Farber Farm Stream Restoration Project
- East Kill -

IMPLEMENTATION & MONITORING REPORT

Farber Farm Project - Jewett, Greene County, NY

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Farber Farm Restoration Project

Implementation & Monitoring Report

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APPENDIX

1.0 Project Background

In response to the January 1996 high flow event, the Farber Farm stream reach was channelized and levees were constructed to alleviate future risk and potential damage from future high flow events. These modifications had left the reach in a over widened condition limiting sediment transport. Assessments of the condition in 1997 and 1998 documented excessive sediment deposition throughout the reach which was potentially due to the modified channel condition. Typically, excessive sediment deposition increases channel bed elevation, which increases the risk of flooding of adjacent properties. Further, the loss of riparian vegetation due to stream side grazing of livestock had led to degradation of the reach's ecological potential and contributed to an increase in downstream channel and bank erosion.

Image of subsurface stream flow condition during summer base flow.

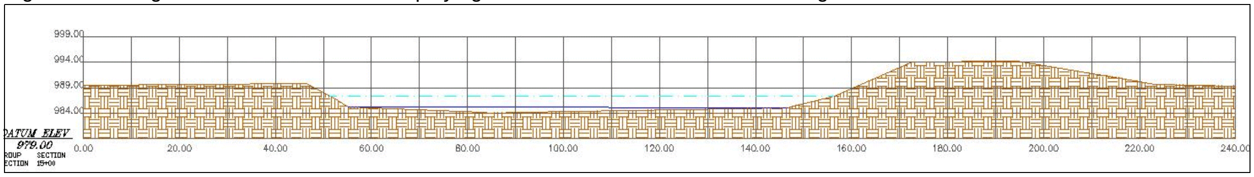
The restoration of the Farber Farm project reach is the first effort implemented in the East Kill stream corridor with the goals of promoting principles of natural channel design and stream corridor restoration. These approaches incorporate a watershed perspective in the planning and design process and typically incorporate multiple project objectives and benefits.

The project reach is located in the center of the East Kill mainstem in the Town of Jewett. The project is located downstream of a private bridge crossing owned by the Farber family, and runs 2,400 feet parallel with County Route 23C. The project represents a cooperative effort between Greene County Soil and Water Conservation District (GCSWCD), New York City Watershed Agricultural Council (NYS WAC), New York City Department of Environmental Protection Stream Management Program (NYCDEP SMP), Natural Resources Conservation Service (NRCS), NY State Department of Agriculture & Markets (NYS AGMKT) and stakeholders of the East Kill watershed. In the sections that follow, planning and coordination, assessment, design, construction and monitoring components of the project are described.

1.1 Project Reach Stability Assessment

The Farber Farm project reach receives flow from a 18.6 mi^2 drainage area. The reach is positioned laterally along a broad alluvial valley containing multiple alluvial river terraces and floodplain. Historically, the stream channel alignment has been heavily manipulated, resulting in the current straightened alignment. Initial field assessments, begun in 1997, classified the channel as a Rosgen C4 stream type; dominated by coarse gravel channel sediment. Channel measurements indicated that the channel bankfull width/depth ratios were greater than 40, which depicts an extremely over-widened condition. Typically, this condition results in inefficient sediment transport through the reach thus promoting sediment deposition and increasing bank erosion potential.

Figure 1 Existing condition cross section displaying over widened condition and berming.



Inventories during low flow conditions documented subsurface flows during the summer thus limiting aquatic habitat. The existing channel did not exhibit the bed diversity that is typical of a natural riffle/pool sequenced stream channel.

Several areas of the project reach exhibited evidence of streambank erosion. Historic aerial photography depicted excessive channel lateral migration in the lower portion of the reach near the confluence with an unnamed tributary. The migration and existing eroded streambank were suspected to be negatively affecting water quality, which may have been further amplified by excessive sedimentation and point bar development. The most significant bank erosion located in the middle of the channelized portion of the project reach and was characterized by several hundred feet ut exposed bank.

Image of excessive deposition and bar formation at the bottom of project reach.

Riparian buffers are crucial in maintaining stream stability within this stream type and valley setting. The riparian area through the Farber Farm reach was primarily maintained as pasture land. Livestock historically grazed on the riparian vegetation, leaving the banks more exposed to erosive forces, and had direct access to the stream channel, which may have impacted water quality.

2.0 Project Goals and Objectives

As the project partners reviewed the condition of the reach and its potential for restoration, a number of issues were identified. Historic management and anthropogenic channel modifications included gravel mining, destruction of the reach riparian buffer, and recent channelization to mitigate flooding. These modifications potentially led to a degradation in fisheries habitat, excessive bank erosion and channel instability. It is believed that if the stream reach were to be left undisturbed, the increased channel width and “flattened” slope would increase deposition, further affecting stream habitat. The existing over-widened shallow channel and lack of

Image of livestock in channel and grazing on streambank vegetation.

overhead cover increased water temperatures. When combined with the lack of pool-riffle complexes, the potential for aquatic habitat is extremely degraded.

The channel modifications also potentially promoted streambank erosion which affected water quality due to excessive entrainment of streambank soils. The partners proposed that the restoration of the reach presented the opportunity to meet a wide range of objectives and provide a number of environmental benefits.

The primary goal of the project was to provide long term channel stabilization while maintaining the integrity and benefit of a naturally functioning channel and floodplain. Secondary project goals included improvement of aquatic and riparian habitat within the project area while maintaining the aesthetic values of a natural stream channel. Thirdly, water quality was to be improved by addressing stream bank erosion and by modifying management and grazing practices.

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

Image of stream bank erosion near bottom of project reach.

