V-C. Stream Corridor Inventory and Assessment

On the Batavia Kill, an assessment of the immediate stream corridor was important for a number of reasons. Stream assessments are central to evaluating current stream stability conditions, to predicting the progression of channel adjustments, and to prioritize stream reaches for restoration. Assessment methodologies can allow the stream manager to describe the complex nature of channel adjustments and provide data that can support management decisions.

The stream corridor assessments performed for the Batavia Kill Pilot Project were initiated to assist the GCSWCD in the inventory, evaluation and monitoring of various characteristics within the Batavia Kill stream corridor. Initial assessments were conducted to characterize the current physical attributes of the corridor for use in comparison with historical data, and to set a baseline for future monitoring. The initial focus of the GCSWCD's assessment efforts was the identification of potential sources of turbidity from streambank and streambed sources. Delineating these unstable reaches would assist in the segmentation of the stream corridor into workable subregions (zones) based upon identifiable features and severity of the disturbance.

The stream corridor assessment activities on the Batavia Kill utilized methodologies that allowed the GCSWCD to monitor a wide range of stream characteristics. The assessments were conducted in several phases to provide different levels of characterization and monitoring. For the purposes of this SMP, the stream corridor assessments were separated into seven primary categories to include: Phase I: Inventory and Assessment; Phase II: Stream Classification; Phase III: Stream Stability Assessment & Verification; Phase IV: Site Feasibility Analysis; Phase V: Reference Condition Assessment; stream corridor geology assessments; and biological feature assessments.

1. PHASE I: INVENTORY AND ASSESSMENT

The Phase I inventory and assessment of the Batavia Kill corridor was undertaken to provide the GCSWCD with a preliminary sense of the existing conditions along the stream corridor. While the GCSWCD had been working on projects along the stream for many years, there was a lack of understanding of the overarching problems on the watershed level. The Phase I inventory and assessment process allowed the GCSWCD project team to develop a geomorphic characterization of the main stream. Phase I methods involved the use of limited available data such as flood maps, topographical maps and aerial photographs, combined with a rapid stream reconnaissance. While the GCSWCD currently uses GPS/GIS technology to complete the Phase I process, at the start of the Batavia Kill project this equipment was unavailable and reconnaissance mapping was completed by hand. The Phase I inventory and assessment process also included a Rosgen Level I stream classification.

Rosgen Level I Classification

As discussed in **Section III**, the Rosgen's Level I classification delineates stream types based on entrenchment, pattern, slope, and shape. The Level I Rosgen classification was used to determine the primary stream types located in the Batavia Kill watershed, and was completed by GCSWCD staff in 1997 using remote sources of information including 1995 aerial photography, and USGS topographic quadrangle maps. The stream types delineated during the Level I classification included A, B, C, F, & E stream types.

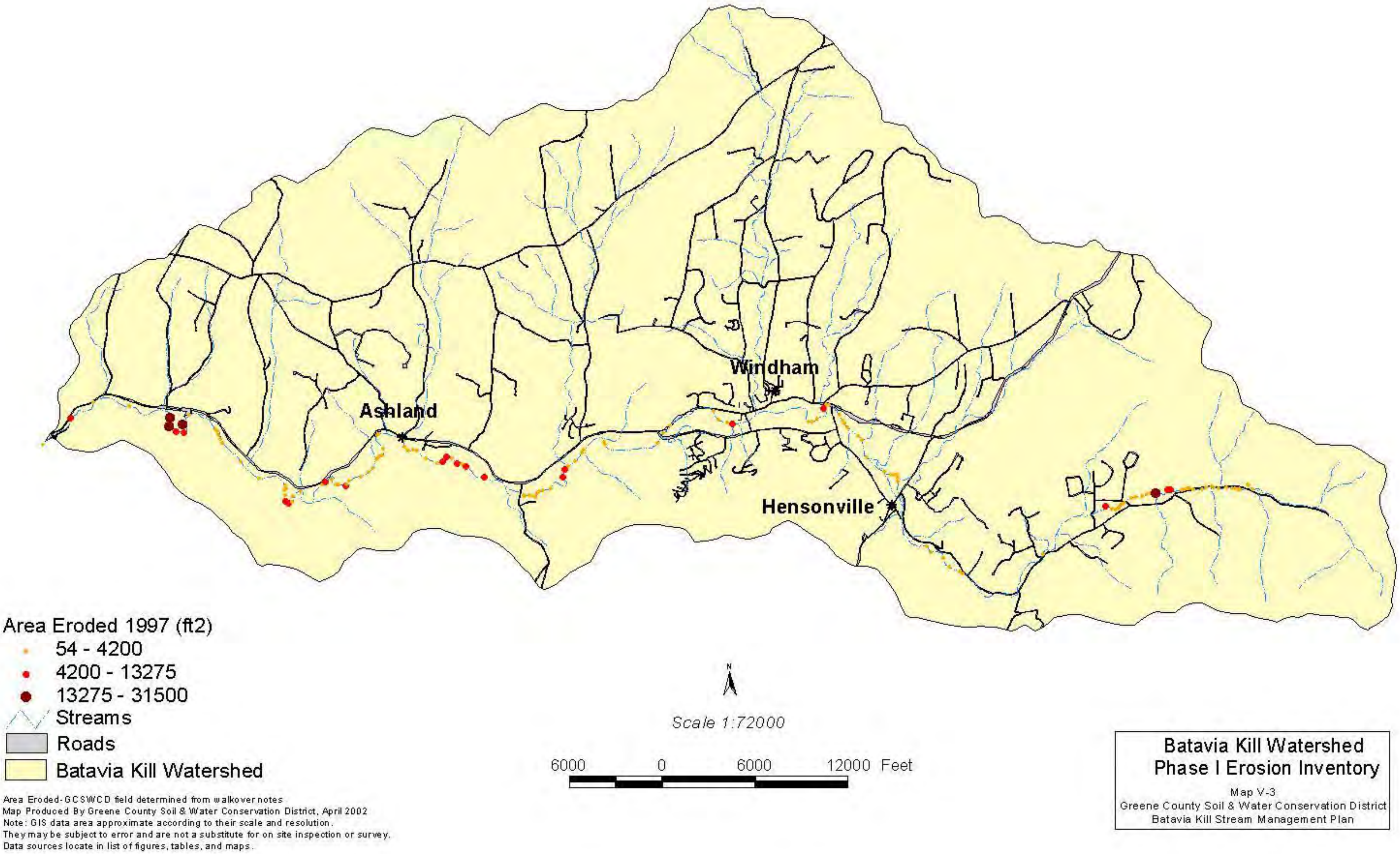
Figure V- 24: B stream type in Hensonville.

Corridor Walkover Inventory

In the Summer of 1997, GCSWCD staff conducted a preliminary inventory of the Batavia Kill by completing a walkover of the entire stream length. During the inventory process, the GCSWCD made observations of any evidence of stream instability and became familiar with the stream corridor and its characteristics. The assessment focused on identifying sites with visible stream bank and bed erosion, and measuring the length and height of each unstable area. Additionally, potential reference reaches were also documented, the Rosgen Level I classification was visually confirmed, and notes were taken as necessary to provide a more detailed description of each site to include bank failure mechanisms, mass wasting, clay exposures, and vegetation status.

The corridor walkover provided the data the GCSWCD required to complete stream bank erosion inventory and to conduct the first cut assessment of stream stability for the entire Batavia Kill main stem. During this inventory process, it was found that approximately 25% of the streambank total length was exhibiting signs of instability in the form of active streambank erosion and stream channel adjustments. With 21 miles of stream length, (42 miles of streambank on the main channel), the initial inventory identified approximately 10 miles of streambank exhibiting some degree of erosion. Based on observations made during the initial inventory process, the GCSWCD selected specific reaches of stream for more detailed study.

As the program resources increased, data were transferred from conventional paper maps into a GIS database. Individual nodes were created in the GIS database to represent the location of each erosion measurement and the corresponding field notes; further



Windham
Ashland
Hensonville
Area Eroded 1997 (ft2)
54 - 4200
4200 - 13275
13275 - 31500
Streams
Roads
Batavia Kill Watershed
Area Eroded-GCSWCD field determined from walkover notes
Map Produced By Greene County Soil & Water Conservation District, April 2002
Note: GIS data area approximate according to their scale and resolution.
They may be subject to error and are not a substitute for on site inspection or survey.
Data sources locate in list of figures, tables, and maps.
N
Scale 1:72000
6000 0 6000 12000 Feet
Batavia Kill Watershed
Phase I Erosion Inventory
Map V-3
Greene County Soil & Water Conservation District
Batavia Kill Stream Management Plan

analysis involved weighting each node, depending on the size of the exposed area. This allowed the corridor to be divided into stable and unstable reaches based on visual indicators of streambank stability and to assist in further spatial segmentation of the stream corridor into management segments and reaches that exhibited similar characteristics. **(Section VI)**. Additionally, the area and length of exposed streambanks in each management segment/reach was paired with the length of stream in each segment/reach in order to rank and prioritize the segments and reaches against one another. A summary is shown in **Table V-5** and **Map V-3.**

Table V-5: Summary of streambank erosion inventory.

