^2)

	No Stratification	Stratified by Hydraulic Region (Region 4)	Stratified by Mean Annual Runoff (>2.3cfsm)	Stratified by Stream Type (C)
Bankfull width: $W_{bf}=$	$12.51(DA)^{0.51}$	$17.07(DA)^{0.46}$	$21.25(DA)^{0.41}$	$7.99(DA)^{0.58}$
Bankfull depth: $D_{bf}=$	$1.01(DA)^{0.31}$	$1.05(DA)^{0..32}$	$1.15(DA)^{0.31}$	$1.03(DA)^{0.29}$
Bankfull area: $A_{bf}=$	$12.67(DA)^{0.81}$	$17.93(DA)^{0.78}$	$24.53(DA)^{0.72}$	$8.31(DA)^{0.88}$

Channel Pattern

The proposed design called for realignment of the majority of the existing stream channel. The channel alignment was created through regime and reference conditions of bounding reaches, and gave consideration to valley slope and the existing floodplain terraces. Substantial effort was taken to minimize disturbance to the existing healthy vegetation. The cut and fill quantities and feasibility of construction were also considered during the design for realignment.

After review of historic trends of channel migration, it was determined that the channel was expanding its belt width and overall sinuosity through erosion of the reaches streambanks. The goal for the realignment was to develop a stable planform, without the erosion and sediment loading required in the natural process, ultimately accelerating a more stable form. Therefore the design called for alignment modifications of the existing meanders. The upstream meander realignment was minimal, with the profile and channel geometry requiring the most modification. Modification to the lower bends was designed to deliver a better alignment of flows through the County Route 17 bridge opening.

Channel Profile

Field assessment determined that the channel was vertically unstable through the reach due to the dramatic planform adjustments and localized aggradation. The design proposed modification of channel dimension and position by re-elevating the channel profile in entrenched areas and reconnecting a single bankfull floodplain through the reach. The channel profile was created by utilizing slope characteristics of the valley, channel and existing floodplain terraces. The profile design included consideration for channel sinuosity, valley slope, channel dimension, sediment characteristics and conveyance, and flood conveyance. The design slope also considered cut and fill quantities (cost) and feasibility of construction.

Flood Routing

Flood surface elevations for the final design were modeled by HAKS Engineers and Land Surveyors, P.C. The project was modeled using HEC-RAS flood modeling software to determine the impact that the project would have on the flood surface elevation of a flood with a 100-year return interval. The existing conditions from the NYC DEC flood study, currently under review, were compared with the final design model prepared by HAKS. The comparison determined there to be no significant change to flood surface elevations.

Summary of Proposed Morphological Values

The methods of determining bankfull discharge, channel dimension, pattern and profile, discussed above, provided a range of values that guided the selection of final design values. The results of the various methods were evaluated, and the values applied to the stabilization design are summarized in the table to the right: Summary of Proposed Morphological Values.

Ashland Connector Reach
Stream Restoration Project
Summary of Morphological Values

STREAM TYPE	C4
DRAINAGE AREA (mi^2)	51
BANKFULL WIDTH (ft)	69.28
BANKFULL MEAN DEPTH (ft)	3.5
WIDTH/DEPTH RATIO	20
XS-AREA (ft^2)	240
MEAN VELOCITY (ft/s)	10.3
DISCHARGE (ft^3/s)	2480
MAX DEPTH (ft)	4.4
MAX DEPTH RATIO	1.3
FLOOD PRONE WIDTH (ft)	600
ENTRENCHMENT RATIO	8.7
MEANDER LENGTH (ft)	1143
MEANDER LENGTH RATIO	16.5
RADIUS OF CURVATURE (ft)	360
Rc RATIO	5.2
BELT WIDTH (ft)	242
MEANDER WIDTH RATIO	3.5
SINUOSITY	1.1
VALLEY SLOPE	0.0032
MEAN CHANNEL SLOPE	0.0029
POOL SLOPE	0.0029
POOL SLOPE RATIO	1.00
MAX DEPTHpool	6.1
POOL DEPTH RATIO	1.8
POOL WIDTH	82
POOL WIDTH RATIO	1.2
POOL-POOL SPACING	513
POOL-POOL RATIO	7.4

Table 4: Summary of Proposed Morphological Values

In-stream Structures

The design incorporated four general types of in-stream structures to promote reach stabilization including; rock vanes, j-hook vanes, cross vanes, and root wads. The structures provide significant benefits by enhancing fisheries habitat through the reach, while generating a bed and bank form suitable for the proposed design stream type.

The use of rock vanes will impede bank erosion within the reach. These structures reduce shear stress along the streambanks in order to allow for the establishment of vegetation. Rock vanes also create scour pools downstream of the arms, thus enhancing fisheries habitat. Similar to the rock vanes, j-hook vanes could have been applied to protect the streambanks and further enhance fisheries habitat. The design could have incorporated the use of available root wads in high stress areas along the streambanks. These structures would have assisted the vanes in providing bank protection and habitat enhancement.

