# THIRD BROOK WATERSHED MANAGEMENT PLAN

December 2013

MMI #4444-01

**THIS DOCUMENT WAS PREPARED FOR THE NEW YORK STATE DEPARTMENT OF STATE WITH FUNDS PROVIDED UNDER TITLE 11 OF THE ENVIRONMENTAL PROTECTION FUND.**

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| | |
|---|---|
| AMA | Agricultural Management Assistance Program |
| BCR | Benefit-Cost Ratio |
| BMP | Best Management Practice |
| CDBG | Community Development Block Grants |
| CEA | Critical Environmental Area |
| CFS | Cubic Feet Per Second |
| CIG | Conservation Innovation Grant |
| CREP | Conservation Reserve Enhancement Program |
| CRP | Conservation Reserve Program |
| CRS | Community Rating Service |
| CSP | Conservation Stewardship Program |
| CWA | Clean Water Act |
| DCAP | Delaware County Action Plan |
| DCPD | Delaware County Planning Department |
| DCSWCD | Delaware County Soil and Water Conservation District |
| DEC | Department of Environmental Conservation |
| DL | Development Limitation |
| ECL | Environmental Conservation Law |
| EIS | Environmental Impact Statement |
| EPA | Environmental Protection Agency |
| EPF | Environmental Protection Fund |
| EQIP | Environmental Quality Incentives Program |
| EWP | Emergency Watershed Protection Program |
| FAD | Filtration Avoidance Determination |
| FEMA | Federal Emergency Management Agency |
| FIRM | Flood Insurance Rate Map |
| FIS | Flood Insurance Study |
| FMA | Flood Mitigation Assistance |
| FPMS | Floodplain Management Services Program |
| FRPP | Farm and Ranch Lands Protection Program |
| FSA | Farm Service Agency |
| GIS | Geographic Information System |
| GPS | Global Positioning System |
| GRP | Grassland Reserve Program |
| HMGP | Hazard Mitigation Grant Program |
| HUD | United States Department of Housing and Urban Development |
| LFHMA | Local Flood Hazard Mitigation Assessment |
| Mg/L | Milligrams Per Liter |
| MMI | Milone & MacBroom, Inc. |
| MOA | Memorandum of Agreement |
| MOU | Memorandum of Understanding |
| MRP | Mean Return Period |

| | |
|---|---|
| NEPA | National Environmental Policy Act |
| NFIP | National Flood Insurance Program |
| NFIRA | National Flood Insurance Reform Act |
| NRCS | Natural Resources Conservation Service |
| NYCDEP | New York City Department of Environmental Protection |
| NYS | New York State |
| NYSDEC | New York State Department of Environmental Conservation |
| NYSDOH | New York State Department of Health |
| NYSDOS | New York State Department of State |
| PDM | Pre-Disaster Mitigation |
| PLA | Prediction Level Assessment |
| PWS | Professional Wetland Scientist |
| RFC | Repetitive Flood Claim |
| RLA | Reconnaissance Level Assessment |
| RRISSC | Rapid Resource Inventory for Sediment and Stability Consequence |
| SCMP | Stream Corridor Management Plan |
| SDWA | Safe Drinking Water Act |
| SEQR | State Environmental Quality Review |
| SFHA | Special Flood Hazard Area |
| SMP | Stream Management Program |
| SRL | Severe Repetitive Loss |
| SWCC | Soil and Water Conservation Committee |
| SWCD | Soil and Water Conservation District |
| SWTR | Surface Water Treatment Rule |
| TMDL | Total Maximum Daily Load |
| USACE | United States Army Corps of Engineers |
| USDA | United States Department of Agriculture |
| USEPA | United States Environmental Protection Agency |
| USFWS | United States Fish & Wildlife Service |
| USGS | United States Geological Survey |
| WARSSS | Watershed Assessment of River Stability & Sediment Supply |
| WHIP-WLFW | Wildlife Habitat Incentive Program – Working Lands for Wildlife |
| WIPWL | Waterbody Inventory/Priority Waterbodies List |
| WOH | West of the Hudson |
| WRP | Wetlands Reserve Program |

# EXECUTIVE SUMMARY

The Village of Walton, Delaware County Soil and Water Conservation District (DCSWCD), Delaware County Planning Department (DCPD), and the New York City Department of Environmental Protection (NYCDEP) have partnered to develop the subject Watershed Management Plan for Third Brook. The preparation of the plan was funded in part by the New York State Department of State. This plan builds on a large body of previous work and included additional assessment focused on geomorphic characteristics of the stream and land use in the watershed.

The Third Brook watershed has been affected by past flooding such as the devastating flooding that occurred in June 2006. As such, a significant element of this plan focuses on creating a stable river valley and decreasing future flood and erosion risks. Beyond the issue of flooding, this management plan addresses strategies associated with stream stability, erosion, and slope failures; stormwater management; land management; sanitary wastewater management; and wetland habitat protection. These strategies have one important common goal and intended outcome, which is to reduce the potential for water quality impairments caused by flooding, erosion, slope failures, loss of appropriate wetland vegetation, and/or poor management of stormwater, land use, and sanitary wastewater. Protection and enhancement of water quality in the Third Brook watershed will improve the quality of life for residents and businesses in the village and town of Walton while helping NYCDEP meet its goals of maintaining good water quality in its water supply watersheds.

This management plan was developed under the guidance of a Project Advisory Committee which was generally coexistent with the pre-existing Walton Flood Commission yet included a few additional members. A public process was followed, including public information meetings held in July 2012 and September 2013. The public was invited to participate in a written survey to help identify the issues of interest in the watershed.

The vision for the Third Brook Watershed is that it becomes a naturally sustainable stream system comprised of stable channels and slopes with flood damage mitigated to the extent possible in order to achieve excellent water quality. The following goals were identified through this planning process:

- ☐ Improve water quality through flood mitigation and prevention of flood damage
- ☐ Improve water quality by reducing erosion and mitigating slope failures
- ☐ Improve water quality by modifying stormwater management
- ☐ Protect water quality by managing land use
- ☐ Protect water quality by managing disposal of sanitary wastewater
- ☐ Protect water quality by enhancing wetland vegetation

A number of management strategies are appropriate in the Third Brook watershed to address the above goals: flood protection and mitigation, stream stability, slope failure and erosion management, stormwater management, land management, sanitary wastewater management, wetland habitat protection and management. The additional strategy of watershed monitoring may also be appropriate.

Some of the key flood management recommendations of this watershed management plan include development of a hydraulic model for the length of Third Brook and use the model to evaluate the creation of benched floodplain and improved flood conveyance in several specific locations; replacement of the Ogden Street and Delaware Street bridge structures with larger openings to reduce backwater conditions and debris blockage (subject to verification with the model); relocation of a number of buildings and businesses from the stream corridor; installation of floodwalls with automatic flood gates at the Kraft facility; and elevation of homes along Lower Third Brook Road and West Street.

Stormwater recommendations include annual inspection and removal of sediment from stormwater collection, conveyance, and discharge systems; and avoidance of the use of unvegetated ditches for stormwater conveyance in the watershed. For example, the ditches along Armstrong Road should be stabilized or eliminated.

Failing slopes should be mitigated through a combination of (1) shifting the channel of Third Brook away from the toes of the slopes where possible; and (2) installing vegetated riprap or fabric-encapsulated soil lifts above low-stacked rock walls. Where the channel can be shifted to the east, use of stacked rock walls may be circumvented in favor of a continuous sloped solution on the failed slope such as vegetated riprap below the 100-year flood elevation and fabric-encapsulated soil lifts above the 100-year flood elevation (or some other design event). Where possible, sections of the Third Brook channel should be evaluated for the feasibility of regrading to increase stability and connect to the floodplain. If the channel can be raised to higher elevations in the vicinity of failing slopes, less intensive engineered solutions may be possible for the slope mitigation.

Dredging sections of Third Brook should be discouraged unless hydraulic modeling demonstrates that removing sediment from the channel will reduce flood elevations and that such dredging will not disturb any equilibrium that has been achieved or may be achievable.

The town and county should work with owners of septic systems in the watershed to ensure that systems are maintained or replaced as needed to reduce the potential for failures. Meanwhile, the town and village should evaluate the cost and feasibility of extending the village's sewer system to the town's portion of West Street, allowing decommissioning of septic systems that are at risk of inundation or erosion.

Of the four wetland types in the Third Brook watershed, palustrine forested wetland systems occur less frequently than predicted due to agriculture land uses. Where possible, opportunities should be identified to reforest some of the wetland areas along the Third Brook corridor. This will increase habitat diversity and will likely have benefits to water quality as well.

Regarding land use and management, the village and town should ensure that the flood damage prevention regulations are applied to structures located where the base flood elevations exceed ground surface elevations, in addition to structures simply mapped in the Third Brook SFHA. Village Zoning Regulations Section 53-57 should be used by the Floodplain Administrator to conduct stringent reviews of applications for development where the section applies (to lots *abutting* watercourses) as this may be the only direct mechanism for the village to regulate structures that are in a floodplain but not within a FEMA-delineated SFHA. The town and village should identify areas that are off limits for development in the Third Brook watershed and ensure that these areas are protected as such. The aforementioned hydraulic modeling will be useful in this effort.

Finally, outreach and education should remain a priority in the watershed and technical assistance must remain available within the watershed regarding agricultural land use, maintaining natural floodplains, and flood damage prevention. Suitable direct and indirect monitoring programs should be considered to determine whether restoration and stabilization projects in the watershed are successful.

# 1.0 INTRODUCTION AND BACKGROUND

## 1.1 Introduction

In recognition of the importance of watershed management, the Village of Walton, in partnership with the Delaware County Soil and Water Conservation District (DCSWCD), Delaware County Planning Department (DCPD), and the New York City Department of Environmental Protection (NYCDEP), has commissioned the subject Watershed Management Plan of the Third Brook. Milone & MacBroom, Inc. (MMI) was retained to work with the project partners to develop this comprehensive plan. The preparation of the plan is funded in part by the New York State Department of State, with funds provided under Title 11 of the Environmental Protection Fund.

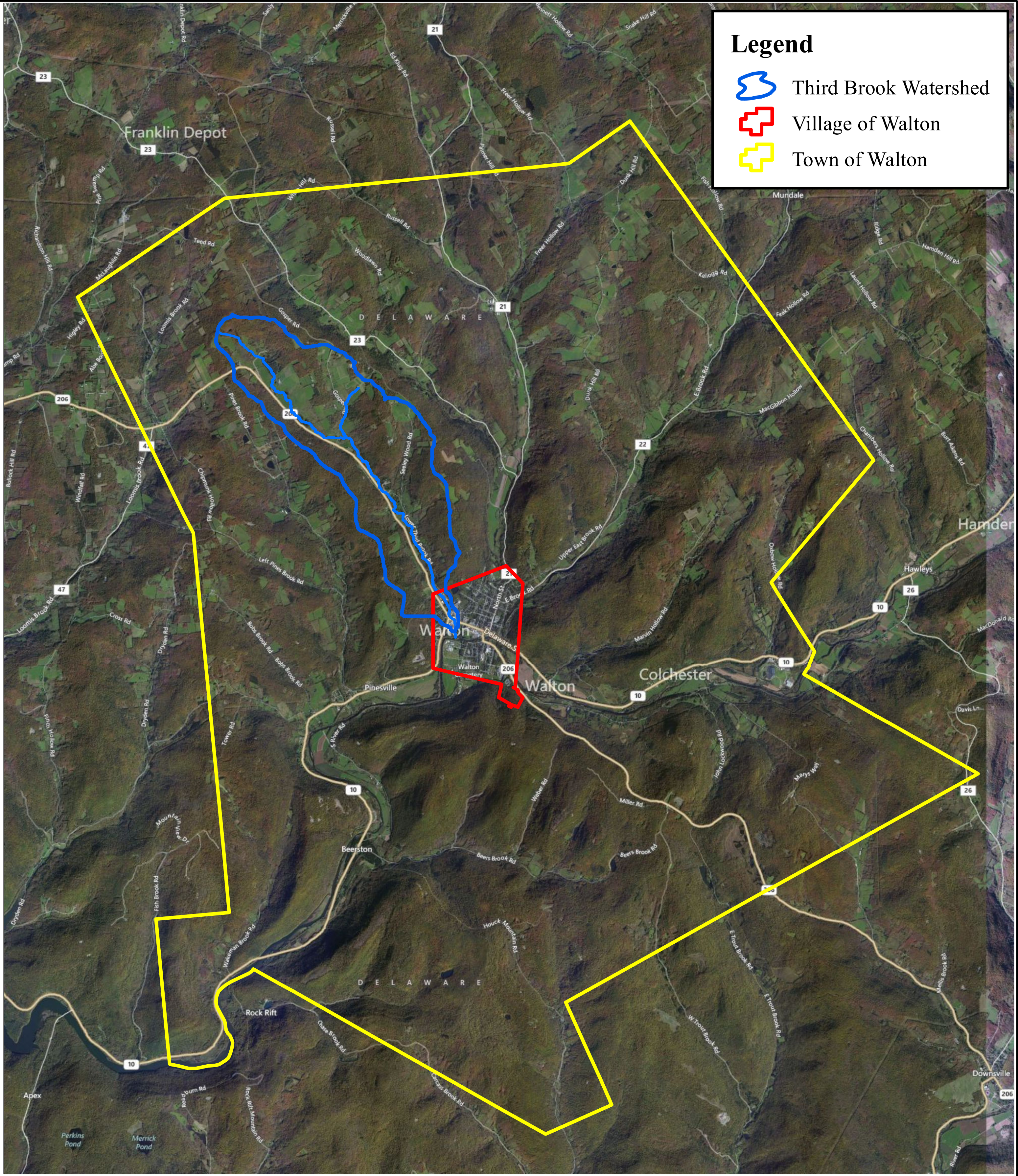
The Third Brook watershed is located within the town and village of Walton, both of which are located within Delaware County, New York. Delaware County is located in the southern part of the state, contains part of the Catskill Mountains, and is separated from Pennsylvania by the Delaware River. The watershed is located within the New York City drinking water supply system and confluences with the West Branch Delaware River in the village of Walton. Figure 1-1 depicts the location of the watershed in Walton. Appended Figure I is a large map of the watershed.

This plan builds on previous work, with additional assessment and analysis. The Third Brook watershed, its residents, critical municipal infrastructure, and businesses crucial to the area economy have been devastated by past flooding, most notably the flooding that occurred in June 2006. As such, a significant element of this plan focuses on creating a stable river valley and decreasing future vulnerability. Beyond the important issue of flooding, this management plan addresses strategies associated with stream stability, erosion, and slope failures; stormwater management; land management; sanitary wastewater management; and wetland habitat protection.

All of the above strategies have one important common goal and intended outcome, which is to reduce the potential for water quality impairments caused by flooding, erosion, slope failures, loss of appropriate wetland vegetation, and/or poor management of stormwater, land use, and sanitary wastewater. Protection and enhancement of water quality in the Third Brook watershed will improve the quality of life for residents and businesses in the village and town of Walton while helping NYCDEP meet its goals of maintaining good water quality in its water supply watersheds.

## 1.2 Overview of Watershed Management

The term "watershed" refers to the area surrounded by high spots, or divides, from which water drains or flows downhill to or past the point in question (Leopold, 1997). Surface water movement through a watershed begins with runoff flowing downhill as sheet flow, collection in small rivulets that erode shallow channels in the soil, and joining of small streams (MacBroom, 1998). These small streams receive additional runoff downstream



**SOURCE(S):**

Bing Maps Hybrid

**Figure 1-1: Location Map**

**LOCATION:**

**Walton, NY**

N

**Third Brook Watershed Management Plan**

**Map By:** JEP
**MMI#:** 4444-01
**MXD:**H:\4444-01\GIS\Maps\Figure1-1.mxd
**1st Version:** 1/7/2013
**Revision:**1/8/2013
**Scale:** 1 inch = 9,000 feet

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and groundwater discharge from locally infiltrated precipitation, eventually merging where valleys meet.

Many factors require that stream management efforts extend far beyond the banks that contain flowing water. Some management issues result from upstream land use, runoff, and sources of pollution. Others arise because of floodplain encroachments, inadequate riparian buffers, or loss of wetlands.

The evolving methods of river management emphasize a holistic approach, addressing the watershed and stream corridor in addition to the actual channel. Traditional approaches to river management are often limited in scope, prohibitively expensive, and environmentally unsound. The concept of managing the watershed and corridor as well as the river channel itself provides an alternate approach that allows each river function to be managed at the appropriate level.

Watershed management has evolved in response to the need for a broad approach that considers rivers to be important natural resources with many, often competing uses. It is essential to recognize that, besides conveying storm runoff, streams serve many other ecological, economic, and social functions, and the planning and design of management systems must consider water supply needs, recreational uses, wildlife, aesthetics, and the cost and maintenance of the management measures that are implemented.

The concept of watershed management has been in existence for many years. The practical application of the watershed management approach is constantly evolving as new technologies are developed. An effective watershed management program should be based on scientific and engineering guidance but also needs to be communicated to and implemented by the stakeholders of the watershed in a complementary and coordinated effort.

Effective watershed protection involves a multifaceted approach that encompasses land use (past, present, and future); stream and wetland buffers; responsible development through adequate site selection, design, and maintenance; stormwater best management practices; control of nonstormwater discharges; control of destructive and unnatural erosion and sedimentation; and watershed stewardship programs that have the ability to span corporate boundaries and governmental divides.

The process of watershed management can include the following basic tasks:

- ☐ identification of the study area
- ☐ identification and notification of interested individuals, organizations, and public agencies
- ☐ establishment of an advisory or coordinating board
- ☐ collection of existing data and evaluation of existing natural and cultural features
- ☐ collection of new data as needed
- ☐ identification of watershed and stream issues and problems

- ☐ identification of highest priority issues
- ☐ evaluation of alternative solutions to problems
- ☐ research of funding sources and needed regulatory programs
- ☐ development of a final strategy
- ☐ adoption of a management plan
- ☐ implementation of the plan

These tasks are more succinctly grouped into the steps outlined in the Guidebook for Watershed Plans: Protecting and Restoring Water Quality[1], prepared by the New York State Department of State. This guidebook lays out a step-by-step process for developing a comprehensive watershed management plan. These steps include:

1. Laying the foundation – Identifying the importance of community involvement showing how partnerships can strengthen the process of watershed planning and implementation
2. Understanding your watershed – Identifying and understanding your watershed and developing a vision and goals for its future
3. Identifying opportunities for improvement – Describing how to use field assessments to evaluate watershed conditions and identify specific recommendations to protect and improve water quality
4. Crafting the watershed plan – Showing how to pull it all together in a watershed plan
5. Putting your plan into action – Providing guidance on how to implement your plan, show early success through on-the-ground projects, sustain momentum, track progress, and make necessary updates to the plan

The subject watershed management plan is designed to follow the above process as well as the steps of the guidebook. The document is organized accordingly:

- ☐ Chapter 1 identifies the study area, project stakeholders, and project goals and objectives.
- ☐ Chapter 2 presents the community outreach plan.
- ☐ Chapter 3 presents an inventory of existing conditions based upon available data and information.
- ☐ Chapter 4 presents the preceding studies and plans that are most directly relevant to the subject plan.
- ☐ Chapter 5 presents new data collection associated with the subject study and presents an assessment of the watershed and stream.
- ☐ Chapter 6 provides a review of plans, policies, and regulations that affect the watershed.
- ☐ Chapter 7 describes potential management strategies for identified problems.

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[1] Watershed Plans: Protecting and Restoring Water Quality, NYSDOS, 2009. http://www.dos.ny.gov/communitieswaterfronts/pdfs/Guidebooks/watershed/WatershedPlansGuidebook%20wo%20secretary.pdf

- ☐ Chapter 8 presents a detailed list of findings and recommendations along with an implementation strategy, including an evaluation of the funding mechanisms for future flood hazard mitigation efforts.

## 1.3 Project Advisory Committee (PAC)

An advisory committee was established for the Third Brook Watershed Management Plan process, representing local, county, and state government, as well as watershed residents with interest in maintaining high water quality and ecological health in the Third Brook watershed. Table 1-1 lists the PAC members and their respective affiliations.

**TABLE 1-1**
**Third Brook Watershed Management Plan Project Advisory Committee**

| ***Committee Member*** | ***Affiliation*** |
|---|---|
| Graydon Dutcher | Delaware County Soil and Water Conservation District |
| Rick Weidenbach | Delaware County Soil and Water Conservation District |
| Jessica Rall | Delaware County Soil and Water Conservation District |
| Duncan Martin | Delaware County Planning Department |
| Dean Frazier | Delaware County Watershed Affairs Commissioner |
| Kelly Blakeslee | Delaware County Watershed Affairs Department |
| Tom Hilson | Delaware County Watershed Affairs Department |
| Bill Willis | Delaware County Economic Development Department |
| Walter Geidel | Town of Walton Highway Department |
| Len Govern | Town Board, Town of Walton |
| Bruce Dolph | Walton Town Supervisor |
| Stephen Dutcher | Village and Town of Walton Code Enforcement Officer |
| Edward Snow | Current Walton Village Mayor |
| Al Reynolds | Village of Walton Trustee |
| Eleanor Anbari | Resident |
| Phil Eskeli | NYCDEP |
| Tracey O'Malley | New York Department of State |

Former members of the PAC who participated in the planning process are Michael Jastremski (formerly of Delaware County Planning Department) and the prior village mayor, Patrick Meredith. In general, the PAC members are also members of the Walton Flood Commission. The Walton Flood Commission is an intermunicipal effort between the Town and Village of Walton to address flood damage threats at a watershed scale but not only focusing on Third Brook. The Walton Flood Commission is supported by the Delaware County Departments of Emergency Services, Public Works, Planning, Watershed Affairs, and Economic Development; the DCSWCD; NYCDEP; and the New York State Department of Environmental Conservation.

Interaction with the PAC is described in Section 2.0.

## 1.4 Existing Data, Mapping, and Reports

Appendix A contains a list of resource materials that were used to inform the development of this plan. These materials have been prepared by a variety of organizations and individuals and are specific to the village and town of Walton, Delaware County, Third Brook, and NYCDEP. They are organized into the categories of municipal plans and regulations, countywide plans, Federal Emergency Management Agency (FEMA) related materials, hazard mitigation plan-related materials, flooding, failing slopes, and miscellaneous. Technical references are provided in Section 9.0 of this plan.

## 1.5 Vision, Expectations, and Goals

A vision statement clearly describes what is hoped for accomplishing for the watershed, sets the tone of the watershed plan, and is used throughout the planning process all the way through implementation. It should look to the future, motivate partners and the community, and bring together assets and resources. Creating a vision involves taking a critical look at the watershed's unique characteristics and thinking about future goals. The vision statement should be written in a way that can be easily translated into a set of goals and objectives[2].

Community participation in the visioning process is key and should be open to everyone. When bringing the interests and ideas of a broad audience together, you can create a vision that is inclusive and dynamic. Community involvement is also important when forming goals and objectives. By listening to a diverse group, it is possible to gain agreement or consensus on the overall goals that will drive the implementation of the plan.

The vision for the Third Brook Watershed is *that it becomes a naturally sustainable stream system comprised of stable channels and slopes with flood damage mitigated to the extent possible in order to achieve excellent water quality.* Although the PAC is generally coincident with the Walton Flood Commission as explained above, the vision statement for the Third Brook Watershed Management Plan differs from the PAC's mission by focusing on water quality.

The following expectations were developed early in the planning process, with some identified through efforts of the Walton Flood Commission although not all of them were initially tied to the improvement or enhancement of water quality in the Third Brook Watershed:

- ☐ Create and Foster a Naturally Sustainable System
- ☐ Stabilize Failing Slopes
- ☐ Protect Infrastructure and Buildings from Flooding
- ☐ Reclaim Floodplain Where Possible

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[2] Watershed Plans: Protecting and Restoring Water Quality, NYSDOS, 2009.

- ☐ Evaluate Relocation Opportunities
- ☐ Site Future Development in Low-Risk Areas
- ☐ Adopt/Amend Local Legislation to be Compatible with Sound Watershed Management Principles
- ☐ Identify Funding Opportunities

With the watershed vision in mind and in consideration of the prior expectations listed above, the following goals were identified through this planning process:

1. Improve water quality through flood mitigation and prevention of flood damage
2. Improve water quality by reducing erosion and mitigating slope failures
3. Improve water quality by modifying stormwater management
4. Protect water quality by managing land use
5. Protect water quality by managing disposal of sanitary wastewater
6. Protect water quality by enhancing wetland vegetation

The six goals correspond to the seven management strategies discussed in Chapter 7 of this plan, with goal #2 addressed by two similar yet distinct management strategies.

# 2.0 COMMUNITY OUTREACH AND PUBLIC PARTICIPATION

A community outreach and public participation plan was developed as part of the watershed planning process. A copy can be found in Appendix B. Highlights are described below.

## 2.1 Role of the PAC

The role of the PAC is to ensure that the watershed management plan development process and the policy recommendations contained therein are clear and appropriate and that as diverse an audience as possible is engaged in developing the plan and its recommendations. The PAC must also be cognizant of keeping the plan "user friendly" and understandable to the target audience to ensure community buy-in.

Potential representatives identified for inclusion on the PAC included the following:

- ☐ Village of Walton
- ☐ Town of Walton
- ☐ Delaware County Soil and Water Conservation District
- ☐ Delaware County Planning Department
- ☐ New York City Department of Environmental Protection
- ☐ New York Department of State
- ☐ New York Department of Transportation
- ☐ USDA Natural Resources Conservation Service
- ☐ Delaware County Chamber of Commerce Representative
- ☐ Watershed Resident Representative(s)
- ☐ Impacted Business Owners in the Floodplain

Ultimately, the PAC included the individuals listed in Table 1-1. In general, the PAC members are also members of the Walton Flood Commission.

## 2.2 Goals of Outreach and Target Audience

As noted in the United States Environmental Protection Agency's (EPA) Handbook for Developing Watershed Plans to Restore and Protect Our Waters, the specific objectives of a watershed management public outreach program "should directly support your watershed management goals and implementation of the watershed management plan."[3] The Guidebook for Watershed Plans: Protecting and Restoring Water Quality notes that *"success in watershed planning comes about by involving people who have a strong interest in the future of your watershed. Developing strong partnerships and involving the community right at the start of your watershed planning process will lay the foundation for the successful implementation of your watershed plan."*

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[3] http://water.epa.gov/polwaste/nps/upload/2008_04_18_NPS_watershed_handbook_ch12.pdf; p.12-2.

Goals for public participation should be based upon specific driving forces, the salient issues of concern within the specific watershed management area. In the Third Brook watershed, the driving forces originate from the need for stream stabilization and flood mitigation, which will in turn improve water quality. The overarching and unifying goal of the public outreach campaign for this Watershed Management Plan was engaging the overall Walton community in addressing the need for improvements in these areas.

The general goals for public outreach as part of the Third Brook Watershed Management Plan included the following:

*Opportunity for involvement* – Provide multiple opportunities for residents, key stakeholders, government officials, and other impacted parties to participate in the development of specific action steps that will result in better management of the watershed.

*Involve a broad base of participants* – Have an outreach program that is designed to draw in the broadest base of participants as possible while still maintaining a manageable and timely planning process.

*Convenience and accessibility* – Provide avenues of participation that are convenient for a diverse set of stakeholders and accessible to participants of varied means. Achieving this goal requires a mix of opportunities for engagement, from standard public meetings to social media to other means of participation.

*Logical progression* – The public outreach program should present the issues facing the watershed, such as flooding and erosion, with supportive data, evidence, and identified potential impacts before offering solutions to these issues. One of the underlying goals of any public outreach campaign is education; in other words, participants must be given the opportunity to learn and understand as much as possible about the underlying issues affecting their watershed before they proceed to evaluate potential solutions to these issues.

*Realistic expectations* – The goals of a public outreach campaign should be as specific as possible so that they can be realistically addressed within a reasonable time frame. Overly broad or grandiose goals may be inspiring and do have their place in the planning process, but the specific goals identified need to be focused, actionable, and measurable so that progress can be achieved and clearly recognized.

*Target audience* – The target audience should include all residents of the village and town of Walton, particularly property owners located along the stream and in the floodplain; business owners, particularly those with businesses located along the stream and in the floodplain; and public agencies and municipal officials. Their understanding of the issues and potential and appropriate remediation/mitigation measures is critical.

## 2.3 Strategy and Process

In order to achieve a thorough and effective public outreach process, the following strategy, process, and schedule were initially proposed: The public outreach and participation program for the Third Brook Watershed Management Plan had at its cornerstone three PAC meetings/workshops and two public outreach workshops. Each of these six "events" is described in greater detail below in terms of logistics, scheduling, and desired outcomes. These meetings were supplemented by informal communications as needed.

### Event 1 – PAC Meeting/Workshop

The initial PAC meeting took place on June 7, 2012. The purpose was to allow the project team to introduce themselves and to discuss the mechanisms and logistics of developing the plan, generating public involvement, and creating implementation strategies. A presentation of initial impressions and characterization of the watershed accompanied the preliminary identification of pertinent issues, strengths, and areas of concern regarding the watershed. These elements were presented to the PAC for reaction and discussion. In addition, a discussion of the roles of the project team and the PAC members took place, which helped to clarify the expectations for everyone as part of this project. Specific responsibilities for individuals and/or groups were identified and agreed upon.

### Event 2 – Public Outreach Workshop

The first public outreach workshop took place on July 24, 2012. The goals of this workshop can be best summarized as "introduce," "characterize," and "identify." The "introduce" component involved introducing the project team from MMI and the PAC. This component also included an educational component regarding what watershed management planning is, as well as what it is not.

The "characterize" component involved describing the watershed in terms of its different characteristics, including the following:

- ☐ Watershed Boundaries
- ☐ Water Quality
- ☐ Habitat
- ☐ Geomorphology
- ☐ Infrastructure
- ☐ History
- ☐ Socioeconomic Characteristics
- ☐ Land Use and Development Patterns

The "identify" component involved soliciting and defining general goals and expectations from meeting participants, developing a framework of both the overall "global" issues impacting the watershed (e.g., land development in the floodplain) and more specific issues impacting the watershed at select points (e.g., if a poorly managed farm led to the runoff of manure and agricultural waste products into a water resource). As part of the "identify" component, additional pertinent organizations, groups, and interested individuals will be identified as part of the meeting discussion.

A survey was distributed to address priority issues and ideal outcomes for the watershed as viewed by attendees. Survey results are summarized in Tables 2-1 and 2-2.

### TABLE 2-1
### Issue Priority Ranking Survey Results

| *Issue* | *High* | *Moderate* | *Low* | *Total Responses* |
|---|---|---|---|---|
| Failing Stream Bank Slopes | 15 | 0 | 1 | 16 |
| Flooding | 13 | 2 | 1 | 16 |
| Floodplain Encroachment | 9 | 4 | 2 | 15 |
| Uncontrolled Stormwater Runoff | 9 | 4 | 2 | 15 |
| Ecological Habitat | 4 | 9 | 1 | 14 |
| Water Quality | 3 | 9 | 3 | 15 |
| Recreation | 2 | 3 | 10 | 15 |
| Water Supply | 2 | 6 | 7 | 15 |
| Aesthetics | 2 | 7 | 5 | 14 |
| Land Use Practices | 1 | 11 | 1 | 13 |

### TABLE 2-2
### Ideal Outcome Survey Results

| *Outcome* | *High* | *Moderate* | *Low* | *Total Responses* |
|---|---|---|---|---|
| Stream and Slope Stabilization | 14 | 1 | 0 | 15 |
| Flood Protection and Mitigation | 13 | 3 | 0 | 16 |
| Establishment of Stream Buffers | 11 | 3 | 1 | 15 |
| Stormwater Management | 10 | 3 | 1 | 14 |
| Floodplain Restoration | 9 | 7 | 0 | 16 |
| Future Development Management | 7 | 5 | 2 | 14 |
| Floodplain Conservation | 6 | 7 | 1 | 14 |
| Habitat Protection | 5 | 8 | 2 | 15 |
| Monitoring and Research | 4 | 10 | 1 | 15 |
| Training, Education, and Stewardship | 4 | 8 | 2 | 14 |
| Pollution Prevention | 4 | 7 | 4 | 15 |
| Improved Water Quality | 2 | 9 | 3 | 14 |
| Adoption of Land Use Regulations | 0 | 7 | 7 | 14 |

The results of the survey show that flooding and slope/stream bank failure are the main concerns in the watershed. Consequently, the highest-ranked ideal outcomes are (1) stream and slope stabilization and (2) flood protection and mitigation. Establishment of stream buffers, stormwater management, and management of future development were also cited as ideal outcomes. Floodplain restoration and floodplain conservation were also ranked relatively highly although these may be grouped with the second-highest ideal outcome (flood protection and mitigation), making it clear that respondents are very concerned with ensuring that flood-related concerns are addressed in the Third Brook watershed.

Ecological habitats and water quality are often important issues in watershed management plans. Although ranked lower than stream stabilization and flood issues, this plan clearly addresses these important and interrelated issues because all of the other issues affect water quality.

### Event 3 – PAC Meeting/Workshop

This meeting of December 20, 2012 served to provide a progress report on the development of the plan. Discussion topics focused on reviewing proposed recommendations in light of the previously completed characterization and analysis tasks. The outcome of this meeting included a general consensus on the potential management practices, approaches, and strategies for watershed protection, restoration, and flood damage prevention for the watershed management area, with prioritization of these elements being key.

Although only one PAC meeting was planned as event 3, two additional PAC meetings were held prior to Event 4 (below). These meetings were held on February 21, 2013 and August 22, 2013. The meeting of February 21, 2013 provided a forum to discuss the draft plan and receive edits from PAC members. Subsequent to this meeting, a new mayor was elected in the village, and the planning process was temporarily put on hold. The meeting of August 22, 2013 served as an opportunity to review the draft plan with the new mayor in advance of the public meeting.

### Event 4 – Public Outreach Workshop

The second public outreach workshop took place on September 25, 2013. In contrast to the goals of the first public outreach workshop in Event 2, the goals of the second public outreach workshop can be described as present, summarize, and respond. The "present" component involved an overview of the entire project and the process from the initial PAC meeting through all public outreach efforts to the compilation of the final draft product. The "summarize" component involved a discussion of the plan's objectives, findings, conclusions, and action items. Describing how the plan will be implemented will also be part of this discussion. Finally, the "respond" component involved gathering feedback from the workshop participants regarding the final presentation of the draft plan.

Approximately 30 members of the public attended the presentation and meeting, including several members of the PAC. Attendees were supportive of the watershed management plan and eager to see its implementation. Specific comments and questions included the following:

- ☐ Bridges need to be replaced to reduce the potential for debris jams; who will fund these upgrades?
- ☐ What is the approach for businesses located in the lower part of the watershed near the brook?
- ☐ Precipitation appears to be increasing. Will projects along the brook be designed to accommodate increasing precipitation and stream discharges?
- ☐ Could flood discharges be partially split from Third Brook and routed along the west side the Kraft facility along an old railroad bed?
- ☐ A representative of Del-Ton Sanitation asked if his business would be forced to relocate, and inquired whether the Ogden Street bridge could be removed. This spurred a discussion about whether Ogden Street is a necessary evacuation route.
- ☐ Several attendees agreed that flood discharges should be slowed and that more space was needed for flooding.
- ☐ Several attendees had questions about the slope failures and concerns about these continuing.

Members of the PAC explained to the public that the watershed management plan presents a set of options and choices for the community, but that nothing in the plan is a mandate. They emphasized that nobody would be forced out of their properties.

In response to the comment about increasing precipitation, a table of precipitation data was added to this watershed management plan at the end of Section 3.3.

### Event 5 – PAC Meeting/Workshop

This meeting will serve to conclude the plan development process. The final plan will be presented and distributed. Discussion topics will focus on the feedback gathered at the second public outreach workshop and how that feedback was integrated into the final draft of the plan, as well as the effective "next steps" that must occur to move the plan forward as a living document. The outcome of this meeting may include a consensus on the specific implementation strategies and responsibilities that specific PAC members need to undertake or assume in order to create positive change in the management of the Third Brook watershed.

# 3.0 WATERSHED CHARACTERIZATION

A basic understanding of a watershed is an essential beginning to developing a sound management plan. A description of the Third Brook watershed is provided in this section. The information contained in the following sections is based on published documents such as those listed in Appendix A, information provided by PAC members, and direct observations by MMI.

## 3.1 Geographic Setting

Delaware County is located in the southern part of the state of New York and is separated from the state of Pennsylvania by the Delaware River. The county contains part of the Catskill Mountains and is adjacent to a region called the "Southern Tier" of New York State. The town of Walton is located in the west central portion of Delaware County, just upstream from New York City's Cannonsville Reservoir and centered approximately 25 miles due south of the city of Oneonta in neighboring Otsego County.

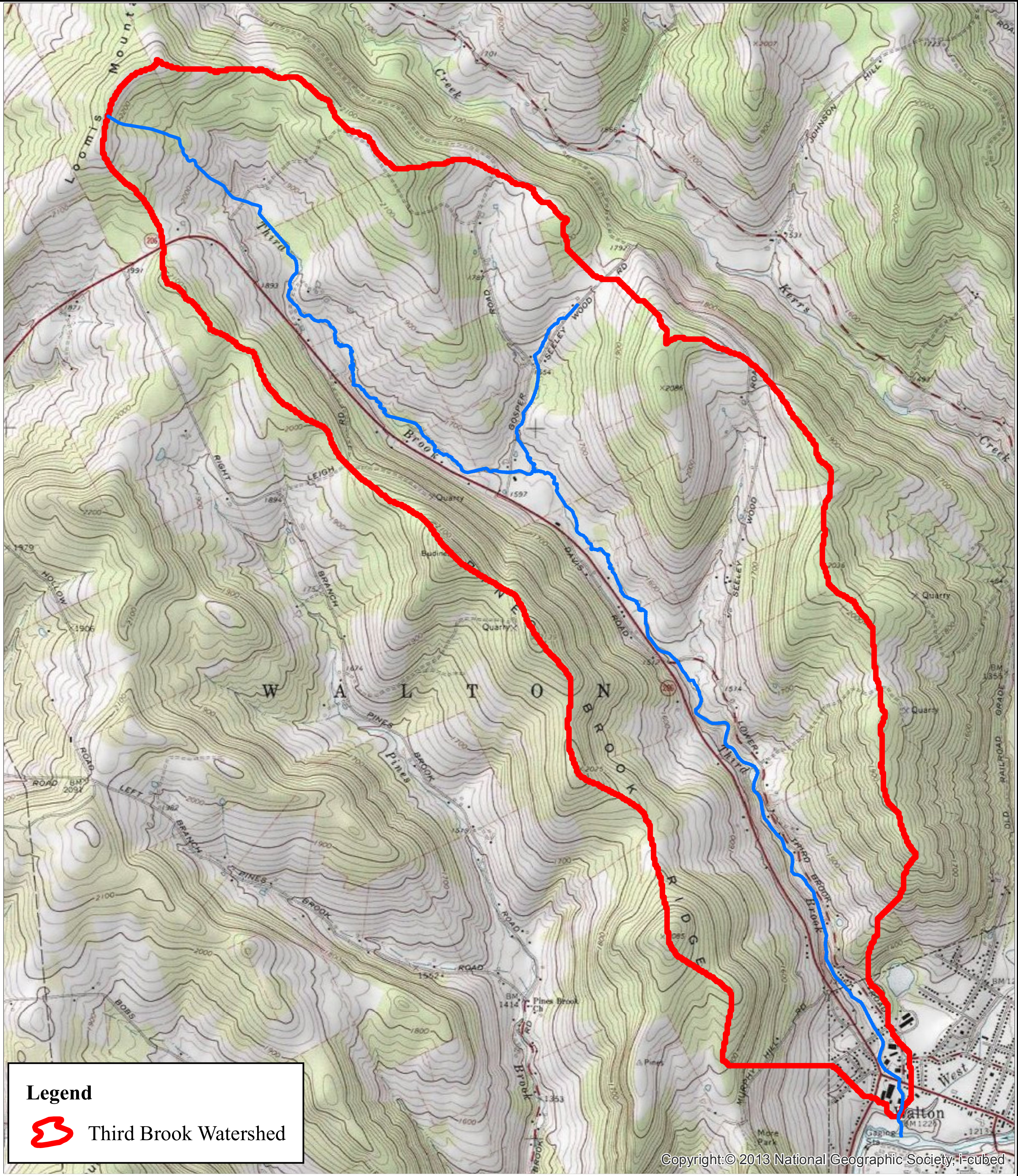
New York State Route 10 traverses the town from east to southwest, and New York State Route 206 traverses from northwest to southeast. The two state highways intersect in the village of Walton, located at the center of the town. According to the U.S. Census Bureau, the town of Walton has a total land area of 97.6 square miles, of which 97.2 square miles are comprised of land and 0.4 square miles open water.

At an elevation of ±2,400 feet, Bear Spring Mountain Game Management Area is the largest mountain within the town of Walton. It is located off Route 206, roughly five miles south of the village of Walton, in the south central portion of the town.

The highest point in the Third Brook watershed is at an elevation of 2,250 feet. The headwaters and tailwaters of the watershed are at elevations of 1,910 feet and 1,200 feet, respectively. The stream falls approximately 700 feet through its length. Figure 3-1 shows the watershed on a topographic base map.

## 3.2 Geology and Soils

The geologic history of a region provides the landforms upon which drainage patterns and watersheds are established and subsequently evolve. Likewise, the type of bedrock and surficial materials present dictate landform, stream characteristics, and background water quality in these surface water features.



**SOURCE(S):**
"USA Topo Maps" Datalayer
Copyright:© 2013
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**Figure 3-1: Third Brook Watershed**

**LOCATION:**
**Walton, NY**

N

**Third Brook Watershed**
**Management Plan**

**MXD:** P:\4444-01\Design\GIS\Maps\Figure3-1.mxd

**Map By:** JEP
**MMI#:** 4444-01-4
**Original:** 1/7/2013
**Revision:** 8/20/2013
**Scale:** 1 inch = 2,700 feet

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Figure 3-2 shows the bedrock fracture traces within the Third Brook watershed as well as the aerial extent of the bedrock faults and fractures within the watershed. The bedrock in the watershed can be categorized into Lower Walton formation in the Sonyea Group and Upper Walton formation in the West Falls Group.

Surficial geology in the Catskills region is a reflection of multiple glacial cycles. The majority of surficial deposits in the Third Brook watershed consist of glacial till. Till is an unsorted, unstratified mixture of clay, silt, sand, gravel, and boulders deposited directly by glaciers. Stratified materials deposited by glacial meltwater are often found along present-day streams, which have largely inherited glacial streams.

Although surficial geologic mapping (Figure 3-3) depicts glacial till along Third Brook, observations by NYCDEP and Hawk Engineering (2010) show that some of the material consists of stratified sand and gravel of glacial meltwater origin. Three test borings supervised by Hawk Engineering (described in Section 4.2 of this plan) encountered glacial till and stratified sand and gravel, demonstrating that both are present along Third Brook. One boring reportedly encountered fill material followed by glacial till to a depth of 30 feet, then lacustrine silt and sand to 55 feet, then sand and gravel to 70 feet.

While it is unusual to find glacial till overlying stratified materials, it is possible where multiple glaciations have occurred. The other two borings found the more typical arrangement of stratified sand and gravel overlying glacial till. Bedrock was deeper than 70 feet in the three locations.

Soil types are typically influenced by bedrock and surficial geology as well as topography and hydrology. The Third Brook watershed can be classified by a handful of different soil types, with the primary being Halcott, Mongaup, and Vly soils; Lackawanna flaggy silt loam; Vly channery silt loam; Wellsboro channery silt loam; and Willowemoc channery silt loam.

Figure 3-4 depicts the soil types in the Third Brook watershed. Tables 3-1 and 3-2 list the soil types in alphabetical order and their respective percentages in the watershed. Descriptions of the soil types can be found in Appendix C.

**SOURCE(S):**

Bing Maps Hybrid

**Figure 3-2: Bedrock Geology**

**LOCATION:**

**Walton, NY**

N

**Third Brook**
**Watershed**
**Management Plan**

**Map By:** JEP
**MMI#:** 4444-01
**MXD:**H:\4444-01\GIS\Maps\Figure3-2.mxd
**1st Version:** 12/17/2012
**Revision:**1/10/2013
**Scale:** 1 inch = 2,500 feet

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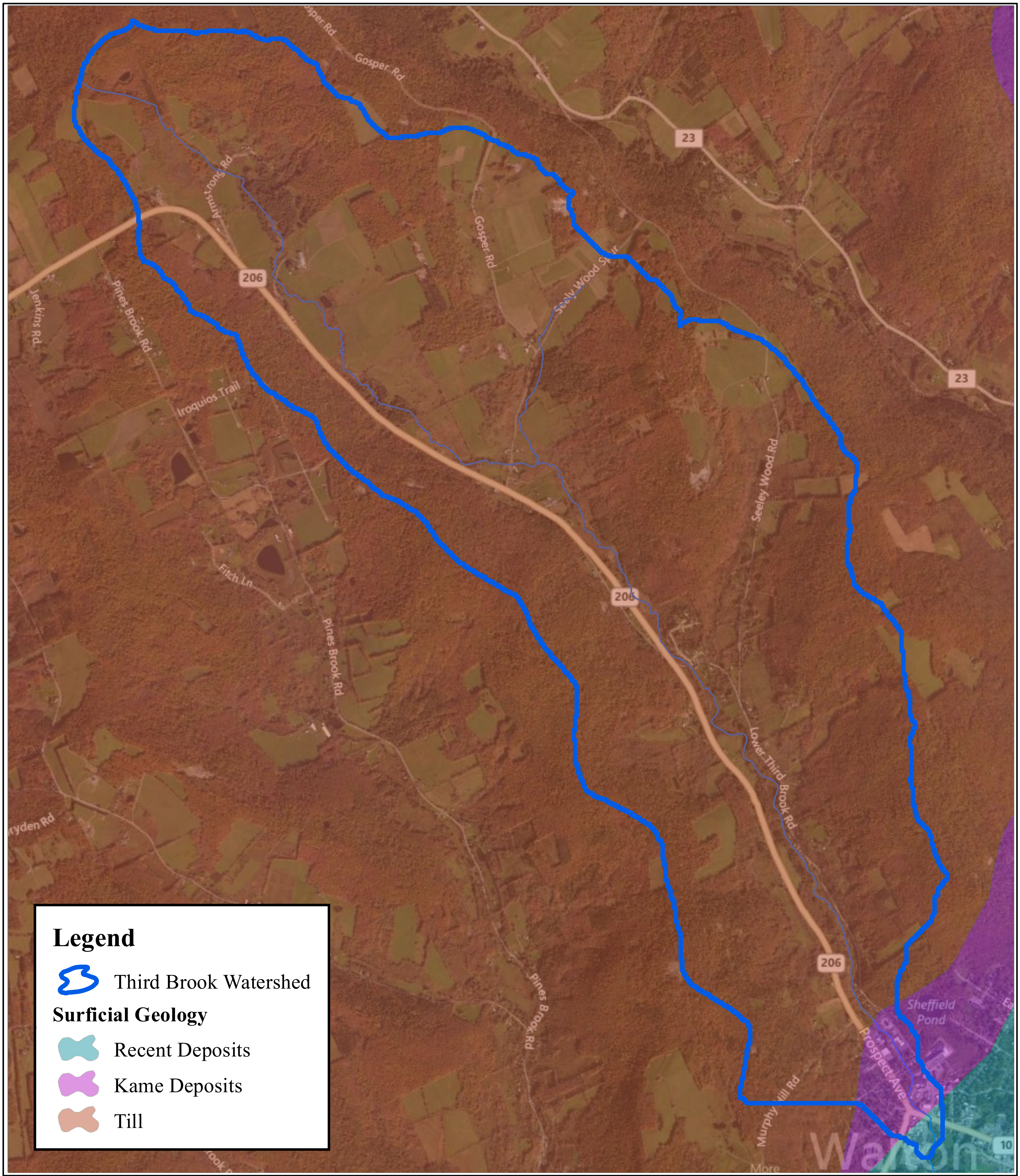

**SOURCE(S):**

Bing Maps Hybrid

## Figure 3-3: Surficial Geology

**LOCATION:**

**Walton, NY**

N

**Third Brook Watershed Management Plan**

**Map By:** JEP
**MMI#:** 4444-01
**MXD:** H:\4444-01\GIS\Maps\Figure3-3.mxd
**1st Version:** 1/8/2013
**Revision:** 1/10/2013
**Scale:** 1 inch = 2,500 feet

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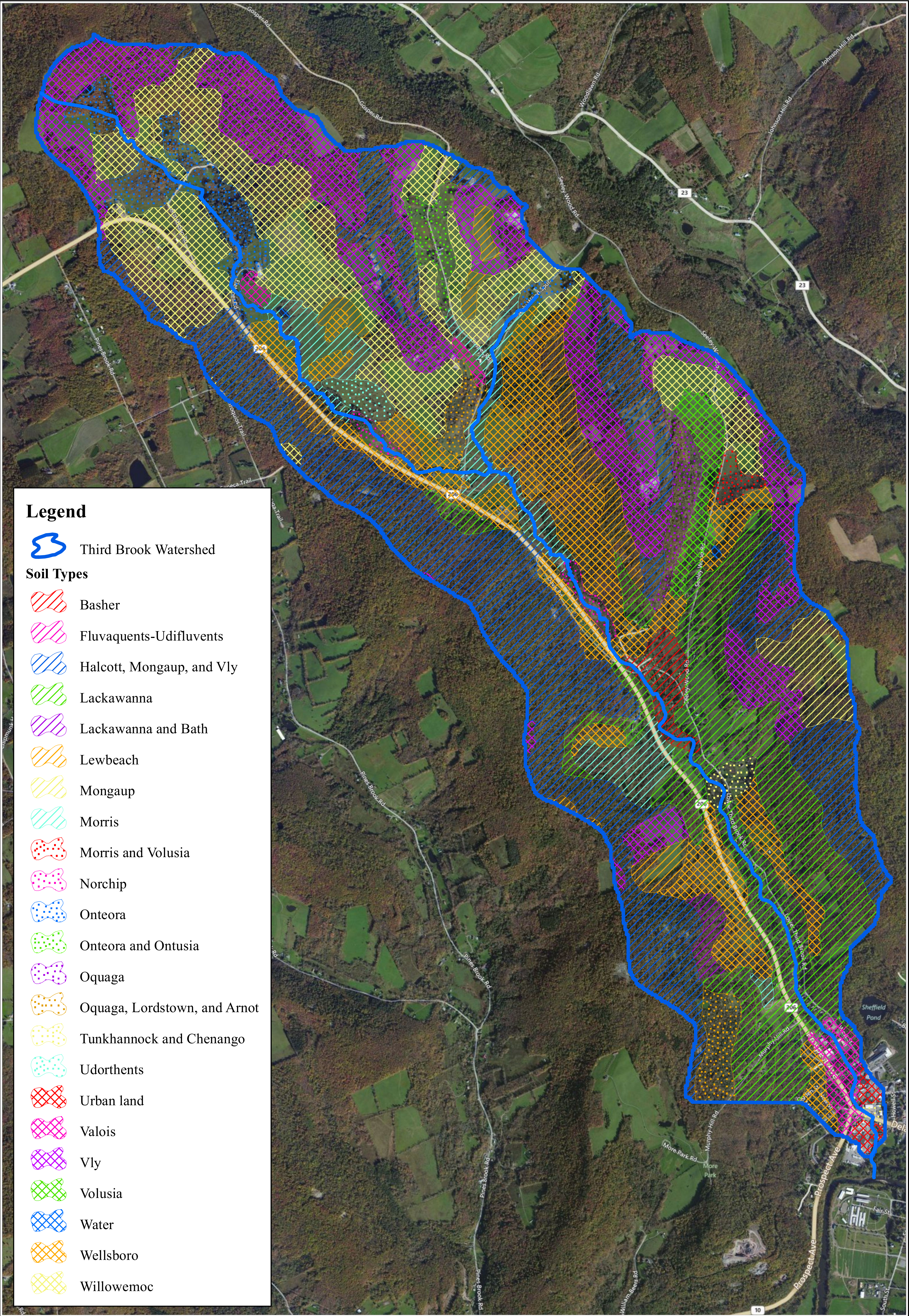

**SOURCE(S):**

Bing Maps Hybrid

NRCS Soils Map

**Figure 3-4: Soil Types**

**Location:**

**Walton, NY**

N

**Third Brook Watershed**
**Management Plan**

**Map By:** JEP
**MMI#:** 4444-01
**MXD:** H:\4444-01\GIS\Maps\Figure3-4.mxd
**1st Version:** 12/17/2012
**Revision:** 1/15/2013
**Scale:** 1 in = 1,750 ft

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## TABLE 3-1
## Soils in Third Brook Watershed

| Soil Type | Soil Name | Acres | Percent |
|---|---|---|---|
| Bs | Basher silt loam | 38.51 | 1.11% |
| Ff | Fluvaquents-Udifluvents complex | 0.22 | 0.01% |
| Hc | Halcott, Mongaup, and Vly soils | 728.78 | 20.99% |
| La | Lackawanna flaggy silt loam | 469.98 | 13.54% |
| Ld | Lackawanna and Bath soils | 17.82 | 0.51% |
| Lh | Lewbeach channery loam | 112.62 | 3.24% |
| Mn | Mongaup channery loam | 61.10 | 1.76% |
| Mr | Morris flaggy silt loam | 160.76 | 4.63% |
| Ms | Morris and Volusia soils | 14.19 | 0.41% |
| No | Norchip silt loam | 22.16 | 0.64% |
| Oe | Onteora channery silt loam | 116.64 | 3.36% |
| Of | Onteora and Ontusia soils | 32.51 | 0.94% |
| Op | Oquaga channery silt loam | 35.35 | 1.02% |
| Or | Oquaga, Lordstown, and Arnot soils | 55.52 | 1.60% |
| Tt | Tunkhannock and Chenango soils | 20.82 | 0.60% |
| Uf | Udorthents | 17.80 | 0.51% |
| Ur | Urban land | 13.76 | 0.40% |
| Va | Valois very fine sandy loam | 46.98 | 1.35% |
| Vl | Vly channery silt loam | 540.33 | 15.56% |
| Vo | Volusia channery silt loam | 46.72 | 1.35% |
| W | Water | 2.00 | 0.06% |
| We | Wellsboro channery silt loam | 426.28 | 12.28% |
| Wm | Willowemoc channery silt loam | 491.28 | 14.15% |

## TABLE 3-2
## Descriptions of Soils in Third Brook Watershed

| Soil Type | Soil Name | Soil Description | Acres | Percent |
|---|---|---|---|---|
| Bs | Basher silt loam |  | 38.51 | 1.11% |
| Ff | Fluvaquents-Udifluvents complex | frequently flooded | 0.22 | 0.01% |
| HcC | Halcott, Mongaup, and Vly soils | 2 to 15 percent slopes, very rocky | 175.48 | 5.05% |
| HcE | Halcott, Mongaup, and Vly soils | 15 to 35 percent slopes, very rocky | 383.96 | 11.06% |
| HcF | Halcott, Mongaup, and Vly soils | 35 to 70 percent slopes, very rocky | 169.34 | 4.88% |
| LaB | Lackawanna flaggy silt loam | 3 to 8 percent slopes | 3.10 | 0.09% |
| LaC | Lackawanna flaggy silt loam | 8 to 15 percent slopes | 6.92 | 0.20% |
| LaD | Lackawanna flaggy silt loam | 15 to 25 percent slopes | 336.45 | 9.69% |
| LaE | Lackawanna flaggy silt loam | 25 to 40 percent slopes | 123.51 | 3.56% |
| LdE | Lackawanna and Bath soils | 15 to 35 percent slopes, very stony | 17.82 | 0.51% |
| LhB | Lewbeach channery loam | 3 to 8 percent slopes | 8.54 | 0.25% |
| LhC | Lewbeach channery loam | 8 to 15 percent slopes | 24.16 | 0.70% |
| LhD | Lewbeach channery loam | 15 to 25 percent slopes | 79.91 | 2.30% |
| MnC | Mongaup channery loam | 8 to 15 percent slopes | 60.71 | 1.75% |

| Soil Type | Soil Name | Soil Description | Acres | Percent |
|---|---|---|---|---|
| MnD | Mongaup channery loam | 15 to 25 percent slopes | 0.39 | 0.01% |
| MrB | Morris flaggy silt loam | 3 to 8 percent slopes | 117.52 | 3.38% |
| MrC | Morris flaggy silt loam | 8 to 15 percent slopes | 43.24 | 1.25% |
| MsB | Morris and Volusia soils | 2 to 10 percent slopes, very stony | 14.19 | 0.41% |
| No | Norchip silt loam | | 22.16 | 0.64% |
| OeB | Onteora channery silt loam | 3 to 8 percent slopes | 49.06 | 1.41% |
| OeC | Onteora channery silt loam | 8 to 15 percent slopes | 67.58 | 1.95% |
| OfB | Onteora and Ontusia soils | 2 to 10 percent slopes, very stony | 32.51 | 0.94% |
| OpE | Oquaga channery silt loam | 25 to 35 percent slopes | 35.35 | 1.02% |
| OrC | Oquaga, Lordstown, and Arnot soils | 2 to 15 percent slopes, very rocky | 0.72 | 0.02% |
| OrE | Oquaga, Lordstown, and Arnot soils | 15 to 35 percent slopes, very rocky | 19.28 | 0.56% |
| OrF | Oquaga, Lordstown, and Arnot soils | 35 to 70 percent slopes, very rocky | 35.51 | 1.02% |
| TtA | Tunkhannock and Chenango soils | fan, 0 to 3 percent slopes | 4.54 | 0.13% |
| TtB | Tunkhannock and Chenango soils | fan, 3 to 8 percent slopes | 16.28 | 0.47% |
| Uf | Udorthents | refuse substratum | 17.80 | 0.51% |
| Ur | Urban land | | 13.76 | 0.40% |
| VaB | Valois very fine sandy loam | 3 to 8 percent slopes | 17.88 | 0.51% |
| VaC | Valois very fine sandy loam | 8 to 15 percent slopes | 23.69 | 0.68% |
| VaD | Valois very fine sandy loam | 15 to 25 percent slopes | 5.42 | 0.16% |
| VlB | Vly channery silt loam | 2 to 8 percent slopes | 126.70 | 3.65% |
| VlC | Vly channery silt loam | 8 to 15 percent slopes | 136.95 | 3.94% |
| VlD | Vly channery silt loam | 15 to 25 percent slopes | 250.38 | 7.21% |
| VlE | Vly channery silt loam | 25 to 40 percent slopes | 26.31 | 0.76% |
| VoC | Volusia channery silt loam | 8 to 15 percent slopes | 46.72 | 1.35% |
| W | Water | | 2.00 | 0.06% |
| WeB | Wellsboro channery silt loam | 3 to 8 percent slopes | 117.61 | 3.39% |
| WeC | Wellsboro channery silt loam | 8 to 15 percent slopes | 277.43 | 7.99% |
| WeD | Wellsboro channery silt loam | 15 to 25 percent slopes | 31.24 | 0.90% |
| WmB | Willowemoc channery silt loam | 3 to 8 percent slopes | 88.52 | 2.55% |
| WmC | Willowemoc channery silt loam | 8 to 15 percent slopes | 289.62 | 8.34% |
| WmD | Willowemoc channery silt loam | 15 to 25 percent slopes | 113.14 | 3.26% |

## 3.3 Hydrology

New York has a humid continental climate. Within Delaware County, average annual precipitation has historically totaled 43 inches, and temperature averages 45°F. Weather in New York is heavily influenced by two continental air masses: a warm, humid one from the southwest and a cold, dry one from the northwest.

Surface water hydrology is the quantitative study of the presence, form, and movement of water in and through the drainage basin. The primary independent variables affecting runoff are precipitation, watershed area, surficial geology, and slope. Dependent variables that change over short and intermediate time spans include vegetative cover, land use, wetland and floodplain water storage, reservoir size and volume, water diversion for irrigation or municipal use, and beaver dams.

For the purpose of studying bank erosion, sediment transport, and flooding, the primary interest is in peak stream flows due to intense precipitation, sometimes in combination with snowmelt. It is the peak flood flows that shape and form the river channels, scour the banks, and carry the majority of sediment. Subsequent storm runoff events, perhaps up to the mean annual flood, also convey sediment and tend to dominate the formation of the inner channel dimensions, bars, pools, and riffles. Monthly mean stream flow rates are a good indicator of seasonal flow patterns that affect water supply, habitat, and recreation.

A watershed's stream flow rate can be obtained or estimated using several different techniques, including direct measurement, use of surrogate gauge data in nearby watersheds, physical deterministic computer models, statistical or stochastic analysis, or empirical techniques.

The United States Geological Survey (USGS) *StreamStats* program was used to estimate peak discharges at four locations along Third Brook. These discharges were based on regression equations developed by the USGS. Table 3-3 summarizes the computed peak discharges for the Delaware Street bridge, the dam of the impoundment, the Lower Third Brook Road crossing near the trailer park, and the Gosper Road bridge.

### TABLE 3-3
### Third Brook Peak Flows from *StreamStats*

| | **Delaware Street Bridge** | **Old Village Reservoir Dam** | **Lower Third Brook Road Bridge** | **Gosper Road Bridge** |
|---|---|---|---|---|
| Drainage Area (square miles) | 5.4 | 4.5 | 3.1 | 1.5 |
| 1.25-year discharge (cfs) | 176 | 147 | 108 | 62 |
| 1.5-year discharge (cfs) | 217 | 182 | 134 | 77 |
| 2-year discharge (cfs) | 272 | 228 | 168 | 98 |
| 5-year discharge (cfs) | 426 | 359 | 268 | 157 |
| 10-year discharge (cfs) | 541 | 457 | 343 | 203 |
| 25-year discharge (cfs) | 696 | 588 | 444 | 264 |
| 50-year discharge (cfs) | 819 | 693 | 525 | 314 |
| 100-year discharge (cfs) | 947 | 803 | 611 | 366 |
| 200-year discharge (cfs) | 1,080 | 915 | 699 | 421 |
| 500-year discharge (cfs) | 1,260 | 1,070 | 819 | 495 |

cfs = cubic feet per second

The current Flood Insurance Study (FIS) for Delaware County became effective on June 19, 2012. The FIS covers all jurisdictions in the county, inclusive of the village and town of Walton. The lower part of Third Brook was included in the study, and a Special Flood Hazard Area (SFHA) is mapped on the Flood Insurance Rate Map (FIRM) from the dam of the impoundment downstream to the East Branch Delaware River. The SFHA is equal to the area inundated by the 1% annual chance flood, also known as the 100-year flood, or base flood. Figure 3-5 depicts the current adopted mapping for Third Brook.

The previous FIS covering Walton resulted in FIRM panels that were effective on April 2, 1991 (village) and September 2, 1988 (town). The extent of the brook studied in the FIS was the same as the extent studied in the current FIS (sections of the brook below the dam). In general, the base flood elevations mapped in 1988 and 1991 are the same as those mapped on the 2012 edition of the FIRM. However, the 2012 FIRM depicts slightly increased base flood elevations at the upstream sides of the Delaware Street bridge (three feet higher) and the Ogden Street bridge (one foot higher).

Table 3-4 compares the peak discharges used by the FIS to those calculated by *StreamStats*. The peak discharges are consistent with one another, largely resulting from the similarity of the methods of calculation employed by the FIS and *StreamStats*.

### TABLE 3-4
### Comparison of Peak Flows at 5.4 Square Mile Watershed Using *StreamStats* and FIS

| | ***StreamStats*** | **FIS** |
|---|---|---|
| Drainage Area (square miles) | 5.4 | 5.4 |
| 1.25-year discharge (cfs) | 176 | -- |
| 1.5-year discharge (cfs) | 217 | -- |
| 2-year discharge (cfs) | 272 | -- |
| 5-year discharge (cfs) | 426 | -- |
| 10-year discharge (cfs) | 541 | 549 |
| 25-year discharge (cfs) | 696 | -- |
| 50-year discharge (cfs) | 819 | 831 |
| 100-year discharge (cfs) | 947 | 961 |
| 200-year discharge (cfs) | 1,080 | -- |
| 500-year discharge (cfs) | 1,260 | 1,280 |

cfs = cubic feet per second
-- = not computed for FIS

FEMA's contractors have completed *new* preliminary revised FIRMs for parts of Delaware County as of autumn 2013. These maps were developed in connection with a hydraulic study of Third Brook extending upstream to the headwaters. The new modeling has resulted in the extension of the SFHA upstream from the previous limit to the headwaters. As the final FIRM and FIS are released, additional information may be available.

*StreamStats* does not yet have the capability to generate statistical low flows and other nonflood flows in the state of New York. However, traditional methods can be used to estimate nonflood flows on Third Brook, such as the application of gauged stream discharge data from a nearby watercourse.

**SOURCE(S):**
Bing Maps Hybrid

FEMA Flood Insurance Rate Map
June 19, 2012

**Figure 3-5: FEMA Mapped Flood Zones**

**LOCATION:**
**Walton, NY**

N

**Third Brook Watershed Management Plan**

**Map By:** JEP
**MMI#:** 4444-01
**MXD:** H:\4444-01\GIS\Maps\Figure3-5.mxd
**1st Version:** 12/17/2012
**Revision:** 1/8/2013
**Scale:** 1 inch = 1,000 feet

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The nearest gauged streams are East Brook and the West Branch Delaware River. Both gauging stations are located in Walton. The West Branch Delaware River gauge data would be inappropriate for translation to West Brook given the large size of its drainage area and the diversity of its watershed.

However, gauged flows from East Brook do provide a suitable substitute for Third Brook as the watercourse is a tributary to the West Branch similar to Third Brook, has a similarly oriented watershed, and a relatively similar watershed composition. The size of the East Brook watershed is not ideal because it is larger than the Third Brook watershed at 24.7 square miles, but the other similarities make it a good surrogate.

Daily average discharges of East Brook were obtained from the USGS water data website for the entire period of record (1998 through present), and the last few months of data were truncated to ensure that the time series consisted of complete "water years" (October through September). The daily data were ranked, and the Weibull method was used to generate a flow duration curve. Table 3-5 summarizes a sample of the statistical flows for East Brook and corresponding statistical flows for points along Third Brook. Watershed area ratios were used to translate the East Brook discharges to Third Brook discharges.

### TABLE 3-5
### Statistical Flows for East Brook and Third Brook (cubic feet per second)

| Flow Duration | East Brook Gauge | Third Brook | | | |
|---|---|---|---|---|---|
| | | Delaware Street | Dam at Old Village Reservoir | Lower Third Brook Road | Gosper Road |
| 0% | 3,540 | 774.0 | 645.0 | 444.0 | 215.0 |
| 1% | 339 | 74.1 | 61.8 | 42.6 | 20.6 |
| 2% | 243 | 53.1 | 44.3 | 30.5 | 14.8 |
| 3% | 205 | 44.8 | 37.4 | 25.7 | 12.5 |
| 4% | 170 | 37.2 | 31.0 | 21.3 | 10.3 |
| 5% | 148 | 32.4 | 27.0 | 18.6 | 8.99 |
| 10% | 104 | 22.7 | 19.0 | 13.1 | 6.32 |
| 20% | 67 | 14.7 | 12.2 | 8.41 | 4.07 |
| 30% | 50 | 10.9 | 9.11 | 6.28 | 3.04 |
| 40% | 39 | 8.53 | 7.11 | 4.89 | 2.37 |
| 50% | 31 | 6.78 | 5.65 | 3.89 | 1.88 |
| 60% | 24 | 5.25 | 4.37 | 3.01 | 1.46 |
| 70% | 16 | 3.50 | 2.91 | 2.01 | 0.97 |
| 80% | 9.6 | 2.10 | 1.75 | 1.20 | 0.58 |
| 90% | 4.6 | 1.01 | 0.84 | 0.58 | 0.28 |
| 95% | 2.9 | 0.63 | 0.53 | 0.36 | 0.18 |
| 99% | 1.7 | 0.37 | 0.31 | 0.21 | 0.10 |
| 100% | 1.2 | 0.26 | 0.22 | 0.15 | 0.07 |

Notes:

1. East Brook discharges taken from a flow duration curve prepared using daily gauged discharge data for the period of record through the end of the last water year (September 30, 2012)
2. Third Brook discharges based on a watershed ratio (Third Brook/East Brook)

The peak discharges listed in Table 3-4 for the 25-year flood and lower (including more frequent flood discharges like the annual flood) would all plot between the 0% and 1% discharge in the daily series. This demonstrates how rarely the peak discharges occur when compared to a daily time series.

The bankfull discharge in Third Brook occurs during a high flow and would appear as very low flow duration (near 0%) in the Third Brook flow duration curve of daily discharges. *StreamStats* generates bankfull flows in New York using regression equations, similar to the estimation of the flood discharges. The bankfull discharge for Third Brook is estimated at approximately 200 cubic feet per second (cfs) at Delaware Street, which is between the 1.25- and 1.5-year flood discharges.

Precipitation rates and patterns are changing as climate changes. Precipitation is increasing on the order of 0.65 inches per decade. Cornell University has found that a storm with a 100-year recurrence interval in central New York now has a 66-year recurrence interval. Likewise, precipitation totals in the Third Brook watershed have been higher than the historical average of 43 inches. Table 3-6 lists the annual precipitation totals for the past decade as provided by a weather station maintained by a resident of the Third Brook watershed.

**TABLE 3-6**
**Annual Precipitation in Third Brook Watershed**

| Year | Total Precipitation (inches) |
|---|---|
| 2003 | 59.34 |
| 2004 | 53.63 |
| 2005 | 47.57 |
| 2006 | 62.72* |
| 2007 | 51.82 |
| 2008 | 52.57 |
| 2009 | 48.76 |
| 2010 | 48.19 |
| 2011 | 69.45** |
| 2012 | 46.57 |
| *Average for 2003-2012* | *54.06* |

*Includes flood of June 2006
** Includes Tropical Storms Irene and Lee

Depending on storm intensities and frequencies, the increasing precipitation totals may lead to increasing storm discharges and flood flows along Third Brook.

## 3.4 Wetland Habitats

The Freshwater Wetlands Act (Article 24 of the Environmental Conservation Law) requires the New York State Department of Environmental Conservation (NYSDEC) to map freshwater wetlands that are subject to jurisdiction of the law. The law requires the maps to show "the approximate location of the actual wetland boundary." NYSDEC will refine its wetland maps by completing field delineations for landowners when they need more precise information, such as when they are planning to work near a wetland area. Wetland areas are delineated based on the three-parameter approach meaning that wetlands must meet specific hydric soil, hydrologic regime, and hydrophytic vegetation requirements.

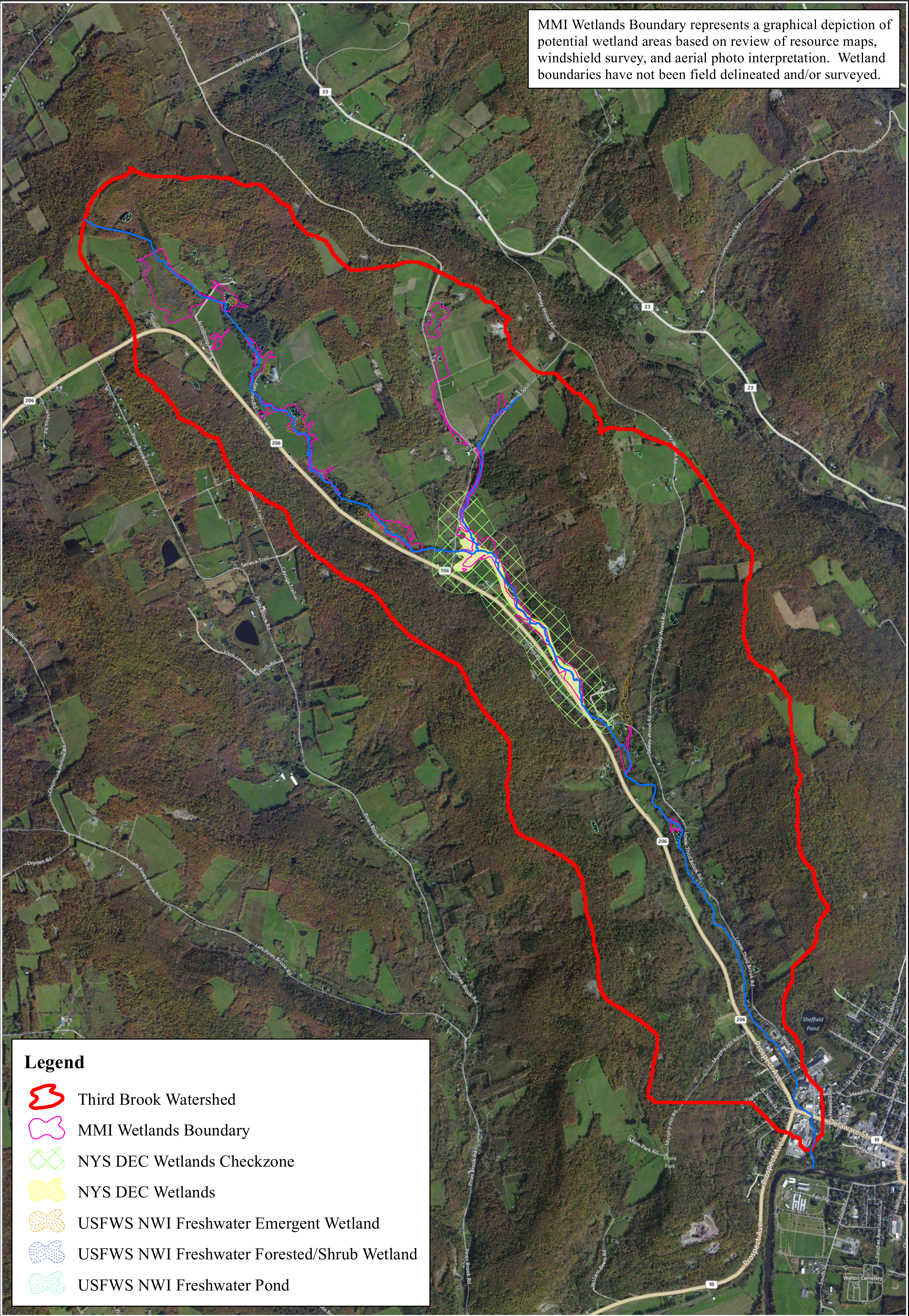
As part of the Third Brook watershed assessment, MMI's Professional Wetland Scientist (PWS) completed a windshield survey reconnaissance and aerial interpretation of the primary wetland and watercourse systems and boundaries within the Third Brook watershed. However, MMI wetland scientists did field delineate wetland boundaries. Prior to completing fieldwork, MMI reviewed the National Wetland Inventory (United States Fish & Wildlife Service), NYSDEC wetland maps, and Natural Resources Conservation Service (NRCS) soil survey maps. Third Brook and its floodplain are located within the moderately steep valleys of the Catskills. Several wetland systems were identified within the watershed and are described below.

Figure 3-6 depicts the wetland areas classified by both the USFWS and the NYSDEC as well as other potential wetland areas identified during the MMI watershed assessment. It should be noted that the wetland areas as shown on Figure 3-6 are graphical in nature and do not represent specific wetland boundaries. As stated previously, the NYSDEC should be contacted for delineating site-specific wetland boundaries. Table 3-6 lists the areal extent and percent coverage of these wetlands in the watershed.

**TABLE 3-7**
**Wetland Areas in the Third Brook Watershed**

| Wetland Classification | Areal Extent (acres) | Percent Coverage in Watershed |
|---|---|---|
| State Wetlands (NYSDEC) | 2.6 | 0.07% |
| Federal Wetlands (USFWS) | 57.8 | 1.67% |

Wetlands within the watershed consist of *palustrine forested, scrub shrub, emergent marsh/wet meadow,* and *open water.*



MMI Wetlands Boundary represents a graphical depiction of potential wetland areas based on review of resource maps, windshield survey, and aerial photo interpretation. Wetland boundaries have not been field delineated and/or surveyed.