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

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

3.0 Restoration Methodology and Strategy

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

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

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

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

- Obtain needed fill materials from on-site sources where possible by re-contouring the floodplain

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

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

- Provide habitat, recreation and aesthetic enhancements concurrent with the development of a naturally functioning channel morphology and floodplain.

In 1998, the GCSWCD initiated the development of a restoration design for the project reach. A topographic survey was conducted and supplemented with geomorphic assessments. Since a stable reference reach for the appropriate stream type could not be found, it was determined that the assessment and design would utilize data collected from adjacent stream reaches and existing aerial photography and would be supplemented with regime analysis, analytical methods and typical reference values developed by other sources.

3.1 Channel Morphology

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

A goal for the channel realignment was to develop a stable plan form, in order to accelerate the channel's evolution toward a more stable state. After reviewing the historic trends of channel alignment, it was determined that the channel was manually straightened and had a low sinuosity. Natural streams in this valley setting would have a meandering alignment with higher sinuosity. The final design included the realignment of a majority of the 2,400 feet of stream channel. The channel alignment was created using regime and reference conditions and other hydraulic considerations.

The channel profile was created by utilizing slope characteristics of the valley, the existing channel and floodplain terraces and regime and reference conditions. The channel profile was also designed to provide for bed feature variation, simulating a more natural riffle/pool complex in order to provide for increased channel habitat and energy dissipation. These variations are common in natural riffle-pool complexes. The channel profile and bed diversity were enhanced using grade control devices in order to promote natural erosion and deposition characteristics throughout the reach.

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

Table 1: Comparison of morphological values.

Variables	Existing Channel	Proposed
Stream Type (Reach)	C4	C4
Bankfull Width (ft.)	105.1	60.0
Bankfull Mean Depth (ft.)	2.5	3.1
Width/Depth Ratio	42.0	19.6
Bankfull Cross Sectional Area (sq. ft.)	264.3	183.3
Bankfull Maximum Depth (ft.)	3.5	4.9
Width of Flood Prone Area (ft.)	>232	279.4
Entrenchment Ratio	>2.2	4.7
Sinuosity	1.06	1.13
Average Water Surface Slope (ft./ft.)	0.005	0.004

3.2 In-stream Structures

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

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

3.3 Riparian Vegetation

The project design planned for the use of traditional bioengineering practices to provide increased streambank stability and to initiate riparian vegetation growth in disturbed areas. Live fascines, native sod mats and large willow transplants were combined with the installation of live stakes, posts, and bare root transplants. The design proposed installation of more than 1,200 feet of live fascines, installed in a double row, on the outside of all meander bends and high stress areas. Locally harvested willow and alder species provided materials for the bioengineering efforts. A seed and mulch mixture was used to provide short term stabilization of disturbed areas.

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

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

4.0 Project Implementation

The restoration project was authorized by NYSDEC under Article 15 of ECL, and approved by the USACOE pursuant to Section 404 of the Clean Water Act, in August of 1998. A Stormwater Pollution Prevention Plan was submitted to the New York City Department of Environmental Protection.

4.1 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. A mandatory site showing was attended by several contractors, and four bids were submitted for the construction. The final accepted project bid was awarded to Fastracs Inc. for a project cost of $135,100.00.

4.2 Project Construction Time Line

Project construction commenced the first week of August 2000. Construction of the new stream channel and in-stream structures required approximately 14 calendar days. Bioengineering components were initiated immediately following the channel construction and continued until late fall of 2000.

4.3 Project Construction Details

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

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

- An water barrier structure was installed above the project reach to dam stream flow while the active work zone was de-watered by pumping all upstream flow around the work area. Stream flow was diverted using a 12" diesel pump and a sealed pipeline. A controlled geotextile outlet was used to discharge the flow into a natural channel which discharged back into the East Kill below the project area.

- Sediment control was accomplished by collecting turbid water at the bottom of the reach and pumping the turbid water to a vegetated floodplain area for natural filtration.

- Stream channel excavation of the new meander bends was initiated in the upper portion of the project reach and progressed downstream. Material generated during the excavation of the meander bends was used to fill and re contour the existing channel.

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

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

- Additional bioengineering and plantings including, live willow fascines, live stakes and posts, and bare root seedlings, were installed by GCSWCD staff and a group of local Trout Unlimited volunteers when the plant material entered dormancy.

- The planted areas were irrigated after planting in order to improve establishment and survivability.

4.4 Project Constructability

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

4.5 Project Construction Cost

The final construction cost was $135,564.13. which included two change orders. This included additional pumping costs, construction of temporary stormwater sediment ponds, and improvements to the passive dewatering system at the outlet of the sealed pipeline.

5.0 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 to 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 are to be conducted annually during the project site survey as well as during and after significant flow events. The project monitoring surveys are to include both physical channel and structural stability assessments.

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

These data 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 channel processes.

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

6.0 Operation and Maintenance

Proper operation and maintenance is a critical element for the success of restoration projects that use geomorphic and natural channel design techniques. Based upon experience with local conditions, the GCSWCD believes that attaining acceptable channel stability requires an extended period for the project to become established. While site 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 re-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 excavation is completed and that evaluation of project's success must be based on performance over a longer period of time.

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

A management plan and strategy is being developed for the East Kill stream corridor by the GCSWCD and NYCDEP SMP. The plan will provide a working document to assist with resource management in the watershed, which will also assist in the operation and maintenance of the project reach.

6.1 Rock Structures

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

6.2 Vegetation

Vegetative establishment in the project area is a critical component of 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 animals, 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 monitoring plan for vegetation is included in Appendix D.