The proposed design incorporated cross vane structures. These cross vanes will provide grade control and assist in flow alignment through the stream reach and bridge.

Riparian Vegetation

The proposed design incorporated the use of traditional bioengineering practices such as live fascines, and establishing transplants, seedlings, grasses and sod mats. Bioengineering materials included the use of willow species, varieties of dogwood and other native riparian species. Short term stabilization was provided by hydroseeding the site with a temporary seed mixture throughout the project area. Permanent seeding was performed after all treatments had been completed.

The design proposed to preserve or place transplanted willow clumps at key stress areas (top of rock structures). These willow clumps may help to accelerate revegetation of the reach, by providing a larger size and age class transplant. The willows were harvested from local borrow areas. Sod mats were also placed along the top and face of the streambanks, between transplants, to promote streambank revegetation. Short term stabilization of the streambanks and floodplain was accomplished by seeding with temporary seed mix and hydro-mulching.

The project site had several stands of knotweed (*Fallopia japonica*). This species is an invasive plant, not native to the region. It is extremely prolific, and can grow from small cuttings of either the rhizome or vegetative growth. This species is detrimental to stream bank stability, and must be handled and disposed of carefully. Areas of Knotweed were grubbed to a depth sufficient to remove most rhizomes as determined by GCSWCD. The grubbed material was disposed of in a disposal pit. The location of the disposal pits was determined by GCSWCD. The material was covered as follows:

A. Where six feet of cover depth is attainable, the material was placed in the disposal pit, and covered with a minimum of six feet of clean fill, free of knotweed material.

B. Where six feet of cover depth is not attainable, the material was placed in the disposal pit, and covered with black plastic and a minimum of three feet of clean fill, free of knotweed material.

Clay Material

The adjoining project reaches were characterized by extensive exposures of glacial clay materials in the bottom of the pools. To mitigate the water quality impacts of the clays during channel reconstruction, the design provided specifications for over excavation of the clay materials and replacement with clean gravel/cobble materials in the channel area.

Wetland Mitigation

Impacted Wetlands

The wetlands within the grading extent of the project amounted to +/- 2.21 acres. These wetlands were of a low quality and are subject to frequent disturbance from various stream processes including: sediment deposition, lateral migration and bed and bank erosion.

Proposed Wetland Mitigation

Wetlands were constructed to mitigate the disturbance of the +/- 2.21 acres of wetland within the grading extent. Two wetlands were developed totaling approximately 2.5 acres. The upstream most wetland was developed on the right floodplain between stations 1+50 and 11+50, and was approximately 1.8 acres in size. The downstream most wetland was developed on the left floodplain between stations 11+00 and 15+00, and was approximately 0.7 acres in size. The project drawings **(ACR-06)** further clarify the proposed locations for the constructed wetlands. Vegetation will be established by use of a wet meadow seed mixture, with species selected for known wetland and wildlife values.

Percent (1)	Common Name	Scientific Name
37.3 %	Canada Mannagrass	Glyceria Canadensis
29.3 %	Reed Meadowgrass	Glyceria grandis
7.5 %	Blue Joint	Calamagrostis canadensis
7.3 %	Smooth Panic Grass	Panicum dichotomiflorum
4.9 %	Rice Cut Grass	Leersia oryzoides
3.9 %	Japanese Millet	Echinochloa crusgalli
3.0 %	Blue Verbain	Verbena hastata
1.7 %	Canada Wildrice	Elymus Canadensis
1.5 %	Water Plaintain	Alisma plantago-aquatica
0.9 %	Pennsylvania Smartweed	Polugomum pensylvanicum
0.8 %	Nodding Bur Marigold	Bidens cernua
0.7 %	Stout Wood Reedgrass	Cinna arundinacea
0.7 %	Spotted Water Hemlock	Cicuta maculata
0.3 %	BeggersTick	Bidensfrondosa
0.2%	Swamp Dock	Rumex verticillatus
(1) Percentage is based on number of seeds, not proportion by weight)		

Wet Meadow Seed Mixture

The emergent species selected for this area were tolerant of irregular surface inundation and are expected to survive in saturated soil conditions. The wetland seed mixture will encourage the establishment of a uniform herbaceous cover. Seed mixes to be used will include “New England Wetmix” marketed by New England Wetland plants, Inc as well as “Northeast Wetland Grass Mix” marketed by Southern Tier Consulting.

This stream restoration project enhanced the stability of the stream and will make the site less susceptible to the processes that degraded the wetlands on site, thereby improving the quality and quantity of future natural wetlands while also protecting the proposed mitigation wetlands.

Project Construction Sequence:

This project included disturbance of approximately 26 acres of riparian lands. The major construction activities were performed in phases intended to minimize the total area vulnerable to erosion at any time.