**SOURCE(S):**
Bing Maps Hybrid

USFWS National Wetlands Inventory
October 1, 2012

NYS DEC Environmental Resource Mapper

**Figure 3-6: Wetland Area Classification**

**Location:**
**Walton, NY**

N

**Third Brook Watershed**
**Management Plan**

**Map By:** JEP
**MMI#:** 4444-01
**MXD:** H:\4444-01\GIS\Maps\Figure3-6.mxd
**1st Version:** 12/17/2012
**Revision:** 1/7/2013
**Scale:** 1 in = 2,000 ft

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Palustrine Emergent/Wet Meadow Wetlands

**Seep wet meadow (soft rush dominated)**

Palustrine emergent wetlands are the predominant wetland community within the watershed. This wetland classification includes areas dominated by emergent marsh and/or wet meadow plant species. These wetlands consist of herbaceous plants with dominant plant species being soft rush, woolgrass, blue vervain, joe-pye weed, tussock sedge, boneset, blue flag iris, sensitive fern, royal fern, reed canary grass, and a variety of other sedges.

Several sloped meadow wetlands were observed within the corridor, and these are predominantly vegetated with soft rush. These wetlands have formed in shallow pan areas where there is a moderately steep slope, a seasonally high groundwater table, and heavy soil compaction from agricultural land uses (i.e., plowing and cattle grazing).

The emergent/wet meadow wetlands provide a variety of important functions and values including nutrient removal, toxicant removal, high stem plant count and species diversity, wildlife habitat, groundwater discharge, and production export. Wetland areas within the Third Brook floodplain provide flood attenuation and desynchronization.

Palustrine Scrub Shrub Wetlands

Intermixed amongst the emergent wetland communities is the palustrine scrub shrub community, which consists of wetland areas that are dominated by herbaceous and woody shrub material. The scrub shrub areas were found along the periphery of the emergent marsh, wet meadow areas. Typical plant species within this community included willows, silky dogwood, speckled alder, common winterberry, and highbush blueberry. Multiflora rose, a nonnative shrub, often becomes intermixed with the native shrubs in somewhat poorly to poorly drained soil areas within the wetlands. Herbaceous plants include soft rush, sensitive fern, royal fern, purple loosestrife, and woolgrass.

**Scrub shrub/emergent marsh wetlands**

The scrub shrub wetlands provide a variety of important functions and values including nutrient removal, toxicant removal, high stem plant count and species diversity, wildlife habitat, groundwater discharge, and production export.

Palustrine Forested Wetland

The palustrine forested wetland system occurs less frequently within this watershed, which is most likely attributed to existing land use (i.e., agriculture) within the watershed. Areas that support forested wetlands occur along Third Brook and its tributaries. Vegetation consists of white pine, grey birch, red maple, willow, winterberry, and sensitive fern.

**Fringe forested wetlands**

The forested wetlands provide a variety of important functions and values including nutrient removal, wildlife habitat, groundwater discharge, and production export.

Palustrine Open Water

**Typical farm ponds within watershed**

Palustrine open water wetland areas consist of those areas that have permanent open water. In this watershed, these areas consist of small farm water and irrigation ponds. The ponds are man-made and are used by cattle for water supply and by some farmers for irrigation. Most ponds are less than one acre in size, and pond depths range from three to six feet based on size, vegetation cover, and landscape position. The fringes of the ponds are vegetated with a variety of emergent wetland plants including yellow flag iris, broad leafed cattail, burreed, pickerelweed, and a variety of other emergent plants. Submerged aquatic vegetation and floating aquatic vegetation are present in some of the ponds.

The open water areas provide a variety of important functions and values including nutrient removal, toxicant removal, shoreline stabilization, wildlife habitat, and fishery habitat.

## 3.5 Natural Heritage Areas

The New York Natural Heritage data was accessed and reviewed using the Environmental Resource Mapper found on the NYSDEC webpage http://www.dec.ny.gov/imsmaps/ERM/viewer.htm. According to the mapper, there are no known and/or documented rare animals and/or plants within the Third Brook watershed. In addition, there are no "significant natural communities" identified within the watershed.

## 3.6 Community Demographics

According to the Town of Walton Comprehensive Plan (2006), "The Town of Walton is a picturesque rural town where scenic views abound. Commercial life and employment are located primarily in the Village of Walton, with hills, forests and farmlands covering most of the rest of the Town." The Comprehensive Plan continues with a brief historical profile of the town and village; this profile is reprinted in the text box to the right.

The Comprehensive Plan describes a general decrease in population of the town and village combined from 1990 through 2000. From 2000 to 2010, the population of the village increased from 3,070 to 3,088 while the population of the town (inclusive of the village) decreased slightly from 5,607 to 5,576. Therefore, the town's rural population *outside* the village decreased from 2,537 to 2,488 from 2000 to 2010. This reflects a slight increase in density in the village where population density is already higher and a slight decrease in density in the outlying parts of the town where density is already low. As of the 2010 census, 55% of the population in the town resides in the village.

The Comprehensive Plan speaks of a significant part-time population of second homeowners in the town and village.

***Historical profile from Walton Comprehensive Plan***

*"Early settlers depended on lumbering, logs being transported via the Delaware River downstream to Trenton and Philadelphia. Saw mills and grist mills were also active in the early years, followed by carding and fulling mills as sheep raising emerged as the major agricultural activity in the 1830s; the 1835 census recorded 5,000 sheep in the Town, approximately three times the human population.*

*With the arrival of the railroad in 1872 dairy production emerged to replace sheep as the primary agricultural activity, leading to the establishment of dairy processing as a major local industry. The Breakstone Company began dairy processing in Walton in 1912 and grew as a producer of condensed milk during World War I. It continues to prosper today even since being purchased by Kraft Foods, which continue to produce under the Breakstone name.*

*Manufacturing of wood products began to replace shipping of raw timber with the establishment of furniture factories in the 1830s and 1840s. Walton Novelty Works produced toys and then baby carriages and doll carts between its opening in 1876 and its closing in the 1930s. The Munn Piano Company produced pianos from 1901 to 1930. S. J. Bailey & Son moved to Walton in 1939, occupying the facility vacated earlier by Walton Novelty. By 1975, Bailey employed 175 persons in Walton, had additional facilities in Honesdale, PA and Fryeburg, MI and was the second largest manufacturer of unfinished furniture in the US, grossing eight million dollars per year. In 1999, however, Bailey left Walton. Quarrying of bluestone emerged early as an important component of the local economy and has continued to be active until the present day."*

Similar discussions can be found in several countywide plans such as those described in Section 6.2, demonstrating that the part-time residents of Delaware County and Walton are important components of the demographic and economy.

As of the 2010 census, 2,958 housing units were located in the town, and 1,514 were located in the village, with 1,444 in the town outside the village. This translates to 51% of the housing units in Walton located in the village. This percentage is slightly lower than the percent of population located in the village, which makes sense because the number of persons per housing unit is likely higher in the village.

The Comprehensive Plan notes that "the number of mobile homes is significant in Walton. According to the 1990 Census, there were 420 mobile homes representing 14.7% of the total housing units in the Town; outside the Village, 373 mobile homes represented 27.8% of all housing units. According to the 2000 Census, there were 433 mobile homes representing 14.6% of the total housing units in the Town; outside the Village, 406 mobile homes represented 28.1% of all housing units. Thus, the number of mobile homes increased outside the Village by 33 units between 1990 and 2000, while the number of mobile homes decreased within the Village by 20 units during the same period."

Given its north-south configuration as a "slice" through the village and the town, the Third Brook watershed is a fitting microcosm of Walton's demographics. Although residences are scattered throughout the watershed, homes are generally clustered where Third Brook crosses under Gosper Road, where Third Brook crosses under Lower Third Brook Road, downstream of the Old Village Reservoir along the left bank of Third Brook (facing downstream), and then further downstream along the left bank of Third Brook on both sides of the village/town line. Some of the residences in the northern part of the watershed are associated with farms. Approximately 35 residential structures are located along the Third Brook corridor within 200 feet of the brook. An additional 200 or so are located in outlying parts of the watershed.

Many of the homes along Third Brook are currently mobile homes or originated as mobile homes, consistent with the discussion in the Comprehensive Plan. A mobile home park is located on the east side of Third Brook at Lower Third Brook Road, and many of the homes along the east bank of Third Brook between the Old Village Reservoir and the town/village line originated as mobile homes but have been anchored for some time.

It is evident from the public participation described in Section 2.0 that residents of Walton have great pride in their homes and neighborhoods. Many of them are employed in Walton, and many own small farms or are active in some aspect of agriculture on their land. Although there appears to be a strong support for conservation within the Third Brook watershed, residents are vocal about wishing to protect their properties and keeping debris of all kinds out of Third Brook. At times, an overemphasis on clearing stream channels can be counter to conservation goals. Meanwhile, ongoing attempts to protect property have led to hard structural controls along Third Brook, which are not necessarily consistent with the present-day understanding of how streams must remain connected to their floodplains.

## 3.7 Land Use Within the Watershed

The Walton Comprehensive Plan describes land use in Walton. Table 3-7 lists the land use categories and percentages by area.

### TABLE 3-8
### Land Use in Walton (Town and Village Combined)

| Land Use | Area (acres) | Percent |
|---|---|---|
| Active Agricultural | 10,961 | 18% |
| Residential | 21,412 | 35% |
| Vacant Land | 11,593 | 19% |
| Commercial/Industrial | 202 | <1% |
| Recreational | 9 | <1% |
| Community/Public Service | 2,119* | 3% |
| Conservation Lands and Public Parks | 14,503 | 24% |

*Includes one 1,981-acre parcel owned by New York City (along the upper Cannonsville Reservoir) and one 63-acre parcel owned by Delaware County (the county landfill)

The Third Brook watershed is similar to the town as a whole with perhaps a higher percentage of agriculture. The watershed is rural upstream of the Old Village Reservoir but has suburban qualities downstream of the dam and extending into the village. Businesses located in the Third Brook watershed are listed in Table 3-8.

### TABLE 3-9
### Businesses in the Third Brook Watershed*

| Address | Name |
|---|---|
| *Town of Walton* | |
| 286 Fletcher Road | Fletcher Construction |
| 1216 Lower Third Brook Road | Healing Waters Farm |
| New York 206 | Bear Farm |
| 15085 New York 206 | Dave's Collision & Body |
| 74 Gosper Road | Furman Cemetery Memorial Service |
| 268 Davis Road | Hillside Body & Collision |
| *Village of Walton* | |
| 200 Prospect Avenue (Route 206) | Scott Machine Corporation |
| 71 West Street | in-home silver and jewelry craft business |
| West Street | Harold Neale Excavating |
| West Street | Frontier Cable |
| 14 Ogden Street | Del-Ton Sanitation |

| Address | Name |
|---|---|
| 33 West Street | Klinger Power Sports |
| 31 West Street | Nails for You |
| 31 West Street | Beyond Measure Hair Design |
| 25 West Street | Jake's Place Garden & Farm |
| 25 West Street | CMR Cleaning/Maintenance |
| 25 West Street | Big & Small Self-Storage |
| 15 West Street | former Agway store |
| 1 West Street | Robinson Auction House |
| West Street and Delaware Street | Hess service station |
| 278 Delaware Street | Four Seasons Auto |
| 277 Delaware Street | Stanton's Garage |
| 261 Delaware Street | Breakstone/Kraft |
| 249 Delaware Street | TA's Place restaurant |
| 247 Delaware Street | Walton Auto Repair |
| 247 Delaware Street | ICO Computer |
| 247 Delaware Street | Subway restaurant |
| 247 Delaware Street | Appliance Plus |
| 247 Delaware Street | Radio Shack |

*Several private farms are not listed.

The small number of businesses in the town's portion of the watershed is consistent with the rural nature of the area. Where nonagricultural businesses are found, they are primarily service based (for example, the two automotive businesses). The Walton Comprehensive Plan notes that small farms and "alternative agricultural" businesses are active in the town. An example is the Healing Waters Farm in the Third Brook watershed. This farm includes a petting zoo with a variety of exotic animals.

Five areas of bluestone excavation are located in the town's portion of the watershed. Four of these quarries are located east of the brook, one is located west of the brook, but none are located immediately adjacent to the brook.

The businesses in the village's portion of the watershed are generally more diverse than those in the town's portion. Two of the most prominent employers in the village – Scott Machine and Kraft/Breakstone – are located in the Third Brook watershed. Other prominent businesses are Klinger Power Sports and Robinson Auction House. Some of the watershed's service-based businesses such as TA's Place restaurant and retail stores such as Radio Shack are well known in the village.

The Walton Comprehensive Plan states that Walton "has experienced a substantial number of subdivisions of land over recent decades." The number of new parcels averaged 47 per year from 1970 to 1990 but was only 13 per year from 1990 to 2000. Thus, subdivisions appear to have slowed considerably. Residential land use in the Third Brook watershed is aligned with the major roads (Route 206, Lower Third Brook Road, Gosper Road, and Seely Wood Road) instead of grouped in traditional subdivisions. Therefore, pressures to subdivide appear largely absent in the Third Brook watershed. If subdivisions were to occur, it is likely that the steep slopes would be avoided. Some of the more gradually sloping agricultural areas would be likely areas for subdivision if residential growth pressures were to arise.

## 3.8 Water Quality

In order to fulfill requirements of the Federal Clean Water Act, the NYSDEC must provide periodic assessments of the quality of the water resources in the state and their ability to support specific uses. These assessments reflect monitoring and water quality information drawn from a number of programs and sources both within and outside the Department of Environmental Conservation (DEC). This information has been compiled by the NYSDEC Division of Water and merged into an inventory database of all water bodies in New York State. The database is used to record current water quality information, characterize known and/or suspected water quality problems and issues, and track progress toward their resolution.

This inventory of water quality information is the division's Waterbody Inventory/Priority Waterbodies List (WI/PWL). The Delaware River Basin WI/PWL was last published in December 2002. Third Brook was listed as having "no known impact." DEC has been working on an update to the WI/PWL, but a formal draft has not been published as of the date of this plan. According to DEC, "since the sample collected in 1999 [for the 2002 list], there has been no additional sampling on this stream. The 1999 assessment is the most current information."

The New York State Section 303(d) List of Impaired Waters (2012, revised 2013) identifies those waters that do not support appropriate uses and that may require development of a Total Maximum Daily Load (TMDL). Third Brook is not listed in this document, nor is the section of the Delaware River just below Third Brook.

A biological (macroinvertebrate) assessment of Third Brook was conducted in 1999. Field sampling results indicated nonimpacted water quality conditions. The sample satisfied field screening criteria and was returned to the stream (DEC/DOW, BWAR/SBU, June 2001).

The NYSDEC Water Quality Standards and Classifications program is responsible for setting New York State ambient water quality standards and guidance values for surface water and groundwaters. The program is also responsible for the classification of surface waters for their best usage. The water quality standards program is a state program with EPA oversight. New York's longstanding water quality standards program predates the federal Clean Water Act and protects both surface waters and groundwaters. All waters in New York State are assigned a letter classification that denotes their best uses. Letter classes such as A, B, C, and D are assigned to fresh surface waters. Table 3-9 lists the water quality assumed for portions of Third Brook.

## TABLE 3-10
## Water Quality Classes and Standards for Third Brook

| Name | Description | Class | Standards |
|---|---|---|---|
| Third Brook | From mouth upstream to reservoir | C | C(TS) |
| Third Brook | From reservoir to Walton water supply source | A | A |
| Tributaries of Third Brook | Tributaries | A | A(T) |

Notes: Class A waters = suitable for drinking, recreation, and fishing
Class C waters = suitable for fishing
T = trout waters
TS = trout-spawning waters

The best usages of Class A waters are a source of water supply for drinking, culinary or food processing purposes; primary and secondary contact recreation; and fishing. The waters shall be suitable for fish, shellfish, and wildlife propagation and survival. This classification may be given to those waters that, if subjected to approved treatment equal to coagulation, sedimentation, filtration, and disinfection, with additional treatment if necessary to reduce naturally present impurities, meet or will meet New York State Department of Health drinking water standards and are or will be considered safe and satisfactory for drinking water purposes.

The best usage of Class C waters is fishing. These waters shall be suitable for fish, shellfish, and wildlife propagation and survival. The water quality shall be suitable for primary and secondary contact recreation although other factors may limit the use for these purposes. The symbol (T) means that the classified waters in that specific item are trout waters. Any water quality standard, guidance value, or thermal criterion that specifically refers to trout or trout waters applies. The symbol (TS) means that the classified waters in that specific item are trout spawning waters. Any water quality standard, guidance value, or thermal criterion that specifically refers to trout, trout spawning, trout waters, or trout spawning waters applies.

## 3.9 Description of Stream, Bridges, Culverts, and Adjacent Land Use

Within the Third Brook watershed there are two primary roads running on either side of the brook: to the east Lower Third Brook Road and along the west NY State Route 206. The first major crossing of Third Brook at its downstream end occurs at station[4] 12+73 with NY State Route 206, known more commonly as Delaware Street; this is a 20-foot bridge supporting two lanes of traffic and two pedestrian walkways. Third Brook approaches the bridge at a nearly 90 degree turn against the northeastern wingwall of the bridge. The bridge appears to be in relatively good condition.

Upstream 1,283 feet at station 25+56 is the next crossing of Third Brook at Ogden Street. The crossing at Ogden Street occurs along a 950-foot straight run of the channel with grade

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[4] Stream stations and stream segments are described in Chapter 5. They are used in Chapter 3 to help describe locations of infrastructure.

control structures constructed periodically upstream. The brook is restricted laterally through this section by stacked rock walls allowing residential, industrial, and commercial buildings to develop immediately adjacent to the river.

Upstream of this straight run, land use transitions from a combination of residential, commercial, and industrial to a mainly residential land use. Third Brook becomes very constricted through this stretch upstream to station 86+69, at points having less than 1,000 feet of lateral play between NY State Route 206 and Lower Third Brook Road. The most downstream impoundment (the Old Village Reservoir) is located at this station. A dam with a 30- to 40-foot spillway has been constructed upon a bedrock protrusion. The impoundment area is approximately 1.75 acres.

Much of the land upstream of the Old Village Reservoir is active agricultural lands. Due to the nature of the area being extensively used for agriculture, some fords were observed through this area of the channel. This is true up to station 126+06 where Lower Third Brook Road crosses the stream. A mobile home park sits along the eastern side of the stream with Route 206 along the west.

Between stations 137+25 and 149+25, Third Brook is a slightly braided stream through a flat grassland area. Upland conditions in this area of the watershed become almost exclusively wooded, mostly deciduous, with some clusters of coniferous trees. Again between stations 164+50 and 185+00, Third Brook is somewhat braided with numerous fords for the agricultural activity that takes place. At the upstream portion of the reach, logging activity appears to be taking place along the eastern side of the brook.

The Gosper Road culvert is the next upstream infrastructure along Third Brook, providing access to significant acreage of farmland in the northeastern portion of the watershed. From the Gosper Road culvert past a private pedestrian culvert (station 222+75) to the Fletcher Road culvert at station 266+75 is residential land giving way to significant amounts of open farmland. It is evident that much of this land may become active floodplain during rain events. Within this area (station 255+00) is a detention basin/pond that drains to Third Brook at a confluence 110 feet downstream. Beyond Route 206 to the west are forested uplands without agricultural lands.

Another impoundment adjacent to farmland is located immediately upstream of Fletcher Road. The inundated area upstream of the dam is approximately 0.33 acres, with access from the east for cattle/livestock to water and/or bathe. This section of Third Brook opens up from a dense area of coniferous trees and wooded area to the east in the watershed. No development in the upland area occurs to the east from here upstream except one house at the Armstrong Road culvert (station 296+50). More agricultural land is located along the western portion of the watershed from here upstream. Route 206 turns away (west) from Third Brook and leaves the watershed entirely at approximately station 289+25.

Two ponds separated by a simple footbridge are located downstream of the Armstrong Road culvert with a combined footprint of 1.25 acres. On the upstream side of the culvert across from the pond(s) is a small basin that drains directly to the culvert crossing. Approximately 900 feet upstream is another small basin that collects the headwaters of Third Brook at the most northern portion of the watershed area. Upstream of this point are wooded areas with a small pond to the very northwest of the watershed. No development has taken place in the headwaters area of this watershed.

The watershed as a whole has an overwhelming abundance of agricultural land and wooded areas with few impervious developed areas upstream of the lowest 3,600 feet of the brook. Once inside of this lower segment, the characteristics of the infrastructure change greatly to the more developed village, with much of the surface area impervious concrete or paved surfaces. The channel is much more constricted and controlled both laterally and horizontally in this area with in-stream features and riprap slopes or stacked walls. Pinch points in the channel also occur more frequently here as well, with two bridges in the lowest 3,600 feet of the stream channel.

## 3.10 Stormwater Systems

Nine short stormwater collection and conveyance systems are present beneath Route 206 along the west side of the Third Brook watershed. These systems were mapped by the county subsequent to the slope failures that occurred in 2006 in order to help draw potential connections between stormwater and the failures. Eight of the nine systems consist of an inlet structure on the west side of the roadway and an outlet structure on the east side of the roadway except in one case where the system has two inlets and one outlet. All nine systems are roughly positioned between the latitude of the Old Village Reservoir and Murphy Hill Road.

Elsewhere in the more rural parts of the Third Brook watershed, stormwater systems are not installed along Lower Third Brook Road, Seely Wood Road, Gosper Road, and Armstrong Road. Roadside swales and ditches are found occasionally in the watershed to convey stormwater along the sides of roads. For example, a distinct gully has been excavated and maintained along the north side of Armstrong Road near the headwaters of Third Brook. Stormwater flows down along the side of Armstrong Road and enters Third Brook and its tributary where they cross under the road in segment 8.[5]

A total of 20 outfalls from a variety of pipes was observed along segments 1 through 5 of Third Brook and mapped using Global Positioning System (GPS) methods. These are summarized in Table 3-10. Culverts conveying Third Brook are present at road crossings but are not included in this table because they are not strictly stormwater conveyances.

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[5] Refer to Section 5.2 for an explanation of stream segments.

## TABLE 3-11
## Observed Outfalls

| Segment | Station or Location (approximate) | Diameter (inches) | Type[1] | Comment[2] |
|---|---|---|---|---|
| 1 | Downstream side of Delaware Street | 18 | RCP | |
| | Delaware Street | 12 | CMP | |
| | 13+50 | 18 | RCP | |
| | 16+50 | 24 | CMP | Flowing |
| | 16+50 | 12 | PVC | |
| | 22+00 | 15 | SLCPP | |
| | 23+00 | 12 | SLCPP | |
| | Ogden Street bridge | 10 | CMP | |
| | Ogden Street bridge | 12 | CMP | |
| 2 | 28+50 | 18 | SLCPP | |
| | 39+50 | -- | -- | Very large engineered outfall is present on the right bank of the brook to convey stormwater from Route 206. |
| | 43+50 | 4 | PVC | |
| | 43+50 | 4 | PVC | |
| | 43+50 | 4 | PVC | |
| 3 | 50+50 | | | |
| 4 | 74+00 | 24 | SLCPP | Flowing |
| | 74+00 | 4 | PVC | |
| | 76+00 | 4 | PVC | |
| 4/5 | 82+50 | 15 | SLCPP | Flowing |
| 5 | Corner of dam | 8 | SLCPP | Flowing |

1. Culvert types as follows:
   RCP = reinforced concrete pipe
   CMP = corrugated metal pipe
   PVC = polyvinyl chloride (plastic)
   SLCPP = smooth lined corrugated plastic pipe
2. For outfalls that were flowing, conditions represent May 15-16, 2012.

Outfalls were not observed along Third Brook upstream of the Old Village Reservoir in the more rural parts of the stream corridor (segments 6, 7, and 8). In these areas, stormwater is either conveyed overland without concentration in channels, or stormwater is conveyed in road gutters, gullies, swales, and channels.

In subwatershed 8[6], stormwater channels and swales appear to join Third Brook in the vicinity of station 285, station 274 (where a small pond is present along the stream), and station 269. These are all farm field drainage swales and channels. Stormwater likely enters the brook at Fletcher Road, where segment 8 transitions to segment 7.

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[6] Refer to Section 5.2 for an explanation of subwatershed numbers.

In subwatershed 7, stormwater drainage channels appear to join Third Brook in the vicinity of station 251, station 249, and station 208. These are all farm field drainage swales and channels. Stormwater likely enters the brook at Gosper Road, where segment 7 transitions to segment 6.

In subwatershed 6, stormwater drainage channels appear to join Third Brook in the vicinity of station 183 (near the confluence of Third Brook and the Gosper Road tributary) and station 145 (from Route 206). Stormwater likely enters the brook at Lower Third Brook Road, where segment 6 transitions to segment 5. Although roadways are located along segment 5, Third Brook appears to be sufficiently removed from the roads such that stormwater channels do not flow toward and meet the brook. Downstream of segment 5, stormwater conveyances are piped as noted in Table 3-7.

## 3.11 History of Flooding

The Third Brook watershed has a notable history of flooding. On January 19 and 20, 1996, the town and village of Walton encountered a devastating flood. Under nearly five feet of water, businesses along Delaware Street sustained severe damage including a fire that destroyed two buildings during the peak of the flood.

In June 2006, the Third Brook watershed experienced the worst flooding in its history. According to the USGS (2009), 13.36 inches of rain were recorded at Walton from June 26 through 29, 2006. The USGS determined that this four-day total precipitation had a recurrence interval *exceeding* the 100-year storm. A state of emergency was declared in Delaware County and many others. The town and village of Walton experienced significant damage and property loss including road and bridge failures, mass failures at adjacent hillsides, bank erosion, channel migration and instability, and gravel deposition.

**Damage in residential area along east side of Third Brook**

The residential area from 67 to 71 West Street (in the village) and from 3 to 173 Lower Third Brook Road (in the town) suffered major damage during the flood of 2006. Properties were inundated, and many buildings were damaged.

Slightly further downstream, materials and debris were picked up from the yard of Harold Neale Excavating and Del-Ton Sanitation. The firehouse and Frontier Cable property were flooded. Homes on Ogden Street near the brook were flooded, and yards were damaged.

Downstream of Ogden Street, the Klinger Power Sports buildings were flooded, and contents were destroyed. Water flowed through the buildings, as shown in the photograph to the right. The entire block of commercial buildings from Klinger down past the old Agway store to the Robinson Auction House was badly flooded, as shown in the photograph below. Additional debris was picked up by floodwaters through this block of commercial properties.

**Klinger Power Sports, courtesy of www.klingerpowersports.com**

**15 West Street through 33 West Street, courtesy of www.floodny06.zoomshare.com**

Water from Third Brook poured onto West Street and flowed downhill between the Robinson Auction House and commercial properties on the east side of the road, damaging it.

**Auction House, TA's Place, and Kraft, courtesy Delaware County**

Debris in the Third Brook floodwaters clogged the bridge at Ogden Street and Delaware Street, making flooding worse. The Hess gasoline service station was flooded on the upstream side of Delaware Street as pictured to the right.

**Hess service station courtesy of www.floodny06.zoomshare.com**

Across the street, TA's Restaurant, Subway, and associated properties were flooded, and buildings were damaged.

**TA's Place courtesy of www.floodny06.zoomshare.com**

Across the brook from TA's Place, floodwaters engulfed the Kraft facility, and floating debris from upstream reaches damaged the buildings.

06/27/2006

**Kraft, courtesy of Delaware County**

28 1:39PM

**Kraft, courtesy of www.floodny06.zoomshare.com**

The flood discharge of June 2006 was not measured because Third Brook is not a gauged stream. Nearby, a discharge of 7,110 cfs was measured on East Brook in Walton, and a flood discharge of 28,600 cfs was measured on the West Branch Delaware River in Walton. East Brook has a watershed area of 24.7 square miles compared to the Third Brook watershed of 5.4 square miles. Using a watershed ratio of 5.4/24.7, a rough estimate of the June flood discharge of Third Brook is 1,554 cfs. With reference to Table 3-8, a flood discharge of 1,554 cfs on Third Brook would exceed a 500-year flood. This is consistent with observations; Third Brook was flowing out of banks and exceeded the estimated base flood width depicted on the FIRM.

In August 2006 with help from the U.S. National Guard, Walton performed emergency repairs to the stream channel. This involved excavating the stream channel to regain capacity, stabilizing sections of the stream bank with stacked rock and riprap, and removal of debris and trees. However, a few months later, another storm event passed through on November 16, 2006, causing more damage, including bank and channel erosion, sedimentation, and channel headcutting.

Heavy rain from Tropical Storm Nichole fell on Walton totaling 5.16 inches (USGS, 2010) on September 30 and October 1, 2010. USGS (2009) computed that the 24-hour precipitation total of five inches had a recurrence interval of 25 years. Walton was placed under a state of emergency, and the West Branch Delaware River flooded areas of downtown along Delaware Street. According to USGS, flood recurrence intervals were in the 10-year to 100-year range for the region, which is generally consistent with the 25-year recurrence interval of the precipitation event. However, the Third Brook watershed did not suffer significant flooding or damage.

In August and September 2011, Hurricane Irene and the remnants of Tropical Storm Lee resulted in record flooding in much of the Catskills. Walton was placed under a state of emergency once again, and the West Branch Delaware River flooded areas of downtown along Delaware Street such as Breakey Motors and McDonalds. However, the Third Brook watershed did not suffer significant flooding or damage as a result of Hurricane Irene or the remnants of Tropical Storm Lee.

Completed flood and erosion damage remedial projects include the following (Woidt, 2010):

- ☐ A slope stability near the town/village line (NRCS Project D-W-061)
- ☐ A stacked and pinned rock wall stream bank stabilization 2,000 feet upstream of the village boundary (NRCS Project D-W-601)
- ☐ A stacked rock wall channel stabilization one mile upstream of the village boundary (NRCS Project D-W-401)
- ☐ A stacked and pinned rock wall with rock vane structure upstream of Ogden Street bridge (independent funding)
- ☐ A new stacked rock wall and repair of existing rock wall downstream of the Ogden Street bridge (funds from Catskill Watershed Corporation)

The results of these projects were observed as noted in Chapter 5.0 of this plan.

## 4.0 PREVIOUS STUDIES AND REPORTS

Numerous studies, reports, designs, and plans have been prepared over the years to address pertinent issues in the Third Brook watershed. These were described in Section 1.4 and listed in Appendix A. Four specific reports provide considerable insight to watershed processes and are described below in this section because they provide key information to the management strategies of this plan.

### 4.1 Needs Assessment Report

A Needs Assessment Report (January 2007) was completed for Third Brook by Integrated River Solutions, Inc. with DCSWCD. The report was completed for the county, town, and village in response to the flooding and erosion of June and November 2006. According to the report, the needs assessment was conducted (1) with recognition that Third Brook remains a serious flood and erosion hazard; and (2) to provide baseline data for future watershed and flood mitigation planning.

The following 12 assessments were recommended in the Needs Assessment Report sequentially; priorities for completion were provided in the report and are repeated below.

1. *Inventory of Flood History* – This assessment was recommended with a low priority. The objective is to document consequences and damages from recent floods in order to assist the village and town with planning for future floods and flood mitigation.

2. *Aerial Photography Assessment* – This assessment was recommended with a moderate priority. The objective is to assist other studies by providing visual evidence of stream channel, bank, and slope changes as well as land use changes.

3. *Rosgen Level 1 Assessment – Stream Classification* – This assessment was recommended with a moderate priority. Rosgen Level 1 classification is meant to provide an initial characterization of stream reaches into different categories, which would then aid further evaluation efforts.

4. *Stream Corridor Walkover* – This assessment was recommended with a high priority. The objective is to characterize the entire stream corridor from its headwaters to the confluence with West Brook and the West Branch Delaware River. During the walkover, various features would be mapped using GPS methods such as bedrock controls, bank erosion, failing slopes, grade controls, bridges, culverts, debris, encroachments, and obstructions. Like the aerial photograph review, this effort would support other studies and assessments.

5. *Rosgen Level 2 Assessment – Classification of Unstable Reaches* – This assessment was recommended with a moderate priority. The objective is to collect field data to characterize sediment supply and transport, stream sensitivity to disturbance, and

potential for recovery. The following are measured: entrenchment, width/depth ratio, sinuosity, channel materials, and slope.

6. *Evaluation of Emergency Stabilization Work* – This assessment was recommended with a high priority. Various emergency actions were taken in August 2006 in response to the flooding earlier that year. The objective is to evaluate the channel excavation and slope stabilization efforts to determine if they are stable or in need of future maintenance. The intent is that the assessment be linked with the Rosgen Level 2 assessment.

7. *Geotechnical Hillslope Failure Assessment* – This assessment was recommended with a high priority, with assessment including site reconnaissance, borings, geotechnical evaluation with preliminary design for the eight large hillslope failures that occurred in 2006, and final design as needed. A geotechnical assessment was completed and published subsequent to the needs assessment (the Hawk Engineering study described below in Section 4.2 of this report).

8. *Channel Headcut/Incision Assessment* – This assessment was recommended with a high priority and focused primarily on a headcut that was active at the time, located 1,200 feet downstream of the dam of the impoundment.

9. *Debris Inventory and Assessment* – This assessment was recommended with a moderate priority. Debris in Third Brook was a problem during the 2006 floods. The objective of the assessment is to locate and describe additional debris in the stream corridor.

10. *Hydrologic and Hydraulic Assessment* – This assessment was recommended with a moderate priority. The objective of a hydrologic and hydraulic assessment is to evaluate potential mitigation actions based on a similar watershed's hydrology and water surface elevations. Two hydrologic/hydraulic assessments were completed and published subsequent to the needs assessment (the FEMA FIS effective May 2012 and the Village of Walton Flood and Hydraulic Study described in Section 4.3 of this report).

11. *Stormwater Inventory Assessment* – This assessment was recommended with a low priority. The objective is to map and describe stormwater infrastructure and features such as roadside ditches and swales, catch basins, culverts, pipes, basins, and outfalls.

12. *Stream Channel Monitoring* – This assessment was recommended with a low priority. Monitoring involves long-term observations along a variety of stream corridor cross sections to document changes in the channel and stream banks.

The subject watershed management plan incorporated some of the assessments recommended by the Third Brook needs assessment. Table 4-1 summarizes which of the 12 assessments were completed in whole or in part for the subject Watershed

Management Plan. Table 4-1 also states whether the individual assessments listed in the needs assessment are still recommended. In some cases, supportive documentation for whether an assessment is recommended can be found later in this plan.

### TABLE 4-1
### Status of Recommendations From Needs Assessment

| | Recommendation From Needs Assessment | Conducted as Part of This Watershed Management Plan? | Recommended by This Watershed Management Plan? |
|---|---|---|---|
| 1. | Inventory of Flood History | Yes | No |
| 2. | Aerial Photography Assessment | Yes (partial) | No; utilize as needed for specific designs. |
| 3. | Rosgen Level 1 Assessment – Stream Classification | Yes | No |
| 4. | Stream Corridor Walkover | Yes | No; repeat as needed for specific designs. |
| 5. | Rosgen Level 2 Assessment – Classification of Unstable Reaches | Yes | No |
| 6. | Evaluation of Emergency Stabilization Work | Yes (partial) | Yes; continue as needed for specific designs. |
| 7. | Geotechnical Hillslope Failure Assessment | No (previously completed) | Repeat as needed for specific designs. |
| 8. | Channel Headcut/Incision Assessment | Yes (partial) | No |
| 9. | Debris Inventory and Assessment | Yes (partial) | No |
| 10. | Hydrologic and Hydraulic Assessment | No | Yes |
| 11. | Stormwater Inventory Assessment | Yes | No |
| 12. | Stream Channel Monitoring | No | Yes |

As noted in the discussion and table above, the geotechnical assessment of slope failures was completed by Hawk Engineering in 2010, and hydrologic/hydraulic studies were completed in 2010 (by Woidt) and 2012 (the FEMA FIS). The geotechnical assessment provided valuable information for the subject plan and is summarized in the following subsection. Although the hydrologic/hydraulic study did not include the entire Third Brook corridor, it also provided valuable information for this plan and is summarized below.

## 4.2 Geotechnical Engineering Evaluation of Third Brook Slope Failures

Hawk Engineering completed a slope failure evaluation report entitled "Geotechnical Engineering Evaluation of Third Brook Slope Failures" dated March 2010. Eight slope failures were identified in the report ("slide 1" through "slide 8"); these were the same eight failures identified soon after the flood of June 2006. All eight are located between the fire station and the Old Village Reservoir in stream segments 2, 3, and 4. Table 4-2 lists the failing slopes that were evaluated by Hawk Engineering in 2010 with a cross reference to the approximate stations used in this plan.

**TABLE 4-2**
**Slope Failures, 2010**

| ID | Status | Approximate Midpoint (Station) | Location Description |
|---|---|---|---|
| 1 | Mitigated | 35+00 | Behind Harold Neale Excavating |
| 2 | Mitigated | 39+50 | Behind 19 and 29 Lower Third Brook Road |
| 3 | Active | 48+50 | Behind 173 Lower Third Brook Road |
| 4 | Active | 55+00 | Behind 269 Lower Third Brook Road |
| 5 | Active | 57+50 | Behind 269 Lower Third Brook Road |
| 6 | Active | 68+00 | Near 599 Lower Third Brook Road |
| 7 | Active | 71+00 | Behind 599 Lower Third Brook Road |
| 8 | Active | 77+00 | Behind 709 Lower Third Brook Road |

Slide 1 was located between the brook and the parking lot of Scott Machine Company, behind Harold Neale Excavating. It was remediated with a stacked rock wall at the base and a filled, terraced and revegetated slope. This slide was not evaluated by Hawk Engineering in the report as it was considered mitigated.

Hawk Engineering conducted three borings and performed slope stability analysis for slides 2 through 8 using the program STABL, which relies on PCSTABL6 for computations. Slope safety factors below 1.0 were assumed to indicate failures, and those at approximately 1.0 were in danger of failure. Safety factors above 1.3 were considered stable.

- Slide 2 was located at a drainage outfall and was remediated with riprap and a new concrete outfall structure. However, the slide was not considered completely mitigated. Boring 1 was completed near slide 2. The boring reportedly encountered fill material followed by glacial till to a depth of 30 feet, then lacustrine silt and sand to 55 feet, then sand and gravel to 70 feet. The slope stability evaluation found a slope safety factor of 0.993, indicating a failure had occurred.

- Slide 3 had a slope safety factor of 1.002 for a groundwater table near the surface of the toe but deeper upslope. This indicated that a failure was imminent although it was noted that failure had occurred.

- Slide 4 had a slope safety factor of 1.047 for a groundwater table near the surface of the toe but deeper upslope. This indicated that a failure was imminent although it was noted that failure had occurred.

- ☐ Slide 5 had a slope safety factor of 1.043 for a groundwater table near the surface of the toe but deeper upslope. This indicated that a failure was imminent although it was noted that failure had occurred.

- ☐ Slide 6 had a slope safety factor of 1.034 for a groundwater table near the surface of the toe but deeper upslope. This indicated that a failure was imminent although it was noted that failure had occurred.

- ☐ Boring 2 was completed near slide 7. The boring encountered sand and gravel deposits to a depth of 19 feet then glacial till to a depth of 70 feet. Slide 7 had a slope safety factor of 1.055 for a groundwater table near the surface of the toe but deeper upslope. This indicated that a failure was imminent although it was noted that failure had occurred.

- ☐ Boring 3 was completed near slide 8. The boring encountered sand and gravel deposits to a depth of 24 feet then glacial till to a depth of 67 feet. Bedrock was believed present just below the bottom of the boring; this is consistent with the bedrock streambed nearby. Slide 8 had a slope safety factor of 1.012 for a groundwater table near the surface of the toe but deeper upslope. This indicated that a failure was imminent although it was noted that failure had occurred.

Hawk Engineering evaluated stabilizing the toe of each slope. For slides 2 through 7, Hawk Engineering recommended a "keyway" extending five feet below the streambed with a stacked rock wall above the keyway to a point at least five feet above existing grade (and at least one foot above the elevation of the east bank). For slide 8, a stacked stone slope was recommended instead of the wall because a wall was already present on the east bank, and there was a desire to avoid additional stream constriction.

Hawk Engineering then evaluated methods of stabilizing the slope surfaces. Initial results of the modeling found that safety factors were below 1.3 with failure planes below the surfaces of the slopes even when four-foot thick stone fill blankets or "geogrids" were considered. To increase stability, Hawk Engineering considered the use of soil nails installed perpendicular to the slope, which would increase resistance and discourage failure. The number of nails required for slide 8 was 1,560. The resulting cost estimate was more than six million dollars for the keyways, stacked rock walls, and soil nails for slides 2 through 8.

Hawk Engineering found that the more typical practice of stabilizing slopes with stacked rock walls and stone slope protection would be insufficient, resulting in safety factors of less than 1.3 "during a heavy rainfall event similar to June 2006" when groundwater levels would rise very high. Hawk Engineering noted that other alternatives may be needed such as relocating the stream or addressing the sediment supply downstream with traps.

## 4.3 Village of Walton Flood and Hydraulic Study

From 2008 through 2010, Woidt Engineering and FIScH Engineering conducted a flood and hydraulic study for the Village of Walton using a grant from the Catskill Watershed Corporation. The study included the development of a hydraulic model in parallel with the FEMA FIS effort that was underway at the same time and later became effective in May 2012. The flood and hydraulic study report acknowledged the presence of the needs assessment completed in 2007 (described above) and stated that decisions about how to prioritize future efforts and funds would be made after completion and review of the flood and hydraulic study. The study included Third Brook, West Brook, East Brook, and the West Branch Delaware River. Relative to Third Brook, the study focused only on the portion of the stream corridor located in the village of Walton.

The flood study report provides a good synopsis of current conditions along Third Brook, noting that the rock walls along the lower reaches of the brook within the village contain flood discharges up to the 100-year discharge. This was verified with the modeling completed by Woidt. Modeling by Woidt also verified that backwater effects from the Delaware River are limited to the most downstream part of Third Brook.

Hydraulic constrictions at the Ogden Street and Delaware Street bridges create backwater effects. One of the important findings of the flood study was that a 50% blockage of either the Ogden Street bridge or the Delaware Street bridge during a flood with significant debris would cause water surface elevations to be up to four feet higher on the upstream side relative to a flood without debris blocking the bridges. This is a significant increase in flood water surface and could easily cause Third Brook to spill out of its rock walls and overtop Ogden Street and Delaware Street.

Furthermore, the angled crossing of the brook under Delaware Street contributes to the accumulation of sediment from bed load and the clogging of debris. A sediment transport model was developed and demonstrated that a large drop in sediment transport capacity occurs immediately upstream of the Delaware Street bridge for the 10- and 100-year flood discharges. After the June 2006 flood, four feet (vertical) of sediment were removed from the channel on the upstream side of the Delaware Street bridge. When the model includes four feet of sediment in the channel, discharge larger than the 10-year flood will overtop Delaware Street.

The flood study correctly notes that flood mitigation options are limited in Walton. Attenuation of peak flows would be challenging due to high costs and limited space in the valley. Miles of levees and floodwalls would likewise be expensive and would exacerbate sediment and debris transport. The flood study therefore focused on options for reducing sedimentation and debris clogging at the Delaware Street bridge (a large box culvert) and at the Ogden Street bridge.

Options for the Delaware Street bridge mainly involve replacing the box culvert with a sheet piling/concrete deck structure that would allow more flexibility in the channel bed (it could mobilize during floods) and improved alignment with the brook although some realignment would still be needed. Modeling demonstrated that this combination of bridge replacement and slight channel realignment would reduce 100-year water surface elevations about 1.5 feet at Delaware Street. Removal of the Ogden Street bridge was also modeled, and results showed that a similar decrease in water surface elevation could be achieved at that location. The potential for debris to clog both bridges was likewise reduced.

Recommendations of the flood study included the adoption of more restrictive floodplain regulations, development of flood evacuation routes, reclamation of floodplains along the West Branch Delaware River, floodproofing of residential and commercial structures, implementation of an early warning system, stream maintenance through debris removal, debris management, stormwater management, bridge capacity improvements, and slope stabilization. While these are good recommendations, the extremely limited delineation of SFHA along Third Brook will tend to diminish the impact of more stringent floodplain management regulations. The recommendations to increase capacities of the Delaware Street and Ogden Street bridges and address the failing slopes are most applicable to the subject Watershed Management Plan.

## 4.4 Delaware County Hazard Mitigation Plan

A draft of the Delaware County Hazard Mitigation Plan Update was developed in 2012 by Tetra Tech. The plan includes annex reports for the Town and Village of Walton, thereby including the entire Third Brook watershed. The following discussions are taken from the hazard mitigation plan annexes.

### Town of Walton

It is estimated that in the town of Walton, 76 residents live within the 1% annual chance (100-year) and 0.2% chance (500-year) floodplains. Of the town's total land area, 3.2 square miles are located within the 1% annual chance flood boundary, and 3.3 square miles are located within the 0.2% annual chance flood boundary. When compared to the very limited SFHA delineated along Third Brook, it is apparent that few (if any) town residents are located in the 1% annual chance and 0.2% chance floodplains of Third Brook.

The computer model HAZUS-MH 2.0 estimates that for a 1% annual chance flood event 120 people may be displaced, and 15 people may seek short-term sheltering, representing 4.7% and 0.6% of the town's population, respectively. For the 0.2% annual chance event, it is estimated that 120 people may be displaced, and 17 people may seek short-term sheltering, representing 4.7% and 0.7% of the town's population, respectively.

The town of Walton has a total of 256 properties located within the 1% annual chance flood boundary and 258 properties located within the 0.2% annual chance flood boundary. It appears that only one structure in the town is located in the 1% annual chance floodplain along Third Brook.

FEMA has identified 24 National Flood Insurance Program (NFIP) flood insurance policies held in the town of Walton, with eight policies located in the 1% annual chance flood boundary, nine policies in the 0.2% annual chance flood boundary, and 15 policies located outside the 0.2% annual chance flood boundary. The town of Walton has two repetitive loss properties.

There is $20,666,816 of total assessed property (structure and land) exposed to the 1% annual chance flood in the town of Walton. For the 0.2% annual chance event, it is estimated that $20,728,732 of total assessed property is exposed in the town of Walton.

The program calculates the estimated potential damage to the general building stock inventory associated with the 1% annual chance and 0.2% annual chance flood events. HAZUS-MH 2.0 estimates approximately $5,321,000 and approximately $5,381,000 of potential general building stock loss as a result of the 1% and 0.2% annual chance mean return period (MRP) events, respectively.

The plan notes that the town has zoning, subdivision, and flood damage prevention ordinances as well as a comprehensive plan and a highway management plan. Two feet of freeboard is required for new construction in flood zones per the New York State Building Code. The town does not have an open space plan or economic development plan and does not participate in the Community Rating Service (CRS), which would enable reductions in flood insurance policies.

Relative to existing flood hazard mitigation, the town's annex notes that riparian buffer planting at Lower Third Brook was completed in 2008. In 2009, a townwide mailing to owners of property within the 1% annual chance (100-year) floodplain was undertaken using the Preliminary Digital Flood Insurance Rate Map (DFIRM). The mailing advised property owners of flood hazards and the availability of flood insurance.

The annex notes that the most significant hazard problem in Walton is "extensive and severe flooding events in steep, narrow valleys" with many roads located in flood hazard zones, stream bank failures threatening roads, structures in flood hazard zones in many valleys, and debris threatening to cause debris jams. Recommendations of the annex include:

- ☐ "Use a watershed approach to manage areas of excessive erosion and debris/gravel deposition throughout the Town and reduce potential damage to infrastructure and property."
- ☐ "Retrofit structures located in hazard-prone areas to protect structures from future damage."
- ☐ "Acquire and demolish or relocate structures located in hazard-prone areas to protect structures from future damage."

One of the recommendations of the hazard mitigation plan directly addresses Third Brook as follows:

- ☐ "Develop a Watershed Management Plan for the Third Brook watershed – Many reaches of Third Brook have been destabilized by recent major flooding (1996, 2005, and 2006) and are a constant source of water quality and flooding problems for the Town and Village of Walton. Recognizing the systemic nature of the problems in the Third Brook watershed, the Walton Flood Commission in cooperation with the Delaware County Soil and Water Conservation District has sought and obtained funding to develop a Watershed Management Plan for Third Brook. This planning process will engage watershed planning experts and important stakeholders to develop management recommendations that will improve channel stability, improve water quality, and decrease flood damage risk."

### Village of Walton

It is estimated that in the village of Walton, 770 residents live within the 1% annual chance floodplain, and 864 residents live within the 0.2% chance floodplain. Of the village's total land area, 0.5 square miles are located within the 1% annual chance flood boundary, and 0.5 square miles are located within the 0.2% annual chance flood boundary. When compared to the very limited SFHA delineated along Third Brook, it is apparent that few (if any) village residents are located in the 1% annual chance and 0.2% chance floodplains of Third Brook.

HAZUS-MH 2.0 estimates that for a 1% annual chance event 801 people may be displaced and 663 people may seek short-term sheltering, representing 26.1% and 21.6% of the village's population, respectively. For the 0.2% annual chance event, it is estimated that 808 people may be displaced, and 697 people may seek short-term sheltering, representing 26.3% and 22.7% of the village's population, respectively.

The village of Walton has a total of 276 properties located within the 1% annual chance flood boundary and 311 properties located within the 0.2% annual chance flood boundary. A handful of these are located in the 1% and 0.2% annual chance floodplains along Third Brook.

FEMA has identified 160 NFIP flood insurance policies for the village of Walton, with 120 policies located in the 1% annual chance flood boundary, 132 policies in the 0.2% annual chance flood boundary, and 28 policies located outside the 0.2% annual chance flood boundary. The village of Walton has seven repetitive loss properties.

There is $14,196,798 of total assessed property (structure and land) exposed to the 1% annual chance flood in the village of Walton. For the 0.2% annual chance event, it is estimated that there is $15,171,940 of total assessed property exposed in the village.

HAZUS-MH 2.0 calculates the estimated potential damage to the general building stock inventory associated with the 1% annual chance and 0.2% annual chance flood events. HAZUS-MH 2.0 estimates approximately $33,001,000 and approximately $33,406,000 of potential general building stock loss as a result of the 1% and 0.2% annual chance MRP events, respectively.

The plan notes that the village has zoning, subdivision, and flood damage prevention ordinances as well as a comprehensive plan. Two feet of freeboard is required for new construction in flood zones per the New York State Building Code. The village does not have an open space plan but does maintain an economic development plan. The village does not participate in the CRS, which would enable reductions in flood insurance policies.

Relative to existing flood hazard mitigation, the village's annex notes completion of "stacked wall/stream bank stabilization by Klinger's on Third Brook" and "emergency watershed protection projects on Third Brook." In 2009, a villagewide mailing to owners of property within the 1% annual chance (100-year) floodplain was undertaken using the Preliminary DFIRM. The mailing advised property owners of flood hazards and the availability of flood insurance. The hydraulic study described in Section 4.2 was also cited as a mitigation effort.

Recommendations of the annex include:

- ☐ "Repair eroded retaining walls and stream banks along Village Roads."
- ☐ "Retrofit structures located in hazard-prone areas to protect structures from future damage."
- ☐ "Acquire and demolish or relocate structures located in hazard-prone areas to protect structures from future damage."

The recommendation in the town's annex that directly addresses Third Brook (listed above) is repeated in the village's annex.

# 5.0 FIELD INVESTIGATIONS

## 5.1 Overview of Field Investigations

Field reconnaissance of Third Brook and its watershed was conducted in support of the development of management strategies corresponding to goals #1, 2, 3, and 6 and was requisite for accomplishing a Rosgen stream geomorphology assessment of the brook.

- ☐ Rosgen's Level I assessment consists of basic geomorphic characterization wherein stream segments are classified into one (or more) of the classes from "A" through "G" based on valley slope, channel shape, and channel patterns.
- ☐ Level II assessment consists of the assignment of morphological descriptions based on width and depth, sinuosity, channel slope, and channel materials.
- ☐ Level III assessment consists of the assignment of stream "state" or conditions and is based on vegetation, sediment sources, bank erosion, depositional patterns, and other indicators.
- ☐ Level IV assessment is the "validation level" and depends on measurements of bedload sediment, suspended sediment, and stream discharge.

Levels I and II were conducted for Third Brook, with aspects of Level III conducted as well. MMI conducted three field reconnaissance visits to the Third Brook watershed on May 15-16, 2012, on September 20, 2012, and on October 8-9, 2012. A brief description of the data collected during the investigations is presented below. Detailed discussions are provided in subsections of this chapter.

May 15-16, 2012 – Watershed Reconnaissance and Rosgen Level I-II Assessment

On May 15 and 16, 2012, MMI project team members conducted a two-day field investigation of Third Brook and its contributing watershed. Topographic maps, aerial photographs, and geographic information system (GIS) land use/cover data were reviewed prior to the initiation of field investigations. During the fieldwork, the following were accomplished:

- ☐ Subwatersheds were inspected to visually assess the properties that could influence downstream surface runoff and sediment loads.
- ☐ An inventory and characterization of watershed infrastructure was developed including roads, bridges, culverts, stormwater controls, rock vanes, dams, etc.
- ☐ A geomorphologic assessment of the Third Brook watershed was undertaken using Rosgen Level I and Level II classification principles.

The investigations targeted areas of previously identified problems as well as representative stream sections, natural and man-made control points (natural falls, reaches flowing over bedrock, bridges), and areas of extensive bank erosion. Based on the gauged discharges at East Brook nearby (average of 267 cfs on May 15 and 196 cfs on May 16), Third Brook was likely flowing at the 2% to 3% duration during this reconnaissance.

September 20, 2012 – Flood Mitigation Evaluation and Rosgen Level I-II Verification

MMI field personnel returned to the watershed to conduct a flooding assessment within the Third Brook watershed that included but was not limited to locating areas of potential floodplain creation, areas of possible flow constrictions/flood magnification, and locations of anthropogenic structures/encroachments in the floodplain. Additionally, Rosgen Level I and II classifications were verified, and potential cross-section sites for additional field characterization were sited downstream of the existing impoundment.

Based on the gauged discharges at East Brook nearby (average of 26 cfs), Third Brook was likely flowing at the 55% duration (close to its average annual discharge) during this reconnaissance.

October 8-9, 2012 – Rosgen Level II Assessment and Wetlands Evaluations

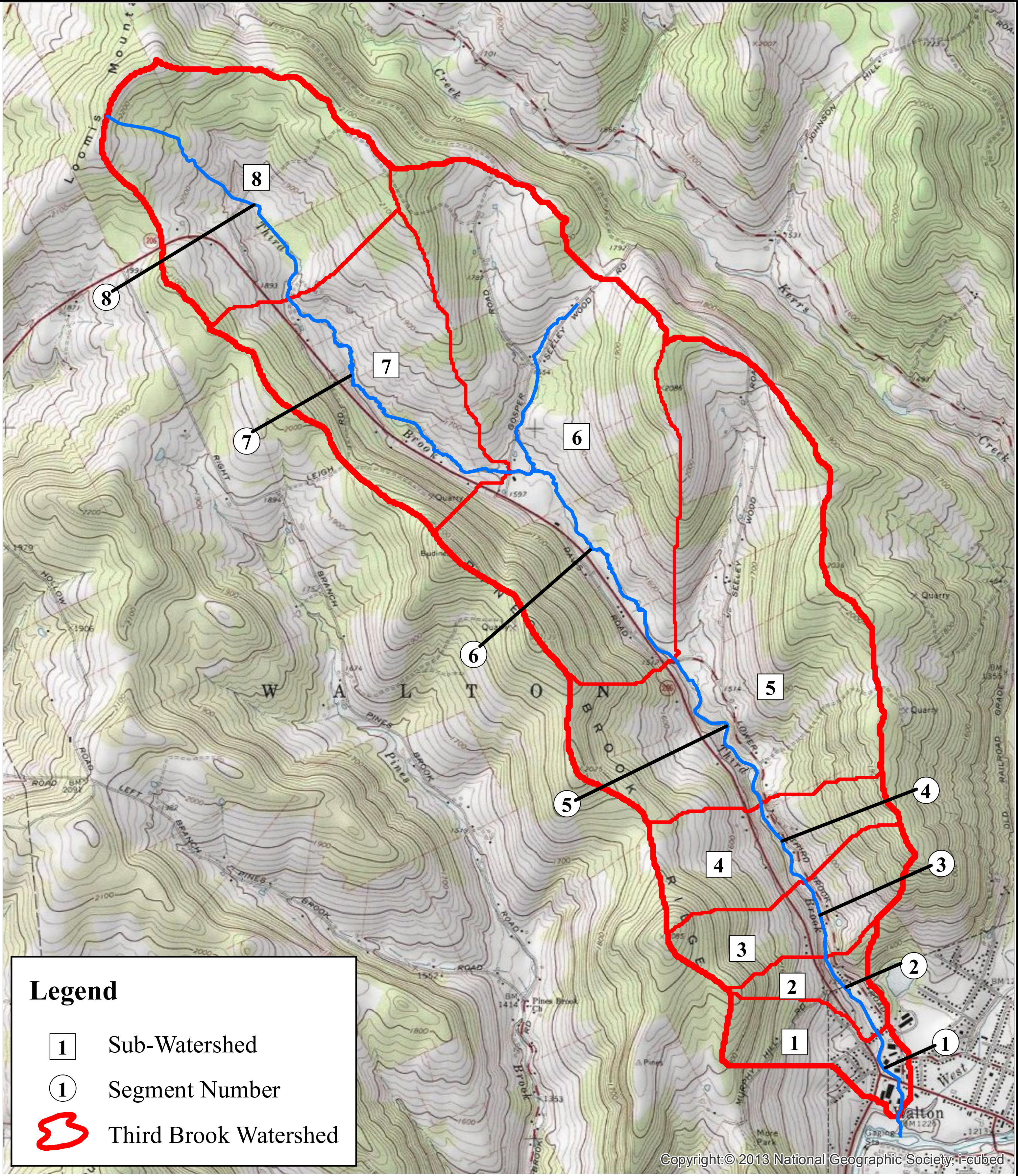
MMI staff returned to the Third Brook watershed to conduct additional Rosgen Level II-type data collection that included detailed measurements at eight cross sections located downstream of the Old Village Reservoir. Cross-section characterizations were completed in segments 1, 2, 3, and 4.

Wetlands reconnaissance and evaluations were also completed during this visit; these findings were described in Section 3.11 of this plan.

Based on the gauged discharges at East Brook nearby (range of 27 cfs to 32 cfs during the two days), Third Brook was likely flowing at the 50% duration (its average annual discharge) during this reconnaissance.

## 5.2 Watershed Delineation and Nomenclature

Stream reach segments were defined along the length of Third Brook according to a variety of physical characteristics described in this chapter. These segments are summarized in Table 5-1 below and are illustrated in Figure 5-1. Stream stations are depicted on Appended Figure I. The stations are in units of 100 feet; for example, station 25+50 is 2,550 feet upstream of the terminus of Third Brook where it discharges into West Brook. The lengths of the stream segments vary from 0.22 mile to 1.41 miles.



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**SOURCE(S):**

"USA Topo Maps" Datalayer
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**Figure 5-1: Sub-Watershed Map**

**LOCATION:**

**Walton, NY**

**Third Brook Watershed**
**Management Plan**

**MXD:** P:\4444-01\Design\GIS\Maps\Figure5-1.mxd

**Map By:** JEP
**MMI#:** 4444-01-4
**Original:** 1/7/2013
**Revision:** 8/20/2013
**Scale:** 1 inch = 2,700 feet

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## TABLE 5-1
## Stream Segment Data

| Segment | Description | Downstream Station | Upstream Station | Length (miles) |
|---|---|---|---|---|
| 1 | Ogden Street Bridge to confluence with West Branch | 0+00 | 25+50 | 0.48 |
| 2 | 119 Lower Third Brook Road to Ogden Street Bridge | 25+50 | 46+50 | 0.40 |
| 3 | 269 Lower Third Brook Road to 119 Lower Third Brook Road | 46+50 | 58+00 | 0.22 |
| 4 | 757 Lower Third Brook Road to 269 Lower Third Brook Road | 58+00 | 81+50 | 0.45 |
| 5 | Lower Third Brook Road Bridge to 757 Lower Third Brook Road | 81+50 | 126+00 | 0.84 |
| 6 | Gosper Road Bridge to Lower Third Brook Road Bridge | 126+00 | 192+00 | 1.25 |
| 7 | Fletcher Road Bridge to Gosper Road Bridge | 192+00 | 266+50 | 1.41 |
| 8 | Third Brook Headwaters to Fletcher Road Bridge | 266+50 | 305+25 | 0.73 |

Subwatershed-scale division of a watershed is typically preferred for assessment studies, stream classification, and management planning for several reasons:

- ☐ First, the influence of impervious cover on hydrology, water quality, and biodiversity is readily apparent at the subwatershed level.

- ☐ Second, subwatersheds are small enough that there is less chance of confounding problem sources, thus confusing management decisions.

- ☐ Third, subwatershed boundaries tend to be located within just a few political jurisdictions where it is easier to establish a clear regulatory authority and incorporate the stakeholders into the management process.

- ☐ Finally, the size of a subwatershed allows monitoring, mapping, and other watershed assessment steps in a rapid time frame.

For analysis purposes, Third Brook has been subdivided into eight subwatersheds that correspond to the eight stream segments, as depicted in Figure 5-1. The relatively low number of subwatersheds delineated for this plan is considered appropriate for Third Brook as the watershed is only 5.4 square miles in size. Table 5-2 presents a list of the subwatersheds.

## TABLE 5-2
## Summary of Subwatershed Areas

| Watershed Designation | Jurisdiction | Subwatershed Area (ac) | Cumulative Watershed Area (ac) |
|---|---|---|---|
| 1 | Village and Town of Walton | 129 acres | 3,472 acres |
| 2 | Village and Town of Walton | 74 acres | 3,343 acres |
| 3 | Town of Walton | 186 acres | 3,268 acres |
| 4 | Town of Walton | 216 acres | 3,083 acres |
| 5 | Town of Walton | 909 acres | 2,867 acres |
| 6 | Town of Walton | 970 acres | 1,958 acres |
| 7 | Town of Walton | 450 acres | 988 acres |
| 8 | Town of Walton | 538 acres | 538 acres |

The consistency of stream segment boundaries with the subwatershed boundaries is necessitated by the "Watershed Assessment of River Stability & Sediment Supply" (WARSSS) methodology utilized later in this plan. The WARSSS methodology uses stream segment and subwatershed characteristics somewhat interchangeably; therefore, maintaining the same boundaries leads to a more straightforward use of WARSSS.

## 5.3 Stream Profile and Control Points

Appended Figure I is a plan view of the Third Brook from its headwaters upstream of Armstrong Road to the confluence with West Brook and the West Branch Delaware River downstream of the Delaware Street bridge. The center line of the channel is highlighted on the map as a black solid line, and the distances along the channel are stationed to aid descriptions. Appended Figure II is a series of plan sheets that provide close-up views of the stream, its stations, and some of the findings and recommendations of this plan.

Not including cross vanes installed after the 2006 floods, two major base control points are present along Third Brook. These are the dam at the Old Village Reservoir and the bedrock stream bed immediately downstream of the dam. The Gosper Road culvert, Lower Third Brook Road culvert, and other upstream culverts are lesser base controls because they enclose the stream but can be undermined by flood flows. The Ogden Street bridge is an open-channel bridge and does not provide base control to the stream bed. The Delaware Street bridge (box culvert) provides base control at its concrete base.

The stream profile is steep, falling over 700 feet from its source to the end at West Brook near the West Branch Delaware River. The profile in FEMA's FIS extends to the upper limit of study, which is 8,000 feet upstream from the confluence with West Brook, immediately downstream of the dam. Because the upper limit of the FEMA study is generally coincident with the bedrock base control near the dam, the profile in the FIS is coincident with the sections that were subject to the Rosgen Level II assessment. The stream bed profile in the FIS falls from elevation 1,387 feet to elevation 1,197 feet, for a total drop of 190 feet over 8,000 feet (slope of 2.4%).

## 5.4 Slope and Sinuosity

The bed slope and sinuosity of Third Brook were estimated for various segments based upon GIS and USGS mapping as well as aerial photography. For each reach, the valley length, stream length, and change in elevation were used to calculate slope and sinuosity. These figures are presented in Table 5-1.

**TABLE 5-3**
**Reach Slope and Sinuosity**

| Segment | Downstream Station | Upstream Station | Sinuosity | Slope | Description |
|---|---|---|---|---|---|
| 1 | 0+00 | 25+50 | 1.1 | 1.2% | Incised channel |
| 2 | 25+50 | 46+50 | 1.2 | 2.8% | Incised channel, significant installed grade control |
| 3 | 46+50 | 58+00 | 1.1 | 3.4% | Incised, unstable channel |
| 4 | 58+00 | 81+50 | 1.0 | 2.1% | Incised, unstable channel |
| 5 | 81+50 | 126+00 | 1.2 | 2.5% | Moderately sinuous, alluvial channel |
| 6 | 126+00 | 192+00 | 1.3 | 1.5% | Sinuous, meandering alluvial stream, some wetlands |
| 7 | 192+00 | 266+50 | 1.3 | 2.4% | Moderately sinuous, headwater stream |
| 8 | 266+50 | 305+25 | 1.6 | 3.4% | Sinuous, steep headwater stream |

Many of the segment slopes (i.e., changes in vertical grade divided by horizontal length) are similar to the overall slope of 2.4% calculated from the FIS profile. A river segment slope is a good indicator of water velocity and sediment transport capacity while the sinuosity is an indicator of the degree of channel meandering and maturity. The typical trend is for river segments that are "geologically" young or actively incising to be fairly steep and straight (low sinuosity) while "mature" channels that have worn down the landscape toward an equilibrium condition have low gradients and a higher sinuosity with a curvilinear meandering pattern and fine-grain sediments. The implications of these metrics on the river segment form and process are further discussed in the individual segment descriptions that follow.

Overall, Third Brook has relatively steeper upstream headwaters and a relatively less steep final segment (segments 8 and 1, respectively), with intermediate slopes in between. However, some of the segments (for example, segments 3 and 6) have slopes that are not consistent with this model.

## 5.5 Geomorphic Assessment by Stream Segment

Many stream classification systems have been developed to help understand the similarities and differences between watercourses. For this study, the Rosgen classification system was used. This classification is first divided into seven major stream type categories that differ in entrenchment, gradient, width/depth ratio, and sinuosity, determined by completing a geomorphic characterization. This is Level I of the process. In Level II of the morphological description, each major category is broken down into six additional types delineated by channel materials from bedrock to silt/clay.

The seven major stream types are designated A through G as follows:

- Stream type A is a steep, entrenched, cascading, and step/pool stream. It has high energy and debris transport. It is very stable, with average entrenchment ratios less than 1.4, width/depth ratios less than 12, sinuosity ranging from 1.0 to 1.2, and slope ranges of 0.04 to 0.10.
- Stream type B is a moderately entrenched, moderate gradient, riffle-dominated channel, with infrequently spaced pools. It has very stable plans, profiles, and banks. This type of stream usually has average entrenchment ratios ranging from 1.4 to 2.2, width/depth ratios greater than 12, sinuosity values greater than 1.2, and slope ranges of 0.02 to 0.039.
- Stream type C has a low gradient, riffle/pool structure. It usually meanders and has alluvial channels with broad, well defined floodplains. This type of stream has average entrenchment ratios greater than 2.2, width/depth ratios greater than 12, sinuosity values greater than 1.2, and slopes less than 0.02.
- Stream type D is a braided channel with longitudinal and transverse bars. It also has very wide channels with eroding banks. This type of stream has width/depth ratios greater than 40 and slopes less than 0.04.
- Stream type E is classified as a low gradient, meandering riffle/pool stream with low width/depth ratio and little deposition. It is very efficient and stable and has a high meander width ratio. This type of stream has average entrenchment ratios greater than 2.2, width/depth ratios less than 12, sinuosity values greater than 1.5, and slopes less than 0.02.
- Stream type F is an entrenched meandering riffle/pool channel on low gradients with high width/depth ratios. This type of stream has average entrenchment ratios less than 1.4, width/depth ratios greater than 12, sinuosity values greater than 1.2, and slopes less than 0.02.
- Stream type G is an entrenched "gully" step/pool stream with low width/depth ratios on moderate gradients. This type of stream has average entrenchment ratios less than 1.4, width/depth ratios less than 12, sinuosity values greater than 1.2, and slopes ranging from 0.02 to 0.039.

The letter of the classification is sometimes followed by a number that identifies stream substrate. The numbers are as follows:

☐ Bedrock is indicated with a "1."
☐ Boulders are indicated with a "2."
☐ Cobbles are indicated with a "3."
☐ Gravel is indicated with a "4."
☐ Sand is indicated with a "5."
☐ Silt and clay are indicated with a "6."

Table 5-2 summarizes the classifications for the eight segments of Third Brook. Only segment 5 has a classification (C3) with a slope (2.5%) that differs slightly from the range of slopes provided above. However, other characteristics of the segment are supportive of its C3 class. Detailed descriptions of the segments are provided below from downstream to upstream.

**TABLE 5-4**
**Rosgen Classification**

| Segment | Downstream Station | Upstream Station | Sinuosity | Slope | Rosgen Classification | Description |
|---|---|---|---|---|---|---|
| 1 | 0+00 | 25+50 | 1.1 | 1.2% | F3 | Incised channel |
| 2 | 25+50 | 46+50 | 1.2 | 2.8% | G3/4 | Incised channel, numerous installed grade controls |
| 3 | 46+50 | 58+00 | 1.1 | 3.4% | G3/4 | Incised, unstable channel |
| 4 | 58+00 | 81+50 | 1.0 | 2.1% | G3/4* | Incised, unstable channel, numerous installed grade controls |
| 5 | 81+50 | 126+00 | 1.2 | 2.5% | C3* | Moderately sinuous, alluvial channel |
| 6 | 126+00 | 192+00 | 1.3 | 1.5% | C3/4 | Sinuous, meandering alluvial stream, some wetlands |
| 7 | 192+00 | 266+50 | 1.3 | 2.4% | B3/4 | Moderately sinuous, headwater stream |
| 8 | 266+50 | 305+25 | 1.6 | 3.4% | B4/5 | Sinuous, steep headwater stream |

*G1 along the bedrock grade control

### 5.5.1 Segment #1

This stream segment includes the lowest 0.48 miles of Third Brook, extending from the Ogden Street bridge (station 25+50) to the confluence with West Branch Delaware River at station 0+00. The overall slope of the channel in this segment is 1.2%, and the sinuosity is 1.1. The channel bed materials are mostly cobble with some boulders. The majority of this river segment is classified as a Rosgen Type F3 channel.

From the Ogden Street bridge to the vicinity of the abandoned buildings near station 19+00, the left bank of Third Brook is bounded by a series of tall walls. The opposite side of the stream is bounded by somewhat more natural conditions, such as wooded and mowed lawn areas, including a wooded area that coincides with one of the few mapped 500-year floodplain areas in the watershed.

Downstream of station 19+00, a variety of berms, walls, and riprap line both sides of the brook until the Delaware Street bridge.  Downstream of the Delaware Street bridge, berms and stacked rocks are found along the brook from station 4+00 to station 5+00. Failing slopes and cross vanes were not observed in segment 1.

**Rock wall bank revetment behind Klinger facility and Jake's Garden Supply**

**Incised channel above Delaware Street bridge**

**Third Brook's confluence with West Brook**

### 5.5.2 Segment #2

This river segment includes 0.40 miles of Third Brook extending from the beginning of the confined channel reaches near station 46+50 (approximately located at 119 Lower Third Brook Road) to the Ogden Street bridge (station 25+50).  The overall slope of the channel in this segment is 2.8%, and the sinuosity is 1.2.  The channel bed materials are mostly gravel and cobble with some boulders.  The majority of this river segment is classified as a Rosgen Type G3/4 channel.

Stacked rock walls were observed through most of the left bank of the brook (looking downstream) although several discontinuities were present toward the upstream portion of the segment.  A stacked rock wall was also observed at the stormwater system outfall located on the right side of the stream behind the homes extending from 67 West Street in the village to 29 Lower Third Brook Road in the town (stations 37+00 to 40+00).  Further downstream on the right bank, a stacked rock wall extends along the length of the Del-Ton Sanitation property, from station 35+50 to station 26+00 (at Ogden Street).

Cross vanes were observed at the following locations:

- Station 43+00, behind 97 Lower Third Brook Road
- Station 33+00, behind Frontier Cable
- Station 31+00, behind the firehouse
- Station 29+00, behind the firehouse
- Station 26+00, immediately upstream of the Ogden Street bridge

A failing slope was observed at stations 44+00 to 46+00, behind 115 Lower Third Brook Road.  Former failing slopes, partly revegetated and mitigated, were observed where the Murphy Hill Road stormwater system outfall is located at station 39+50 (slope from 38+50 to 41+00) and behind Harold Neale Excavating at station 35+00.  Evidence of slight but continued failure was observed at the slope associated with the stormwater system outfall.

**Incised channel with riprap slope stabilization on the right descending bank**

**Stacked rock wall bank revetment near station 36+00**

**Rock cross vane grade control structures extending from the Ogden Street bridge to station 32+50**

### 5.5.3 Segment #3

Stream segment 3 includes a relatively short 0.22 miles of Third Brook, extending from the beginning of the suburban development on the left bank near station 58+00 (approximately located at 269 Lower Third Brook Road) to the beginning of the confined channel reaches near station 46+50 (approximately located at 119 Lower Third Brook Road). The overall slope of the channel in this segment is 3.4%, and the sinuosity is 1.1. The channel bed materials are mostly gravel and cobble with some boulders. The majority of this river segment is classified as a Rosgen Type G3/4 channel.

**Bank slope failure near station 58+00**

**Third Brook main stem near station 52+00, facing upstream**

Cross vanes were not observed in segment 3. Failing slopes were observed at the following locations:

- ☐ Stations 56+50 to 58+00
- ☐ Stations 54+00 to 56+00, behind 269 Lower Third Brook Road
- ☐ Stations 47+50 to 49+50, behind 173 Lower Third Brook Road

Notable stacked rock walls and other walls were not observed in segment 3.

### 5.5.4 Segment #4

Stream segment 4 includes 0.45 miles of Third Brook, extending from the downstream end of the bedrock grade and planform control downstream of the Old Village Reservoir dam (station 81+50, approximately located at 757 Lower Third Brook Road) to the beginning of the suburban development on the left bank near station 58+00. The overall slope of the channel in this segment is 2.1%, and the sinuosity is 1.0. The channel bed materials are mostly gravel and cobble with some boulders. The majority of this river segment is classified as a Rosgen Type G3/4 channel although the bedrock section is more accurately classified as G1. The channel is incised and confined on both banks.

**Third Brook main stem near station 75+00, facing downstream**

**Third Brook main stem near station 72+50, facing upstream**

**Bedrock control point downstream of dam, near station 81+50 at the upstream end of segment 4**

**Third Brook main stem near station 59+50, facing upstream from the downstream end of segment 4**

Cross vanes were observed at the following locations:

- ☐ Station 77+50, behind 709 Lower Third Brook Road
- ☐ Station 76+50, behind 683 Lower Third Brook Road
- ☐ Station 75+50, behind 683 Lower Third Brook Road
- ☐ Station 74+50, behind 683 Lower Third Brook Road
- ☐ Station 73+50, behind garage and shed
- ☐ Station 72+00, behind 599 Lower Third Brook Road
- ☐ Station 70+50, behind 599 Lower Third Brook Road

☐ Station 70+00, behind 599 Lower Third Brook Road
☐ Station 68+50
☐ Station 67+50
☐ Station 66+00

Failing slopes were observed at the following locations:

☐ Stations 75+50 to 78+00, behind 683 and 709 Lower Third Brook Road
☐ Stations 69+50 to 72+00, behind 599 Lower Third Brook Road
☐ Stations 66+00 to 67+00

An actively eroding bank was observed along the base of one of the failing slopes from station 64 to station 67.

A very old failed slope (preflood of 2006) appears to be located behind the space between 599 and 683 Lower Third Brook Road, from station 72+50 to station 75+00. This area is vegetated.

Stacked rock walls are found intermittently in segment 4 along the left bank of Third Brook. They were observed from 599 to 757 Lower Third Brook Road, or station 72 to station 81 (all the way up to the bedrock base control and the start of segment 5).

### 5.5.5 Segment #5

**Old Village Reservoir dam**

Stream segment 5 includes 0.84 miles of Third Brook, extending from the Lower Third Brook Road bridge (station 126+00) to the downstream end of the bedrock grade and planform control near the Old Village Reservoir dam (station 81+50, approximately located at 757 Lower Third Brook Road).

The overall slope of the channel in this segment is 2.5%, and the sinuosity is 1.2. The channel bed materials are mostly cobble with some gravel. Although the contribution of the dam and the resulting steep slope would indicate a Rosgen B channel, the reaches upstream of the dam are very similar in sinuosity and floodplain connectivity to a Rosgen C3 channel. The section flowing on bedrock is G1 as noted for segment 4.