F.7 Project Status: 2009 Inspection - Survey

Site Inspection and Monitoring Survey

In November of 2009 the project site was inspected and surveyed by GCSWCD staff in order to review the project status and to document the physical condition and stability of the stream channel. The inspection included a review of the overall stability, rock structures, and riparian vegetation. The monitoring survey included surveying the eight monumented cross sections and the complete longitudinal profile, and taking a bar sample. A summary of the inspection results and recommendations is provided below. Repair work was performed on the site during the summer of 2008. This repair work removed several of the damaged rock vanes and used the removed vane rock to rebuild several other damaged vanes.

Rock Structures:

During repair work in 2008 three rock vanes were removed, and two rock vanes as well as one cross vane was repaired. During the monitoring survey in 2009 all three cross vanes were located as well as ten of the remaining twelve rock vanes. The missing two rock vanes are located between stations 9+00 and 11+00, and are believed to have been buried due to slight channel migration and aggradation in this portion of the reach. The following table summarizes the condition of the fifteen remaining structures in the project reach.

Table 1: Summary of the Condition of Rock Structures

Structure Type	Missing Structures	Functional Condition			Structural Condition		
		Poor	Fair	Good	Poor	Fair	Good
Rock Vane	2	4	6	0	2	7	1
Cross Vane	0	1	2	0	0	1	2

The functional condition is a measure of how well the structure is performing its intended role. The structural condition is a measure of how closely the structure resembles its as-built condition.

The remaining fifteen structures range from good to poor functional condition. The poor functional condition of structures is mainly due to changes in the channel geometry which have resulted in them no longer being positioned properly to provide energy dissipation on the outer bends. Structural damage to these structures includes rotational collapse, and movement of top rocks along the vane arm. The primary cause for these failures was excess scour leading to collapse. Additional damage includes some flanking at structure's keyways.

Recommendations include:

- Continue monitoring structures for additional damage

Riparian Vegetation:

During repair work in 2008 approximately 1150 containerized trees and shrubs were planted in the riparian area along the lower half of the project reach. Additionally there was over 1000 feet of willow fascines installed along the lower toe, and low terrace of the regarded banks. Several hundred willow stakes were also installed on the stream banks.

Visual inspection of the vegetation installed during the 2008 repair indicates that the majority of the vegetation is surviving, however deer browse and drought seem to be impacting many of the installed trees and shrubs. It appears that less than half of the installed fascines and willow stakes which were installed have become successfully established. Detailed vegetation monitoring at this site is being performed and the results will be compiled in a separate report.

The trees and shrubs installed in 2008 appear to have been planted at a high enough density that die-off of some plants will not negatively impact the riparian restoration efforts. The existing vegetation on the site is growing well. Willow clumps show signs that they are experiencing new growth, and grasses and herbaceous plants are growing densely across the site.

Recommendations include:

- Continued monitoring of plantings from 2008
- Continued monitoring for invasive species

Channel Stability:

Repair work was performed on the site during the summer of 2008. This repair work addressed several channel stability issues including bank erosion between cross sections 3 and 6, as well as a large center bar formation near cross section 5, station 13+40. Bank erosion was addressed by grading the outer bank and creating a bankfull bench. The back channel by the center bar was filled and willow fascines installed across the opening to restore the channel to a single thread.

During the 2009 monitoring survey the channel showed no evidence of large-scale deposition (aggradation) or incision (degradation) through the reach. Minor bank erosion was present around the repaired rock vanes at stations 19+00 and 18+25.

A small center bar remains near cross section 3, station 8+30. In addition, a beaver dam has been built across the channel near a rock vane located at station 10+00. This beaver dam is backing up water during low flows and causing aggradation directly upstream.

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

Recommendations include:

- Evaluate bank erosion by vane arms
- Evaluate the impact of the center bar formation
- Evaluate impact of beaver dam

Project Reach Survey:

A monitoring survey was initiated in November of 2009 to document the annual project status and physical condition of the stream channel. The monitoring included surveying the eight monumented cross sections and the complete longitudinal profile, taking a bar sample, and writing a summary of conditions.

Cross Section Survey

At the time of the as-built survey, eight monumented cross sections were installed for use in future detailed monitoring efforts. Cross sections were monumented using capped rebar pins which are located in the topographic survey as well as recorded using GPS. Cross sections were stationed at various locations along the channel profile in order to provide monitoring for stream process and stability. The cross sections were installed through various stream features (pools, riffles, etc.) and structures in order to document stream classification, potential erosion and scour, and to document the overall channel stability. A summary of cross sectional data is presented in Table 2 and ratios of particular interest are presented in Table 3.

Table 2: Summary of bankfull cross section dimensions, November 2009.

Cross Section	Feature	Area (ft.)	Width (ft.)	Max. Depth (ft.)	Mean Depth (ft.)
1	Riffle	184.85	64.87	4.19	2.85
2	Riffle	175.30	91.52	3.34	1.92
3	Riffle	350.92	94.64	7.79	3.71
4	Pool	239.86	85.78	5.99	2.80
5	Pool	295.39	98.78	6.26	2.99
6	Riffle	252.16	75.35	5.32	3.35
7	Riffle	237.05	80.61	4.81	2.94
8	Pool	284.43	77.59	6.95	3.67
Average Riffles		240.06	81.40	5.09	2.95
Average Pools		273.22	87.38	6.40	3.15
Reach Average		252.49	83.64	5.58	3.03

Table 3: Summary of bankfull cross section ratios, November 2009.