Construction Phasing

Phase I

Phase I included the installation of project erosion and sediment controls and the construction of stream restoration measures beginning at Station 0+00 and continuing to Station 18+00. The access road and staging area disturbed an additional 1.1 acres. Phase I construction sequencing progressed as follows:

1. Commenced Clearing and Grubbing.
2. Installed access road and staging area.
3. Installed phase I coffer dams and de-watering pump and pipeline.
4. Installed turbidity pumps and pipe lines
5. Installed dewatering outlet controls.
6. Installed turbidity pump outlet controls.
7. Performed stream channel excavation.
8. Constructed rock structures
9. Installed vegetative measures of seed & mulch as specified.

Phase II

Phase II included the installation of project erosion and sediment controls and the construction of stream restoration measures beginning at Station 18+00 and continuing to Station 28+00. Phase II Construction Sequencing progressed as follows:

1. Commenced Clearing and Grubbing.
2. Installed phase II coffer dam and de-watering pump and pipeline.
3. Installed turbidity pumps and pipe lines.
4. Installed dewatering outlet controls.
5. Installed turbidity pump outlet controls.
6. Performed stream channel excavation
7. Constructed rock structures
8. Installed vegetative measures of seed & mulch as specified

Phase III

Phase III included the installation of project erosion and sediment controls and the construction of stream restoration measures beginning at Station 28+00 and continuing to Station 34+00. Phase III Construction Sequencing progressed as follows:

1. Commenced Clearing and Grubbing.
2. Installed Phase III coffer dams and de-watering pump and pipeline.
3. Installed turbidity pumps and pipe lines.
4. Installed dewatering outlet controls.
5. Installed turbidity pump outlet controls.
6. Performed stream channel excavation.
7. Constructed rock structures
8. Installed vegetative measures of seed & mulch as specified

Phase IV

Phase IV was scheduled to include the installation of project erosion and sediment controls and the construction of stream restoration measures beginning at Station 34+00 and continuing to Station 39+40. This phase of the project was not implemented due to flood surface elevation increases associated with the proposed channel modifications and landowner permission issues. Payments for lump sum bid items were reduced to reflect the quantity of work not completed due to the reduction in project extent.

Project Bidding:

Bidding Process

The contractor used for implementation of this project was selected through a public sealed bid process. Bidders were required to attend a mandatory pre-bid site meeting prior to submission of a project of a sealed bid. Bidders were asked to prepare bids on the basis of six Primary Bid Item and seven Alternate Bid Items. Bidders were also instructed to provide a schedule of equipment and labor rates to be applied to any work required outside the scope of the bid. The bids were evaluated and awarded on the basis of the aggregate costs of all of the Primary Bid Items for the provided estimated quantities. Alternate bid items were not used for the purpose of evaluating the bids and determining the low bidder.

Contract Award

Two sealed bids were received for the project. The bids were received from Evergreen Mountain Contracting, Inc., and Fastracs Rentals, Inc. The aggregate costs of all of the Primary Bid Items for the respective bids as well as the Engineer's Estimate for the project are presented below:

Evergreen Mountain Contracting, Inc.	$ 797,400.00
Fastracs Rentals, Inc.	$1,425,335.00
Engineer's Estimate	$1,100,000.00

The contract was awarded to Evergreen Mountain Contracting, Inc. by the Greene County Soil and Water Conservation District Board of Directors at their August 4, 2006 board meeting. The bid forms received are on file and available for further review at the Greene County Soil and Water Conservation District office.

Project Contract Activities:

Project construction commenced on July 21, 2006 with clearing and grubbing activities in Phase I of the project sequence. Project dewatering began on July 27th, 2006, and continued through August 29th, 2006. Project dewatering was sustained for a total of 34 days. Planting of containerized material was conducted by GCSWCD outside of the primary construction time frame. Bioengineering activities completed by Evergreen Mountain Contracting, Inc. were also conducted outside of the primary construction window in order to allow sufficient time for plant materials to enter their dormant period.

Primary Bid Items

The primary bid items for this project represent the principle work items and were the basis of the bid evaluation and contract award process.

Mobilization / Demobilization

This item covered mobilization of all equipment and labor forces to the project site for the duration of the project construction. This item was bid as a lump sum to include all equipment necessary to complete all phases of the project.

The contract bid price scheduled for this item was $50,000.00. The total amount paid for this item was $50,000.00. The bid specifications for this item are on file and available for further review at the Greene County Soil and Water Conservation District office.

All aspects of this bid item were completed as expected.

De-watering

This item covered assembly, operation, maintenance, and disassembly of all dewatering equipment necessary to dewater stream flow up to 20 cubic feet per second of stream discharge. Also included within this item is turbidity control equipment with adequate capacity to capture and treat all turbid water within the dewatered work area. This item was bid as a lump sum to include all equipment necessary to complete all phases of the project.