A wetland system with a braided channel is located from station 112+00 to station 121+00 downstream of the Lower Third Brook Road bridge but upstream of the impoundment. The slope is less than 0.5% in this braided section, the channel is alluvial, and a pool-riffle system was observed.

**Third Brook main stem near station 103+00**

Stacked rock walls, cross vanes, and failing slopes were not observed in segment 5. However, stream bank erosion was observed immediately downstream of the dam on the east side of Third Brook at the base of the road embankment.

**Third Brook entering wetland as braided channel near station 121+00**

A short section of the stream bank is lined with riprap immediately downstream of the Lower Third Brook Road bridge near station 125+00.

**Seeley Woods Spur tributary upstream of Seeley Woods Spur Crossing**

### 5.5.6 Segment #6

Stream segment 6 includes 1.25 miles of Third Brook extending from the Gosper Road culvert (station 192+00) to the Lower Third Brook Road bridge (station 126+00). The slope of the channel in this segment is 1.5%, and the sinuosity is 1.3. The channel bed materials are mostly cobble and gravel with some sand. The Rosgen Classification of this stream segment is C3/4.

Third Brook is conveyed under Gosper Road through a 72-inch culvert. Slightly downstream of Gosper Road, the "Gosper Road tributary" joins Third Brook. Stacked rock walls, cross vanes, and failing slopes are not found in segment 6. The overall low slope of the segment is believed to be partly due to the dam and impoundment, which provide local base control even though they are located in segment 5.

Third Brook main stem approaching Lower Third Brook Road bridge

Gosper Road tributary

Gosper Road tributary upstream of Seeley Woods Spur Crossing

### 5.5.7 Segment #7

This stream segment includes 1.41 miles of Third Brook extending from the Fletcher Road culvert (station 266+50) to the Gosper Road culvert (station 192+00). The slope of the channel in this segment is 2.4%, and the sinuosity is 1.3. The channel bed materials are mostly cobble and gravel with some sand. The Rosgen Classification of this stream segment is B3/4.

Third Brook is conveyed under Fletcher Road through a 48-inch culvert. Stacked rock walls, cross vanes, and failing slopes are not found in segment 7.

**Third Brook flowing through Fletcher Road**

**Third Brook approaching Gosper Road culvert near station 192+00**

**Third Brook main stem upstream of private road crossing, near station 222+00**

**Third Brook main stem near station 205+00 viewed from State Route 206**

**Third Brook near station 238+00 viewed from State Route 206**

### 5.5.8 Segment #8

Stream segment 8 includes 0.73 miles of Third Brook, extending from the headwaters to the Fletcher Road culvert (station 266+50). The slope of the channel in this segment is 3.4%, and the sinuosity is 1.6. The channel bed materials are mostly sand and gravel with some cobbles. The Rosgen Classification of this stream segment is B4/5.

Third Brook is believed to begin in a small round pond. It flows out of the pond to the south, forming a very small pond at Armstrong Road, and is conveyed beneath Armstrong Road in an 18-inch culvert. Nearby, a small stream begins west of the round pond and crosses beneath Armstrong Road in a 36-inch culvert that is located only a couple hundred feet west of the 18-inch culvert. Either stream may be considered the headwaters of Third Brook although for the purpose of this plan the round pond is considered the source.

The two streams join in the vicinity of two ponds located on the southeast side of Armstrong Road. From this point, Third Brook flows through a heavily wooded area until it enters a small pond located immediately upstream of Fletcher Road.

**Third Brook flowing through wetland just downstream of earthen dam and Armstrong Road crossing near station 295+00**

**Tributary to Third Brook flowing over pasture with soil erosion evident. Confluence with Third Brook is between stations 290+00 and 280+00.**

## 5.6 Current Status of Slope Failures

Failing slopes were noted in the discussion above pertaining to the individual stream segments. Table 5-3 lists the failing slopes and stream segment numbers and provides a cross reference between the identification numbers used in this plan and those used by Hawk Engineering in 2010. Hawk Engineering referred to each failure as "slide 1" or "slide 2" whereas they will be known as "failure 1" or "failure 2" from this point forward in this document.

### TABLE 5-5
### Failed or Failing Slopes Observed in 2012

| Current ID "Failure" | Prior ID[1] "Slide" | Status[2] | Segment | Location (Station) | Location Description |
|---|---|---|---|---|---|
| 1 | 1 | Mitigated | 2 | 35+00 | Behind Harold Neale Excavating |
| 2 | 2 | Mitigated | 2 | 39+50 | Behind 19 and 29 Lower Third Brook Road |
| 3 | -- | Active | 2 | 45+00 | Behind 115 and 119 Lower Third Brook Road |
| 4 | 3 | Active | 3 | 48+50 | Behind 173 Lower Third Brook Road |
| 5 | 4 | Active | 3 | 55+00 | Behind 269 Lower Third Brook Road |
| 6 | 5 | Active | 3 | 57+50 | Behind 269 Lower Third Brook Road |
| 7 | 6 | Active | 4 | 68+00 | Near 599 Lower Third Brook Road |
| 8 | 7 | Active | 4 | 71+00 | Behind 599 Lower Third Brook Road |
| 9 | 8 | Active | 4 | 77+00 | Behind 709 Lower Third Brook Road |

1. Hawk Engineering, 2010 and previous correspondence
2. Mitigated failures may have ongoing needs as described in this plan.

**View of failure 1 from Harold Neale Excavating Company**

Failure 1 is considered mitigated at this time. The slope was regraded, fitted with fabric-wrapped soil lifts, and vegetated. A stacked rock wall was installed at the toe.

Failure 2 was partly addressed with riprap and installation of a new outfall structure to convey drainage from Route 206 to the Third Brook channel (this is one of the stormwater systems described in Section 3.7). When facing the new outfall, it is apparent that the right-hand side of the former failed slope is still at risk. The toe of the slope is eroding, and a scarp is visible near the top of the slope. Few trees are located on the slope; it is primarily grassy. The area of the failing part of the slope is 11,145 square feet.

**View of failure 2 from opposite side of brook**

**View of failure 3 from opposite side of brook**

Failure 3 is located between two intermittent streams that are associated with the drainage systems in Route 206. However, drainage does not flow down the face of the slope. This failure is not as high as some of the others, but the scarp is quite steep, and trees are actively sliding. The area of the failing part of the slope is 2,680 square feet.

Failure 4 has a variable surface with some fallen trees. Photographs from March 2007 show groundwater seeping from the face of the slope. The area of the failing part of the slope is 20,758 square feet.

**View of failure 4 from opposite side of brook**

**View of failure 5 from opposite side of brook**

Failure 5 is an erosional feature as well as a failing slope. An intermittent watercourse flows downhill through the centerline of the failure. This watercourse appears to be associated with one of the drainage systems along Route 206.

Failure 6 has a variable surface with some fallen trees. The scarp does not appear to reach the top of the slope. The combined area of failures 5 and 6 is 32,807 square feet.

**View of failure 6 from opposite side of brook**

**View of failure 7 from opposite side of brook**

Failure 7 is much smaller in stature than the others. The area of the failing part of the slope is only a few thousand square feet and has been summed with the area of failure 8.

Failure 8 is downhill from a field, and it may receive some runoff from this area, especially given that drainage outfalls associated with Route 206 are located along this field. The scarp reaches from the top of the slope to the brook and is therefore higher than some of the others. The combined area of failures 7 and 8 is 100,234 square feet (over two acres).

**View of failure 8 from opposite side of brook**

**View of failure 9 from opposite side of brook**

Failure 9 is located downhill from a field and may receive some runoff from this area, especially given that drainage outfalls associated with Route 206 are located along this field. The scarp reaches from the top of the slope to the brook and is therefore higher than some of the others. The area of the failing part of the slope is 25,564 square feet.

## 5.7 Additional Geomorphic Assessment

MMI staff returned to the Third Brook watershed to conduct additional assessment downstream of the Old Village Reservoir, concentrated in segments 1 through 5 where the slope failures, bank erosion, and major flooding have occurred. This work included cross-sectional surveys and pebble counts at nine positions along Third Brook throughout this approximately 1.5-mile stretch of the brook from the reservoir to its confluence with West Brook.

Cross-sectional surveys were conducted using a rod and level. Stakes were driven at both banks, and a tape (graduated in tenths of a foot) was run across the brook. The stake nearest the level was determined to be the benchmark stake. An arbitrary elevation was assigned to each benchmark as formal elevational surveys were not conducted. The level was positioned at a location toward the upland and landward of the benchmark. The benchmark was always on the left bank (looking downstream) and was the terminus of one end of the tape that stretched the river at an elevation above twice the bankfull elevation. The benchmark was labeled by MMI staff as such.

The nine locations of cross sections were conducted in the sequence noted on Table 5-4. The field names and assigned final identification numbers are listed in the table. The final identification numbers are in consecutive numerical order from the cross section closest to Third Brook's confluence with West Brook to the first cross section downstream of the reservoir. In other words, cross sections were numbered from downstream to upstream, like the stream segments but unlike the subwatersheds.

**TABLE 5-6**
**Cross Sections**

| Sequential Order | Field Name | Final Section ID | Station | Stream Segment |
|---|---|---|---|---|
| 9 | Site #9 | Cross Section #1 | 6+00 | 1 |
| 8 | Site #8 | Cross Section #2 | 15+50 | 1 |
| 1 | Ogden Street | Cross Section #3 | 25+50 | 1/2 |
| 2 | Fire Station | Cross Section #4 | 29+50 | 2 |
| 3 | Vacant Lot | Cross Section #5 | 42+00 | 2 |
| 4 | Site #4 | Cross Section #6 | 50+00 | 3 |
| 5 | Site #5 | Cross Section #7 | 60+50 | 4 |
| 6 | Site #6 | Cross Section #8 | 74+50 | 4 |
| 7 | Site #7 | Cross Section #9 | 81+00 | 4 |

All benchmark/stake elevations obtained in the field survey were taken from the ground surface at the base of the benchmark. Twice bankfull elevation (to deepest point in cross section) is the elevation that provides the area of floodprone width according to the Rosgen classification system.

Pebble counts were conducted at all but two sites: at cross section #9, where the streambed is bedrock, and at cross section #1, where pebble size and distribution were determined to be similar to cross section #2. The cross-section plots are provided in Appendix D. The results of the pebble counts are reported in Appendix E. The results of the pebble counts were used to refine the Rosgen classifications of the stream segments and complete some of the WARSSS worksheets, described below.

## 5.8 Watershed Assessment of River Stability and Sediment Supply (WARSSS)

According to the U.S. Environmental Protection Agency (EPA), excess sediment has been a leading cause of water quality impairment across the United States, but methods to assess sediment problems and plan solutions have been limited. WARSSS is a technical procedure developed by Dr. David L. Rosgen for water quality scientists to use in evaluating streams and rivers impaired by excess sediment. WARSSS is a three-phase technical framework of methods for evaluating suspended and bedload sediment in rivers and streams using a watershed assessment approach. WARSSS can be used to analyze suspected sediment problems, develop sediment remediation and management components of watershed plans, or develop sediment TMDLs.

The WARSSS methodology is broken into three levels: the Reconnaissance Level Assessment (RLA), the Rapid Resource Inventory for Sediment and Stability Consequence (RRISSC), and the Prediction Level Assessment (PLA):

- ☐ RLA is the first and most general of three phases of the WARSSS assessment. This phase helps the assessor to: (1) identify places in the watershed that represent likely sediment sources and channel stability problems and thereby limit the effort and costs of the more intensive WARSSS phases; (2) begin assembling and examining existing information; (3) verify or redirect the problem identification; (4) eliminate subwatersheds, reaches, or areas within the watershed (e.g., stable slopes) that do not contribute excessive sediment; and (5) locate and focus on potentially important problem areas, reaches, or subwatersheds for the next phase.

- ☐ RRISSC begins with the subset of key areas identified during RLA as potentially significant sediment sources. RRISSC allows sensitive landscapes, potentially unstable stream systems, and sediment-generating land use activities to be identified, prioritized, and assessed for potential impacts. Like the RLA, RRISSC reduces the number of key areas that will be moved onward in WARSSS to the next, most intensive phase of PLA.

- ☐ The PLA is the most detailed level of investigation for slopes, subwatersheds, and river reaches identified as being high risk associated with sediment and/or river stability problems. A major benefit associated with PLA is the ability to link quantitative evaluation of sediment sources and/or river stability problems to an individual source at a specific location, affecting a particular process. The results allow the user to identify proportional distribution of sediment yields, consequences of sediment on river stability, and the influence of river instability on sediment yields.

To address PLA's uncertainty of prediction, validation monitoring is a key objective for this level of assessment that compares predicted to observed values. The same monitoring approach can also determine the effectiveness of any attempted mitigation.

The PLA assessment typically utilizes a "reference condition" that represents stable natural land and/or stream systems to compare direction, rate, nature, and extent of departure from natural rates of sediment and/or natural stability and to document "acceptable" erosion and sedimentation rates. For Third Brook, a suitable reference reach or segment is not readily available. The segments upstream of the Old Village Reservoir are markedly different in land use and watershed size as compared to the segments downstream of the Old Village Reservoir and, therefore, would constitute poor reference segments. On the other hand, none of the segments downstream of the Old Village Reservoir would be good reference segments because they are all impacted to some degree by flooding, failing slopes, incision, etc.

All eight of the Third Brook segments and their associated subwatersheds were evaluated via the RLA. Segments 1 through 5 were advanced to the RRISSC phase primarily because these are the segments where slopes are failing, the channel is downcutting, and/or sedimentation is taking place. However, only a small portion of segment 5 is undergoing bank erosion. The majority of segment 5 and its subwatershed was not evaluated through RRISSC. Segments 1 through 5 were advanced from the RRISSC phase to the PLA phase.

It is important to note that the WARSSS methodology is not an ideal fit for the Third Brook watershed for several reasons.

- ☐ According to Rosgen, candidates for the WARSSS assessment usually include Clean Water Act Section 303(d)-listed streams with a variety of impairments that may be caused by sediment imbalances or channel instability. The *Final New York State 2012 Section 303(d) List of Impaired Waters Requiring a TMDL/Other Strategy* (July 2012) lists only one stream in Delaware County, and this is Trout Creek located west of the town and village of Walton. Third Brook has therefore been assessed through WARSSS *without* a 303(d) listing.

- ☐ Also according to Rosgen, the WARSSS methodology provides a procedure to assess large watersheds. The oft-cited WARSSS case studies include Wolf Creek (Colorado) with a drainage area of 22 square miles, the South Branch Buffalo River (Minnesota) with a drainage area in excess of 454 square miles, and Horseshoe Run (West Virginia) with a drainage area of 60 square miles. All case studies are much larger than the Third Brook watershed. In small watersheds such as Third Brook, the sediment and instability issues are often much more straightforward to evaluate directly through observations because vast land areas and numerous stream segments do not need to be organized.

- WARSSS is organized to characterize changing land uses such as deforestation, logging, expansion of agriculture, or other activities that directly affect the landscape. The Third Brook watershed is not undergoing these types of changes. In fact, the static conditions in the watershed differ from all of the WARSSS case studies cited above and found in the literature.

- Finally, the WARSSS methodology provides a significant number of evaluation tools and worksheets to characterize sediment production and quantify sediment yields from land uses, roads, and bank erosion. However, WARSSS does not address slope failures in the same way, leaving a gap that requires sediment from failing slopes to be calculated somewhat separately.

The fourth drawback listed above is important because the slope failures are the largest current source of sediment loading to Third Brook. To ensure that they were directly included in the WARSSS evaluation, the total area of failing slopes in each stream segment was used in Worksheet 5-10 instead of bank lengths and study bank heights. In other words, the failing slopes were treated as if they were eroding stream banks.

Because suspended sediment and bedload sediment were not measured in Third Brook during the development of this plan and have not been measured in the past, it was necessary to make assumptions regarding suspended sediment and bedload sediment in the brook. A series of water quality data sets is available in a USGS publication (2006) that characterizes quality of waters in the NYCDEP watersheds. The bankfull suspended sediment value for Third Brook was assumed to be 22,900 milligrams per Liter (mg/L) based on suspended sediment measurements nearby in Town Brook. The suspended sediment value at very low flows was assumed to be zero.

Bedload sediment is infrequently measured. Practitioners typically assume that bedload sediment is 10% (Bloom, 1978) or within a range of 5% to 25% of the total sediment transported in a stream in a year. Because total sediment is largely equal to suspended sediment plus bedload sediment, one can estimate bedload sediment if suspended sediment is understood or assumed. Rosgen (1989) notes that bedload sediment can be as high as 75% of total sediment for some streams. However, the 10% figure has been assumed representative of Third Brook because the sediment from failing slopes has been estimated separately.

Appendix F contains the WARSSS worksheets. The RLA worksheets were completed for Third Brook's eight segments and their respective subwatersheds. The RRISSC and RLA worksheets focused on segments 1 through 5 although the information found in the forms for segment 5 was primarily focused downstream of the Old Village Reservoir. The statistical flows and flow duration curve discussed in Section 3.0 were used for many of the worksheets that rely on discharge data; excel sheets are included among the worksheets where necessary.

Worksheet 5-10 provides the annual stream bank erosion estimates for the five stream segments advanced to the RLA. The form was divided into two parts, one for stream bank erosion and one for slope failures. The total stream bank erosion sediment yield was estimated at 19 tons/year whereas the figure for slope failure sediment yield was estimated at 2,326 tons/year. These two figures were carried forward to worksheet 5-23 and combined with the figure estimated for roadways contributions (1.5 tons/year) for a total of 2,347 tons/year. Given the proportion of this figure originating from failing slopes, the remediation of these slopes is a high priority for the county, village of Walton, and town of Walton.

# 6.0 POLICIES, PROGRAMS, PLANS, AND REGULATIONS

## 6.1 Federal and State Plans, Policies, and Regulations

The New York City water supply system consists of unfiltered surface water sources that supply an average of 1.3 billion gallons per day of drinking water to more than nine million people in the New York City metropolitan area. The West Branch Delaware River's Cannonsville Reservoir watershed covers 455 square miles and accounts for 28% of the Catskill/Delaware Watersheds. The Cannonsville Reservoir watershed provides approximately 12% of the city's drinking water whereas the Catskill watersheds together provide half of the city's drinking water. The NYCDEP is the city agency with primary responsibility for oversight of the operation, maintenance, and management of the water supply infrastructure and the protection of these watersheds.

As a tributary of the West Branch Delaware River upstream of the Cannonsville Reservoir, Third Brook is in the New York City drinking water supply watershed. Watershed protection has historically been addressed at the county level, described below in Section 6.2. However, watershed protection is first enabled at the federal and state levels.

### Clean Water Act (CWA)

The CWA (Water Pollution Prevention and Control, U.S. C Title 33 Section 1251) requires states to classify waters according to their best uses and to adopt water quality standards that support those uses. Section 404 of the CWA requires that anyone interested in depositing dredged or fill material into waters of the United States, including wetlands, must receive authorization for such activities. The U.S. Army Corps of Engineers (USACE) has been assigned responsibility for administering the Section 404 permitting process.

### Safe Drinking Water Act (SDWA)

The SDWA amendments of 1986 required the United States EPA to develop criteria under which filtration would be required for public surface drinking water supplies. In 1989, United States EPA promulgated the Surface Water Treatment Rule (SWTR), which requires all public water supply systems supplied by unfiltered surface water sources to either provide filtration or meet a series of water quality, operational, and watershed control criteria ("filtration avoidance criteria"). NYCDEP filed for and received a conditional, renewable Filtration Avoidance Determination (FAD) in May 1997. The FAD is periodically reviewed and evaluated by the United States EPA and the New York State Department of Health.

The protection and enhancement of water quality in the New York City watersheds depend upon the cooperation and efforts of the communities and residents of the watersheds. Under the SWTR, the avoidance of filtration requires that the "public water system must demonstrate through ownership and/or written agreements with landowners within the watershed that it can control all human activities."  The New York City Watershed Memorandum of Agreement (MOA) provides that control and is the mechanism that allows the United States EPA to grant the FAD.

Involvement of local stakeholders in meeting the TMDL requirements of the CWA is also a necessity recognized by EPA.  Therefore, under both the SDWA and CWA, local agencies and communities have significant roles in watershed protection.

### New York State Department of Environmental Conservation (NYSDEC)

The NYSDEC works to reduce water pollution through technical assistance for prevention, education, and monitoring. The NYSDEC also provides financial assistance to local governments for a variety of water quality projects.  The NYSDEC has extensive regulatory authority through its administration of the New York State Environmental Conservation Law (ECL).

### New York State Department of State (NYSDOS) Division of Coastal Resources

The Division of Coastal Resources helps protect and enhance coastal and inland water resources and encourage appropriate land use.  The Division also works in partnership with local governments in preparation of Local Waterfront Revitalization Programs, which serve as comprehensive land and water use plans, as well as intermunicipal watershed management plans, which identify problems and threats and opportunities for achieving long-lasting improvements in water quality and establish priorities for action. Financial assistance for the preparation and implementation of such programs and plans is available through the Environmental Protection Fund (EPF).

### New York State Department of Agriculture and Markets

The Department of Agriculture and Markets provides administrative support to the State Soil and Water Conservation Committee (SWCC), which in turn provides guidance to the county Soil and Water Conservation Districts (SWCD).  In addition, the Department of Agriculture and Markets oversees many aspects of farming that cannot be regulated by municipalities.

### New York State Department of Health (NYSDOH)

The DOH monitors impacts of nonpoint source pollution through water quality monitoring and reporting programs.  New York Public Health Law contains statutes regulating the protection of public water supplies from contamination due to source and nonpoint source pollution.  Given the importance of this law, it is described separately below.

New York State (NYS) Watershed Rules and Regulations

The NYS Public Health Law allows local water supply officials to initiate a process leading to enactment of watershed rules and regulations by the Commissioner of the State Health Department. These rules were first developed in the late 19th century to protect tributary streams and reservoirs used to supply drinking water. They were later applied to public wellfields and adjacent aquifer areas. Most of the nearly 200 public water supply systems in New York that adopted watershed rules did so prior to 1940.

Watershed rules specify minimum linear setbacks for different uses. For example, many regulations prohibit the location of salt storage sites within 500 feet of public supply wells, reservoirs, or tributary streams to reservoirs. The limitations of existing watershed rules were documented in the 1981 NYS Department of Health study "Water Supply Source Protection Rules and Regulations Project." The report concluded that water supply protection regulations should be customized to the particular conditions existing at the public supply wellfield or reservoir and that the concept of minimum acceptable distance does not address the differences between types of potential contaminants such as pathogens and synthetic organic chemicals.

Watershed rules and regulations are unique in being the only controls specifically designed to protect public water supplies. These regulations are prepared jointly by the water purveyor and the NYS Department of Health local public health engineer. Enforcement responsibility, such as with the use of a designated "Watershed Inspector," rests with the water utility, the district health officer or, in some cases, the municipal or county health department. The NYS Department of Health provides a form entitled "Annual Report on Violations of Watershed Rules and Regulations" on its website. This form can be used by a water utility that has adopted rules and regulations.

The NYS Sanitary Code Subpart 5-1 covers public water systems. Section 5-1.12, "Water quality for existing sources of water supply" specifies the following:

(a) Whenever the supplier of water determines or is advised by the State that one or more of the MCLs set forth in this Subpart are or may be exceeded; or that effectiveness of treatment processes diminishes to the extent that a violation of the treatment techniques or MCLs set forth in this Subpart may occur; or that any deleterious changes in raw water quality have occurred; or that a change in the character of the watershed or aquifer has been observed which may affect water quality; or that any combination of the preceding exists, the supplier of water shall notify the State and do the following:

1. undertake a study to determine the cause or causes of such conditions, independent of known or anticipated treatment technology;
2. modify existing or install treatment to comply, to the extent practicable, with sections 5-1.30, 5-1.50, 5-1.51 and 5-1.60 of this Subpart;

3. initiate water sampling as needed to delineate the extent and nature of the cause of concern;
4. investigate all or part of the watershed or aquifer to verify any existing or potential changes in the character of the sources of water supply; and
5. submit a written report to the State within 30 days of the onset of the foregoing conditions summarizing the findings outlined in paragraphs (1) through (4) of this subdivision.

(b) The State may require the supplier of water to conduct sanitary surveys and to conduct water sampling related to watersheds and groundwater aquifers which are sources of water supply to identify and evaluate the significance of existing and potential sources of pollution and to report the results to the State. Also, sanitary surveys shall be used to evaluate the adequacy of the public water system, the source or sources of water supply and the water treatment plant to produce potable water.

The State of New York Title 10, Department of Health, Chapter II, Part 75, "Standards for individual water supply and individual sewage treatment systems" provides a linkage to watershed protection. Specifically, where sewage treatment systems are to be located on the watersheds of public water supplies, the rules and regulations enacted by the State Department of Health for the protection of these supplies must be observed.

## 6.2 County and NYCDEP Plans, Policies, and Regulations

### Delaware County Action Plan

*Under the New York City watershed regulations, Delaware County was faced with a prohibition on the expansion or building of new wastewater treatment plants (WWTP) with surface discharges in the Cannonsville watershed. This prohibition created a negative impact on opportunities for growth in the county. The potential economic consequence created the circumstances under which the county was compelled to take action under one of the variance provisions for its own economic well-being: Section 18-83 of the New York City Watershed Regulations provides for new WWTPs or the expansion of an existing WWTP if a comprehensive strategy is developed and implemented. As a practical matter, only by complying with Section 18-83 can the county use flexibility in complying with the regulations in a phosphorus-restricted basin, protect water quality, and address its economic objectives.*

The Delaware County Action Plan (DCAP) for Watershed Protection and Economic Vitality was developed in 1999 per Section 18-83 of the *Rules and Regulations for the Protection from Contamination, Degradation and Pollution of the New York City Water Supply and its Sources* as a result of the phosphorus-restricted basin designation of the Cannonsville watershed. The second edition of the DCAP was published in May 2002.

The DCAP is a comprehensive strategy. To successfully accomplish its mission for improving water quality, two specific goals were identified: (1) institute specific contaminant reductions for individual management sources of the contaminants; and (2) meet overall basin-level goals of contaminant load reductions such as the operational goal of reducing phosphorus by 10,000 kilograms/year. The DCAP coordinates with public and private agencies to develop water-quality initiatives and seek funding for implementation.

The DCAP has adopted a multiple-barrier approach to address pollutants. The barriers utilized are called the Initial Source Barrier, the Transport Barrier, and the Stream Corridor Barrier. Current components of DCAP include management programs for stormwater and flooding, highway runoff, septic systems, precision livestock feeding, forage management, and monitoring and modeling of best management practices to assess phosphorus reduction. By coordinating all water quality efforts under the DCAP umbrella, these programs are reportedly working together to collectively reduce pollutants entering watercourses and to improve overall water quality. Individual components of the DCAP are listed below.

Storm Water and Flood Management

- Characterize and quantify storm water sources from various land uses.
- Identify and adopt storm water pollution prevention measures.
- Collect GIS information and create databases to assist businesses and communities in their decision-making.

Animal Manure and Farm Nutrient Input

- Describe and identify the excess phosphorus on farms.
- Develop strategies to reduce phosphorus importation to farms.
- Seek measures to reduce the phosphorus loading by immobilizing or instituting options such as composting.
- Improve nutrient cycling to increase exports from the basin or to better contain them on farms.

Septic Systems and Waste Water Treatment Plants

- Identification and needs assessment of septic systems will quantify pollutant levels.
- Develop long-range strategy to maintain, repair, or replace individual systems.
- Aid communities, when appropriate, by planning long-term solutions for wastewater treatment.

Highway Drainage

- Conduct an inventory to determine need and opportunity for improved drainage and run-off for infrastructure improvement and phosphorus control.
- Identify short-term management opportunities.
- Describe long-term infrastructure improvements that will reduce adverse impacts on water quality.

Stream Corridor Protection and Rehabilitation

- Identify stream corridors where management will provide the greatest benefit.
- Reduce risks posed by excessive floodwater activity.
- Reduce contaminant transport that results from flooding.

### Building Local Capacity

- ❑ Demonstrate that quality drinking water can be delivered to New York City under the Filtration Avoidance Determination criteria.
- ❑ Assist businesses, institutions and municipalities that own non-complying activities.
- ❑ Educate the public on the importance of their role in projects and their implementation.

### Monitoring and Modeling and Scientific Credibility

- ❑ Monitoring of water quality before and after various project implementations necessary for a more complete accounting of phosphorus.
- ❑ Monitoring water quality will continue in order to take advantage of phosphorus offsets mechanisms described in the Memorandum of Agreement.
- ❑ Watershed models will be developed to describe and manage point and non-point sources of phosphorus over a long period of time.
- ❑ Quantifying imports and exports of phosphorus in the basin.

### West Branch of the Delaware River Stream Corridor Management Plan

Central to maintaining NYCDEP's FAD is a series of partnership programs between New York City and the upstate communities along with the set of rules and regulations administered by the NYCDEP. As required in the FAD, Stream Corridor Management Plans are developed and implemented under the Stream Management Program (SMP). The West Branch Delaware River Stream Corridor Management Plan (SCMP) was developed by DCSWCD and the DCPD under contract with NYCDEP. One component of the SMP is the preservation of water quality through effective management of the streams and associated floodplains that feed water supply reservoirs.

According to the Executive Summary of the SCMP, the plan "provides a foundation for local residents, municipalities, interested organizations and cooperating agencies to enhance stewardship of the West Branch Delaware River and its tributaries. Funded by the New York City Department of Environmental Protection and the U. S. Army Corps of Engineers, this Plan is a culmination of four years of study and assessment in coordination with the Delaware County Action Plan (DCAP). Guided by a local Project Advisory Committee, this Stream Corridor Management Plan is representative of how both upstate and downstate stakeholders can work in partnership to protect and enhance a mutually beneficial resource."

The SCMP states that "West Branch Delaware River has a tendency to become shallower and wider than is desirable due to increased sediment supply from excessive bank and bed erosion in the main river and its tributaries. While erosion and deposition are natural processes, many management activities can significantly increase erosion rates that in turn contribute to increases in sediment supply. These conditions demonstrate the need for comprehensive management and stewardship by all stakeholders."

The erosion and deposition problems articulated in the SCMP are not new phenomena. Interest in developing a coordinated management strategy for the West Branch of the Delaware River emerged after the January 19, 1996 flood event. After this flood, the dramatic stream and infrastructure damages that resulted, and subsequent emergency repair work, it was apparent that stream-related activities in certain areas, although well intentioned, had set the stage for excess damages during a flood. As a result, the condition of the West Branch significantly changed in many areas of the watershed. Small instability and erosion problems worsened, small eroding banks became larger failures, and some stream courses were significantly altered.

It is important to note that the current version of the SCMP was published in May 2006, only a month before the devastating flood of June 2006 in the Third Brook watershed. Recommendations of the SCMP include the following:

1. Integration of the Stream Corridor Management Program and Watershed Agricultural Program
2. Provide Technical Support to the USDA Conservation Reserve Enhancement Program (CREP)[7]
3. Enhance the Implementation of CREP on New York City Watershed Cropland and Explore Long-Term CREP Contracts
4. Implement a Variable Width Riparian Buffer Pilot Program
5. Participation with the Catskill Watershed Corporation
6. Stream Corridor Management Plans for Non-Agricultural Riparian Landowner Stewardship
7. Stream Gravel Deposition Issues
8. Streamline Stream Work Permitting
9. Assist Municipalities with Culvert Sizing and Design
10. Participation with the DCAP
11. Expand Public Education and Outreach Efforts
12. Geomorphic Assessments at Bridges and Culverts
13. Flood Hazard Mitigation and Flood Recovery
14. Continuation of Geomorphic Research/Assessments
15. Seek Funds Necessary for Construction of Walton Stream bank Stabilization Projects
16. Prioritization of Identified Stream Intervention Projects
17. Develop a Process for Updating the West Branch Delaware River Stream Corridor Management Plan

The SCMP provides a framework for general stream management decision making in the watershed. The plan provides documentation of current stream conditions along the West Branch and a broad assessment of the condition of existing infrastructure. All of the above recommendations are considered consistent with the goals of this Third Brook watershed management plan.

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[7] Several properties in the Third Brook watershed are already in the CREP. These include Healing Waters Farm and the Gunther Farm.

## 6.3 Local Plans, Policies, and Regulations

### Town of Walton Comprehensive Plan (2006), Zoning, and Subdivision

The Town of Walton prepared a Comprehensive Plan in 2006 under the direction of the Town Board and the Planning Board. The Comprehensive Plan is divided into three sections. Section I describes existing conditions in the town, inclusive of the village. Physical characteristics, demographics, housing, land use, the local economy, and the New York City watershed program are described. Section II presents the goals, objectives, and action items. Section III is an appendix and describes the results of the public participation process and surveys.

The Comprehensive Plan states that the commercial and industrial sectors of the local economy are located within the village limits and describes some of these land uses. The Comprehensive Plan notes in Section I(A)(3)(d) that *"East Brook, West Brook, and Third Brook all flow into the Delaware River within the limits of the Village. The convergence of these four water courses in a very small area has the potential to create a serious flood hazard area, especially within the Village. According to the Flood Insurance Rate Maps issued by FEMA, each of these streams represents a serious flood hazard. Recent experience of the Town and Village confirms this flood hazard; in January 1996, a warm temperature spike and heavy rain falling on deep snow cover in the surrounding hills resulted in a very serious flooding (and a fire) in the downtown commercial area of the Village."*

The Comprehensive Plan includes a detailed description of the town's zoning law. The Town of Walton Zoning Law was adopted in 1991 and amended in 1997 with regard to land use. Two subsequent amendments were adopted specifically to address mobile phone towers and wind turbine proposals.

The three zoning districts are Rural II (R-2), Rural V (R-5), and Industrial. The only land in the town (outside the village) that is zoned Industrial is 16 acres located south of the village, distant from the Third Brook watershed. Portions of the rural districts are located in the Third Brook watershed.

The R-2 district has a two-acre lot size and 200-foot frontage minimum, and the R-5 district has a five-acre lot size and 300-foot frontage minimum. The location of the two R districts is defined by distance from roads. The R-2 district includes all land within 1,000 feet of the centerline of a state or county road or within 500 feet of the centerline of any town road and with direct frontage and direct access to the road. All other lands are in the R-5 district. In the Third Brook watershed, R-2 zones lie along Route 206, Lower Third Brook Road, Gosper Road, Seely Wood Road, Seely Wood Road Spur, and Armstrong Road.

Agricultural, forest, wildlife management uses, and noncommercial residential uses are permitted by right throughout the town, and many other uses are allowed by Special

Permit in the R-2 district. Many commercial and industrial uses are permitted by Special Permit in the R-2 district (along roads) but not in the R-5. According to the Comprehensive Plan, the effect of the zoning code is to encourage development along roads.

The town has one overlay zone, known as the Development Limitations Overlay (DL) zone. The overlay zone includes FEMA-delineated SFHAs, freshwater wetlands protected by the state, and steep slopes exceeding 25%. The purpose of the overlay is to prevent "overdevelopment in and around natural areas and environmentally sensitive areas important to the people of the Town of Walton." Allowed uses are essentially the same as the underlying zones except that special permits are required for developments in SFHAs, and activities within or near state wetlands require the applicable state and federal permits.

The Town of Walton Subdivision Regulation was enacted in 1986 and has remained unchanged since. The regulation establishes three levels of subdivision as follows: a simple division (up to three lots; no approval required), a minor subdivision (up to six lots; approved through a simplified process), and a major subdivision. A major subdivision results in seven or more lots and/or requires creation or extension of public facilities or improvements. A major subdivision requires a public hearing and preliminary and final plan approval by the Town Planning Board.

According to the Comprehensive Plan, the town does not have a process for allowing "cluster" or "open space" development. The Comprehensive Plan concludes that the current zoning and subdivision regulations encourage strip development along roads, whether residential or nonresidential, and notes that this is counter to the goal of preserving rural characteristics. Nevertheless, less than 1% of the parcels located in the town (outside the village) are classified as commercial or industrial.

The Comprehensive Plan notes that "there is substantial small farm activity in the Town of Walton." An example is the Healing Waters Farm, which is located in the Third Brook watershed and featured in the Comprehensive Plan with a photograph.

In Section II, the Comprehensive Plan states that the town and village combined have a desire for economic development and job creation, but such development activity should be located in and immediately surrounding the village. In the outlying areas, public policy should support agricultural activity, properly managed forestry and logging, continued bluestone production, and continued rural residential development. Table 6-1 lists the individual goals and objectives from Section II.

# TABLE 6-1
# Comprehensive Plan Goals and Objectives

| Objective | Responsible Entities | Potential Funding Sources* | Consistent with Third Brook Watershed Management Plan? |
|---|---|---|---|
| *Land Use Goal – Preserve Rural, Scenic, and Natural Resources* | | | |
| Revise zoning to incorporate NYS legislative changes and land use trends | Planning Board, County | DOS | Yes |
| Revise Subdivision Regulations to incorporate NYS legislative changes and land use trends | Planning Board, County | DOS | Yes |
| Establish critical environmental areas (CEAs) to protect natural resources | Planning Board, County | DEC | Yes |
| Consider other land use regulations for wind turbines and communications towers | Planning Board, County | DOS | Not applicable |
| *Infrastructure Goal – Investigate Improvements to Infrastructure* | | | |
| Develop highway management plan | Highway Department, County Public Works | DOS, CWC | Yes |
| *Local Economy Goal – Preserve Existing Economic Resources* | | | |
| Encourage organic agriculture | Town Board, County | DOA&M | Yes |
| Encourage alternative agriculture | Town Board, County | DOA&M | Yes |
| Support development of small and home-based businesses | Town Board, County | CED, COC | Yes |
| Encourage second homeowners to relocate businesses to Walton | Town Board, County | CED, COC | Not applicable |
| Encourage second homeownership | Town Board | -- | Not applicable |
| Continue to support well-managed forestry and logging | Town Board | CED, COC | Yes |
| Continue to support bluestone production | Town Board | CED, COC | Not applicable |
| *Watersheds Goal – Ensure Town is Prepared for Future Challenges in NYC Watershed* | | | |
| Support the Delaware County Action Plan and maintain awareness of regional watershed groups | Town and Planning Boards, County | County Watershed Affairs | Yes |
| *Recreation Goal – Identify Recreational Activities and Promote Them* | | | |
| Identify recreational activities and promote to benefit potential participants | Town and Planning Boards, County, COC | -- | Not applicable |
| *Education and Outreach Goals – Enhance Code Enforcement and Improve Website* | | | |
| Enhance code enforcement | Town Board, County | DOS | Yes |
| Improve town's website | Town and Planning Boards, County, Town Clerk | DOS | Not applicable |

*DOS = Department of State
DEC = Department of Environmental Conservation
CWC = Catskill Watershed Corporation
DOA&M = Department of Agriculture and Markets
CED = County Economic Development
COC = Chambers of Commerce

The Walton Comprehensive Plan notes that "Within its geographic area of regulatory jurisdiction, which includes the entire Town of Walton, NYC regulations establish a series of requirements, standards, setbacks, prohibitions and NYC permits and inspections associated with almost any new development." NYC also maintains a land acquisition program although this program has not targeted property in the town or village of Walton in recent decades.

### Town of Walton Flood Damage Prevention

The Town of Walton has adopted a local law for flood damage prevention. Revisions were adopted in 2012 to be consistent with the guidance provided by the state in 2007 for counties where new FEMA studies were being conducted. The town adopted the recommended revisions. These are identical to the revisions adopted in the village, as described below.

The Town of Walton has posted a public notice in its town hall regarding flooding. The notice was posted in 2011 after storms Irene and Lee and states that the town is "aggressively pursuing preemptive management of our flooding problems with FEMA allotted funds and permits from the DEC to remove fallen and falling trees as well as cleaning out rocks, gravel, soil, branches, tree trunks and other troublesome vegetative debris from our streams…." The notice provides the names and contact information for various town officials and contractors who may assist with debris management.

### Village of Walton Flood Damage Prevention

As authorized by the New York State Constitution, Article IX, Section 2 and Environmental Conservation Law, Article 36, the Village of Walton has adopted a local law for flood damage prevention. Chapter 25 of the municipal code is the Flood Damage Prevention code. Revisions were adopted in 2012 to be consistent with the guidance provided by the state in 2007 for counties where new FEMA studies were being conducted.

The stated purposes of this local law are to:

- Regulate uses that are dangerous to health, safety, and property due to water or erosion hazards, or that result in damaging increases in erosion or in flood heights or velocities;
- Require that uses vulnerable to floods, including facilities which serve such uses, be protected against flood damage at the time of initial construction;
- Control the alteration of natural floodplains, stream channels, and natural protective barriers that are involved in the accommodation of flood waters;
- Control filling, grading, dredging and other development that may increase erosion or flood damages;
- Regulate the construction of flood barriers that will unnaturally divert flood waters or that may increase flood hazards to other lands, and;
- Qualify and maintain for participation in the National Flood Insurance Program.

The stated objectives of the local law are:

- ☐ To protect human life and health;
- ☐ To minimize expenditure of public money for costly flood control projects;
- ☐ To minimize the need for rescue and relief efforts associated with flooding and generally undertaken at the expense of the general public;
- ☐ To minimize prolonged business interruptions;
- ☐ To minimize damage to public facilities and utilities such as water and gas mains, electric, telephone, sewer lines, streets and bridges located in areas of special flood hazard;
- ☐ To help maintain a stable tax base by providing for the sound use and development of areas of special flood hazard so as to minimize future flood blight areas;
- ☐ To provide that developers are notified that property is in an area of special flood hazard; and,
- ☐ To ensure that those who occupy the areas of special flood hazard assume responsibility for their actions.

The Code Enforcement Officer or the Building Inspector is empowered as the Local Administrator for administering and implementing the Flood Damage Prevention local law. The primary responsibility of the Local Administrator is the granting or denying of floodplain development permits. The Local Administrator must conduct a thorough permit application review prior to approval and must make periodic inspections during the construction phase of a project after permit approval. Finally, upon completion of a project, the Local Administrator must issue a Certificate of Compliance stating that the project conforms to all requirements of the local law.

The local law identifies a series of Construction Standards for development in the floodplain, broken down into General Standards, Standards for All Structures, Residential Structures, Non-Residential Structures, and Manufactured Homes and Recreational Vehicles.

The General Standards section is broken down into standards for subdivision proposals and encroachments. All new subdivision proposals and other development proposed in a SFHA must be consistent with the need to minimize flood damage, minimize flood damage to utilities, and provide adequate drainage. When encroaching on zones A1-A30 and AE along streams without a regulatory floodway, development must not increase the base flood elevation by more than one foot. Along streams with a regulatory floodway (such as Third Brook), development must not create any increase in the base flood elevation.

Standards for All Structures include provisions for anchoring, construction materials and methods, and utilities. New structures must be anchored so as to prevent flotation, collapse, or lateral movement during the base flood. Construction materials must be resistant to flood damage, and construction methods must minimize flood damage.

Enclosed areas below the lowest floor in zones A1-A30, AE and AH, and, in some cases, Zone A must be designed to allow for the entry and exit of floodwaters. Utility equipment such as electrical, HVAC and plumbing connections must be located at a minimum of two feet above the base flood elevation. Water supply and sanitary sewage systems must be designed to minimize or eliminate the infiltration of floodwaters.

The elevation of residential and nonresidential structures is required in areas of special flood hazard. In zones A1-A30, AE and AH, and, in some cases, Zone A, new residential construction and substantial improvements must have their lowest floor elevated at or above two feet above the base flood elevation. In cases where base flood elevation data is not known for Zone A, new residential construction and substantial improvements must have their lowest floor elevated at or above three feet above the highest adjacent grade.

For nonresidential structures in zones A1-A30, AE and AH, and, in some cases, Zone A, developers have the option of either elevating the structure or improvements by a minimum of two feet above the base flood elevation or floodproofing the structure so that it is watertight below two feet above the base flood elevation. In cases where base flood elevation data is not known for Zone A, new construction and substantial improvements must have their lowest floor elevated at or above three feet above the highest adjacent grade.

Recreational vehicles are only allowed in zones A1-A30, AE, and AH if they are on site fewer than 180 consecutive days and are licensed and ready for highway use, or meet the construction standards for manufactured homes. Manufactured homes in the A1-A30, AE, and AH zones must be placed on a permanent foundation with the lowest floor elevated at or above two feet above the base flood elevation. In Zone A, such structures must be placed on reinforced piers or similar elements that are at least three feet above the base flood elevation.

## Village of Walton Code

### *Environmental Quality Review Act*

Modeled after the National Environmental Policy Act (NEPA) and State Environmental Quality Review Act (SEQR), Chapter 19 of the Village Code establishes a local Environmental Quality Review process, which serves to protect water quality and other natural resources. The law establishes actions that may have a significant effect on the environment as the following:

- Substantial or adverse change to air or water quality, noise, solid waste production, drainage, erosion or flooding
- The removal or destruction of large quantities of vegetation or fauna
- A substantial change in the number of people attracted to a place
- Creation of a conflict with the community's existing goals or plans

- Impairment of historical, archaeological, architectural or aesthetic resources, or neighborhood character
- Major change in use of either quantity or type of energy
- Creation of hazards
- Creation of a material demand that could result in any of the above
- Substantial changes in use or intensity of use of land or natural resources, except when an action has been included in a community plan or statement
- Changes in two or more elements of the environment, which are not substantial individually, but taken together result in significant change in the environment
- An action that was determined not to require a federal impact statement under the National Environmental Policy Act
- Actions classified as Title I actions under Part 667 of Title 6 of the New York Codes

Applicants for permits or other approvals for any actions listed above must file a written statement with the Board of Trustees that explains why the action may or will not have a significant effect on the environment.

The Board of Trustees determines whether actions meet the provisions of the local Environmental Quality Review Act and indeed may have a significant effect on the environment. If the Board of Trustees determines that a proposed action may affect the environment, then the Board must notify the applicant and request a draft environmental impact statement, or prepare a draft environmental impact statement (EIS) for village proposals, in accordance with SEQR provisions. The process for submitting, hearing, and reviewing an EIS provides an opportunity to explore ways to avoid or reduce potential adverse environmental effects and enables agencies and the public to provide input on the planning process.

### *Fire and Building Code Administration and Enforcement*

Chapter 22 of the Walton Village Code addresses fire and building code administration and enforcement. The stated purpose of this chapter is to provide for "the administration and enforcement of the New York State Uniform Fire Prevention and Building Code (the Uniform Code) and the State Energy Conservation Construction Code (the Energy Code) in this Village."

Section 22-7 of this chapter empowers the Code Enforcement Officer to issue certificates of occupancy and certificates of compliance if all work has been completed in compliance with the applicable codes. Any necessary flood hazard certifications must be submitted to the Code Enforcement Officer before a certificate of occupancy or certificate of compliance may be issued.

### *Zoning Regulations*

The Village of Walton manages land uses through the Subdivision of Land and Zoning sections of its Town Code, found in Chapters 44 and 53, respectively. Certain elements of these regulations are of interest with regard to watershed management for the protection of the public water supply. The Subdivision of Land Regulations are administered by the Village Planning Board while the Zoning Regulations are administered by the Village Board.

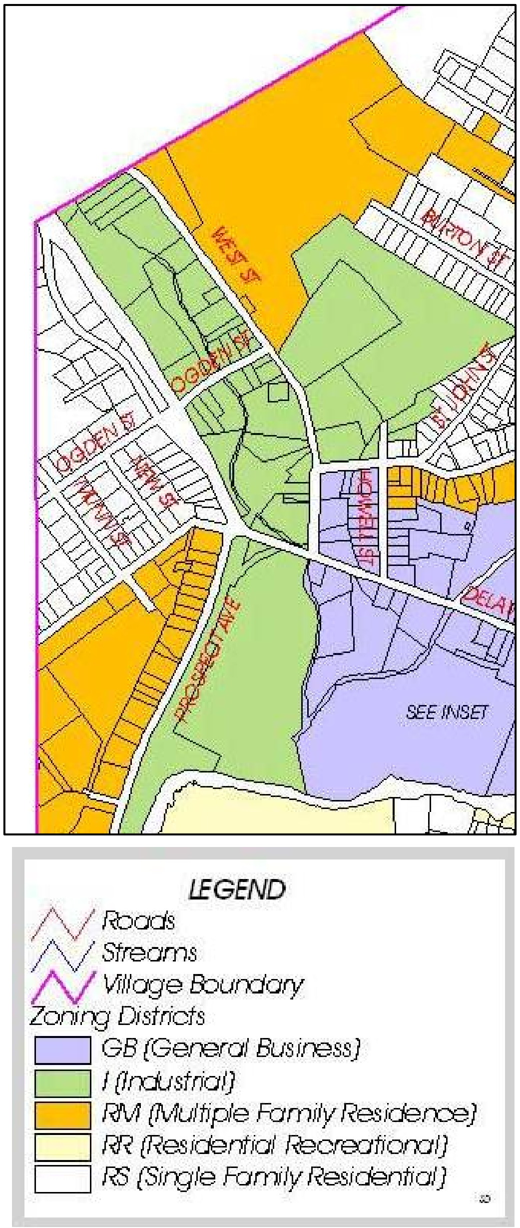
The stated purposes of the Zoning Regulations are to:

- Provide for the lessening of congestion in the streets or roads and reducing the waste of excessive amounts of roads.
- Secure safety from fire, flood, panic and other dangers.
- Provide adequate light and air.
- Prevent excessive and wasteful scattering of population or settlement.
- Promote distributions of populations, classification of land uses, distribution of land development and utilization of lands as will tend to facilitate and provide adequate provisions for public requirements, including transportation, water flowage, water supply, drainage, sanitation, educational opportunities, recreation, soil fertility and food supply.
- Protect the tax base; secure economy in governmental expenditures.
- Foster the municipality's agricultural and other industries.
- Protect both urban and nonurban development.
- Prevent destruction of or encroachment upon historic areas.
- Protect and restore banks of waterways.
- Make provisions for, so far as conditions may permit, the accommodation of solar energy systems and equipment and access to sunlight necessary therefor.
- Encourage a good civic design and arrangement.
- Facilitate the creation of a convenient, attractive and harmonious community by regulation and limiting or determining the height and bulk of buildings and structures, the area of yards and other open spaces, and the density of use.

Many of these goals are consistent with watershed management and the protection of public water supply watersheds.

The specific zoning districts that fall within the Third Brook watershed are the Single-Family Residential (R-S), Multiple-Family Residential (R-M), General Business (B-G), and General Industry (I-G) zones, described below:

- The purpose of the *Single-Family Residential* district is to provide for low-density single-family residential development on smaller lots where water and sewer facilities generally are provided or will be provided in the near future, together with such religious institutions, recreational facilities, and accessory uses as may be necessary or are normally compatible with residential surroundings. The base density of this zone is based upon a sliding scale that ranges from 7,000 square feet per lot for single- or two-family dwellings with public sewer and public water to 10,000 square feet for lots without public sewer or public water.  A lot size of only 10,000 square feet is quite small for septic systems and could present water quality issues.  In addition, a minimum lot size of 40,000 square feet is required for religious institutions such as churches and synagogues.



- The purpose of the *Multiple-Family Residential* district is to encourage variety in housing types and provide for residential densities as might be appropriate for relatively spacious garden apartments or townhouse developments in areas approximately located for such use, which areas are served by sanitary sewers and public water systems and which are well located with respect to major thoroughfares, shopping facilities, and centers of employment.  Similar to the R-S zone, the R-M zone has a sliding scale for its base density based upon whether or not a lot has access to public sewer and public water service.  For single- or two-family dwellings with public water and public sewer, a minimum of 6,000 square feet of lot area is required; for those lots lacking one or both of these public services, the minimum lot size is 12,500 square feet.  Again, 12,500 square feet is a small lot area requirement for septic systems and could present water quality issues and challenges.  For three-family and four-family dwellings, the minimum lot sizes are 7,000 square feet and 8,000 square feet, respectively.  Townhomes require a minimum lot size of 1,440 square feet per unit, with the entire property being no less than 2,000 square feet in size.

- ☐ The purpose of the *General Business* district is to provide sufficient space in appropriate locations for a wide variety of commercial and miscellaneous service activities, generally serving a wide area and located particularly along certain existing major thoroughfares where a general mixture of commercial and service activity now exists but which uses are not characterized by extensive warehousing, frequent heavy trucking activity, open storage of material, or the nuisance factors of dust, odor, and noise associated with manufacturing. There is no minimum lot size in the B-G district except as may be required by the municipality's engineer to meet sanitary standards, except for religious institutions such as churches and synagogues, which require a lot of at least one acre in size.

- ☐ The purpose of the *General Industry* district is to provide for a wide variety of manufacturing, fabricating, processing, wholesale distributing, and warehousing uses appropriately located for access by major thoroughfares but to restrict or prohibit those industries that have characteristics likely to produce serious adverse effects within or beyond the limits of the district. There is no minimum lot size in the I-G district except as may be required by the municipality's engineer to meet sanitary standards.

The Zoning Regulations include Section 53-57, special regulations for the protection of banks and waterways. This section requires approval of the Floodplain Administrator prior to issuing a building permit for any lot that abuts one or more banks of a waterway. Applicants must demonstrate that proper conservation methods will be used and maintained to protect banks and waterways and submit plans for treatment of banks with a statement from a licensed engineer or other appropriate professional. This section of the Zoning Regulations also refers to the village's Environmental Quality Review Law for projects that the Floodplain Administrator determines to have a significant environmental impact.

The standards for development established in Section 53-71 of the Zoning Regulations also contain provisions that help to protect or maintain water quality. The removal of significant trees (those measuring 24 inches in circumference at three feet above grade) from residential development sites is limited to those in the building margin and necessary for improved grading and/or the installation of accessory structures and features. In addition, this section of the regulations requires that the Village Engineer certify the adequacy of sewage and stormwater drainage plans prior to Planning Board approval. Finally, site plan applications must comply with the state's Environmental Quality Review Act as well as requirements for development in flood hazard zones.

### *Subdivision Regulations*

Chapter 44 of the Village Code regulates the subdivision of land. The village Planning Board is the duly authorized body charged with applying and enforcing the Subdivision Regulations. The purpose of these regulations is as follows:

- ☐ That land to be subdivided shall be of such character that it is compatible with the future growth and development plans of the village as defined in the Comprehensive Plan and is of such character that it can be used safely for building purposes without danger to health or peril from fire, flood, or other menace.
- ☐ That the design and layout of the subdivision shall not cause any adverse effects, such as erosion, traffic congestion, and inadequate or unavailable utilities.
- ☐ That the subdivision insures provisions for open spaces or parks and playgrounds where applicable.

In studying preliminary plats, the Planning Board is specifically instructed that "particular attention shall be given to the arrangement, location, width and design of roads and their relation to topography, water supply, sewage disposal, surface drainage, lot sizes and arrangement, potential flood hazards…" Further, under Article V "Minimum Design Standards; General Improvements," Section 44-26, the regulations state that "All parcels must be designed to assure proper drainage, water supply, sewage disposal and the preservation of important ecological features." It is also noted that lot drainage should be designed to provide positive drainage away from buildings and coordinated with the general storm drainage pattern for the given area.

Under Article VI, "Design Standards for Streets," Section 44-35, there is provision for drainage ditches alongside streets and roads to manage stormwater runoff. Drainage ditches must be placed at a suitable distance from the road or street centerline and must be adequate to carry all stormwater runoff. However, the installation of drainage ditches must be satisfactory to and approved by the Road Review Committee. The committee can also mandate that storm sewers be implemented if in its opinion such sewers are warranted or necessary. In addition, under Section 44-36, if there is no natural stream or watercourse to receive roadway storm drainage, the Road Review Committee can direct a developer to secure rights-of-way and either provide drainage ditches or install storm sewers as it believes are warranted. Finally, Section 44-41 requires that "storm and surface water drainage shall be designed for the subdivision in relation to the drainage area above the site and drainage outlets into adjacent areas." Adequate drainage must be provided for the site, and storm sewers are required in all new subdivisions unless physical conditions make their implementation impractical or infeasible.

Article VIII, "Environmental Considerations," Section 44-44 provides for the preservation of flood-prone areas susceptible to serious or regular flooding. Such land shall not be subdivided for homes and shall not be used for any other purposes where doing so increases the danger or risk to life or property from flooding, or increases the hazard of flooding on the land. This section is applicable to all land within the 100-year flood limit.

# 7.0 MANAGEMENT STRATEGIES

A number of management strategies are possible for the Third Brook watershed based on the six goals, the public outreach conducted for this Watershed Management Plan, the watershed characteristics described in Chapter 3.0, the prior studies described in Chapter 4.0, the observations described in Chapter 5.0, and the regulatory and planning frameworks described in Chapter 6.0. These management strategies are discussed and critiqued below. All of the management strategies have one intended outcome, which is to reduce the potential for water quality impairments caused by flooding, erosion, slope failures, loss of appropriate wetland vegetation, and/or poor management of stormwater, land use, and sanitary wastewater.

## 7.1 Flood Protection and Mitigation Strategies

Flooding presents many safety hazards to people and property and can cause extensive damage and potential injury or loss of life. Furthermore, the water quality impacts can be significant. Gasoline, pesticides, poorly treated sewage, and other aqueous pollutants can be carried into and out of yards and buildings by floodwaters and soak into soil, building components, and furniture or travel downstream to other water bodies. Therefore, flood protection and mitigation strategies are needed to advance goal #1 of this plan.

Numerous measures can be taken to reduce the impact of a flood event. These include measures that prevent increases in flood losses by managing new development, measures that reduce the exposure of existing development to flood risk, and measures to preserve and restore natural resources. These are listed below under the categories of *prevention, property protection, structural projects, public education and awareness, natural resource protection,* and *emergency services.*

- ***Prevention*** does not mean prevention of a flood; it refers to prevention of damage. Prevention of damage from flood losses takes the form of floodplain regulations and redevelopment policies that restrict the building of new structures within defined areas. These are usually administered by building, zoning, planning, and/or code enforcement offices through capital improvement programs and through zoning, subdivision, floodplain, and wetland ordinances. It also occurs when land is prevented from being developed through the use of conservation easements or conversion of land into open space. Prevention may also include maintenance of existing mitigation systems such as drainage systems.

- Measures for ***property protection*** include elevation or relocation of structures at risk for flooding (either to a higher location on the same lot or to a different lot outside of the floodplain), floodproofing, purchase and use of flood insurance, and relocating valuable belongings above flood levels to reduce the amount of damage caused during a flood event.

☐ Floodplains can provide a number of ***natural resources*** and benefits, including storage of floodwaters, open space, recreation, water quality protection, erosion control, and preservation of natural habitats. Retaining the natural resources and functions of floodplains can not only reduce the frequency and consequences of flooding but also minimize stormwater management and nonpoint source pollution. Projects that improve the natural condition of areas or restore diminished or destroyed resources can reestablish an environment in which the functions and values of these resources are again optimized. Acquisitions of floodprone property with conversion to open space are the most common of these types of projects. Administrative measures that assist such projects include the development of land reuse policies focused on resource restoration and review of community programs to identify opportunities for floodplain restoration.

☐ ***Structural projects*** include the construction of new structures or modification of existing structures to lessen the impacts of a flood event. Stormwater controls such as drainage systems, detention dams and reservoirs, and culvert resizing may be employed to lessen or control floodwater runoff. On-site detention can provide temporary storage of stormwater runoff. Barriers such as levees, floodwalls, and dikes physically control the hazard to protect certain areas from floodwaters. Channel alterations can be made to confine more water to the channel and accelerate flood flows. Care should be taken when using these techniques to ensure that problems are not exacerbated in other areas of the watershed.

☐ ***Emergency services*** that would be appropriate mitigation measures for flooding include forecasting systems to provide information on the time of occurrence and magnitude of flooding; a system to issue flood warnings to the community and responsible officials; implementing an emergency notification system that combines database and GIS mapping technologies to deliver outbound emergency notifications to geographic areas or specific groups of people, such as emergency responder teams; and emergency protective measures, such as outlining procedures for the mobilization and position of staff, equipment, and resources to facilitate evacuations and emergency floodwater control.

☐ The objective of ***public education*** is to provide an understanding of the nature of flood risk and the means by which that risk can be mitigated on an individual basis. Public information materials should encourage individuals to be aware of flood mitigation techniques, including discouraging the public from modifying channels near their yards and dumping in or otherwise altering watercourses. The public should also understand what to expect when a hazard event occurs and the procedures and time frames necessary for evacuation.

*Prevention*, *emergency services*, and *public education* will remain ongoing, important categories of flood hazard mitigation in the Third Brook watershed and in the village and town of Walton. The Flood Damage Prevention ordinance must be enforced in the town and village although the ability to apply these ordinances in the SFHAs will limit their applicability in the

Third Brook watershed because the Third Brook SFHA is very limited in terms of width and upstream extent.

For the Third Brook watershed, specific mitigation techniques with the most potential for use can be grouped into (1) centralized hydrologic, hydraulic conveyance, and barrier techniques; and (2) decentralized floodproofing, raising building elevations, and relocations. Techniques from the first group are generally considered ***structural projects***:

- *Hydrologic techniques* focus upon reducing or containing the peak flow rates at the watershed scale such as floodwater storage dams, wetland preservation, and enhancing floodplain functions.
- *Hydraulic techniques* include methods that decrease floodwater elevations by removing or reducing flow contraction points at bridges or narrow channel sections, increasing the flow capacity of channels and floodplains, use of broad low-velocity floodways, or by diverting floodwaters around sensitive areas.
- *Barrier techniques* include the installation of levees, floodwalls, or fill material to physically separate floodwaters from developed areas. They may require interior drainage pump stations, use of removable panels at road crossings, and maintenance.

Techniques from the second group are generally culled from the mitigation categories of ***property protection*** and ***natural resource protection***:

- *Elevation* involves the removal of the building structure from its foundation or basement and elevating it on piers or a new foundation to a height such that the first floor is located above a flood level. The basement area is abandoned and filled to be no higher than the existing grade. All utilities and appliances located within the basement must be relocated to the first floor level.
- *Relocation* of a structure involves removing it from the flood zone and siting it elsewhere. In some cases, structures (and property) are acquired, and the floodprone site is restored for floodplain functionality.
- For *dry floodproofing*, areas below the flood elevation are made watertight. Walls may be coated with compound or plastic sheathing. Openings such as windows and vents should be either permanently closed or covered with removable shields. Flood protection should extend only two to three feet above the top of the concrete foundation because building walls and floors cannot withstand the pressure of deeper water.
- *Wet floodproofing* refers to intentionally letting floodwater into a building to equalize interior and exterior water pressures and should only be used as a last resort. If considered, furniture and electrical appliances should be moved away or elevated above the 100-year flood elevation. However, wet floodproofing is not appropriate for residential structures.

## Floodplain and Floodway Encroachments

Third Brook has a very narrow floodplain downstream of the Old Village Reservoir. The brook's real floodplain is wider than its SFHA, but it has been disconnected from the brook due to encroachment, use of concrete and rock walls, and the more recent incision that has occurred. Residents of the watershed have reported that the floodplain on the east side of the brook between stations 71 and 74 (approximate) was filled many years ago.

Despite this limited floodplain, there may be several opportunities to reconnect Third Brook to its narrow floodplain through a combination of hydraulic improvements and natural resources protection/restoration. Newly graded floodplain is not likely to provide floodwater storage due to its limited potential area, but it may provide "room for the river" and lower erosive velocities by providing additional capacity for flood conveyance at reduced flood elevations. Floodplain bench areas would also serve as a lower velocity zone for debris deposition. Potential project areas include the following:

**Potential area of floodplain bench behind 599 and 683 Lower Third Brook Road**

- A mature previously failed slope is located across the brook from the homes at 683 and 599 Lower Third Brook Road. Cross section 8 is located in this area. The slope is vegetated and appears stable. The lower part of the slope is currently not mapped as a SFHA but may provide limited floodplain function. It may be possible to excavate the lower part of this slope and create a lower floodplain. If so, the new floodplain may allow some spreading of flood flows in this area, possibly providing flood mitigation immediately upstream for the homes at 683 and 709 Lower Third Brook Road or providing lower shear stress on the rock walls on the left bank.

- Harold Neale Excavating utilizes the rear of its property (toward the brook) for storage of equipment, materials, and fill material. The rear of the site could be regraded to serve as a floodplain, which may reduce flooding of the remainder of the Harold Neale Excavating site as well as a few of the residences located immediately upstream.

**Potential area of floodplain benches behind Harold Neale Excavating and on Del-Ton Sanitation site**

- Del-Ton Sanitation occupies a long, narrow strip of property along Third Brook that would be ideal for creating a floodplain bench. The benefits of using this property are both logistical (it would be easier to work with one property owner rather than many) and hydrologic (the site is well positioned to be converted to a floodplain bench). Creation of floodplain on the Del-Ton site may provide relief to those properties immediately across the brook, including Frontier Communications, the Walton Fire Department, the backyard of 57 West Street, and the home at 8 Ogden Street, or may cause lower shear stress on the rock and concrete walls on the left bank.

- A low grassy and wooded area is located on the south side of Ogden Street and the west side of the brook. This grassy area extends to the south and merges with FEMA-delineated 100-year and 500-year flood zones located as far south as station 20+00. This area is well suited for creation of floodplain and conversion of the existing 500-year floodplain to a more frequently inundated lower bench floodplain. This effort may benefit the businesses across the stream such as Klinger Power Sports, Beyond Measure Hair Design, and Nails for You at 31-33 West Street; and Jake's Place, CMR, and Big & Small Self-Storage at 25 West Street; or may cause lower shear stress on the rock and concrete walls on the left bank.

- The cut stone storage yard and old garage behind the Agway store could be cleared, and the connection to the stream channel could be restored to return this area to active floodplain. To make space for the displaced cut stone storage, the former Agway store building could be removed. This new floodplain would naturally connect to the Robinson Auction House site, which is already in the FEMA-delineated SFHA. The berm located between the Robinson Auction House building and the brook would need to be removed as it may not be providing much flood protection.

Flood discharges of Third Brook are generally believed to be supercritical with regard to the energy state of the discharge. For a given discharge, supercritical flows have a higher velocity and are shallower than subcritical flows. Where new floodplain and flood conveyance is created along Third Brook, care must be taken to ensure that supercritical flows remain supercritical without shifting to subcritical flows, which could worsen (increase) flood elevations.

The potential for supercritical discharges to flip to subcritical discharges is best evaluated through HEC-RAS modeling or other modeling methods but can also be checked using simple equations. Froude numbers were estimated for existing conditions and proposed conditions at three of the cross sections that were measured for this plan and are presented in Table 7-1. The 10-year flood was used for these estimates because it is important that the more frequent, low-discharge floods remain in their current energy state as these conditions will be anticipated to occur more often than catastrophic floods. Higher flows like the 100-year flood will be more likely to remain supercritical during proposed conditions.

### TABLE 7-1
### Froude Number Estimates for Existing and Proposed Conditions

| **Input Parameters** | **Cross Section 3** | | **Cross Section 4** | | **Cross Section 8** | |
|---|---|---|---|---|---|---|
| | ***Existing*** | ***Proposed*** | ***Existing*** | ***Proposed*** | ***Existing*** | ***Proposed*** |
| Q (cfs) | 549 | 549 | 549 | 549 | 549 | 549 |
| n | 0.035 | 0.05 | 0.035 | 0.05 | 0.035 | 0.05 |
| W (ft) | 20 | 60 | 22 | 85 | 23 | 44 |
| S (ft/ft) | 0.0267 | 0.0267 | 0.0267 | 0.0267 | 0.03 | 0.03 |
| R (ft) | 1.67 | 1.27 | 1.62 | 1.11 | 1.56 | 1.39 |
| Area | 33.50 | 51.09 | 35.56 | 59.54 | 53.65 | 75.96 |
| V | 16.39 | 10.74 | 15.44 | 9.22 | 10.23 | 7.23 |
| *Froude #* | *2.23* | *1.68* | *2.14* | *1.54* | *1.45* | *1.08* |

In all cases, the Froude numbers remain above 1.0, indicating that supercritical conditions will remain in play. These will need to be re-evaluated when hydraulic modeling is performed in conjunction with specific designs.

Ogden Street and Delaware Street Bridges

Sufficient evidence was developed in Woidt's hydraulic study (refer to Section 4.0) to investigate replacement of the bridges at Ogden Street and Delaware Street. Increasing the capacity of each bridge would improve backwater flooding on the upstream sides of the bridges and would also provide more capacity for flood-borne debris, which would then be less likely to clog the bridge opening.

If floodplain benches were created on the upstream side of the Ogden Street bridge (at the Del-Ton site) and the downstream side (where a lawn area is currently located), then a new Ogden Street bridge would need to have a sufficiently long span, or a double span, to provide connection between the upstream and downstream floodplain benches. Otherwise, the village would need to accept the condition that some floods may overtop the road.

Potential Floodproofing, Elevation, and Removal of Structures

Although the current FEMA mapping does not extend as far upstream as Gosper Road, the four residential properties situated where Third Brook crosses under Gosper Road may share some level of flood risk[8]. Two of these properties include farm buildings and farm land, and one of them (74 Gosper Road) includes a headstone business. The remaining home (97 Gosper Road) is situated on the highest ground of the four and likely has the least flood risk. Sufficient land appears to be available on the north side of the brook to create a lower floodplain bench (more frequently flooded land), but this land is owned by the residents on the north side of the brook. The land on the east side of the road is partly utilized for grazing. Hydraulic modeling of Third Brook would help determine if and where there is an appreciable benefit to floodplain enhancement in this location.

Ballard Mobile Home Park is located along the east side of Third Brook at Lower Third Brook Road[9]. Three trailer homes are located between the brook and the mobile home park access road whereas the rest of the trailer homes are located further east, more distant from the brook. Relocation of trailer homes within a mobile home park is likely the best method of flood mitigation for flooded homes. If relocation within the park is not possible, elevation and re-anchoring of the affected trailers should be considered.

The home at 1553 Lower Third Brook Road is located in close proximity to the road crossing of the brook[10]. This home should be elevated if it is floodprone at the more frequent flood discharges.

**Barn at 757 Lower Third Brook Road is one of the few structures in the FEMA SFHA.**

The barn at 757 Lower Third Brook Road is located in the SFHA and should be considered for removal. The home on this property is adjacent to the SFHA and lies low on the property. As such, it should be elevated or removed if it is floodprone at the more frequent flood discharges.

The next two homes along Third Brook are located at 683 and 709 Lower Third Brook Road. Both homes have basements and detached garages. The presence of the basements will make these homes difficult to elevate. Creation of floodplain on the opposite side of the brook (described

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[8] The year 2013 preliminary FIRM depicts the SFHA in the front yard of the home at 97 Gosper Road and surrounding the home and headstone business at 74 Gosper Road.

[9] None of the mobile homes are depicted in the SFHA on the year 2013 preliminary FIRM.

[10] The home at 1553 Lower Third Brook Road is not depicted in the SFHA on the year 2013 preliminary FIRM.

above) may help alleviate flooding at some flood frequencies; this could be confirmed with hydraulic modeling.

Creation of new benched floodplain is not proposed along the east side of Third Brook from 173 Lower Third Brook Road downstream to 67 West Street. Approximately 14 primary structures (houses, trailer homes, and one nonresidential building) are located here, and a number of sheds and garages are also present on the properties. The primary structures on these properties should be elevated as the properties cannot be made less floodprone. Elevating the structures on piles would have the secondary benefit of reducing the encroachment of the floodplain while allowing water to flood the space beneath the homes. Outbuildings such as sheds should be removed, and garages should be moved forward toward the street, away from the brook. Septic systems located in the backyards would continue to be inundated, but the frequency of inundation may decrease as encroachments are lessened by elevating homes, removing sheds, and relocating garages. An alternative method of addressing septic systems is to extend the village's sewer system to this part of the town, thereby eliminating the need for septic systems.

**Example of outbuilding along Third Brook**

The Frontier Communications buildings and Walton Fire Department buildings may be potential candidates for dry floodproofing. Floodplain bench creation across the brook at the Del-Ton site may reduce the frequency of flooding of these two properties. This could be confirmed with hydraulic modeling.

The unused old Agway store building and the old garage behind the Agway store building should be demolished and removed as they have the potential to become flood-borne debris during large floods. This area could then be converted to a lower floodplain.

The Robinson Auction House is already located in the SFHA and is a good candidate for relocation, acquisition/demolition, or dry floodproofing, depending on the ability of the owners to move their business or desire to remain on site. If the auction house is relocated, then newly created floodplain immediately upstream (where the old Agway store building and garage were located) should be connected for a continuous floodplain.

Breakstone/Kraft

All of the above improvements will not prevent occasional flooding of the Kraft property, which is located in the SFHA. The upstream improvements will likely have many localized benefits, such as decreased water surface elevations, reduced shear stress, and reduced production of flood-borne debris, but they will not provide detention or storage of floodwaters. Therefore, floodwaters will need space to spread when they reach the terminus of the watershed. The Kraft property (and the auction house site to a lesser degree) provides that space.

**Existing Low Wall at Kraft Facility**

A low floodwall was built on the Kraft site after the flooding of 2006, but the purpose of the wall is to prevent debris caught in floodwaters from damaging the facility. The wall will not prevent flooding and is not continuous around the facility.

The Kraft site is arguably a critical facility due to its prominent role in the history of Walton as well as its employment of village, town, and county residents. Future editions of the Delaware County hazard mitigation plan should identify it as a critical facility. Across the United States, one potential method of protecting floodprone critical facilities is to protect them with floodwalls. Unlike levees and walls running along a watercourse, a floodwall would closely follow the outline of the facility. This would allow the property to flood while the facility does not flood.

Binghamton's Lourdes Hospital provides a recent nearby example of a critical facility protected with a floodwall. The wall was deemed the most cost effective and reasonable solution for flooding from the Susquehanna River. The wall was built over five years, completed in 2011, and protected the hospital from the severe flooding that occurred a few months later due to storms Irene and Lee. The reinforced concrete floodwall extends 1,365 feet around the hospital between the parking lots and main rear entrance and reaches heights of 14 feet. It has 10 control gates, which can be operated electronically or manually and accommodates both vehicle and foot traffic.

**Images of the Lourdes Hospital floodwall during flood of September 2011; courtesy of hospital**

A floodwall around the Kraft facility would be approximately 1,250 feet long with a height up to 10 or 12 feet, depending on the ground surface elevation relative to the selected design flood elevation. Note that FEMA's base flood elevation varies from 1,218 feet at Delaware Street to less than 1,207 feet at the downstream end of the property; thus, a wall with variable height may be feasible. Unlike a hospital that requires many points of vehicle access, a wall around the Kraft facility may require only two or three gates. Given the slightly lesser length than the hospital's wall (1,250 feet vs. 1,365 feet at the hospital), slightly lower height, and lower number of gates, a floodwall for the Kraft facility would likely be lower in cost than the hospital's wall. Nevertheless, it is recognized that a floodwall could be a costly solution for protecting the Kraft facility.

Other Downstream Properties

Properties on the east side of Third Brook that are located downstream of Delaware Street (such as TA's Place restaurant and the Radio Shack building) are situated at a higher elevation than the Kraft property and are not in the mapped SFHA. Although the property associated with TA's Place, Radio Shack, and the industrial buildings to the south could be converted to floodplain through extensive grading, it is not likely that this would provide significant benefits to Kraft or any other occupants of the Third Brook watershed. This plan does not recommend any specific actions for these properties. Rather, future hydraulic modeling should be used to determine if any mitigation actions are appropriate for these properties.

Summary

In summary, a variety of actions can be taken to reduce flood damage along the Third Brook corridor. These are primarily in the traditional categories of property protection, natural resources protection, and structural projects. For all of the above potential mitigation actions, it will be important to develop design criteria. For example, should the improvement protect a facility from the 10-year flood, 50-year flood, or 100-year flood? It is important to keep in mind the fact that the flood of 2006 was (and will likely remain) a relatively rare event, even in the face of a changing climate with increased precipitation. Design for protection from a future flood of this magnitude may be beyond the capabilities of the communities.

