Upper Delaware River Watershed
Livingston Manor, NY

Flood Risk Management
And
Ecosystem Restoration

Interim Feasibility Report

May 2013

U.S. ARMY CORPS OF
ENGINEERS
PHILADELPHIA DISTRICT

New York State Department of
Environmental Conservation

Executive Summary

1. Introduction

This report presents the results of the Upper Delaware River Watershed, Livingston Manor, New York, Interim Feasibility Study. The purpose of the Livingston Manor Interim Feasibility Study (hereafter called the Study) was to provide recommendations for future actions and programs to investigate potential flood risk management solutions and identify ecosystem restoration opportunities that could be implemented within the study area. The flood risk management and restoration opportunities included alternative solutions to reduce the recurrence of frequent flooding and to restore and/or improve degraded fish and wildlife habitat within the community of Livingston Manor. Restoration opportunities that contributed to the reduction of nuisance flooding were considered a high priority for this study since these opportunities could also provide incidental flood damage reduction in addition to ecosystem restoration benefits.

The Livingston Manor Study was authorized through Resolution #2495 adopted by the Committee on Transportation and Infrastructure of the U.S. House of Representatives on May 9, 1996. Pursuant to the Congressional resolution on the Upper Delaware River Watershed, the District completed an Expedited Reconnaissance Report in July 1997 (amended in February 2008) to determine Federal interest in the areas of flood control, ecosystem restoration, water quality control, comprehensive watershed management and other allied purposes.

The recurring flooding problem in the Livingston Manor area have been documented since the late 1800's with significant events recorded in June 1969, June 1973, January 1996, November 1996, September 2004, April 2005, June 2006, and September 2012. Typical damages include inundation of residential and commercial structures, as well as erosion of roads, retaining walls, and bridge abutments. In addition, some of the storms have resulted in the loss of local bridges. From the January, 1996 storm alone, Sullivan County reported infrastructure damages of $5,500,000 and property damages of $4,400,000.

This interim feasibility report documents the initial planning and engineering efforts required to determine potentially implementable solutions that provide reduction in surface water levels during frequently recurring events, as well as those that could provide ecosystem benefits through habitat improvements. The analysis for this reported focused mainly on the Little Beaver Kill (LBK) Watershed, since historically that is the area with most annual flood damages.

The New York Department of Environmental Conservation (NYDEC), as the non-Federal Sponsor, and the U.S. Army Corps of Engineers (Corps) initiated the feasibility phase of the study on May 26, 2009. The study work began in September 2009 when the non-federal cost share funds were received by the Corps. The feasibility phase study cost was shared equally between the Corps and the Sponsor.

2. Major Conclusions and Findings

a. Planning Objectives

The investigation of the problems and opportunities in the study area led to the establishment of the following planning objectives:

- Reduce flooding damages in the Livingston Manor area for the less than 20-year storms by 2016.
- Reduce flooding damage along Main Street and Pearl Street in downtown Livingston Manor by 2016.
- Reduce the water surface elevation of storm floods along Pearl Street in Livingston Manor by 2016.
- Restore approximately one mile of ecologically degraded stream channel along the LBK at the old airport site by 2016.
- Improve water quality in Cattail Brook and the LBK in the Town of Rockland by 2016.
- Restore degraded riparian buffers with native vegetation by 2016.
- Eradicate invasive plant species in riparian buffer areas by 2016.

b. Alternatives

A wide range of alternatives were formulated to address the planning objectives. Findings relative to these alternatives are as follows: based on an evaluation of the various alternatives, including the environmental impacts, design elements, estimated costs, and flood reduction benefits, Plan G was determined to be the tentatively selected plan. Plan G is composed of a detention structure with open channel at the old airport site combined with the widening of the Little Beaver Kill below the Main Street Bridge. This plan has measurable flood damage reduction benefits, as well as significant ecosystem restoration benefits.

The Federal objective in water resources planning is to contribute to the National Economic Development (NED) consistent with protecting the Nation's environment, pursuant to national environmental statutes, applicable executive orders and other planning requirements. Accordingly, it was found that Plan G best meets the NED objective and is the NED plan. In addition, Plan G reasonably maximizes net ecosystem restoration benefits; therefore, this plan is also designated as the National Ecosystem Restoration Plan. Furthermore, Plan G has strong local support and in the opinion of the sponsor best meets the needs of the local community. Therefore, Plan G can also be classified as the locally preferred plan.

c. Features of the Tentatively Selected Plan

Primary features of the tentatively selected plan (Plan G) are shown in Figures 4.26 and 4.27, and are summarized below:

- A combination of Plans F & H
- ✓ Plan F – the Fulton Plan (airport site) involving a water detention structure with an open channel
- ✓ Plan H - widening of the Little Beaver Kill floodplain below Main Street Bridge

d. Benefits and Costs of the Tentatively Selected Plan

The economic results indicate a 1.23 benefit/cost ratio with $41,935 in annual net benefits to the Nation. In addition, this plan restores approximately 3200 linear feet of stream channel to a more natural condition, 12 acres of riparian habitat, and 11 acres of wetland habitat in the project area. Plan G provides key flood damage reduction benefits to Livingston Manor. Under Plan G, annual damages from flooding should decrease by approximately $220,000. Furthermore, since trout fishing is a large component of the economy in the region and important to the culture of the region, Plan G provides essential benefits desired by the local community by restoring in-stream habitat beneficial to trout.

3. Areas of Controversy

There has been very little controversy for the study to date. Potential future areas of controversy may include the non-structural alternative of property buyouts. The potential social and political ramifications will have to be examined if this alternative is further investigated.

4. Unresolved Issues

Due to financial constraints of the non-federal sponsor, this study was limited in its scope and focused mainly on the Little Beaver Kill Watershed. If additional funding becomes available, further investigations on other watersheds (e.g., Willowemoc) and other possible solutions (e.g., former poultry plant) could be explored.

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1.0 Introduction

This report presents the results of the Upper Delaware River Watershed, Livingston Manor, New York, Interim Feasibility Study. The purpose of the Livingston Manor Interim Feasibility Study (hereafter called the Livingston Manor Study) was to provide recommendations for future actions and programs to investigate potential flood risk management solutions and identify ecosystem restoration opportunities that could be implemented within the study area. The flood risk management and restoration opportunities included alternative solutions to reduce the recurrence of frequent flooding and restore and/or improve degraded fish and wildlife habitat within the community of Livingston Manor. Ecosystem restoration opportunities that also contributed to the reduction of nuisance flooding were considered a high priority for this study.

1.1 Study Authorization

The Livingston Manor Study was authorized through Resolution #2495 adopted by the Committee on Transportation and Infrastructure of the U.S. House of Representatives on May 9, 1996. The resolution states:

> "Resolved by the Committee on Transportation and Infrastructure of the United States House of Representatives, That, the Secretary of the Army is requested to review the report of the Chief of Engineers on the Delaware River, published as House Document numbered 522, 87th Congress, 2nd Session; as it relates to the Upper Delaware River Watershed in New York State, and other pertinent reports, with a view to determine whether any modifications of the recommendations contained therein are advisable in the interest of flood control, ecosystem restoration, water quality control, comprehensive watershed management and other allied purposes."

1.2 Study Area

The study area is located at the junction of the Little Beaver Kill and Willowemoc Creeks within the hamlet of Livingston Manor (population 1,482), Town of Rockland, Sullivan County, about 76 miles northwest of New York City (Figures 1.1 through 1.5). Livingston Manor has been flooded five times out of eight years from 1999 - 2006, including three consecutive major events during September 2004, April 2005 and June 2006. The main damage area is located in the downtown Livingston Manor consisting of residences and businesses is situated adjacent to the confluence of the Little Beaver Kill and Willowemoc Creeks. Some damage occurs along the left bank (facing downstream) of Willowemoc Creek during major flood stages, and to the sewage treatment plant on the left bank downstream of the main damage area. Although overbank flows of Willowemoc Creek are relatively rare occurrences, high flows in that stream cause a backwater condition in the Little Beaver Kill, and occasionally Cattail Brook, frequently resulting in overbank flooding of those streams. An additional contributing factor to the backwater flooding along the Little Beaver Kill can be attributed to the development encroachment into the floodplain adjacent to the Main Street Bridge as well as the narrow opening of the bridge itself.

The Little Beaver Kill channel has changed course away from its previous alignment into a series of gravel borrow pits along an abandoned airstrip located approximately one mile upstream of downtown Livingston Manor. This interruption in the natural hydrologic flow along with a lack of riparian buffer has degraded the aquatic habitat in the Little Beaver Kill by raising water temperatures and removing riffle pool complexes. Thermal conditions on the Little Beaver Kill have been extensively studied by the New York State Department of Environmental Conservation (NYSDEC). Resolution of the thermal problem and other ecological issues involving channel stability, erosion and deposition, and wetland/floodplain losses are also a high priority of the NYSDEC and stakeholder organizations such as The Nature Conservancy and Trout Unlimited. As a result of this channel realignment, the quality of aquatic habitat in the Little Beaver Kill has declined, as summer temperatures regularly exceed growth tolerances for brown trout and reach lethal thermal limits for native brook trout.