Alternate Bid Item #7 was also included in the bidding process which provided 10 cubic feet per second of additional dewatering capacity in the event that stream flow exceeded the capacity of the primary dewatering equipment. The alternate bid item was bid on a weekly basis at $18,000.00 per week with the understanding that the item would be paid for a minimum of one week from the date of activation. Activation of this alternate bid item would bring the overall dewatering capacity to a maximum of 30 cubic feet per second.

Stream flow conditions during the construction period frequently exceeded the 30 cubic feet per second maximum capacity under Alternate Bid Item #7. In order to ensure that the project continued to progress in a timely fashion, the contracting officer negotiated an additional dewatering capacity increase of 10 cubic feet per second at $7,000 per week. The additional 10 cubic feet per second resulted in an overall maximum dewatering capacity of 40 cubic feet per second.

The initial Primary Bid price for dewatering was $115,000.00. This price was reduced as in response to the reduction in project length that resulted from cancellation of work items downstream of the County Route 17 Bridge. The final Primary Contract price for dewatering was $113,275.00. The total amount paid for this item was $194,846.00.

Completion of the project required 34 days of dewatering. A summary of the days that the various levels of dewatering capacity were applied is presented below:

Primary Dewatering Bid Item only	8 days	@ Primary Bid Rate	= $113,275.00
Primary Dewatering Bid Item plus 10 CFS	11 days	@ $18,000 per week	= $ 28,000.00
Primary Dewatering Bid Item plus 20 CFS	15 days	@ $25,000 per week	= $ 53,571.00
	34 days		$194,846.00

The number of days for which pumping capacity was required in excess of the primary bid capacity indicates that the capacity included in the base bid may have been insufficient. A rate of 1 cubic foot per second per square mile of drainage area could serve as a gross initial estimate of required pump capacity. The estimates should be refined on the basis of available USGS gage data to achieve an acceptable probability of protection from the specified pump capacity. In this case, the rate of protection from the Primary Bid pump capacity was less than 24% indicating that additional pump capacity should have been included in the Primary Bid Item.

Clean water bypass on this project was achieved through the use of a hydraulically driven axial pump. The advantage of this type of pump is the relatively good fuel efficiency for the discharge capacity of the pump. The most significant limitation of this pump type is the limited pressure-head that it is capable of producing. The limited pressure head makes this type of pump unsuitable for very long pumping distances in a closed pipe system or pumping circumstances where pumping more than very limited vertical distance is required. In this case, only short lengths of closed pipe over nominal vertical distances were required to achieve sufficient site dewatering. This type of pump system was very well suited to these site conditions.

The bid specifications for this item are on file and available for further review at the Greene County Soil and Water Conservation District office.

Stream Channel Excavation

This bid item covered all aspects of channel and floodplain grading to the design grades and elevations. This item was bid as a lump sum to include all equipment, labor, fuel and other expenses necessary to complete the channel and floodplain excavation.

Stream channel excavation results in disturbance of significant land area. This portion of the project implementation was scheduled in phases to minimize the land area vulnerable to erosion at all times. The phased approach to the excavation work was an effective means of reducing soil loss and erosion on the construction site.

The channel grading design was developed using a photogrammetry based topographic survey. Grading estimates developed from the survey indicated that approximately 17,000 yds^3 of excess fill material would be generated from the cuts and fills in the first phase of the excavation work. The estimates also indicated that the cuts and fills over the entire project would result in a net fill surplus.

Excess fill material from the first phase of the excavation was scheduled to be hauled to the staging area where a power deck screen would be used to process the fill material into three size classes. The deck screening process was included within the lump sum bid for stream channel excavation. Alternate Bid Item #6 (Deduct Gravel Screening) was included in the bidding process in the event that the channel excavation yielded either less material than expected or material that was unsuitable for screening.

Alternate Bid Item #6 was activated as the first phase of channel excavation yielded only 3400 yds^3 of excess fill material. The reduced fill yield from the first phase of the excavation work carried through the rest of the project excavation, and resulted in a fill deficit project wide.

Material needed to complete the cuts and fills through the later phases of the excavation was obtained from a combination of on-site borrow areas and over excavation of the wetland mitigation areas on the site. Fill materials were excavated from the source areas, hauled to its final location and installed to grade on a time and materials basis according to the equipment and labor rates provided by the contractor as a component of the bidding process.

The initial Primary Bid price for stream channel excavation was $260,000.00. This price was reduced in response to the reduction in project length that resulted from cancellation of work items downstream of the County Route 17 Bridge. The final Primary Contract price for stream channel excavation was $256,100.00. The time and material work required to mitigate the fill deficit totaled $81,446.92. The total amount paid to complete the stream channel excavation component of the project was $337,546.92.