Cross Section	Feature	Width to Depth Ratio (W/D)	Max. Depth to Mean Depth Ratio (D_{max}/D)	Bank Height Ratio (D_{tob}/D)	Pool Width Ratio (W_{pool}/W_{bkf})
1	Riffle	22.77	1.47	2.15	
2	Riffle	47.78	1.74	1.07	
3	Riffle	25.52	2.10	1.34	
4	Pool	30.68	2.14	1.13	1.05
5	Pool	33.03	2.09	1.47	1.21
6	Riffle	22.52	1.59	1.15	
7	Riffle	27.41	1.64	1.33	
8	Pool	21.17	1.09	1.08	0.95
Average Riffles		29.20	1.71	1.41	-
Average Pools		28.29	2.04	1.23	1.07
Reach Average		28.86	-	1.34	-

The values presented in Table 4 are averages taken from multiple cross sections. Values for riffle comparisons for the 2009 data were obtained from cross sections 1, 2, 3, 6 and 7 while values for pool comparisons were obtained from cross sections 4, 5, and 8.

Table 4: Summary of bankfull cross sectional measurements.

Variable	As-Built	2003	2004	2007	2009
Stream Type	C4	C4	C4	C4	C4
Width (ft.)	86.2	81.8	82.7	100.7	81.4
Mean Depth (ft.)	2.7	2.7	2.7	3.72	2.95
Max. Depth (ft.)	4.3	4.1	4.3	6.21	5.09
Area ($ft.^2$)	230.0	217.9	221.6	380.5	240.1
Pool Area ($ft.^2$)	239.1	233.9	237.7	236.2	273.2
Max. Pool Depth (ft.)	6.2	6.0	6.0	5.86	6.40
Pool Width (ft.)	85.5	81.9	79.7	96.4	87.4

Longitudinal Profile

The longitudinal profile survey included the sampling of bankfull, ground, and water surface elevations along the slope breaks of the thalweg. The 2009 survey included a detailed profile beginning and ending at the top and bottom of the project reach. The stationing along the thalweg of the channel varies between years as a result of the selection of features by field staff and minor changes in thalweg plan form.

Table 5: Summary of profile measurements.

Variable	2007	2009
Valley Slope (S_{val})	0.57%	0.54%
Channel Slope (S_{chan})	0.42%	0.52%
Riffle/Run Slope (S_{rr})	1.01%	0.77%
Riffle/Run Slope Ratio (S_{rr}/S_{chan})	2.408	1.502
Pool/Glide Slope (S_{pg})	-0.19%	0.27%
Pool/Glide Slope Ratio (S_{pg}/S_{chan})	-0.443	0.520
Percent Riffle	50.6%	48.8%
Percent Pool	49.4%	51.2%

Channel Pattern

Channel alignment changes were analyzed by reviewing the cross sections and lateral alignment of the thalweg of the stream profile. Although minor erosion and deposition were noted through isolated areas of the project reach there appears to be no evidence of unstable lateral migration or plan form change of meander radius, meander length, or sinuosity. A summary of the channel pattern measurements can be found below in Table 6.

Table 6: Summary of channel pattern measurements.

Variable	2007	2009
Bankfull Width (W_{bkf})	100.7	81.4
Meander Length Ratio (L_m/W_{bkf})	12.23	12.72
Radius of Curvature Ratio (R_c/W_{bkf})	3.77	8.16
Meander Width Ratio (W_{blt}/W_{bkf})	3.30	2.62
Pool to Pool Spacing Ratio (L_{pp}/W_{bkf})	1.62	1.72
Sinuosity	1.10	1.09

Sediment Characteristics

A gravel bar sample was collected (Table 7) to be used as a surrogate for stream subpavement particle size. This sample was collected according to the procedure utilized for the "bottomless bucket method." The procedure to this approach is as follows: locate the sampling site along the lower 1/3 of a meander bend at an elevation equal to the thalweg elevation plus one half the elevation difference between the thalweg and bankfull elevations, locate the two largest particles that may be mobile at bankfull flow in the vicinity and average their intermediate axis, excavate and collect all material from an area the size of the mouth of a standard five gallon pail to a depth equal to twice the average intermediate axis of the two aforementioned particles, finally, wet sieve the material to obtain the particle size distribution. This analysis produces values that are used in various classification equations and may be used in conjunction with the pebble counts to help determine particle size distributions of the stream pavement and sub-pavement.

Table 7: Gravel bar sample

Dominant Particle Size	Bar Sample
D_{95}	58.65
D_{85}	49.08
D_{50}	20.70
D_{35}	11.22
D_{15}	1.16

Photographs and Descriptions

Photograph 1: Bridge at top of project reach.

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

Photograph 3: Cross vane looking upstream near cross section 3.

Photograph 4: Low level crossing shown from left bank upstream of cross section 3.

Photograph 5: Erosion along left bank downstream of cross section 3.

Photograph 6: View across stream from right bank at cross section 4.

Photograph 7: View across stream of location of former center bar near cross section 5.

Photograph 8: Minor bank erosion and rock vane located upstream of cross section 6.

Photograph 9: Cross vane upstream of cross section 7.

Photograph 10: View from left bank across stream at cross section 7.

Photograph 11: Small tributary with a beaver dam on it entering left side of stream near cross section 8.

Photograph 12: Rock vane at downstream end of project reach.