## 7.2 Stream Stability

The concept of a "graded stream" has been in the literature since 1948. According to Leopold and Maddock (1953), a graded stream is one in which *"over a period of years, slope and channel characteristics are delicately adjusted to provide, with available discharge, just the velocity required for the transportation of the load supplied from the drainage basin. The graded stream is a system in equilibrium; its diagnostic characteristic is that any change in any of the controlling factors will cause a* *displacement of the equilibrium in a direction that will tend to absorb the effect of the change."*

Bloom (1978) notes that grade is a condition, not an altitude or slope, and that *"it develops first near the mouths of rivers and then gradually extends headward… A graded river is in a steady state only with regard to short-term changes."*

More recently, Rosgen (1996 and 1998) has used the term "stability" instead of grade, noting that a stable stream is one that *"over time, (in the present climate), that transports the flows and sediment provided by its watershed in such a manner that the dimension, pattern, and profile are maintained without either aggrading or degrading."*

A stable stream is necessary to begin addressing erosion. Therefore, stream stability is desired to address goal #2 of this plan. Whether or not a stream is considered stable is closely related to its sensitivity to disturbance. According to Rosgen (1994):

- ☐ Class F3 streams (such as segment 1 of Third Brook) are "moderately" sensitive to disturbance, have a poor potential for recovery, and have a very high potential for stream bank erosion.
- ☐ Class G3 streams (such as portions of segments 2, 3, and 4 of Third Brook) are "very highly" sensitive to disturbance, have a poor potential for recovery, and have a very high potential for stream bank erosion.
- ☐ Class G4 streams (such as portions of segments 2, 3, and 4 of Third Brook) are "extremely" sensitive to disturbance, have a very poor potential for recovery, and have a very high potential for stream bank erosion.

Class A, B, C, D, and E streams have varying degrees of sensitivity to disturbance and potential for recovery, but the segments of Third Brook found upstream of the Old Reservoir Dam are not particularly sensitive and have good to excellent ratings for potential for recovery if they are disturbed.

The concept of a "reference reach" is important in Rosgen's work. The reference reach represents a stable channel within a particular watershed and is typically necessary to locate in order to understand how to restore or stabilize impaired segments. The reference reach can provide important information for design along impaired reaches, such as appropriate widths, depths, entrenchment, sinuosity, and the like. The reference reach is typically taken from the same watershed as the impaired reach.

The concept of a reference reach does not work well for Third Brook. The segments downstream of the Old Village Reservoir would be inappropriate to use as a reference reach as they are undergoing incision, abutted by slope failures or eroding banks, or contained within walls. However, the upstream segments are not ideal as reference reaches because the valley is much broader, the Old Village Reservoir provides a localized base control, and the land use is different. To guide the restoration of downstream segments using an upstream segment as a "model" could lead to overly high expectations. The downstream segments will continue to have developed floodplains and steep valley walls in close proximity to the stream channel even if some of the flood mitigation alternatives are pursued.

The best reference reach for Third Brook would be a segment downstream of the Old Village Reservoir under conditions that existed prior to the flood of 2006. Since this is not possible, stabilization of Third Brook must proceed in a logical manner that fits the current conditions of the stream.

Rosgen (1997) provides four methods for restoring incised rivers such as Third Brook. These are summarized in Table 7-2.

### TABLE 7-2
### Priorities, Descriptions, and Summary for Incised River Restoration (Rosgen, 1997)

| Description | Methods* | Advantages | Disadvantages |
|---|---|---|---|
| Priority 1<br>Convert G or F to C or E at the previous (higher) elevation with a floodplain also restored at that elevation | Construct new channel on previous floodplain; fill in the existing incised channel | Re-establishes floodplain and stable channel, decreases bank height and bank erosion | Floodplain re-establishment could cause flood damage to structures; downstream end requires grade control to prevent headcutting. |
| Priority 2<br>Convert G or F to C or E with a floodplain at the existing stream level | Convert existing channel to floodplain and excavate new channel in existing streambed; or excavate stream bank walls to make floodplain | Establishes a floodplain, decreases bank height and bank erosion | Velocity and shear stress are higher during floods; upper banks need to be sloped and stabilized. |
| Priority 3<br>Convert G to B or F to Bc without a floodplain but containing a floodprone area | Excavate channels to make appropriate width/depth and entrenchment ratios, stabilize beds and banks | No need to relocate structures near river, reduces the land needed, and decreases the flood stages | High cost for bed and bank stabilization |
| Priority 4<br>Stabilize channel in place | Use concrete, gabions, boulders, and bioengineered methods | Excavation volumes are reduced, and minimal land is needed. | High cost for stabilization; high risk of excessive velocity and shear stress |

*None of these methods are equivalent to dredging, which is a method of removing accumulated sediment from a water body.

The priority 1 option would require excavating a new channel for Third Brook and filling the existing channel whereas the priority 2 option would require creating a new floodplain along the brook at its existing grade. Both would require significant land that is simply not available except perhaps in the limited sections of segments 3 and 4 where less encroachment has occurred.  Neither option is considered feasible downstream of the Old Village Reservoir.

Rosgen notes that priority 3 options are "implemented where streams are laterally confined and physical constraints limit the use of priority 1 or 2."  Conversions of this type in the Third Brook watershed, from class G to B in segments 2, 3, and 4, would require creation of a step/pool bed morphology rather than riffle/pool.  In addition, width/depth and entrenchment ratios would be increased.

Rosgen notes that priority 4 options are the "most common of incised river improvement. The costs, high risk of failure, loss of natural function, and loss of visual and biological value are the reasons this option is presented last on the priority list.  Often, however, to protect road fills, homes, and historic features, this option is about all that can be done within the existing constraints."  This is believed the case facing significant lengths of Third Brook in segments 1, 2, 3, and 4 where commercial, industrial, and residential structures are in close proximity to the brook.

Hey (1994) provides an option for incised streams that is similar to Rosgen's option 2 in the above table.  He explains that "for small alluvial channels where incision is of the order of the original bankfull depth of the river, it would be possible to stabilize the river by forming a new regime channel within a lowered valley in the incising section and by constructing grade control structures to prevent continued headward erosion."  He adds that "the new valley floor would be formed at a level corresponding to the depth of incision and its width would need to accommodate the amplitude of the meanders of a new channel."  This approach could be possible for the less-incised sections of Third Brook although meanders are not present downstream of the Old Village Reservoir and therefore would not be replicated.

On the other hand, Hey states that "grade control structures represent the only sensible procedure for stabilizing large rivers or those where incision exceeds the original local bankfull depth.  Deep excavations to create a new valley would be prohibitively expensive as large volumes of material would have to be removed."  This approach is more or less consistent with Rosgen's options 3 and 4 in the above table, both of which require bed stabilization.

Overall, options 2, 3, and 4 of Rosgen's table of alternatives for incised streams should be considered for Third Brook.  Where possible, these improvements should be combined with the potential hydraulic improvements described in Section 7.1.

## 7.3 Slope Failure and Erosion Management Strategies

Although the failing slopes along Third Brook are closely related to the incision that has occurred, separate measures are necessary to address the failing slopes.  Slope failure mitigation is desired to help address goal #2 of this plan.

Numerous methods of mitigating failing slopes are available throughout the northeastern United States. These methods are meant to control surface water runoff and erosion on top of the slope, groundwater within the slope (and the resulting pore fluid pressures) that can lead to failure, weight on the surface of the slope, loss of support at the toe of the slope, and shear stress at the base of the slope:

- Stormwater traveling downslope can erode the surface of a slope and form gullies that help induce failure. If stormwater can be collected and conveyed elsewhere, surficial erosion can be reduced.

- Stormwater can also increase infiltration of the soil surface above the rates that would occur from direct precipitation, leading to groundwater recharge. If stormwater can be collected and conveyed elsewhere, groundwater recharge can be minimized.

- High groundwater levels beneath the surface of a slope can cause high pore fluid pressure, which destabilizes soil and can lead to failure. If groundwater can be drained or otherwise controlled, pore fluid pressures can be lessened. In some cases, activities uphill from a failing slope are found to be creating high groundwater, and these activities can be modified.

- Excessive mass on the surface of a slope can help induce failure as gravity pulls down on this mass. Certain trees are a good example; if the roots of the trees cannot offset the mass of the trees, the mass can help pull down the slope. Removing excessive mass such as trees can reduce the potential for failure.

- The loss of a material at the toe of a slope can lead to failure because the necessary lateral support has been removed. Returning lateral support to the toe can help mitigate or stop slope failures.

- High stream discharges along the base of a slope can erode soils through shear stress, leading to loss of material at the toe. Moving the stream laterally can reduce shear stress along the toe. If possible, relocation of a stream should be coupled with creation of a new floodplain bench at the base of the slope.

- The toe of a slope can lose support if the stream bed begins cutting downward. Returning the streambed to a prior (higher) elevation can help reduce further failure of a slope.

Hawk Engineering concluded that soil nails were a method that could be used to help hold slopes together along Third Brook. This method differs from those listed above as it does not address the causes and contributors of the slope failures and instead attempts to treat the symptom.

Recall that Hawk Engineering found that the more typical practice of stabilizing slopes with stacked rock walls and stone slope protection would be insufficient during a heavy rainfall event similar to June 2006. However, the use of thousands of soil nails on the eight slopes needing attention would have an excessive cost as discussed in the Hawk Engineering report. Hawk Engineering notes that other alternatives may be used such as relocating Third Brook or capturing the sediment supply downstream.

It is important to understand that the Hawk Engineering report does not draw a distinction between mitigation that is sufficient for a rare event such as the June 2006 storm (and flood) and a more frequent event with a lesser intensity of precipitation and lower stream discharge. While it may seem desirable to design slope mitigation that is capable of surviving severe storms, it may be more reasonable and cost effective to select appropriate mitigation methods and design for less severe, more frequent storms. Less severe storms may not cause the high groundwater of the magnitude caused by the June 2006 event and will certainly not cause the 500-year flood discharge realized in June 2006. Stakeholders in the Third Brook watershed may be able to reach consensus about accepting a lower level of design that is appropriate for more common and less intense storms, even as these storms may be increasing in frequency, because the potential solutions will be more affordable.

Given the need to avoid the expensive option of installing soil nails, this plan supports the use of several combined options for each slope in order to maximize the likelihood that these slope failures can be suspended. While specific designs are outside the scope of this plan, the following combinations appear to be most feasible given the particular characteristics of each failure:

- ☐ Failure 1 is considered mitigated at this time. Long-term monitoring of conditions will demonstrate whether additional efforts are necessary.

- ☐ Failure 2 requires additional attention north of the riprap and new outfall structure. However, stormwater is already controlled at this location, and Third Brook cannot be moved laterally due to the high density of homes. A localized base control already appears to be present in the streambed at the location of the outfall structure, but some downcutting may be occurring at the base of the failing slope. The available options are to reverse or stop the downcutting, further stabilize the toe of the slope, remove mass from the slope, and stabilize the surface of the slope.

- ☐ Failure 3 is located *between* two intermittent streams that are associated with drainage from Route 206. Thus, stormwater does not appear to be a factor in the failure because it is already being directed to areas outside the failure. Third Brook cannot be moved laterally due to the density of homes. The available options are to reverse or stop any downcutting, stabilize the toe of the slope, remove mass from the slope, and stabilize the surface of the slope.

- Failure 4 has a variable surface with some fallen trees. Photographs from March 2007 show groundwater seeping from the face of the slope. The available options are to reverse or stop any downcutting, stabilize the toe of the slope, remove mass from the slope, drain groundwater from the slope and/or reduce groundwater infiltration above the slope, and stabilize the surface of the slope. It may be feasible to slightly shift Third Brook to the east in this location, which would require the use of a backyard but not the relocation of homes.

- Failure 5 is an erosional feature as well as a failing slope. An intermittent watercourse flows downhill through the centerline of the failure. This watercourse appears to be associated with drainage along Route 206. The available options are to control or redirect this watercourse so it does not flow on the slope surface, reverse or stop any downcutting, stabilize the toe of the slope, remove mass from the slope, and stabilize the surface of the slope. It may be feasible to slightly shift Third Brook to the east in this location.

- Failure 6 has a variable surface with some fallen trees. The available options are to reverse or stop any downcutting, stabilize the toe of the slope, remove mass from the slope, and stabilize the surface of the slope. It may be feasible to shift Third Brook to the east in this location as well.

- Failure 7 is much smaller in stature than the others and may not require as much mitigation. The available options are to reverse or stop any downcutting, stabilize the toe of the slope, remove mass from the slope, and stabilize the surface of the slope. It may be feasible to shift Third Brook to the east in this location as well.

- Failure 8 is downhill from a field, and it may receive some runoff from this area, especially given that drainage outfalls associated with Route 206 are located along this field. The available options are to control or redirect this drainage, reverse or stop any downcutting, stabilize the toe of the slope, drain groundwater from the slope and/or reduce groundwater infiltration above the slope, remove mass from the slope, and stabilize the surface of the slope.

- Failure 9 is located downhill from a field, and it may receive some runoff from this area, especially given that drainage outfalls associated with Route 206 are located along this field. The available options are to control or redirect this drainage, reverse or stop any downcutting, stabilize the toe of the slope, drain groundwater from the slope and/or reduce groundwater infiltration above the slope, remove mass from the slope, and stabilize the surface of the slope.

Table 7-3 summarizes the methods of mitigation that are available to the failing slopes to reduce sediment loading and debris formation along Third Brook.

## TABLE 7-3
## Potential Mitigation Options for Each Failure

| | Slope Failure Number | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| ***Current ID:*** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** |
| *Previous ID:* | 1 | 2 | -- | 3 | 4 | 5 | 6 | 7 | 8 |
| Redirect stormwater away from slope | -- | -- | -- | -- | ✓ | -- | ✓ | ✓ | ✓ |
| Reduce formation of groundwater | -- | -- | -- | ✓ | -- | -- | -- | ✓ | ✓ |
| Drain groundwater from slope | -- | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Remove excessive mass from surface | -- | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Stabilize the surface of the slope | -- | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Shore up the toe of the slope | -- | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Relocate stream away from toe of slope | -- | -- | -- | ✓ | ✓ | ✓ | ✓ | -- | -- |
| Increase elevation of streambed | -- | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Soil nails | -- | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |

Note: Methods are not proposed for failure 1 as it is considered mitigated.

Because resources are not unlimited, it may be necessary to prioritize mitigation of failing slopes. Failures that are contributing the most sediment and those that are threatening private property should be prioritized for action. Table 7-4 presents a simple prioritization matrix using a small set of indices for different risks. This matrix was developed for this plan and is not based on a particular prioritization method.

## TABLE 7-4
## Potential Priority of Mitigation for Each Failure

| | Slope Failure Number | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| ***Current ID:*** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** |
| *Previous ID:* | 1 | 2 | -- | 3 | 4 | 5 | 6 | 7 | 8 |
| Slope stability (stable = 0, moderately unstable = 2, very unstable = 4) | -- | 2 | 4 | 4 | 2 | 4 | 2 | 4 | 4 |
| Relative sediment contribution (low = 1, medium = 2, high = 3) | -- | 1 | 2 | 3 | 2 | 3 | 2 | 3 | 3 |
| Relative woody debris contribution (low = 1, medium = 2, high = 3) | -- | 1 | 3 | 3 | 3 | 3 | 2 | 3 | 3 |
| Direct threat to private structures such as homes (low = 1, medium = 2, high = 3) | -- | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Indirect threat to structures or yards through stream constriction (low = 1, medium = 2, high = 3) | -- | 2 | 3 | 2 | 1 | 1 | 1 | 3 | 3 |
| Totals | -- | 7 | 13 | 13 | 9 | 12 | 8 | 14 | 14 |
| **Priority for mitigation** | -- | **8** | **3** | **4** | **6** | **5** | **7** | **2** | **1** |

Note: Failure 1 is considered mitigated.

Using this matrix, failures 8 and 9 at the upstream end of the impaired section of Third Brook (segment 4) rank highest. This is a section of the stream that has undergone significant incision. Failures 3 and 4 are ranked closely behind 8 and 9.

Although failure 2 does not rank highly for action, it is notable that this slope has been partly mitigated and therefore should be addressed in order to reduce the potential for compromising the work that has already been completed.

Ideally, slope failure mitigation should be consistent with the potential stream stabilization methods described in Section 7.2 if they are used along Third Brook. For example, if priority 2 options from Table 7-2 are selected and used for certain sections of Third Brook, they could be paired with moving the brook laterally away from the toe of a failing slope.

## 7.4 Stormwater Management Strategies

At present, stormwater management is not a critical issue in the Third Brook watershed. However, sediment will continue to enter the brook through stormwater drainage, and there may be opportunities to reduce this sedimentation. Improved stormwater management is desired to address goal #3 of this plan.

Best Management Practices (BMPs) for stormwater management have improved over the years as new technologies have become available. The EPA classifies BMPs as structural or nonstructural:

- ☐ Nonstructural BMPs include good housekeeping, optimizing the use of road sands and salts, semiannual street sweeping, and cleaning of catch basins to remove accumulated sediments.

- ☐ The following is a summary of structural BMPs as published in *Preliminary Data Summary of Urban Stormwater Best Management Practices* (EPA, August 1999).

  - → Infiltration systems that capture runoff and promote recharge of groundwater.
  - → Detention systems that capture runoff and temporarily retain it for subsequent release. Detention systems are typically dry between storm events.
  - → Retention systems that capture runoff and retain that volume until it is displaced by the next rain event. These systems maintain a significant pool of water between runoff events.
  - → Constructed wetland systems are similar to retention and detention systems except a major portion of the area contains vegetation.
  - → Filtration systems typically employ a filter media such as sand, soil, organic material, carbon, or other membrane to remove contaminants from stormwater.
  - → Vegetated systems (biofilters) such as swales and filter strips.
  - → Vendor-supplied systems that include catch basin inserts, filtration devices, and hydrodynamic devices.

New development projects in the Third Brook watershed should incorporate BMPs to the greatest extent practical. New development is not imminent in the watershed, nor are large developments anticipated. However, should this change, Table 7-5 presents a summary of preferred BMPs specific to different proposed land uses.

### TABLE 7-5
### Best Management Practices on Individual Sites

| **Residential** | **Retail/Commercial** | **Both** |
|---|---|---|
| Rain gardens or barrels | Pervious parking | Grass swales |
| Infiltration basins or trenches | Green roof storage | Deep sump catch basins in roads/parking areas |
| Dry wells | Single sidewalks | Hydrodynamic separators |
| | Reduction in building footprint | Oil/water separators |
| | Parking lot storage | Created wetland systems |
| | Decentralized parking | Bioretention facilities |
| | Bioretention at parking lot islands | Detention basins |

The selection of specific BMPs varies from site to site. Some applications, such as infiltration systems, may not be appropriate for all land uses or all sites. Table 7-6 summarizes the uses and limitations of some common BMPs.

### TABLE 7-6
### Use and Limitation of Some Common BMPs

| ***BMP Type*** | ***Watershed Size*** | ***Space Requirements*** | ***Site Considerations*** | ***Maintenance*** |
|---|---|---|---|---|
| Rain Barrels | Limited to roof area. Provide multiple barrels to accommodate larger roof areas. | Limited | None | Low |
| Infiltration Basins or Trenches | Trenches: five acres maximum; two acres recommended.<br>Basins: 25 acres maximum; 10 acres recommended. | Varies with watershed size. Minimum 20 square feet. | Do not use at properties with high potential for sediment load. Keep minimum of 50' from slopes 15% or greater; bottom of unit >3' to water; 75' minimum from wells and septic. | Moderate to High |
| Dry Wells | < one acre | Varies with watershed size. Minimum 20 square feet. | Not for use where rooftop may contribute pollutants. Bottom of unit 3' above water, 4' above bedrock; 75' minimum from wells and septic. | Low |

| ***BMP Type*** | ***Watershed Size*** | ***Space Requirements*** | ***Site Considerations*** | ***Maintenance*** |
|---|---|---|---|---|
| Pervious Pavement | Traffic volume <500 Average Daily Traffic (ADT). | Not applicable. | Minimum infiltration of underlying soils 0.3 in/hr but less than 5.0 in/hr; no use in aquifer recharge areas except in approved "clean" applications; no use on slopes greater than 15%; depth to water – 3' min., depth to bedrock – 4' min., 75' minimum from wells. | Moderate |
| Green Roof Storage | Generally limited to roof area. | Varies with size of roof. | Depending on materials used, structural considerations may be needed. | Low |
| Bioretention/Rain Gardens | 5-10 acres; rooftop area for rain gardens. | 200-square-foot minimum; 25-square-foot rain garden. | Slopes 6% or less; 3' from bottom of structure to water. | Low |
| Grass Swales | As space permits for swale construction. | 2' minimum bottom width. | Avoid steep slopes to prevent erosion. | Low |
| Oil/Water or Hydrodynamic Separators | <1 acre impervious cover. | None. Below grade structure. | None | Low |
| Created Wetlands | 25-acre minimum | Proportional to watershed size. | Must intersect groundwater if unlined; not appropriate for land uses generating large amounts of contamination; must have base flow into system; steep slopes not appropriate. | Moderate to High |
| Detention Basins | One-acre minimum | Proportional to watershed size. | Must intersect groundwater if unlined and wet basin; not appropriate for land uses generating large amounts of contamination; must have base flow into system; steep slopes not appropriate. | Moderate |

Existing developments can be retrofitted for improved stormwater management. In some cases, it may be possible to analyze an entire area as a whole and develop stormwater management measures to address the aggregate impervious coverage resulting from the various existing developments. This approach is referred to as centralized BMPs. In particular, adjacent or clustered commercial and industrial developments can be designed to share storm drainage structures and detention basins to address water quality issues on sites that may otherwise be too restrictive to provide individual management measures. Designs such as this will require cooperation between landowners and developers and may involve permanent easements and/or operation and maintenance programs such as memorandums of understanding (MOU).

As noted above in the bullet list and Table 7-6, the use of swales can be considered an effective stormwater BMP. However, they must remain vegetated and avoid steep slopes in order to prevent erosion due to high velocities. Agricultural landowners can run swales across slopes to help avoid the steepest inclines; evidence of this was observed in parts of the Third Brook watershed.

Some rural parts of the Third Brook watershed may be good candidates for improved stormwater conveyance. The use of unvegetated ditches for stormwater conveyance should be minimized. For example, the ditches along Armstrong Road should be lined with riprap and vegetated – or eliminated – to prevent erosion of soil and transport to Third Brook.

Swales are located along parts of Third Brook Road. In many cases, these appear to be vegetated and/or stable. However, the town should monitor conditions to ensure that erosion does not take place.

Stormwater management will be a component of slope failure mitigation as discussed in Section 7.3. For example, runoff flowing down the face of failure 5 will need to be controlled or otherwise conveyed to reduce its erosive qualities.

Finally, as noted in Chapter 3, five areas of bluestone excavation are located in the town's portion of the Third Brook watershed. Although none are located immediately adjacent to the brook, these quarries are potential sources of rock dust, silt, and sediment that can make its way to Third Brook during precipitation and runoff events. The town and the county should work together to ensure that the quarry owners receive proper technical assistance to manage runoff from their facilities.

## 7.5 Land Management Strategies

Land management strategies are associated with goal #4 of this watershed management plan.

### Town of Walton

The Walton Comprehensive Plan discussed zoning in detail and notes that the town does not have a process for allowing "cluster" or "open space" development. The Comprehensive Plan concludes that the current zoning and subdivision regulations encourage strip development along roads, whether residential or nonresidential, and notes that this is counter to the goal of preserving rural characteristics. However, less than 1% of the parcels located in the town (outside the village) are classified as commercial or industrial, and this does not appear to be an urgent issue within the Third Brook watershed.

The Walton Comprehensive Plan is supportive of natural resources protection, water quality protection, and agriculture. In particular, the town and its residents are supportive of organic and alternative forms of agriculture, as well as well-planned logging. While promotion of agriculture and logging may appear counter to the protection of natural resources and water quality, accomplishing both will continue to be important in the town of Walton. The Comprehensive Plan recommends adoption of CEAs to protect natural resources; this is one method of supporting these multiple objectives because it will enhance protection for certain areas while recognizing that other areas will continue to be used for agriculture and logging.

Although the town has adopted the revised flood damage prevention regulations suggested by the state, these regulations apply only in SFHAs shown on the FIRMs. In the town of Walton, the only structure mapped in the Third Brook SFHA is the barn located at 757 Lower Third Brook Road. Other structures may be located in flood zones based on a comparison of flood elevations and ground topography; however, these comparisons have not been made at this time. Therefore, while the new flood damage prevention regulations are stringent, they may rarely be applied in the town's portion of the Third Brook watershed.

One recommendation of the Comprehensive Plan is to provide more funding and education for the town's code enforcement officer. The Comprehensive Plan notes that "buildings or sites that are hastily constructed out of shoddy materials often look unappealing and can also be unsafe. The code enforcement officer is the first line of defense in this process."

As the Town of Walton begins supporting flood mitigation efforts in the residential areas lining the left bank of Third Brook, code enforcement will be crucial. The NFIP regulations and their local counterparts in the flood damage prevention regulations can be complex, and improvements to residential structures must be undertaken with care. Complicating matters is the issue raised above; most of these residential structures are either not located in SFHAs on the FIRM (although they may be located below base flood elevations), or many are located upstream of the FEMA mapping. An empowered code enforcement officer can promote flood-resilient upgrades and construction near Third Brook in addition to simply requiring it where the NFIP makes it mandatory.

### Village of Walton

The Town of Walton's Comprehensive Plan notes that the Village of Walton recently completed a Comprehensive Land Use Plan. Among its recommendations are a series of goals and objectives that call for shared participation of the town and village. One of the objectives is to "establish visual continuity" by "beginning design treatment outside the Village along roadways and intensify amenities as one approaches/enters the Village."

While this recommendation appears innocuous, its application along Lower Third Brook Road/West Street must be considered in the context of flood mitigation. Intensifying amenities may not be prudent when some of these properties may be prone to flooding or erosion. Open space may be considered an amenity. If so, then acquisition of properties and removal from flood zones could be in line with the above objective.

Although the village has adopted the revised flood damage prevention regulations suggested by the state, these regulations apply only in SFHAs shown on the FIRMs. In the village of Walton, the only structures mapped in the Third Brook SFHA are the Robinson Auction House and the Kraft facility. Other structures may be located in flood zones based on a comparison of flood elevations and ground topography; however, these comparisons have not been made at this time. Therefore, while the new flood damage prevention regulations are stringent, they may rarely be applied in the village's portion of the Third Brook watershed.

The Zoning Regulations have a section (Section 53-57) for special regulations for the protection of banks and waterways. This section requires approval of the Floodplain Administrator prior to issuing a building permit for any lot that abuts one or more banks of a waterway. Applicants must demonstrate that proper conservation methods will be used and maintained to protect banks and waterways and submit plans for treatment of banks with a statement from a licensed engineer or other appropriate professional. This section of the Zoning Regulations also refers to the village's Environmental Quality Review Law for projects that the Floodplain Administrator determines to have a significant environmental impact.

Section 53-57 may be a mechanism for the village to regulate structures that are near or in the floodplain but not within a FEMA-delineated SFHA. Its applicability to lots abutting watercourses would open up many properties along Third Brook to review and regulation.

## 7.6 Sanitary Wastewater Management Strategies

Sanitary wastewater treatment is associated with goal #5 of this watershed management plan.

Sanitary wastewater is treated by individual septic systems in the town's portion of the Third Brook watershed and by a combination of septic systems and sanitary sewers in the village's portion of the watershed. While many septic systems in the watershed are believed to be operating as required, those located in floodprone areas may be subject to inundation that decreases the function of the systems or erosion that can destroy the systems outright. As noted earlier in this chapter, septic systems located in the backyards from 173 Lower Third Brook Road downstream to 67 West Street will continue to be inundated even if homes are elevated to reduce flood damage; an alternative method of addressing septic systems is to extend the village's sewer system to this part of the town, thereby eliminating the need for septic systems.

Septic systems elsewhere in the watershed that are not inundated and not at risk from erosion can still impair water quality if they fail. For this reason, all septic systems and septic tanks must be maintained and replaced as needed to ensure that property owners can properly dispose of sanitary wastewater.

## 7.7 Wetland Habitat Protection and Management Strategies

Goal #6 of this watershed management plan addresses wetlands and their role in maintaining water quality. Through decades of well documented research, it is understood that wetlands and watercourses provide a host of important physical and chemical functions as well as a suite of beneficial societal values. These functions and values operate at all scales, from the microscopic up to the local and regional landscape. While most wetlands perform some, or even many, of these functions and values, some wetland types are inherently more valuable than others because of their location, vegetation, geology, aesthetics, prior impacts, or history.

Of the four wetland types in the Third Brook watershed, palustrine forested wetland systems occur less frequently than anticipated due to agriculture land uses. Forested wetlands are an important wetland type that provides a wide range of functions and values that are not provided by the other wetlands within this watershed. Therefore, where possible, opportunities should be identified to reforest several wetland areas located along Third Brook and its tributaries. Reforesting wetland/riparian zone areas will increase habitat biodiversity and will provide benefits to water quality including thermal protection, nutrient filtering, allochthonous inputs, and bank stabilization. Areas that have the potential to support forested wetland/riparian zone vegetation have been identified on the plan sheets in Appended Figure II.

## 7.8 Monitoring

In the WARSSS textbook, Rosgen notes that a monitoring program can accomplish or contribute to the following:

- Measure the response of the system to a change
- Document the response of a specific process and compare to the predicted response for the prescribed treatment
- Define short-term vs. long-term changes
- Document spatial variability of process and system responses
- Reduce prediction uncertainty
- Provide confidence in management practice modifications or recommendations
- Determine if mitigation is implemented correctly
- Evaluate effectiveness of stabilization approaches
- Build a database to extrapolate for similar applications

While some of these objectives may be inappropriate for the small size of the Third Brook watershed and the nature of issues in the watershed, monitoring will be necessary to determine at a minimum whether improvements in the Third Brook watershed are (1) successful for their stated purpose; and (2) result in improved water quality through reduced sediment loading and transport.

One method of monitoring the success of specific mitigation projects for slope and channel stabilization is to periodically measure changes of the slopes and channels where the project was focused, as well as downstream. "Permanent cross sections" are recommended to be set in three approximate locations: segment 1 or 2, segment 2 or 3, and segment 4. These cross sections would then be used to periodically measure channel dimensions and bed elevations relative to known surveyed elevations. The comparison of measurements from one year to the next will provide a direct measure of whether the channel is aggrading, degrading/incising, or neither.

For failing slopes, photographic documentation along with direct measurements can help demonstrate whether stabilization techniques are effective. A stable surveyed benchmark should be established near the slope of concern but not on the slope or anywhere influenced by the failure.

It may be beneficial to estimate sediment transport rates in the future as an indirect measure of stabilization project success rates. To do so, discharge rates, suspended sediment, and bedload sediment must be measured from time to time. Two gauging stations should be set up in Third Brook for this purpose. Because it is unrealistic to expect the USGS to install gauging stations on Third Brook and maintain such gauges, they should be stations that can be set up and maintained by DCSWCD or designated persons. One gauging station should be located at the upstream end of the reaches of concern, near the segment 4/5 boundary, and one should be located downstream in segment 1. Each station should be fitted with a durable staff gauge, and a rating curve should be developed for each by measuring stream discharges periodically. Suspended sediment and bedload sediment would be measured at the two gauging stations periodically as well.

The combination of indirect data from the gauging stations and direct data from the permanent cross sections will provide a solid record of whether stabilization projects are working as intended.

One other type of restoration project would benefit from monitoring. If wetland areas are reforested, annual vegetation surveys should be conducted in selected locations. These are typically conducted by walking the same transect through the wetland on an annual basis and recording the numbers of plants present in different species and the condition of these plants.

# 8.0 SUMMARY OF FINDINGS AND RECOMMENDATIONS

## 8.1 Findings

### General

- Protection and enhancement of water quality in the Third Brook watershed will improve the quality of life for residents and businesses in the village and town of Walton while helping NYCDEP meet its goals of maintaining good water quality in its water supply watersheds.

- The primary focus of the subject Watershed Management Plan is to develop naturally sustainable solutions for flood mitigation and erosion control along Third Brook with emphasis downstream of the impoundment although the entire watershed was addressed. This desired stability is crucial to reduce the potential for water quality impairments caused by flooding, erosion, and slope failures.

- Loss of appropriate wetland vegetation and/or poor management of stormwater, land use, and sanitary wastewater will also negatively impact water quality in the watershed.

- The Third Brook watershed is rural upstream of the Old Village Reservoir but has suburban qualities downstream of the dam. Businesses located in the town's part of the watershed include Fletcher Construction, Healing Waters Farm, Bear Farm, Dave's Collision & Body, a headstone dealer, and Hillside Body & Collision.

- Businesses in the village's part of the watershed include Scott Machine Corporation, Harold Neale Excavating, Frontier Cable, Del-Ton Sanitation, Klinger Power Sports, Nails for You, Beyond Measure Hair Design, Jake's Place Garden & Farm, CMR Cleaning/Maintenance, a self-storage facility, Robinson Auction House, a Hess service station, Four Seasons Auto, Stanton's Garage, Breakstone/Kraft, TA's Place restaurant, Walton Auto Repair, ICO Computer, Subway restaurant, and Radio Shack.

- Although residences are scattered throughout the watershed, homes are generally clustered where Third Brook crosses under Gosper Road, where Third Brook crosses under Lower Third Brook Road, downstream of the Old Village Reservoir along the left bank of Third Brook (facing downstream), and then further downstream along the left bank of Third Brook on both sides of the village/town line.

### Flooding and Flood Mitigation

- Precipitation rates and patterns are changing as the climate changes. Precipitation is increasing on the order of 0.65 inches per decade. Cornell University has found that a storm with a 100-year recurrence interval now has a 66-year recurrence interval.

Anecdotal evidence includes common observations in the watershed of water breaking out of slopes where it was not observed previously.

- The 15 inches of rain recorded over the period June 26-29, 2006 caused the worst flood in recent history in the Third Brook watershed. Based on the discharges recorded in the West Branch Delaware River and East Brook, the flood on Third Brook was much greater than a 100-year event and may have exceeded a 500-year event.

- Third Brook has been confined by a variety of walls along much of its length below the Old Village Reservoir. The SFHA and floodway are generally coincident with the bankfull channel from the impoundment to a point immediately upstream of Delaware Street, indicating that flood discharges up to the 100-year flood (1% annual chance flood) are conveyed in the channel between walls where they are present. However, this is not the case when the channel is blocked with debris. This also demonstrates that the brook has been disconnected from the narrow floodplain that existed prior to development.

- Upstream of the dam, the SFHA of Third Brook was delineated and mapped with preliminary mapping available in autumn 2013. It appears that the brook is bounded by floodplains upstream of the impoundment, and these floodplains are generally well connected to the brook. The impoundment does not provide any flood control as it does not have any significant freeboard.

- It will likely be impossible to prevent all larger woody debris from entering the stream corridor and becoming entrained in floodwaters. However, other types of debris can be kept out of areas that flood or that may have the potential to erode easily into Third Brook using a well-executed debris management program.

- Potentially floodprone homes are located on Gosper Road adjacent to Third Brook; in the Ballard Mobile Home Park on Lower Third Brook Road; at 1553 Lower Third Brook Road; from 67 West Street to 757 Lower Third Brook Road; and at 7 and 8 Ogden Street. Few of these homes are located in the SFHAs. However, the boundaries of SFHAs should not be interpreted as rigid lines. Some of the homes may be located outside SFHAs but at elevations lower than base floods; some may have been flooded in June 2006; and some may become increasingly floodprone as precipitation patterns change.

- Despite the limited floodplain downstream of the dam, there may be several opportunities to reconnect Third Brook to a narrow floodplain. Newly graded floodplain is not likely to provide floodwater storage due to its limited potential area, but it may provide "room for the river" and lower erosive velocities by providing additional capacity for flood conveyance at reduced flood elevations. Where new floodplain and flood conveyance is created, care must be taken to ensure that supercritical flows remain supercritical without shifting to subcritical flows, which could worsen flood elevations.

- ☐ The Robinson Auction House and Kraft facility lie at low elevations within the mapped SFHA and will remain floodprone. Many floodprone critical facilities in the United States have been evaluated for the use of floodwalls with automatic flood gates. These are techniques that may be feasible for Kraft. Either floodproofing or relocation is a more appropriate solution for the Auction House.

- ☐ The Ogden Street and Delaware Street bridges appear to have suitable capacity for some design flows but are prone to blockage by debris carried in floodwaters, which can cause overtopping. This occurred during the June 2006 flood.

Stormwater

- ☐ Stormwater collection, conveyance, and discharge systems are not extensive in the Third Brook watershed and are generally found in the village but not the town. Stormwater detention and retention basins are believed absent from the watershed.

- ☐ Stormwater outfalls were observed downstream of the impoundment but not upstream in the more rural parts of the watershed. In these areas, stormwater is either conveyed overland without concentration in channels, or stormwater is conveyed in road gutters, gullies, swales, and channels. For example, a distinct gully has been excavated and maintained along the north side of Armstrong Road near the headwaters of Third Brook.

- ☐ Areas of bluestone excavation are located in the town's portion of the Third Brook watershed. Although none are located immediately adjacent to the brook, these quarries are potential sources of rock dust, silt, and sediment that can make their way to Third Brook during precipitation and runoff events.

Slope Failures and Channel Erosion

- ☐ The dam and its impoundment are located on the Healing Waters Farm. The dam is a Class B hazard dam. The impoundment provides a local base control, which helps stabilize the portion of Third Brook upstream of the impoundment. However, the downstream segment of the stream is more prone to erosion and somewhat starved for sediment when it flows over the dam.

- ☐ Sections of Third Brook have become very incised downstream of the Old Village Reservoir. Cross vanes are currently providing localized base controls along segments 2 and 4 of Third Brook from Ogden Street to 709 Lower Third Brook Road, almost as far upstream as the bedrock base level control. Five of the cross vanes are in segment 2, and 11 are in segment 4 where incision was reportedly severe since 2006.

☐ Even with cross vanes present, sections of Third Brook may still be at elevations that are not ideal relative to local base controls and other channel constraints, resulting in continued instability.

☐ Eight slope failures were observed after the June 2006 flood along the right bank of Third Brook. Two mitigated failures and seven active failures are currently positioned along Third Brook for a total of nine. Although geologic mapping depicts glacial till along the brook, observations by NYCDEP and Hawk Engineering show that some of the material is stratified sand and gravel. Failures are believed to have occurred from a combination of overland stormwater flow, lateral groundwater seepage, and removal of slope toes as a result of stream scour and incision. Despite their deep roots, trees and other vegetation have fallen and slumped downslope with the failures rather than anchoring the slopes.

☐ Slope failures can be mitigated through a combination of some of the following: (1) regrading the slope to a stable angle and providing vegetation; (2) moving the stream channel away from the toe of the slope and creation of floodplain if possible; (3) armoring the base of the failure with riprap, stacked rock walls, or bioengineered materials; and (4) raising the streambed back to a previous higher grade. Surface water and groundwater drainage control can also help, as well as controlling the weight and types of vegetation on the slopes. Not all of the measures are appropriate for all slopes.

### Sanitary Wastewater

☐ Septic systems are located throughout the watershed in nonsewered areas. These systems must be maintained and replaced as needed to ensure that failures will not occur, which could lead to water quality impairment.

☐ Septic systems near Third Brook are at risk for inundation and erosion. Sewers could be used to collect sanitary wastewater in these areas, allowing decommissioning of septic systems that are at risk.

### Wetlands

☐ Emergent/wet meadow wetlands in the watershed provide important functions and values such as nutrient removal, toxicant removal, high stem plant count and species diversity, wildlife habitat, groundwater discharge, and production export. Wetland areas within the Third Brook floodplain provide flood attenuation and desynchronization.

☐ Scrub shrub wetlands in the watershed provide important functions and values such as nutrient removal, toxicant removal, high stem plant count and species diversity, wildlife habitat, groundwater discharge, and production export.

- ☐ Open water wetland areas provide important functions and values such as nutrient removal, toxicant removal, shoreline stabilization, wildlife habitat, and fishery habitat.

- ☐ Palustrine forested wetland systems occur less frequently within the Third Brook watershed, which is most likely attributed to agriculture land use within the watershed. Areas that supported forested wetlands along Third Brook and its tributaries have been farmed for many years. Where present, forested wetlands provide important functions and values such as nutrient removal, wildlife habitat, groundwater discharge, and production export.

Land Use Planning and Regulations

- ☐ The Town and Village of Walton have both adopted the revisions to their local flood damage prevention regulations, effective 2012. The regulations include stringent requirements for new construction and substantial repairs, such as the requirement for residential structures to be elevated two feet above base flood elevations. Unfortunately, these regulations apply only to the small handful of structures mapped in the SFHA, such as the barn at 757 Lower Third Brook Road, the Robinson Auction House, and the Kraft facility.

- ☐ The Walton Comprehensive Plan notes that the town does not have a process for allowing "cluster" or "open space" development and concludes that the current zoning and subdivision regulations encourage strip development along roads, whether residential or nonresidential, and notes that this is counter to the goal of preserving rural characteristics. However, less than 1% of the parcels located in the town are classified as commercial or industrial, and this does not appear to be an urgent issue within the Third Brook watershed.

- ☐ The Walton Comprehensive Plan is supportive of natural resources protection, water quality protection, and agriculture. In particular, the town and its residents are supportive of organic and alternative forms of agriculture, as well as well-planned logging. While promotion of agriculture and logging may appear counter to the protection of natural resources and water quality, accomplishing both will continue to be important in the town of Walton. The Comprehensive Plan recommends adoption of CEAs to protect natural resources; this is one method of supporting these multiple objectives because it will enhance protection for certain areas while recognizing that other areas will continue to be used for agriculture and logging.

- ☐ One recommendation of the Comprehensive Plan is to provide more funding and education for the town's code enforcement officer. As the Town of Walton begins supporting flood mitigation efforts in the residential areas lining the left bank of Third Brook, code enforcement will be crucial. An empowered code enforcement officer can promote flood-resilient upgrades and construction near Third Brook in addition to simply requiring it where the NFIP makes it mandatory.

- The village has completed a Comprehensive Land Use Plan. One of the objectives is to "establish visual continuity" by "beginning design treatment outside the Village along roadways and intensify amenities as one approaches/enters the Village." Its application along Lower Third Brook Road/West Street must be considered in the context of flood mitigation because intensifying amenities may not be prudent when some of these properties may be prone to flooding or erosion. Open space may be considered an amenity. If so, then acquisition of properties and removal from flood zones could be in line with the above objective.

## 8.2 Recommendations

Flooding and Flood Mitigation

- A hydraulic model should be prepared for the length of Third Brook from a point between Fletcher Road and Gosper Road to the end of the brook. The model should incorporate the FEMA FIS model. It should also tie into the revised hydraulic model being developed for the West Branch Delaware River.

- Through hydraulic modeling, evaluate the creation of benched floodplain and improved flood conveyance in the following locations:
    - West side of stream behind 683 and 599 Lower Third Brook Road
    - East side of stream in the current location of Harold Neale Excavating
    - West side of stream in the current location of Del-Ton Sanitation
    - West side of stream from Ogden Street downstream, merging into the existing 500-year floodplain, which would then be regraded to provide additional flood storage and conveyance
    - East side of stream including the rear of the old Agway property

- The Ogden Street bridge should be replaced to provide a larger opening. A larger opening will reduce backwater conditions and debris blockage. A larger opening should also be linked to the regraded floodplain upstream of the bridge (Del-Ton site) and downstream of the bridge. The hydraulic model should be used to ensure that downstream flooding is not worsened.

- Consider relocation of Harold Neale Excavating; if relocated, the site should be regraded as noted above.

- Abandoned and underutilized buildings at the rear of the old Agway site should be removed in conjunction with the floodplain connection described above.

- Consider dry floodproofing and relocation as options for flood mitigation of the Auction House building. If the Auction House business relocates, the building should be demolished and returned to open space, and Third Brook should be realigned through the property to cross under Delaware Street at a right angle.

- ☐ The Delaware Street bridge should be replaced to provide a larger opening. A larger opening will reduce backwater conditions and debris blockage. If possible, Third Brook should be realigned to approach the bridge in a manner that eliminates the 90-degree turn. This would require some use of the Robinson Auction House site. The hydraulic model should be used to ensure that downstream flooding is not worsened.

- ☐ Consider the use of floodwalls with automatic flood gates to prevent future flood damage at the Kraft facility. The Delaware County Hazard Mitigation Plan and Village of Walton annex should be amended to list Kraft as a critical facility since it is a key employer and taxpayer. This may help open up opportunities for federal cost sharing in the selected mitigation action.

- ☐ Areas of Walton should be identified to accommodate the relocation of businesses from floodprone areas along Third Brook, such as the Auction House, Del-Ton Sanitation, and Harold Neale Excavating. The village should investigate methods of assisting the relocation of businesses to these new locations, perhaps with the assistance of federal mitigation funds.

- ☐ Consider elevating and re-anchoring the three westernmost homes in the trailer park at Lower Third Brook Road to reduce the potential for flood damage and/or detachment from foundations during floods. Additional trailer homes in this park may be candidates for anchoring or relocation, depending on their elevations relative to future floods.

- ☐ As funding allows, consider elevating on piers the homes located from 67 West Street to 757 Lower Third Brook Road. This will accomplish two things: the living spaces can be raised above potential future flood elevations, and the spaces beneath the homes will be able to convey floodwaters. Outbuildings and garages should be removed or relocated closer to the road, away from the brook. Removing or relocating outbuildings and garages may provide reserve areas for septic systems.

- ☐ Nonvegetative debris such as containers, equipment, and vehicles should be kept out of areas that can flood or that can erode easily into Third Brook. The ongoing debris management programs should be leveraged to minimize debris in Third Brook.

- ☐ The town and village should work with utility companies to provide adequate separations between utility poles and the banks of Third Brook.

- ☐ Although the dam owned by Healing Waters Farm is not a high-hazard class dam, the town and village should work with the owners to maintain an Emergency Action Plan for the dam. The Emergency Action Plan should define protocols for monitoring the dam during storms and could be used to notify downstream residents of a potential for dam failure.

Stormwater

☐ Stormwater collection, conveyance, and discharge systems should be inspected annually, and sediment should be removed if found.

☐ The use of unvegetated ditches for stormwater conveyance should be minimized in the watershed. For example, the ditches along Armstrong Road should be lined with riprap and vegetated to prevent erosion of soil and transport to Third Brook, or eliminated.

☐ The town and the county should work together to ensure that bluestone quarry owners receive proper technical assistance to manage runoff from their facilities, which will help prevent rock dust, silt, and sediment from reaching Third Brook.

Slope Failures and Channel Erosion

☐ Failing slopes should be mitigated through a combination of (1) shifting the channel of Third Brook away from the toes of the slopes where possible; and (2) installing vegetated riprap or fabric-encapsulated soil lifts above low-stacked rock walls. Where the channel can be shifted to the east, use of stacked rock walls may be circumvented in favor of a continuous sloped solution on the failed slope such as vegetated riprap below the 100-year flood elevation and fabric-encapsulated soil lifts above the 100-year flood elevation (or some other design event).

☐ Overall, options 2, 3, and 4 of Rosgen's table of alternatives for incised streams (Table 7-2) should be considered for Third Brook. Where possible, these improvements should be combined with the potential hydraulic improvements and slope failure mitigation.

☐ Where possible, sections of the Third Brook channel should be evaluated for the feasibility of regrading to increase stability and connect to the floodplain. If the channel can be raised to higher elevations in the vicinity of failing slopes, less intensive engineered solutions may be possible for the slope mitigation.

☐ The 11 closely spaced cross vanes in segments 3 and 4 should be evaluated to determine their utility in maintaining channel grades. If this section of the channel is raised, the cross vanes will not be effective.

Sediment Management

☐ The Old Village Reservoir impoundment should be evaluated for the feasibility of removing sediment. A feasibility study should consider methods (hydraulic dredging vs. conventional excavation), costs, and environmental permitting. If found feasible, sediment should be removed from the impoundment to provide a means of catching sediment from areas upstream of the dam, thereby helping to improve water quality downstream.

- ☐ Dredging sections of Third Brook should be discouraged unless hydraulic modeling demonstrates that removing sediment from the channel will reduce flood elevations and that such dredging will not disturb any equilibrium that has been achieved or may be achievable.

Sanitary Wastewater

- ☐ The town and county should work with owners of septic systems in the watershed to ensure that systems are maintained or replaced as needed to reduce the potential for failures. The Catskill Watershed Corporation could be involved with these efforts.

- ☐ The town and village should evaluate the cost and feasibility of extending the village's sewer system to the town's portion of West Street, allowing decommissioning of septic systems that are at risk of inundation or erosion.

Wetlands

- ☐ Of the four wetland types in the Third Brook watershed, palustrine forested wetland systems occur less frequently than anticipated due to agriculture land uses. Where possible, opportunities should be identified to reforest some of the wetland areas along the Third Brook corridor. This will increase habitat diversity and will likely have benefits to water quality as well.

Land Use Planning and Regulations

- ☐ If the Town of Walton proceeds with allowing "cluster" or "open space" development, ensure that the new regulations recognize the need for stormwater management and water quality protection.

- ☐ Support the town's efforts to adopt CEAs to protect natural resources in the Third Brook watershed.

- ☐ Support the town's efforts to provide more funding and education for the town's code enforcement officer so he or she can promote flood-resilient upgrades and construction near Third Brook.

- ☐ If the village and town work together to develop design treatments outside the village along roadways for intensification of amenities as one approaches/enters the village, ensure that this be accomplished in the context of flood mitigation. Conversion of developed land to open space should be considered as an amenity.

- The village and town should ensure that the flood damage prevention regulations are applied to structures located where base flood elevations exceed ground surface elevations, in addition to structures simply mapped in the Third Brook SFHA.

- Village Zoning Regulations Section 53-57 should be used by the Floodplain Administrator to conduct stringent reviews of applications for development where the section applies (to lots abutting watercourses). This may be the only direct mechanism for the village to regulate structures that are in a floodplain but not within a FEMA-delineated SFHA.

- Identify areas that are off limits for development in the Third Brook watershed in both the town and the village and ensure that these areas are protected as such. The aforementioned hydraulic modeling will be useful in this effort.

### Miscellaneous

- Ensure that outreach and education remain a priority and continue to provide technical assistance within the watershed regarding agricultural land use, maintaining natural floodplains, and flood damage prevention.

- Implement suitable direct and indirect monitoring programs to determine whether restoration and stabilization projects in the watershed are successful.

## 8.3 Implementation

Table 8-1 presents a list of recommendations with minor reorganization such that longer recommendations have been listed as separate line items. Potential costs are provided qualitatively as "low," "medium," or "high" with the following assumptions:

- "Low" costs have either no cost or they can be handled by existing municipal, county, or state personnel with few outside expenses.
- "Medium" costs would require less than $100,000 to implement and may include studies or investigations.
- "High" costs would require a greater level of funding with identified sources of the funding and may include capital expenditures for land acquisition or major projects involving construction or infrastructure.

# TABLE 8-1
# Implementation Plan

| Recommendation | Time Frame | Cost | Potential Funding Sources* | Responsible Party |
|---|---|---|---|---|
| *Goal #1 – Flooding and Flood Mitigation* | | | | |
| Prepare hydraulic model for the length of Third Brook from a point between Fletcher Road and Gosper Road to the end of the brook. | Near-Term | Intermediate | NYCDEP, USACE | Town, Village, and County |
| Through hydraulic modeling, evaluate the creation of benched floodplain and improved flood conveyance in the following locations:<br>• West side of stream behind 683 and 599 Lower Third Brook Road<br>• East side of stream in the current location of Harold Neale Excavating<br>• West side of stream in the current location of Del-Ton Sanitation<br>• West side of stream from Ogden Street downstream, merging into the existing 500-year floodplain, which would then be regraded to provide additional flood storage and conveyance<br>• East side of stream including the rear of the old Agway property | Near-Term | Intermediate | NYCDEP, USACE | Town, Village, and County |
| Replace Ogden Street bridge to provide a larger opening and reduce backwater conditions and debris blockage. Link to regraded floodplain upstream and downstream of the bridge. (Use hydraulic model to evaluate.) | Long-Term | High | Village and County, USACE, FEMA | Village and County |
| Consider relocation of Harold Neale Excavating; if relocated, the site should be regraded as noted above. | Long-Term | High | NYCDEP, USACE | Village and County |
| Remove abandoned and underutilized buildings at the rear of the old Agway site in conjunction with the floodplain connection described above. | Long-Term | High | NYCDEP, USACE | Village and County |

## TABLE 8-1 (continued)
## Implementation Plan

| Recommendation | Time Frame | Cost | Potential Funding Sources* | Responsible Party |
|---|---|---|---|---|
| Consider dry flood proofing and relocation as options for flood mitigation of the Auction House building. If the Auction House business relocates, the building should be demolished and returned to open space, and Third Brook should be realigned through the property to cross under Delaware Street at a right angle. | Long-Term | High | FEMA | Village and County |
| Replace Delaware Street bridge to provide a larger opening and reduce backwater conditions and debris blockage. If possible, Third Brook should be realigned to approach the bridge at a right angle. This would require some use of the Robinson Auction House site. (Use hydraulic model to evaluate.) | Long-Term | High | State and County, USACE, FEMA | State and County |
| Consider the use of floodwalls with automatic flood gates to prevent future flood damage at the Kraft facility. First, the Delaware County Hazard Mitigation Plan and Village of Walton annex should be amended to list Kraft as a critical facility; this may help open up opportunities for federal cost sharing. | Near-Term | High | FEMA | Kraft, Village, and County |
| Identify areas of Walton to accommodate the relocation of businesses from floodprone areas along Third Brook, such as the Auction House, Del-Ton Sanitation, and Harold Neale Excavating. Investigate methods of assisting the relocation of businesses to these new locations, perhaps with the assistance of federal mitigation funds. | Near-Term | Intermediate | Village, Town, County, and DOS | Village, Town, and County |
| Consider elevating and re-anchoring the three westernmost homes in the trailer park at Lower Third Brook Road to reduce the potential for flood damage and/or detachment from foundations during floods. Additional trailer homes in this park may be candidates for anchoring or relocation, depending on their elevations relative to future floods. | Long-Term | Intermediate to High | NYCDEP, HUD | Town |

## TABLE 8-1 (continued)
## Implementation Plan

| Recommendation | Time Frame | Cost | Potential Funding Sources* | Responsible Party |
|---|---|---|---|---|
| Consider elevating on piers the homes located from 67 West Street to 757 Lower Third Brook Road, as funding allows, which will accomplish two things: the living spaces can be raised above potential future flood elevations, and the spaces beneath the homes will be able to convey floodwaters. Outbuildings and garages should be removed or relocated closer to the road, away from the brook. | Long-Term | High | NYCDEP, HUD | Town, Village, and County |
| Nonvegetative debris such as containers, equipment, and vehicles should be kept out of areas that can flood or that can erode easily into Third Brook. | Near-Term | Low to Intermediate | Not applicable | Town, Village, and County |
| Leverage the ongoing debris management programs to minimize debris in Third Brook. | Ongoing/Near-Term | Intermediate to High | Town, Village, County, USACE | Town, Village, and County |
| Work with utility companies to provide adequate separations between utility poles and the banks of Third Brook. | Near-Term | Low | Not applicable | Town, Village, and County |
| Work with the owners of the dam to maintain an Emergency Action Plan for monitoring the dam during storms and notification of downstream residents of a potential for dam failure. | Near-Term | Low to Intermediate | Town and Village | Town and Village |
| *Goal #2 – Slope Failures and Channel Erosion* | | | | |
| Mitigate failing slopes through a combination of (1) shifting the channel of Third Brook away from the toes of the slopes where possible and (2) installing vegetated riprap or fabric-encapsulated soil lifts above low-stacked rock walls.<br>Stormwater control, groundwater control, and other design elements may be required for some slopes as described in this plan. | Near-Term | High | NYCDEP, NRCS | Town, Village, and County |
| Consider designs based on options 2, 3, and 4 of Rosgen's table of alternatives for incised streams (Table 7-2). Where possible, these improvements should be combined with the potential hydraulic improvements and slope failure mitigation. | Near-Term | High | NYCDEP, NRCS | Town, Village, and County |

## TABLE 8-1 (continued)
## Implementation Plan

| Recommendation | Time Frame | Cost | Potential Funding Sources* | Responsible Party |
|---|---|---|---|---|
| Evaluate sections of the Third Brook channel for feasibility of regrading to increase stability and connect to the floodplain. If the channel can be raised to higher elevations in the vicinity of failing slopes, less intensive engineered solutions may be possible for the slope mitigation. | Near-Term | Intermediate (evaluation) to High (grading) | NYCDEP, NRCS, DOS | Town, Village, and County |
| Evaluate the 11 closely spaced cross vanes in segments 3 and 4 to determine their utility in improving channel grades as opposed to maintaining the status quo. | Near-Term | Intermediate | County | County |
| *Goal #3 – Stormwater* | | | | |
| Inspect stormwater collection, conveyance, and discharge systems annually and remove sediment if found. | Ongoing | Intermediate | Operating budgets | Village and County |
| Minimize use of unvegetated ditches for stormwater conveyance. Remediate as needed. | Ongoing | Intermediate | EPA, CWC, Town, Village, County | Town, Village, and County |
| Ensure that bluestone quarry owners receive proper technical assistance to manage runoff from their facilities, which will help prevent rock dust, silt, and sediment from reaching Third Brook. | Near-Term | Low | Town and County | Town and County |
| *Goal #4 – Land Use Planning and Regulations* | | | | |
| If the Town of Walton proceeds with allowing "cluster" or "open space" development, ensure that the new regulations recognize the need for stormwater management and water quality protection. | Ongoing | Low | Town | Town |
| Adopt CEAs to protect natural resources in the Third Brook watershed. | Near-Term | Low | Town | Town |
| Provide more funding and education for the town's code enforcement officer and the village's code enforcement officer so they can promote flood-resilient upgrades and construction near Third Brook. | Ongoing | Intermediate | Town and Village | Town and Village |

## TABLE 8-1 (continued)
## Implementation Plan

| Recommendation | Time Frame | Cost | Potential Funding Sources* | Responsible Party |
|---|---|---|---|---|
| If the village and town work together to develop design treatments outside the village along roadways for intensification of amenities as one approaches/enters the village, ensure that this is accomplished in the context of flood mitigation. Conversion of developed land to open space should be considered as an amenity. | Ongoing | Low | Town and Village | Town and Village |
| Ensure that flood damage prevention regulations are applied to structures located where base flood elevations exceed ground surface elevations, in addition to structures simply mapped in the Third Brook SFHA. | Ongoing | Low | Town and Village | Town and Village |
| Village Zoning Regulations Section 53-57 should be used by the Floodplain Administrator to conduct stringent reviews of applications for development where the section applies (to lots abutting watercourses). This may be the only direct mechanism for the village to regulate structures that are in a floodplain but not within a FEMA-delineated SFHA. | Ongoing | Low | Village | Village |
| Identify areas that are off limits for development in the Third Brook watershed in both the town and the village and ensure that these areas are protected as such. | Ongoing | Low | Town and Village | Town and Village |
| *Goal #5 – Sanitary Wastewater* | | | | |
| Work with owners of septic systems in the watershed to ensure that systems are maintained or replaced as needed to reduce the potential for failures. | Long-Term | Intermediate | CWC | Town and County |
| The town and village should evaluate the cost and feasibility of extending the village sewer system to the town's portion of West Street, allowing decommissioning of septic systems that are at risk of inundation or erosion. | Long-Term | High | EPA, DOS, County | Town and Village |
| *Goal #6 – Wetlands* | | | | |
| Reforest some of the wetland areas along the Third Brook corridor. This will increase habitat diversity and will likely have benefits to water quality as well. | Long-Term | High | USFWS, EPA | County |

# TABLE 8-1 (continued)
## Implementation Plan

| | | | | |
|---|---|---|---|---|
| *Sediment Management* | | | | |
| Evaluate Old Village Reservoir for the feasibility of removing sediment. This feasibility study should consider methods (hydraulic dredging vs. conventional excavation), costs, and environmental permitting. | Near-Term | Intermediate | County and DOS | County |
| If found feasible, sediment should be removed from the impoundment to provide a means of catching sediment from areas upstream of the dam, thereby helping to improve water quality downstream. | Long-Term | High | County | County |
| Discourage dredging sections of Third Brook unless hydraulic modeling demonstrates that removing sediment from the channel will reduce flood elevations and that such dredging will not disturb any equilibrium that has been achieved or may be achievable. | Ongoing | Low | County | County |
| *Miscellaneous* | | | | |
| Ensure that outreach and education remain a priority and continue to provide technical assistance within the watershed regarding agricultural land use, maintaining natural floodplains, and flood damage prevention. | Ongoing | Low | County, Town, and Village | County, Town, and Village |
| Implement suitable direct and indirect monitoring programs to determine whether restoration and stabilization projects in the watershed are successful. | Ongoing | Intermediate | County, Town, and Village | County, Town, and Village |

*Funding Sources:

NYCDEP = New York City Department of Environmental Protection
USACE = U.S. Army Corps of Engineers
FEMA = Federal Emergency Management Agency
HUD = U.S. Department of Housing and Urban Development
EPA = U.S. Environmental Protection Agency
CWC = Catskill Watershed Corporation
NRCS = U.S. Department of Agriculture Natural Resources Conservation Service
USFWS = U.S. Fish and Wildlife Service
Town = Town of Walton
Village = Village of Walton
County = Delaware County (department not specified)
DOS = NYS Department of State

The entries in the timetable column are similarly divided into three categories:

- ☐ "Ongoing" indicates recommendations that may be underway and should continue, or should commence upon plan completion.
- ☐ "Near-Term" indicates recommendations that should be implemented in the next two years, some of which may continue for a period of time or indefinitely.
- ☐ "Long-Term" indicates recommendations that should be pursued within 10 years, some of which may continue for a period of time or indefinitely.

## 8.4 Funding Sources

Numerous potential funding sources may be available to the Village and Town of Walton as well as Delaware County and its departments for the implementation of recommendations of this plan. In most cases, these programs can fund only projects that result in tangible benefits. Studies such as hydraulic modeling are typically not funded through these programs although one new program being developed by NYCDEP will be able to fund modeling studies.

### Natural Resources Conservation Service (NRCS)

The NRCS provides technical assistance to individual landowners, groups of landowners, communities, and soil and water conservation districts on land use and conservation planning, resource development, stormwater management, flood prevention, erosion control and sediment reduction, detailed soil surveys, watershed/river basin planning and recreation, and fish and wildlife management. Financial assistance is available to reduce flood damage in small watersheds and to improve water quality. Several major programs are described below.

### *Emergency Watershed Protection Program (EWP)*

Through the EWP program, the U.S. Department of Agriculture's NRCS can help communities address watershed impairments that pose imminent threats to lives and property. Most EWP work is for the protection of threatened infrastructure from continued stream erosion. NRCS may pay up to 75% of the construction costs of emergency measures. The remaining costs must come from local sources and can be made in cash or in-kind services. No work done prior to a project agreement can be included as in-kind services or part of the cost share. EWP projects must reduce threats to lives and property; be economically, environmentally, and socially defensible; be designed and implemented according to sound technical standards; and conserve natural resources.

Completed flood and erosion damage remedial projects along Third Brook include slope stabilization near the town/village line (NRCS Project D-W-061), a stacked and pinned rock wall stream bank stabilization 2,000 feet upstream of the village boundary (NRCS

Project D-W-601), and a stacked rock wall channel stabilization one mile upstream of the village boundary (NRCS Project D-W-401). Since the EWP program has already been used for remedial actions in the Third Brook watershed, it is possible that additional projects could be funded through this program.

### *Watersheds and Flood Prevention Operations*

This program element contains two separate and distinct programs, "Watershed Operations" and "Small Watersheds." The purpose of these programs is to cooperate with state and local agencies, tribal governments, and other federal agencies to prevent damages caused by erosion, floodwater, and sediment and to further the conservation, development, utilization, and disposal of water and the conservation and utilization of the land. The objectives of these programs are to assist local sponsors in assessing conditions in their watershed, developing solutions to their problems, and installing necessary measures to alleviate the problems. Measures may include land treatment and structural and nonstructural measures. Federal cost sharing for installation of the measures is available. The amount depends upon the purposes of the project.

### *Financial Assistance Programs and Initiatives*

NRCS offers voluntary programs to eligible landowners and agricultural producers to provide financial and technical assistance to help manage natural resources in a sustainable manner. Through these programs, the agency approves contracts to provide financial assistance to help plan and implement conservation practices that address natural resource concerns or opportunities to help save energy and improve soil, water, plant, air, animal, and related resources on agricultural lands and nonindustrial private forest land. Financial assistance programs include the following:

☐ Agricultural Management Assistance Program (AMA)
☐ Conservation Innovation Grants (CIG)
☐ Environmental Quality Incentives Program (EQIP)
☐ Wildlife Habitat Incentive Program - Working Lands for Wildlife (WHIP - WLFW)
☐ Conservation Stewardship Program (CSP)

### *Easement Programs*

NRCS offers easement programs to landowners who want to maintain or enhance their land in a way beneficial to agriculture and/or the environment. All NRCS easement programs are voluntary. NRCS provides technical help and financial assistance, but local landowners and organizations are needed to make NRCS easement programs successful. Easement programs include the following:

☐ Farm and Ranch Lands Protection Program (FRPP)
☐ Grassland Reserve Program (GRP)
☐ Wetlands Reserve Program (WRP)

### United States Department of Agriculture (USDA) Farm Service Agency (FSA)

#### *Conservation Reserve Program (CRP)*

The CRP is a land conservation program administered by FSA. In exchange for a yearly rental payment, farmers enrolled in the program agree to remove environmentally sensitive land from agricultural production and plant species that will improve environmental health and quality. Contracts for land enrolled in CRP are 10 to 15 years in length. The long-term goal of the program is to re-establish valuable land cover to help improve water quality, prevent soil erosion, and reduce loss of wildlife habitat.

### FEMA

#### *Pre-Disaster Mitigation (PDM) Program*

The Pre-Disaster Mitigation Program was authorized by Part 203 of the Robert T. Stafford Disaster Assistance and Emergency Relief Act (Stafford Act), 42 U.S.C. 5133. The PDM program provides funds to states, territories, tribal governments, communities, and universities for hazard mitigation planning and implementation of mitigation projects prior to disasters, providing an opportunity to reduce the nation's disaster losses through pre-disaster mitigation planning and the implementation of feasible, effective, and cost-efficient mitigation measures. Funding of pre-disaster plans and projects is meant to reduce overall risks to populations and facilities.

The PDM program was one of the FEMA programs with the most potential fit to potential projects in the Third Brook watershed, with the other being the Hazard Mitigation Grant Program (HMGP) (described below). After two years without support, Congress reauthorized the PDM program at a lower level of funding for application solicited in 2013. It is possible that some of the projects in the Third Brook watershed could be funded if PDM remains supported and if the projects meet FEMA's requirement of cost effectiveness.

*Hazard Mitigation Grant Program (HMGP)*

The HMGP is authorized under Section 404 of the Robert T. Stafford Disaster Relief and Emergency Assistance Act. The HMGP provides grants to states and local governments to implement long-term hazard mitigation measures after a major disaster declaration. The purpose of the HMGP is to reduce the loss of life and property due to natural disasters and to enable mitigation measures to be implemented during the immediate recovery from a disaster. A key purpose of the HMGP is to ensure that any opportunities to take critical mitigation measures to protect life and property from future disasters are not "lost" during the recovery and reconstruction process following a disaster.

The HMGP is one of the FEMA programs with the greatest potential fit to potential projects in the Third Brook watershed. However, it is available only in the months subsequent to a federal disaster declaration in the State of New York. Because the state administers the HMGP directly, application cycles will need to be closely monitored after disasters are declared in New York. It is possible that some of the projects in the Third Brook watershed could be funded if they meet FEMA's requirement of cost effectiveness.

*Flood Mitigation Assistance (FMA) Program*

The FMA program was created as part of the National Flood Insurance Reform Act (NFIRA) of 1994 (42 U.S.C. 4101) with the goal of reducing or eliminating claims under the NFIP. FEMA provides FMA funds to assist states and communities with implementing measures that reduce or eliminate the long-term risk of flood damage to buildings, homes, and other structures insurable under the NFIP. The long-term goal of FMA is to reduce or eliminate claims under the NFIP through mitigation activities.

One limitation of the FMA program is that it is generally used to provide mitigation for structures that are insured or located in SFHAs. In the Third Brook watershed, only a few properties are located in the SFHA such as Robinson Auction House and the Kraft facility.

The Biggert-Waters Flood Insurance Reform Act of 2012 eliminated the Repetitive Flood Claims (RFC) and Severe Repetitive Loss (SRL) programs and made the following significant changes to the FMA program:

- The definitions of repetitive loss and severe repetitive loss properties have been modified.
- Cost-share requirements have changed to allow more federal funds for properties with repetitive flood claims and severe repetitive loss properties.
- There is no longer a limit on in-kind contributions for the non-federal cost share.

The NFIP provides the funding for the FMA program. The PDM and FMA programs are subject to the availability of appropriation funding, as well as any program-specific directive or restriction made with respect to such funds.

One potentially important (yet still untested) change to the PDM, HMGP, and FMA programs is that "green open space and riparian area benefits can now be included in the project benefit cost ratio (BCR) once the project BCR reaches 0.75 or greater. The inclusion of environmental benefits in the project BCR is limited to acquisition-related activities." This may be an important consideration in the Third Brook watershed if properties have a BCR of 0.75 or greater, but not greater than 1.0.

### U.S. Army Corps of Engineers (USACE)

The USACE provides 100% funding for floodplain management planning and technical assistance to states and local governments under several flood control acts and the Floodplain Management Services Program (FPMS). Specific programs used by the USACE for mitigation are listed below.

#### *Section 205 – Small Flood Damage Reduction Projects*

This section of the 1948 Flood Control Act authorizes the USACE to study, design, and construct small flood control projects in partnership with non-federal government agencies. Feasibility studies are 100% federally funded up to $100,000, with additional costs shared equally. Costs for preparation of plans and construction are funded 65% with a 35% non-federal match. In certain cases, the non-federal share for construction could be as high as 50%. The maximum federal expenditure for any project is $7 million.

#### *Section 14 – Emergency Stream Bank and Shoreline Protection*

This section of the 1946 Flood Control Act authorizes the USACE to construct emergency shoreline and stream bank protection works to protect public facilities such as bridges, roads, public buildings, sewage treatment plants, water wells, and nonprofit public facilities such as churches, hospitals, and schools. Cost sharing is similar to Section 205 projects above. The maximum federal expenditure for any project is $1.5 million.

### *Section 208 – Clearing and Snagging Projects*

This section of the 1954 Flood Control Act authorizes the USACE to perform channel clearing and excavation with limited embankment construction to reduce nuisance flood damages caused by debris and minor shoaling of rivers. Cost sharing is similar to Section 205 projects above. The maximum federal expenditure for any project is $500,000.

### *Section 206 – Floodplain Management Services*

This section of the 1960 Flood Control Act, as amended, authorizes the USACE to provide a full range of technical services and planning guidance necessary to support effective floodplain management. General technical assistance efforts include determining the following: site-specific data on obstructions to flood flows, flood formation, and timing; flood depths, stages, or floodwater velocities; the extent, duration, and frequency of flooding; information on natural and cultural floodplain resources; and flood loss potentials before and after the use of floodplain management measures. Types of studies conducted under FPMS include floodplain delineation, dam failure, hurricane evacuation, flood warning, floodway, flood damage reduction, stormwater management, floodproofing, and inventories of floodprone structures. When funding is available, this work is 100% federally funded.

In addition, the USACE also provides emergency flood assistance (under Public Law 84-99) after local and state funding has been used. This assistance can be used for both flood response and postflood response. USACE assistance is limited to the preservation of life and improved property; direct assistance to individual homeowners or businesses is not permitted. In addition, the USACE can loan or issue supplies and equipment once local sources are exhausted during emergencies.

### U.S. Department of Housing and Urban Development (HUD)

HUD offers *Community Development Block Grants (CDBG)* to communities with populations greater than 50,000, who may contact HUD directly regarding CDBG. One program objective is to improve housing conditions for low- and moderate-income families. Projects can include acquiring floodprone homes or protecting them from flood damage. Funding is a 100% grant and can be used as a source of local matching funds for other funding programs such as FEMA's "404" HMGP. Funds can also be applied toward "blighted" conditions, which is often the postflood condition. A separate set of funds exists for conditions that create an "imminent threat." The funds have been used in the past to replace (and redesign) bridges where flood damage eliminates police and fire access to the other side of the waterway. It is possible that recommendations of this plan regarding floodproofing or removal of structures along Third Brook could be matched with some of these grant programs.

The U.S. Fish and Wildlife Service

The U.S. Fish and Wildlife Service provides technical and financial assistance to restore wetlands and riparian habitats through the North American Wetland Conservation Fund and Partners for Wildlife programs. It also administers the North American Wetlands Conservation Act Grants Program, which provides 1-to-1 matching grants to organizations and individuals who have developed partnerships to carry out wetlands projects in the United States, Canada, and Mexico. Funds are available for projects focusing on protecting, restoring, and/or enhancing critical habitat. It is possible that recommendations of this plan regarding restoration of wetlands along Third Brook could be matched with some of these grant programs.

U.S. Environmental Protection Agency (EPA)

CWA Section 319 grants are cost-share grants to state agencies that can be used for funding watershed resource restoration activities, including wetlands and other aquatic habitats such as riparian zones. Only those activities that control nonpoint pollution are eligible. It is possible that recommendations of this plan regarding restoration of wetlands along Third Brook or management of stormwater in the watershed could be matched with a Section 319 grant.

NYCDEP

NYCDEP administers the *Stream Management Program* for planning and projects that protect and restore stream stability. This program does not specifically require a match, but applicants are encouraged to leverage these funds with other funding sources such as those described herein.

NYCDEP has developed a *Local Flood Hazard Mitigation Assessment* (LFHMA) program to streamline the prioritization of funding various flood mitigation projects in its watershed communities. This is somewhat analogous to FEMA's requirement for hazard mitigation planning as a prerequisite for administering funds through its mitigation programs. One important benefit of the LFHMA program is that it will provide funding for hydraulic/hydrologic modeling in order to prioritize mitigation actions. The other programs listed in this section do not typically fund modeling studies.

NYCDEP has an *Agriculture* program to allow agricultural uses of City-owned watershed lands when these uses are compatible with water quality protection. Agricultural uses may include tapping maple trees for sap, harvesting hay, and harvesting row crops such as corn, and pasturing livestock. Properties can be made available to interested parties who either contact NYCDEP directly or respond to a NYCDEP-issued Request for Proposals. Interested farmers then submit a proposal that describes how specific land will be used for agriculture in a manner that protects water quality. NYCDEP sets minimum requirements such as 25-foot buffers along all streams and wetlands, and encourages the use of agricultural BMPs such as contour tilling, no till methods, the use of cover crops, and use of organic farming methods.

Catskill Watershed Corporation

The Catskill Watershed Corporation is a local development corporation established to protect the water resources of the New York City watershed west of the Hudson River (WOH); to preserve and strengthen communities located in the region; and to increase awareness and understanding of the importance of the NYC water system. The Catskill Watershed Corporation administers a number of programs under this mission, such as:

- ☐ Septic Repair and Maintenance – Funds residential septic system repairs, replacements, and maintenance.
- ☐ Stormwater Planning and Control – Funds planning, assessment, design, and implementation of stormwater and erosion controls for existing conditions, as well as stormwater requirements for new construction.
- ☐ Education – Provides grants to schools and organizations.
- ☐ Community Wastewater Management – Funds a program to evaluate and build community-specific wastewater solutions, which may include septic maintenance districts, community septic systems, or wastewater treatment plants.
- ☐ Local Technical Assistance Program – Provides grants to communities conducting watershed protection and land use planning initiatives.

The Stream Corridor Protection/Flood Debris Removal program ended in 2010. Thirteen projects were initially funded through this program. After the flood of 2006 in Walton, funds from Catskill Watershed Corporation were used for a new stacked rock wall and repair of existing rock wall downstream of the Ogden Street bridge.

In December 2011, the program was modified and re-funded ($2.5 million) to provide grants for the removal of flood debris in stream channels and/or floodplains in the watershed in the aftermath of storms Irene and Lee. Applicants included towns, villages, property owners, and Soil and Water Conservation Districts. A total of 120 applications was reviewed by the submission deadline and, as of June 2012, work was proceeding on approved sites.

At the present time, the Catskill Watershed Corporation is not a viable source of funding for many of the recommendations of the Third Brook watershed management plan. However, the Stormwater Planning and Control program may be a good fit for small-scale projects that involve stormwater and erosion controls.