The deficit in fill material on the project appears to be the result of the limited accuracy of the photogrammetry based topographic survey techniques. In the event that future projects are designed from similar topographic data, onsite QAQC measures should be taken to ensure that a fill deficit does not occur. Onsite topographic shots should be checked against the tin data that resulted from the photogrammetry survey, and elevation discrepancies should be evaluated and accounted for in the grading design.

Rock Structures

This bid item covered all aspects of in-stream and floodplain stream stabilization rock structures. This item was bid on a unit price basis using rock tonnage as the measure for payment. The unit bid price included all equipment, labor, fuel and other expenses necessary to obtain and install the rock material as specified in the project documents.

The initial Primary Bid price for rock structures was developed based on an estimated rock tonnage of 7300 tons and resulted in a bid price of $292,000.00. This estimate was reduced in response to the reduction in project length and number of structures that resulted from cancellation of work items downstream of the County Route 17 Bridge. The final estimated rock tonnage was 6439 tons resulting in a Primary Contract price for rock structures of $257,560.00. The total tonnage actually used to complete the project implementation was 7078.44 tons resulting in an actual final expenditure of $283,137.60.

The rock tonnage applied to this project is somewhat larger than projects of similar character due to the installation of long subsurface floodplain grade control sills. These grade control sills were installed at the request of the NYCDEP Stream Management Program in response to channel avulsions and floodplain scour observed at the Big Hollow Stream Restoration Project following an out-of-bank flow event in 2004. These portions of the rock structures accounted for approximately 20% of the overall project rock budget. Necessity for these types of floodplain grade control structures should be evaluated on a case by case basis.

The actual rock tonnage used to complete the project exceeded the estimated tonnage by approximately 10%. Although this difference is within normal tolerance, future estimates of required rock tonnage could be increased by a factor of 1.1 to achieve a more accurate estimate.

Live Fascines

This bid item covered the live fascine portion of the bioengineering implementation. This item was bid on a unit basis by linear foot of fascine installed. This item covered all aspects of the fascine installation including harvest of the live vegetative material, assembly of the fascines, and installation of the fascines as directed by the contracting officer.

The fascine quantities were measured in place to determine the amount to be paid for the bid item. The bid was prepared based on an estimated quantity of 8,000 ft. of live fascines for a total contract price of $30,000.00. The quantity of fascines actually installed on the project was 6,971 ft. for a total expenditure of $26,141.25. Installation of the full quantity of contract units was not deemed necessary by the contracting officer due to the high density of containerized plant material installed on the site by GCSWCD.

Live Posts

This bid item covered the live post portion of the bioengineering implementation. This item was bid on a unit basis by the number of live posts installed. This item covered all aspects of the live post installation including harvest of the live vegetative material, fabrication of the posts, and installation of the posts as directed by the contracting officer.

The live post quantities were counted in place to determine the amount to be paid for the bid item. The bid was prepared based on an estimated quantity of 20,000 live posts for a total contract price of $50,000.00. The actual quantity of live posts actually installed on the project was 8,298 posts for a total expenditure of $20,745.00. Installation of the full quantity of contract units was not deemed necessary by the contracting officer due to the high density of containerized plant material installed on the site by GCSWCD.

Alternate Bid Items

The alternate bid items for this project represent work items that were activated at the discretion of the contracting officer and were not a component of the bid evaluation and contract award process.

Root Wads

No root wads were installed as a component of this project.

Live Material Transplants – shrubs/trees

All live material transplants were installed by Green County Soil & Water Conservation District Staff and volunteers. No live material transplants were installed by the project contractor.

Sediment Control Fence

No sediment control fence was installed as a component of this project.

Clay Removal and Disposal with Replacement

This bid item included over-excavation of clay deposits found within the final grades and elevations of the project design. Clay materials were removed from the stream channel. The materials were then disposed of in a location specified by the contracting officer. The over-excavated area was then backfilled with cobble and gravel material suitable for use in the stream bed. This item was bid on a unit basis with cubic yards of disposed clay used as the measure for payment. The clay volume was determined based on the number of truck loads hauled to the disposal site. The loads were counted by the contracting officer and confirmed daily by the contractor.

The bid price for Clay Removal and Disposal with Replacement was \$40.00 per yds^3. A total of 28 yds^3 of clay were removed and replaced with cobble material, resulting in an overall expenditure of \$1,120.00.

Clay Removal and Disposal without Replacement

This bid item included excavation of clay deposits found within the final grades and elevations of the project design, or in the excavated trenches created during installation of the rock structures. Clay materials were removed from the stream channel. The materials were then disposed of in a location specified by the contracting officer. This item was bid on a unit basis with cubic yards of disposed clay used as the measure for payment. The clay volume was determined based on the number of truck loads hauled to the disposal site. The loads were counted by the contracting officer and confirmed daily by the contractor.

The bid price for Clay Removal and Disposal with out Replacement was \$15.00 per yds^3. A total of 784 yds^3 of clay were removed, resulting in an overall expenditure of \$11,760.00.