Batavia Kill - Corridor Assessment Prioritization					
Management Segment	**Length of Segment(ft)**	**Area of Erosion (ft^2)**	**Length of Erosion (ft)**	**Erosion Area/Segment Length**	**Erosion Length/Segment Length**
4	36,905	148,318	16,698	4.02	**0.45**
1	24,935	84,620	5,340	3.39	0.21
3	25,472	43,429	4,510	1.70	0.18
5	23,004	118,571	3,877	**5.15**	0.17
2	20,568	2,890	373	0.14	0.02

Recently the GCSWCD has incorporated Global Positioning System (GPS) inventory capabilities which are easily integrated with Geographic Information System (GIS) mapping technology. The shared assessment capabilities, as well as opportunities for web-based mapping, will be used to aid in stakeholder familiarization with watershed activities performed by the GCSWCD and NYCDEP Stream Management Program within the Batavia Kill.

Aerial Photography Assessment

When available, aerial photographs provide an excellent resource to help understand stream corridor conditions. When a series of aerials are available for different time periods, the benefits are even greater in that stream managers can evaluate stream reach changes that have occurred over time. At the beginning of the project, the GCSWCD obtained a series of historical aerial photographs for the entire Batavia Kill corridor, with photographs from August 1959, September 1967, June 1980, May 1995, and April 1997 available from the USDA. In the fall of 2000, the GCSWCD contracted for a true color aerial photo series of the entire stream corridor at 1"=200' scale.

The photographs were used to complete Rosgen Level I classification and to evaluate changes in stream morphology. Initially, the GCSWCD used the aerial photos to get a broad sense of changes in stream planform, with more detailed comparisons completed in later assessment phases. As the project progressed, the aerial photographs assisted the GCSWCD in assessments of management practices, the identification of reference and unstable reaches, and to perform a broad assessment of riparian vegetation change. An example of a photographic series is shown in **Figure V-25**. A more detailed summary of the aerial photograph interpretation on a stream reach scale is included in **Section VI; Stream Reach Descriptions** section of this document.

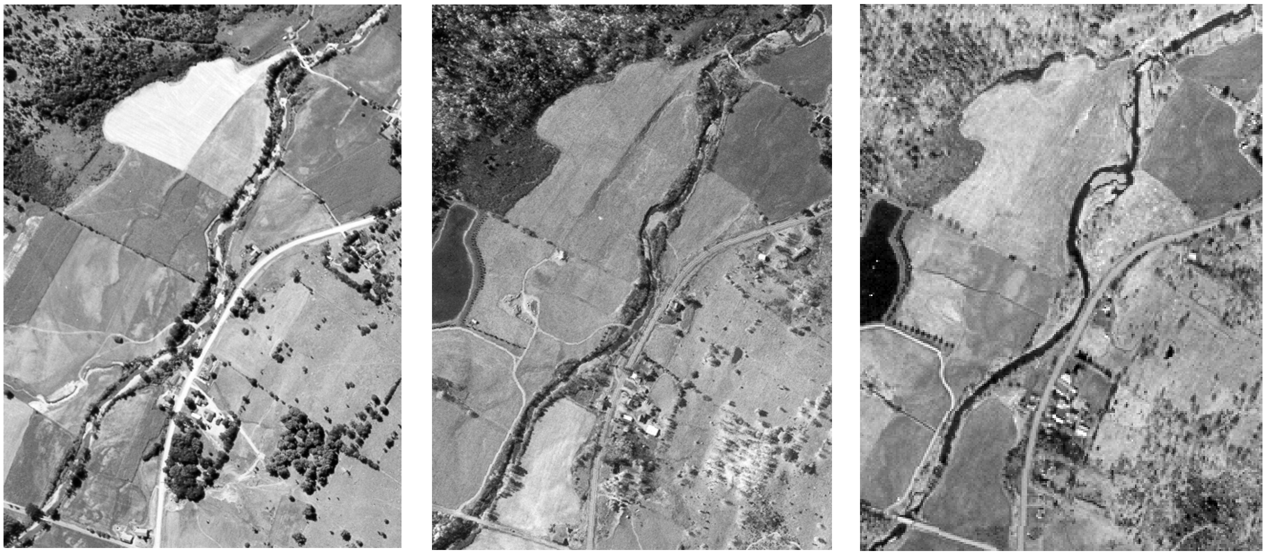


Figure V-25: Comparison of aerial photographs from 1959 to 2000.

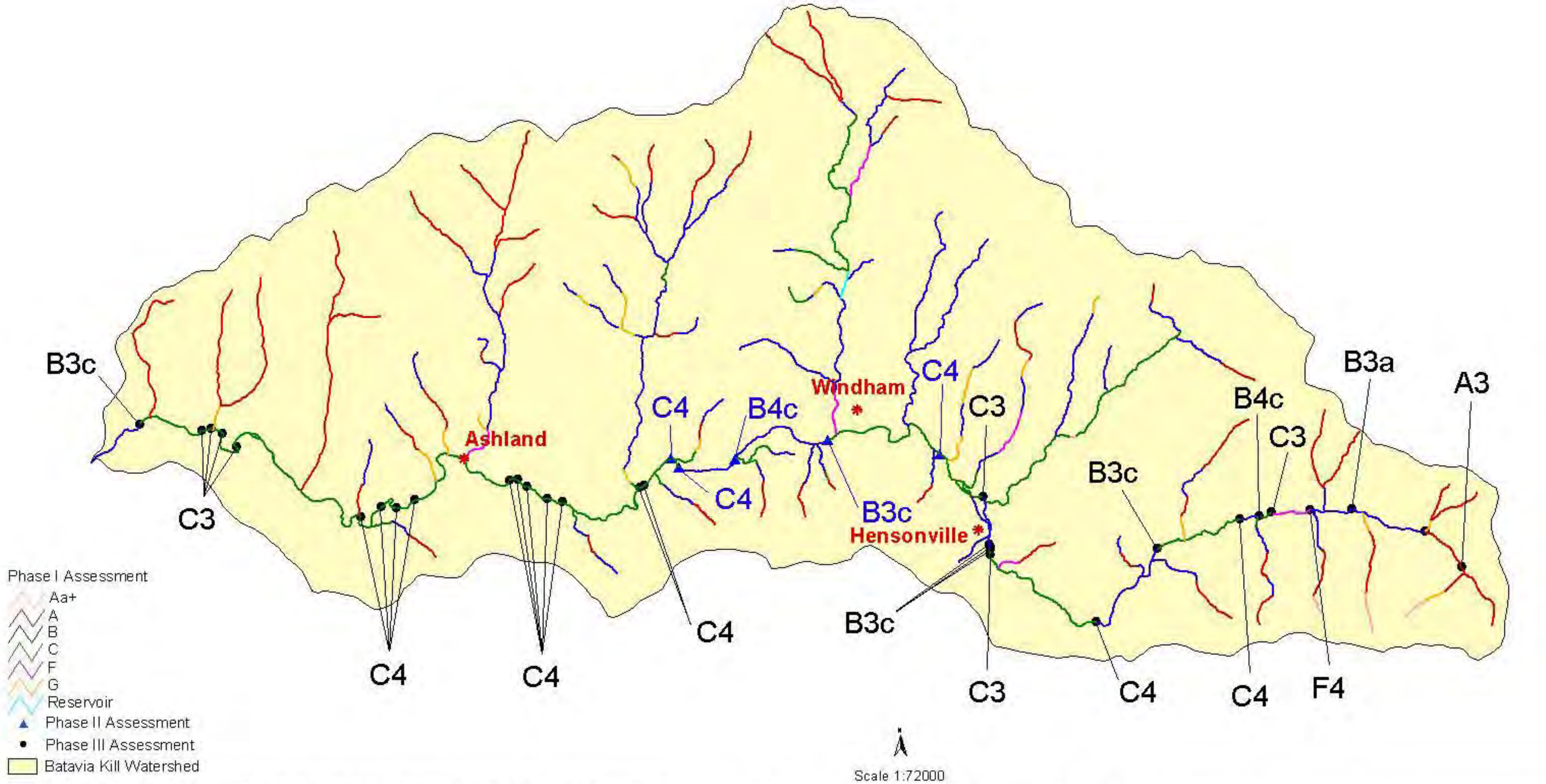
2.PHASE II - STREAM CLASSIFICATION & HYDRAULIC GEOMETRY

To build upon the information from the Phase I Inventory & Assessment, the GCSWCD completed field data collection to allow for Level II stream classification, and the development of an understanding of the relationship between channel geometry and drainage area in the Batavia Kill **(Map V-4)**. Detailed reach classification and measurements of channel geometry greatly adds to the stream manager's understanding of the stream system.

Level II Stream Classification

The first step in the Phase II assessment involves classification of the Batavia Kill into Rosgen Level II stream types. The Level II classification provides field verification of the Level I classification determined from remote data, and integrates a sediment particle size analysis to determine the dominant channel material. Data collected for Level II classification includes measurements of channel cross section, longitudinal profile and plan form features, and can be used to generate a three-dimensional perspective of the channel.