NYS Department of State

The Department of State funded this watershed management plan and may be able to fund some of the recommendations or strategies from this plan. In order to be eligible, a project should link water quality improvement to economic benefits. An example from this plan would be flood mitigation of the Kraft facility as this would reduce damages to an important local employer while reducing the potential for water quality impairments that could occur when the facility is flooded.

### New York Rising Community Reconstruction Program

The New York Rising Community Reconstruction Program was established to provide additional rebuilding and revitalization assistance to communities severely damaged by Hurricanes Sandy and Irene and Tropical Storm Lee.  To facilitate community redevelopment planning and the resilience of communities, the State has allocated $25 million for planning in the most affected communities.  Walton is not currently a community identified by New York Rising, but Delaware County includes communities that are currently identified for funds and planning.

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# 9.0 TECHNICAL REFERENCES

Bloom, A.L., 1978, Geomorphology – A Systematic Analysis of Late Cenozoic Landforms.

Hey, R.D., 1994, The Rivers Handbook, Volume II, Chapter 18, Environmentally Sensitive River Engineering.

Leopold, L.B, and Maddock, T., 1953, Hydraulic Geometry of Stream Channels and some Physiographic Implications, USGS Professional Paper 252.

Rosgen, D.L., 1998, The Reference Reach – A Blueprint for Natural Channel Design.  ASCE Wetlands, Engineering, and River Restoration Conference, Denver, CO.

Rosgen, D.L, 1997, A Geomorphological Approach to Restoration of Incised Rivers, Proceedings of the Conference on Management of Landscapes Disturbed by Channel Incision.

Rosgen, D.L., 1994, A Classification of Natural Rivers, Catena – An Interdisciplinary Journal of Soil Science, Hydrology, and Geomorphology, Volume 22 No. 3.

Rosgen, D.L., 2006, Watershed Assessment of River Stability & Sediment Supply.

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# Appendix A
# Resource Materials

# Appendix A
## Resource Materials

The following is a list of resources and materials that have been compiled and reviewed as part of this plan:

### Municipal Plans and Regulations

- ☐ Town of Walton Comprehensive Plan
- ☐ Town of Walton Zoning Law and Zoning Map
- ☐ Town of Walton Subdivision Law
- ☐ Village of Walton Municipal Code Chapters 19, 22, 25, 44, and 53
- ☐ Village of Walton Zoning Map
- ☐ Town of Walton Flood Damage Prevention Code
- ☐ Village of Walton Flood Damage Prevention Code

### Countywide Plans

- ☐ Delaware County Action Plan (DCAP) for Watershed Protection and Economic Vitality (2002)
- ☐ West Branch Delaware River Stream Corridor Management Plan (2006)

### Hazard Mitigation Plan Materials

- ☐ Delaware County Hazard Mitigation Plan (2006)
- ☐ Hazard Mitigation Plan Update, Delaware County, New York. Section 9.28: Town of Walton (2012)
- ☐ Hazard Mitigation Plan Update, Delaware County, New York. Section 9.29: Village of Walton (2012)

### FEMA-Related Materials

- ☐ FEMA Flood Insurance Study (FIS) and Flood Insurance Rate Map (FIRM) (2012)
- ☐ Town of Walton FIRM (1988)
- ☐ Village of Walton FIRM (1991)

### Flooding-Related Materials

- ☐ Village of Walton, NY: Flood and Hydraulic Study. Prepared for Village of Walton, Delaware County Planning Department and Delaware County Natural Resources Conservation District. Woidt Engineering and FIScH Engineering (May 30, 2008) – *This flood and hydraulic study includes flooding history, a review of existing/ongoing studies, hydrology, emergency repairs/ongoing mitigation stream project, existing hydraulic conditions, flood mitigation strategies, and conclusions and recommendations. The study also includes a project location map, cross section location map, FEMA floodplain designations, and HEC-RAS summary tables and water surface profiles.*

- ☐ Press Coverage
    - o http://www.dcswcd.org/SWCD/News/December%202010/Walton%20Flood%20Commission-3rd%20Brook%20Plan.pdf
    - o http://old.thedailystar.com/news/stories/2006/12/22/dcwaltonflood7.html
    - o http://www.redorbit.com/news/science/1436291/local_villages_to_get_flood_grants/
    - o http://www.cwconline.org/programs/tech/LTAPgrantrecipients07.pdf
    - o http://www.watershedpost.com/2011/dredge-or-not-dredge
- ☐ Flood of April 4-5, 1987, in Southeastern New York State, with Flood Profiles of Schoharie Creek. U.S. Geological Survey and New York State DOT (1989) – *Describes the intense rainfall of April 3-5, 1987. Includes a summary of peak stages and discharges, precipitation maps, floodflow hydrographs, inflow hydrographs, and flood profiles along Schoharie Creek.*
- ☐ Flood of January 19-20, 1996 in New York State. U.S. Geological Survey and New York State DOT (1998) – *Describes the intense rainfall and warm temperatures of January 18-19, 1996 that resulted in rapid snowmelt and flooding. Includes a summary of peak stages and discharges, precipitation maps, floodflow hydrographs, inflow-outflow hydrographs, and flood profiles along Schoharie Creek.*
- ☐ Flood of June 26-29, 2006, Mohawk, Delaware and Susquehanna River Basins, New York. U.S. Geological Survey and Federal Emergency Management Agency (2009) – *Describes flooding in the Mohawk, Delaware, and Susquehanna River basins from June 26-29, 2006.*
- ☐ Brief Summary of the Flood of Oct. 1, 2010 in Eastern New York. Thomas P. Suro, US Geological Survey (Oct. 12, 2010) – *Describes the effects of Tropical Storm Nichole in eastern New York on September 30 and October 1, 2010.*
- ☐ Flood of 2006 Third Brook Photos, Post Flood Conditions. Delaware County Soil & Water Conservation District – *Photos taken in early July 2006 after flood of June 27-28, 2006.*
- ☐ Kraft Tunnel Photo Log (January 16, 2009) – *Includes photos of sump area and water coming up through floor.*
- ☐ Third Brook Flood Damage Aerial Survey – Downstream to Upstream (July 7, 2006) – *Photos of Kraft Plant, Marlett's Garage, Radio Shack, and other structures along Third Brook.*
- ☐ East Brook Photo Log – Sites 1 through 5 – *Photos taken in July and August 2006.*
- ☐ Conference Call: Flood Response for the Catskills – Next Steps (April 20, 2007) – Attended by Christine Delorier (USACE, NYC office), Rob Tranter (FEMA), Mari-Beth DeLucia (TNC), Doug DeKoskie (Integrated River Solutions), Jack Isaacs (NYS DEC Region 3), Julie Allen (Congressman Hinchey's Office), Beth Reichheld (NYC DEP Stream Management Program), Nat Gillespie (Trout Unlimited). *Flood Response Workshop PowerPoint, outline, and notes from conference call about next steps after the workshop.*

## Failing Slopes

- ☐ Third Brook Landowners – *Shows map of property locations and mailing addresses of property owners along Third Brook.*
- ☐ Helicopter Photos (July 7, 2006), Ground Photos (March and April 2009) – *Images of slope failures along Third Brook.*
- ☐ Third Brook Photos (March 15, 2007) – *Photos of mass failures along Third Brook with aerials and handwritten notes.*

- ☐ Project Fact Sheet for the Third Brook Corridor Mass Slope Failure Mitigation Project, New York City Watershed Environmental Assistance Program Proposal, Town and Village of Walton, New York. (Feb. 23, 2007) – *Draft of environmental assistance program proposal sponsored by the Delaware County Board of Supervisors. Discusses cost of the project and years of construction.*
- ☐ Third Brook Geotechnical Study, Existing Plan View – Slide 8. Delaware County Stream Corridor Management Program. Delaware County Soil & Water Conservation District.
- ☐ Third Brook Geotechnical Study, Existing Plan View – Slide 6 & 7. Delaware County Stream Corridor Management Program. Delaware County Soil & Water Conservation District.
- ☐ Hawk Engineering Geotechnical Report – Subsurface Logs September 8, 2009 – Copies of the subsurface logs for three borings and an explanation of the log format.
- ☐ New York City Watershed Environmental Assistance Program: Third Brook Corridor Mass Slope Failure Mitigation Project Schedule, Town and Village of Walton, New York (as of Dec. 23, 2009) – Draft project schedule and cost estimate.
- ☐ New York City Watershed Environmental Assistance Program: Project Management Plan, Third Brook Corridor Mass Slope Failure Mitigation Project, Town and Village of Walton, New York (2010) – *Project management plan including West Branch Delaware River existing conditions, project plan, and division of responsibilities between US Army Corps of Engineers, NYSDEC, and Town and Village of Walton.*
- ☐ Geotechnical Assessment of Slope Failures, East Brook and Third Brook, Village and Town of Walton (July 13, 2006) – Attended by Charles Gaynor, PE (President, Hawk Engineering), Dave Ohman (Walton Village Engineer), Sarah Miller (NYCDEP), Larry Day, Scotty Gladstone, Tom Mallory (DCSWCD). *Notes from meeting intended to find out which alternatives Charles Gaynor preferred for stabilizing large slope failures after the June 27-28 storm event.*
- ☐ Draft Geotechnical Engineering Evaluation for Third Brook Slope Failures. Hawk Engineering, PC (March 5, 2010) – *Includes general description of geology, surface and subsurface conditions, slide safety factors, slope stabilization, and cost estimates.*
- ☐ Hawk Engineering, PC Bid Tabulation – Third Brook Slope Failure – *Includes costs of M&D, Overburden Drilling (0'-50'), Overburden Drilling (50'-70'), Split Spoon Sampling, Rock Coring, Natural Moisture Content, Atterberg Limits, and Sieve Analysis.*

Miscellaneous Materials

- ☐ West Branch Action Plan http://www.nyc.gov/html/dep/pdf/reports/fad_46_smp_west_branch_action_plan.pdf
- ☐ Third Brook, Needs Assessment Report, Delaware County, New York. Integrated River Solutions, Inc. with Delaware County Soil & Water Conservation District (January 2007) – *Report by Integrated River Solutions, Inc. for the DCDWA to be used in watershed planning. Includes recommended Third Brook Assessment schedule.*
- ☐ Local Technical Assistance Program (LTAP), Application Form for LTAP Grant 2010 – LTAP application for Box Culvert Replacement Design – NY Rte. 10/206 over Third Brook. Includes project summary, background, schedule, and budget.
- ☐ Delaware County Soil and Water Conservation District: Preliminary Findings: Third Brook Conceptual Design (Nov. 15, 2007) – Covers the area from the confluence with West Brook

to the Village Reservoir. Discusses the work done by the EWP program in response to the June 2006 flood and the current state of the stream. Provides several alternative design ideas.

- ☐ Fax to Kent Sanders at NYSDEC from Scotty Gladstone (July 13, 2006) – Third Brook Phase II cross sections and model input data and results.
- ☐ Summary of Geologic Observations from July 7, 2006 Field Visit. Email from Dan Davis to Scotty Gladstone and Phil Eskeli (July 11, 2006) – Contains notes on Third Brook and East Brook field visit and postflood photo log. Photos were taken at 13 locations along Third Brook and East Brook.
- ☐ Agreement Between Delaware County and Delaware County Soil and Water Conservation District under Local Technical Assistance Program from Catskill Watershed Corporation (May 15, 2009) – Contract for Third Brook Flood Mitigation and Stream Corridor Management plan.
- ☐ USACE Meeting Notes, Delaware River Basin Agenda for Assistant Secretary of the Army (Civil Works) (Sept. 2007)
- ☐ Third Brook Investigation, Village and Town of Walton, Delaware County (April 1, 2009) – Compilation of USACE Meeting Notes, Meeting Agenda, and Third Brook Investigation report detailing recommendations for Rt. 206 culvert flooding. Report provides a review of documents provided by Delaware County: Summary of Third Brook Issues, Rt. 206 Crossing Proposed Solution, Summary of USDA Emergency Flood Protection 2007 Work.
- ☐ Plans – Compilation of Rt. 206 Drainage map, Third Brook conceptual plan, and Delaware Street Plan and Profile (Sept. 1973).
- ☐ Schematic Plan – Rt. 206/Third Brook Crossing – *Shows bridge deck, stub abutments, existing channel, x-vanes, and sheet pile. Not to scale.*
- ☐ Third Brook Conceptual Plan, Village of Walton – NYS Rt. 10/206 to Ogden St. Bridge – *Shows approximate floodplain delineation, culvert, proposed rock wall, existing stone wall or riprap, sewer line, and manhole.*
- ☐ Water Quality:
  - http://www.dec.ny.gov/docs/water_pdf/pwldelawbrd.pdf
  - http://www.dec.ny.gov/docs/water_pdf/sbu30yrbs14.pdf
- ☐ Bankfull Discharge and Channel Characteristics of Streams in New York State. New York State DEC, New York Department of State, New York State DOT, New York City DEP (2010) – *Analyzes seven regional bankfull-discharge and channel-characteristics curves. Discusses factors affecting bankfull discharge and channel characteristics in New York State.*
- ☐ U.S. Geological Survey Catskill/Delaware Water Quality Network: Water-Quality Report Water Year 2006. U.S. Geological Survey and U.S. Department of the Interior (2010) – *In 2006, an average of 62 water-quality samples were collected at each of 13 stations in the Catskill/Delaware stream gaging network.*
- ☐ Third Brook at Rte. 10 Existing Conditions Plan (March 5, 1975) – *Includes hydraulic data and channel curve data.*
- ☐ 2001 Walton LIDAR – *Aerial photo with 2 meter contours.*
- ☐ RE: Third Brook Wall Extension, Walton, NY (January 24, 2007) – *Compilation of Third Brook survey information, maps, profiles, meeting agendas, emails, photos, HEC-RAS model data, permits, etc. from 2006 and 2007.*
- ☐ USDA Natural Resources Conservation Service Emergency Watershed Protection, Town of Walton, Lower Third Brook, Delaware Co., NY. USDA and NRCS – *Collection of plans including profiles, cross sections, and details related to Lower Third Brook.*

- ☐ Walton Soil Classification – Map of Walton, NY showing soil classifications and nontechnical descriptions of soil types.

# Appendix B
# Community Outreach Plan

# THIRD BROOK WATERSHED MANAGEMENT PLAN
## *COMMUNITY OUTREACH PLAN*

**MAY 2012**

MMI #4444-01

**THIS DOCUMENT WAS PREPARED FOR THE NEW YORK STATE DEPARTMENT OF STATE WITH FUNDS PROVIDED UNDER TITLE 11 OF THE ENVIRONMENTAL PROTECTION FUND**

***Prepared for:***

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***Prepared by:***

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## ***Introduction***

The Village of Walton, in partnership with the Delaware County Soil and Water Conservation District (DCSWCD), Delaware County Planning Department (DCPD), and the New York City Department of Environmental Protection (NYCDEP) has commissioned the preparation of a watershed management plan for Third Brook. Milone & MacBroom, Inc. (MMI) was retained to work with the project partners to develop this comprehensive plan. The preparation of the plan is funded in part by the New York State Department of State with funds provided under Title 11 of the Environmental Protection Fund.

The Third Brook watershed has an area of approximately five square miles and is located within the Town and Village of Walton, within Delaware County, New York. Residents, critical municipal infrastructure, and businesses that are crucial to the county's economy have been devastated by flooding in the watershed and by severe erosion that has resulted from flooding and flood recovery. As such, a significant element of the watershed management plan focuses on creating a stable river valley and decreasing future vulnerability.

Beyond the important issue of flooding, the management plan will address strategies associated with stream stability, erosion, and slope failures; stormwater management; land management; and wetland habitat protection. All of these issues directly affect water quality. Debris that is dislodged and carried in floodwaters can be a significant source of pollution. Reducing the potential for debris to be carried into floodwaters can reduce the potential for pollution resulting from the debris. Sediment entering Third Brook from eroding banks, failing slopes, and stormwater continues to impair the watercourse. Stabilizing eroding banks and failing slopes is a therefore believed to be a high priority. Although wetlands are believed intact and functioning in the watershed, protecting and enhancing wetlands may help protect and improve water quality.

The primary contact for the watershed planning process is:

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Delaware County Soil and Water Conservation District
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Walton, NY 13856
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The consultant retained to develop the watershed management plan is:

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## ***Role of the Project Advisory Committee (PAC)***

The role of the Project Advisory Committee is to ensure that the watershed management plan development process and the policy recommendations contained therein are clear and appropriate, and that as diverse an audience as possible is engaged in developing the plan and its recommendations. The PAC must also be cognizant of keeping the plan "user-friendly" and understandable to the target audience to ensure community buy-in.

Representatives on the PAC were taken from the following potential entities:

- Village of Walton
- Town of Walton
- Delaware County Soil and Water Conservation District
- Delaware County Planning Department
- New York City Department of Environmental Protection
- New York Department of State
- New York Department of Transportation
- USDA Natural Resource Conservation Service
- Delaware County Chamber of Commerce representative
- Watershed residents
- Impacted business owners in the floodplain such as Breakstone/Kraft
- Churches and other non-profit organizations
- Agricultural organizations

The final list of PAC members is provided in the following table.

## Third Brook Watershed Management Plan Project Advisory Committee

| ***Committee Member*** | ***Affiliation*** | ***Telephone*** | ***Email Address*** |
|---|---|---|---|
| Graydon Dutcher | Delaware County Soil and Water Conservation District | (607) 865-7161 | graydon-dutcher@dcswcd.org |
| Rick Weidenbach | Delaware County Soil and Water Conservation District | (607) 865-7161 | rick-weidenbach@dcswcd.org |
| Jessica Rall | Delaware County Soil and Water Conservation District | (607) 865-7161 | Jessica-Rall@dcswcd.org |
| Duncan Martin | Delaware County Planning Department | (607) 746-2944 | duncan.martin@co.delaware.ny.us |
| Michael Jastremski | Delaware County Planning Department | (607) 746-2944 | michael.jastremski@co.delaware.ny.us |
| Walter Geidel | Town of Walton Highway Department | (607) 865-5120 | waltonhighway@stny.rr.com |
| Len Govern | Town Board, Town of Walton | (607) 865-5766 | Lengovern@funnybearllc.com |
| Bruce Dolph | Walton Town Supervisor | (607) 865-4052 | bbdolph1@hotmail.com,<br>Waltonsupervisor@stny.rr.com |
| Patrick Meredith | Walton Village Mayor | (607) 865-4358 | patrick_meredith89@yahoo.com,<br>patrick.meredith89@gmail.com |
| Dean Frazier | Delaware County Watershed Affairs Commissioner | (607) 746-8914 | dean.frazier@co.delaware.ny.us |
| Eleanor Anbari | Resident | (607) 865-4322 | ---- |
| Phil Eskeli | NYCDEP | | PEskeli@dep.nyc.gov |
| Tracey O’Malley | NYS DOS | (518) 473-3371 | Tracey.O'Malley@dos.state.ny.us |

Ultimately, the PAC concluded that churches and nonprofit groups were not present in the watershed and could be removed from the list of potential attendees. The Delaware County Planning Department was considered appropriate as the county representative, making it unnecessary to require inclusion of the Delaware County Emergency Services and Delaware County Public Works departments. Rather than including businesses in the PAC, the representatives of the county, town, and village were relied upon for linking the businesses’ concerns to the planning effort.

## ***Goals of Outreach and Target Audience***

As noted in the U.S. EPA's "Handbook for Developing Watershed Plans to Restore and Protect Our Waters," the specific objectives of a watershed management public outreach program "should directly support your watershed management goals and implementation of the watershed management plan."[1] Goals should be based upon specific driving forces, the salient issues of concern within the specific watershed management area. In the Third Brook Watershed Management Area, the driving forces will likely originate from the need for flood control and flood mitigation. The overarching and unifying goal of the public outreach campaign for this Watershed Management Plan will be engaging the overall Walton community in addressing the need for improvements in these areas.

The general goals for public outreach as part of the Third Brook WMP include the following:

- ***Opportunity for involvement*** – Provide multiple opportunities for residents, key stakeholders, government officials and other impacted parties to participate in the development of specific action steps that will result in better management of the watershed.

- ***Involve a broad base of participants*** – Have an outreach program that is designed to draw in the broadest base of participants as possible, while still maintaining a manageable and timely planning process.

- ***Convenience and accessibility*** – Provide avenues of participation that are convenient for a diverse set of stakeholders and accessible to participants of varied means. Achieving this goal requires a mix of opportunities for engagement, from standard public meetings to social media to other means of participation.

- ***Logical progression*** – The public outreach program should present the issues facing the watershed, such as flooding, with supportive data, evidence and identified potential impacts before offering solutions to these issues. One of the underlying goals of any public outreach campaign is education; in other words, participants must be given the opportunity to learn and understand as much as possible about the underlying issues affecting their watershed before they proceed to evaluate potential solutions to these issues.

- ***Realistic expectations*** – The goals of a public outreach campaign should be as specific as possible so that they can be realistically addressed within a reasonable time frame. Overly broad or grandiose goals may be inspiring and do have their place in the planning process,

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[1] http://water.epa.gov/polwaste/nps/upload/2008_04_18_NPS_watershed_handbook_ch12.pdf; p.12-2.

but the specific goals identified need to be focused, actionable and measurable so that progress can be achieved and clearly recognized.

***Target Audience***

- All residents of Walton, particularly property owners located in the floodplain.
- Business owners, particularly those with businesses located in the floodplain.
- Public agencies and municipal officials – their understanding of the issues and potential and appropriate remediation/mitigation measures is critical.

***Strategy and Process***

In order to achieve a thorough and effective public outreach process the following strategy, process and schedule is proposed:

***Events***

The public outreach program for the Third Brook Watershed Management Plan (WMP) will have as its cornerstone four PAC meetings/workshops and two public outreach workshops. Each of these events is described in greater detail below in terms of logistics, scheduling and desired outcomes. These meetings will be supplemented by informal communications.

- **Event 1 – PAC Meeting/Workshop at DCSWCD Office (June 2012)**

  PAC meetings will be held at the office of the DCSWCD. The benefits of this location are three-fold: the building is located on the edge of the Third Brook watershed; the office has sufficient space and seating for participants; and the office is equipped with a laptop, projector, and screen for ease of presentations. The meeting will be preceded by an email to potential PAC participants.

  This initial meeting will allow the project team to introduce themselves to the PAC and to discuss the mechanisms and logistics of developing the WMP, generating public involvement and creating implementation strategies. A presentation of MMI's initial impressions and characterization of the watershed will accompany the preliminary identification of pertinent issues, strengths and areas of concern that the project team has regarding the watershed. These elements will be presented to the PAC for reaction and discussion, with the goal being to have the group come to a preliminary consensus as to the areas of greatest concern that will help focus the watershed management plan.

  In addition, a discussion of the roles of the project team and the PAC members will occur which will be designed to clarify the expectations for everyone as part of this project. Specific responsibilities for individuals and/or groups will be identified and agreed upon so that the plan development process can move forward seamlessly. By the conclusion of this meeting, participants should be able to clearly answer the question "What are we trying to accomplish as part of this planning process?"

- **Event 2 – Public Outreach Workshop – Task 4.3 (July 2012)**
  The initial public outreach workshop will be held at the Village of Walton Fire House. The benefits of this location are three-fold: the fire house is located in the watershed alongside Third Brook and was the site of flooding in 2006; the fire house is a municipal facility; and the fire house has sufficient space and seating for participants. The workshop will be preceded by a press release and article in the Walton Reporter and distribution of the press release to village, town, and county officials.

  The goals of the first public outreach workshop can be best summarized as introduce, characterize and identify. The "introduce" component will involve introducing the project team from MMI and the PAC. This component will also include an educational component regarding what watershed management planning is, as well as what it is not.

  The "characterize" component will involve describing the watershed in terms of a number of different characteristics in accordance with Task 4.1 of the Scope of Services, including the following:

    - Boundaries
    - Water quality
    - Habitat
    - Geomorphology
    - Infrastructure
    - History
    - Socio-Economic Characteristics
    - Land Use & Development Patterns

  The "identify" component will involve soliciting and defining general goals and expectations from meeting participants, developing a framework of both the overall "global" issues impacting the watershed (e.g., land development in the floodplain) and more specific issues impacting the watershed at select points (e.g., a poorly managed farm has led to the runoff of manure and agricultural waste products into a water resource). As part of the "identify" component, additional pertinent organizations, groups and interested individuals should be identified as part of the meeting discussion.

  ***Breakout Sessions:*** Topical (e.g., Habitats & Wildlife; Water Quality; Flooding & Sedimentation). Have stations for each topic area with maps that participants can use to pinpoint specific issues of concern and to also point out positive attributes of the watershed. Have a list of issues/survey form that participants can use to prioritize in order of greatest importance. Have a list of potential outcomes that an effective watershed management plan could have that participants can then rank/score by importance. Come back together as a group and summarize results.

- **Event 3 – PAC Meeting/Workshop at DCSWCD Office (September 2012)**
  This meeting will serve primarily to provide a Progress Report on the development of the WMP to date. The meeting will be preceded by an email to PAC participants and staff of the Walton Reporter.

  Discussion topics will likely include the presentation of a synthesis of goals and objectives determined to date from the initial PAC meeting and the first public workshop and all issues that have been identified at this point in the plan development process. A written summary of the first public workshop feedback will also be reviewed at this meeting. Completed materials for Tasks 4.1 and 4.2 of the Scope of Services will be presented, as will a draft product addressing Task 4.4, for discussion and review.

- **Event 4 – PAC Meeting/Workshop at DCSWCD Office (November 2012)**
  This meeting will serve to provide a progress report on the development of the WMP to date, including completed materials for Task 4.4 of the Scope of Services and draft products addressing Tasks 4.5 (Recommendations) and 4.6 (Implementation). The meeting will be preceded by an email to PAC participants and staff of the Walton Reporter.

  Discussion topics will likely focus on taking the proposed recommendations under Task 4.5 and reviewing them in light of the previously completed characterization and analysis tasks from Tasks 4.2 and 4.4. The outcome of this meeting should include a general consensus on the potential management practices, approaches and strategies for watershed protection, restoration and flood damage prevention for the watershed management area, with prioritization of these elements being key. A draft implementation strategy and schedule should also result from the discussions held during this meeting.

- **Event 5 – Public Outreach Workshop – Task 5.0 (December 2012)**
  The second public outreach workshop will be held at the Village of Walton Fire House for the same reasons cited under “Event 2” above. The workshop will be preceded by a press release and article in the Walton Reporter and distribution of the press release to village, town, and county officials.

  In contrast to the goals of the first public outreach workshop in Event 2, the goals of the second public outreach workshop can be described as present, summarize and respond. The “present” component will involve an overview of the entire project and the process from the initial PAC meeting through all public outreach efforts to the compilation of the final draft product. The “summarize” component will involve a discussion of the plan’s objectives, findings, conclusions and action items. Clarifying how the WMP will be implemented into the future will also be part of this discussion. Finally, the "respond" component will involve gathering feedback from the workshop participants regarding the final presentation of the draft WMP.

- **Event 6 – PAC Meeting/Workshop at DCSWCD Office (January 2013)**
  This meeting will serve to conclude the WMP development process. The meeting will be preceded by an email to PAC participants and staff of the Walton Reporter. The Final WMP will be presented and distributed. Discussion topics will focus on the feedback gathered at the second public outreach workshop and how that feedback was integrated into the final draft of the WMP, as well as the effective "next steps" that must occur to move the WMP forward as a living document. The outcome of this meeting should include a consensus on the specific implementation strategies and responsibilities that specific PAC members need to undertake or assume in order to create real and positive change in the management of the Third Brook Watershed.

***Logistics for Discussion***

- Town/Village website(s)
- Project FTP site
- Use of social media
- Email lists
- Direct mailing to lists supplied by participating organizations
- Flyers at municipal and county facilities, Town Hall, public library
- Emails to local and state elected officials
- Flyers and e-mail to all participating public agencies and nongovernmental organizations
- Public notices and articles in the Walton Reporter

# Appendix C
# Soil Descriptions

- ☐ Basher silt loam is a dark reddish brown, very deep (greater than 60"), moderately well drained, medium-textured soil. It occupies nearly level floodplains where occasional flooding occurs. Unlimed, it is very strongly to medium acid in the surface and subsoil. Permeability is moderate in the surface and upper subsoil and moderately slow in the lower subsoil and substratum. Available water capacity is moderate to high. This soil is well suited to all cultivated crops grown in the area and hay or pasture. The main problems are a slight seasonal wetness, occasional flooding, and stream bank erosion. It is ideal for farmland. The hydrologic group is B/D.

- ☐ Fluvaquents-Udifluvents is composed of many soils along narrow stream channels. Fluvaquents are located in lower, wetter areas while Udifluvents are in slightly higher, better drained areas of the map unit. These soils flood frequently, resulting in both erosion and deposition. Texture is variable. These soils are not suitable for crops. Some of these areas are pastured, but brush predominates. Hydrologic group is A/D.

- ☐ Halcott, Mongaup, and Vly soils are strongly sloping and are on hilltops and hillsides in higher parts of the uplands where the growing season is several weeks shorter than it is in larger valleys. These soils consists of the shallow (10-20"), somewhat excessively drained, medium-textured Halcott soil, the moderately deep (20-40"), well drained, medium-textured Mongaup and Vly soils, and frequent outcroppings of bedrock. This complex of soils and rock is mapped above approximately 1,750 feet elevation on ridgetops. Hydrologic group is D.

- ☐ Lackawanna flaggy silt loam is a reddish brown, very deep (greater than 60"), well drained, medium-textured soil that has a fragipan at 20 to 36 inches. It occupies gently sloping areas of glacial till in the uplands. Unlimed, it is very strongly to strongly acid above the fragipan. Permeability is moderate above the fragipan and slow in the fragipan. Available water capacity is moderate. This soil is well suited for cropland, hay land, and pasture. The main problems are flagstones that may interfere with tillage, and a slight erosion hazard when tilled. It is ideal for farmland. Hydrologic group is C/D.

- ☐ Lackawanna and Bath soils are very deep (greater than 60"), well drained, medium textured, and have a fragipan at 20 to 36 inches. They occupy moderately steep and steep areas in the uplands. Unlimed, they are very strongly to medium acid above the fragipan. Permeability is moderate above and slow within the fragipan. Available water capacity is moderate. The steep slopes and excessive surface stones limit the use of these soils to woodland and pasture. Hydrologic group is C/D.

- ☐ Lewbeach channery loam is reddish brown, very deep (greater than 60"), well drained, medium textured, and has a fragipan at 18 to 36 inches. It occupies gently sloping areas above approximately 1,750 feet elevation in the uplands. Unlimed, it is very strongly to strongly acid above the fragipan. Permeability is moderate above the fragipan and slow in the fragipan. Available water capacity is moderate. This soil is suitable for cropland, hay land, and pasture. The main problems are a shortened growing season due to elevation, flagstones that may interfere with tillage, and a slight erosion hazard when tilled. It is ideal for farmland. Hydrologic group is D.

- Mongaup channery loam is brown, moderately deep (20-40"), well to excessively drained, and medium textured. It occupies gently sloping areas on ridges and hilltops above approximately 1,750 feet elevation in the uplands. Unlimed, it is strongly to very strongly acid. Permeability is moderate. Available water capacity is moderate. This soil is suitable for cropland, hay, or pasture. The main problems are the shallow depth to bedrock, a slight erosion hazard when tilled, and a shortened growing season due to elevation. Hydrologic group is C.

- Morris flaggy silt loam is a reddish brown, very deep (greater than 60"), somewhat poorly drained, medium-textured soil that has a fragipan at 10 to 20 inches. It occupies nearly level areas in the uplands. Unlimed, it is strongly to slightly acid. Permeability is moderate above the fragipan and slow to moderately slow in the fragipan. Available water capacity is moderate. This soil is suited for cropland, hay, and pasture. The main problems are the prolonged wetness and the flagstones that may interfere with tillage. The wetness limits the choice of crops that can be grown. Hydrologic group is D.

- Morris and Volusia soils are very stony, very deep (greater than 60"), somewhat poorly drained, medium textured, and have fragipans. They occupy gently sloping and sloping areas in the uplands. Unlimed, they are very strongly to slightly acid. Permeability is moderate above the fragipan and slow to very slow in the fragipan. Available water capacity is moderate. These soils are best suited to woodland and wildlife. Some areas are pastured. The main problems are excessive stoniness and wetness. Hydrologic group is D.

- Norchip silt loam is very deep (greater than 60"), poorly drained, medium textured, and has a fragipan. It occupies nearly level areas in the uplands. Unlimed, it is very strongly to slightly acid above the fragipan. Permeability is moderate or moderately slow above the fragipan and slow or very slow in the fragipan and substratum. Available water capacity is moderate. This soil is best suited to woodland and wildlife although some areas are pastured. The main problem is prolonged wetness. Hydrologic group is D.

- Onteora channery silt loam is reddish brown, very deep (greater than 60"), somewhat poorly drained, medium textured and has a fragipan at 10 to 25 inches. It occupies nearly level areas above approximately 1,750 feet elevation in the uplands. Unlimed, it is strongly to slightly acid. Permeability is moderate above the fragipan and slow to moderately slow in the fragipan. Available water capacity is moderate. This soil is suited for cropland, hay, and pasture. The main problems are the prolonged wetness and a shortened growing season due to elevation, which limit the choice of crops that can be grown. Hydrologic group is D.

- Onteora and Ontusia soils are brown or reddish brown, very stony, very deep (greater than 60"), somewhat poorly drained, medium textured, and have fragipans. They occupy gently sloping and sloping areas above 1,750 feet elevation in the uplands. Unlimed, they are very strongly to slightly acid. Permeability is moderate above the fragipan and slow to very slow in the fragipan. Available water capacity is moderate. These soils are best suited to woodland and wildlife. Some areas are pastured. The main problems are excessive stoniness and wetness. Hydrologic group is D.

☐ Oquaga channery silt loam is a reddish brown, moderately deep, well to excessively drained, medium-textured soil. It occupies gently sloping areas on ridges and hilltops. Bedrock occurs at 20 to 40 inches below this soil. Unlimed, it is very strongly to medium acid. Permeability is moderate. Available water capacity is low to moderate. This soil is suited for crops, hay, and pasture. The main problems are the flagstones that may interfere with cultivation, the shallowness to bedrock, the tendency to be droughty, and the slight erosion hazard when tilled. Many of these areas are used for hay, pasture, or woodland. Hydrologic group is C.

☐ Oquaga, Lordstown, and Arnot soils consist of the moderately deep (20-40"), well or somewhat excessively drained, medium-textured Oquaga and Lordstown soils, the shallow (10-20"), somewhat excessively drained, medium-textured Arnot soil, and frequent outcroppings of bedrock. It occupies gently sloping and sloping areas in the uplands on ridges and hilltops. Due to shallow depths to and exposures of bedrock, these areas are best suited to woodland and wildlife uses. It is a fragile soil. Hydrologic group is C.

☐ Tunkhannock and Chenango soils are very deep (greater than 60"), well drained, and nearly level, and are formed in outwash deposited where tributary streams enter a main valley. These areas are usually adjacent to the first bottom floodplain. Flooding can be from the main stream or the enclosed tributary stream. Permeability is moderately rapid to rapid. Available water capacity is moderate. The soils are suited to most crops grown in the area and are ideal for farmland. Hydrologic group is A.

☐ Udorthents, refuse substratum are of nearly level to steep, loamy soils in sanitary landfills that have been reworked by earth-moving and grading equipment to cover trash and other refuse. Often the refuse is partly covered or mixed with the loamy fill material. The depths of soil cover and refuse material are variable. Some areas of this map unit are in former sand and gravel pits. Hydrologic group is A.

☐ Urban land consists of areas where the surface is covered with asphalt, concrete, other impervious materials, or buildings. These areas are mostly parking lots, industrial parks, or business centers in villages and cities, which were graded or filled before being covered with nonsoil materials. Most are nearly level or gently sloping, yet runoff may be very rapid due to the largely impervious surface.

☐ Valois very fine sandy loam is very deep (greater than 60"), gently sloping, well drained, and medium textured and is underlain by gravel and gravelly sands. Unlimed, it is very strongly to moderately acid in the surface and subsoil. Available water capacity is high in the surface and low in the substratum. Permeability is moderate in the surface and upper subsoil, and moderate to moderately rapid in the substratum. This soil is suited to cultivated crops, pasture, and trees. It is ideal for farmland. Hydrologic group is B.

☐ Vly channery silt loam is reddish brown, moderately deep (20-40"), well to excessively drained, and medium textured. It occupies gently sloping areas on ridges and hilltops above approximately 1,750 feet elevation in the uplands. Unlimed, it is strongly to very strongly acid.  Permeability is moderate.  Available water capacity is moderate.  This soil is suitable for cropland, hay, or pasture.  The main problems are the shallow depth to bedrock, a slight erosion hazard when tilled, and a shortened growing season due to elevation.  Hydrologic group is C.

- ☐ Volusia channery silt loam is very deep (greater than 60"), somewhat poorly drained, and medium textured and has a fragipan at 10 to 22 inches.  It occupies nearly level areas in the uplands.  Unlimed, it is very strongly to medium acid.  Permeability is moderate above the fragipan and very slow in the fragipan.  Available water capacity is moderate.  This soil is suited for crops, hay, and pasture.  The main problem is the prolonged wetness that limits the choice of crops that can be grown.  Hydrologic group is D.

- ☐ Wellsboro channery silt loam is reddish brown, very deep (greater than 60"), moderately well drained, and medium textured and has a fragipan at 15 to 26 inches.  It occupies gently sloping areas in the uplands.  Unlimed, it is very strongly to medium acid.  Permeability is moderate above the fragipan and slow in the fragipan.  Available water capacity is moderate.  This soil is suited for cropland, hay, and pasture.  The main problems are a slight seasonal wetness and the flagstones that may interfere with tillage.  Hydrologic group is C/D.

- ☐ Willowemoc channery silt loam is reddish brown, very deep (greater than 60"), moderately well drained, and medium textured and has a fragipan at 17 to 26 inches.  It occupies nearly level areas above approximately 1,750 feet elevation in the uplands.  Unlimed, it is very strongly to medium acid.  Permeability is moderate above the fragipan and slow in the fragipan.  Available water capacity is moderate.  This soil is suited for cropland, hay, and pasture.  The main problems are a slight seasonal wetness and a shortened growing season due to elevation.  It is ideal for farmland.  Hydrologic group is D.

# Appendix D
# Cross Section Measurements and Plots

## Cross Section #1[1, 2]
## (Approximately Station 6+00)

| Tag (ft) | Elevation (ft) | Comment |
|---|---|---|
| Left Bank Stake | 5.98 | Benchmark on terrace |
| 68 | 6.24 | Top of terrace at edge of bank |
| 66 | 6.94 | Bank |
| 64 | 8.09 | Bank |
| 62 | 9.94 | Bank |
| 60 | 11.14 | Bank |
| 58 | 12.70 | Bank |
| 57.1 | 12.94 | Bankfull (left bank) |
| 56 | 14.28 | Bank |
| 55 | 14.71 | Edge of water |
| 54 | 15.66 | Channel |
| 53 | 15.65 | Channel |
| 52 | 15.36 | Channel |
| 51 | 15.43 | Channel |
| 50 | 15.22 | Channel |
| 49 | 15.01 | Channel |
| 48.9 | 14.76 | Edge of water |
| 48 | 14.18 | Shelf |
| 46 | 13.87 | Bank |
| 44 | 13.53 | Bank |
| 42 | 13.19 | Bank |
| 40 | 13.14 | Bank |
| 38 | 13.02 | Bank |
| 36 | 13.08 | Bank |
| 34 | 12.84 | Bank |
| 32 | 12.68 | Bank |
| 30 | 12.37 | Bank |
| 28 | 12.34 | Bank |
| 26 | 12.23 | Bankfull |
| 24 | 12.30 | Bank |
| 22 | 12.52 | Bank |
| 20 | 12.88 | Bank |
| 18 | 13.12 | Bank |
| 16 | 12.83 | Bank |
| 14 | 13.62 | Bank |
| 12 | 13.50 | Bank |
| 10 | 13.46 | Bank |
| 8 | 12.50 | Bank |
| 6 | 11.44 | Bank |
| 4 | 11.62 | Bank |
| Right Bank Stake | 11.14 | Bank close to top of terrace |

[1] Elevation of level from ground surface was 4.54 ft. (54.5 in.).

[2] Twice bankfull was calculated to be Elevation 8.8 ft. Twice bankfull was achieved on the left terrace but was impossible to achieve on the right terrace due to the fence/the Kraft property.

## Cross Section #2[1, 2]
## (Approximately Station 15+50)

| Tag (ft) | Elevation (ft) | Comment |
|---|---|---|
| Left Bank Stake | 3.28 | Benchmark/top of terrace |
| 42 | 3.40 | Top of terrace at edge of bank |
| 40 | 3.75 | Bank |
| 38 | 4.74 | Bank |
| 36 | 6.19 | Bank |
| 34 | 7.44 | Bankfull |
| 32 | 8.20 | Edge of water |
| 30 | 8.58 | Channel |
| 28 | 8.77 | Channel |
| 26 | 8.95 | Channel |
| 24 | 8.90 | Channel |
| 22 | 8.76 | Channel |
| 20 | 8.64 | Channel |
| 18 | 8.56 | Channel |
| 15.8 | 8.16 | Edge of water |
| 14 | 8.20 | Shelf |
| 12 | 7.65 | Bankfull |
| 10 | 6.16 | Bank |
| 8 | 4.68 | Bank |
| 6 | 3.56 | Bank |
| 2.8 | 2.10 | Top of terrace at edge of bank |
| Right Bank Stake | 2.03 | On terrace |

[1] Elevation of level from ground surface was 4.80 ft. (57.5 in.).

[2] Twice bankfull was calculated to be Elevation 5.93 ft. As such, twice bankfull was achieved on both terraces.

## Cross Section #3[1, 2]
## (Approximately Station 25+50)

| Tag (ft) | Elevation (ft) | Comment |
|---|---|---|
| Right Bank Stake | 1.98 | Benchmark on right terrace |
| 6.0 | 1.26 | Top of terrace at edge of right bank |
| See Comment | 1.09 | Top chord of bridge railing – right bank |
| See Comment | 2.74 | Top of wall at right bank |
| 6.9 | 12.32 | Toe of wall |
| 12.0 | 12.66 | Channel |
| 14.0 | 12.66 | Channel |
| 20.0 | 12.86 | Channel |
| 22.0 | 12.81 | Channel |
| 24.0 | 12.46 | Channel |
| 24.7 | 12.14 | Edge of water |
| 26.0 | 12.06 | Channel aggradation |
| 28.0 | 11.75 | Channel aggradation |
| 28.7 | 11.58 | Toe of wall |
| See Comment | 10.40 | Bankfull (from water line on wall under bridge) |
| See Comment | 2.59 | Top of wall at left bank; on terrace |
| Left Bank Stake | 3.10 | On terrace at left bank |
| See Comment | 1.28 | Top bottom rail at left bank |

[1] Elevation of level from ground surface was 4.54 ft. (54.5 in.).

[2] Twice bankfull was calculated to be Elevation 7.94 ft.  As such, twice bankfull was achieved on both terraces.

## Cross Section #4[1, 2]
## (Approximately Station 29+50)

| Tag (ft) | Elevation (ft) | Comment |
|---|---|---|
| Left Bank Stake | 5.87 | Benchmark on left terrace |
| Top of Wall at Left Bank | 5.98 | Bank |
| 27.0 | 12.91 | Bankfull (based on vegetation/top of bar) |
| 26.0 | 13.47 | Edge of water/toe of wall |
| 24.0 | 13.91 | Channel |
| 21.0 | 13.98 | Channel |
| 17.0 | 13.91 | Channel |
| 14.0 | 14.28 | Channel |
| 11.0 | 13.96 | Channel |
| 9.0 | 13.60 | Channel |
| 7.0 | 13.57 | Edge of water/toe of wall |
| 5.0 | 12.41 | Bankfull |
| 3.4 | 7.70 | Top of wall/terrace on right bank |
| Right Bank Stake | 6.86 | Sumac tree on right bank (stake) |

[1] Elevation of level from ground surface was 4.21 ft. (50.5 in.).

[2] Twice bankfull was calculated to be Elevation 10.54 ft. As such, twice bankfull was achieved on both terraces.

## Cross Section #5[1, 2]
## (Approximately Station 42+00)

| Tag (ft) | Elevation (ft) | Comment |
|---|---|---|
| Left Bank Stake | 3.94 | Benchmark on left terrace |
| 54.8 | 4.23 | Terrace at edge of bank |
| 50.0 | 6.87 | Bank |
| 47.0 | 8.31 | Bank |
| 43.9 | 9.53 | Bankfull (based on vegetation/top of bar) |
| 40.0 | 9.85 | Shelf |
| 38.0 | 11.41 | Side bar (aggradation area) |
| 34.0 | 11.82 | Edge of water |
| 32.0 | 12.37 | Channel |
| 30.0 | 12.36 | Channel |
| 28.0 | 12.42 | Channel |
| 26.0 | 12.51 | Channel |
| 24.0 | 12.52 | Channel |
| 22.0 | 12.08 | Channel |
| 20.0 | 12.08 | Edge of water |
| 19.7 | 10.46 | Shelf |
| 16.0 | 9.56 | Shelf |
| 14.0 | 9.28 | Bankfull |
| 10.0 | 7.48 | Bank |
| 6.0 | 5.70 | Bank |
| Right Terrace Stake/2.0 | 4.64 | Right terrace stake on right bank |

[1] Elevation of level from ground surface was 4.12 ft. (49.375 in.).

[2] Twice bankfull was calculated to be Elevation 6.04 ft. As such, twice bankfull was achieved on both terraces.

## Cross Section #6[1, 2]
## (Approximately Station 50+00)

| Tag (ft) | Elevation (ft) | Comment |
|---|---|---|
| Left Bank Stake | 5.01 | Benchmark on left terrace |
| 80.0 | 5.13 | On terrace |
| 76.0 | 5.26 | On terrace |
| 72.0 | 5.96 | On terrace |
| 70.0 | 6.24 | Edge of left terrace/bank |
| 68.0 | 7.75 | Bank |
| 66.0 | 9.12 | Bank |
| 65.0 | 9.86 | Bankfull (based on vegetation/top of bar) |
| 62.0 | 10.38 | Shelf/high-flow channel |
| 60.0 | 10.55 | Shelf/high-flow channel |
| 58.0 | 10.10 | Shelf |
| 56.0 | 9.90 | Shelf |
| 54.0 | 9.76 | Shelf |
| 52.0 | 11.36 | Edge of water |
| 50.0 | 11.85 | Channel |
| 48.0 | 12.24 | Channel |
| 46.0 | 11.91 | Channel |
| 44.0 | 12.12 | Channel |
| 42.0 | 12.11 | Channel |
| 40.0 | 11.98 | Channel |
| 38.0 | 11.97 | Channel |
| 36.0 | 11.88 | Channel |
| 34.0 | 11.89 | Channel |
| 32.0 | 11.67 | Channel |
| 30.6 | 11.65 | Edge of water |
| 30.0 | 11.63 | Shelf |
| 28.0 | 11.66 | Shelf |
| 26.0 | 11.56 | Shelf |
| 24.0 | 11.20 | Shelf |
| 22.0 | 10.30 | Shelf |
| 20.0 | 10.08 | Shelf |
| 18.0 | 10.09 | Shelf |
| 16.0 | 9.69 | Bankfull at right bank |
| 14.0 | 9.19 | Bank |
| 12.0 | 8.58 | Bank |
| 10.0 | 8.08 | Bank |
| 6.0 | 7.28 | Bank |
| Right Bank Stake/3.6 | 6.28 | Stake on right bank |

[1] Elevation of level from ground surface was 4.27 ft. (51.25 in.).

[2] Twice bankfull was calculated to be Elevation 7.14 ft. As such, twice bankfull was achieved on both terraces.

## Cross Section #7[1, 2]
## (Approximately Station 60+50)

| Tag (ft) | Elevation (ft) | Comment |
|---|---|---|
| Left Bank Stake | 5.32 | Benchmark on left floodplain |
| 82.0 | 5.39 | On floodplain |
| 80.0 | 5.42 | Edge of floodplain/bank |
| 78.0 | 5.83 | Bank |
| 76.0 | 6.54 | Bank |
| 74.0 | 7.31 | Bank |
| 72.0 | 8.02 | Bank |
| 70.0 | 8.58 | Bank |
| 68.0 | 9.20 | Bank |
| 66.0 | 9.94 | Bank |
| 64.0 | 11.60 | Bank |
| 62.0 | 12.69 | Bankfull (based on vegetation/top of bar) |
| 60.0 | 13.72 | Edge of water |
| 58.0 | 13.99 | Channel |
| 56.0 | 13.83 | Channel |
| 54.0 | 14.18 | Channel |
| 52.0 | 14.40 | Channel |
| 50.0 | 14.36 | Channel |
| 48.0 | 14.24 | Channel |
| 46.0 | 14.30 | Channel |
| 44.0 | 14.25 | Channel |
| 42.0 | 13.83 | Channel |
| 40.0 | 14.04 | Channel |
| 38.0 | 13.95 | Channel |
| 36.0 | 13.42 | Channel |
| 34.0 | 13.91 | Channel |
| 32.0 | 13.76 | Edge of water |
| 30.0 | 13.34 | Bank |
| 28.0 | 12.86 | Shelf |
| 26.0 | 12.84 | Shelf |
| 24.0 | 12.66 | Bankfull |
| 22.0 | 11.64 | Bank |
| 19.0 | 10.75 | Bank |
| 16.0 | 9.20 | Bank |
| 12.0 | 8.12 | Bank |
| 10.0 | 7.96 | Top of bank/on floodplain |
| 4.0 | 6.90 | On floodplain |
| 2.0 | 6.16 | On floodplain |
| Right Floodplain Stake/1.0 | 6.74 | Stake on right floodplain |

[1] Elevation of level from ground surface was 4.92 ft. (59 in.).

[2] Twice bankfull was calculated to be Elevation 10.92 ft. As such, twice bankfull was achieved on both terraces.

## Cross Section #8[1, 2]
## (Approximately Station 74+50)

| Tag (ft) | Elevation (ft) | Comment |
|---|---|---|
| Left Terrace Stake | 6.21 | Benchmark on left terrace |
| 58.0 | 6.43 | Top of wall at left terrace |
| 54.0 | 17.57 | Edge of water/toe of wall |
| 52.0 | 17.54 | Channel |
| 50.0 | 17.62 | Channel |
| 48.0 | 17.91 | Channel |
| 46.0 | 17.85 | Channel |
| 44.0 | 18.15 | Channel |
| 42.0 | 17.97 | Channel |
| 40.0 | 17.55 | Channel |
| 38.0 | 17.48 | Channel |
| 37.2 | 16.94 | Edge of water |
| 31.0 | 16.00 | Bankfull (determined by scour line) |
| 28.0 | 13.84 | Bank |
| 26.0 | 13.40 | Bank |
| 24.0 | 12.90 | Bank |
| 22.0 | 12.12 | Bank |
| 20.0 | 11.35 | Bank |
| 18.0 | 10.79 | Bank |
| 14.0 | 9.84 | Bank |
| 10.0 | 8.62 | Bank |
| 6.0 | 6.33 | Bank |
| Right Terrace Stake | 5.22 | Right terrace stake on right terrace |

[1] Elevation of level from ground surface was 4.25 ft. (51 in.).

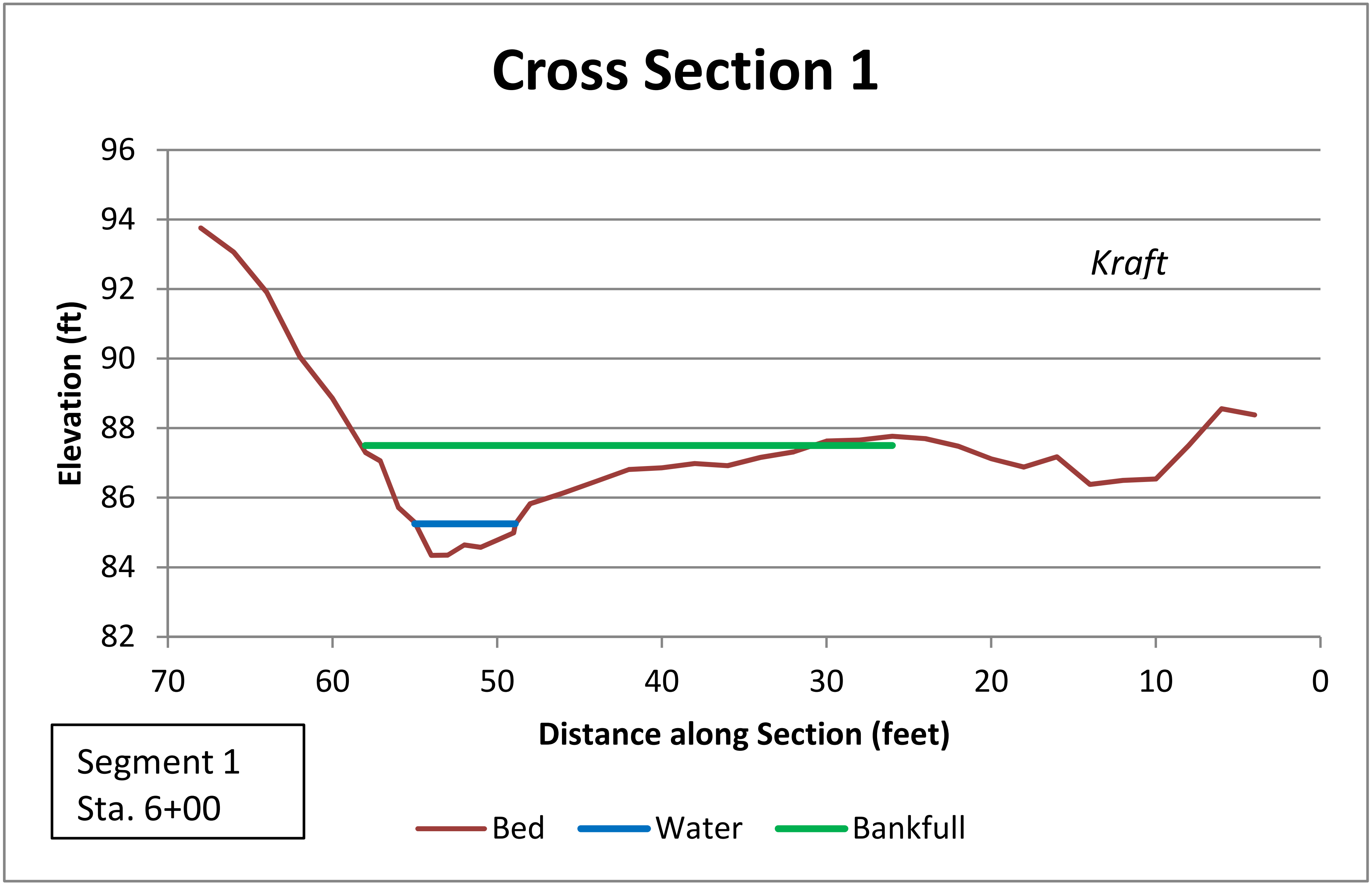
[2] Twice bankfull was calculated to be Elevation 13.85 ft. As such, twice bankfull was achieved on both terraces.

## Cross Section #9[1, 2]
## (Approximately Station 81+00)

| Tag (ft) | Elevation (ft) | Comment |
|---|---|---|
| Left Terrace Stake | 5.36 | Benchmark on left terrace |
| 30.0 | 5.54 | Top of wall at left terrace |
| 28.7 | 10.98 | Edge of water/toe of wall |
| 28.0 | 10.92 | Channel |
| 26.0 | 10.92 | Channel |
| 24.0 | 11.08 | Channel |
| 22.0 | 11.00 | Channel |
| 20.0 | 10.95 | Channel |
| 18.0 | 11.02 | Channel |
| 16.0 | 11.56 | Channel |
| 14.0 | 10.84 | Channel |
| 12.0 | 10.83 | Channel |
| 10.0 | 10.81 | Channel |
| 8.0 | 10.79 | Channel |
| 6.9 | 10.80 | Edge of water |
| 6.6 | 10.16 | Shelf |
| 3.3 | 9.98 | Bankfull (determined by water level line on wall on left edge of channel) |
| Right Terrace Stake/3.0 | 8.36 | Stake on right valley wall |

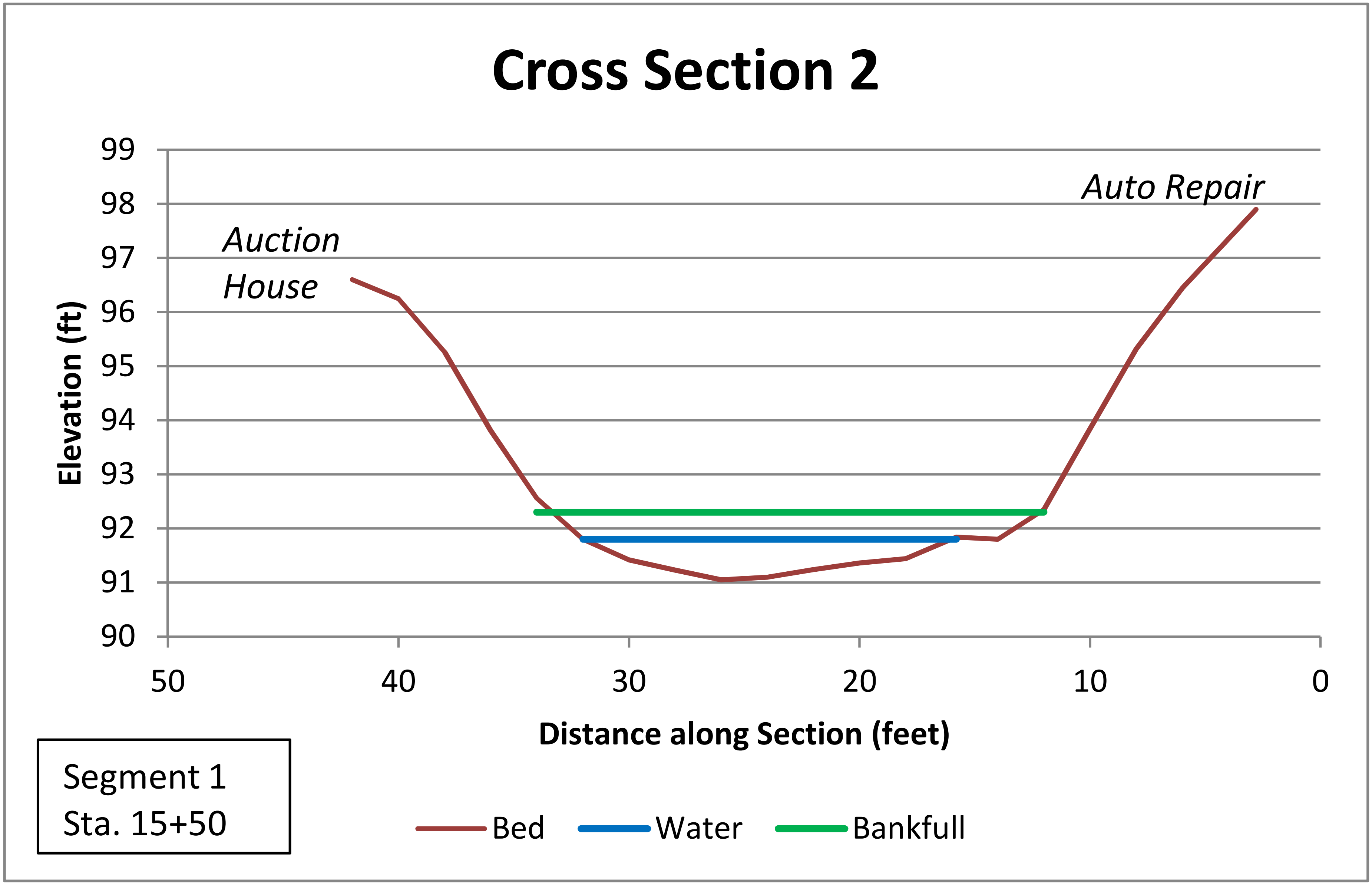
[1] Elevation of level from ground surface was 4.46 ft. (53.56 in.).

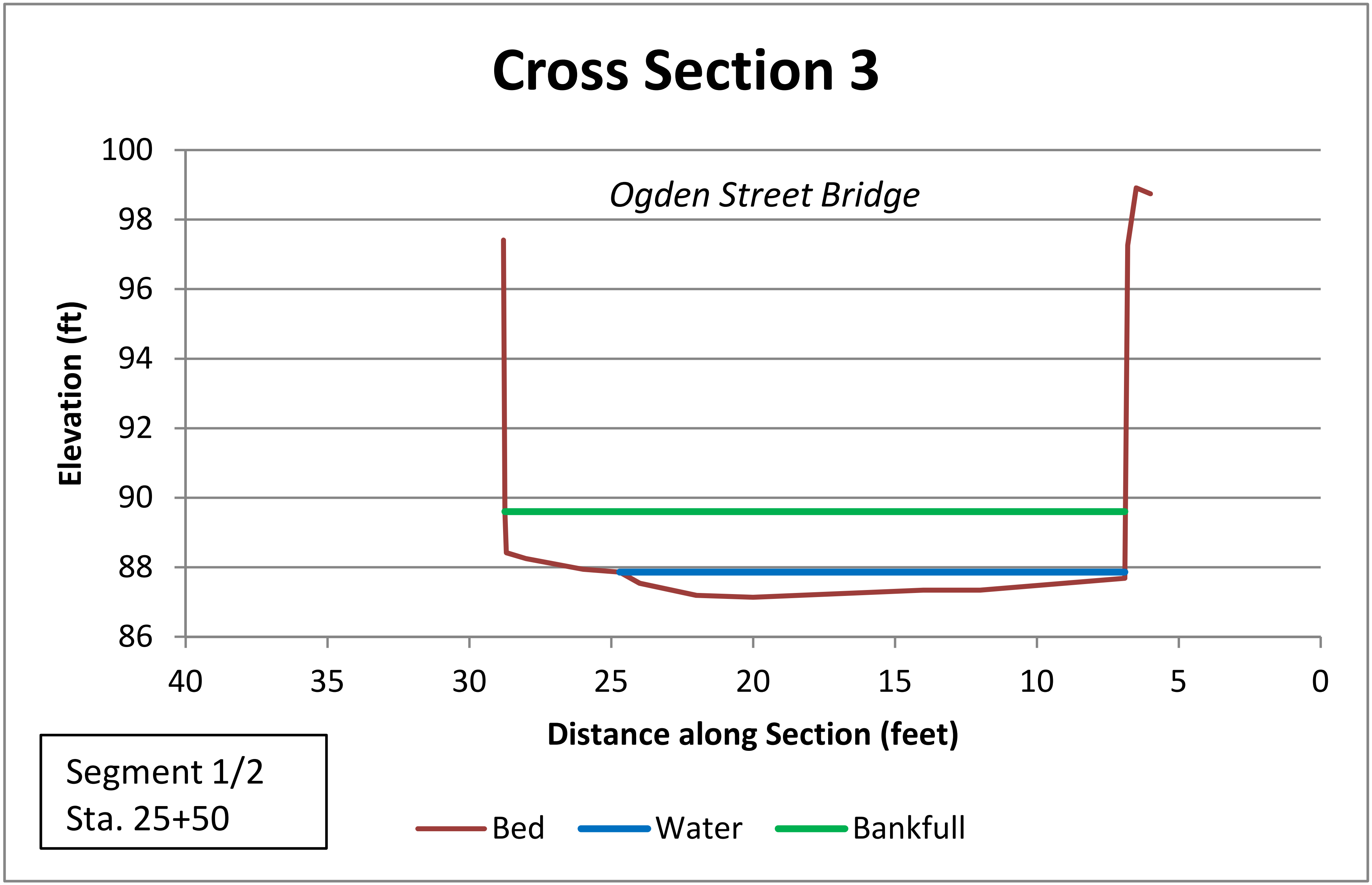
[2] Twice bankfull was calculated to be Elevation 8.40 ft. As such, twice bankfull was achieved on both terraces.

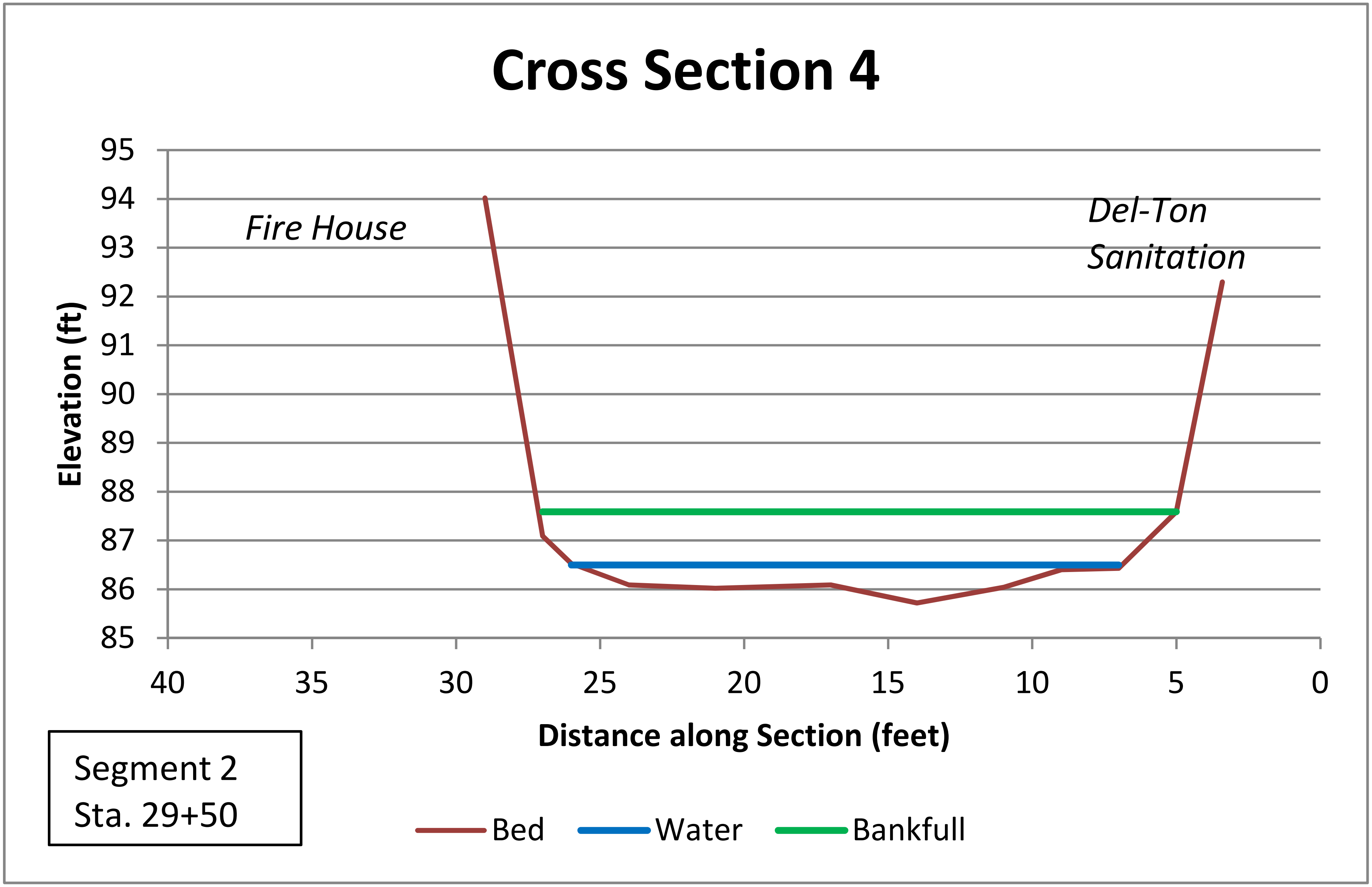


Cross Section 1

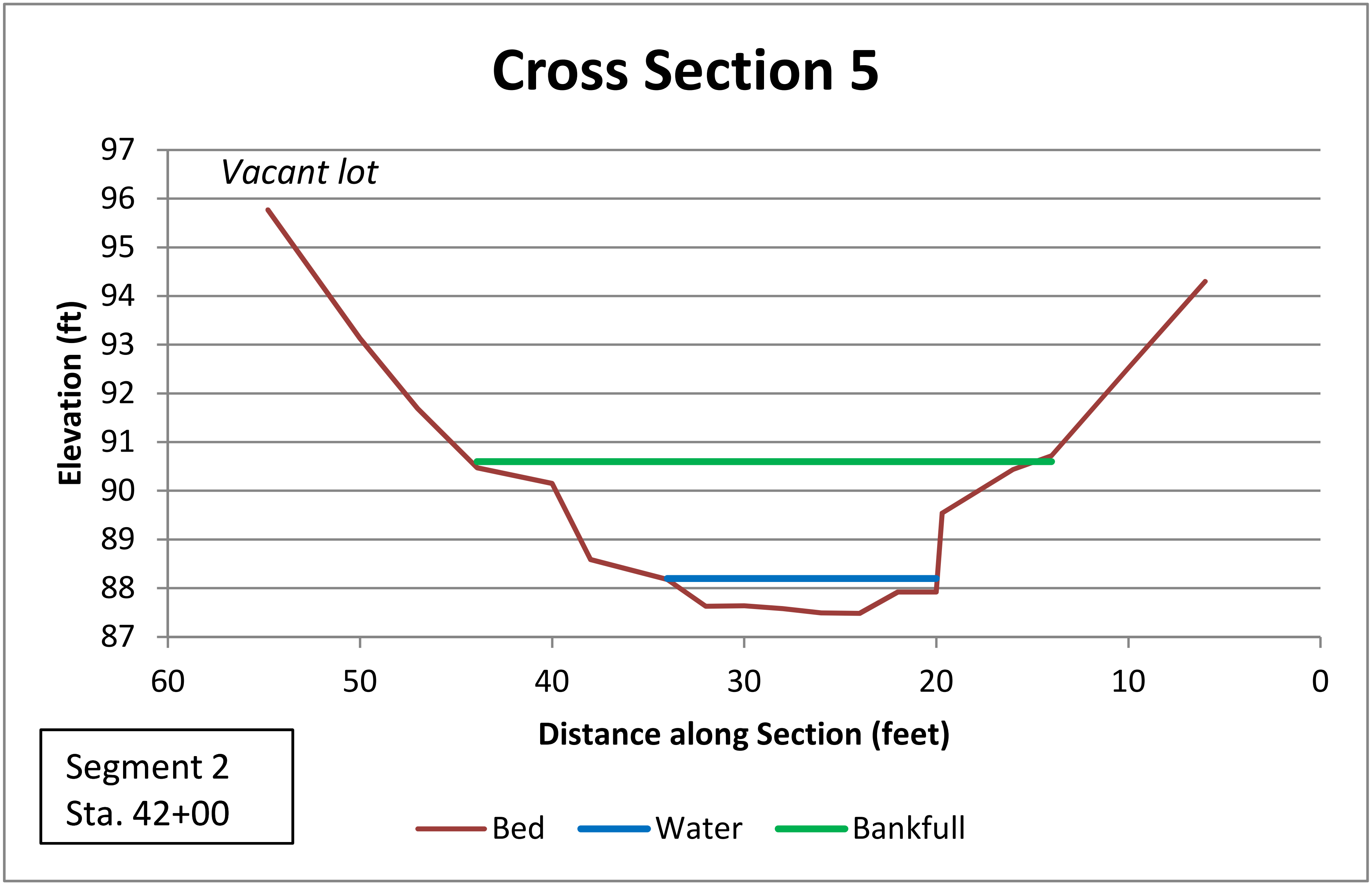
Segment 1
Sta. 6+00

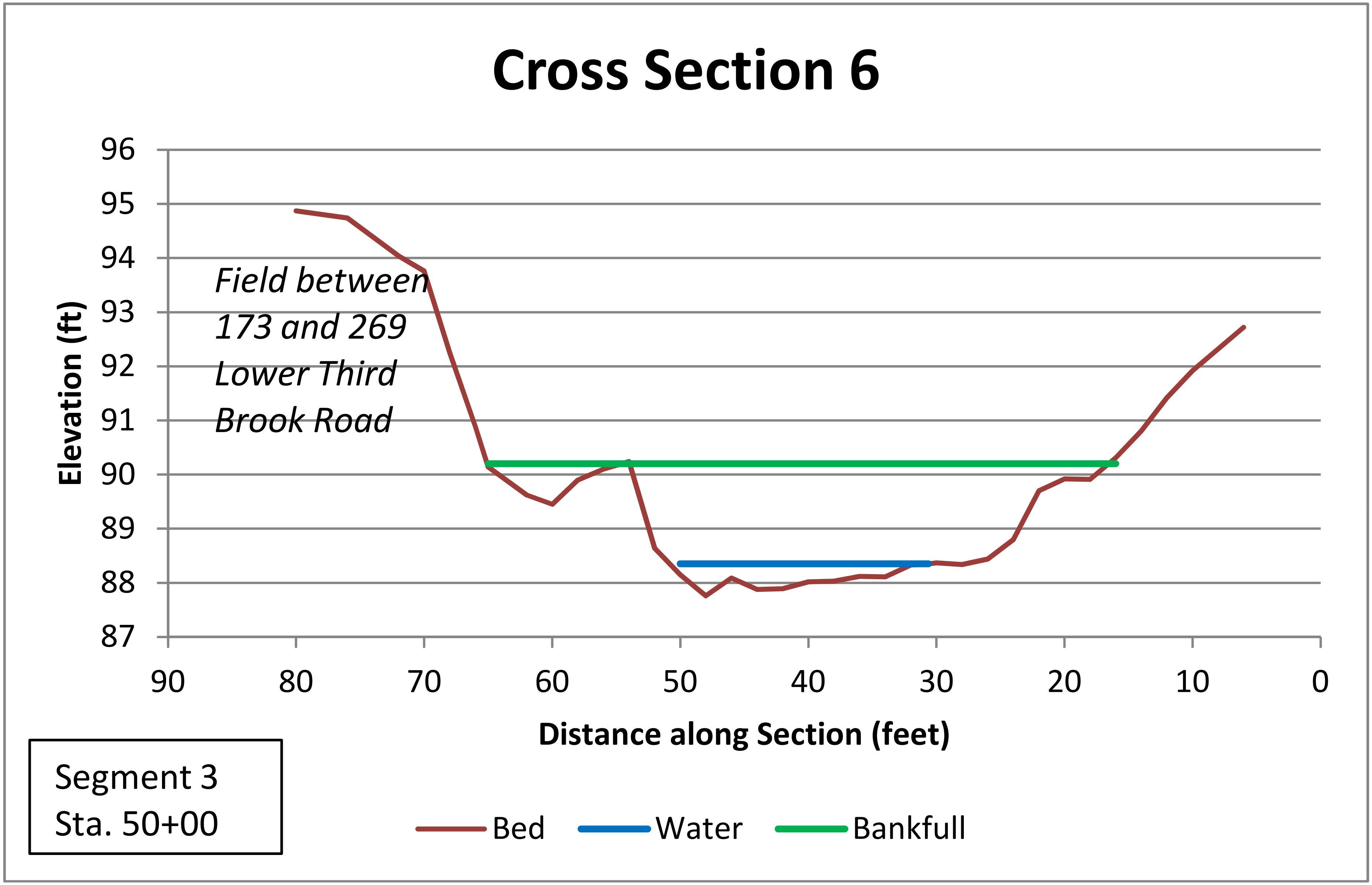

Cross Section 2
99
98
97
96
95
94
93
92
91
90
Elevation (ft)
Auction
House
Auto Repair
50
40
30
20
10
0
Distance along Section (feet)
Segment 1
Sta. 15+50
Bed
Water
Bankfull