Deduct Gravel Screen

This bid item was included in the bidding process in the event that the channel excavation yielded either less material than expected or material that was unsuitable for screening. This item was bid on a lump sum basis and was bid at a deduction of \$17,000.00.

This alternative was activated near the end of the first phase of channel excavation. Grading estimates developed for the project indicated that approximately 17,000 yds^3 of excess fill material would be generated from the cuts and fills in the first phase of the excavation work. The first phase of channel excavation yielded only 3400 yds^3 of excess fill material. The reduced fill yield from the first phase of the excavation work carried through the rest of the project excavation, and result in a fill deficit project wide.

Activation of this alternative bid item resulted in a reduction in project expenditures of \$17,000.00.

10 Cubic Feet per Second Additional De-watering – all costs included

This bid item was included in the bidding process in order to provide 10 cubic feet per second of additional dewatering capacity in the event that stream flow exceeded the capacity of the primary dewatering equipment. The alternate bid item was bid on a weekly basis at \$18,000.00 per week with the understanding that the item would be paid for a minimum of one week from the date of activation. Activation of this alternate bid item would bring the overall dewatering capacity to a maximum of 30 cubic feet per second.

Stream flow conditions during the construction period frequently exceeded the 30 cubic feet per second maximum capacity under Alternate Bid Item #7. In order to ensure that the project continued to progress in a timely fashion, the contracting officer negotiated an additional dewatering capacity increase of 10 cubic feet per second at \$7,000 per week. The additional 10 cubic feet per second resulted in an overall maximum dewatering capacity of 40 cubic feet per second.

The total expenditures associated with additional dewatering capacity were \$81,571.00. Additional information on dewatering is discussed in the Dewatering portion of the Primary Bid Item section.

Time & Materials Work

Clearing & Grubbing

Clearing and grubbing necessary to complete the project implementation was conducted on a time and materials basis according to the equipment and labor rates provided by the contractor as a component of the bidding process.

The total project expenditure associated with clearing and grubbing was $42,841.50.

Additional Fill Excavation and Placement

The channel grading design was developed using a photogrammetry based topographic survey. Grading estimates developed from the survey indicated that approximately 17,000 yds^3 of excess fill material would be generated from the cuts and fills in the first phase of the excavation work. The estimates also indicated that the cuts and fills over the entire project would result in a net fill surplus.

The first phase of channel excavation yielded only 3400 yds^3 of excess fill material. The reduced fill yield from the first phase of the excavation work carried through the rest of the project excavation, and result in a fill deficit project wide.

Fill material needed to complete the cuts and fills through the later phases of the excavation was obtained from a combination of on-site borrow areas and over excavation of the wetland mitigation areas on the site. The fill materials were excavated from the source areas, hauled to its final location and installed to grade on a time and materials basis according to the equipment and labor rates provided by the contractor as a component of the bidding process.

The total project expenditure associated with additional fill excavation and placement was $75,471.92.

Wetland Grading

Mitigation of 2.2 acres of wetland was required as a component of the United States Army Corps of Engineers permit. Excavation necessary to create the wetland mitigation work was conducted on a time and materials basis according to the equipment and labor rates provided by the contractor as a component of the bidding process.

The total project expenditure associated with wetland grading was $5,975.00.

Contract Expenditure Summary

The total contract expenditures on this project amounted to $951,137.02. The contract bid items, unit prices and total expenditures are summarized in Table 5 on the next page.

Ashland Connector Reach Stream Restoration Project

PRIMARY BID ITEMS

Bid Item	Item Description	Estimated Units	Bid Unit Cost	Total Cost to Date
1	Mobilization/Demobilization	Lump Sum		$ 50,000.00
2	De-watering	Lump Sum		$113,275.00
3	Stream Channel Excavation	Lump Sum		$256,100.00
4	Rock Structures	per ton	$ 40.00	$283,137.60
5	Live Fascines	per foot	$ 3.75	$ 26,139.00
6	Live Posts	each	$ 2.50	$ 20,745.00
			Total	$749,396.60

ALTERNATE BID ITEMS

Alt 1	Root Wads	each	$ 800.00	$ -
Alt 2	Live Materials Transplants	each	$ 250.00	$ -
Alt 3	Silt Fence	per foot	$ 8.00	$ -
Alt 4	Clay w/replacement	cuyd	$ 40.00	$ 1,120.00
Alt 5	Clay w/out replacement	cuyd	$ 15.00	$ 11,760.00
Alt 6	Deduct Gravel Screening	Lump sum	$(17,000.00)	$ (17,000.00)
Alt 7	10cfs additional DW	Week	$ 18,000.00	$ 81,571.00
			Total	$ 77,451.00

TIME & MATERIALS WORK

TM-1	Clearing & Grubbing - bid rate			$ 42,842.50
TM-2	Excavate & move additional fill - bid rate			$ 81,446.92
			Total	$124,289.42

	TOTALS
Total Payments	$951,137.02

Table 5: Summary of Contract expenditures

Project total costs, excluding design, flood routing study, archaeology study and topographic survey, is $279.00 per linear foot. Total cost including these studies but excluding design and plant materials/planting by GCSWCD was $1,005,514.41 or $295.74 per linear foot.