The procedure used by the GCSWCD builds upon the Rosgen Level II classification protocol by providing semi-permanent monuments on all cross sections. This allows the GCSWCD to use each cross section for monitoring subsequent change, or lack of change, in the stream channel. The rebar pins used to monument each cross section



Phase I Assessment- Stream types determined from aerial photographs, topographic maps and visual investigation. Includes broad based determinations of valley type, plan view, channel cross section, sinuosity, channel slope, and bed features.
Phase II Assessment- Stream types verified in field using entrenchment ratio, width/depth ratio, dominant channel materials, slope, bed features, sinuosity, and meander pattern using monumented control points.
Phase III Assessment- stream types verified by reach specific survey encompassing plan view, profile, and cross sectional measurements to establish reach specific analysis with future replication for monitoring purposes. Reach specific summary of site conditions including riparian vegetation, flow regime, stream size and order, depositional patterns, meander patterns, debris and channel blockages, and stream channel stability. Reach specific characterization of sediment size by sampling channel substrate (Wolman 1954), and point bar sampling (Rosgen 1991).

Data Sources: Hydrography-digitized by NYCDEP from USGS Quad and SCS soil Survey maps 1993, edited by GCSWCD to show only streams found on USGS topo quads.
Stream Assessment- GCSWCD using Rosgen classification system and techniques detailed above
Map produced by Greene County Soil & Water Conservation District, April 2001.
Note: GIS data are approximate according to their scale and resolution. They may be subject to error and are not a substitute for on-site inspection or survey.

Batavia Kill Watershed Stream Classification

Map V-4
Greene County Soil & Water Conservation District
Batavia Kill Stream Corridor Management Plan

were located using a GPS unit and photo-documented for incorporation into the GIS database for the stream corridor. Longitudinal profiles were also modified at this stage to include collection of slope measurements including, bankfull, thalweg and water surface slopes.

HYDRAULIC GEOMETRY ASSESSMENT

During the Batavia Kill Pilot Project, the GCSWCD collected four years of hydraulic geometry data on the main stem of the Batavia Kill. This data was collected from Phase II and Phase III monitored reaches, and includes over 100 sections that have been classified and dimensioned for management interpretation within the corridor. Some of the uses for the Batavia Kill hydraulic geometry include:

- Identify and monitor instability within the system.
- Examine the geometric and hydraulic relationships of Batavia Kill channel dimensions as affected by the flood control structures, to include the impact from increased duration of the bankfull flow.
- Identify and verify hydro-physiographic consistencies with other regional regression equations. Generate relationship of Catskill Mountain-wide regional regression type power equation.
- Generate Batavia Kill hydraulic geometry curves to allow for effective management and design relations with respect to bankfull channel.

The hydraulic geometry data builds upon data collected for field identification of bankfull flow presented in **Section III** of this report, to include the bankfull dimensions of channel area, width and depth. Stream channel features such as riffles/pools, step/pools and cascades are documented. Data on planform geometry includes the verification of the channel's sinuosity and determination of the meander width ratio, which describes the lateral channel containment.

On the Batavia Kill, the relationship between watershed area and hydraulic geometry is complicated by the presence of the flood control structures. As discussed previously, impoundments are designed to modify stream flow, and one would expect to see different relationships between drainage area and channel features above the flood structures influence, and stream morphology features below the structures. To assist the GCSWCD with validation of hydraulic geometry for restoration designs, data collected based on field observations of bankfull were used to develop local curves for the watershed **(Figure V-26)**. While the use of visual indicators to develop hydraulic geometry curves is not a recommended procedure, in the absence of adequate gage data on the Batavia Kill and in recognition of the flood structure influences, the GCSWCD used the best available data. To the extent possible, the GCSWCD used other methods such as regional regression curves for discharge to determine/verify observations made on the Batavia Kill.

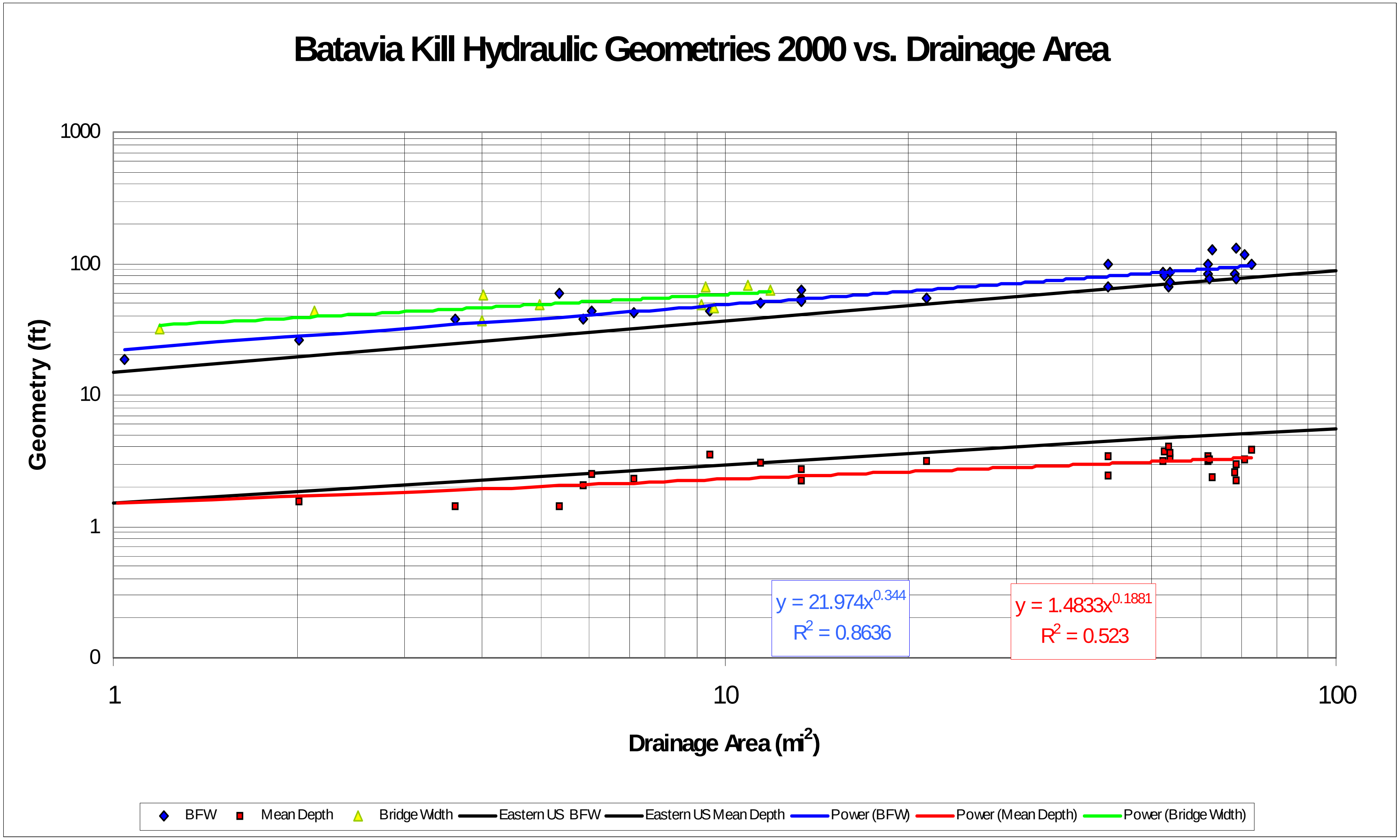


Figure V-26: Local hydraulic geometry relationships for the Batavia Kill base on bankfull indicators.

The NYCDEP Stream Management Program is currently developing and testing a field protocol for bankfull discharge calibration at USGS gages, and conducting calibration surveys at numerous USGS gages located within the region (*Identifying Bankfull Discharge and Hydraulic Geometry Relationships in the Catskill Mountains* , 2001). The protocol involved the identification of bankfull discharge and hydraulic geometry relationships at each stream gage, with the hydraulic geometry and discharge data plotted against drainage area to develop regional curves. These regional hydraulic geometry curves will be used to assist in identification or verification of the bankfull stage during watershed-scale or site specific stream reconnaissance.

3. PHASE III - STREAM STABILITY ASSESSMENT

As the GCSWCD became more familiar with the watershed, it was evident that additional data would be required to accurately determine the sources of instability on the reach scale. As conducted by the GCSWCD, Phase III assessment activities included both Rosgen Level III (stability assessment) and IV (verification) protocols, as well as a detailed aerial photograph overlay of targeted stream reaches. The GCSWCD selected those reaches that exhibited the most instability for Level III Assessment **(Map V-5)**.

Rosgen Level III Assessment

As developed by Rosgen (1996), Level III assessment methods are conducted at the stream reach scale, and include more detailed assessments of a stream channel's geomorphic form, as well as the application of several protocols developed to assess instability potential at the streambank scale (BEHI) and the reach scale (Pfankuch). The assessments of the reach's geomorphic form includes the streams plan form, profile, and cross sectional measurements. The reach level assessment of site conditions also incorporates riparian vegetation, flow regime, stream size/stream order, depositional features, meander patterns, debris/channel blockages, and stream bank erosion potential. Additionally, a reach specific characterization of sediment size by sampling channel substrate and point bars is added to characterize the sediment composition of the reach.