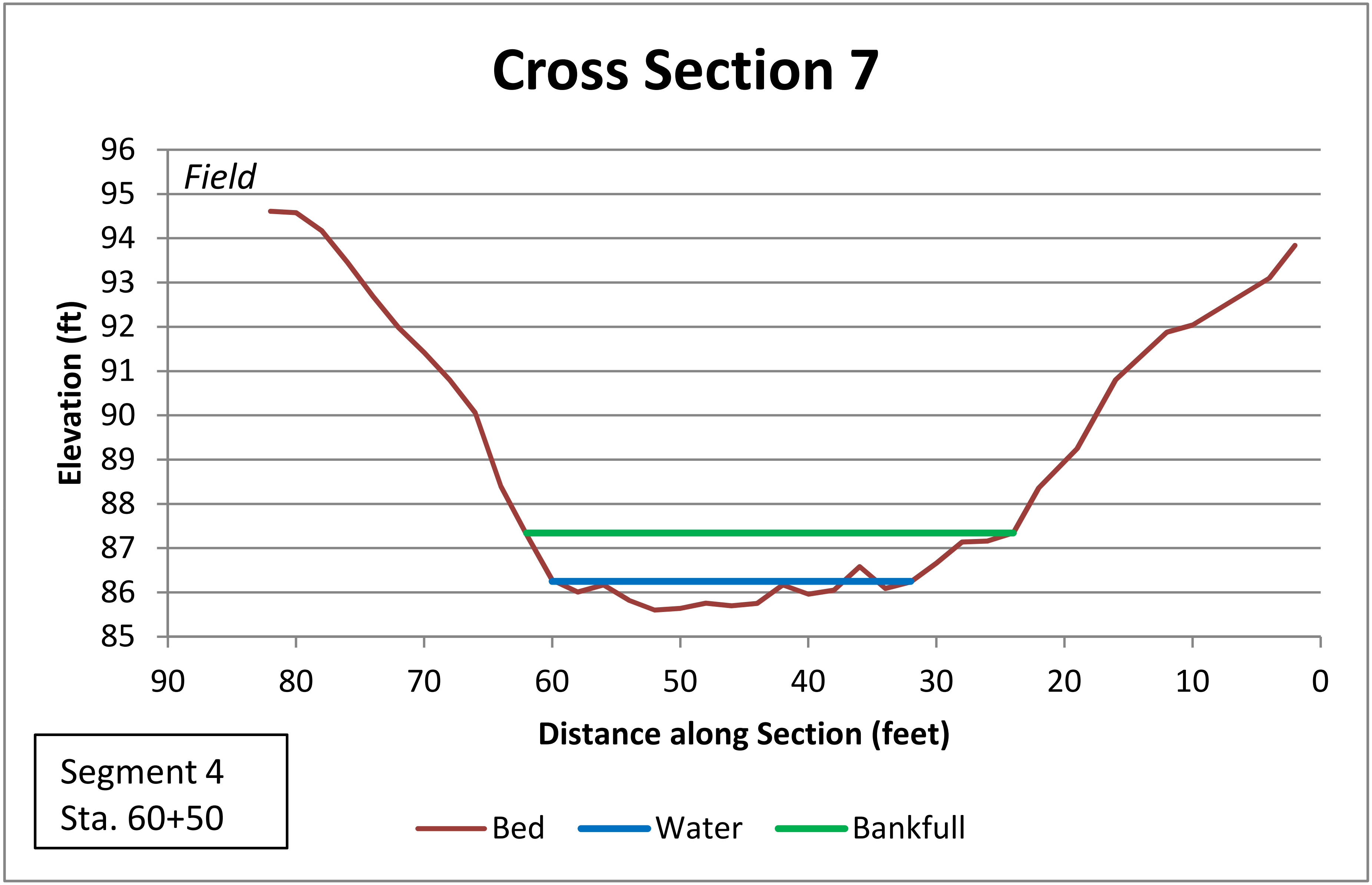

Cross Section 3
Ogden Street Bridge
Elevation (ft)
100
98
96
94
92
90
88
86
40
35
30
25
20
15
10
5
0
Distance along Section (feet)
Segment 1/2
Sta. 25+50
Bed
Water
Bankfull

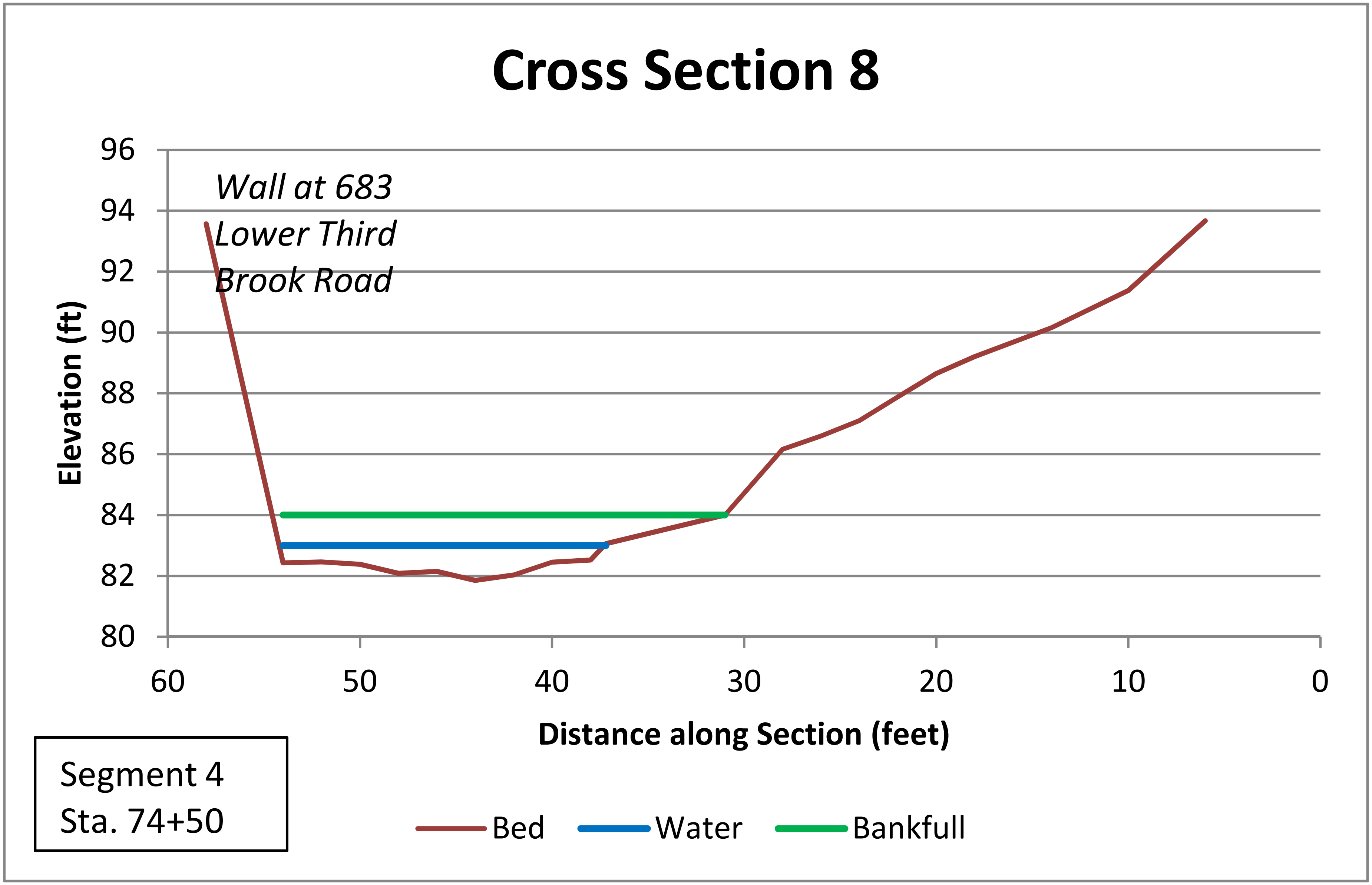


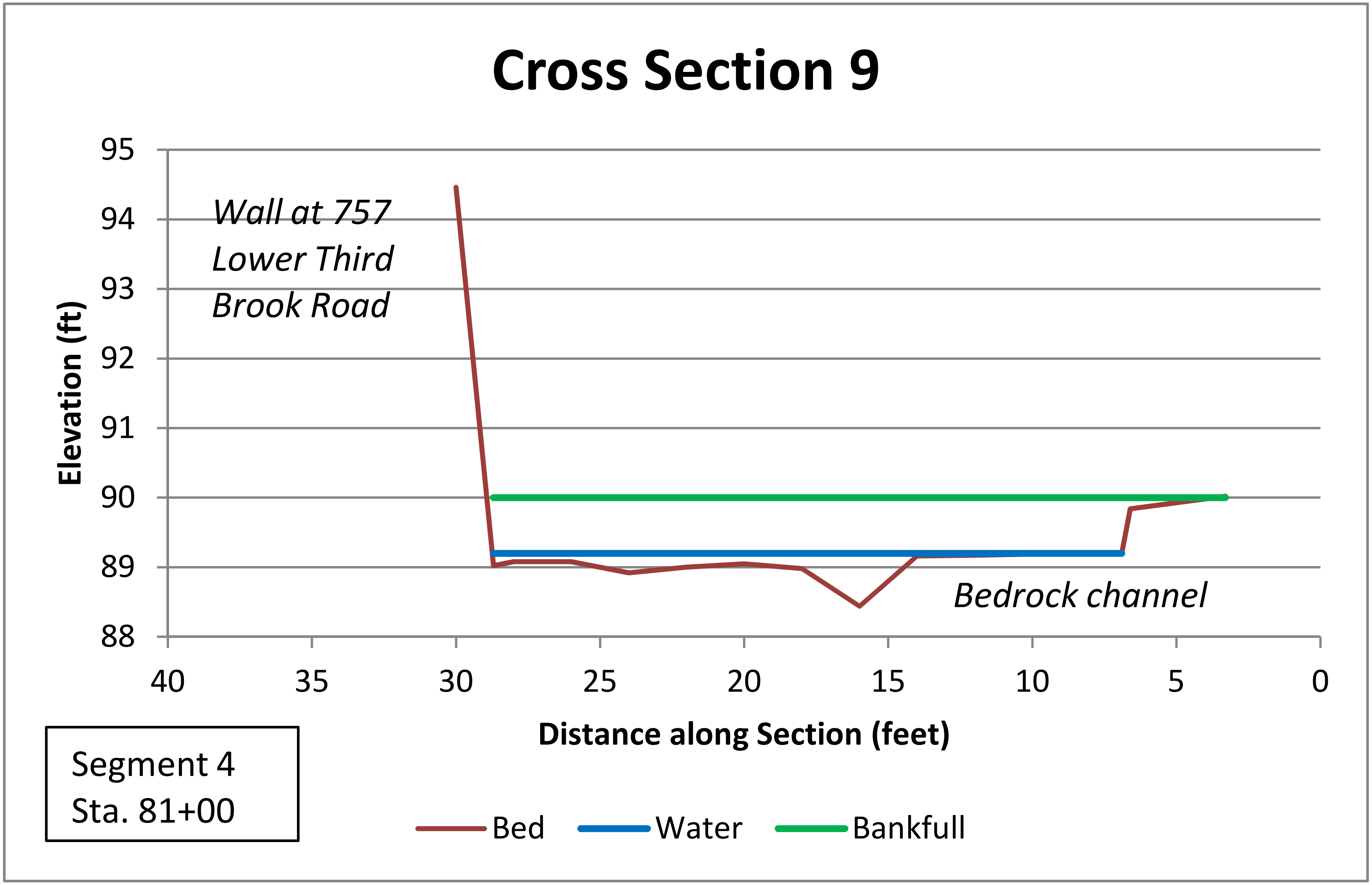
Cross Section 4


Cross Section 5
Vacant lot
Elevation (ft)
97
96
95
94
93
92
91
90
89
88
87
60
50
40
30
20
10
0
Distance along Section (feet)
Segment 2
Sta. 42+00
Bed
Water
Bankfull

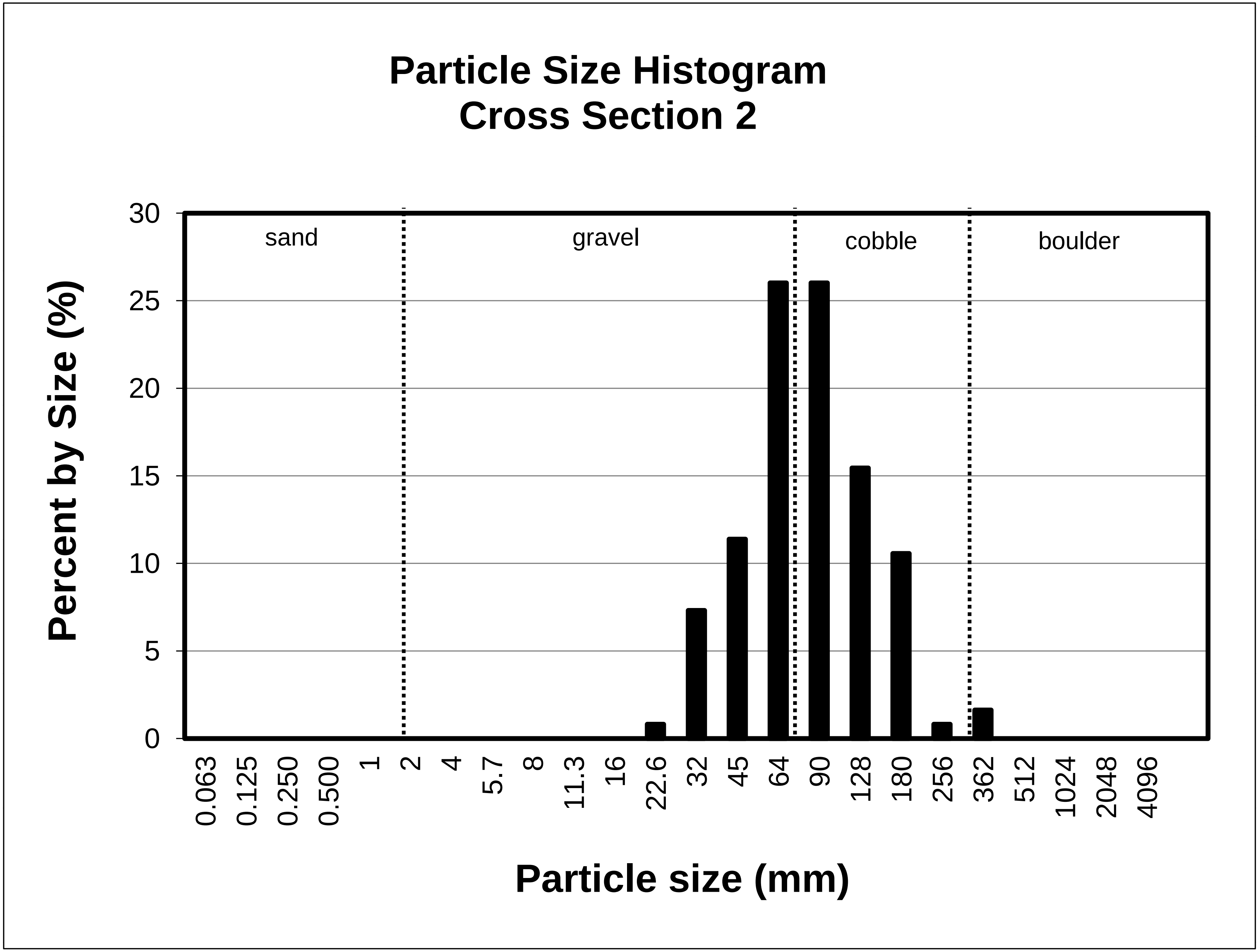

Cross Section 6
Field between
173 and 269
Lower Third
Brook Road
Elevation (ft)
96
95
94
93
92
91
90
89
88
87
90
80
70
60
50
40
30
20
10
0
Distance along Section (feet)
Segment 3
Sta. 50+00
Bed
Water
Bankfull

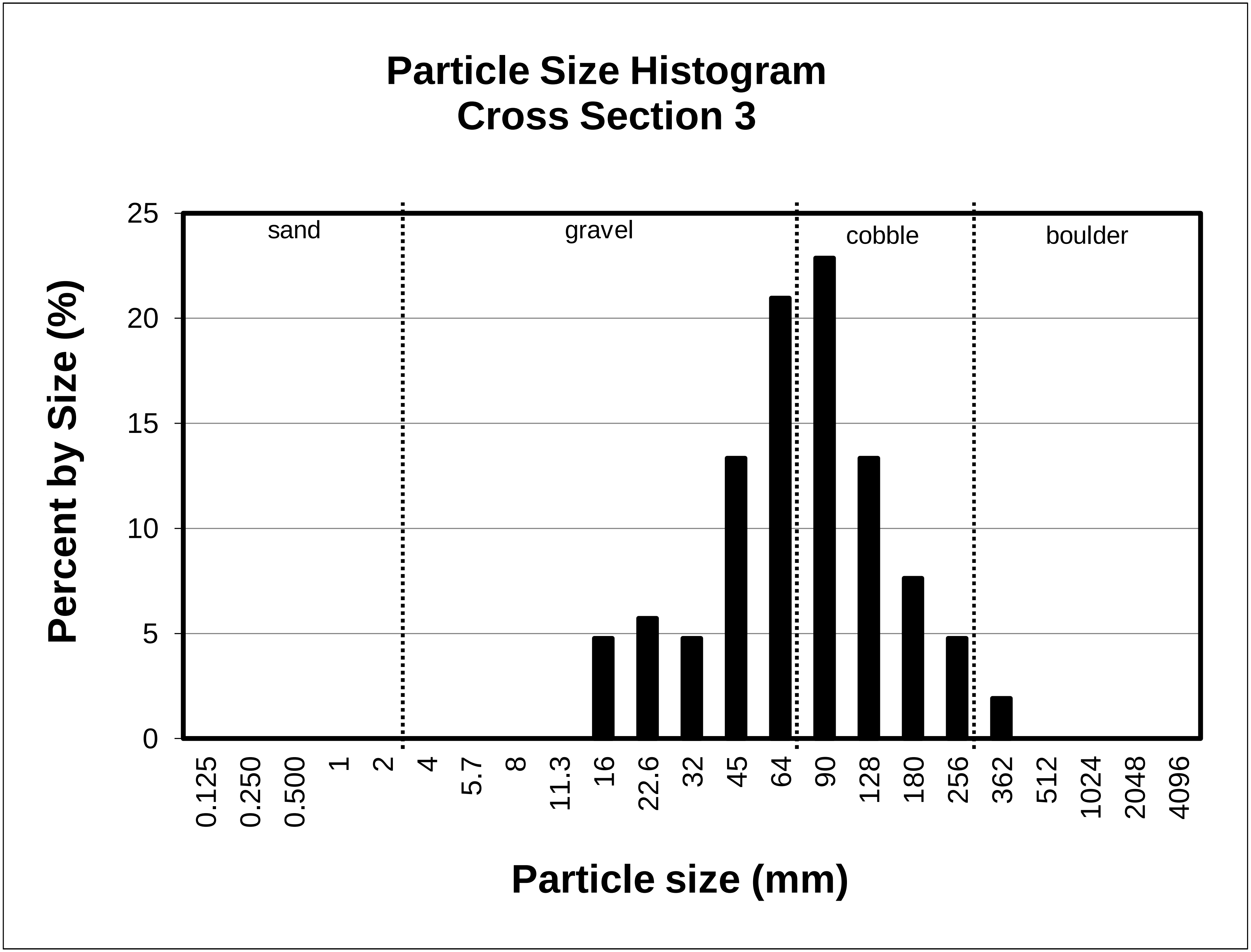

Cross Section 7
Field
Elevation (ft)
96
95
94
93
92
91
90
89
88
87
86
85
90
80
70
60
50
40
30
20
10
0
Distance along Section (feet)
Segment 4
Sta. 60+50
Bed
Water
Bankfull

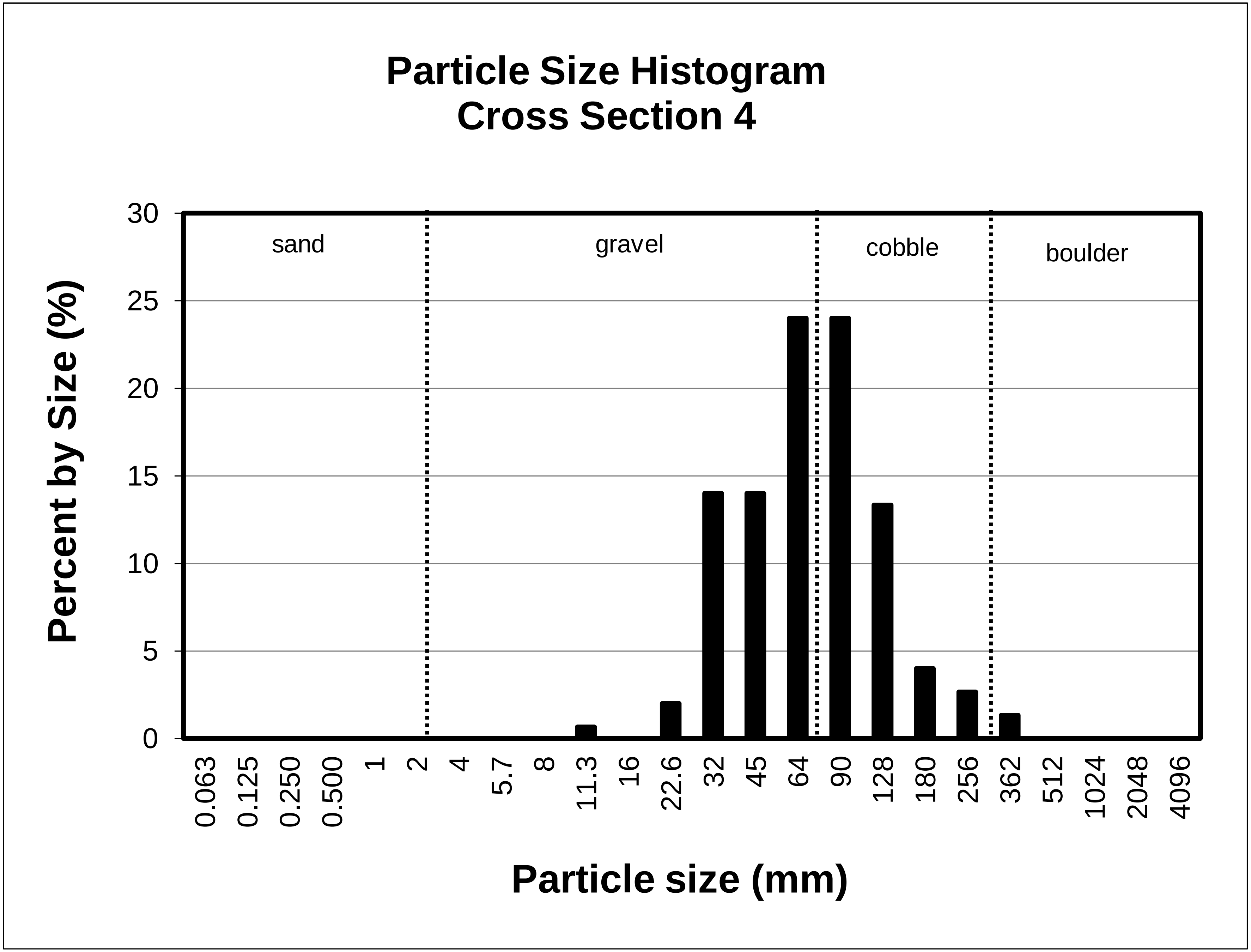

Cross Section 8
Wall at 683
Lower Third
Brook Road
Elevation (ft)
96
94
92
90
88
86
84
82
80
60
50
40
30
20
10
0
Distance along Section (feet)
Segment 4
Sta. 74+50
Bed
Water
Bankfull

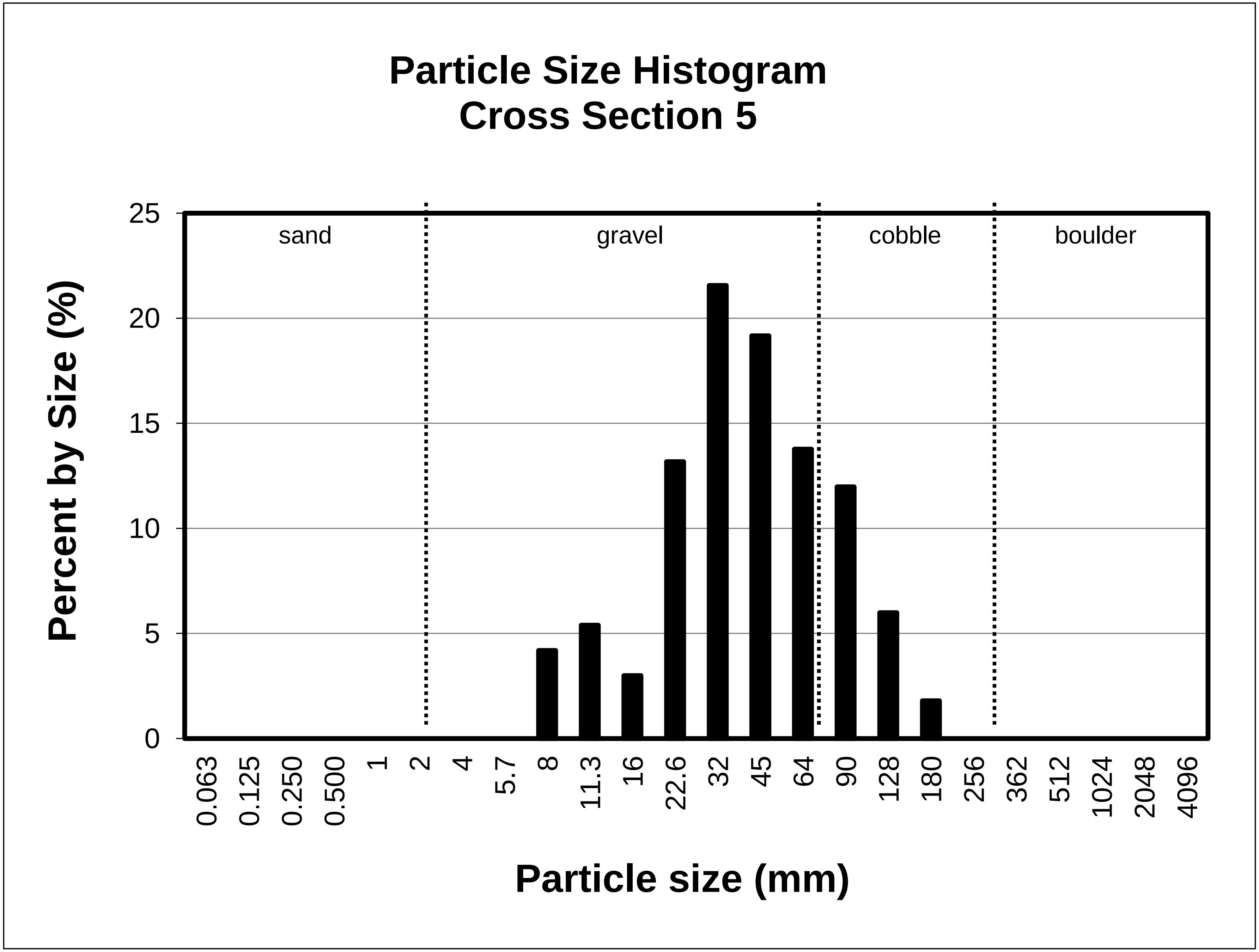

Cross Section 9
Elevation (ft)
95
94
93
92
91
90
89
88
Wall at 757
Lower Third
Brook Road
Bedrock channel
40
35
30
25
20
15
10
5
0
Distance along Section (feet)
Segment 4
Sta. 81+00
Bed
Water
Bankfull

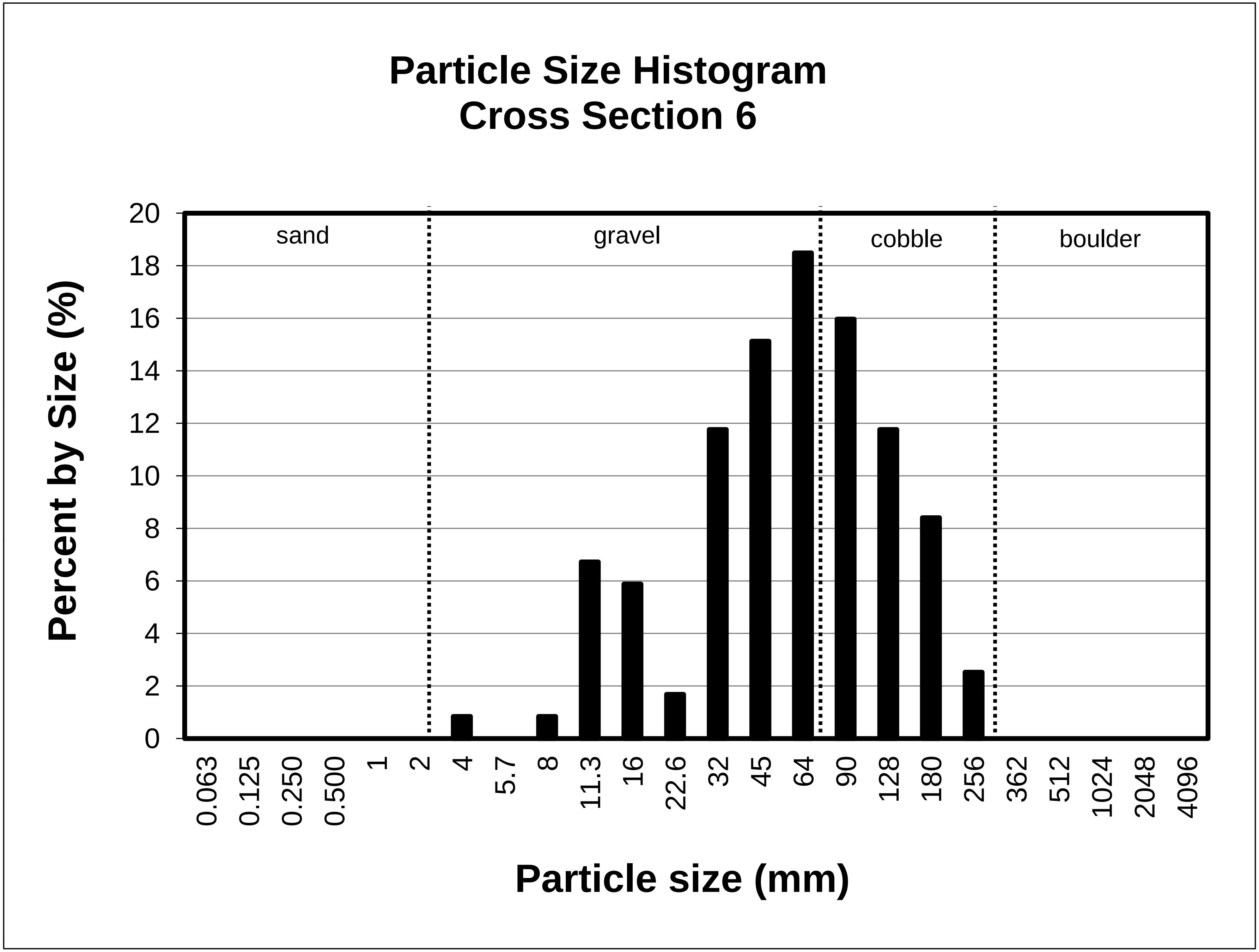
# Appendix E
# Pebble Counts

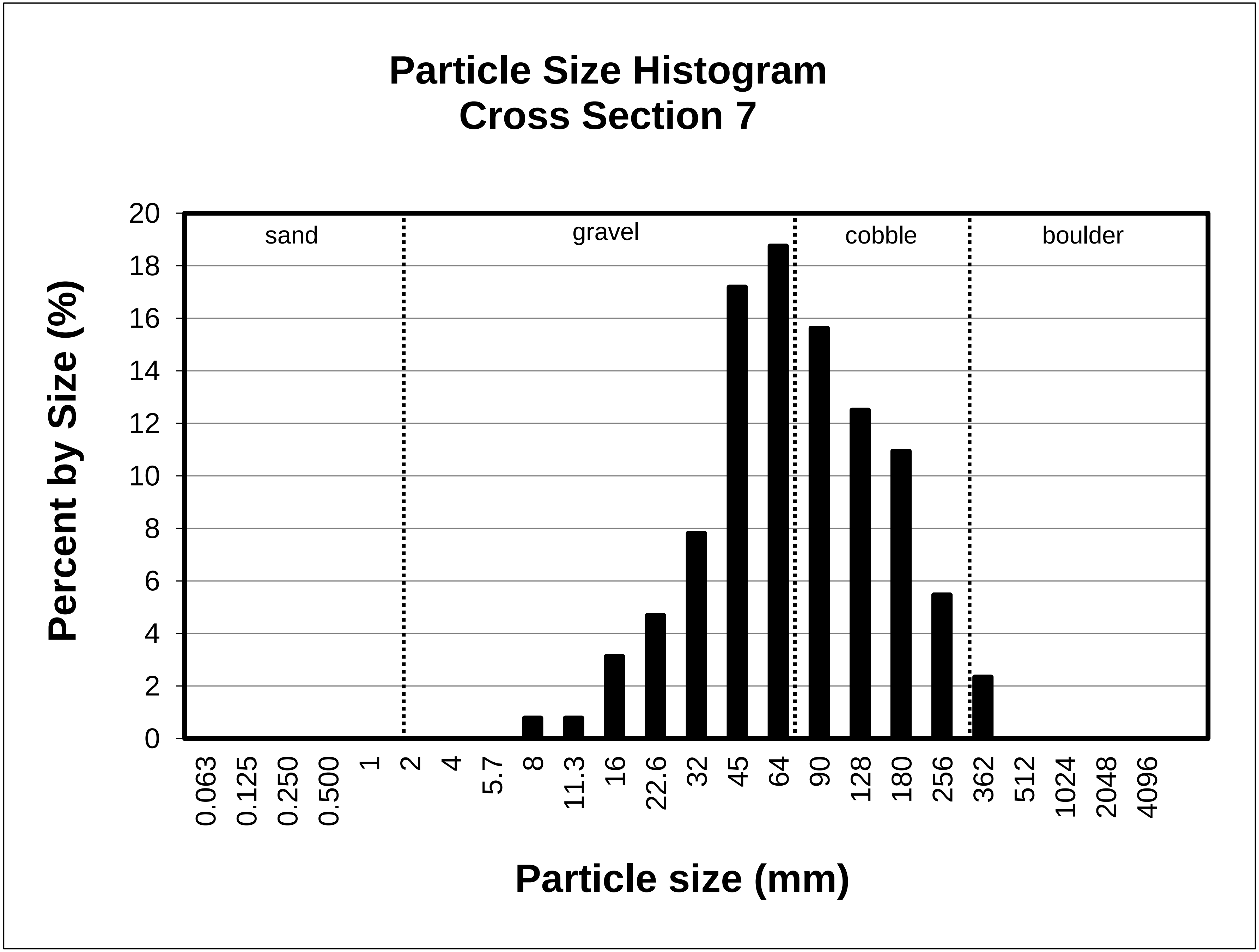

Particle Size Histogram
Cross Section 2
Percent by Size (%)
30
25
20
15
10
5
0
sand
gravel
cobble
boulder
0.063
0.125
0.250
0.500
1
2
4
5.7
8
11.3
16
22.6
32
45
64
90
128
180
256
362
512
1024
2048
4096
Particle size (mm)


Particle Size Histogram
Cross Section 3
Percent by Size (%)
0
5
10
15
20
25
sand
gravel
cobble
boulder
0.125
0.250
0.500
1
2
4
5.7
8
11.3
16
22.6
32
45
64
90
128
180
256
362
512
1024
2048
4096
Particle size (mm)

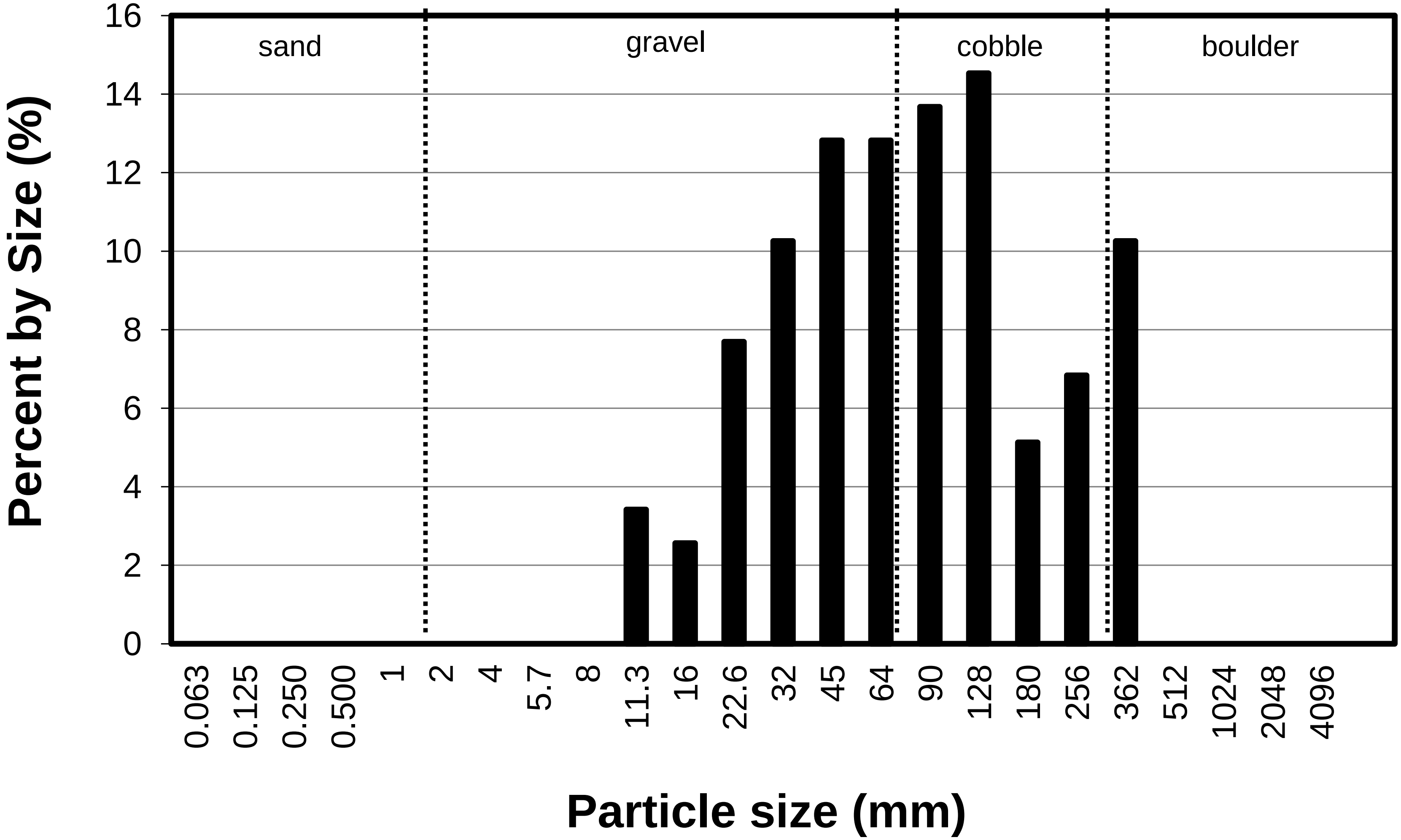

Particle Size Histogram
Cross Section 4
Percent by Size (%)
30
25
20
15
10
5
0
sand
gravel
cobble
boulder
0.063
0.125
0.250
0.500
1
2
4
5.7
8
11.3
16
22.6
32
45
64
90
128
180
256
362
512
1024
2048
4096
Particle size (mm)


Particle Size Histogram
Cross Section 5
Percent by Size (%)
25
20
15
10
5
0
sand
gravel
cobble
boulder
0.063
0.125
0.250
0.500
1
2
4
5.7
8
11.3
16
22.6
32
45
64
90
128
180
256
362
512
1024
2048
4096
Particle size (mm)


Particle Size Histogram
Cross Section 6
Percent by Size (%)
20
18
16
14
12
10
8
6
4
2
0
sand
gravel
cobble
boulder
0.063
0.125
0.250
0.500
1
2
4
5.7
8
11.3
16
22.6
32
45
64
90
128
180
256
362
512
1024
2048
4096
Particle size (mm)


Particle Size Histogram
Cross Section 7
Percent by Size (%)
0
2
4
6
8
10
12
14
16
18
20
sand
gravel
cobble
boulder
0.063
0.125
0.250
0.500
1
2
4
5.7
8
11.3
16
22.6
32
45
64
90
128
180
256
362
512
1024
2048
4096
Particle size (mm)

# Particle Size Histogram
# Cross Section 8



# Appendix F
# WARSSS Worksheets

What about from
changing precip?

**Table 3-1.** Direct and indirect potential influences of land use variables on stream channels and sediment supply.

| Land Uses | Potential Impacts | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | (1) Streamflow changes (magnitude/ timing/ duration) | (2) Riparian vegetation change (composition/ density) | (3) Surface disturbance (% bare ground/ compaction) | (4) Surface/ sub-surface slope hydrology | (5) Direct channel impacts that destabilize channel | (6) Clear water discharge | (7) Loss of stream buffers, surface filters, ground cover | (8) Altered dimension, pattern and profile | (9) Excess sediment deposition/ supply (all sources) | (10) Large woody debris in channel | (11) Stream power change (energy distribution) | (12) Floodplain encroachment channel confinement (lateral containment) |
| Urban development | D | D | D | D | D | D | D | D | I | D | D | D |
| Silvicultural | D | D | D | D | D | | D | I | D | D | I | D |
| Agricultural | D | D | D | D | D | | D | D | D | D | D | D |
| Channelization | D | D | | D | D | | D | D | D | D | D | D |
| Fires | D | D | D | D | I | | D | | D | D | | |
| Flood control, clearing, veg. removal, dredging, levees | I | D | | D | D | I | D | D | I | D | D | D |
| Reservoir storage, hydropower | D | I | | I | D | D | | I | I/D | I | D | |
| Diversions, depletions ( - ) Imported ( + ) | D | I | | I | D | D | | | I/D | | | |
| Grazing | I | D | D | D | D | | D | D | D | D | D | |
| Roads | D | | D | D | D | | I | D | D | D | D | D |
| Mining | D | D | D | D | D | | D | D | D | D | D | D |
| In-channel mining | | D | | D | D | | D | D | D | D | D | D |

**D = Direct potential impact**
**I = Indirect potential impact**
**Blank = Little to no impact**

Table 3-2. Relation of stream and channel variables to erosional processes.

| | Potential Erosional Process Impacts | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Variables Influenced | Surface erosion | Mass erosion | Gully erosion | Streambank erosion | Channel enlargement | Aggradation | Degradation | Channel succession state | Sediment delivery efficiency |
| (1) Streamflow changes (magnitude/ timing/ duration) | | I | D | D | D | D | D | D | I |
| (2) Riparian vegetation change (composition/ density) | | | D | D | D | D | D | D | I |
| (3) Surface disturbance (% bare ground/ compaction) | D | I (debris torrents) | D (rills-gully) | I | I | I | I | I | D |
| (4) Surface/ sub-surface slope hydrology | D | D | D | I | I | I | I | I | D |
| (5) Direct channel impacts that destabilize channel | | | D | D | D | D | D | D | I |
| (6) Clear water discharge | | | D | D | D | I | D | D | |
| (7) Loss of stream buffers, surface filters, ground cover | D | | I | | | | | | D |
| (8) Altered dimension, pattern and profile | | | | D | D | D | D | D | |
| (9) Excess sediment deposition/ supply | | | | D | D | D | D | D | |
| (10) Large woody debris in-channel | | D | D | D | D | D | D | D | |
| (11) Stream power change (energy redistribution) | | | D | D | D | D | D | D | |
| (12) Floodplain encroachment channel confinement (lateral containment) | | I | I | D | D | D | | I | D |

**D = Direct potential contribution**
**I = Indirect potential contribution**
**Blank = Little to no influence**

**Worksheet 3-1.** Evaluation and summary of guidance criteria for selection of sub-watershed to proceed to *RRISSC* or to exclude from further assessment.

| Clarification | Sub-watershed/ reach location ID | Step 7: Surface erosion | | Step 8: Mass erosion | | Step 10: Streamflow change | | | Step 11: Channel processes | | Step 12: Direct channel impacts | | Step 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Circle selected guidance criteria number (Table 3-3)* | Reason for exclusion | Circle selected guidance criteria number (Table 3-4)* | Reason for exclusion | Circle selected guidance criteria number (Table 3-5)* | Roads | Reason for exclusion | Circle selected guidance criteria number (Table 3-6)* | Reason for exclusion | Circle selected guidance criteria number (Table 3-7)* | Reason for exclusion | Check location selected for advance-ment to *RRISSC*** |
| F | 1. Below Ogden | (1) (2) [✓ (3)] (4) | | (1) (2) (3) (4) (5) | | (1) [✓ (2)] (3) (4) (5) | [✓ (6)] | | [✓ (1)] [✓ (2)] (3) [✓ (4)] (5) (6) | | [✓ (1)] (2) | | ✓ |
| G | 2. 119 LTB Rd to Ogden | (1) (2) (3) (4) | | [✓ (1)] [✓ (2)] (3) [✓ (4)] (5) | | (1) [✓ (2)] (3) (4) (5) | [✓ (6)] | | [✓ (1)] [✓ (2)] (3) [✓ (4)] (5) (6) | | [✓ (1)] (2) | | ✓ |
| G | 3. 269 to 119 LTB Rd | (1) (2) (3) (4) | | [✓ (1)] [✓ (2)] (3) [✓ (4)] (5) | | (1) (2) (3) (4) (5) | [✓ (6)] | | [✓ (1)] [✓ (2)] (3) [✓ (4)] (5) (6) | | [✓ (1)] (2) | | ✓ |
| G | 4. bedrock to 269 LTB Rd | (1) (2) (3) (4) | | [✓ (1)] [✓ (2)] (3) [✓ (4)] (5) | | (1) (2) (3) (4) (5) | [✓ (6)] | | [✓ (1)] [✓ (2)] (3) [✓ (4)] (5) (6) | | [✓ (1)] (2) | | ✓ |
| C3 | 5. LTB Rd to bedrock | (1) (2) (3) (4) | | (1) (2) (3) (4) (5) | | (1) (2) (3) (4) (5) | [✓ (6)] | | [✓ (1)] [✓ (2)] (3) [✓ (4)] (5) (6) | | (1) [✓ (2)] | | ✓ |
| C3/4 | 6. Gosper to LTB Rd | (1) (2) (3) [✓ (4)] | | (1) (2) (3) (4) (5) | | (1) (2) (3) (4) (5) | (6) | | [✓ (1)] (2) (3) (4) (5) (6) | | (1) [✓ (2)] | | |
| B3/4 | 7. Fletcher to Gosper | (1) (2) (3) [✓ (4)] | | (1) (2) (3) (4) (5) | | (1) (2) (3) (4) (5) | (6) | | [✓ (1)] (2) (3) (4) (5) (6) | | (1) [✓ (2)] | | |
| B4/5 | 8. Above Fletcher | (1) (2) [✓ (3)] [✓ (4)] | | (1) (2) (3) (4) (5) | | (1) (2) (3) (4) (5) | (6) | | [✓ (1)] (2) (3) (4) (5) (6) | | (1) [✓ (2)] | | |
| | 9. | (1) (2) (3) (4) | | (1) (2) (3) (4) (5) | | (1) (2) (3) (4) (5) | (6) | | (1) (2) (3) (4) (5) (6) | | (1) (2) | | |
| | 10. | (1) (2) (3) (4) | | (1) (2) (3) (4) (5) | | (1) (2) (3) (4) (5) | (6) | | (1) (2) (3) (4) (5) (6) | | (1) (2) | | |
| | 11. | (1) (2) (3) (4) | | (1) (2) (3) (4) (5) | | (1) (2) (3) (4) (5) | (6) | | (1) (2) (3) (4) (5) (6) | | (1) (2) | | |
| | 12. | (1) (2) (3) (4) | | (1) (2) (3) (4) (5) | | (1) (2) (3) (4) (5) | (6) | | (1) (2) (3) (4) (5) (6) | | (1) (2) | | |
| | 13. | (1) (2) (3) (4) | | (1) (2) (3) (4) (5) | | (1) (2) (3) (4) (5) | (6) | | (1) (2) (3) (4) (5) (6) | | (1) (2) | | |
| | 14. | (1) (2) (3) (4) | | (1) (2) (3) (4) (5) | | (1) (2) (3) (4) (5) | (6) | | (1) (2) (3) (4) (5) (6) | | (1) (2) | | |
| | 15. | (1) (2) (3) (4) | | (1) (2) (3) (4) (5) | | (1) (2) (3) (4) (5) | (6) | | (1) (2) (3) (4) (5) (6) | | (1) (2) | | |
| | 16. | (1) (2) (3) (4) | | (1) (2) (3) (4) (5) | | (1) (2) (3) (4) (5) | (6) | | (1) (2) (3) (4) (5) (6) | | (1) (2) | | |

*Criteria based on overall review of the list in Tables 3-1 and 3-2.

**Locations that meet one or more selection criteria should proceed to the *RRISSC* assessment level.

**Worksheet 4-9.** Risk rating worksheet for direct channel impacts.

| (1) Location code/ river reach I.D. | (2) Total channel length in feet | (3) Riparian vegetation change in feet | (4) % of total length impacted [(3)/(2)X100] | (5) Risk rating: % riparian vegetation change (Fig. 4-23) (4) by stream type | (6) Length impacted by direct channel disturbance in feet | (7) % of total length impacted [(6)/(2)X100] | (8) Risk rating: % channel length impacted (Fig. 4-24) (7) by stream type | (9) Length impacted by large woody debris in feet | (10) % of length of debris blockage [(9)/(2)X100] | (11) Risk rating: debris blockage (Fig. 4-25) | (12) Overall risk rating for direct channel impacts (Insert highest risk rating from Columns 5, 8 and 11) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | — | — | — | VL 1 | — | — | VL 1 | — | — | VL 1 | VL 1 |
| 2. | — | — | — | ↓ | — | — | ↓ | — | — | ↓ | ↓ |
| 3. | — | — | — | ↓ | — | — | ↓ | — | — | ↓ | ↓ |
| 4. | — | — | — | ↓ | — | — | ↓ | — | — | ↓ | ↓ |
| 5. | — | — | — | ↓ | — | — | ↓ | — | — | ↓ | ↓ |
| 6. | | | | | | | | | | | |
| 7. | | | | | | | | | | | |
| 8. | | | | | | | | | | | |
| 9. | | | | | | | | | | | |
| 10. | | | | | | | | | | | |
| 11. | | | | | | | | | | | |
| 12. | | | | | | | | | | | |
| 13. | | | | | | | | | | | |

**Worksheet 4-8.** Risk rating worksheet for in-channel mining.

| (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|
| Location code/ reach I.D. | Total acres of reach | Total acres impacted by in-channel mining | % of channel length impacted by in-channel mining **[(3)/(2)X100]** | Overall adjective and numeric risk rating **(Fig. 4-22)** (4) by stream type |
| 1. | | | | VL 1 |
| 2. | | | | 〃 |
| 3. | | | | 〃 |
| 4. | | | | 〃 |
| 5. | | | | 〃 |
| 6. | | | | |
| 7. | | | | |
| 8. | | | | |
| 9. | | | | |
| 10. | | | | |
| 11. | | | | |
| 12. | | | | |
| 13. | | | | |
| 14. | | | | |
| 15. | | | | |

Check

height of bank ≈ 3,4,5
bankfull depth

**Worksheet 4-7.** Risk rating worksheet for streambank erosion.

| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
|---|---|---|---|---|---|---|---|---|
| Location code/ river reach I.D. type | Vegetation composition | Risk rating: vegetation composition **(Fig. 4-18)** | Bank-height ratio | Risk rating: bank-height ratio **(Fig. 4-19)** | Radius of curvature divided by bankfull width | Risk rating: radius of curvature divided by bankfull width **(Fig. 4-20)** | Total individual risk rating points by reach **∑[(3)+(5)+(7)]** | Overall risk rating by stream type **(Fig. 4-21)** |
| 1. F | Stone | VL 1 | 3.7 | VH 5 | — | VL 1 | 7 | M 3 |
| 2. G | grass/Conifers | H 4 | 4.3 | VH 5 | — | ↓ | 10 | VH 5 |
| 3. G | ↓ | ↓ | 3,5 | VH 5 | — |  | ↓ | VH 5 |
| 4. G |  |  |  | VH 5 | — |  |  | VH 5 |
| 5. C3 |  |  |  | VH 5 | — |  |  | M 3 |
| 6. |  |  |  |  |  |  |  |  |
| 7. |  |  |  |  |  |  |  |  |
| 8. |  |  |  |  |  |  |  |  |
| 9. |  |  |  |  |  |  |  |  |
| 10. |  |  |  |  |  |  |  |  |
| 11. |  |  |  |  |  |  |  |  |
| 12. |  |  |  |  |  |  |  |  |
| 13. |  |  |  |  |  |  |  |  |
| 14. |  |  |  |  |  |  |  |  |
| 15. |  |  |  |  |  |  |  |  |

**Worksheet 4-6.** Risk rating worksheet for streamflow changes.

| | | Rural Sub-watershed Risk | | | | Urban Sub-watershed Risk | | | | Adjustments | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) |
| **Sub-watershed location/river reach I.D. (include cumulative total watershed following sub-watershed I.D.s)** | Total acres | Acres cleared/ harvested (include **roads**) **[roads + clearcut = total]** | % cleared/ harvested of total **[(3)/(2)X100]** | Stream type most susceptible to change **or "weak link"** | Risk rating: rural **sub-**watershed **risk (Fig. 4-14) (4)** by **stream** type (5) | Total impervious acres | % impervious **[(7)/(2)X100]** | Stream type most susceptible to change **or "weak link"** | Risk rating: urban **sub-**watershed risk **(Fig. 4-15) (8)** by **stream** type (9) | Risk rating: % increase over bankfull discharge **(Fig. 4-16)*** | Risk rating: % reduction **in** bankfull discharge **(Fig. 4-17)*** | Overall **risk** rating: streamflow changes (insert adjective **and** numeric rating) |
| 1. | 3472<br>400 | | ~~50~~ | ~~F~~ | ~~VH 5~~ | 30 | 50 23 | F | VH 5 | | | VH 5 |
| 2. | 3343 ,, | | ~~"~~ | ~~G~~ | ~~VH 5~~ | | 20 | G | VH 5 | | | ↓ |
| 3. | 3268 ,, | | ~~"~~ | ~~G~~ | ~~VH 5~~ | | 20 | G | VH 5 | | | |
| 4. | 3083 ,, | 40 | ~~19%~~ | ~~G~~ G | ~~VH 5~~ H4 | | ~~10~~ | ~~G~~ | ~~VH 5~~ | | | H4 |
| 5. | 2867 ,, | 273 | " 10% | C3 | VH 5<br>↑ M 3 | | | [illegible] | | | | M3 |
| 6. | | | | | | | | | | | | |
| 7. | | | | | | | | | | | | |
| 8. | | | | | | | | | | | | |
| 9. | | | | | | | | | | | | |
| 10. | | | | | | | | | | | | |
| 11. | | | | | | | | | | | | |
| 12. | | | | | | | | | | | | |
| 13. | | | | | | | | | | | | |
| 14. | | | | | | | | | | | | |
| 15. | | | | | | | | | | | | |

*** Describe source of increased or decreased bankfull discharge adjustment, i.e., operational hydrology of resevoir.**

**Worksheet 4-5.** Risk rating worksheet for surface erosion and sedient delivery potential.

| | Surface Erosion Potential | | | | | | | Sediment Delivery Potential | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Continue only if rating in Column (8) is *High* or *Very High* | | | | | | | |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) | (15) | (16) |
| **Location** of sub-watershed (I.D.) | Total **acres** of sub-watershed | Acres impacted* | % **acres** impacted acres [(3)/(2)X100] | Acres impacted (3) **with** more **than** 50% **bare** ground | % of **acres** impacted with **more** than **50%** bare **ground** [(5)/(3)X100] | Landscape type **(stable** or unstable) | Overall risk rating: surface erosion (Fig. 4-7) | Converted ratios or conditions for numerical risk ratings of sediment delivery potential | | | | | | Overall risk rating: sediment delivery potential; use (14) points (Fig. 4-13) | % of sub-watershed with *H* or *VH* erosion potential, and with *H* or *VH* sediment delivery potential (see map) |
| | | | | | | | | Risk rating: drainage density by slope gradient (%) (Fig. 4-8) | Risk rating: slope **position** (Fig. 4-9) | Risk rating: % ground cover (Fig. 4-10) | Risk rating: distance of disturbance to stream (ft) (Fig. 4-11) | Risk rating: stream **buffer** (ft) (Fig. 4-12) | Total individual risk rating points Σ[(9) through (13)] | | |
| 1. | 400 | — | — | 0 | 0 | S | VL 1 | — | — | — | — | — | — | — | — |
| 2. | " | — | — | 0 | 0 | S | VL 1 | — | — | — | — | — | — | — | — |
| 3. | " | — | — | 0 | 0 | S | VL 1 | — | — | — | — | — | — | — | — |
| 4. | " | — | — | 0 | 0 | S | VL 1 | — | — | — | — | — | — | — | — |
| 5. | " | — | — | 0 | 0 | S | VL 1 | — | — | — | — | — | — | — | — |
| 6. | | | | | | | | | | | | | | | |
| 7. | | | | | | | | | | | | | | | |
| 8. | | | | | | | | | | | | | | | |
| 9. | | | | | | | | | | | | | | | |
| 10. | | | | | | | | | | | | | | | |
| 11. | | | | | | | | | | | | | | | |
| 12. | | | | | | | | | | | | | | | |
| 13. | | | | | | | | | | | | | | | |
| 14. | | | | | | | | | | | | | | | |
| 15. | | | | | | | | | | | | | | | |

***Do not include road acres.**

**Worksheet 4-4.** Risk rating worksheet for potential sediment delivery from roads.

| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) | | | | (15) | (16) | (17) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Location of sub-watershed (I.D.)** | **Acres of** sub-watershed (200–5000 acres) | Acres disturbance of road (include **cut** bank, **fill** slope, **road** surface) | Number of stream crossings | Calculate road impact index [(3)/(2)X(4)] *If crossings = 0, **multiply** by **1.** | Slope position (lower or mid-upper) | Risk rating: road impact index (5) by **slope** position (**Fig. 4-3**) | Distance of road fill to stream (ft) | Risk rating: distance of road **fill** to **stream** (ft) (**Fig. 4-4**) | Slope of road (%) | Risk rating: slope **of** road **(%)** (**Fig. 4-5**) | Total individual risk rating points ∑[(7)+(9)+(11)] | Overall risk **rating** for potential sediment from roads (Fig. **4-6**) | Adjustments for construction, design **and age of road** | | | | Risk **rating** adjustments for **mass** erosion potential slump/ earthflow*** (Table **4-4**, Figures 4-1, 4-2) | Debris torrent/ avalanche. **If** erosion **risk** and **sediment** delivery potential is *High*, **raise** final **road risk** rating **to** ***Very High*** **(Table 4-4, Figures 4-1, 4-2)** | **Final risk rating of potential sediment from roads** |
| | | | | | | | | | | | | | Age of road. **If > 7 yrs and** sediment delivery potential = ***Low***, reduce one **risk** category* | Road surfacing. If **gravel/** asphalt, then reduce one **risk** category** | Ditch line: If surfacing out-sloped, reduce one **risk** category | Vegetative condition of cut **banks**, road **fills** If **> 50%** ground cover, reduce one risk category | | | |
| 1. | 400 | 20 | 2 | 0.1 | L | H 4 | 50+ | M 3 | <2 | VL 1 | 8 | M 3 | L | L | L | L | L | L | L |
| 2. | " | 10 | 0 | 0.03 | L | H 4 | 100-200 | L 2 | <2 | VL 1 | 7 | L 2 | L | L | L | L | M | M | M |
| 3. | " | 3 | 0 | 0.01 | L | H 4 | 100-400 | L 2 | <2 | VL 1 | 7 | L 2 | L | L | L | L | M | M | M |
| 4. | " | 5 | 0 | 0.01 | L | H 4 | 50-100 | M 3 | <2 | VL 1 | 8 | M 3 | L | L | L | L | M | M. | M |
| 5. | " | 10 | 2 | 0.05 | L | H 4 | 100-400 | L 2 | <2 | VL 1 | 7 | L 2 | L | L | L | L | L | L | L |
| 6. | | | | | | | | | | | | | | | | | | | |
| 7. | | | | | | | | | | | | | | | | | | | |
| 8. | | | | | | | | | | | | | | | | | | | |
| 9. | | | | | | | | | | | | | | | | | | | |
| 10. | | | | | | | | | | | | | | | | | | | |
| 11. | | | | | | | | | | | | | | | | | | | |
| 12. | | | | | | | | | | | | | | | | | | | |
| 13. | | | | | | | | | | | | | | | | | | | |
| 14. | | | | | | | | | | | | | | | | | | | |
| 15. | | | | | | | | | | | | | | | | | | | |

***Unless: road has not recovered; poor maintenance; poor vegetative cover on cut bank and fill slopes - ditch line is still leading water into stream.**

****Unless: road cut bank, fills and ditch line continue to provide sediment source to stream.**

*****If risk is *high* for potential sediment delivery of mass erosion (Worksheet 4-3), then adjust overall risk up one category.**

**Worksheet 4-3.** Risk rating worksheet for mass erosion sediment delivery.

| (1) Sub-watershed location (I.D.) | (2) Slope gradient (degrees) | (3) Slope shape (discontinuous or continuous) | (4) Risk rating: **slope** gradient by slope shape (**Figure 4-1**) | (5) Slope position (**lower** 1/4, mid to lower 1/4, mid to upper 1/4, upper 1/4 or stream adjacent) | (6) Risk rating: slope position (**Figure 4-2**) | (7) Total risk rating points by sub-watershed ∑[(4)+(6)] | (8) Overall mass erosion risk rating (use column (7) points; insert adjective and numerical risk rating)<br>VL(1) = 2–3<br>L(2) = 3–4<br>M(3) = 5–6<br>H(4) = 7–8<br>VH(5) = 9–10 |
|---|---|---|---|---|---|---|---|
| 1. | < 30 | D | VL 1 | ~~Adjacent~~ L/Mid | ~~VH 5~~ M 3 | 4 | L 4 |
| 2. | 30 + | C | L 2 | Adjacent | VH " 5 | 7 + | VH 10 |
| 3. | 30 + | C | L 2 | " | " | 7 + | VH 10 |
| 4. | 30 + | C | L 2 | " | " | 7 + | VH 10 |
| 5. | < 30 | D | VL 1 | L/Mid ~~"~~ | " M 3 | 4 | L 4 |
| 6. | | | | | | | |
| 7. | | | | | | | |
| 8. | | | | | | | |
| 9. | | | | | | | |
| 10. | | | | | | | |
| 11. | | | | | | | |
| 12. | | | | | | | |
| 13. | | | | | | | |
| 14. | | | | | | | |
| 15. | | | | | | | |

Failures Occurring Already so I Kicked these up to 10

**Worksheet 4-2.** *RRISSC* summary worksheet for multiple sites/river reaches within a study watershed. Insert both the adjective and numeric overall risk rating.

**Watershed Name:** **Date:** **Observer(s):**

| | Geographic Location | | | | Stream Type Location | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Location code/ river reach I.D.** | **Step 6:** Mass erosion **(Worksheet 4-3)** | **Step 7:** Roads **(Worksheet 4-4)** | **Step 8:** Surface erosion **(Worksheet 4-5)** | **Step 10:** Streamflow change **(Worksheet 4-6)** | **Step 13:** Streambank erosion **(Worksheet 4-7)** | **Step 14:** In-channel mining **(Worksheet 4-8)** | **Step 15:** Direct channel impacts **(Worksheet 4-9)** | **Step 16:** Channel enlargement **(Worksheet 4-10)** | **Step 17:** Aggradation/ excess sediment **(Worksheet 4-11)** | **Step 18:** Channel evolution/ successional states **(Table 4-5)** | **Step 19:** Degradation **(Worksheet 4-12)** | Processes identified by **step for** advancement to *PLA* | Check location selected for advancement to *PLA* |
| F3 1. Below ogden | L 4 | L 2 | VL 1 | VH 5 | M 3 | VL 1 | VL 1 | VH 5 | VH 5 | L 2 | VH 5 | 10, 16, 17, 19 | ✓ |
| G3/4 2. 119 LTB to ogden | VH 10 | M 3 | VL 1 | VH 5 | VH 5 | VL 1 | VL 1 | VH 5 | VH 5 | L 2 | VH 5 | 6, 10, 13, 16, 17, 19 | ✓ |
| G3/4 3. 269 to 119 LTB | VH 10 | M 3 | VL 1 | VH 5 | VH 5 | VL 1 | VL 1 | VH 5 | VH 5 | L 2 | VH 5 | 6, 10, 13, 16, 17, 19 | ✓ |
| G3/4 4. bedrock to 269 LTB | VH 10 | M 3 | VL 1 | H 4 | VH 5 | VL 1 | VL 1 | VH 5 | VH 5 | L 2 | H 4 | 6, 10, 13, 16, 17, 19 | ✓ |
| C3 5. LTB bridge to bedrock | L 4 | L 2 | VL 1 | H 4 | M 3 | VL 1 | VL 1 | M 3 | H 4 | L 2 | H 4 | 10, 17, 19 | ✓ |
| 6. | | | | | | | | | | | | | |
| 7. | | | | | | | | | | | | | |
| 8. | | | | | | | | | | | | | |
| 9. | | | | | | | | | | | | | |
| 10. | | | | | | | | | | | | | |
| 11. | | | | | | | | | | | | | |
| 12. | | | | | | | | | | | | | |
| 13. | | | | | | | | | | | | | |
| 14. | | | | | | | | | | | | | |
| 15. | | | | | | | | | | | | | |

**Worksheet 4-10.** Risk rating worksheet for channel enlargement.

| (1) | (2) | (3) | (4) | (5) | (6) | (7) |
|---|---|---|---|---|---|---|
| Location code/ river reach I.D. type | Overall risk rating: streamflow changes **(Step 10 in Worksheet 4-2; Worksheet 4-6)** | Overall risk rating: streambank erosion **(Step 13 in Worksheet 4-2; Worksheet 4-7)** | Overall risk rating: direct channel impacts **(Step 15 in Worksheet 4-2; Worksheet 4-9)** | Total numeric score **∑[(2)+(3)+(4)]** | Overall risk rating for channel enlargement **(Fig. 4-26)** (5) by stream type | Adjustment due to in-channel mining* |
| 1. F | VH 5 | M 3 | VL 1 | 9 | VH 5 | — |
| 2. G | VH 5 | VH 5 | VL 1 | 11 | VH 5 | — |
| 3. G | VH 5 | VH 5 | VL 1 | 11 | VH 5 | — |
| 4. G | H 4 | VH 5 | VL 1 | 10 | VH 5 | — |
| 5. C3 | H 4 | M 3 | VL 1 | 8 | M 3 | — |
| 6. | | | | | | |
| 7. | | | | | | |
| 8. | | | | | | |
| 9. | | | | | | |
| 10. | | | | | | |
| 11. | | | | | | |
| 12. | | | | | | |
| 13. | | | | | | |
| 14. | | | | | | |
| 15. | | | | | | |

***Any in-channel mining automatically raises reach to *high* risk for enlargement and advances reach to *PLA*.**

some deposition in segment 1

**Worksheet 4-11.** Summary of risk ratings for potential aggradation and/or excess sediment deposition.

| | Hillslope Risk Ratings (Sediment Supply) | | | | | Channel Process Response to Excess Sediment | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) | (15) |
| Location code/ river reach I.D. | Risk rating: mass erosion (Step 6 in Worksheet 4-2; Worksheet 4-3) | Risk rating: roads (Step 7 in Worksheet 4-2; Worksheet 4-4) | Risk rating: surface erosion risk/ delivered sediment risk (Step 8 in Worksheet 4-2; Worksheet 4-5) | Point subtotal ∑[(2)+(3)+(4)] | Hillslope summary overall rating; use points from column (5) (Insert both numeric and adjective ratings) VL(1) = 3 L(2) = 4–7 M(3) = 8–10 H(4) = 11–14 VH(5) = >14 | Representative location and associated rating points from column (6)* | Risk rating: width/depth ratio departure (Fig. 4-27) VL(1) = HS L(2) = S M(3) = MU H(4) = U VH(5) = HU | Risk rating: channel enlargement (Step 16 in Worksheet 4-2; Worksheet 4-10) | Risk rating: streambank erosion (Step 13 in Worksheet 4-2; Worksheet 4-7) | Point subtotal ∑[(7)+(8)+(9)+(10)] | Risk rating: use points from column (11) (Insert adjective risk rating) VL(1) < 5 L(2) = 5–8 M(3) = 9–12 H(4) = 13–16 VH(5) >16 | Adjustments: aggradation/excess sediment indicators** a. obvious excess deposition b. filling of pools c. deposition of sand or larger material on floodplain d. Bi-modal e. depositional patterns B3, B5-B7 (Fig. 4-28) (note categories that apply) | Adjustment: reduction in flow due to regulation** | Final aggradation/ excess sediment deposition risk rating (insert adjective risk rating) |
| rock wall 1. | L 4 | H 4 | VL 1 | 9 | M 9 | M 9 | VL 1 | VH 5 | M 3 | 18 | VH 5 | — | — | VH 5 |
| use failing slope 2. | VH 10 | H 4 | VL 1 | 15 | VH 15 | VH 15 | VL 1 | VH 5 | VH 5 | 26 | \| | — | — | \| |
| 3. | VH 10 | H 4 | VL 1 | 15 | VH 15 | VH 15 | VL 1 | VH 5 | VH 5 | 26 | \| | — | — | \| |
| eroding bank 4. | VH 10 | H 4 | VL 1 | 15 | VH 15 | VH 15 | VL 1 | VH 5 | VH 5 | 26 | ↓ | — | — | ↓ |
| 5. | L 4 | H 4 | VL 1 | 9 | M 9 | M 9 | VL 1 | M 3 | M 3 | 16 | H 4 | — | — | H 4 |
| 6. | | | | | | | | | | | | | | |
| 7. | | | | | | | | | | | | | | |
| 8. | | | | | | | | | | | | | | |
| 9. | | | | | | | | | | | | | | |
| 10. | | | | | | | | | | | | | | |
| 11. | | | | | | | | | | | | | | |
| 12. | | | | | | | | | | | | | | |
| 13. | | | | | | | | | | | | | | |
| 14. | | | | | | | | | | | | | | |
| 15. | | | | | | | | | | | | | | |

* To apply risk rating from Hillslope Processes for aggradation risk, it is important to identify the location of the sediment supply in relation to the most representative or "weak link" stream type.

** Adjust a full risk category upward if streamflow decrease and/or indicators provide evidence appropriate to the observed condition such as aggradation indicators on categories a,b,c,d and e.

**Worksheet 4-12.** Risk rating worksheet for degradation.

| (1) | (2) | (3) | (4) | (5) | (6) | (7) |
|---|---|---|---|---|---|---|
| Location code/ river reach I.D. | Risk rating: streamflow changes **(Step 10 in Worksheet 4-2; Worksheet 4-6)** | Risk rating: in-channel mining associated with base-level shifts **(Step 14 in Worksheet 4-2; Worksheet 4-8)** | Risk rating: channel evolution **(Step 18 in Worksheet 4-2; Table 4-5)** | Risk rating: road drainage designs, "shot gun" culverts (base-level shifts) **(Worksheet 4-13)** | Risk rating: direct channel impacts **(Step 15 in Worksheet 4-2; Worksheet 4-9)** | Overall risk rating for degradation (Insert highest adjective rating from Columns 2–6) |
| 1. | VH 5 | VL 1 | VL 1 | L 2 | VL 1 | VH 5 |
| 2. | VH 5 | ↓ | ↓ | ↓ | ↓ | \| |
| 3. | VH 5 | ↓ | ↓ | ↓ | ↓ | \| |
| 4. | H 4 | ↓ | ↓ | ↓ | ↓ | H 4 |
| 5. | H 4 | ↓ | ↓ | ↓ | ↓ | H 4 |
| 6. | | | | | | |
| 7. | | | | | | |
| 8. | | | | | | |
| 9. | | | | | | |
| 10. | | | | | | |
| 11. | | | | | | |
| 12. | | | | | | |
| 13. | | | | | | |
| 14. | | | | | | |
| 15. | | | | | | |

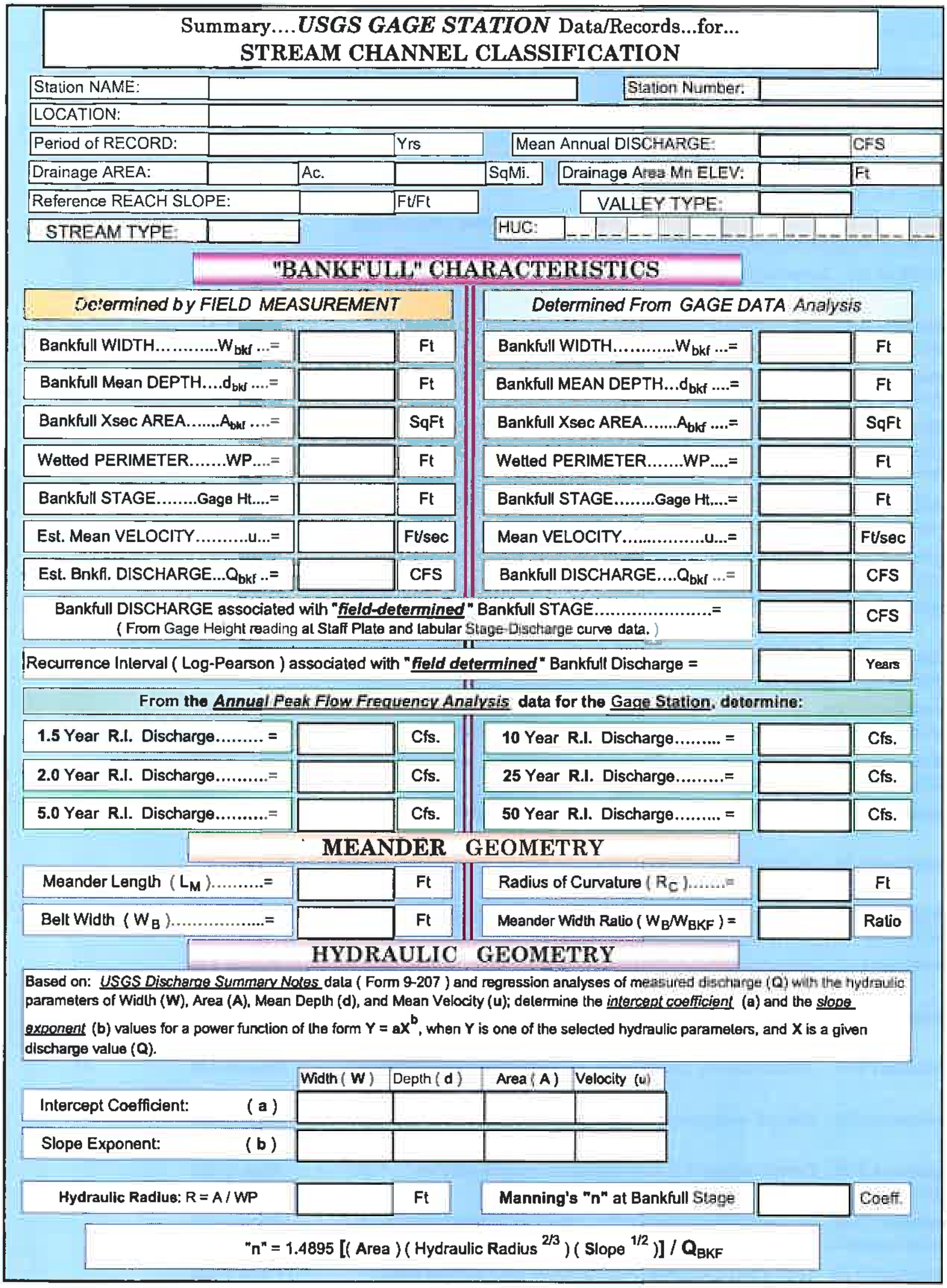
1/2 Ogden } bridges
1 Delaware

lower TBR bridge
goper culvert
Fletcher culvert

**Worksheet 4-13.** Risk rating worksheet for potential contraction scour/degradation/channel incision due to culverts or bridges.

| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) |
|---|---|---|---|---|---|---|---|---|---|
| **Location code/ river reach I.D.** | **Percent reduction of** sinuousity (insert numeric rating)<br>(1) = No change<br>(2) = Sinuosity reduced up to 50%<br>(3) = Sinuosity reduced 50–80%<br>(4) = Sinuosity reduced more than 80% | Stream crossing structure (insert numeric rating)<br>(1) = Bridge<br>(2) = Arch culvert<br>(3) = Culvert<br>(4) = Over-steepened culvert | Subtotal Σ[(2)+(3)] | Increase in energy slope (use (4) points and insert numeric rating)<br>VL (1) = 2<br>L (2) = 3<br>M (3) = 4<br>H (4) = 5–6<br>VH (5) = 7–8 | Ratio of a decrease in w/d ratio to existing reference w/d ratio (Figure 4-29) (insert numeric rating)<br>VL (1) > 8.0<br>L (2) = 0.61–0.80<br>M (3) = 0.41–0.60<br>H (4) = 0.21–0.40<br>VH (5) ≤ 0.20 | Backwater potential above structure (insert numeric rating)<br>VL (1) = None<br>L (2) = Slight only for floods > 50 yr recurrence interval<br>M (3) = Some for floods 11–50 yr recurrence interval<br>H (4) = Evident for floods 2–10 yr recurrence interval<br>VH (5) = Backwater at bankfull discharge | Presence of floodplain drains (through fills) (insert numeric rating)<br>VL (1) = All floods greater than bankfull drain through fill<br>L (2) = Accomodates 90% of floods<br>M (3) = Accomodates 50–89% of floods<br>H (4) = Evident for floods 2–10 yr recurrence interval<br>VH (5) = Backwater at bankfull discharge | Subtotal Σ[(5)+(6)+(7)+(8)] | **Overall risk** rating, culverts or bridges<br>VL (1) = 4<br>L (2) = 5–8<br>M (3) = 9–12<br>H (4) = 13–16<br>VH (5) = 17–20 |
| 1. | 1 | 1 | 2 | VL 1 | L 2 | L 2 | L 2 | 7 | L 2 |
| 2. | 1 | 1 | 2 | | | | | | |
| 3. | 1 | 0 | 1 | | | | | | |
| 4. | 1 | 0 | 1 | | | | | | |
| 5. | 1 | 1 | 2 | | | | | | |
| 6. | | | | | | | | | |
| 7. | | | | | | | | | |
| 8. | | | | | | | | | |
| 9. | | | | | | | | | |
| 10. | | | | | | | | | |
| 11. | | | | | | | | | |
| 12. | | | | | | | | | |
| 13. | | | | | | | | | |
| 14. | | | | | | | | | |
| 15. | | | | | | | | | |

**Worksheet 5-1.** Sample form for recording gage station and field data from *The Reference Reach Field Book* (Rosgen and Silvey, 2005).