View from helicopter on September 9, 2006. Ashland project in foreground with Brandwyine project in background.

Project Non-contract Activities

A variety of project implementation tasks, outside the scope of the contract with Evergreen Mountain Contracting Inc., were completed by GCSWCD with the help of both volunteer and inmate labor forces. These tasks included project site survey control, installation of containerized plant material, production and placement of pre-vegetated sod mats, preparation of knotweed control test plots and design and installation of public universal access recreation features.

Project Site Survey Control

Precision grading of the stream channel and floodplain is an integral part of NCD project success. In order to achieve the fine grading tolerances necessary for this type of project, GCSWCD maintained survey staff on-site at all times that grading and structure placement activities were in progress. Grade stakes, spot elevation checks, survey control network, and quantity estimates were all performed and maintained by GCSWCD staff.

Containerized Plant Material

Riparian vegetation is a key component of stability for C stream types like the one designed for this restoration project. In order to accelerate the revitalization of the riparian vegetation community on the project site, more than 8,000 containerized trees and shrubs were planted on the disturbed portions of the floodplain and terrace slopes.

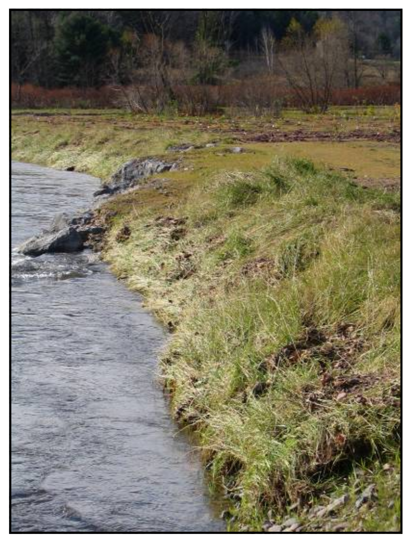
The trees and shrubs were planted by GCSWCD staff with the help of inmate and volunteer labor forces. The volunteer planting day served as a valuable opportunity to convey the goals and objectives of not only the Ashland Connector Reach Stream Restoration Project, but also of the cooperative stream management initiative being undertaken by NYCDEP and their project partners.

Volunteer Planting Day

An educational presentation was given at the volunteer planting day by Jenn Grieser of NYCDEP Stream Management Program and Joel DuBois of GCSWCD. The presentation outlined the accomplishments of the Stream Management Program and included a discussion of the fundamentals of stream process.

Pre-vegetated Sod Mats

NCD projects are at their weakest immediately following construction due to the nature of disturbance necessary to install the restoration design. Restoration of vegetation, critical to stream stability, is a priority from a soil stabilization standpoint. In order to establish mature stream bank vegetation immediately follow construction GCSWCD prepared seed beds on top of erosion control blankets and planted them with a specially design riparian grass seed mix early in the 2006 growing season. These seed beds were created on lands owned by NYCDEP adjacent to the project area.



Pre-vegetated Sod Mats

Upon completion of the project channel and floodplain grading, the pre-vegetated sod mats were cut from the ground using a custom fabricated loader bucket. The mats were then transported to the streamside, and placed in areas expected to be particularly vulnerable to erosion. Several of the mats were placed on the face of the stream bank on the outside of meander bends were erosive forces are greatest. The mats provide a dense root network that serve to stabilize the stream bank. The root network of the pre-vegetated mat is far more developed than what could be achieved by simply seeding the bank following construction. The aesthetic quality of the banks treated with the mats is also far superior to that of the untreated banks.

Application of sod mats to eroded stream banks may be a more appealing and financially feasible stream bank stabilization treatment for stream side landowners when compared to the appearance and cost of rock rip rap.

The mats will be monitored over time to determine their level of effectiveness and to evaluate their applicability to future project designs.

Knotweed Control Test Plots

Knotweed control was a special concern on this project as much of the flood plain to the south and some areas to the north were heavily colonized by the invasive species Japanese Knotweed (*Fallopia japonica*).

Following removal of the invasive plant species, a variety of treatments were installed by GCSWCD to hinder the re-colonization of the area by the plant. The treatments used erosion control blanket and wood chip mulch in various applications to reduce or eliminate the return of the plant. Four treatments were installed; wood chips alone, erosion control blanket alone, wood chips over erosion control blanket, and erosion control blanket over wood chips.

The knotweed control treatments will be monitored as the project matures to evaluate the effectiveness of the various treatments.