According to Rosgen (1996), the objectives of the Level III analyses are to allow stream managers to:

- Develop a quantitative basis for comparing streams having similar morphologies, but which are in different states or condition.
- Describe the potential natural stability of a stream, as contrasted with an existing condition.
- Determine the departure of a stream's existing condition from a reference baseline.
- Provide guidelines for documenting and evaluating additional field parameters that influence stream state (e.g., flow regime , stream size, sediment size, sediment supply, channel stability, bank erodibility and direct

channel disturbances).

- Provide a framework for integrating companion studies (e.g., fish habitat indices, and composition and density of riparian vegetation).

- Develop and/or refine channel stability prediction methods.

- Provide the basis for efficient Level IV validation sampling and data analysis.

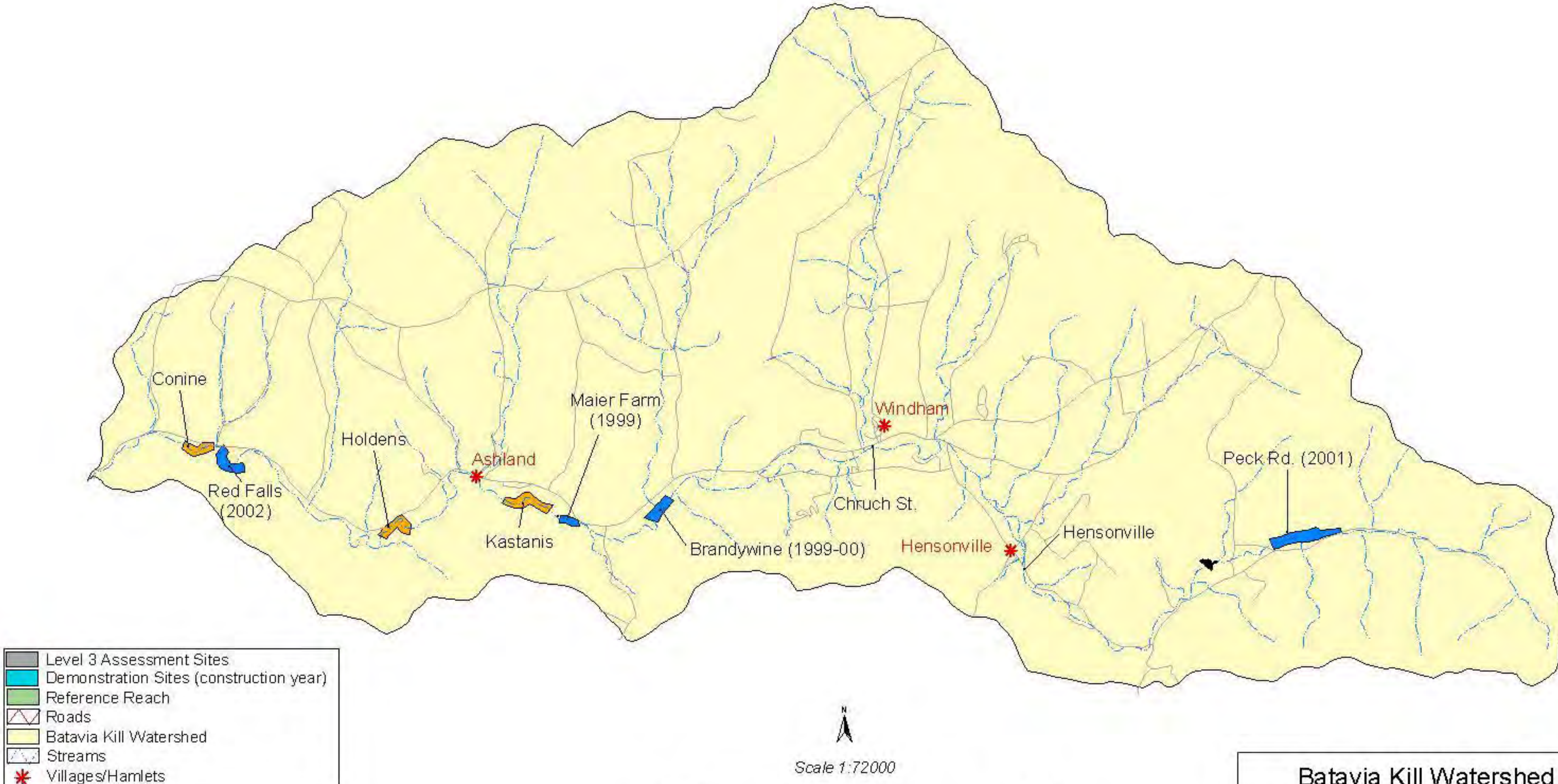
As discussed previously, the methodology addresses the stream reach morphology by establishing monumented cross sections and conducting field surveys of channel measurements. The surveys are more detailed than those completed for Level II Rosgen Stream Classification, and include measurements of specific stream features and their spatial distribution along the stream reach. The Level III surveys provide the stream manager with a detailed characterization of the stream's form. By comparing the existing features in unstable reaches to the same features on stable reaches, stream managers can make predictions of future changes in the stream reach.

In addition to the collection of detailed morphology data, the Rosgen Level III stability assessment procedure includes the evaluation of stream bank erosion potential (BEHI), as well as a method for assessing overall stream reach stability, based on a wide range of stream corridor features (Pfankuch). Developed by Dave Rosgen (Wildland Hydrology, 1996), the Bank Erodibility Hazard Index (BEHI) protocol is used to evaluate the ability of a stream bank to resist erosion. The procedure integrates multiple factors which have a direct impact on streambank stability and includes;

- ratio of streambank height to bankfull stage;
- ratio of riparian vegetation rooting depth to streambank height;
- degree of rooting density;
- composition of streambank materials;
- streambank angle;
- bank material stratigraphy and presence of soil lenses; and
- bank surface protection afforded by debris and vegetation.

The BEHI index addresses these seven measurable parameters, and allows for determination of a numerical score that rates the potential of a streambank to erode from very low to extreme. When a database is developed on a watershed or regional scale, BEHI scores can be correlated to measurements of erosion rates on monitored cross sections to develop curves that allow for erosion prediction.

The GCSWCD is currently developing predictive curves that are calibrated from the Batavia Kill cross-sections. These curves will address the effectiveness of the adjective ratings, BEHI scoring criteria and the relationships of near bank shear stress distribution



Batavia Kill Watershed Stream Assessment & Demonstration Sites

Map V-5
Greene County Soil & Water Conservation District
Batavia Kill Stream Corridor Management Plan

Data Sources:
Hydrography- digitized by NYCDEP from USGS Quad and SCS Soil Survey Maps 1993, edited by GCSWCD is show only streams found on USGS topo quads
Watershed Boundary- NYCDEP derived from USGS topography 1965.
Assessment, Demonstration, Reference sites-GCSWCD derived from cross section GPS points
Roads-US Department of Commerce, Bureau of the Census 1998, from 1995 TIGER/Line files.
Villages/Hamlets-GCSWCD derived from USGS topo map .tif file
Map produced by Greene County Soil & Water Conservation District, January 2001.

Note: GIS data are approximate according to their scale and resolution.
They may be subject to error and are not a substitute for on-site inspection or survey.

(channel form). Quantitative assessment of bank stability in terms of force and resistence will be developed from data on stratigraphy columns collected by NYCDEP.

Additional monitoring, a longer period of record, and the correlation of stability scores with Rosgen stream types will enhance stream bank erosion prediction. Future monitoring will be incorporated on segments that rate lower on bank erosion potential, or those reaches that are characterized by a high degree of stability. Analytical approaches to stream bank failure analysis has also been considered within future assessment, analysis and management of the Batavia Kill stream banks.

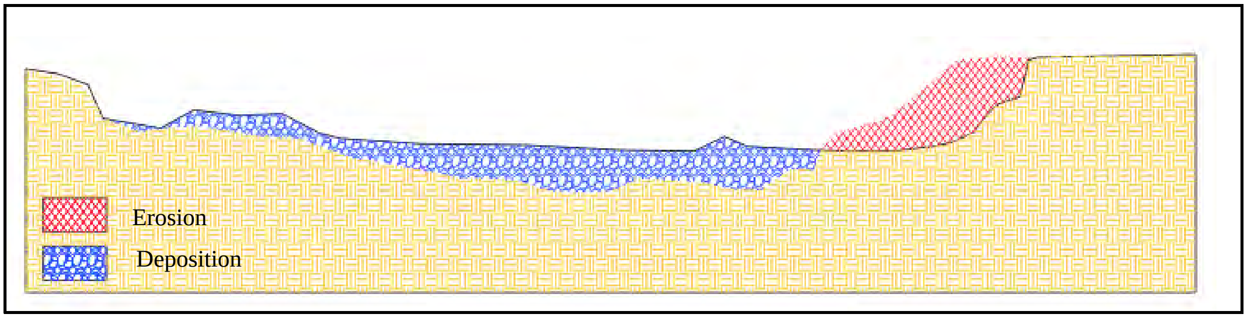
In addition to channel surveys and the BEHI procedure, the GCSWCD uses a modified version of a stream reach stability assessment methodology developed by D. Pfankuch (US Forest Service, 1975). While BEHI focuses on assessment of specific stream banks, the Pfankuch procedure allows stream managers to evaluate larger sections of the stream reach based on a number of factors. Pfankuch's protocol evaluates stream stability factors to include landform slope, mass wasting, debris jams, vegetation, deposition, scouring and deposition, among others. When used in conjunction with surveys to monitor the channel's hydraulic geometry, the BEHI and Pfankuch procedures help characterize the overall stability of the stream reach.