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Farber Farm Stream Restoration Project
Project Inspection - November 2009

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Farber Farm Project Site
Summary of Survey Data
Updated: Apr. 5, 2010

Farber Farm 2009 Survey
Cross Section Data

Cross Section	Station	Feature	Area (ft^2)	Width (ft)	Max Depth (ft)	Mean Depth (ft)	Width to Depth Ratio (W/D)	Riffle Max Depth Ratio (D_{max}/D)	Pool Max Depth Ratio (D_{max}/D)	Bank Height (ft)	Bank Height Ratio (D_{top}/D_{max})	Pool Width Ratio (W_{pool}/W_{bkf})
1	1+17	Riffle	184.85	64.87	4.19	2.85	22.77	1.47		8.99	2.15	
2	3+84	Riffle	175.30	91.52	3.34	1.92	47.78	1.74		3.58	1.07	
3	8+40	Riffle	350.92	94.64	7.79	3.71	25.52	2.10		10.42	1.34	
4	10+67	Pool	239.86	85.78	5.99	2.80	30.68		2.14	6.80	1.13	1.05
5	13+22	Pool	295.39	98.78	6.26	2.99	33.03		2.09	9.20	1.47	1.21
6	16+83	Riffle	252.16	75.35	5.32	3.35	22.52	1.59		6.11	1.15	
7	20+32	Riffle	237.05	80.61	4.81	2.94	27.41	1.64		6.39	1.33	
8	21+87	Pool	284.43	77.59	6.95	3.67	21.17		1.90	7.53	1.08	0.95
Average for Riffles			240.06	81.40	5.09	2.95	29.20	1.71		7.10	1.41	
Average for Pools			273.22	87.38	6.40	3.15	28.29		2.04	7.84	1.23	1.07
Reach Averages			252.49	83.64	5.58	3.03	28.86			7.37	1.34	

Cross Section	Width	Flood-Prone Width	Entrenchment
1	64.87	96.76	1.49
2	91.52	130.76	1.43
Reach Averages			1.46

Farber Farm Project Site
Summary of Survey Data
Updated: Apr. 5, 2010

Farber Farm 2009 Survey
Stream Pattern Data

Attribute	Sample Number												Average
	1	2	3	4	5	6	7	8	9	10	11	12	
Meander Length (ft)	1026	1045											1036
Radius of Curvature (ft)	1146	353	494										664
Meander Width (ft)	173	253											213
Pool to Pool Length (ft)	281	103	77	50	190								140

Meander Length Ratio (L_m/W_{bkf})	12.72
Radius of Curvature Ratio (R_c/W_{bkf})	8.16
Meander Width Ratio (W_{blt}/W_{bkf})	2.62
Pool to Pool Spacing Ratio	1.72

Valley Length	2081
Channel Length	2273
Sinuosity	1.09
Bankfull Width (W_{bkf})	81.4

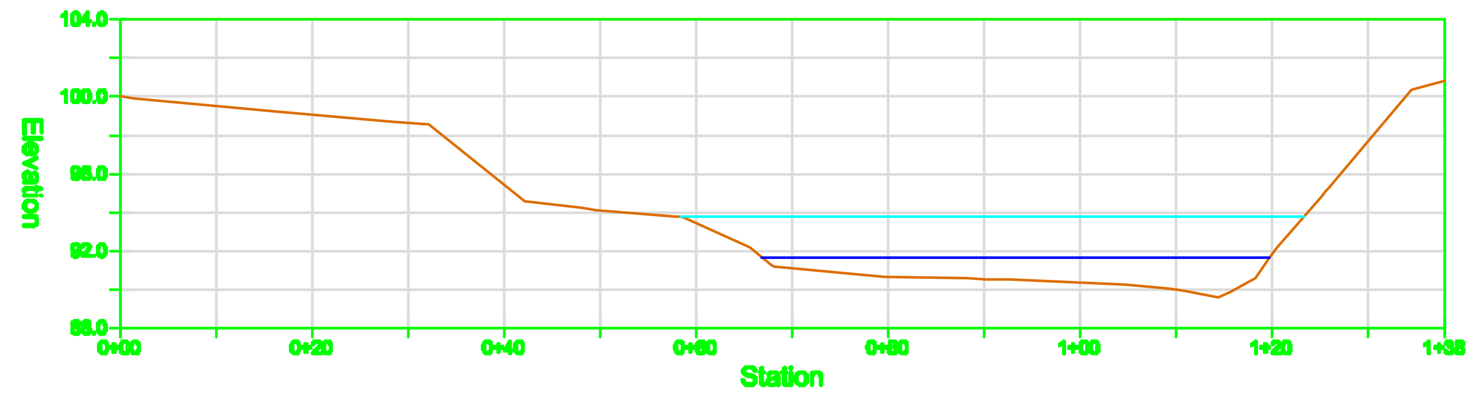
Farber Farm Project Site
Summary of Survey Data
Updated: Apr. 5, 2010

Farber Farm 2009 Survey
Profile Data

Attribute	Sample Number												Totals
	1	2	3	4	5	6	7	8	9	10	11	12	
Riffle Length	183.27	102.81	50.09	86.65									422.82
Riffle Drop	2.35	0.75	1.34	1.09									5.52
Riffle Slope	0.013	0.007	0.027	0.013									0.013
Run Length	355.60	98.17	77.10	103.77									634.64
Run Drop	0.54	0.53	1.06	0.54									2.67
Run Slope	0.002	0.005	0.014	0.005									0.004
Glide Length	45.36	39.43	35.26	40.27	32.19	24.12							216.63
Glide Drop	0.44	-0.09	0.10	-0.29	-0.14	-0.50							-0.47
Glide Slope	0.010	-0.002	0.003	-0.007	-0.004	-0.021							-0.002
Glide Length													0.00
Glide Drop													0.00
Glide Slope													#DIV/0!
Pool Length	251.12	140.76	124.22	98.49	105.96	85.40	84.71						890.66
Pool Drop	0.65	0.60	0.57	0.24	0.09	0.29	1.01						3.44
Pool Slope	0.003	0.004	0.005	0.002	0.001	0.003	0.012						0.004
Pool Length													0.00
Pool Drop													0.00
Pool Slope													#DIV/0!
Riffle-Run Length													0.00
Riffle-Run Drop													0.00
Riffle-Run Slope													#DIV/0!
Riffle-Run Length													0.00
Riffle-Run Drop													0.00
Riffle-Run Slope													#DIV/0!