Public Recreation

A NYS DEC fishing right-of-way extends from the County Route 17 bridge upstream through the Ashland Connector project to the downstream portion of the Brandywine project. NYC DEP purchased a 143-acre parcel in the project reach that crosses both streambanks and connects to the DEC right-of-way. Prior to project construction the parcel was approved by DEP Land Management Program (LMP) to be opened for public fishing. The opening was delayed until after project construction. DEP SMP and LMP are currently working with GCSWCD to develop universal access to the project to make the reach available for the enjoyment of anglers of all abilities. This includes the placement of a small parking lot, short trail and informational kiosk.

An angler at the Brandywine project enjoying fishing the pools created by cross vanes.

As-built Survey

The as-built condition of the project site has been surveyed by the Kaaterskill Engineering, the licensing engineer on the project. Currently, data collection has been completed and data reduction is in progress. Upon delivery of the survey GCSWCD will evaluate the data and compare the observed topographic conditions with the grades and elevations proposed in the restoration design.

Project Monitoring & Maintenance

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 will be conducted. Project inspections include photographic documentation of the project reach and a visual inspection of the rock structures, channel stability, bioengineering and riparian vegetation. The inspections will be conducted annually during the project site survey as well as during and after significant flow events. The project monitoring surveys will include both physical channel and structural stability assessments. Transects to measure the survival, vigor and height of the vegetation in 10% of the project will be set-up and revisited annually for at least five years. Observations about natural regeneration and non-native species invasion will be noted during measurement. Long term monitoring of water quality is being performed by NYCDEP, which includes measurements of total suspended solids (TSS) and turbidity at the outlet of the Batavia Kill and at the Conine restoration project site (to be built in 2007).

Should the structural and stream survey indicate a change in channel morphology or a decrease in structural integrity, which might lead to stream instability, project modifications will be made. Additional plantings will take place if a less than desirable survival rate is observed. Lastly, great attention will be paid to the growth of Japanese knotweed within the project area. GCSWCD and NYCDEP will continue to work on a management plan to limit and eventually eliminate the presence of Japanese knotweed.

Discussion

The Batavia Kill Stream Corridor Pilot Project focused on using fluvial geomorphic based stream classification, assessment and restoration principles in an attempt to reduce turbidity and TSS loading in the Batavia Kill. The primary goal of the Batavia Kill Pilot Project was to demonstrate the effectiveness of using fluvial geomorphic restoration techniques for reducing turbidity & TSS loading from in-stream sources. The Ashland Connector Reach Stream Restoration Project was an EPA mandated deliverable under the 2002 NYC Filtration Avoidance Determination (FAD) and was undertaken with a primary objective of water quality protection.

A fundamental component of the Batavia Kill Pilot Project was to demonstrate the use of NCD techniques and their effectiveness at meeting multiple goals of a stream restoration project. The design strategy for the Ashland Connector Reach applied NCD techniques in order to achieve multiple project goals. The project was intended to restore the following:

- Channel Stability
- Sediment Transport Function
- Flood Conveyance
- Fisheries Habitat
- Riparian Functions
- Aquatic and Wildlife Habitat
- Aesthetic Value
- Stream Recreation

More than 45% of this segment's streambanks were experiencing active erosion and bank failure. Treatment alternatives for this stream were limited by a variety of potential issues. These potential issues included physical site constraints, landowner approval and access, project permitting and data needs and limitations. The restoration strategy, selected for the project reach, involved the proposed construction of a Rosgen C4 stream type with meandering riffle pool channel morphology.

Project construction commenced on July 21, 2006 and continued through August 29, 2006. A variety of lessons can be drawn from the experiences gained as a result of implementing a project of this scale. These lessons should be applied to the design and implementation strategy selected for future projects. These lessons include the following:

> The rate of protection provided by the Primary Bid pump capacity on this project was less than 24%, indicating that additional pump capacity should have been included in the Primary Bid Item. A rate of 1 cubic foot per second per square mile of drainage area could serve as a gross initial estimate of required pump capacity. The estimates should be refined on the basis of available USGS gage data to achieve an acceptable probability of protection from the specified pump capacity. Specification of a more

appropriate pumping capacity may have significantly reduced the overall project dewatering expenditures.

The first phase of stream channel excavation yielded only 3400 yds^3 of the expected 17,000 yds^3. The deficit in fill material on the project appears to be the result of the limited accuracy of the photogrammetry based topographic survey techniques. In the event that future projects are designed from similar topographic data, onsite QAQC measures should be taken to ensure that a fill deficit does not occur. Onsite topographic shots should be checked against the tin data that resulted from the photogrammetry survey, and elevation discrepancies should be evaluated and accounted for in the grading design.

Conclusion

Careful monitoring and evaluation of project performance is the most critical component of evaluating project success. Observations made relevant to the performance of various aspects of project should be incorporated into future restoration designs. As restoration projects mature, they may serve as valuable additions to our limited stream reference condition data set.