Summary....*USGS GAGE STATION* Data/Records...for...
**STREAM CHANNEL CLASSIFICATION**

| | | | |
|---|---|---|---|
| Station NAME: | | Station Number: | |
| LOCATION: | | | |
| Period of RECORD: | Yrs | Mean Annual DISCHARGE: | CFS |
| Drainage AREA: | Ac. / SqMi. | Drainage Area Mn ELEV: | Ft |
| Reference REACH SLOPE: | Ft/Ft | VALLEY TYPE: | |
| STREAM TYPE: | | HUC: | |

**"BANKFULL" CHARACTERISTICS**

| *Determined by FIELD MEASUREMENT* | | | *Determined From GAGE DATA Analysis* | | |
|---|---|---|---|---|---|
| Bankfull WIDTH...........$W_{bkf}$ ...= | | Ft | Bankfull WIDTH...........$W_{bkf}$ ...= | | Ft |
| Bankfull Mean DEPTH....$d_{bkf}$ ....= | | Ft | Bankfull MEAN DEPTH...$d_{bkf}$ ....= | | Ft |
| Bankfull Xsec AREA.......$A_{bkf}$ ....= | | SqFt | Bankfull Xsec AREA.......$A_{bkf}$ ....= | | SqFt |
| Wetted PERIMETER.......WP....= | | Ft | Wetted PERIMETER.......WP....= | | Ft |
| Bankfull STAGE........Gage Ht....= | | Ft | Bankfull STAGE........Gage Ht....= | | Ft |
| Est. Mean VELOCITY..........u...= | | Ft/sec | Mean VELOCITY................u...= | | Ft/sec |
| Est. Bnkfl. DISCHARGE...$Q_{bkf}$ ..= | | CFS | Bankfull DISCHARGE....$Q_{bkf}$ ...= | | CFS |

Bankfull DISCHARGE associated with "***field-determined***" Bankfull STAGE.....................= CFS
( From Gage Height reading at Staff Plate and tabular Stage-Discharge curve data. )

Recurrence Interval ( Log-Pearson ) associated with "***field determined***" Bankfull Discharge = Years

From the ***Annual Peak Flow Frequency Analysis*** data for the Gage Station, determine:

| | | | | | |
|---|---|---|---|---|---|
| 1.5 Year R.I. Discharge......... = | | Cfs. | 10 Year R.I. Discharge......... = | | Cfs. |
| 2.0 Year R.I. Discharge..........= | | Cfs. | 25 Year R.I. Discharge.........= | | Cfs. |
| 5.0 Year R.I. Discharge..........= | | Cfs. | 50 Year R.I. Discharge......... = | | Cfs. |

**MEANDER GEOMETRY**

| | | | | | |
|---|---|---|---|---|---|
| Meander Length ( $L_M$ )..........= | | Ft | Radius of Curvature ( $R_C$ ).......= | | Ft |
| Belt Width ( $W_B$ )..................= | | Ft | Meander Width Ratio ( $W_B/W_{BKF}$ ) = | | Ratio |

**HYDRAULIC GEOMETRY**

Based on: *USGS Discharge Summary Notes* data ( Form 9-207 ) and regression analyses of measured discharge (Q) with the hydraulic parameters of Width (W), Area (A), Mean Depth (d), and Mean Velocity (u); determine the *intercept coefficient* (a) and the *slope exponent* (b) values for a power function of the form $Y = aX^b$, when Y is one of the selected hydraulic parameters, and X is a given discharge value (Q).

| | Width ( W ) | Depth ( d ) | Area ( A ) | Velocity (u) |
|---|---|---|---|---|
| Intercept Coefficient: ( a ) | | | | |
| Slope Exponent: ( b ) | | | | |

| | | | | | |
|---|---|---|---|---|---|
| **Hydraulic Radius:** R = A / WP | | Ft | **Manning's "n" at Bankfull Stage** | | Coeff. |

$$"n" = 1.4895\ [(\text{Area})(\text{Hydraulic Radius}^{2/3})(\text{Slope}^{1/2})]\ /\ Q_{BKF}$$

**Worksheet 5-2.** Computations of velocity and bankfull discharge using various methods (Rosgen and Silvey, 2005).

## Bankfull VELOCITY / DISCHARGE Estimates

| | | | | | |
|---|---|---|---|---|---|
| Site | | | | Location | |
| Date | | Stream Type | | Valley Type | |
| Observers | | | | HUC | __ __ __ __ __ __ __ __ __ __ __ __ |

| INPUT VARIABLES | | | OUTPUT VARIABLES | | |
|---|---|---|---|---|---|
| Bankfull Cross-section AREA | | $A_{bkf}$ (SqFt) | Bankfull Mean DEPTH | | $D_{bkf}$ (Ft) |
| Bankfull WIDTH | | $W_{bkf}$ (Ft) | Wetted PERIMETER<br>$\sim 2 * d_{bkf} + W_{bkf}$ | | $W_{Pbkf}$ (Ft) |
| D84 @ Riffle | | Dia. (mm) | D84 mm / 304.8 = | | D84 (Ft) |
| Bankfull SLOPE | | S (Ft / Ft) | Hydraulic RADIUS<br>$A_{bkf} / W_{Pbkf}$ | | R (Ft) |
| Gravitational Acceleration | | g (Ft /Sec²) | Relative Roughness<br>R (ft) / D84 (ft) | | |
| Drainage AREA | | DA (SqMi) | Shear Velocity<br>$u* = \sqrt{gRS}$ | | u* (Ft / Sec) |

| ESTIMATION METHODS | Bankfull VELOCITY | | Bankfull DISCHARGE | |
|---|---|---|---|---|
| 1. Friction Factor / Relative Roughness  u = [ 2.83 + 5.66Log{ R / D84 } ]u* | | Ft / Sec | | CFS |
| 2. Roughness Coefficient: a) Manning's 'n' from friction factor / relative roughness. (Figs. 5-6, 5-7) $u = 1.4895*R^{2/3}*S^{1/2}/n$  n = | | Ft / Sec | | CFS |
| 2. Roughness Coefficient: $u = 1.4895*R^{2/3}*S^{1/2}/n$<br>b) Manning's 'n' from Jarrett ( USGS ): $n = 0.39S^{.38}R^{-.16}$  n =<br>Note: This equation is for applications involving steep, step-pool, high boundary roughness, cobble-boulder-dominated stream systems; i.e., for stream types A1, A2, A3, B1, B2, B3, C2 and E3. | | Ft / Sec | | CFS |
| 2. Roughness Coefficient: $u = 1.4895*R^{2/3}*S^{1/2}/n$<br>c) Manning's 'n' from Stream Type  n = | | Ft / Sec | | CFS |
| 3. Other Methods, ie. Hydraulic Geometry (Hey, Darcy-Weisbach, Chezy C, etc.) | | Ft / Sec | | CFS |
| 3. Other Methods, ie. Hydraulic Geometry (Hey, Darcy-Weisbach, Chezy C, etc.) | | Ft / Sec | | CFS |
| 4. Continuity Equations: a) USGS Gage: u = Q / A<br>Return Period for Bankfull Discharge (Yr.) Q = | | Ft / Sec | | CFS |
| 4. Continuity Equations: b) Regional Curves u = Q / A | | Ft / Sec | | CFS |

Options for using the D84 term in the **relative roughness relation (R/D84)**, when using estimation method 1.

Option 1. **For sand-bed** channels: **measure the "protrusion height" ($h_{sd}$) of sand dunes** above channel bed elevations. Substitute an average **sand dune** protrusion height ($h_{sd}$ **in feet) for the D84 term in estimation method 1.**

Option 2. For **boulder-dominated** channels: measure several **"protrusion heights"** ($h_{bo}$) of boulders above channel bed elevations. **Substitute** an average **boulder protrusion** height ($h_{bo}$ **in feet) for the D84 term in** estimation method 1.

Option 3. For **bedrock-dominated** channels: measure several **"protrusion heights"** ($h_{br}$) of rock separations/steps/joints/ uplifted surfaces above **channel bed elevations. Substitute an average bedrock protrusion** height ($h_{br}$ in feet) for the D84 term in estimation method 1.

**Worksheet 5-4.** Morphological relations, including dimensionless ratios of river reach sites (Rosgen and Silvey, 2005).

Stream: Location:

Observers: Date: Valley Type: Stream Type:

**River Reach Summary Data**

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Channel Dimension | Mean Riffle Depth ($d_{bkf}$) | | ft | Riffle Width ($W_{bkf}$) | | ft | Riffle Area ($A_{bkf}$) | | ft$^2$ |
| | Mean Pool Depth ($d_{bkfp}$) | | ft | Pool Width ($W_{bkfp}$) | | ft | Pool Area ($A_{bkfp}$) | | ft$^2$ |
| | Mean Pool Depth/Mean Riffle Depth | | $d_{bkfp}/d_{bkf}$ | Pool Width/Riffle Width | | $W_{bkfp}/W_{bkf}$ | Pool Area / Riffle Area | | $A_{bkfp}/A_{bkf}$ |
| | Max Riffle Depth ($d_{mbkf}$) | | ft | Max Pool Depth ($d_{mbkfp}$) | | ft | Max Riffle Depth/Mean Riffle Depth | | |
| | Max Pool Depth/Mean Riffle Depth | | | | | | Point Bar Slope | | |
| | Streamflow: Estimated Mean Velocity at Bankfull Stage ($u_{bkf}$) | | ft/s | | | | Estimation Method | | |
| | Streamflow: Estimated Discharge at Bankfull Stage ($Q_{bkf}$) | | cfs | | | | Drainage Area | | mi$^2$ |

| | Geometry | Mean | Min | Max | | Dimensionless Geometry Ratios | Mean | Min | Max |
|---|---|---|---|---|---|---|---|---|---|
| Channel Pattern | Meander Length (Lm) | | | | ft | Meander Length Ratio ($Lm/W_{bkf}$) | | | |
| | Radius of Curvature (Rc) | | | | ft | Radius of Curvature/Riffle Width ($Rc/W_{bkf}$) | | | |
| | Belt Width ($W_{blt}$) | | | | ft | Meander Width Ratio ($W_{blt}/W_{bkf}$) | | | |
| | Individual Pool Length | | | | ft | Pool Length/Riffle Width | | | |
| | Pool to Pool Spacing | | | | ft | Pool to Pool Spacing/Riffle Width | | | |
| | Riffle Length | | | | ft | Riffle Length/Riffle Width | | | |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Channel Profile | Valley Slope (VS) | | ft/ft | Average Water Surface Slope (S) | | ft/ft | Sinuosity (VS/S) | | |
| | Stream Length (SL) | | ft | Valley Length (VL) | | ft | Sinuosity (SL/VL) | | |
| | Low Bank Height (LBH) start | | ft | Max Riffle Depth start | | ft | Bank-Height Ratio (BHR) (LBH/Max Riffle Depth) start | | |
| | end | | ft | end | | ft | end | | |

| | Facet Slopes | Mean | Min | Max | | Dimensionless Slope Ratios | Mean | Min | Max |
|---|---|---|---|---|---|---|---|---|---|
| Channel Profile | Riffle Slope ($S_{rif}$) | | | | ft/ft | Riffle Slope/Average Water Surface Slope ($S_{rif}$ / S) | | | |
| | Run Slope ($S_{run}$) | | | | ft/ft | Run Slope/Average Water Surface Slope ($S_{run}$ / S) | | | |
| | Pool Slope ($S_p$) | | | | ft/ft | Pool Slope/Average Water Surface Slope ($S_p$ / S) | | | |
| | Glide Slope ($S_g$) | | | | ft/ft | Glide Slope/Average Water Surface Slope ($S_g$ / S) | | | |

| | Feature Midpoint [a] | Mean | Min | Max | | Dimensionless Depth Ratios | Mean | Min | Max |
|---|---|---|---|---|---|---|---|---|---|
| Channel Profile | Riffle Depth ($d_{rif}$) | | | | ft | Riffle Depth/Mean Riffle Depth ($d_{rif}$ / $d_{bkf}$) | | | |
| | Run Depth ($d_{run}$) | | | | ft | Run Depth/Mean Riffle Depth ($d_{run}$ / $d_{bkf}$) | | | |
| | Pool Depth ($d_p$) | | | | ft | Pool Depth/Mean Riffle Depth ($d_p$ / $d_{bkf}$) | | | |
| | Glide Depth ($d_g$) | | | | ft | Glide Depth/Mean Riffle Depth ($d_g$ / $d_{bkf}$) | | | |

| | | Reach [b] | Riffle [c] | Bar | | Reach [b] | Riffle [c] | Bar | Protrusion Height [d] | |
|---|---|---|---|---|---|---|---|---|---|---|
| Channel Materials | % Silt/Clay | | | | $D_{16}$ | | | | | mm |
| | % Sand | | | | $D_{35}$ | | | | | mm |
| | % Gravel | | | | $D_{50}$ | | | | | mm |
| | % Cobble | | | | $D_{84}$ | | | | | mm |
| | % Boulder | | | | $D_{95}$ | | | | | mm |
| | % Bedrock | | | | $D_{100}$ | | | | | mm |

a Min, max, mean depths are the average mid-point values except pools, which are taken at deepest part of pool.

b Composite sample of riffles and pools within the designated reach.

c Active bed of a riffle.

d Height of roughness feature above bed.

What to use as ref. ratio?
60 + 50

**Worksheet 5-5.** Summary of stream stability ratings for multiple reaches.

Stream: Location: Observers: Date:

| (1) | (2) | (3) | | (4) | (5) | (6) | (7) | (8) | (9) | | (10) | (11) | | (12) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Reach location | Stream type (Worksheet 5-3) | a. Riparian vegetation (Worksheet 5-6) | | b. Flow regime (Fig. 5-9) | c. Stream order/size (Table 5-3) | d. Meander patterns (Fig. 5-10) | e. Depositional patterns (Fig. 5-11) | f. Channel blockages (Table 5-4) | g. Width/depth ratio state | | h. Pfankuch channel stability rating (Worksheet 5-7) | i. Degree of channel incision | | j. Degree of channel confinement | |
| | | Existing species composition | Potential species composition | | | | | | W/d ratio (Worksheet 5-3) | W/d stability rating (Fig. 5-13) | | Bank-Height Ratio (BHR) (Worksheet 5-4) | Stability rating (Fig. 5-15) | MWR divided by $MWR_{ref}$ | Degree of confinement (Fig. 5-17) |
| 1. 1 | F3 | grass/ Conifers | Same | P 2 | S-6(2) | M1 | B 2 | D 2 | 11 | U | Good | >2 | DI | | SC |
| 2. 2 | G3/4 | | | P 2 | S-7(2) | M1 | B 2 | D 2 | 11 | U | GOOD | | | | SC |
| 3. 3 | G3/4 | | | P 2 | S-9(2) | M1 | B 2 | D 2 | 25 | MU | GOOD | | | | MC |
| 4. 4 | G3/4 | | | P 2 | S-7(2) | M1 | B 2 | D 2 | 16 | MU/S | GOOD | | | | C |
| 5. 5 | C3 | ↓ | ↓ | P 2 | S-7(2) | M1 | B2 | D 10 | 17 | S | Good | ↓ | ↓ | | MC |
| 6. | | | | | | | | | | | | | | | |
| 7. | | | | | | | | | | | | | | | |
| 8. | | | | | | | | | | | | | | | |
| 9. | | | | | | | | | | | | | | | |
| 10. | | | | | | | | | | | | | | | |
| 11. | | | | | | | | | | | | | | | |
| 12. | | | | | | | | | | | | | | | |
| 13. | | | | | | | | | | | | | | | |
| 14. | | | | | | | | | | | | | | | |
| 15. | | | | | | | | | | | | | | | |

**Worksheet 5-6.** Riparian vegetation composition/density used for channel stability assessment.

Stream: Third Brook

Location: All reaches

Observers:

Reference reach ☐

Disturbed (impacted reach) ☐

Date:

Existing species composition: Grass/ Conifers

Potential species composition: Grass/Conifers

| Riparian cover categories | | Percent aerial cover* | Percent of site coverage** | Species composition | Percent of total species composition |
|---|---|---|---|---|---|
| 1. Overstory | Canopy layer | | | | |
| | | | | | 100% |
| 2. Understory | Shrub layer | ▨ | | | |
| | | | | | 100% |
| 3. Ground level | Herbaceous | ▨ | | | |
| | | | | | 100% |
| | Leaf or needle litter | ▨ | | | |
| | Bare ground | ▨ | | | |
| | | | Column total = 100% | | |

**Remarks:**
Condition, vigor and/or usage of existing reach:

*Based on crown closure.
**Based on basal area to surface area.

**Worksheet 5-7.** Pfankuch (1975) stream channel stability rating procedure, as modified by Rosgen (1996, 2001b).

Stream: Location: Segment 1 F3 Valley Type: Observers: Date:

| Location | Key | Category | Excellent | | Good | | Fair | | Poor | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Description | Rating | Description | Rating | Description | Rating | Description | Rating |
| Upper banks | 1 | Landform slope | Bank slope gradient <30%. | 2 | Bank slope gradient 30–40%. | 4 | Bank slope gradient 40–60%. | [✓ 6] | Bank slope gradient > 60%. | 8 |
| | 2 | Mass erosion | No evidence of past or future mass erosion. | 3 | Infrequent. Mostly healed over. Low future potential. | [✓ 6] | Frequent or large, causing sediment nearly yearlong. | 9 | Frequent or large, causing sediment nearly yearlong OR imminent danger of same. | 12 |
| | 3 | Debris jam potential | Essentially absent from immediate channel area. | [✓ 2] | Present, but mostly small twigs and limbs. | 4 | Moderate to heavy amounts, mostly larger sizes. | 6 | Moderate to heavy amounts, predominantly larger sizes. | 8 |
| | 4 | Vegetative bank protection | > 90% plant density. Vigor and variety suggest a deep, dense soil-binding root mass. | 3 | 70–90% density. Fewer species or less vigor suggest less dense or deep root mass. | 6 | 50–70% density. Lower vigor and fewer species from a shallow, discontinuous root mass. | [✓ 9] | <50% density plus fewer species & less vigor indicating poor, discontinuous and shallow root mass. | 12 |
| Lower banks | 5 | Channel capacity | Bank heights sufficient to contain the bankfull stage. Width/depth ratio departure from reference width/depth ratio = 1.0. Bank-Height Ratio (BHR) = 1.0. | 1 | Bankfull stage is contained within banks. Width/depth ratio departure from reference width/depth ratio = 1.0–1.2. Bank-Height Ratio (BHR) = 1.0–1.1. | [✓ 2] | Bankfull stage is not contained. Width/depth ratio departure from reference width/depth ratio = 1.2–1.4. Bank-Height Ratio (BHR) = 1.1–1.3. | 3 | Bankfull stage is not contained, over-bank flows are common with flows less than bankfull. Width/depth ratio departure from reference width/depth ratio > 1.4. Bank-Height Ratio (BHR) > 1.3. | 4 |
| | 6 | Bank rock content | > 65% with large angular boulders. 12"+ common. stone wall | [✓ 2] | 40–65%. Mostly boulders and small cobbles 6–12". | 4 | 20–40%. Most in the 3–6" diameter class. | 6 | <20% rock fragments of gravel sizes, 1–3" or less. | 8 |
| | 7 | Obstructions to flow | Rocks and logs firmly imbedded. Flow pattern w/o cutting or deposition. Stable bed. | [✓ 2] | Some present causing erosive cross currents and minor pool filling. Obstructions fewer and less firm. | 4 | Moderately frequent, unstable obstructions move with high flows causing bank cutting and pool filling. | 6 | Frequent obstructions and deflectors cause bank erosion yearlong. Sediment traps full, channel migration occurring. | 8 |
| | 8 | Cutting | Little or none. Infrequent raw banks <6". | 4 | Some, intermittently at outcurves and constrictions. Raw banks may be up to 12". | [✓ 6] | Significant. Cuts 12–24" high. Root mat overhangs and sloughing evident. | 12 | Almost continuous cuts, some over 24" high. Failure of overhangs frequent. | 16 |
| | 9 | Deposition | Little or no enlargement of channel or point bars. | 4 | Some new bar increase, mostly from coarse gravel. | [✓ 8] | Moderate deposition of new gravel and coarse sand on old and some new bars. | 12 | Extensive deposit of predominantly fine particles. Accelerated bar development. | 16 |
| Bottom | 10 | Rock angularity | Sharp edges and corners. Plane surfaces rough. | 1 | Rounded corners and edges. Surfaces smooth and flat. | [✓ 2] | Corners and edges well rounded in 2 dimensions. | 3 | Well rounded in all dimensions, surfaces smooth. | 4 |
| | 11 | Brightness | Surfaces dull, dark or stained. Generally not bright. | 1 | Mostly dull, but may have <35% bright surfaces. | 2 | Mixture dull and bright, i.e., 35–65% mixture range. | [✓ 3] | Predominantly bright > 65%, exposed or scoured surfaces. | 4 |
| | 12 | Consolidation of particles | Assorted sizes tightly packed or overlapping. | 2 | Moderately packed with some overlapping. | 4 | Mostly loose assortment with no apparent overlap. | [✓ 6] | No packing evident. Loose assortment, easily moved. | 8 |
| | 13 | Bottom size distribution | No size change evident. Stable material 80–100%. | 4 | Distribution shift light. Stable material 50–80%. | 8 | Moderate change in sizes. Stable materials 20–50%. | [✓ 12] | Marked distribution change. Stable materials 0–20%. | 16 |
| | 14 | Scouring and deposition | <5% of bottom affected by scour or deposition. | 6 | 5–30% affected. Scour at constrictions and where grades steepen. Some deposition in pools. | [✓ 12] | 30–50% affected. Deposits and scour at obstructions, constrictions and bends. Some filling of pools. | 18 | More than 50% of the bottom in a state of flux or change nearly yearlong. | 24 |
| | 15 | Aquatic vegetation | Abundant growth moss-like, dark green perennial. In swift water, too. | 1 | Common. Algae forms in low velocity and pool areas. Moss here, too. | 2 | Present but spotty, mostly in backwater. Seasonal algae growth makes rocks slick. | [✓ 3] | Perennial types scarce or absent. Yellow-green, short-term bloom may be present. | 4 |

Excellent total = 6 Good total = 36 Fair total = 39 Poor total = 0

| Stream type | A1 | A2 | A3 | A4 | A5 | A6 | B1 | B2 | B3 | B4 | B5 | B6 | C1 | C2 | C3 | C4 | C5 | C6 | D3 | D4 | D5 | D6 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Good (Stable) | 38-43 | 38-43 | 54-90 | 60-95 | 60-95 | 50-80 | 38-45 | 38-45 | 40-60 | 40-64 | 48-68 | 40-60 | 38-50 | 38-50 | 60-85 | 70-90 | 70-90 | 60-85 | 85-107 | 85-107 | 85-107 | 67-98 |
| Fair (Mod. unstable) | 44-47 | 44-47 | 91-129 | 96-132 | 96-142 | 81-110 | 46-58 | 46-58 | 61-78 | 65-84 | 69-88 | 61-78 | 51-61 | 51-61 | 86-105 | 91-110 | 91-110 | 86-105 | 108-132 | 108-132 | 108-132 | 99-125 |
| Poor (Unstable) | 48+ | 48+ | 130+ | 133+ | 143+ | 111+ | 59+ | 59+ | 79+ | 85+ | 89+ | 79+ | 62+ | 62+ | 106+ | 111+ | 111+ | 106+ | 133+ | 133+ | 133+ | 126+ |

| Stream type | DA3 | DA4 | DA5 | DA6 | E3 | E4 | E5 | E6 | F1 | F2 | F3 | F4 | F5 | F6 | G1 | G2 | G3 | G4 | G5 | G6 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Good (Stable) | 40-63 | 40-63 | 40-63 | 40-63 | 40-63 | 50-75 | 50-75 | 40-63 | 60-85 | 60-85 | 85-110 | 85-110 | 90-115 | 80-95 | 40-60 | 40-60 | 85-107 | 85-107 | 90-112 | 85-107 |
| Fair (Mod. unstable) | 64-86 | 64-86 | 64-86 | 64-86 | 64-86 | 76-96 | 76-96 | 64-86 | 86-105 | 86-105 | 111-125 | 111-125 | 116-130 | 96-110 | 61-78 | 61-78 | 108-120 | 108-120 | 113-125 | 108-120 |
| Poor (Unstable) | 87+ | 87+ | 87+ | 87+ | 87+ | 97+ | 97+ | 87+ | 106+ | 106+ | 126+ | 126+ | 131+ | 111+ | 79+ | 79+ | 121+ | 121+ | 126+ | 121+ |

*Rating should be adjusted to potential stream type, not existing.

Grand total = 81
Existing stream type = F3
*Potential stream type = F3
Modified channel stability rating = Good

**Worksheet 5-7.** Pfankuch (1975) stream channel stability rating procedure, as modified by Rosgen (1996, 2001b).

Stream:
Location: Segment 2
Valley Type:
Observers:
Date:

| Location | Key | Category | Excellent | | Good | | Fair | | Poor | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Description | Rating | Description | Rating | Description | Rating | Description | Rating |
| Upper banks | 1 | Landform slope | Bank slope gradient <30%. | 2 | Bank slope gradient 30–40%. | 4 | Bank slope gradient 40–60%. | 6 | Bank slope gradient > 60%. | [✓ 8] |
| | 2 | Mass erosion | No evidence of past or future mass erosion. | 3 | Infrequent. Mostly healed over. Low future potential. | 6 | Frequent or large, causing sediment nearly yearlong. | [✓ 9] | Frequent or large, causing sediment nearly yearlong OR imminent danger of same. | 12 |
| | 3 | Debris jam potential | Essentially absent from immediate channel area. | 2 | Present, but mostly small twigs and limbs. | [✓ 4] | Moderate to heavy amounts, mostly larger sizes. | 6 | Moderate to heavy amounts, predominantly larger sizes. | 8 |
| | 4 | Vegetative bank protection | > 90% plant density. Vigor and variety suggest a deep, dense soil-binding root mass. | 3 | 70–90% density. Fewer species or less vigor suggest less dense or deep root mass. | [✓ 6] | 50–70% density. Lower vigor and fewer species from a shallow, discontinuous root mass. | 9 | <50% density plus fewer species & less vigor indicating poor, discontinuous and shallow root mass. | 12 |
| Lower banks | 5 | Channel capacity | Bank heights sufficient to contain the bankfull stage. Width/depth ratio departure from reference width/depth ratio = 1.0. Bank-Height Ratio (BHR) = 1.0. | 1 | Bankfull stage is contained within banks. Width/depth ratio departure from reference width/depth ratio = 1.0–1.2. Bank-Height Ratio (BHR) = 1.0–1.1. | [✓ 2] | Bankfull stage is not contained. Width/depth ratio departure from reference width/depth ratio = 1.2–1.4. Bank-Height Ratio (BHR) = 1.1–1.3. | 3 | Bankfull stage is not contained; over-bank flows are common with flows less than bankfull. Width/depth ratio departure from reference width/depth ratio > 1.4. Bank-Height Ratio (BHR) > 1.3. | 4 |
| | 6 | Bank rock content | > 65% with large angular boulders. 12"+ common. | 2 | 40–65%. Mostly boulders and small cobbles 6–12". | [✓ 4] | 20–40%. Most in the 3–6" diameter class. | 6 | <20% rock fragments of gravel sizes, 1–3" or less. | 8 |
| | 7 | Obstructions to flow | Rocks and logs firmly imbedded. Flow pattern w/o cutting or deposition. Stable bed. | [✓ 2] | Some present causing erosive cross currents and minor pool filling. Obstructions fewer and less firm. | 4 | Moderately frequent, unstable obstructions move with high flows causing bank cutting and pool filling. | 6 | Frequent obstructions and deflectors cause bank erosion yearlong. Sediment traps full, channel migration occurring. | 8 |
| | 8 | Cutting | Little or none. Infrequent raw banks <6". | 4 | Some, intermittently at outcurves and constrictions. Raw banks may be up to 12". | 6 | Significant. Cuts 12–24" high. Root mat overhangs and sloughing evident. | [✓ 12] | Almost continuous cuts, some over 24" high. Failure of overhangs frequent. | 16 |
| | 9 | Deposition | Little or no enlargement of channel or point bars. | 4 | Some new bar increase, mostly from coarse gravel. | [✓ 8] | Moderate deposition of new gravel and coarse sand on old and some new bars. | 12 | Extensive deposit of predominantly fine particles. Accelerated bar development. | 16 |
| Bottom | 10 | Rock angularity | Sharp edges and corners. Plane surfaces rough. | 1 | Rounded corners and edges. Surfaces smooth and flat. | [✓ 2] | Corners and edges well rounded in 2 dimensions. | 3 | Well rounded in all dimensions, surfaces smooth. | 4 |
| | 11 | Brightness | Surfaces dull, dark or stained. Generally not bright. | 1 | Mostly dull, but may have <35% bright surfaces. | 2 | Mixture dull and bright, i.e., 35–65% mixture range. | [✓ 3] | Predominantly bright, > 65%, exposed or scoured surfaces. | 4 |
| | 12 | Consolidation of particles | Assorted sizes tightly packed or overlapping. | 2 | Moderately packed with some overlapping. | 4 | Mostly loose assortment with no apparent overlap. | [✓ 6] | No packing evident. Loose assortment, easily moved. | 8 |
| | 13 | Bottom size distribution | No size change evident. Stable material 80–100%. | 4 | Distribution shift light. Stable material 50–80%. | 8 | Moderate change in sizes. Stable materials 20–50%. | [✓ 12] | Marked distribution change. Stable materials 0–20%. | 16 |
| | 14 | Scouring and deposition | <5% of bottom affected by scour or deposition. | 6 | 5–30% affected. Scour at constrictions and where grades steepen. Some deposition in pools. | [✓ 12] | 30–50% affected. Deposits and scour at obstructions, constrictions and bends. Some filling of pools. | 18 | More than 50% of the bottom in a state of flux or change nearly yearlong. | 24 |
| | 15 | Aquatic vegetation | Abundant growth moss-like, dark green perennial. In swift water, too. | 1 | Common. Algae forms in low velocity and pool areas. Moss here, too. | 2 | Present but spotty, mostly in backwater. Seasonal algae growth makes rocks slick. | [✓ 3] | Perennial types scarce or absent. Yellow-green, short-term bloom may be present. | 4 |
| | | | Excellent total = | 2 | Good total = | 38 | Fair total = | 45 | Poor total = | 8 |

| Stream type | A1 | A2 | A3 | A4 | A5 | A6 | B1 | B2 | B3 | B4 | B5 | B6 | C1 | C2 | C3 | C4 | C5 | C6 | D3 | D4 | D5 | D6 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Good (Stable) | 38-43 | 38-43 | 54-90 | 60-95 | 60-95 | 50-80 | 38-45 | 38-45 | 40-60 | 40-64 | 48-68 | 40-60 | 38-50 | 38-50 | 60-85 | 70-90 | 70-90 | 60-85 | 85-107 | 85-107 | 85-107 | 67-98 |
| Fair (Mod. unstable) | 44-47 | 44-47 | 91-129 | 96-132 | 96-142 | 81-110 | 46-58 | 46-58 | 61-78 | 65-84 | 69-88 | 61-78 | 51-61 | 51-61 | 86-105 | 91-110 | 91-110 | 86-105 | 108-132 | 108-132 | 108-132 | 99-125 |
| Poor (Unstable) | 48+ | 48+ | 130+ | 133+ | 143+ | 111+ | 59+ | 59+ | 79+ | 85+ | 89+ | 79+ | 62+ | 62+ | 106+ | 111+ | 111+ | 106+ | 133+ | 133+ | 133+ | 126+ |

| Stream type | DA3 | DA4 | DA5 | DA6 | E3 | E4 | E5 | E6 | F1 | F2 | F3 | F4 | F5 | F6 | G1 | G2 | G3 | G4 | G5 | G6 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Good (Stable) | 40-63 | 40-63 | 40-63 | 40-63 | 40-63 | 50-75 | 50-75 | 40-63 | 60-85 | 60-85 | 85-110 | 85-110 | 90-115 | 80-95 | 40-60 | 40-60 | 85-107 | 85-107 | 90-112 | 85-107 |
| Fair (Mod. unstable) | 64-86 | 64-86 | 64-86 | 64-86 | 64-86 | 76-96 | 76-96 | 64-86 | 86-105 | 86-105 | 111-125 | 111-125 | 116-130 | 96-110 | 61-78 | 61-78 | 108-120 | 108-120 | 113-125 | 108-120 |
| Poor (Unstable) | 87+ | 87+ | 87+ | 87+ | 87+ | 97+ | 97+ | 87+ | 106+ | 106+ | 126+ | 126+ | 131+ | 111+ | 79+ | 79+ | 121+ | 121+ | 126+ | 121+ |

Grand total = 93
Existing stream type = G3/4
*Potential stream type = G3/4
Modified channel stability rating = Good

*Rating should be adjusted to potential stream type, not existing.

**Worksheet 5-7.** Pfankuch (1975) stream channel stability rating procedure, as modified by Rosgen (1996, 2001b).

**Stream:** **Location:** Segment 3 G3/4 **Valley Type:** **Observers:** **Date:**

| Location | Key | Category | Excellent |  | Good |  | Fair |  | Poor |  |
|---|---|---|---|---|---|---|---|---|---|---|
|  |  |  | Description | Rating | Description | Rating | Description | Rating | Description | Rating |
| Upper banks | 1 | Landform slope | Bank slope gradient <30%. | 2 | Bank slope gradient 30–40%. | [✓ 4] | Bank slope gradient 40–60%. | 6 | Bank slope gradient > 60%. | 8 |
|  | 2 | Mass erosion | No evidence of past or future mass erosion. | 3 | Infrequent. Mostly healed over. Low future potential. | 6 | Frequent or large, causing sediment nearly yearlong. | [✓ 9] | Frequent or large, causing sediment nearly yearlong OR imminent danger of same. | 12 |
|  | 3 | Debris jam potential | Essentially absent from immediate channel area. | 2 | Present, but mostly small twigs and limbs. | [✓ 4] | Moderate to heavy amounts, mostly larger sizes. | 6 | Moderate to heavy amounts, predominantly larger sizes. | 8 |
|  | 4 | Vegetative bank protection | > 90% plant density. Vigor and variety suggest a deep, dense soil-binding root mass. | 3 | 70–90% density. Fewer species or less vigor suggest less dense or deep root mass. | 6 | 50–70% density. Lower vigor and fewer species from a shallow, discontinuous root mass. | [✓ 9] | <50% density plus fewer species & less vigor indicating poor, discontinuous and shallow root mass. | 12 |
| Lower banks | 5 | Channel capacity | Bank heights sufficient to contain the bankfull stage. Width/depth ratio departure from reference width/depth ratio = 1.0. Bank-Height Ratio (BHR) = 1.0. | 1 | Bankfull stage is contained within banks. Width/depth ratio departure from reference width/depth ratio = 1.0–1.2. Bank-Height Ratio (BHR) = 1.0–1.1. | [✓ 2] | Bankfull stage is not contained. Width/depth ratio departure from reference width/depth ratio = 1.2–1.4. Bank-Height Ratio (BHR) = 1.1–1.3. | 3 | Bankfull stage is not contained; over-bank flows are common with flows less than bankfull. Width/depth ratio departure from reference width/depth ratio > 1.4. Bank-Height Ratio (BHR) > 1.3. | 4 |
|  | 6 | Bank rock content | > 65% with large angular boulders. 12"+ common. | 2 | 40–65%. Mostly boulders and small cobbles 6–12". | [✓ 4] | 20–40%. Most in the 3–6" diameter class. | 6 | <20% rock fragments of gravel sizes, 1–3" or less. | 8 |
|  | 7 | Obstructions to flow | Rocks and logs firmly imbedded. Flow pattern w/o cutting or deposition. Stable bed. | [✓ 2] | Some present causing erosive cross currents and minor pool filling. Obstructions fewer and less firm. | 4 | Moderately frequent, unstable obstructions move with high flows causing bank cutting and pool filling. | 6 | Frequent obstructions and deflectors cause bank erosion yearlong. Sediment traps full, channel migration occuring. | 8 |
|  | 8 | Cutting | Little or none. Infrequent raw banks <6". | 4 | Some, intermittently at outcurves and constrictions. Raw banks may be up to 12". | 6 | Significant. Cuts 12–24" high. Root mat overhangs and sloughing evident. | [✓ 12] | Almost continuous cuts, some over 24" high. Failure of overhangs frequent. | 16 |
|  | 9 | Deposition | Little or no enlargement of channel or point bars. | 4 | Some new bar increase, mostly from coarse gravel. | [✓ 8] | Moderate depostion of new gravel and coarse sand on old and some new bars. | 12 | Extensive deposit of predominantly fine particles. Accelerated bar development. | 16 |
| Bottom | 10 | Rock angularity | Sharp edges and corners. Plane surfaces rough. | 1 | Rounded corners and edges. Surfaces smooth and flat. | [✓ 2] | Corners and edges well rounded in 2 dimensions. | 3 | Well rounded in all dimensions, surfaces smooth. | 4 |
|  | 11 | Brightness | Surfaces dull, dark or stained. Generally not bright. | 1 | Mostly dull, but may have <35% bright surfaces. | 2 | Mixture dull and bright, i.e., 35–65% mixture range. | [✓ 3] | Predominantly bright, > 65%, exposed or scoured surfaces. | 4 |
|  | 12 | Consolidation of particles | Assorted sizes tightly packed or overlapping. | 2 | Moderately packed with some overlapping. | 4 | Mostly loose assortment with no apparent overlap. | [✓ 6] | No packing evident. Loose assortment, easily moved. | 8 |
|  | 13 | Bottom size distribution | No size change evident. Stable material 80–100%. | 4 | Distribution shift light. Stable material 50–80%. | 8 | Moderate change in sizes. Stable materials 20–50%. | [✓ 12] | Marked distribution change. Stable materials 0–20%. | 16 |
|  | 14 | Scouring and deposition | <5% of bottom affected by scour or deposition. | 6 | 5–30% affected. Scour at constrictions and where grades steepen. Some deposition in pools. | [✓ 12] | 30–50% affected. Deposits and scour at obstructions, constrictions and bends. Some filling of pools. | 18 | More than 50% of the bottom in a state of flux or change nearly yearlong. | 24 |
|  | 15 | Aquatic vegetation | Abundant growth moss-like, dark green perennial. In swift water, too. | 1 | Common. Algae forms in low velocity and pool areas. Moss here, too. | 2 | Present but spotty, mostly in backwater. Seasonal algae growth makes rocks slick. | [✓ 3] | Perennial types scarce or absent. Yellow-green, short-term bloom may be present. | 4 |
|  |  |  | Excellent total = | 2 | Good total = | 36 | Fair total = | 54 | Poor total = | 0 |

| Stream type | A1 | A2 | A3 | A4 | A5 | A6 | B1 | B2 | B3 | B4 | B5 | B6 | C1 | C2 | C3 | C4 | C5 | C6 | D3 | D4 | D5 | D6 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Good (Stable) | 38-43 | 38-43 | 54-90 | 60-95 | 60-95 | 50-80 | 38-45 | 38-45 | 40-60 | 40-64 | 48-68 | 40-60 | 38-50 | 38-50 | 60-85 | 70-90 | 70-90 | 60-85 | 85-107 | 85-107 | 85-107 | 67-98 |
| Fair (Mod. unstable) | 44-47 | 44-47 | 91-129 | 96-132 | 96-142 | 81-110 | 46-58 | 46-58 | 61-78 | 65-84 | 69-88 | 61-78 | 51-61 | 51-61 | 86-105 | 91-110 | 91-110 | 86-105 | 108-132 | 108-132 | 108-132 | 99-125 |
| Poor (Unstable) | 48+ | 48+ | 130+ | 133+ | 143+ | 111+ | 59+ | 59+ | 79+ | 85+ | 89+ | 79+ | 62+ | 62+ | 106+ | 111+ | 111+ | 106+ | 133+ | 133+ | 133+ | 126+ |

| Stream type | DA3 | DA4 | DA5 | DA6 | E3 | E4 | E5 | E6 | F1 | F2 | F3 | F4 | F5 | F6 | G1 | G2 | G3 | G4 | G5 | G6 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Good (Stable) | 40-63 | 40-63 | 40-63 | 40-63 | 40-63 | 50-75 | 50-75 | 40-63 | 60-85 | 60-85 | 85-110 | 85-110 | 90-115 | 80-95 | 40-60 | 40-60 | 85-107 | 85-107 | 90-112 | 85-107 |
| Fair (Mod. unstable) | 64-86 | 64-86 | 64-86 | 64-86 | 64-86 | 76-96 | 76-96 | 64-86 | 86-105 | 86-105 | 111-125 | 111-125 | 116-130 | 96-110 | 61-78 | 61-78 | 108-120 | 108-120 | 113-125 | 108-120 |
| Poor (Unstable) | 87+ | 87+ | 87+ | 87+ | 87+ | 97+ | 97+ | 87+ | 106+ | 106+ | 126+ | 126+ | 131+ | 111+ | 79+ | 79+ | 121+ | 121+ | 126+ | 121+ |

Grand total = 92

Existing stream type = G3

*Potential stream type = G3

**Modified channel stability rating =** Good

*Rating should be adjusted to potential stream type, not existing.

**Worksheet 5-7.** Pfankuch (1975) stream channel stability rating procedure, as modified by Rosgen (1996, 2001b).

Stream:
Location: Segment 4 G
Valley Type:
Observers:
Date:

| Location | Key | Category | Excellent |  | Good |  | Fair |  | Poor |  |
|---|---|---|---|---|---|---|---|---|---|---|
|  |  |  | Description | Rating | Description | Rating | Description | Rating | Description | Rating |
| Upper banks | 1 | Landform slope | Bank slope gradient <30%. | 2 | Bank slope gradient 30–40%. | 4 | Bank slope gradient 40–60%. | 6 | Bank slope gradient > 60%. | [✓ 8] |
|  | 2 | Mass erosion | No evidence of past or future mass erosion. | 3 | Infrequent. Mostly healed over. Low future potential. | 6 | Frequent or large, causing sediment nearly yearlong. | [✓ 9] | Frequent or large, causing sediment nearly yearlong OR imminent danger of same. | 12 |
|  | 3 | Debris jam potential | Essentially absent from immediate channel area. | 2 | Present, but mostly small twigs and limbs. | [✓ 4] | Moderate to heavy amounts, mostly larger sizes. | 6 | Moderate to heavy amounts, predominantly larger sizes. | 8 |
|  | 4 | Vegetative bank protection | > 90% plant density. Vigor and variety suggest a deep, dense soil-binding root mass. | 3 | 70–90% density. Fewer species or less vigor suggest less dense or deep root mass. | 6 | 50–70% density. Lower vigor and fewer species from a shallow, discontinuous root mass. | [✓ 9] | <50% density plus fewer species & less vigor indicating poor, discontinuous and shallow root mass. | 12 |
| Lower banks | 5 | Channel capacity | Bank heights sufficient to contain the bankfull stage. Width/depth ratio departure from reference width/depth ratio = 1.0. Bank-Height Ratio (BHR) = 1.0. | 1 | Bankfull stage is contained within banks. Width/depth ratio departure from reference width/depth ratio = 1.0–1.2. Bank-Height Ratio (BHR) = 1.0–1.1. | [✓ 2] | Bankfull stage is not contained. Width/depth ratio departure from reference width/depth ratio = 1.2–1.4. Bank-Height Ratio (BHR) = 1.1–1.3. | 3 | Bankfull stage is not contained; over-bank flows are common with flows less than bankfull. Width/depth ratio departure from reference width/depth ratio > 1.4. Bank-Height Ratio (BHR) > 1.3. | 4 |
|  | 6 | Bank rock content | > 65% with large angular boulders. 12"+ common. | 2 | 40–65%. Mostly boulders and small cobbles 6–12". | [✓ 4] | 20–40%. Most in the 3–6" diameter class. | 6 | <20% rock fragments of gravel sizes, 1–3" or less. | 8 |
|  | 7 | Obstructions to flow | Rocks and logs firmly imbedded. Flow pattern w/o cutting or deposition. Stable bed. | [✓ 2] | Some present causing erosive cross currents and minor pool filling. Obstructions fewer and less firm. | 4 | Moderately frequent, unstable obstructions move with high flows causing bank cutting and pool filling. | 6 | Frequent obstructions and deflectors cause bank erosion yearlong. Sediment traps full, channel migration occurring. | 8 |
|  | 8 | Cutting | Little or none. Infrequent raw banks <6". | 4 | Some, intermittently at outcurves and constrictions. Raw banks may be up to 12". | 6 | Significant. Cuts 12–24" high. Root mat overhangs and sloughing evident. | [✓ 12] | Almost continuous cuts, some over 24" high. Failure of overhangs frequent. | 16 |
|  | 9 | Deposition | Little or no enlargement of channel or point bars. | [✓ 4] | Some new bar increase, mostly from coarse gravel. | 8 | Moderate deposition of new gravel and coarse sand on old and some new bars. | 12 | Extensive deposit of predominantly fine particles. Accelerated bar development. | 16 |
| Bottom | 10 | Rock angularity | Sharp edges and corners. Plane surfaces rough. | 1 | Rounded corners and edges. Surfaces smooth and flat. | [✓ 2] | Corners and edges well rounded in 2 dimensions. | 3 | Well rounded in all dimensions, surfaces smooth. | 4 |
|  | 11 | Brightness | Surfaces dull, dark or stained. Generally not bright. | 1 | Mostly dull, but may have <35% bright surfaces. | 2 | Mixture dull and bright, i.e., 35–65% mixture range. | [✓ 3] | Predominantly bright, > 65%, exposed or scoured surfaces. | 4 |
|  | 12 | Consolidation of particles | Assorted sizes tightly packed or overlapping. | 2 | Moderately packed with some overlapping. | 4 | Mostly loose assortment with no apparent overlap. | [✓ 6] | No packing evident. Loose assortment, easily moved. | 8 |
|  | 13 | Bottom size distribution | No size change evident. Stable material 80–100%. | 4 | Distribution shift light. Stable material 50–80%. | 8 | Moderate change in sizes. Stable materials 20–50%. | [✓ 12] | Marked distribution change. Stable materials 0–20%. | 16 |
|  | 14 | Scouring and deposition | <5% of bottom affected by scour or deposition. | 6 | 5–30% affected. Scour at constrictions and where grades steepen. Some deposition in pools. | [✓ 12] | 30–50% affected. Deposits and scour at obstructions, constrictions and bends. Some filling of pools. | 18 | More than 50% of the bottom in a state of flux or change nearly yearlong. | 24 |
|  | 15 | Aquatic vegetation | Abundant growth moss-like, dark green perennial. In swift water, too. | 1 | Common. Algae forms in low velocity and pool areas. Moss here, too. | 2 | Present but spotty, mostly in backwater. Seasonal algae growth makes rocks slick. | [✓ 3] | Perennial types scarce or absent. Yellow-green, short-term bloom may be present. | 4 |
|  |  |  | Excellent total = | 6 | Good total = | 24 | Fair total = | 54 | Poor total = | 8 |

| Stream type | A1 | A2 | A3 | A4 | A5 | A6 | B1 | B2 | B3 | B4 | B5 | B6 | C1 | C2 | C3 | C4 | C5 | C6 | D3 | D4 | D5 | D6 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Good (Stable) | 38-43 | 38-43 | 54-90 | 60-95 | 60-95 | 50-80 | 38-45 | 38-45 | 40-60 | 40-64 | 48-68 | 40-60 | 38-50 | 38-50 | 60-85 | 70-90 | 70-90 | 60-85 | 85-107 | 85-107 | 85-107 | 67-98 |
| Fair (Mod. unstable) | 44-47 | 44-47 | 91-129 | 96-132 | 96-142 | 81-110 | 46-58 | 46-58 | 61-78 | 65-84 | 69-88 | 61-78 | 51-61 | 51-61 | 86-105 | 91-110 | 91-110 | 86-105 | 108-132 | 108-132 | 108-132 | 99-125 |
| Poor (Unstable) | 48+ | 48+ | 130+ | 133+ | 143+ | 111+ | 59+ | 59+ | 79+ | 85+ | 89+ | 79+ | 62+ | 62+ | 106+ | 111+ | 111+ | 106+ | 133+ | 133+ | 133+ | 126+ |

| Stream type | DA3 | DA4 | DA5 | DA6 | E3 | E4 | E5 | E6 | F1 | F2 | F3 | F4 | F5 | F6 | G1 | G2 | [✓ G3] | G4 | G5 | G6 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Good (Stable) | 40-63 | 40-63 | 40-63 | 40-63 | 40-63 | 50-75 | 50-75 | 40-63 | 60-85 | 60-85 | 85-110 | 85-110 | 90-115 | 80-95 | 40-60 | 40-60 | 85-107 | 85-107 | 90-112 | 85-107 |
| Fair (Mod. unstable) | 64-86 | 64-86 | 64-86 | 64-86 | 64-86 | 76-96 | 76-96 | 64-86 | 86-105 | 86-105 | 111-125 | 111-125 | 116-130 | 96-110 | 61-78 | 61-78 | 108-120 | 108-120 | 113-125 | 108-120 |
| Poor (Unstable) | 87+ | 87+ | 87+ | 87+ | 87+ | 97+ | 97+ | 87+ | 106+ | 106+ | 126+ | 126+ | 131+ | 111+ | 79+ | 79+ | 121+ | 121+ | 126+ | 121+ |

| | |
|---|---|
| Grand total = | 92 |
| Existing stream type = | G3/4 |
| *Potential stream type = | G3/4 |
| Modified channel stability rating = | GOOD |

*Rating should be adjusted to potential stream type, not existing.

**Worksheet 5-7.** Pfankuch (1975) stream channel stability rating procedure, as modified by Rosgen (1996, 2001b).

**Stream:** **Location:** Segment 5 G **Valley Type:** **Observers:** **Date:**

| Location | Key | Category | Excellent Description | Rating | Good Description | Rating | Fair Description | Rating | Poor Description | Rating |
|---|---|---|---|---|---|---|---|---|---|---|
| Upper banks | 1 | Landform slope | Bank slope gradient <30%. | 2 | Bank slope gradient 30–40%. | 4 | Bank slope gradient 40–60%. | [✓ 6] | Bank slope gradient > 60%. | 8 |
| | 2 | Mass erosion | No evidence of past or future mass erosion. | 3 | Infrequent. Mostly healed over. Low future potential. | [✓ 6] | Frequent or large, causing sediment nearly yearlong. | 9 | Frequent or large, causing sediment nearly yearlong OR imminent danger of same. | 12 |
| | 3 | Debris jam potential | Essentially absent from immediate channel area. | 2 | Present, but mostly small twigs and limbs. | [✓ 4] | Moderate to heavy amounts, mostly larger sizes. | 6 | Moderate to heavy amounts, predominantly larger sizes. | 8 |
| | 4 | Vegetative bank protection | > 90% plant density. Vigor and variety suggest a deep, dense soil-binding root mass. | 3 | 70–90% density. Fewer species or less vigor suggest less dense or deep root mass. | [✓ 6] | 50–70% density. Lower vigor and fewer species from a shallow, discontinuous root mass. | 9 | <50% density plus fewer species & less vigor indicating poor, discontinuous and shallow root mass. | 12 |
| Lower banks | 5 | Channel capacity | Bank heights sufficient to contain the bankfull stage. Width/depth ratio departure from reference width/depth ratio = 1.0. Bank-Height Ratio (BHR) = 1.0. | 1 | Bankfull stage is contained within banks. Width/depth ratio departure from reference width/depth ratio = 1.0–1.2. Bank-Height Ratio (BHR) = 1.0–1.1. | [✓ 2] | Bankfull stage is not contained. Width/depth ratio departure from reference width/depth ratio = 1.2–1.4. Bank-Height Ratio (BHR) = 1.1–1.3. | 3 | Bankfull stage is not contained; over-bank flows are common with flows less than bankfull. Width/depth ratio departure from reference width/depth ratio > 1.4. Bank-Height Ratio (BHR) > 1.3. | 4 |
| | 6 | Bank rock content | > 65% with large angular boulders. 12"+ common. | 2 | 40–65%. Mostly boulders and small cobbles 6–12". | 4 | 20–40%. Most in the 3–6" diameter class. | [✓ 6] | <20% rock fragments of gravel sizes, 1–3" or less. | 8 |
| | 7 | Obstructions to flow | Rocks and logs firmly imbedded. Flow pattern w/o cutting or deposition. Stable bed. | [✓ 2] | Some present causing erosive cross currents and minor pool filling. Obstructions fewer and less firm. | 4 | Moderately frequent, unstable obstructions move with high flows causing bank cutting and pool filling. | 6 | Frequent obstructions and deflectors cause bank erosion yearlong. Sediment traps full, channel migration occurring. | 8 |
| | 8 | Cutting | Little or none. Infrequent raw banks <6". | 4 | Some, intermittently at outcurves and constrictions. Raw banks may be up to 12". | [✓ 6] | Significant. Cuts 12–24" high. Root mat overhangs and sloughing evident. | 12 | Almost continuous cuts, some over 24" high. Failure of overhangs frequent. | 16 |
| | 9 | Deposition | Little or no enlargement of channel or point bars. | [✓ 4] | Some new bar increase, mostly from coarse gravel. | 8 | Moderate deposition of new gravel and coarse sand on old and some new bars. | 12 | Extensive deposit of predominantly fine particles. Accelerated bar development. | 16 |
| Bottom | 10 | Rock angularity | Sharp edges and corners. Plane surfaces rough. | 1 | Rounded corners and edges. Surfaces smooth and flat. | [✓ 2] | Corners and edges well rounded in 2 dimensions. | 3 | Well rounded in all dimensions, surfaces smooth. | 4 |
| | 11 | Brightness | Surfaces dull, dark or stained. Generally not bright. | 1 | Mostly dull, but may have <35% bright surfaces. | 2 | Mixture dull and bright, i.e., 35–65% mixture range. | [✓ 3] | Predominantly bright, > 65%, exposed or scoured surfaces. | 4 |
| | 12 | Consolidation of particles | Assorted sizes tightly packed or overlapping. | 2 | Moderately packed with some overlapping. | 4 | Mostly loose assortment with no apparent overlap. | [✓ 6] | No packing evident. Loose assortment, easily moved. | 8 |
| | 13 | Bottom size distribution | No size change evident. Stable material 80–100%. | 4 | Distribution shift light. Stable material 50–80%. | 8 | Moderate change in sizes. Stable materials 20–50%. | [✓ 12] | Marked distribution change. Stable materials 0–20%. | 16 |
| | 14 | Scouring and deposition | <5% of bottom affected by scour or deposition. | 6 | 5–30% affected. Scour at constrictions and where grades steepen. Some deposition in pools. | [✓ 12] | 30–50% affected. Deposits and scour at obstructions, constrictions and bends. Some filling of pools. | 18 | More than 50% of the bottom in a state of flux or change nearly yearlong. | 24 |
| | 15 | Aquatic vegetation | Abundant growth moss-like, dark green perennial. In swift water, too. | 1 | Common. Algae forms in low velocity and pool areas. Moss here, too. | 2 | Present but spotty, mostly in backwater. Seasonal algae growth makes rocks slick. | [✓ 3] | Perennial types scarce or absent. Yellow-green, short-term bloom may be present. | 4 |
| | | | Excellent total = | 6 | Good total = | 38 | Fair total = | 36 | Poor total = | |

| Stream type | A1 | A2 | A3 | A4 | A5 | A6 | B1 | B2 | B3 | B4 | B5 | B6 | C1 | C2 | [✓ C3] | C4 | C5 | C6 | D3 | D4 | D5 | D6 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Good (Stable) | 38-43 | 38-43 | 54-90 | 60-95 | 60-95 | 50-80 | 38-45 | 38-45 | 40-60 | 40-64 | 48-68 | 40-60 | 38-50 | 38-50 | 60-85 | 70-90 | 70-90 | 60-85 | 85-107 | 85-107 | 85-107 | 67-98 |
| Fair (Mod. unstable) | 44-47 | 44-47 | 91-129 | 96-132 | 96-142 | 81-110 | 46-58 | 46-58 | 61-78 | 65-84 | 69-88 | 61-78 | 51-61 | 51-61 | 86-105 | 91-110 | 91-110 | 86-105 | 108-132 | 108-132 | 108-132 | 99-125 |
| Poor (Unstable) | 48+ | 48+ | 130+ | 133+ | 143+ | 111+ | 59+ | 59+ | 79+ | 85+ | 89+ | 79+ | 62+ | 62+ | 106+ | 111+ | 111+ | 106+ | 133+ | 133+ | 133+ | 126+ |

| Stream type | DA3 | DA4 | DA5 | DA6 | E3 | E4 | E5 | E6 | F1 | F2 | F3 | F4 | F5 | F6 | G1 | G2 | G3 | G4 | G5 | G6 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Good (Stable) | 40-63 | 40-63 | 40-63 | 40-63 | 40-63 | 50-75 | 50-75 | 40-63 | 60-85 | 60-85 | 85-110 | 85-110 | 90-115 | 80-95 | 40-60 | 40-60 | 85-107 | 85-107 | 90-112 | 85-107 |
| Fair (Mod. unstable) | 64-86 | 64-86 | 64-86 | 64-86 | 64-86 | 76-96 | 76-96 | 64-86 | 86-105 | 86-105 | 111-125 | 111-125 | 116-130 | 96-110 | 61-78 | 61-78 | 108-120 | 108-120 | 113-125 | 108-120 |
| Poor (Unstable) | 87+ | 87+ | 87+ | 87+ | 87+ | 97+ | 97+ | 87+ | 106+ | 106+ | 126+ | 126+ | 131+ | 111+ | 79+ | 79+ | 121+ | 121+ | 126+ | 121+ |

| | |
|---|---|
| Grand total = | 80 |
| Existing stream type = | C3 |
| *Potential stream type = | C3 |
| Modified channel stability rating = | GOOD |

*Rating should be adjusted to potential stream type, not existing.

6" grass
12-18" shrubs
12-36" trees

**Worksheet 5-8.** Form to calculate Bank Erosion Hazard Index (BEHI) variables and an overall BEHI rating (Rosgen, 1996, 2001a). Use **Figure 5-19** with BEHI variables to determine BEHI score.

Stream: Location: Segment 2
Station: Observers:
Date: Stream Type: Valley Type:

**BEHI Score (Fig. 5-19)**

**Study Bank Height / Bankfull Height ( C )**

| | | | | | | |
|---|---|---|---|---|---|---|
| **Study Bank Height** (ft) = | 7.5 (A) | **Bankfull Height** (ft) = | 1 (B) | (A)/(B) = | 7.5 (C) | extreme<br>10 |

**Root Depth / Study Bank Height ( E )**

| | | | | | | |
|---|---|---|---|---|---|---|
| **Root Depth** (ft) = | .5 (D) | **Study Bank Height** (ft) = | 7.5 (A) | (D)/(A) = | 0.07 (E) | Very High<br>9 |

**Weighted Root Density ( G )**

| | | | | |
|---|---|---|---|---|
| **Root Density** as % = | 30 (F) | (F) x (E) = | 2.1 (G) | extreme<br>10 |

**Bank Angle ( H )**

| | | |
|---|---|---|
| **Bank Angle** as *Degrees* = | 60° (H) | Mod<br>4 |

**Surface Protection ( I )**

| | | |
|---|---|---|
| **Surface Protection** as % = | 50 (I) | Mod<br>5 |

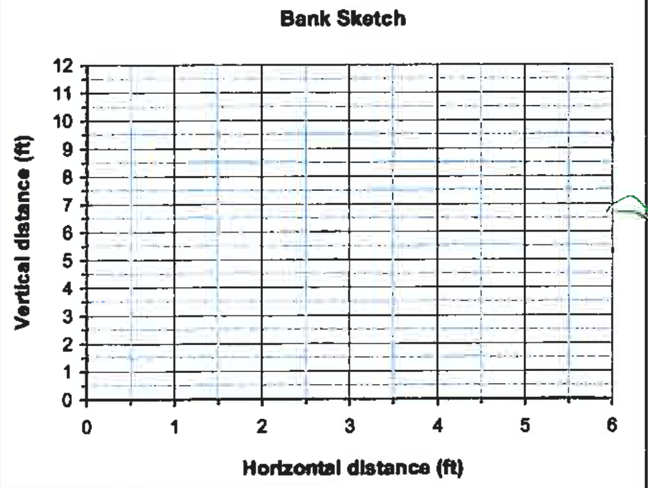
**Bank Material Adjustment:**
- **Bedrock** (Overall Very Low BEHI)
- **Boulders** (Overall Low BEHI)
- **Cobble** (Subtract 10 points if uniform medium to large cobble)
- **Gravel or Composite Matrix** (Add 5–10 points depending on percentage of bank material that is composed of sand)
- **Sand** (Add 10 points)
- **Silt/Clay** (no adjustment)

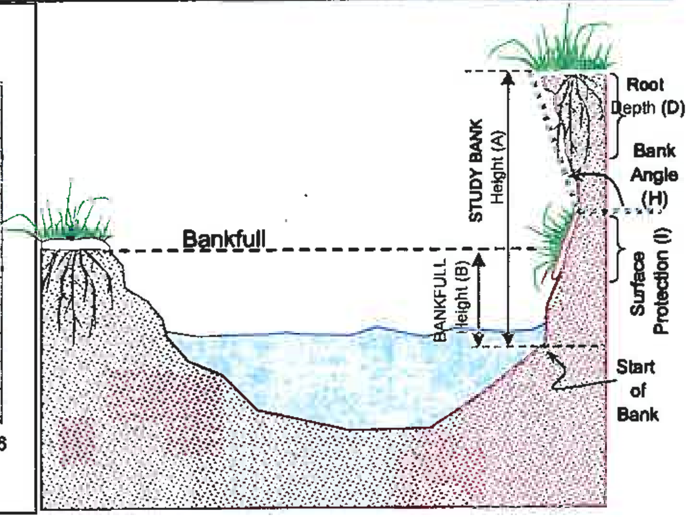
**Bank Material Adjustment** -5

**Stratification Adjustment**
Add 5–10 points, depending on position of unstable layers in relation to bankfull stage

| Very Low | Low | Moderate | High | Very High | Extreme | **Adjective Rating and Total Score** |
|---|---|---|---|---|---|---|
| 5 – 9.5 | 10 – 19.5 | 20 – 29.5 | 30 – 39.5 | 40 – 45 | 46 – 50 | High<br>33 |

**Bank Sketch**





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6" grass
12-18" shrubs
12-36" trees

**Worksheet 5-8.** Form to calculate Bank Erosion Hazard Index (BEHI) variables and an overall BEHI rating (Rosgen, 1996, 2001a). Use **Figure 5-19** with BEHI variables to determine BEHI score.

Stream: Location: Segment 3

Station: [redacted] Observers:

Date: Stream Type: Valley Type:

**BEHI Score (Fig. 5-19)**

**Study Bank Height / Bankfull Height ( C )**

| | | | | | | |
|---|---|---|---|---|---|---|
| **Study Bank Height** (ft) = | 6.5 (A) | **Bankfull Height** (ft) = | 2 (B) | (A)/(B) = | 3.3 (C) | Extreme 10 |

**Root Depth / Study Bank Height ( E )**

| | | | | | | |
|---|---|---|---|---|---|---|
| **Root Depth** (ft) = | 0.5 (D) | **Study Bank Height** (ft) = | 6.5 (A) | (D)/(A) = | 0.08 (E) | Very High 9 |

**Weighted Root Density ( G )**

| | | | | |
|---|---|---|---|---|
| **Root Density** as % = | 30 (F) | (F) x (E) = | 2.4 (G) | Extreme 10 |

**Bank Angle ( H )**

| | | |
|---|---|---|
| **Bank Angle** as *Degrees* = | 30 (H) | Low 3 |

**Surface Protection ( I )**

| | | |
|---|---|---|
| **Surface Protection** as % = | 60 (I) | Mod 4 |

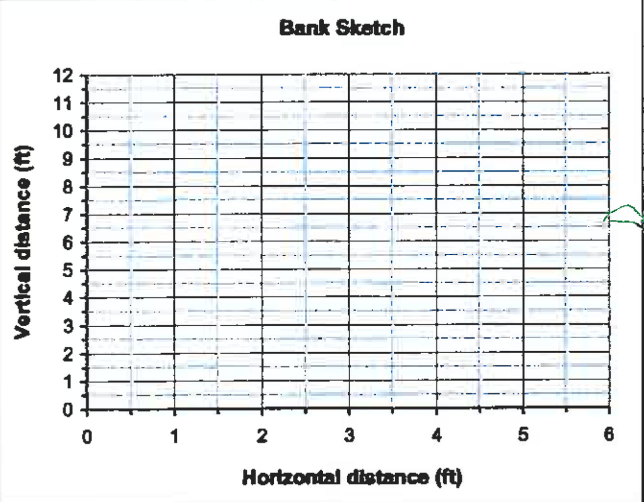
**Bank Material Adjustment:**
- **Bedrock** (Overall Very Low BEHI)
- **Boulders** (Overall Low BEHI)
- **Cobble** (Subtract 10 points if uniform medium to large cobble)
- **Gravel or Composite Matrix** (Add 5–10 points depending on percentage of bank material that is composed of sand)
- **Sand** (Add 10 points)
- **Silt/Clay** (no adjustment)

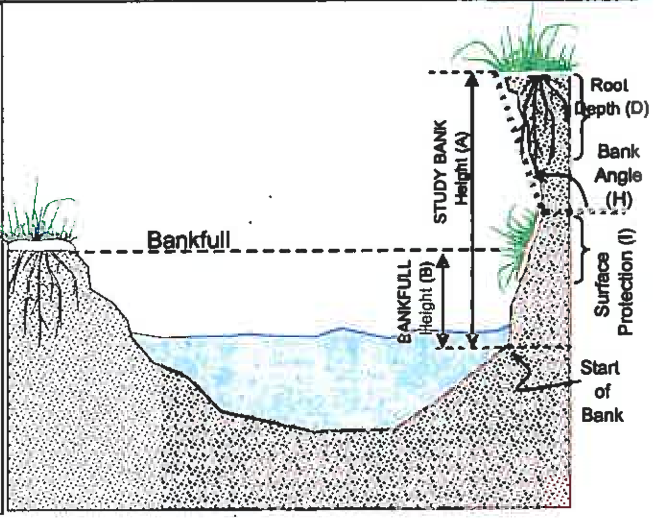
**Bank Material Adjustment** -5

**Stratification Adjustment**
Add 5–10 points, depending on position of unstable layers in relation to bankfull stage

| Very Low | Low | Moderate | High | Very High | Extreme |
|---|---|---|---|---|---|
| 5 – 9.5 | 10 – 19.5 | 20 – 29.5 | 30 – 39.5 | 40 – 45 | 46 – 50 |

**Adjective Rating** and **Total Score**: High 31





6" grass
12-18" shrubs
12-36" trees

**Worksheet 5-8.** Form to calculate Bank Erosion Hazard Index (BEHI) variables and an overall BEHI rating (Rosgen, 1996, 2001a). Use **Figure 5-19** with BEHI variables to determine BEHI score.

Stream: Location: Segment 4

Station: [redacted] Observers:

Date: Stream Type: Valley Type:

**BEHI Score (Fig. 5-19)**

**Study Bank Height / Bankfull Height ( C )**

| | | | | | | |
|---|---|---|---|---|---|---|
| Study Bank Height (ft) = | 8.5 (A) | Bankfull Height (ft) = | 1' (B) | (A)/(B) = | 8.5 (C) | Extreme<br>10 |

**Root Depth / Study Bank Height ( E )**

| | | | | | | |
|---|---|---|---|---|---|---|
| Root Depth (ft) = | 0.5 (D) | Study Bank Height (ft) = | 8.5 (A) | (D)/(A) = | 0.06 (E) | Extreme<br>9 |

**Weighted Root Density ( G )**

| | | | | |
|---|---|---|---|---|
| Root Density as % = | 30 (F) | (F) x (E) = | 1.8 (G) | Extreme<br>10 |

**Bank Angle ( H )**

| | | |
|---|---|---|
| Bank Angle as *Degrees* = | 35° (H) | Low<br>3 |

**Surface Protection ( I )**

| | | |
|---|---|---|
| Surface Protection as % = | 50 (I) | Mod<br>5 |

**Bank Material Adjustment:**

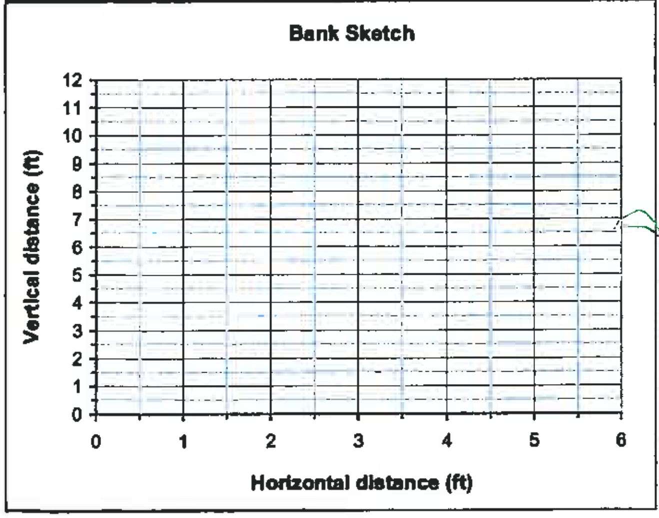
- **Bedrock** (Overall Very Low BEHI)
- **Boulders** (Overall Low BEHI)
- **Cobble** (Subtract 10 points if uniform medium to large cobble)
- **Gravel or Composite Matrix** (Add 5–10 points depending on percentage of bank material that is composed of sand)
- **Sand** (Add 10 points)
- **Silt/Clay** (no adjustment)

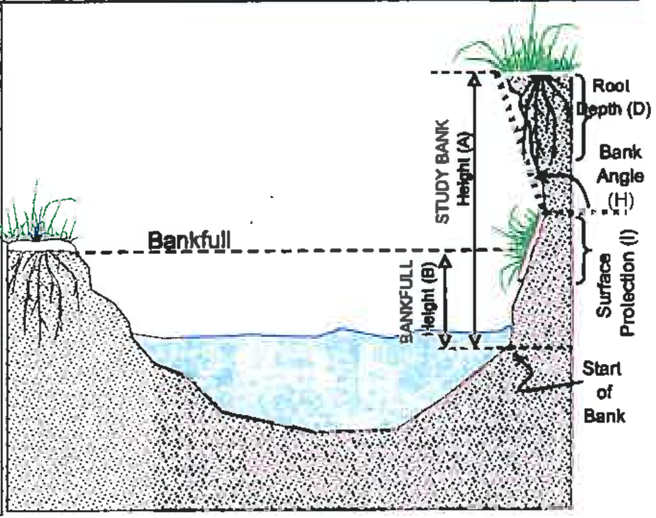
**Bank Material Adjustment** -5

**Stratification Adjustment**
Add 5–10 points, depending on position of unstable layers in relation to bankfull stage

| Very Low | Low | Moderate | High | Very High | Extreme |
|---|---|---|---|---|---|
| 5 – 9.5 | 10 – 19.5 | 20 – 29.5 | 30 – 39.5 | 40 – 45 | 46 – 50 |

**Adjective Rating** and **Total Score**: High 32





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6" grass
12-18" shrubs
12-36" trees

**Worksheet 5-8.** Form to calculate Bank Erosion Hazard Index (BEHI) variables and an overall BEHI rating (Rosgen, 1996, 2001a). Use **Figure 5-19** with BEHI variables to determine BEHI score.

Stream: Location: Segment 5

Station: ~~15+50~~ 81+00 Observers:

Date: Stream Type: Valley Type:

**BEHI Score (Fig. 5-19)**

**Study Bank Height / Bankfull Height ( C )**

| | | | | | | |
|---|---|---|---|---|---|---|
| **Study Bank Height** (ft) = | 5.5 **(A)** | **Bankfull Height** (ft) = | 1' **(B)** | **( A ) / ( B ) =** | 5.5 **(C)** | Extreme 10 |

**Root Depth / Study Bank Height ( E )**

| | | | | | | |
|---|---|---|---|---|---|---|
| **Root Depth** (ft) = | 0.5 **(D)** | **Study Bank Height** (ft) = | 5.5 **(A)** | **( D ) / ( A ) =** | 0.09 **(E)** | Very High 9 |

**Weighted Root Density ( G )**

| | | | | |
|---|---|---|---|---|
| **Root Density** as **%** = | 30 **(F)** | **( F ) x ( E ) =** | 2.7 **(G)** | Extreme 10 |

**Bank Angle ( H )**

| | | |
|---|---|---|
| **Bank Angle** as *Degrees* = | 20 **(H)** | Low 2 |

**Surface Protection ( I )**

| | | |
|---|---|---|
| **Surface Protection** as **%** = | 70 **( I )** | Low 3 |

**Bank Material Adjustment:**

**Bedrock** (Overall Very Low BEHI)
**Boulders** (Overall Low BEHI)
**Cobble** (Subtract 10 points if uniform medium to large cobble)
**Gravel or Composite Matrix** (Add 5–10 points depending on percentage of bank material that is composed of sand)
**Sand** (Add 10 points)
**Silt/Clay** (no adjustment)

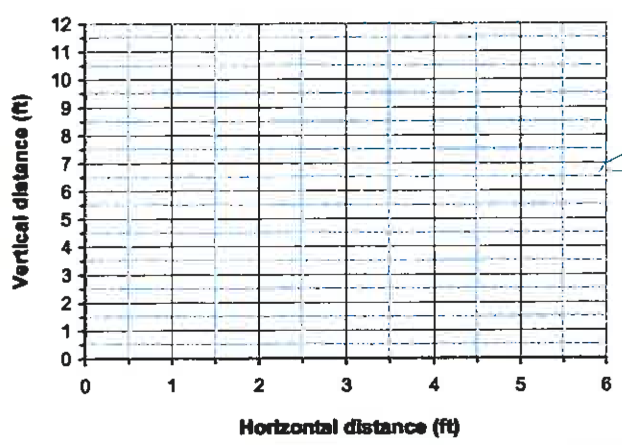
**Bank Material Adjustment** −5

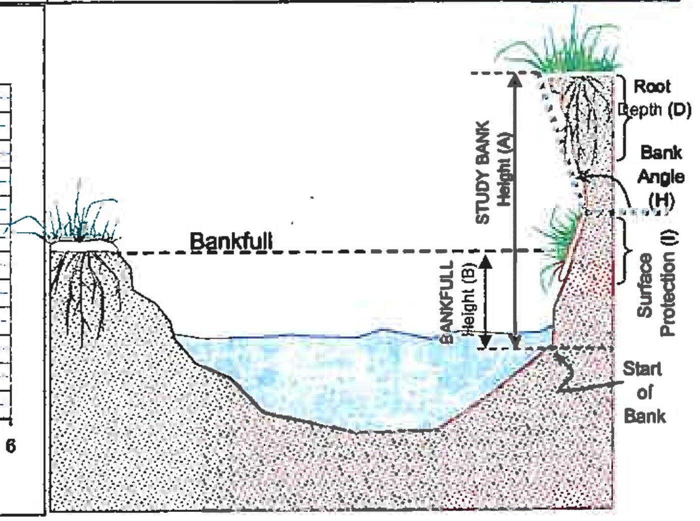
**Stratification Adjustment**
Add 5–10 points, depending on position of unstable layers in relation to bankfull stage

| Very Low | Low | Moderate | High | Very High | Extreme |
|---|---|---|---|---|---|
| 5 – 9.5 | 10 – 19.5 | 20 – 29.5 | 30 – 39.5 | 40 – 45 | 46 – 50 |

**Adjective Rating and Total Score** Moderate 29

**Bank Sketch**





6" grass
12-18" shrubs
12-36" trees

**Worksheet 5-8.** Form to calculate Bank Erosion Hazard Index (BEHI) variables and an overall BEHI rating (Rosgen, 1996, 2001a). Use **Figure 5-19** with BEHI variables to determine BEHI score.