Overall Riffle-Run Length	1057.46	Overall Pool-Glide Length	1107.29	Riffle-Run Slope Ratio (S_{rif}/S_{chan})	1.502
Overall Riffle-Run Drop	8.20	Overall Pool-Glide Drop	2.97	Pool-Glide Slope Ratio (S_{pool}/S_{chan})	0.520
Overall Riffle-Run Slope	0.0077	Overall Pool-Glide Slope	0.0027	Percent Riffle	48.8%
Overall Channel Slope (measured run to run)	0.00516	Valley Slope (ft/ft)	0.00537	Percent Pool	51.2%

CROSS SECTION 1



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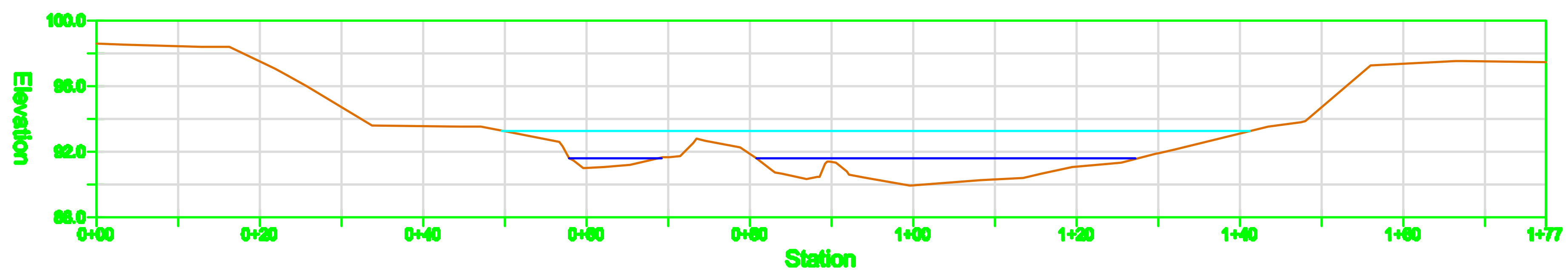

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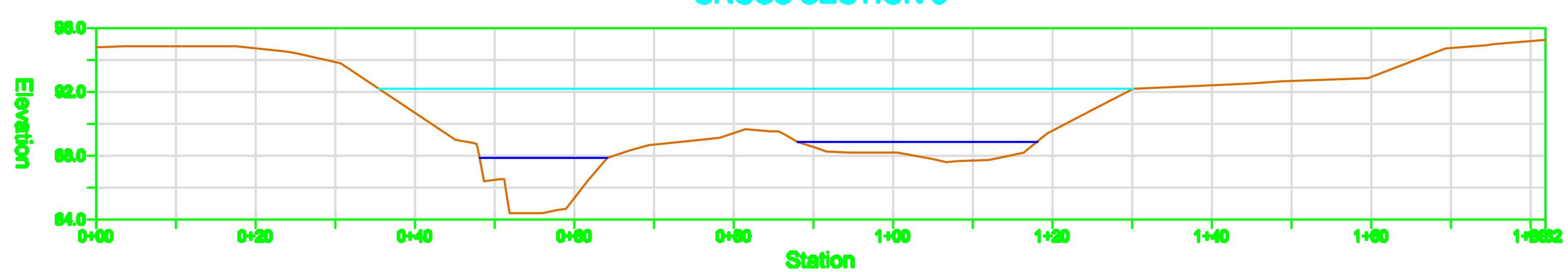

GREENE COUNTY SOIL & WATER CONSERVATION DISTRICT

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FARBER FARM STREAM RESTORATION PROJECT

FOR

ACOE

STATE ROUTE 23C
TOWN OF JEWETT
GREENE COUNTY, NY

2009 CROSS SECTIONS 1-3

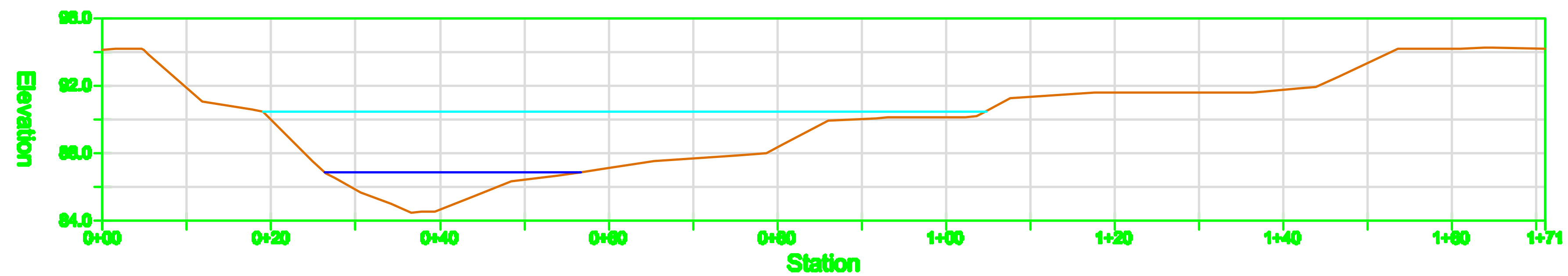
PROJECT:
DATE: 04-09-10
SCALE: AS SHOWN
DRAWN BY: NSH
DESIGN BY:

DRAWING:

FF-01

SHEET 1 OF 4

CROSS SECTION 4



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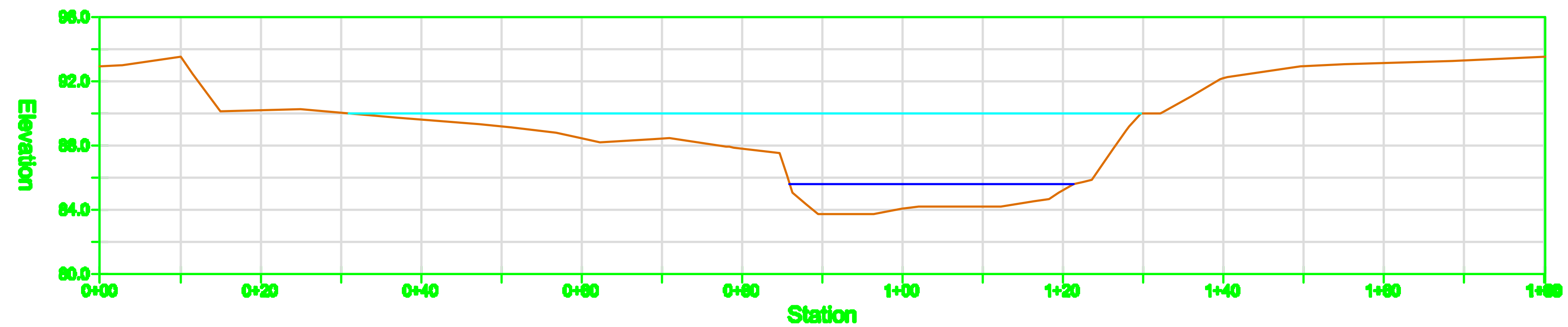

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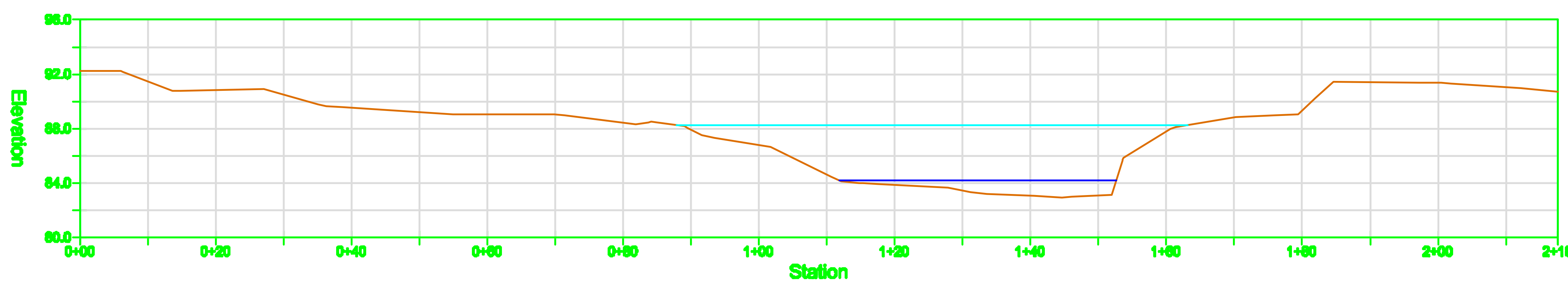

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FARBER FARM STREAM RESTORATION PROJECT

FOR

ACOE

STATE ROUTE 23C
TOWN OF JEWETT
GREENE COUNTY, NY

2009 CROSS SECTIONS 4-6

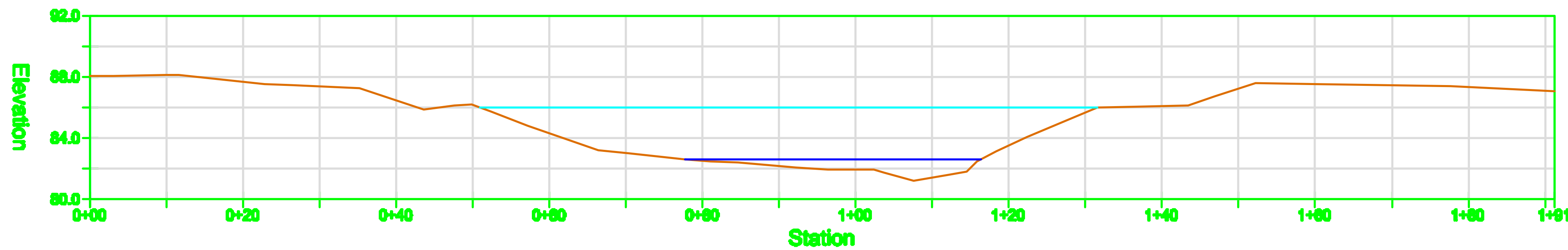
PROJECT:
DATE: 04-09-10
SCALE: AS SHOWN
DRAWN BY: NSH
DESIGN BY:

DRAWING:

FF-02

SHEET 2 OF 4

CROSS SECTION 7



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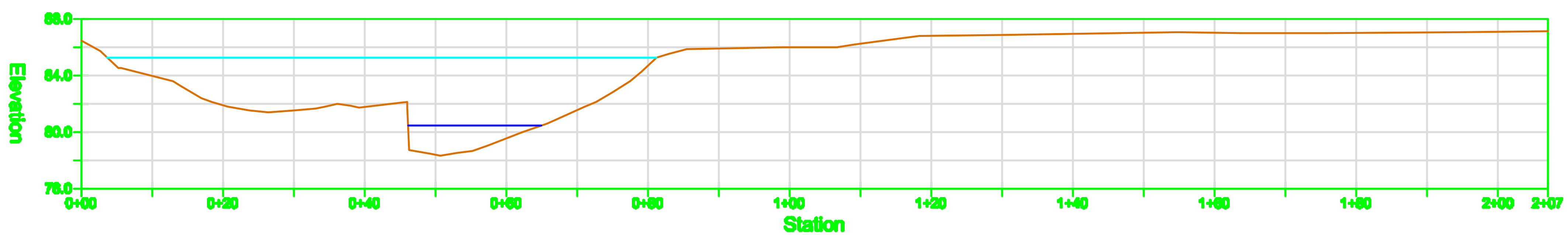