Rosgen Level IV Assessment

The level IV assessment protocol, as created by Rosgen (1996) provides for verification of predictions made based on data collected during the Level III stability assessment. Level IV assessment methods basically involve periodic repeat surveys of cross sections established in Level III, as well as other stream features such as slope and planform. The surveys are called monitoring surveys, and are typically conducted annually, as well as after significant flow events.

During the Batavia Kill Pilot Project, the GCSWCD established the initial cross sections in 1997, with the majority of the monitoring sections placed in 1998. Data from these sections was collected in 1998, 1999, 2000 and 2001. In 2002, the GCSWCD established additional monitoring sections to assess an observed stability problem in the Big Hollow area, and re-surveyed a smaller selection of the previously installed monitoring cross sections. To evaluate changes in the stream channel morphology, the GCSWCD used AutoCAD (Computer Aided Design) software to plot and overlay surveys of the cross sections.

Figure V-27, is a representative cross section (#5) from the Batavia Kill headwaters area, and represents the changes in the stream channel between 1999 and 2000. The areas hatched in red, represent an erosional area, where the streambank lost significant material during the monitoring period. The blue hatched area represents areas of deposition, or those parts of the channel where bedload has accumulated during the monitoring period. Surveys are conducted of the cross sections, and entered into AutoCAD to produce the diagrams and compare the measurements.



V-27: Example of a monitoring cross section from Batavia Kill headwaters showing change between 1999 and 2000.

Using this data, the GCSWCD can determine the rate of erosion on a streambank, or the presence of aggradation in the stream channel. Additionally, the data allow the stream manager to observe changes in channel features such as maximum depth, channel cross sectional area, width to depth ratio, entrenchment, and others. By evaluating the rate of change, and the way channel changes impact critical morphological relationships, the GCSWCD was able to determine the types of stream processes impacting stream stability. The use of monitored cross sections and stream profiles provide the stream manager with an excellent way to observe changes in the stream reach morphology over time, verify process-based assessments of stream condition performed in the Level III classification, and provide validated empirical data for use in hydraulic geometry relationships, bank erosion rates, and channel stability.

Aerial Photograph Overlay

As discussed previously, aerial photography is an extremely important tool for stream managers. In the Phase III assessment process, the GCSWCD completed detailed evaluations of historical changes in those areas where detailed monitoring was being implemented. The assessment technique is based on the overlay of a stream channel's planform from various years in a series of aerial photographs (**Figure V-28**). In addition to observing morphological changes and channel stability, the aerial assessment is used to

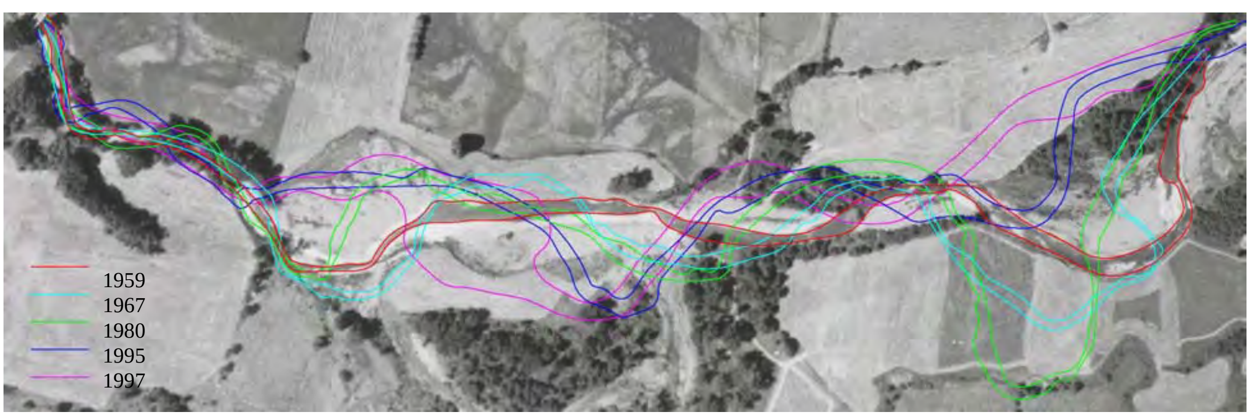


Figure V-28: Sample historic channel planform evaluation for reach in Ashland. Base photo was taken in 2000.

document changes in riparian vegetation and infrastructure modifications.

To complete this assessment, the aerial photographs were scanned into digital format and then correlated with one another using the AutoCAD Overlay program. The AutoCAD program allowed the GCSWCD to import digital images of aerial flights from various years, and matched and scaled the images using a series of control points located in each photograph. Control points are generally features, such as bridges, buildings or road intersections, that can be identified in each of the various photo series.

Because the digital images contain distortions as the result of the scanning process, unevenness of the terrain, or camera lens distortion, the GCSWCD must address uneven image alignments. This is done by using a feature in the AutoCAD program which allows for "rubber-sheeting" images over each other. Rubber-sheeting works by transforming an image so that points match between photographs using polynomial and triangular methods. Images are adjusted so that they can be additionally correlated to topographic ground surveys during phase IV assessments. The results of the aerial photograph assessment is discussed on a reach by reach basis later in this SMP.

4. PHASE IV: SITE FEASIBILITY EVALUATION

The Phase IV assessment of the Batavia Kill corridor includes the evaluation of restoration opportunities by performing a site feasibility analysis. This includes detailed analysis and evaluation of the reach and it's disturbances, the development of a preliminary design, design evaluation, and the creation of a final design. The Phase IV assessment includes a full topographic survey on these sites with temporary benchmarks established, and location of channel and flood plain features. These features include geomorphic channel features, utilities, and the location of instabilities (erosion) as well as previous monumented cross sections. The topographic survey can be used for design and integrated into performance monitoring of installed projects.

5. PHASE V: WATERSHED REFERENCE CONDITIONS

While the previous assessment activities focused on the evaluation of stream instability, it is equally important for the stream manager to conduct similar assessments on stable stream reaches. Stream reaches that are characterized by low erosion rates, effective riparian buffers, and good habitat conditions typically exhibit a high degree of stability. Commonly called "reference reaches", stream sections that are stable can be compared to unstable reaches to determine the degree and stage of the instability. The reference reach represents conditions where the stream is characterized not only by a stable form, but also by proper function in that it is able to pass a wide range of flows and bedload generated by the watershed.

In the Catskills, the NYCDEP is undertaking a study to evaluate reference reaches. The NYCDEP will be compiling data from stable reaches throughout the watershed to document stable channel morphology and to develop a database of reference conditions for use in restoration designs. This database will define the range of hydraulic, geomorphic and biological characteristics of typical stable reference reaches in the Catskills. The comprehensive set of data compiled for a reference reach database will:

- provide project designers with a valuable set of templates. Stable reference reaches are used as “blue prints” for restoration designs, as well as to evaluate the effectiveness of restoration projects;

- provide a baseline of sediment transport and hydraulic characteristics for stable streams that can be used to calibrate empirically derived relationships currently used to predict sediment transport capacity and scour depths in both traditional and geomorphic designs;

- to inform municipal officials about the distinguishing physical characteristics of their local streams from Catskill Region streams, and their implications for management.

Batavia Kill Reference Reaches

With the exception of headwater segments above the flood control structures, the Batavia Kill is characterized by poor reference conditions. While short segments exhibit stable conditions, the high levels of disturbances within the system have presented the GCSWCD with a challenge when developing restoration designs.

Figure V-29: Hensonville Reference Reach.

Since 1997, GCSWCD has surveyed two reaches within the stream corridor that were determined to be stable enough to be considered reference reaches. While both reaches are highly stable, they are limited in their application to restoration designs due to the influence of the C.D.Lane flood control structure on the stream’s flow and sediment regime. The two reaches (Hensonville and Church Street) are also vertically controlled by the presence of bedrock, which also limits their use in other sections of the stream where bedrock is not present in the stream corridor. The reaches have been valuable, however, in understanding the stream’s function in relation to the flood control structures.

In general, the C stream type accounts for a large portion of valley floor along the Batavia Kill where the most instability has been found. Unfortunately, to date neither the GCSWCD nor NYCDEP has located a C4 reference reach within the hydro-physiographic region. Reference reach data for stable C stream types is essential for the effective management of Batavia Kill. Absent a suitable reference reach, the GCSWCD has been using typical values developed by others for C stream types, as well as data collected from smaller sections that exhibit stable characteristics. The NYCDEP is continuing to try and locate reaches that meet the C4 stable delineation.