Stream: | Location: Segment 1
Station: | Observers:
Date: | Stream Type: | Valley Type:

**BEHI Score (Fig. 5-19)**

**Study Bank Height / Bankfull Height ( C )**

| | | | | | | |
|---|---|---|---|---|---|---|
| Study Bank Height (ft) = | 5' (A) | Bankfull Height (ft) = | 0.5' (B) | ( A ) / ( B ) = | 10 (C) | Extreme 10 |

**Root Depth / Study Bank Height ( E )**

| | | | | | | |
|---|---|---|---|---|---|---|
| Root Depth (ft) = | 1 (D) | Study Bank Height (ft) = | 5' (A) | ( D ) / ( A ) = | 0.2 (E) | High 7 |

**Weighted Root Density ( G )**

| | | | | |
|---|---|---|---|---|
| Root Density as % = | 30 % (F) | ( F ) x ( E ) = | 6 (G) | Very high 9 |

**Bank Angle ( H )**

| | | |
|---|---|---|
| Bank Angle as *Degrees* = | 60° (H) | Mod 4 |

**Surface Protection ( I )**

| | | |
|---|---|---|
| Surface Protection as % = | 50 ( I ) | Mod 5 |

**Bank Material Adjustment:**

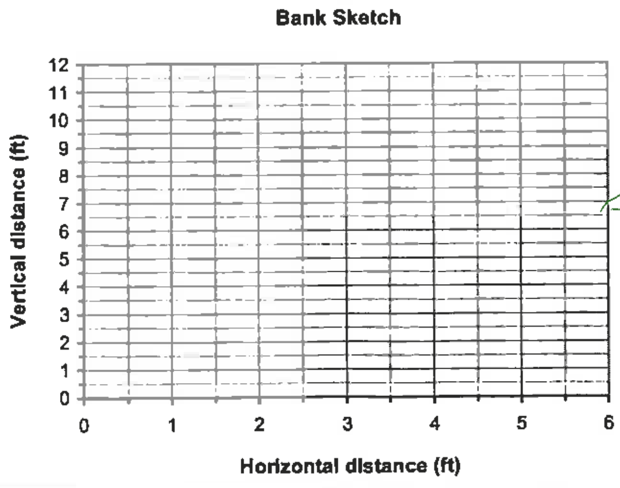
**Bedrock** (Overall Very Low BEHI)
**Boulders** (Overall Low BEHI)
**Cobble** (Subtract 10 points if uniform medium to large cobble)
**Gravel or Composite Matrix** (Add 5–10 points depending on percentage of bank material that is composed of sand)
**Sand** (Add 10 points)
**Silt/Clay** (no adjustment)

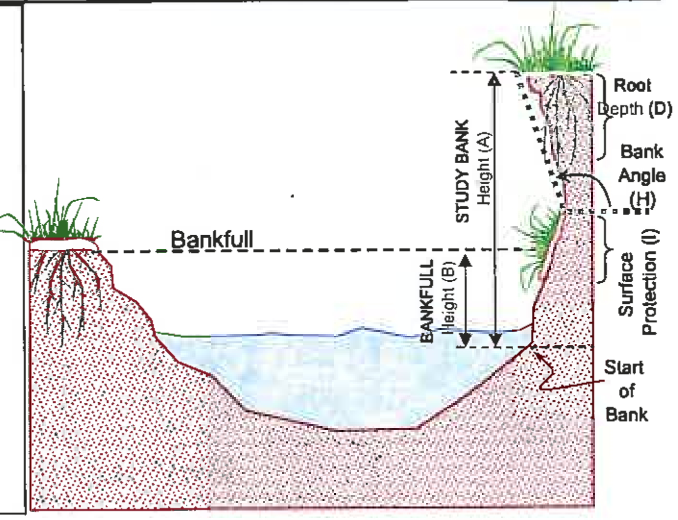
**Bank Material Adjustment** -10

**Stratification Adjustment**
Add 5–10 points, depending on position of unstable layers in relation to bankfull stage

| Very Low | Low | Moderate | High | Very High | Extreme | **Adjective Rating** and **Total Score** | Moderate<br>25 |
|---|---|---|---|---|---|---|---|
| 5 – 9.5 | 10 – 19.5 | 20 – 29.5 | 30 – 39.5 | 40 – 45 | 46 – 50 | | |

**Bank Sketch**





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**Worksheet 5-9.** Various field methods of estimating Near-Bank Stress (NBS) risk ratings to calculate erosion rate.

## Estimating Near-Bank Stress ( NBS )

Stream: Location: Segment 1

Station: Stream Type: Valley Type:

Observers: Date:

### Methods for estimating Near-Bank Stress (NBS)

| | | |
|---|---|---|
| (1) Channel pattern, transverse bar or split channel/central bar creating NBS.......... | Level I | Reconaissance |
| (2) Ratio of radius of curvature to bankfull width ( $R_c / W_{bkf}$ )........................................ | Level II | General prediction |
| (3) Ratio of pool slope to average water surface slope ( $S_p / S$ )........................................ | Level II | General prediction |
| (4) Ratio of pool slope to riffle slope ( $S_p / S_{rif}$ )........................................ | Level II | General prediction |
| (5) Ratio of near-bank maximum depth to bankfull mean depth ( $d_{nb} / d_{bkf}$ )...................... | Level III | Detailed prediction |
| (6) Ratio of near-bank shear stress to bankfull shear stress ( $\tau_{nb} / \tau_{bkf}$ )...................... | Level III | Detailed prediction |
| (7) Velocity profiles / Isovels / Velocity gradient........................................ | Level IV | Validation |

**Level I**

(1)

Transverse and/or central bars-short and/or discontinuous.........................................NBS = High / Very High

Extensive deposition (continuous, cross-channel)...........................................NBS = Extreme

Chute cutoffs, down-valley meander migration, converging flow.......................................NBS = Extreme

**Level II**

| (2) | Radius of Curvature $R_c$ (ft) | Bankfull Width $W_{bkf}$ (ft) | *Ratio* $R_c / W_{bkf}$ | Near-Bank Stress (NBS) |
|---|---|---|---|---|
| | high | 20 | high | Low |

| (3) | Pool Slope $S_p$ | Average Slope S | *Ratio* $S_p / S$ | Near-Bank Stress (NBS) |
|---|---|---|---|---|
| | | | | |

| (4) | Pool Slope $S_p$ | Riffle Slope $S_{rif}$ | *Ratio* $S_p / S_{rif}$ | Near-Bank Stress (NBS) |
|---|---|---|---|---|
| | | | | |

| Dominant **Near-Bank Stress** |
|---|
| 2 |

**Level III**

| (5) | Near-Bank Max Depth $d_{nb}$ (ft) | Mean Depth $d_{bkf}$ (ft) | *Ratio* $d_{nb} / d_{bkf}$ | Near-Bank Stress (NBS) |
|---|---|---|---|---|
| | | | | |

| (6) | Near-Bank Max Depth $d_{nb}$ (ft) | Near-Bank Slope $S_{nb}$ | Near-Bank Shear Stress $\tau_{nb}$ ( $lb/ft^2$ ) | Mean Depth $d_{bkf}$ (ft) | Average Slope S | Bankfull Shear Stress $\tau_{bkf}$ ( $lb/ft^2$ ) | Ratio $\tau_{nb} / \tau_{bkf}$ | Near-Bank Stress (NBS) |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |

**Level IV**

| (7) | Velocity Gradient ( ft / sec / ft ) | Near-Bank Stress (NBS) |
|---|---|---|
| | | |

### Converting values to a Near-Bank Stress (NBS) rating

| Near-Bank Stress (NBS) ratings | Method number | | | | | | |
|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| Very Low | N / A | > 3.00 | < 0.20 | < 0.40 | < 1.00 | < 0.80 | < 0.50 |
| Low | N / A | 2.21 – 3.00 | 0.20 – 0.40 | 0.41 – 0.60 | 1.00 – 1.50 | 0.80 – 1.05 | 0.50 – 1.00 |
| Moderate | N / A | 2.01 – 2.20 | 0.41 – 0.60 | 0.61 – 0.80 | 1.51 – 1.80 | 1.06 – 1.14 | 1.01 – 1.60 |
| High | See | 1.81 – 2.00 | 0.61 – 0.80 | 0.81 – 1.00 | 1.81 – 2.50 | 1.15 – 1.19 | 1.61 – 2.00 |
| Very High | (1) | 1.50 – 1.80 | 0.81 – 1.00 | 1.01 – 1.20 | 2.51 – 3.00 | 1.20 – 1.60 | 2.01 – 2.40 |
| Extreme | Above | < 1.50 | > 1.00 | > 1.20 | > 3.00 | > 1.60 | > 2.40 |

**Overall Near-Bank Stress (NBS) rating** 3.00

**Worksheet 5-9.** Various field methods of estimating Near-Bank Stress (NBS) risk ratings to calculate erosion rate.

## Estimating Near-Bank Stress ( NBS )

Stream: Location: Segment 2
Station: Stream Type: C Valley Type:
Observers: Date:

### Methods for estimating Near-Bank Stress (NBS)

| | | |
|---|---|---|
| (1) Channel pattern, transverse bar or split channel/central bar creating NBS.......... | Level I | Reconaissance |
| (2) Ratio of radius of curvature to bankfull width ( $R_c$ / $W_{bkf}$ )........................................ | Level II | General prediction |
| (3) Ratio of pool slope to average water surface slope ( $S_p$ / S ).......................................... | Level II | General prediction |
| (4) Ratio of pool slope to riffle slope ( $S_p$ / $S_{rif}$ )................................................................ | Level II | General prediction |
| (5) Ratio of near-bank maximum depth to bankfull mean depth ( $d_{nb}$ / $d_{bkf}$ )...................... | Level III | Detailed prediction |
| (6) Ratio of near-bank shear stress to bankfull shear stress ( $\tau_{nb}$ / $\tau_{bkf}$ )........................... | Level III | Detailed prediction |
| (7) Velocity profiles / Isovels / Velocity gradient........................................................ | Level IV | Validation |

**Level I**

(1)
Transverse and/or central bars-short and/or discontinuous............ ......................NBS = High / Very High
Extensive deposition (continuous, cross-channel)........................................ ...............NBS = Extreme
Chute cutoffs, down-valley meander migration, converging flow.......................................NBS = Extreme

**Level II**

| (2) | Radius of Curvature $R_c$ (ft) | Bankfull Width $W_{bkf}$ (ft) | *Ratio* $R_c$ / $W_{bkf}$ | Near-Bank Stress (NBS) |
|---|---|---|---|---|
| | high | 27' | high | Low |

| (3) | Pool Slope $S_p$ | Average Slope S | *Ratio* $S_p$ / S | Near-Bank Stress (NBS) |
|---|---|---|---|---|
| | | | | |

| (4) | Pool Slope $S_p$ | Riffle Slope $S_{rif}$ | *Ratio* $S_p$ / $S_{rif}$ | Near-Bank Stress (NBS) |
|---|---|---|---|---|
| | | | | |

| Dominant Near-Bank Stress |
|---|
| 2 |

**Level III**

| (5) | Near-Bank Max Depth $d_{nb}$ (ft) | Mean Depth $d_{bkf}$ (ft) | *Ratio* $d_{nb}$ / $d_{bkf}$ | Near-Bank Stress (NBS) |
|---|---|---|---|---|
| | | | | |

| (6) | Near-Bank Max Depth $d_{nb}$ (ft) | Near-Bank Slope $S_{nb}$ | Near-Bank Shear Stress $\tau_{nb}$ ( lb/ft$^2$ ) | Mean Depth $d_{bkf}$ (ft) | Average Slope S | Bankfull Shear Stress $\tau_{bkf}$ ( lb/ft$^2$ ) | Ratio $\tau_{nb}$ / $\tau_{bkf}$ | Near-Bank Stress (NBS) |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |

**Level IV**

| (7) | Velocity Gradient ( ft / sec / ft ) | Near-Bank Stress (NBS) |
|---|---|---|
| | | |

### Converting values to a Near-Bank Stress (NBS) rating

| Near-Bank Stress (NBS) ratings | Method number | | | | | | |
|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| Very Low | N / A | > 3.00 | < 0.20 | < 0.40 | < 1.00 | < 0.80 | < 0.50 |
| Low | N / A | 2.21 – 3.00 | 0.20 – 0.40 | 0.41 – 0.60 | 1.00 – 1.50 | 0.80 – 1.05 | 0.50 – 1.00 |
| Moderate | N / A | 2.01 – 2.20 | 0.41 – 0.60 | 0.61 – 0.80 | 1.51 – 1.80 | 1.06 – 1.14 | 1.01 – 1.60 |
| High | See | 1.81 – 2.00 | 0.61 – 0.80 | 0.81 – 1.00 | 1.81 – 2.50 | 1.15 – 1.19 | 1.61 – 2.00 |
| Very High | (1) | 1.50 – 1.80 | 0.81 – 1.00 | 1.01 – 1.20 | 2.51 – 3.00 | 1.20 – 1.60 | 2.01 – 2.40 |
| Extreme | Above | < 1.50 | > 1.00 | > 1.20 | > 3.00 | > 1.60 | > 2.40 |

**Overall Near-Bank Stress (NBS) rating** 3.00 Low

**Worksheet 5-9.** Various field methods of estimating Near-Bank Stress (NBS) risk ratings to calculate erosion rate.

## Estimating Near-Bank Stress ( NBS )

Stream: Location: Segment 3

Station: Stream Type: C Valley Type:

Observers: Date:

### Methods for estimating Near-Bank Stress (NBS)

| | | |
|---|---|---|
| (1) Channel pattern, transverse bar or split channel/central bar creating NBS.......... | Level I | Reconaissance |
| (2) Ratio of radius of curvature to bankfull width ( $R_c$ / $W_{bkf}$ ).......... | Level II | General prediction |
| (3) Ratio of pool slope to average water surface slope ( $S_p$ / S ).......... | Level II | General prediction |
| (4) Ratio of pool slope to riffle slope ( $S_p$ / $S_{rif}$ ).......... | Level II | General prediction |
| (5) Ratio of near-bank maximum depth to bankfull mean depth ( $d_{nb}$ / $d_{bkf}$ ).......... | Level III | Detailed prediction |
| (6) Ratio of near-bank shear stress to bankfull shear stress ( $\tau_{nb}$ / $\tau_{bkf}$ ).......... | Level III | Detailed prediction |
| (7) Velocity profiles / Isovels / Velocity gradient.......... | Level IV | Validation |

**Level I**

(1)
Transverse and/or central bars-short and/or discontinuous.......... NBS = High / Very High
Extensive deposition (continuous, cross-channel).......... NBS = Extreme
Chute cutoffs, down-valley meander migration, converging flow.......... NBS = Extreme

**Level II**

| | Radius of Curvature $R_c$ (ft) | Bankfull Width $W_{bkf}$ (ft) | Ratio $R_c$ / $W_{bkf}$ | Near-Bank Stress (NBS) |
|---|---|---|---|---|
| (2) | high | 49' | high | Low |

| | Pool Slope $S_p$ | Average Slope S | Ratio $S_p$ / S | Near-Bank Stress (NBS) |
|---|---|---|---|---|
| (3) | | | | |

| | Pool Slope $S_p$ | Riffle Slope $S_{rif}$ | Ratio $S_p$ / $S_{rif}$ | Near-Bank Stress (NBS) |
|---|---|---|---|---|
| (4) | | | | |

| Dominant Near-Bank Stress |
|---|
| 2 |

**Level III**

| | Near-Bank Max Depth $d_{nb}$ (ft) | Mean Depth $d_{bkf}$ (ft) | Ratio $d_{nb}$ / $d_{bkf}$ | Near-Bank Stress (NBS) |
|---|---|---|---|---|
| (5) | | | | |

| | Near-Bank Max Depth $d_{nb}$ (ft) | Near-Bank Slope $S_{nb}$ | Near-Bank Shear Stress $\tau_{nb}$ ( lb/ft$^2$ ) | Mean Depth $d_{bkf}$ (ft) | Average Slope S | Bankfull Shear Stress $\tau_{bkf}$ ( lb/ft$^2$ ) | Ratio $\tau_{nb}$ / $\tau_{bkf}$ | Near-Bank Stress (NBS) |
|---|---|---|---|---|---|---|---|---|
| (6) | | | | | | | | |

**Level IV**

| | Velocity Gradient ( ft / sec / ft ) | Near-Bank Stress (NBS) |
|---|---|---|
| (7) | | |

### Converting values to a Near-Bank Stress (NBS) rating

| Near-Bank Stress (NBS) ratings | Method number | | | | | | |
|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| Very Low | N / A | > 3.00 | < 0.20 | < 0.40 | < 1.00 | < 0.80 | < 0.50 |
| Low | N / A | 2.21 – 3.00 | 0.20 – 0.40 | 0.41 – 0.60 | 1.00 – 1.50 | 0.80 – 1.05 | 0.50 – 1.00 |
| Moderate | N / A | 2.01 – 2.20 | 0.41 – 0.60 | 0.61 – 0.80 | 1.51 – 1.80 | 1.06 – 1.14 | 1.01 – 1.60 |
| High | See | 1.81 – 2.00 | 0.61 – 0.80 | 0.81 – 1.00 | 1.81 – 2.50 | 1.15 – 1.19 | 1.61 – 2.00 |
| Very High | (1) | 1.50 – 1.80 | 0.81 – 1.00 | 1.01 – 1.20 | 2.51 – 3.00 | 1.20 – 1.60 | 2.01 – 2.40 |
| Extreme | Above | < 1.50 | > 1.00 | > 1.20 | > 3.00 | > 1.60 | > 2.40 |

**Overall Near-Bank Stress (NBS) rating** 3.00

**Worksheet 5-9.** Various field methods of estimating Near-Bank Stress (NBS) risk ratings to calculate erosion rate.

## Estimating Near-Bank Stress ( NBS )

Stream: Location: Segment 4
Station: Stream Type: C Valley Type:
Observers: Date:

## Methods for estimating Near-Bank Stress (NBS)

| | | |
|---|---|---|
| (1) Channel pattern, transverse bar or split channel/central bar creating NBS.......... | Level I | Reconaissance |
| (2) Ratio of radius of curvature to bankfull width ( $R_c$ / $W_{bkf}$ )...................................... | Level II | General prediction |
| (3) Ratio of pool slope to average water surface slope ( $S_p$ / S )...................................... | Level II | General prediction |
| (4) Ratio of pool slope to riffle slope ( $S_p$ / $S_{rif}$ )...................................... | Level II | General prediction |
| (5) Ratio of near-bank maximum depth to bankfull mean depth ( $d_{nb}$ / $d_{bkf}$ )...................... | Level III | Detailed prediction |
| (6) Ratio of near-bank shear stress to bankfull shear stress ( $\tau_{nb}$ / $\tau_{bkf}$ )...................... | Level III | Detailed prediction |
| (7) Velocity profiles / Isovels / Velocity gradient...................................... | Level IV | Validation |

**Level I**

(1)
Transverse and/or central bars-short and/or discontinuous........................................NBS = High / Very High
Extensive deposition (continuous, cross-channel).......................................................NBS = Extreme
Chute cutoffs, down-valley meander migration, converging flow........................................NBS = Extreme

**Level II**

(2)

| Radius of Curvature $R_c$ (ft) | Bankfull Width $W_{bkf}$ (ft) | *Ratio* $R_c$ / $W_{bkf}$ | Near-Bank Stress (NBS) |
|---|---|---|---|
| high | 29' | high | Low |

(3)

| Pool Slope $S_p$ | Average Slope S | *Ratio* $S_p$ / S | Near-Bank Stress (NBS) |
|---|---|---|---|
| | | | |

(4)

| Pool Slope $S_p$ | Riffle Slope $S_{rif}$ | *Ratio* $S_p$ / $S_{rif}$ | Near-Bank Stress (NBS) |
|---|---|---|---|
| | | | |

| Dominant Near-Bank Stress |
|---|
| 2 |

**Level III**

(5)

| Near-Bank Max Depth $d_{nb}$ (ft) | Mean Depth $d_{bkf}$ (ft) | *Ratio* $d_{nb}$ / $d_{bkf}$ | Near-Bank Stress (NBS) |
|---|---|---|---|
| | | | |

(6)

| Near-Bank Max Depth $d_{nb}$ (ft) | Near-Bank Slope $S_{nb}$ | Near-Bank Shear Stress $\tau_{nb}$ ( lb/ft$^2$ ) | Mean Depth $d_{bkf}$ (ft) | Average Slope S | Bankfull Shear Stress $\tau_{bkf}$ ( lb/ft$^2$ ) | Ratio $\tau_{nb}$ / $\tau_{bkf}$ | Near-Bank Stress (NBS) |
|---|---|---|---|---|---|---|---|
| | | | | | | | |

**Level IV**

(7)

| Velocity Gradient ( ft / sec / ft ) | Near-Bank Stress (NBS) |
|---|---|
| | |

## Converting values to a Near-Bank Stress (NBS) rating

| Near-Bank Stress (NBS) ratings | Method number | | | | | | |
|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| Very Low | N / A | > 3.00 | < 0.20 | < 0.40 | < 1.00 | < 0.80 | < 0.50 |
| Low | N / A | 2.21 – [✓ 3.00] | 0.20 – 0.40 | 0.41 – 0.60 | 1.00 – 1.50 | 0.80 – 1.05 | 0.50 – 1.00 |
| Moderate | N / A | 2.01 – 2.20 | 0.41 – 0.60 | 0.61 – 0.80 | 1.51 – 1.80 | 1.06 – 1.14 | 1.01 – 1.60 |
| High | See | 1.81 – 2.00 | 0.61 – 0.80 | 0.81 – 1.00 | 1.81 – 2.50 | 1.15 – 1.19 | 1.61 – 2.00 |
| Very High | (1) | 1.50 – 1.80 | 0.81 – 1.00 | 1.01 – 1.20 | 2.51 – 3.00 | 1.20 – 1.60 | 2.01 – 2.40 |
| Extreme | Above | < 1.50 | > 1.00 | > 1.20 | > 3.00 | > 1.60 | > 2.40 |

**Overall Near-Bank Stress (NBS) rating** 3.00

**Worksheet 5-9.** Various field methods of estimating Near-Bank Stress (NBS) risk ratings to calculate erosion rate.

## Estimating Near-Bank Stress ( NBS )

Stream: Location: Segment 5

Station: Stream Type: Valley Type:

Observers: Date:

### Methods for estimating Near-Bank Stress (NBS)

| | | |
|---|---|---|
| (1) Channel pattern, transverse bar or split channel/central bar creating NBS........... | Level I | Reconaissance |
| (2) Ratio of radius of curvature to bankfull width ( $R_c / W_{bkf}$ )........................................ | Level II | General prediction |
| (3) Ratio of pool slope to average water surface slope ( $S_p / S$ )........................................ | Level II | General prediction |
| (4) Ratio of pool slope to riffle slope ( $S_p / S_{rif}$ )........................................ | Level II | General prediction |
| (5) Ratio of near-bank maximum depth to bankfull mean depth ( $d_{nb} / d_{bkf}$ )........................ | Level III | Detailed prediction |
| (6) Ratio of near-bank shear stress to bankfull shear stress ( $\tau_{nb} / \tau_{bkf}$ )........................ | Level III | Detailed prediction |
| (7) Velocity profiles / Isovels / Velocity gradient........................................ | Level IV | Validation |

**Level I**

(1)

Transverse and/or central bars-short and/or discontinuous..........................................NBS = High / Very High

Extensive deposition (continuous, cross-channel)..........................................NBS = Extreme

Chute cutoffs, down-valley meander migration, converging flow..........................................NBS = Extreme

**Level II**

| (2) | Radius of Curvature $R_c$ (ft) | Bankfull Width $W_{bkf}$ (ft) | Ratio $R_c / W_{bkf}$ | Near-Bank Stress (NBS) |
|---|---|---|---|---|
| | high | 40' | high | Low |

| (3) | Pool Slope $S_p$ | Average Slope S | Ratio $S_p / S$ | Near-Bank Stress (NBS) |
|---|---|---|---|---|
| | | | | |

| Dominant Near-Bank Stress |
|---|
| 2 |

| (4) | Pool Slope $S_p$ | Riffle Slope $S_{rif}$ | Ratio $S_p / S_{rif}$ | Near-Bank Stress (NBS) |
|---|---|---|---|---|
| | | | | |

**Level III**

| (5) | Near-Bank Max Depth $d_{nb}$ (ft) | Mean Depth $d_{bkf}$ (ft) | Ratio $d_{nb} / d_{bkf}$ | Near-Bank Stress (NBS) |
|---|---|---|---|---|
| | | | | |

| (6) | Near-Bank Max Depth $d_{nb}$ (ft) | Near-Bank Slope $S_{nb}$ | Near-Bank Shear Stress $\tau_{nb}$ ( lb/ft$^2$ ) | Mean Depth $d_{bkf}$ (ft) | Average Slope S | Bankfull Shear Stress $\tau_{bkf}$ ( lb/ft$^2$ ) | Ratio $\tau_{nb} / \tau_{bkf}$ | Near-Bank Stress (NBS) |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |

**Level IV**

| (7) | Velocity Gradient ( ft / sec / ft ) | Near-Bank Stress (NBS) |
|---|---|---|
| | | |

### Converting values to a Near-Bank Stress (NBS) rating

| Near-Bank Stress (NBS) ratings | Method number | | | | | | |
|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| Very Low | N / A | > 3.00 | < 0.20 | < 0.40 | < 1.00 | < 0.80 | < 0.50 |
| Low | N / A | 2.21 – 3.00 | 0.20 – 0.40 | 0.41 – 0.60 | 1.00 – 1.50 | 0.80 – 1.05 | 0.50 – 1.00 |
| Moderate | N / A | 2.01 – 2.20 | 0.41 – 0.60 | 0.61 – 0.80 | 1.51 – 1.80 | 1.06 – 1.14 | 1.01 – 1.60 |
| High | See | 1.81 – 2.00 | 0.61 – 0.80 | 0.81 – 1.00 | 1.81 – 2.50 | 1.15 – 1.19 | 1.61 – 2.00 |
| Very High | (1) | 1.50 – 1.80 | 0.81 – 1.00 | 1.01 – 1.20 | 2.51 – 3.00 | 1.20 – 1.60 | 2.01 – 2.40 |
| Extreme | Above | < 1.50 | > 1.00 | > 1.20 | > 3.00 | > 1.60 | > 2.40 |

**Overall Near-Bank Stress (NBS) rating** 3.00

Streambank Erosion

**Worksheet 5-10.** Summary form of annual streambank erosion estimates for various study reaches.

Stream: Location:

Graph Used: Stream Type: Total Bank Length (ft):

Observers: Valley Type: Date:

| (1) Station (ft) | (2) BEHI rating (Worksheet 5-8) (adjective) | (3) NBS rating (Worksheet 5-9) (adjective) | (4) Bank erosion rate (Figure 5-38 or 5-39) (ft/yr) | (5) Length of bank (ft) | (6) Study bank height (ft) | (7) Erosion subtotal [(4)X(5)X(6)] ($ft^3$/yr) |
|---|---|---|---|---|---|---|
| 1. Segment 1 | Moderate | Low | 0.15 | 0 | 0 | 0 |
| 2. 2 | High | Low | 0.25 | 0 | 0 | 0 |
| 3. 3 | High | Low | 0.25 | 0 | 0 | 0 |
| 4. 4 | High | Low | 0.25 | 334 | 4 | 334 |
| 5. 5 | Moderate | Low | 0.15 | 75 | 5 | 56 |
| 6. | | | | | | |
| 7. | | | | | | |
| 8. | | | | | | |
| 9. | | | | | | |
| 10. | | | | | | |
| 11. | | | | | | |
| 12. | | | | | | |
| 13. | | | | | | |
| 14. | | | | | | |
| 15. | | | | | | |

| | | |
|---|---|---|
| Sum erosion subtotals in Column (7) for each BEHI/NBS combination | **Total erosion ($ft^3$/yr)** | 390 |
| Convert erosion in $ft^3$/yr to $yds^3$/yr {divide Total erosion ($ft^3$/yr) by 27} | **Total erosion ($yds^3$/yr)** | 14 |
| Convert erosion in $yds^3$/yr to tons/yr {multiply Total erosion ($yds^3$/yr) by 1.3} | **Total erosion (tons/yr)** | 19 |
| Calculate erosion per unit length of channel {divide Total erosion (tons/yr) by total length of stream (ft) surveyed} 12,500 ft | **Total erosion (tons/yr/ft)** | 0.002 |

Mass Failures

**Worksheet 5-10.** Summary form of annual streambank erosion estimates for various study reaches.

Stream: Third Brook Location:

Graph Used: Stream Type: Total Bank Length (ft):

Observers: Valley Type: Date:

| (1) Station (ft) | (2) BEHI rating (Worksheet 5-8) (adjective) | (3) NBS rating (Worksheet 5-9) (adjective) | (4) Bank erosion rate (Figure 5-38 or 5-39) (ft/yr) | (5) Length of bank (ft) Area of Failing Slopes | (6) Study bank height (ft) | (7) Erosion subtotal [(4)X(5)X(6)] (ft$^3$/yr) |
|---|---|---|---|---|---|---|
| 1. Segment 2 | High | Low | 0.25 | 13,825 ft$^2$ | | 3,456 |
| 2. Segment 3 | High | Low | 0.25 | 53,570 ft$^2$ | | 13,393 |
| 3. Segment 4 | High | Low | 0.25 | 125,800 ft$^2$ | | 31,450 |
| 4. | | | | | | |
| 5. | | | | | | |
| 6. | | | | | | |
| 7. | | | | | | |
| 8. | | | | | | |
| 9. | | | | | | |
| 10. | | | | | | |
| 11. | | | | | | |
| 12. | | | | | | |
| 13. | | | | | | |
| 14. | | | | | | |
| 15. | | | | | | |

| | | |
|---|---|---|
| Sum erosion subtotals in Column (7) for each BEHI/NBS combination | Total erosion (ft$^3$/yr) | 48,299 |
| Convert erosion in ft$^3$/yr to yds$^3$/yr {divide Total erosion (ft$^3$/yr) by 27} | Total erosion (yds$^3$/yr) | 1,789 |
| Convert erosion in yds$^3$/yr to tons/yr {multiply Total erosion (yds$^3$/yr) by 1.3} | Total erosion (tons/yr) | 2,326 |
| Calculate erosion per unit length of channel {divide Total erosion (tons/yr) by total length of stream (ft) surveyed} 12,500 ft | Total erosion (tons/yr/ft) | 0.19 |

**Worksheet 5-11**

Bankfull: 192 Bankfull suspended (mg/l): 22900

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Exceedenc | Discharge | Mid-ordina | Time(%) | Time(d) | Mid-ordina | Dimensionl S/Sbkf | SS (mg/L) | SS D (tons/ | Bs/Bbkf | Bedload(tons/da | Time Adjus | SS (tons) | Bedload | SS + Bedload |
| 0 | 644.94 | | | | | | | | | | | | | |
| 1 | 61.76 | 0.5 | 1 | 3.65 | 353.3506 | 1.840368 | 22900.00 | 770.81 | | 85.65 | 3.53 | 2813.46 | 312.61 | 3126.07 |
| 2 | 44.27 | 0.5 | 1 | 3.65 | 53.01619 | 0.276126 | 3435.88 | 17.35 | | 1.93 | 0.53 | 63.34 | 7.04 | 70.37 |
| 3 | 37.35 | 0.5 | 1 | 3.65 | 40.80972 | 0.212551 | 2644.80 | 10.28 | | 1.14 | 0.41 | 37.53 | 4.17 | 41.70 |
| 4 | 30.97 | 0.5 | 1 | 3.65 | 34.15992 | 0.177916 | 2213.84 | 7.20 | | 0.80 | 0.34 | 26.29 | 2.92 | 29.22 |
| 5 | 26.96 | 0.5 | 1 | 3.65 | 28.96761 | 0.150873 | 1877.34 | 5.18 | | 0.58 | 0.29 | 18.91 | 2.10 | 21.01 |
| 10 | 18.95 | 2.5 | 5 | 18.25 | 22.95547 | 0.11956 | 1487.70 | 3.25 | | 0.36 | 1.15 | 59.37 | 6.60 | 65.97 |
| 20 | 12.21 | 5 | 10 | 36.5 | 15.57692 | 0.08113 | 1009.51 | 1.50 | | 0.17 | 1.56 | 54.68 | 6.08 | 60.75 |
| 30 | 9.11 | 5 | 10 | 36.5 | 10.65789 | 0.05551 | 690.72 | 0.70 | | 0.08 | 1.07 | 25.60 | 2.84 | 28.44 |
| 40 | 7.11 | 5 | 10 | 36.5 | 8.107287 | 0.042225 | 525.42 | 0.41 | | 0.05 | 0.81 | 14.81 | 1.65 | 16.46 |
| 50 | 5.65 | 5 | 10 | 36.5 | 6.376518 | 0.033211 | 413.25 | 0.25 | | 0.03 | 0.64 | 9.16 | 1.02 | 10.18 |
| 60 | 4.37 | 5 | 10 | 36.5 | 5.010121 | 0.026094 | 324.70 | 0.15 | | 0.02 | 0.50 | 5.66 | 0.63 | 6.28 |
| 70 | 2.91 | 5 | 10 | 36.5 | 3.643725 | 0.018978 | 236.14 | 0.08 | | 0.01 | 0.36 | 2.99 | 0.33 | 3.32 |
| 80 | 1.75 | 5 | 10 | 36.5 | 2.331984 | 0.012146 | 151.13 | 0.03 | | 0.00 | 0.23 | 1.23 | 0.14 | 1.36 |
| 90 | 0.84 | 5 | 10 | 36.5 | 1.294494 | 0.006742 | 83.89 | 0.01 | | 0.00 | 0.13 | 0.38 | 0.04 | 0.42 |
| 100 | 0.22 | 5 | 10 | 36.5 | 0.529312 | 0.002757 | 34.30 | 0.00 | | 0.00 | 0.05 | 0.06 | 0.01 | 0.07 |
| | | | | | | | | | | **Annual Totals (tons/yr):** | | **3133.45** | **348.16** | **3481.62** |

**Worksheet 5-12**
Sta. 60+50

Bankfull: 192

Bankfull suspended (mg/l): 22900

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Exceedence | Discharge | Mid-ordinate | Area (sf) | Width (ft) | Depth(ft) | V (ft/s) | Slope (ft/ft) | Shear Stress | Stream Power (lb/s) | Unit Power (lb/ft/s) | Time Increment | Time(d) | Daily Mean | Daily Mean | Bedload Transport (tons) | Suspended Sand Transport (tons) | Total Transport (tons) |
| 100 | 0.22 | | | | | | | | | | | | | | | | |
| 90 | 0.84 | 0.53 | 2.16 | 5.40 | 0.16 | 0.25 | 0.02 | 0.21 | 0.28 | 0.05 | 10 | 36.5 | 0.00 | 0.00 | 0.00 | 0.01 | 0.01 |
| 80 | 1.75 | 1.29 | 4.32 | 10.80 | 0.32 | 0.30 | 0.02 | 0.42 | 1.36 | 0.13 | 10 | 36.5 | 0.00 | 0.00 | 0.03 | 0.13 | 0.16 |
| 70 | 2.91 | 2.33 | 6.48 | 16.20 | 0.48 | 0.36 | 0.02 | 0.63 | 3.67 | 0.23 | 10 | 36.5 | 0.00 | 0.02 | 0.16 | 0.72 | 0.89 |
| 60 | 4.37 | 3.64 | 8.64 | 21.60 | 0.64 | 0.42 | 0.02 | 0.84 | 7.64 | 0.35 | 10 | 36.5 | 0.02 | 0.07 | 0.57 | 2.53 | 3.10 |
| 50 | 5.65 | 5.01 | 10.80 | 27.00 | 0.80 | 0.46 | 0.02 | 1.05 | 13.13 | 0.49 | 10 | 36.5 | 0.04 | 0.18 | 1.44 | 6.39 | 7.83 |
| 40 | 7.11 | 6.38 | 18.27 | 29.61 | 1.04 | 0.35 | 0.02 | 1.36 | 14.10 | 0.48 | 10 | 36.5 | 0.04 | 0.20 | 1.63 | 7.22 | 8.84 |
| 30 | 9.11 | 8.11 | 25.74 | 32.22 | 1.28 | 0.31 | 0.02 | 1.68 | 17.05 | 0.53 | 10 | 36.5 | 0.06 | 0.27 | 2.25 | 9.99 | 12.24 |
| 20 | 12.21 | 10.66 | 33.21 | 34.83 | 1.52 | 0.32 | 0.02 | 2.00 | 22.31 | 0.64 | 10 | 36.5 | 0.10 | 0.43 | 3.57 | 15.81 | 19.38 |
| 10 | 18.95 | 15.58 | 40.68 | 37.44 | 1.76 | 0.38 | 0.02 | 2.31 | 33.14 | 0.89 | 10 | 36.5 | 0.19 | 0.85 | 7.02 | 31.10 | 38.13 |
| 5 | 26.96 | 22.96 | 44.41 | 38.75 | 1.88 | 0.52 | 0.02 | 2.47 | 49.45 | 1.28 | 5 | 18.25 | 0.38 | 1.69 | 6.96 | 30.83 | 37.79 |
| 4 | 30.97 | 28.97 | 45.16 | 39.01 | 1.91 | 0.64 | 0.02 | 2.50 | 62.57 | 1.60 | 1 | 3.65 | 0.57 | 2.53 | 2.08 | 9.22 | 11.30 |
| 3 | 37.35 | 34.16 | 45.91 | 39.27 | 1.93 | 0.74 | 0.02 | 2.53 | 73.99 | 1.88 | 1 | 3.65 | 0.76 | 3.36 | 2.77 | 12.28 | 15.05 |
| 2 | 44.27 | 40.81 | 46.66 | 39.53 | 1.96 | 0.87 | 0.02 | 2.56 | 88.65 | 2.24 | 1 | 3.65 | 1.03 | 4.58 | 3.78 | 16.72 | 20.50 |
| 1 | 61.76 | 53.02 | 47.40 | 39.79 | 1.98 | 1.12 | 0.02 | 2.60 | 115.51 | 2.90 | 1 | 3.65 | 1.63 | 7.20 | 5.94 | 26.29 | 32.23 |
| 0 | 644.94 | 353.35 | 48.15 | 40.05 | 2.00 | 7.34 | 0.02 | 2.63 | 772.18 | 19.28 | 1 | 3.65 | 41.85 | 185.33 | 152.74 | 676.44 | 829.18 |
| | | | | | | | | | | | **Total Annual Sediment Yield (tons/year)** | | | | **190.96** | **845.68** | **1036.64** |

**Worksheet 5-13.** Road Impact Index (RII) and corresponding annual sediment yield from roads (use the steps in **Table 5-14**).

Stream: Location:

Observers: Date:

| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) |
|---|---|---|---|---|---|---|---|---|---|---|
| Sub-watershed location ID# | Total acres of sub-watershed (*Step 1*) | Total acres of road (*Step 3*) | Number of stream crossings (*Step 4*) | Road impact index **[(3)/(2)X(4)]** (*Step 5*) | Dominant slope position (lower, mid or upper slope) (*Step 6*) | Sediment yield (tons/acre of road) (**Fig. 5-46**, *Step 7*) | Total tons **[(3)X(7)]** | Erosion rate recovery (% from **Fig. 5-47**, *Step 9*) (convert to decimal) | Total tons/yr **[(8) - (8)×(9)]** | Mitigation adjustments (*Step 10*) |
| 1. | 3472 | 4.3 | 2 | 0.003 | L | 1.8 | 7.7 | .95 | 0.39 | |
| 2. | 3343 | 2.4 | 0 | 0 | L | 1.7 | 4.1 | ↓ | 0.085 | |
| 3. | 3268 | 1.6 | 0 | 0 | L | 1.7 | 2.7 | | 0.14 | |
| 4. | 3083 | 2.0 | 0 | 0 | L | 1.7 | 3.4 | | 0.17 | |
| 5. | 2867 | 7.4 | 2 | 0.005 | L | 1.9 | 14.1 | | 0.71 | |
| 6. | | | | | | | | | | |
| 7. | | | | | | | | | | |
| 8. | | | | | | | | | | |
| 9. | | | | | | | | | | |
| 10. | | | | | | | | | | |
| 11. | | | | | | | | | | |
| 12. | | | | | | | | | | |
| 13. | | | | | | | | | | |
| 14. | | | | | | | | | | |
| 15. | | | | | | | | | | |
| | | | | | | **Total road sediment yield (tons/year):** | | | 1.5 | |

**Worksheet 5-14.** Bar sample data collection and sieve analysis form.

## Point / Side BAR-BULK MATERIALS SAMPLE DATA: Size Distribution Analysis

Observers:

Stream:

Location:

Date:

| Subsamples | Catch Pan or BUCKET | | Sieve SIZE mm | | Sieve SIZE mm | | Sieve SIZE mm | | Sieve SIZE mm | | Sieve SIZE mm | | Sieve SIZE mm | | Sieve SIZE mm | | Sieve SIZE mm | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Tare weight | | Tare weight | | Tare weight | | Tare weight | | Tare weight | | Tare weight | | Tare weight | | Tare weight | | Tare weight | |
| | Sample weights | | Sample weights | | Sample weights | | Sample weights | | Sample weights | | Sample weights | | Sample weights | | Sample weights | | Sample weights | |
| | Total | Net | Total | Net | Total | Net | Total | Net | Total | Net | Total | Net | Total | Net | Total | Net | Total | Net |
| 1 | | | | | | | | | | | | | | | | | | |
| 2 | | | | | | | | | | | | | | | | | | |
| 3 | | | | | | | | | | | | | | | | | | |
| 4 | | | | | | | | | | | | | | | | | | |
| 5 | | | | | | | | | | | | | | | | | | |
| 6 | | | | | | | | | | | | | | | | | | |
| 7 | | | | | | | | | | | | | | | | | | |
| 8 | | | | | | | | | | | | | | | | | | |
| 9 | | | | | | | | | | | | | | | | | | |
| 10 | | | | | | | | | | | | | | | | | | |
| 11 | | | | | | | | | | | | | | | | | | |
| 12 | | | | | | | | | | | | | | | | | | |
| 13 | | | | | | | | | | | | | | | | | | |
| 14 | | | | | | | | | | | | | | | | | | |
| 15 | | | | | | | | | | | | | | | | | | |
| Net wt. total | | | | | | | | | | | | | | | | | | |
| % Grand total | | | | | | | | | | | | | | | | | | |
| Accum. % =< | | | | | | | | | | | | | | | | | | |

### SURFACE MATERIALS DATA
( Two largest particles)

| No. | Dia. | WT. |
|---|---|---|
| 1 | | |
| 2 | | |

| | |
|---|---|
| Bucket + materials weight | |
| Bucket tare weight | |
| Materials weight | |
| Materials less than: | mm |

*Be sure to add separate material weights to grand total*

GRAND TOTAL SAMPLE WEIGHT

Sample location notes

Sample location sketch

**Worksheet 5-15.** Sediment competence calculation form to assess bed stability.

| | |
|---|---|
| Stream: Third Brook | Stream Type: |
| Location: 42+00 | Valley Type: |
| Observers: | Date: |

**Enter required information**

| | | | | | |
|---|---|---|---|---|---|
| 34 | $D_{50}$ | Riffle bed material $D_{50}$ (mm) | | | |
| 34 | $\hat{D}_{50}$ | Bar sample $D_{50}$ (mm) | | | |
| 0.59 | $D_{max}$ | Largest particle from bar sample (ft) | 180 | (mm) | 304.8 mm/ft |
| 0.028 | S | Existing bankfull water surface slope (ft/ft) | | | |
| 3 | d | Existing bankfull mean depth (ft) | | | |
| 2.00 | $\gamma_s$ | Submerged specific weight of sediment | | | |

**Select the appropriate equation and calculate critical dimensionless shear stress**

| | | | | |
|---|---|---|---|---|
| 1 | $D_{50}/\hat{D}_{50}$ | Range: 3 – 7 | Use EQUATION 1: $\tau^* = 0.0834\ (D_{50}/\hat{D}_{50})^{-0.872}$ | |
| 5.3 | $D_{max}/D_{50}$ | Range: 1.3 – 3.0 | Use EQUATION 2: $\tau^* = 0.0384\ (D_{max}/D_{50})^{-0.887}$ | |
| | $\tau^*$ | Bankfull Dimensionless Shear Stress | EQUATION USED: | dimensional |

**Calculate bankfull mean depth required for entrainment of largest particle in bar sample**

| | | | |
|---|---|---|---|
| | d | Required bankfull mean depth (ft) | $d = \frac{\tau^* \gamma_s D_{max}}{S}$ |

**Check:** ☐ Stable ☐ Aggrading ☑ Degrading

**Calculate bankfull water surface slope required for entrainment of largest particle in bar sample**

| | | | |
|---|---|---|---|
| | S | Required bankfull water surface slope (ft/ft) | $S = \frac{\tau^* \gamma_s D_{max}}{d}$ |

**Check:** ☐ Stable ☐ Aggrading ☑ Degrading

**Sediment competence using dimensional shear stress**

| | |
|---|---|
| 10.5 | Bankfull shear stress $\tau = \gamma dS$ ($lbs/ft^2$) (substitute hydraulic radius, R, with mean depth, d ) |
| 800 mm | Moveable particle size (mm) at bankfull shear stress **(Figure 5-54)** |
| 2.5 $lb/ft^2$ | Predicted shear stress required to initiate movement of $D_{max}$ (mm) **(Figure 5-54)** |
| 0.71 ft | Predicted mean depth required to initiate movement of $D_{max}$ (mm) $d = \frac{\tau}{\gamma S}$ |
| 0.007 | Predicted slope required to initiate movement of $D_{max}$ (mm) $S = \frac{\tau}{\gamma d}$ |

**Worksheet 5-15.** Sediment competence calculation form to assess bed stability.

Stream: Third Brook — Stream Type:

Location: 60 + 50 — Valley Type:

Observers: — Date:

**Enter required information**

| | | | | | |
|---|---|---|---|---|---|
| 60 | $D_{50}$ | Riffle bed material $D_{50}$ (mm) | | | |
| 60 | $\hat{D}_{50}$ | Bar sample $D_{50}$ (mm) | | | |
| 1.19 | $D_{max}$ | Largest particle from bar sample (ft) | 362 | (mm) | 304.8 mm/ft |
| 0.021 | S | Existing bankfull water surface slope (ft/ft) | | | |
| 2 | d | Existing bankfull mean depth (ft) | | | |
| 2.00 | $\gamma_s$ | Submerged specific weight of sediment | | | |

**Select the appropriate equation and calculate critical dimensionless shear stress**

| | | | | |
|---|---|---|---|---|
| 1 | $D_{50}/\hat{D}_{50}$ | Range: 3 – 7 | Use EQUATION 1: | $\tau^* = 0.0834\,(D_{50}/\hat{D}_{50})^{-0.872}$ |
| 6.0 | $D_{max}/D_{50}$ | Range: 1.3 – 3.0 | Use EQUATION 2: | $\tau^* = 0.0384\,(D_{max}/D_{50})^{-0.887}$ |
| | $\tau^*$ | Bankfull Dimensionless Shear Stress | EQUATION USED: | dimensional |

**Calculate bankfull mean depth required for entrainment of largest particle in bar sample**

| | | | |
|---|---|---|---|
| | d | Required bankfull mean depth (ft) | $d = \dfrac{\tau^* \gamma_s D_{max}}{S}$ |

Check: ☐ Stable ☐ Aggrading ☑ Degrading

**Calculate bankfull water surface slope required for entrainment of largest particle in bar sample**

| | | | |
|---|---|---|---|
| | S | Required bankfull water surface slope (ft/ft) | $S = \dfrac{\tau^* \gamma_s D_{max}}{d}$ |

Check: ☐ Stable ☐ Aggrading ☑ Degrading

**Sediment competence using dimensional shear stress**

| | | |
|---|---|---|
| 5.25 | Bankfull shear stress $\tau = \gamma dS$ (lbs/ft$^2$) (substitute hydraulic radius, R, with mean depth, d ) | |
| 410 | Moveable particle size (mm) at bankfull shear stress **(Figure 5-54)** | |
| 4.0 lb/ft² | Predicted shear stress required to initiate movement of $D_{max}$ (mm) **(Figure 5-54)** | |
| 1.5 ft | Predicted mean depth required to initiate movement of $D_{max}$ (mm) | $d = \dfrac{\tau}{\gamma S}$ |
| 0.016 | Predicted slope required to initiate movement of $D_{max}$ (mm) | $S = \dfrac{\tau}{\gamma d}$ |

**Worksheet 5-16.** Stability ratings for corresponding successional stage shifts of stream types. Check the appropriate stability rating.

Stream: Third Brook Stream Type: G

Location: 60+50 Valley Type:

Observers: Date:

| **Stream type changes due to successional stage shifts (Figure 5-55)** | **Stability rating (check appropriate rating)** |
|---|---|
| Stream type at potential, (C→E), (F$_b$→B), (G→B), (F→B$_c$), (F→C), (D→C) | ☐ Stable |
| (E→C) | ☐ Moderately unstable |
| (G→F), (F→D) | ☐ Unstable |
| (C→D), (B→G), (D→G), (C→G), (E→G) | ☑ Highly unstable |

**Worksheet 5-16.** Stability ratings for corresponding successional stage shifts of stream types. Check the appropriate stability rating.

Stream: Third Brook Stream Type: G

Location: 42+00 Valley Type:

Observers: Date:

| Stream type changes due to successional stage shifts (Figure 5-55) | Stability rating (check appropriate rating) |
|---|---|
| Stream type at potential, (C→E),<br>($F_b$→B), (G→B), (F→$B_c$), (F→C), (D→C) | ☐ Stable |
| (E→C) | ☐ Moderately unstable |
| (G→F), (F→D) | ☐ Unstable |
| (C→D), (B→G), (D→G), (C→G), (E→G) | ☑ Highly unstable |

**Worksheet 5-17.** Lateral stability prediction summary.

Stream: Stream Type:
Location: 60+50 Valley Type:
Observers: Date:

| | Lateral stability criteria (choose one stability category for each criterion 1–5) | Lateral stability categories | | | | Selected points (from each row) |
|---|---|---|---|---|---|---|
| | | Stable | Moderately unstable | Unstable | Highly unstable | |
| 1 | **W/d ratio state (Worksheet 5-5)** | < 1.2 | 1.2 – 1.4 | 1.4 – 1.6 | [✓ > 1.6] | 8 |
| | | (2) | (4) | (6) | 16 (8) | |
| 2 | **Depositional pattern (Worksheet 5-5)** | B1, B2 | B4, B8 | B3 | B5, B6, B7 | 1 |
| | | B2 [✓ (1)] | (2) | (3) | (4) | |
| 3 | **Meander pattern (Worksheet 5-5)** | M1, M3, M4 | | M2, M5, M6, M7, M8 | | 1 |
| | | M1 [✓ (1)] | | (3) | | |
| 4 | **Dominant BEHI / NBS (Worksheet 5-10)** | L/VL, L/L, L/M, L/H, L/VH, M/VL | M/L, M/M, M/H, L/Ex, H/L | M/VH, M/Ex, H/L, H/M, H/H, VH/VL, Ex/VL | H/H, H/Ex, Ex/M, Ex/H, Ex/VH, VH/VH, Ex/Ex | 6 |
| | | (2) | (4) | H/L [✓ (6)] | (8) | |
| 5 | **Degree of confinement ($MWR / MWR_{ref}$) (Worksheet 5-5)** | 0.8 – 1.0 | 0.3 – 0.79 | 0.1 – 0.29 | < 0.1 | 3 |
| | | (1) | (2) | C [✓ (3)] | (4) | |
| | | | | | **Total points** | 19 |
| | | **Lateral stability category point range** | | | | |
| | **Overall lateral stability category (use total points and check stability rating)** | **Stable**<br>**7 – 9**<br>☐ | **Moderately unstable**<br>**10 – 12**<br>☐ | **Unstable**<br>**13 – 21**<br>☑ | **Highly unstable**<br>**> 21**<br>☐ | |

**Worksheet 5-17.** Lateral stability prediction summary.

Stream: Third Brook
Stream Type:
Location: 42+00
Valley Type:
Observers:
Date:

| Lateral stability criteria (choose one stability category for each criterion 1–5) | Lateral stability categories | | | | Selected points (from each row) |
|---|---|---|---|---|---|
| | Stable | Moderately unstable | Unstable | Highly unstable | |
| 1 W/d ratio state (Worksheet 5-5) | < 1.2<br>(2) | 1.2 – 1.4<br>(4) | 1.4 – 1.6<br>(6) | > 1.6<br>11 [✓ (8)] | 8 |
| 2 Depositional pattern (Worksheet 5-5) | B1, B2<br>B2 [✓ (1)] | B4, B8<br>(2) | B3<br>(3) | B5, B6, B7<br>(4) | 1 |
| 3 Meander pattern (Worksheet 5-5) | M1, M3, M4<br>M1 [✓ (1)] | | M2, M5, M6, M7, M8<br>(3) | | 1 |
| 4 Dominant BEHI / NBS (Worksheet 5-10) | L/VL, L/L, L/M, L/H, L/VH, M/VL<br>(2) | M/L, M/M, M/H, L/Ex, H/L<br>(4) | M/VH, M/Ex, H/L, H/M, H/H, VH/VL, Ex/VL<br>H/L [✓ (6)] | H/H, H/Ex, Ex/M, Ex/H, Ex/VH, VH/VH, Ex/Ex<br>(8) | 6 |
| 5 Degree of confinement (MWR / MWR$_{ref}$) (Worksheet 5-5) | 0.8 – 1.0<br>(1) | 0.3 – 0.79<br>(2) | 0.1 – 0.29<br>(3) | < 0.1<br>SC [✓ (4)] | 4 |
| | | | | **Total points** | 20 |

| | Lateral stability category point range | | | |
|---|---|---|---|---|
| | Stable | Moderately unstable | Unstable | Highly unstable |
| Overall lateral stability category (use total points and check stability rating) | 7 – 9<br>☐ | 10 – 12<br>☐ | 13 – 21<br>☑ | > 21<br>☐ |

**Worksheet 5-18.** Vertical stability prediction for excess deposition/aggradation.

Stream: Stream Type: G
Location: 60+50 Valley Type:
Observers: Date:

| Vertical stability criteria (choose one stability category for each criterion 1–6) | Vertical stability categories for excess deposition / aggradation | | | | Selected points (from each row) |
|---|---|---|---|---|---|
| | No deposition | Moderate deposition | Excess deposition | Aggradation | |
| 1 Sediment competence (Worksheet 5-15) | Sufficient depth and/or slope to transport largest size available<br>[✓ (2)] | Trend toward insufficient depth and/or slope- slightly incompetent<br>(4) | Cannot move $D_{35}$ of bed material and/or $D_{100}$ of bar material<br>(6) | Cannot move $D_{16}$ of bed material and/or $D_{100}$ of bar or sub-pavement size<br>(8) | 2 |
| 2 Sediment capacity (POWERSED) (Worksheet 5-12) | Sufficient capacity to transport annual load<br>[✓ (2)] | Trend toward insufficient sediment capacity<br>(4) | Reduction up to 25% of annual sediment yield of bedload and/or suspended<br>(6) | Reduction over 25% of annual sediment yield for bedload and/or suspended<br>(8) | |
| 3 W/d ratio state (Worksheet 5-5) | 1.0 – 1.2<br>(2) | 1.2 – 1.4<br>(4) | 1.4 – 1.6<br>(6) | >1.6<br>16 [✓ (8)] | 8 |
| 4 Stream sucession states (Worksheet 5-16) | Current stream type at potential<br>[✓ (2)] | (E→C)<br>(4) | (C→High w/d C), (B→High w/d B)<br>(6) | (C→D), (F→D)<br>(8) | 2 |
| 5 Depositional patterns (Worksheet 5-5) | B1<br>(1) | B2, B4<br>B2 [✓ (2)] | B3, B5<br>(3) | B6, B7, B8<br>(4) | 2 |
| 6 Debris / blockages (Worksheet 5-5) | D1, D2, D3<br>D2 [✓ (1)] | D4, D7<br>(2) | D5, D8<br>(3) | D6, D9, D10<br>(4) | 1 |
| | | | | **Total points** | 17 |

| Vertical stability for excess deposition / aggradation (use total points and check stability rating) | Vertical stability category point range for excess deposition / aggradation | | | |
|---|---|---|---|---|
| | No deposition<br>10 – 14<br>☐ | Moderate deposition<br>15 – 20<br>☑ | Excess deposition<br>21 – 30<br>☐ | Aggradation<br>> 30<br>☐ |

**Worksheet 5-18.** Vertical stability prediction for excess deposition/aggradation.

Stream: Stream Type: G

Location: 42+00 Valley Type:

Observers: Date:

| Vertical stability criteria (choose one stability category for each criterion 1–6) | Vertical stability categories for excess deposition / aggradation | | | | Selected points (from each row) |
|---|---|---|---|---|---|
| | No deposition | Moderate deposition | Excess deposition | Aggradation | |
| 1 **Sediment competence (Worksheet 5-15)** | Sufficient depth and/or slope to transport largest size available<br>[✓ (2)] | Trend toward insufficient depth and/or slope- slightly incompetent<br>(4) | Cannot move $D_{35}$ of bed material and/or $D_{100}$ of bar material<br>(6) | Cannot move $D_{16}$ of bed material and/or $D_{100}$ of bar or sub-pavement size<br>(8) | 2 |
| 2 **Sediment capacity (POWERSED) (Worksheet 5-12)** | Sufficient capacity to transport annual load<br>[✓ (2)] | Trend toward insufficient sediment capacity<br>(4) | Reduction up to 25% of annual sediment yield of bedload and/or suspended<br>(6) | Reduction over 25% of annual sediment yield for bedload and/or suspended<br>(8) | |
| 3 **W/d ratio state (Worksheet 5-5)** | 1.0 – 1.2<br>(2) | 1.2 – 1.4<br>(4) | 1.4 – 1.6<br>(6) | >1.6<br>11 [✓ (8)] | 8 |
| 4 **Stream sucession states (Worksheet 5-16)** | Current stream type at potential<br>[✓ (2)] | (E→C)<br>(4) | (C→High w/d C), (B→High w/d B)<br>(6) | (C→D), (F→D)<br>(8) | 2 |
| 5 **Depositional patterns (Worksheet 5-5)** | B1<br>(1) | B2, B4<br>B2 [✓ (2)] | B3, B5<br>(3) | B6, B7, B8<br>(4) | 2 |
| 6 **Debris / blockages (Worksheet 5-5)** | D1, D2, D3<br>D2 [✓ (1)] | D4, D7<br>(2) | D5, D8<br>(3) | D6, D9, D10<br>(4) | 1 |
| | | | | **Total points** | 19 |

| | Vertical stability category point range for excess deposition / aggradation | | | |
|---|---|---|---|---|
| **Vertical stability for excess deposition / aggradation (use total points and check stability rating)** | **No deposition 10 – 14**<br>☐ | **Moderate deposition 15 – 20**<br>☑ | **Excess deposition 21 – 30**<br>☐ | **Aggradation > 30**<br>☐ |

**Worksheet 5-19.** Vertical stability prediction for channel incision/degradation.

Stream: Stream Type:

Location: 60 + 50 Valley Type:

Observers: Date:

| Vertical stability criteria (choose one stability category for each criterion 1–5) | Vertical stability categories for channel incision / degradation | | | | Selected points (from each row) |
|---|---|---|---|---|---|
| | Not incised | Slightly incised | Moderately incised | Degradation | |
| 1 **Sediment competence (Worksheet 5-15)** | Does not indicate excess competence | Trend to move larger sizes than $D_{100}$ of bar or > $D_{84}$ of bed | $D_{100}$ of bed moved | Particles much larger than $D_{100}$ of bed moved | 6 |
| | (2) | (4) | [✓ (6)] | (8) | |
| 2 **Sediment capacity (POWERSED) (Worksheet 5-12)** | Does not indicate excess capacity | Slight excess energy: up to 10% increase above reference | Excess energy sufficient to increase load up to 50% of annual load | Excess energy transporting more than 50% of annual load | 8 |
| | (2) | (4) | (6) | [✓ (8)] | |
| 3 **Degree of channel incision (BHR) (Worksheet 5-5)** | 1.00 – 1.10 | 1.11 – 1.30 | 1.31 – 1.50 | > 1.50 | 8 |
| | (2) | (4) | (6) | [✓ (8)] | |
| 4 **Stream sucession states (Worksheets 5-5 and 5-16)** | Does not indicate incision or degradation | If BHR > 1.1 and stream type has w/d between 5–10 | If BHR > 1.1 and stream type has w/d less than 5 | (B→G), (C→G), (E→G), (D→G) | 8 |
| | (2) | (4) | (6) | [✓ (8)] | |
| 5 **Confinement (MWR / $MWR_{ref}$) (Worksheet 5-5)** | 0.80 – 1.00 | 0.30 – 0.79 | 0.10 – 0.29 | < 0.10 | 3 |
| | (1) | (2) | [✓ (3)] | (4) | |
| | | | | **Total points** | 33 |

| | Vertical stability category point range for channel incision / degradation | | | |
|---|---|---|---|---|
| **Vertical stability for channel incision/ degradation** (use total points and check stability rating) | **Not incised**<br>**9 – 11**<br>☐ | **Slightly incised**<br>**12 – 18**<br>☐ | **Moderately incised**<br>**19 – 27**<br>☐ | **Degradation**<br>**> 27**<br>☑ |

**Worksheet 5-19.** Vertical stability prediction for channel incision/degradation.

Stream: Stream Type:
Location: 42+00 Valley Type:
Observers: Date:

| Vertical stability criteria (choose one stability category for each criterion 1–5) | Vertical stability categories for channel incision / degradation | | | | Selected points (from each row) |
|---|---|---|---|---|---|
| | Not incised | Slightly incised | Moderately incised | Degradation | |
| 1 **Sediment competence (Worksheet 5-15)** | Does not indicate excess competence<br>(2) | Trend to move larger sizes than $D_{100}$ of bar or > $D_{84}$ of bed<br>(4) | $D_{100}$ of bed moved<br>[✓ (6)] | Particles much larger than $D_{100}$ of bed moved<br>(8) | 6 |
| 2 **Sediment capacity (POWERSED) (Worksheet 5-12)** | Does not indicate excess capacity<br>(2) | Slight excess energy: up to 10% increase above reference<br>(4) | Excess energy sufficient to increase load up to 50% of annual load<br>(6) | Excess energy transporting more than 50% of annual load<br>[✓ (8)] | 8 |
| 3 **Degree of channel incision (BHR) (Worksheet 5-5)** | 1.00 – 1.10<br>(2) | 1.11 – 1.30<br>(4) | 1.31 – 1.50<br>(6) | > 1.50<br>>2 [✓ (8)] | 8 |
| 4 **Stream sucession states (Worksheets 5-5 and 5-16)** | Does not indicate incision or degradation<br>(2) | If BHR > 1.1 and stream type has w/d between 5–10<br>(4) | If BHR > 1.1 and stream type has w/d less than 5<br>(6) | (B→G), (C→G), (E→G), (D→G)<br>[✓ (8)] | 8 |
| 5 **Confinement ($MWR / MWR_{ref}$) (Worksheet 5-5)** | 0.80 – 1.00<br>(1) | 0.30 – 0.79<br>(2) | 0.10 – 0.29<br>(3) | < 0.10<br>SC [✓ (4)] | 4 |
| | | | | **Total points** | 32 |

| | Vertical stability category point range for channel incision / degradation | | | |
|---|---|---|---|---|
| **Vertical stability for channel incision/ degradation** (use total points and check stability rating) | **Not incised**<br>**9 – 11**<br>☐ | **Slightly incised**<br>**12 – 18**<br>☐ | **Moderately incised**<br>**19 – 27**<br>☐ | **Degradation**<br>**> 27**<br>☑ |

**Worksheet 5-20.** Channel enlargement prediction summary.

Stream: Stream Type:
Location: 60+50 Valley Type:
Observers: Date:

| | | | | | |
|---|---|---|---|---|---|
| **Channel enlargement prediction criteria** (choose one stability category for each criterion 1–4) | **Channel enlargement prediction categories** | | | | **Selected points** (from each row) |
| | **No increase** | **Slight increase** | **Moderate increase** | **Extensive** | |
| 1 **Successional stage shift (Worksheet 5-16)** | Stream type at potential, (C→E), ($F_b$→B), (G→B), (F→$B_c$), (F→C), (D→C)<br>(2) | (E→C)<br>(4) | (G→F), (F→D)<br>(6) | (C→D), (B→G), (D→G), (C→G), (E→G)<br>[✓ (8)] | 8 |
| 2 **Lateral stability (Worksheet 5-17)** | Stable<br>(2) | Moderately unstable<br>(4) | Unstable<br>[✓ (6)] | Highly unstable<br>(8) | 6 |
| 3 **Vertical stability excess deposition/ aggradation (Worksheet 5-18)** | No deposition<br>(2) | Moderate deposition<br>[✓ (4)] | Excess deposition<br>(6) | Aggradation<br>(8) | 4 |
| 4 **Vertical stability incision/ degradation (Worksheet 5-19)** | Not incised<br>(2) | Slightly incised<br>(4) | Moderately incised<br>(6) | Degradation<br>[✓ (8)] | 8 |
| | | | | **Total points** | 26 |
| | **Category point range** | | | | |
| **Channel enlargement prediction** (use total points and check stability rating) | **No increase**<br>**8 – 10**<br>☐ | **Slight increase**<br>**11 – 16**<br>☐ | **Moderate increase**<br>**17 – 24**<br>☐ | **Extensive**<br>**> 24**<br>☑ | |

**Worksheet 5-20.** Channel enlargement prediction summary.

Stream: Stream Type:
Location: 42 +00 Valley Type:
Observers: Date:

| Channel enlargement prediction criteria (choose one stability category for each criterion 1–4) | Channel enlargement prediction categories | | | | Selected points (from each row) |
|---|---|---|---|---|---|
| | No increase | Slight increase | Moderate increase | Extensive | |
| 1 **Successional stage shift (Worksheet 5-16)** | Stream type at potential, (C→E), ($F_b$→B), (G→B), (F→$B_c$), (F→C), (D→C)<br>(2) | (E→C)<br>(4) | (G→F), (F→D)<br>(6) | (C→D), (B→G), (D→G), (C→G), (E→G)<br>[✓ (8)] | 8 |
| 2 **Lateral stability (Worksheet 5-17)** | Stable<br>(2) | Moderately unstable<br>(4) | Unstable<br>[✓ (6)] | Highly unstable<br>(8) | 6 |
| 3 **Vertical stability excess deposition/ aggradation (Worksheet 5-18)** | No deposition<br>(2) | Moderate deposition<br>[✓ (4)] | Excess deposition<br>(6) | Aggradation<br>(8) | 4 |
| 4 **Vertical stability incision/ degradation (Worksheet 5-19)** | Not incised<br>(2) | Slightly incised<br>(4) | Moderately incised<br>(6) | Degradation<br>[✓ (8)] | 8 |
| | | | | **Total points** | 26 |

| | Category point range | | | | |
|---|---|---|---|---|---|
| **Channel enlargement prediction (use total points and check stability rating)** | **No increase 8 – 10** ☐ | **Slight increase 11 – 16** ☐ | **Moderate increase 17 – 24** ☐ | **Extensive > 24** ☑ | |

Worksheet 5-21. Overall sediment supply ratings for multiple reaches determined from individual stability rating categories.

Stream: Location: Observers: Date:

| (1) | (2) | (3) | | (4) | | (5) | | (6) | | (7) | | (8) | (9) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Reach location | Successional stage shift stability rating (Worksheet 5-16)* | Lateral stability rating (Worksheet 5-17) | | Vertical stability for excess deposition/aggradation (Worksheet 5-18) | | Vertical stability for channel incision/degradation (Worksheet 5-19) | | Channel enlargement prediction (Worksheet 5-20) | | Pfankuch channel stability (Worksheet 5-7) | | Add points from Columns (3) to (7) | Overall sediment supply rating; use column (8) points to determine adjective rating |
| | Stability rating: | Stability rating: | Points: | Stability rating: | Points: | Stability rating: | Points: | Stability rating: | Points: | Stability rating: | Points: | | Sediment supply rating: |
| | Stable | Stable | 1 | No deposition | 1 | Not incised | 1 | No increase | 1 | Good; stable | 1 | | 5 = Low |
| | Mod. unstable | Mod. unstable | 2 | Mod. deposition | 2 | Slightly incised | 2 | Slight increase | 2 | Fair: mod. unstable | 2 | | 6–10 = Moderate |
| | Unstable | Unstable | 3 | Excess deposition | 3 | Mod. incised | 3 | Mod. increase | 3 | | | | 11–15 = High |
| | Highly unstable | Highly unstable | 4 | Aggradation | 4 | Degradation | 4 | Extensive | 4 | Poor: unstable | 4 | | 16–20 = Very high |
| 1. 60+50 Impaired | HU | U | 3 | MD | 2 | D | 4 | E | 4 | Poor | 4 | 17 | VH |
| 2. | | | | | | | | | | | | | |
| 3. | | | | | | | | | | | | | |
| 4. | | | | | | | | | | | | | |
| 5. | | | | | | | | | | | | | |
| 6. | | | | | | | | | | | | | |
| 7. | | | | | | | | | | | | | |
| 8. | | | | | | | | | | | | | |
| 9. | | | | | | | | | | | | | |
| 10. | | | | | | | | | | | | | |
| 11. | | | | | | | | | | | | | |
| 12. | | | | | | | | | | | | | |
| 13. | | | | | | | | | | | | | |
| 14. | | | | | | | | | | | | | |
| 15. | | | | | | | | | | | | | |

*Successional stage shift stability rating is not used to determine overall sediment supply rating.

**Worksheet 5-22.** *PLA* summary of sediment sources and stability ratings for multiple locations.

Stream: Location: Observers: Date:

| (1) | (2) | (3) | (4) | (5) | (6) | | | (7) | (8) | (9) | (10) | (11) | | | (12) | | | (13) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sub-watershed or reach location | Step 9: Stream-bank erosion (Worksheet 5-10) | Step 15: Total annual sediment yield (Worksheet 5-11) | Step 17: Flow-related sediment (Worksheet 5-11) | Step 19: Sediment transport capacity stability rating (Worksheet 5-12b) | Step 20: | | | Step 21: Hillslope (total sediment yield) | Step 22: Sediment competence/ entrainment (Worksheet 5-16) | Step 23: Overall channel response due to sediment competence and capacity | Step 28: Overall channel source sediment supply rating (Worksheet 5-21) | Step 29: Total sediment yield (Worksheet 5-11) | | | Step 30: Difference in sediment from baseline (Worksheet 5-23) | | | Step 31: Potential consequence for overall stability |
| | | | | | Roads (total sediment yield) (Worksheet 5-13) | Surface erosion (total sediment yield) | Mass erosion (total sediment yield) | | | | | Bedload | Suspended | Total | Bedload | Suspended | Total | |
| | (tons/yr) | (tons/yr) | (tons/yr) | stable/ aggrading/ degrading | (tons/yr) | (tons/yr) | (tons/yr) | (tons/yr) | stable/ aggrading/ degrading | stable/ aggradation/ degradation | low/ moderate/ high/ very high | (tons/yr) | (tons/yr) | (tons/yr) | (tons/yr) | (tons/yr) | (tons/yr) | stable/ aggradation/ degradation |
| 1. **Baseline condition** | | | n/a | n/a | | | | | n/a | n/a | n/a | | | | n/a | n/a | n/a | |
| 2. Impaired | 19 | 3482 | — | D | 1.5 | 0 | 2326 | 4675 | D | D | VH | 348 | 3133 | 3482 | — | — | — | D |
| 3. | | | | | | | | | | | | | | | | | | |
| 4. | | | | | | | | | | | | | | | | | | |
| 5. | | | | | | | | | | | | | | | | | | |
| 6. | | | | | | | | | | | | | | | | | | |
| 7. | | | | | | | | | | | | | | | | | | |
| 8. | | | | | | | | | | | | | | | | | | |
| 9. | | | | | | | | | | | | | | | | | | |
| 10 | | | | | | | | | | | | | | | | | | |
| 11. | | | | | | | | | | | | | | | | | | |
| 12. | | | | | | | | | | | | | | | | | | |
| 13. | | | | | | | | | | | | | | | | | | |
| 14. | | | | | | | | | | | | | | | | | | |
| 15. | | | | | | | | | | | | | | | | | | |

**Worksheet 5-23.** Annual sediment yield by sources for an individual reach location, including hillslope, streambank erosion and flow-related processes.

Stream: Third Brook - Impaired
Observers:
Location:
Date:
Stream type:
Valley Type:

**Introduced sediment sources**

**Hillslope Processes (Steps 20–21)**

| | Sediment yield (tons/yr) | | Total percent contribution | |
|---|---|---|---|---|
| Roads | 1.5 | → | 0.04% | Relative percent contribution of total watershed |
| Surface erosion | 0 | → | 0% | |
| Mass erosion | 2,326 | → | 67% | |
| Total hillslope source | 2,328 | → | 67% | |

**Channel Processes (Steps 8–9)**

| | | | | |
|---|---|---|---|---|
| Streambank erosion | 19 | → | 0.6% | Percent of total introduced sediment yield |

**Totals**

| | | | | |
|---|---|---|---|---|
| Total introduced sediment | 2347 | → | 67% | Percent of total annual sediment yield |

**Flow-related sediment increase (Steps 10–17)**

| | | Bedload sediment | | Suspended sediment | | Total sediment |
|---|---|---|---|---|---|---|
| Summary of streamflow change in sediment | Pre-treatment | — | + | — | = | — |
| | Post-treatment | 348 | + | 3133 | = | 3482 |
| Sediment increase due to streamflow increase | | — | + | — | = | — |
| Percent increase above pre-treatment in sediment | | — | | — | | — |

**Bed-material load transport capacity (comparison to upstream condition) (Steps 18–19)**

| | | |
|---|---|---|
| Upstream annual sediment yield | — | ☐ Aggradation |
| Downstream (impaired) annual sediment yield | 1037 | ☐ Stable bed |
| Difference in sediment transport capacity | — | ☑ Degradation |

**Total annual sediment yield (tons/yr)**

| | Bedload sediment | | Suspended sediment | | Total sediment |
|---|---|---|---|---|---|
| Baseline | — | + | — | = | — |
| Existing | 348 | + | 3133 | = | 3482 |
| Increase above baseline | — | | — | | — |