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FARBER FARM STREAM RESTORATION PROJECT

FOR

ACOE

STATE ROUTE 23C
TOWN OF JEWETT
GREENE COUNTY, NY

2009 CROSS SECTIONS 7-8

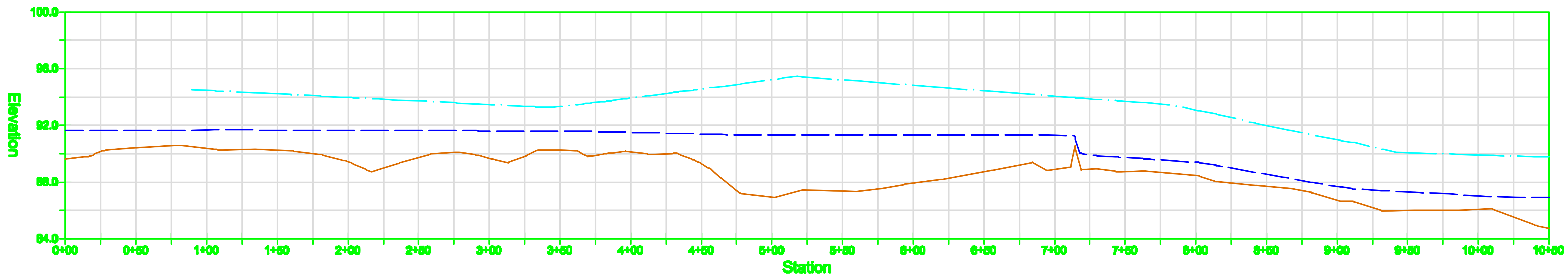
PROJECT:
DATE: 04-09-10
SCALE: AS SHOWN
DRAWN BY: NSH
DESIGN BY:

DRAWING:

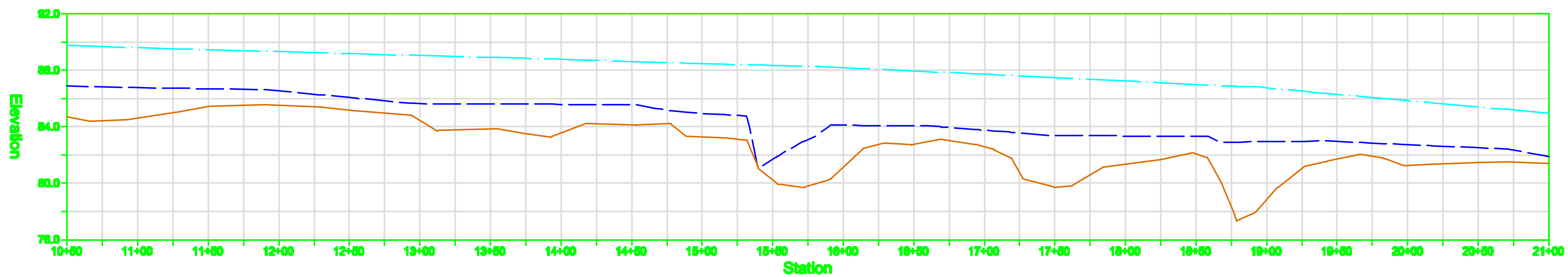
FF-03

SHEET 3 OF 4

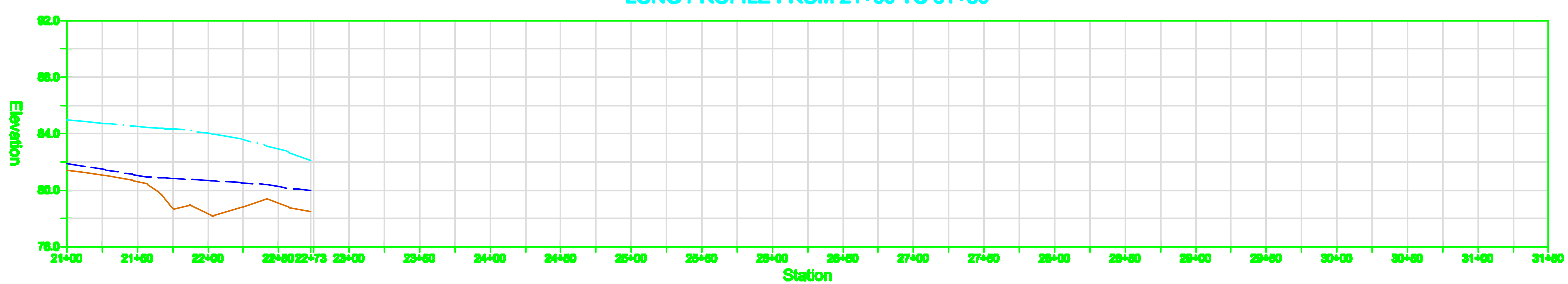
LONG PROFILE FROM 0+00 TO 10+50



LONG PROFILE FROM 10+50 TO 21+00



LONG PROFILE FROM 21+00 TO 31+50



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FARBER FARM STREAM RESTORATION PROJECT

FOR

ACOE

STATE ROUTE 23C
TOWN OF JEWETT
GREENE COUNTY, NY

2009 LONGITUDINAL PROFILE

PROJECT:
DATE: 04-09-10
SCALE: AS SHOWN
DRAWN BY: NSH
DESIGN BY:

DRAWING:

FF-04

SHEET 4 OF 4