6. GEOLOGY ASSESSMENT

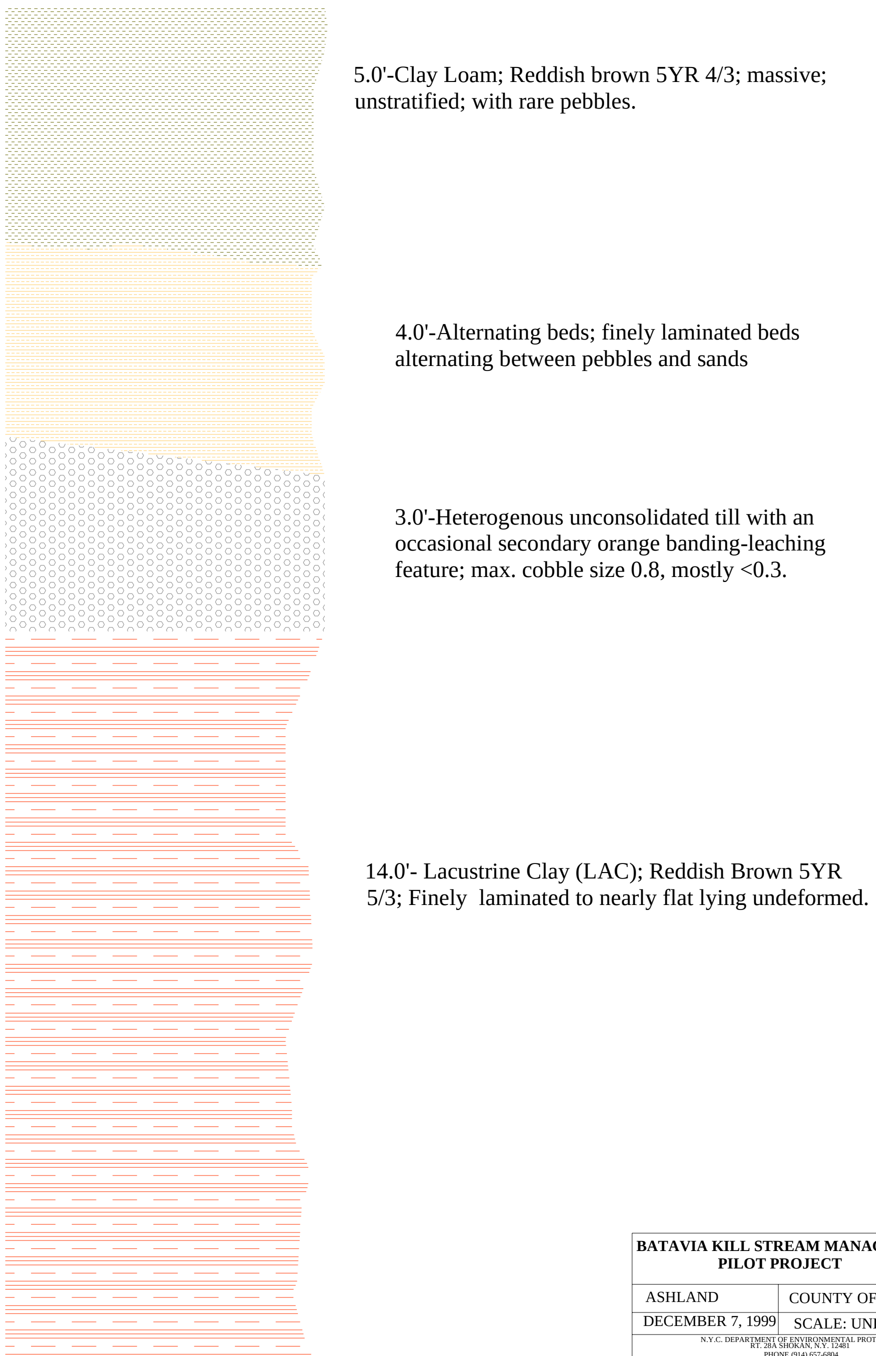
In the summer of 1998, the GCSWCD, initiated a project to inventory and map clay exposures in the stream corridor in partnership with the NYCDEP. During 1998 and 1999, NYCDEP staff completed extensive mapping of the Batavia Kill stream, with emphasis on those locations where the GCSWCD was conducting assessments of the stream's physical stability. During the mapping process, the NYCDEP mapped soil exposures on cross sections monitored by the GCSWCD and stratigraphic columns on selected bank exposures. The stratigraphic column shown in **Figure V-31** is from an exposed stream bank on the Holden property in the town of Ashland, and is visible from NYS Route 23. The stratigraphic column was mapped at an eroding streambank located just upstream of the green swinging footbridge west of the hamlet of Ashland.

As seen in the diagram **(Figure V-31)**, the bottom 14' of the exposed bank is comprised of the Lacustrine clays. As discussed in Section IV, these soils can have significant impacts on water quality. The remainder of the column is comprised of unconsolidated till, thin layers of pebbles/sand and a clay loam topsoil. This stratigraphic column is typical of the exposed banks along the Batavia Kill. While the erosion of the clay layers presents a challenge to water quality in the watershed, the unconsolidated tills and gravel/sand layers are also difficult to stabilize with vegetation due to dry conditions.

The magnitude of lacustrine clay exposures at Red Falls (**Figure V-30**) results in significant water quality impacts. The clay exposures are well represented by the stratigraphic column presented in **Figure V-32**, which is a cross section being monitored by the GCSWCD. As seen in **Figure V-32**, lacustrine deposits are exposed along significant portions of the eroded bank, while in the remainder of the channel area the clays are covered by a thin layer of gravel and cobble. This streambed cover is clearly inadequate in depth, and it is suspected that the underlying clays are exposed to erosional forces when the stream flows are elevated and the bed load is mobile.

Figure V-30: Unstable banks such as these at Red Falls are characterized by soils that are a challenge to restore.

Stratigraphic Column
Holden Property



BATAVIA KILL STREAM MANAGEMENT PILOT PROJECT	
ASHLAND	COUNTY OF GREENE
DECEMBER 7, 1999	SCALE: UNDEFINED
N.Y.C. DEPARTMENT OF ENVIRONMENTAL PROTECTION RT. 28A SHOKAN, N.Y. 12481 PHONE (914) 657-6804 FAX (914) 657-5776	
HOLDEN PROPERTY	
DRAWN BY: ALISSA SCHETZEL	
SHEET 1 OF 1	

Figure V-31: Stratigraphic Column from eroded streambank in Ashland.

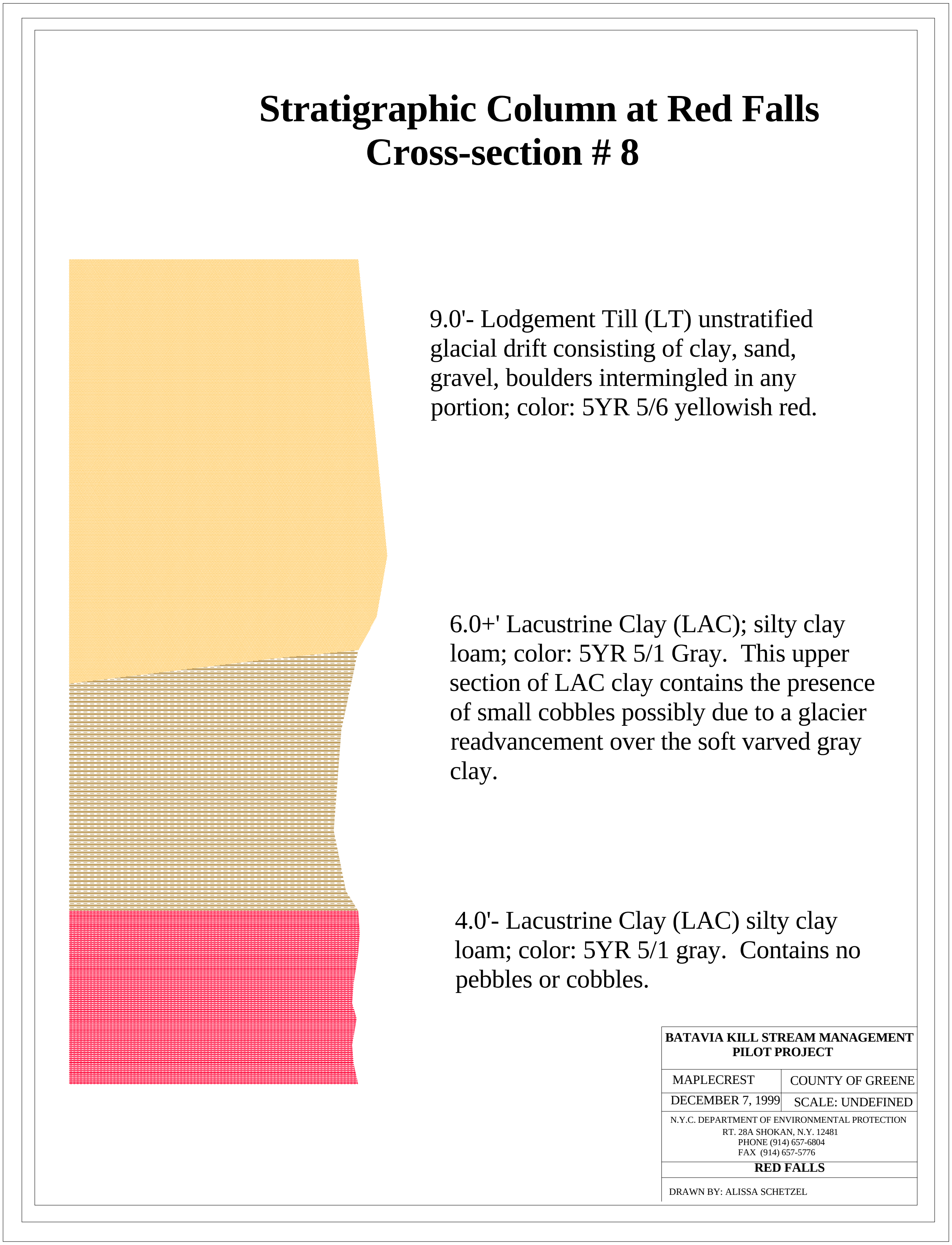


Figure V-32: Stratigraphic Column from eroded streambank at Red Falls. Provisional, NYCDEP 2001.

According to locally published references on glacial activities in the Batavia Kill watershed (Titus 1996), during the last glacial period two alpine glaciers approached each other from opposite ends of the Batavia Kill valley. Titus's investigations lead him to conclude that these glaciers may have met in the lower Batavia Kill valley, possibly in the Red Falls area. In this area of the valley, observations have been made of the "folding" of the clay layers, which would suggest that some large force, most likely a later glacier, pushed up the clays that had been exposed in earlier glacial periods.

During the stream assessment and geologic mapping activities undertaken by the GCSWCD and NYCDEP, lacustrine clay soils were found exposed, or just below the streambed armor, throughout most of the watershed. Lacustrine clays have been found exposed in the streambed or streambanks almost all the way up to the upper most county bridge on Route 56 (above Bentley's Saw Mill).

7. BIOLOGICAL SURVEYS

In the Batavia Kill watershed, a number of efforts to examine the stream's biological health are underway. The NYCDEP has been conducting macroinvertebrate assessments for a number of years, but the data from this work was not available at the time of this report. As a component of the NYCDEP evaluation of the restoration projects in the Catskills, the U.S. Geological Survey (USGS) is conducting a study on the impact of restoration projects on both macroinvertebrate and fish communities on the Batavia Kill. While the USGS is focused on a limited number of stream reaches, their findings may be extrapolated to the rest of the watershed when the stream demonstrates similar characteristics to the study area.

Fishery Assessment

The U.S. Geological Survey (USGS), in cooperation with the NYCDEP and GCSWCD, has been conducting fisheries assessments on stable and unstable reaches from several streams in southeastern New York State as part of a stream restoration program. Major objectives of the fishery monitoring effort are to determine (1) if fish populations and communities differ between stable (reference) and unstable (control and project) stream reaches and (2) if improved stability of restored reaches is reflected by improvements in affected fish populations and communities. Fishery surveys were initiated in the summer of 2000 at three reaches on the upper Batavia Kill, and repeated in 2001 and 2002. Surveys were initiated prior to construction of the Big Hollow project to establish baseline conditions at the project site as well as on a stable reference reach, and an unstable control reach.

Preliminary results from the 2000 survey **(Table V-6, Figure V-33 to Figure V-37)** indicate that the stable Batavia Kill reference site had more fish species and higher biomass and diversity than that observed at both unstable control and project reaches. At the stable reference site, the fish community was typical of the Catskill's headwater streams, with mature and juvenile brook trout common and brown trout rare. Slimy sculpin were also common in the reference reach with lesser numbers of black nose dace. Density was lower at the reference reach than at the other two reaches. The community at a sampling site within the project reach was unusual in that it contained almost equal numbers of sculpin and dace with no brook or brown trout sampled. An unstable control reach immediately upstream from the restoration site was intermediate between the project and reference sites with low numbers of brown and brook trout and large numbers of sculpin and dace present (B. Baldigo, Personal Communication).

Table V-6: Fish-community indices from treatment, control, and reference reaches in the Upper Batavia Kill Basin, 2000.

Index	Treatment	Control	Reference
Community richness (number of fish species)	3	4	5
Community density (number of fish/sq. meter)	1.38	1.43	1.09
Community biomass (grams of fish/sq. meter)	4.28	5.81	6.79
Species diversity	1.03	1.48	1.81

Density of fish populations observed at the three reaches **(Figure V-33)** show the underlying cause for differences in community indices. The fish community at the treatment reach (red) consisted almost entirely of slimy sculpin and black nose dace (one rock bass was also collected). The community at the reference reach (green) was composed of a very large number of sculpin, but fewer dace and a small number of brook and brown trout (a few creek chubs were also collected).

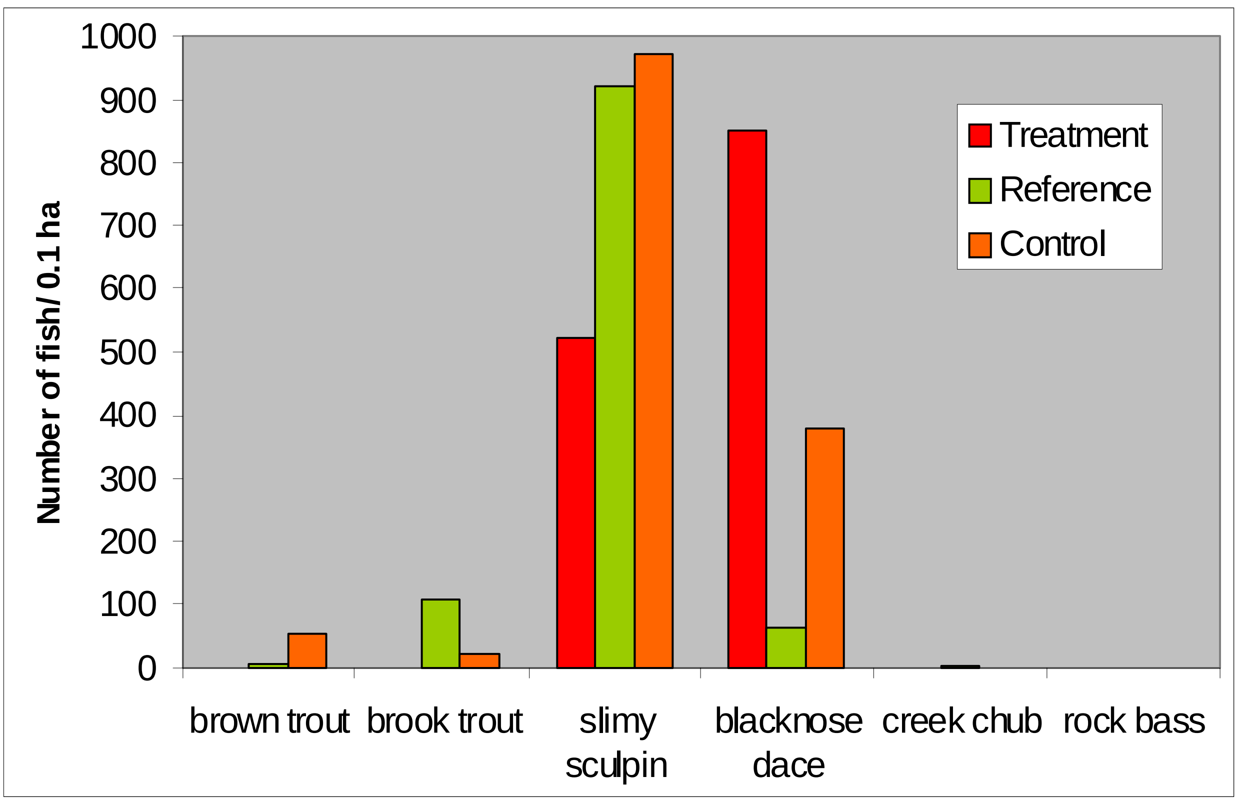


Figure V-33: Density of fish species on project, reference and control reaches in Big Hollow. Provisional data, USGS 2001.

The community at the unstable control reach was intermediate, but more similar to the adjacent reference reach. Community biomass and density estimates are based on unit-area samples and vary with discharge conditions, thus, interpretations of annual trends or changes in each index will need to be standardized against flow. At first glance, these findings appear to support the hypothesis that fish communities in unstable reaches are affected by poor habitat. Additional fishery and habitat surveys and more complete data analyses, however, are needed in order to verify this supposition.

Estimates of species biomass at the three reaches **(Figure V-34)** tell a slightly different story. Biomass of slimy sculpin and black nose dace still dominate (98%) at the treatment reach (red), however, brook and brown trout constitute 32 to 35 percent of the community biomass at the reference (green) and control (orange) reaches. Sculpin biomass does not change greatly across study reaches.

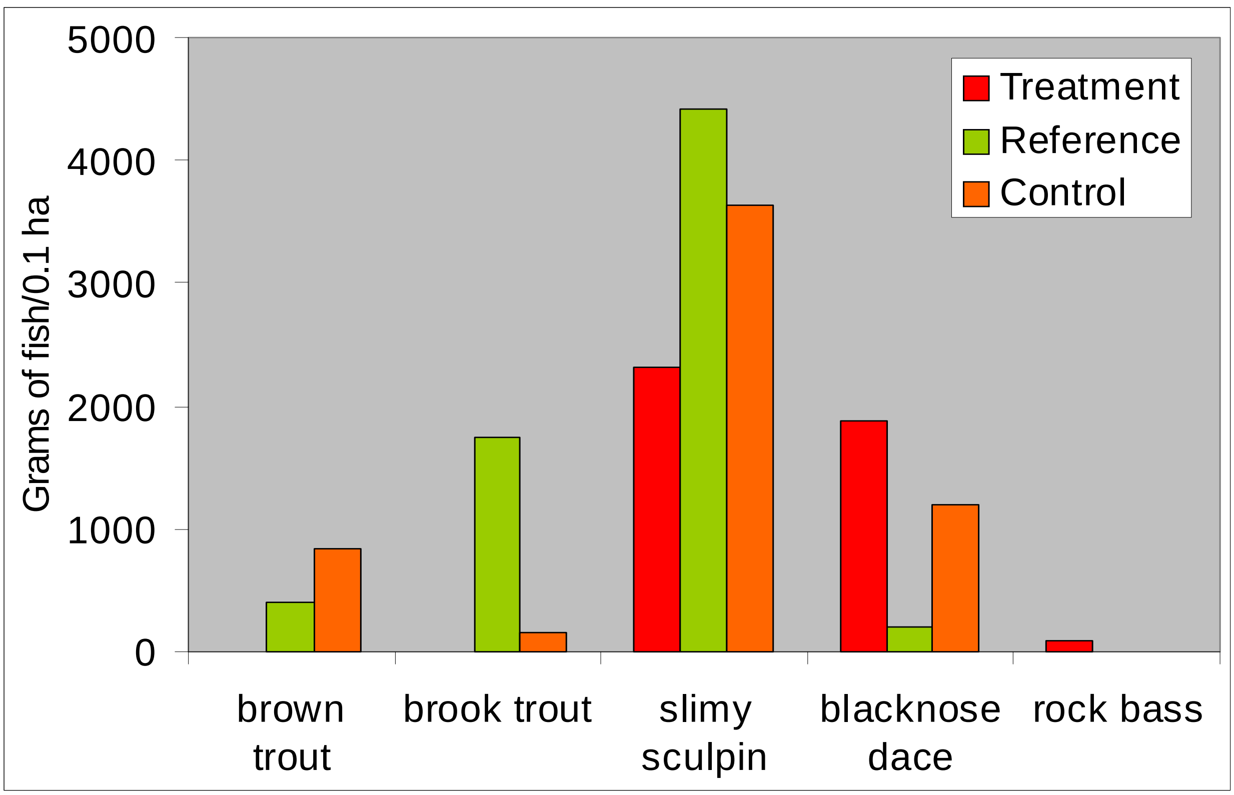


Figure V-34: Biomass of fish populations from treatment, control, and reference reaches in the Upper Batavia Kill Basin, Provisional data, USGS 2000.

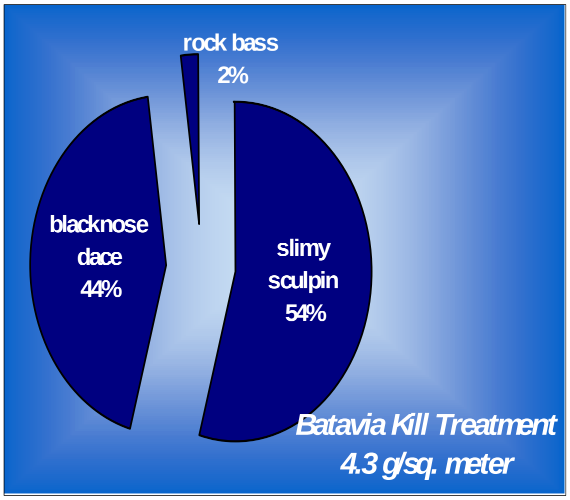


Figure V-35: Biomass of fish populations at the treatment reach, Upper Batavia Kill Basin, Provisional data, USGS 2001

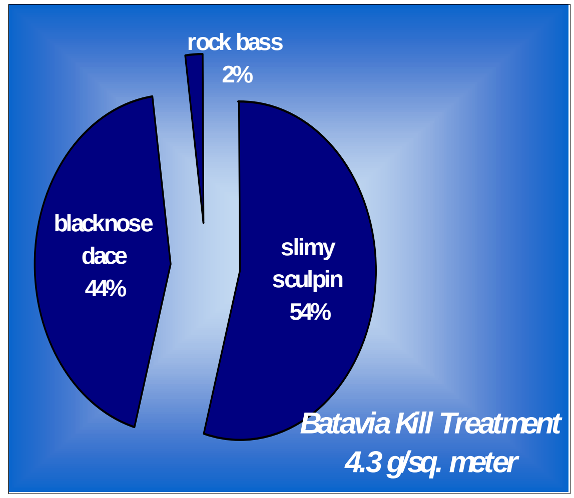


Figure V-36: Biomass of fish populations at the treatment reach, Upper Batavia Kill Basin, Provisional data, USGS 2001.

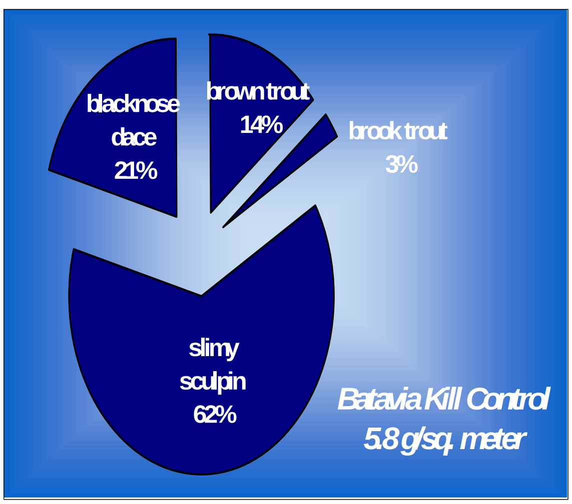


Figure V-37: Biomass of fish populations at the reference reach, Upper Batavia Kill Basin, Provisional data, USGS 2001.

Increases in trout biomass appear to correspond to decreases in dace biomass at the control and reference reaches. Whether these changes correspond to differences in habitat preference, thermal regimes, or altered predator/prey pressure among sites, cannot be discerned by present data and analyses. The differences in biomass of each species population is shown in **Figure V-35, V-36** and **V-37**. In general, fish communities at stable reference reaches were typical of productive headwater systems; juvenile and mature brook trout and slimy sculpin were common, brown trout were relatively rare, and black nose dace and cyprinid minnows were present in low to moderate numbers. Communities at unstable treatment and control sites were unusual; large numbers of slimy sculpin and black nose dace were present and few if any brook trout and brown trout were observed.

While the GCSWCD's assessment work did not evaluate fisheries habitat in detail along the entire stream corridor, several limitations appear to be prevalent on much of the stream system. First, the absence of significant in- stream structure such as large boulders, woody debris, and deep stable pools, limit stream capacity to sustain fish populations during the extremes of summer and winter. It is speculated that the boulders and other features that provide a varied stream structure long ago fell prey to bulldozers.

Other limitations to habitat are primarily associated with impacting the stream thermal condition. With trout species very sensitive to high water temperatures, the absence of effective riparian vegetation cover that provides shading is a problem on many sections of the Batavia Kill. Additionally, large depositional areas and rip-rap are also present. Depositional areas and rip-rap generally act as heat sinks, absorbing solar energy and transferring it to the stream. In the summer months, stream temperatures on the Batavia Kill frequently exceed the cooler temperatures necessary to sustain cold water fish species.

Lastly, another limitation on fisheries habitat in the Batavia Kill system is the presence of migration barriers. In some cases, these barriers permanently block fish passage and cut off tributaries that are essential nursery and rearing areas for young fish. With the three flood control structures controlling close to 30% of the watershed area, miles of the stream system have been cut off and are no longer available to fish.

Figure V-38: Concrete dam presents a fisheries migration barrier on a small tributary on the Batavia Kill.

On the Batavia Kill, the GCSWCD has identified several structural migration barriers, including a private bridge and several man made grade control structures. While some of these barriers may be passable during higher flows, they impede fish movement through the stream system during the summer low flows, and may prevent fish from moving to areas of adequate refuge.

8. SUMMARY OF STREAM CORRIDOR ASSESSMENTS

In the previous sections, the GCSWCD presented a brief overview of the various stream corridor features, which were examined during the course of the Batavia Kill project, and the methods used to assess these important features. While an evaluation of these features is important to an understanding of the watershed, they are most effective when applied at the reach scale. In following sections of this SMP, the GCSWCD has provided a more detailed assessment of the Batavia Kill stream corridor on a reach by reach basis.