There are several water resources problems associated with the area surrounding Livingston Manor along the Little Beaver Kill, Willowemoc Creek and Cattail Brook. These problems include flooding, fish habitat impairment, sediment management, as well as loss of floodplain and riparian buffer habitat. The study examined all practicable ecosystem restoration and flood damage reduction alternatives, including, but not limited to structural (floodwalls, levees, wetland creation/restoration, etc) or non-structural (flood proofing, buy-outs, etc.) solutions.

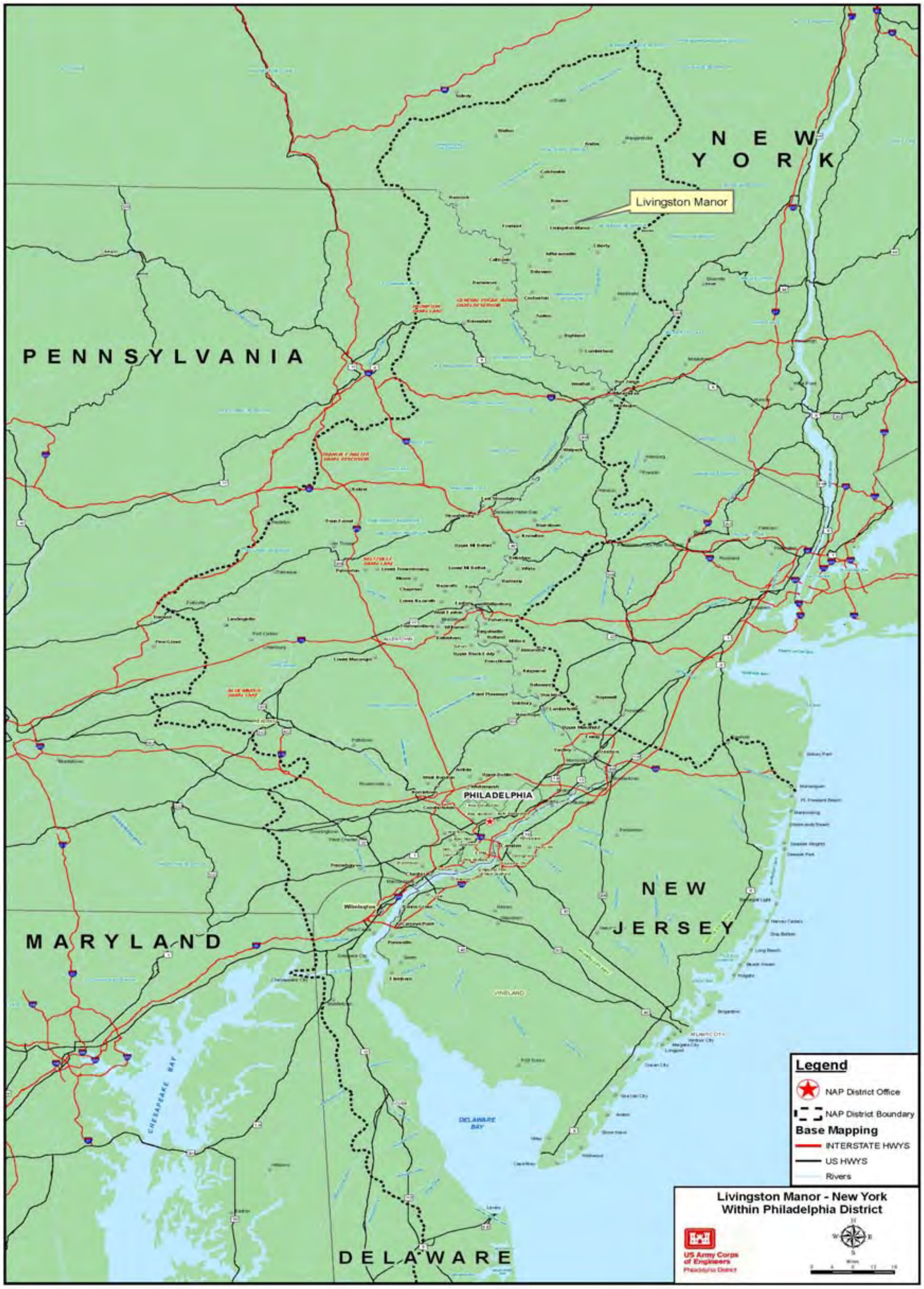


Figure 1.1: Location of Livingston Manor

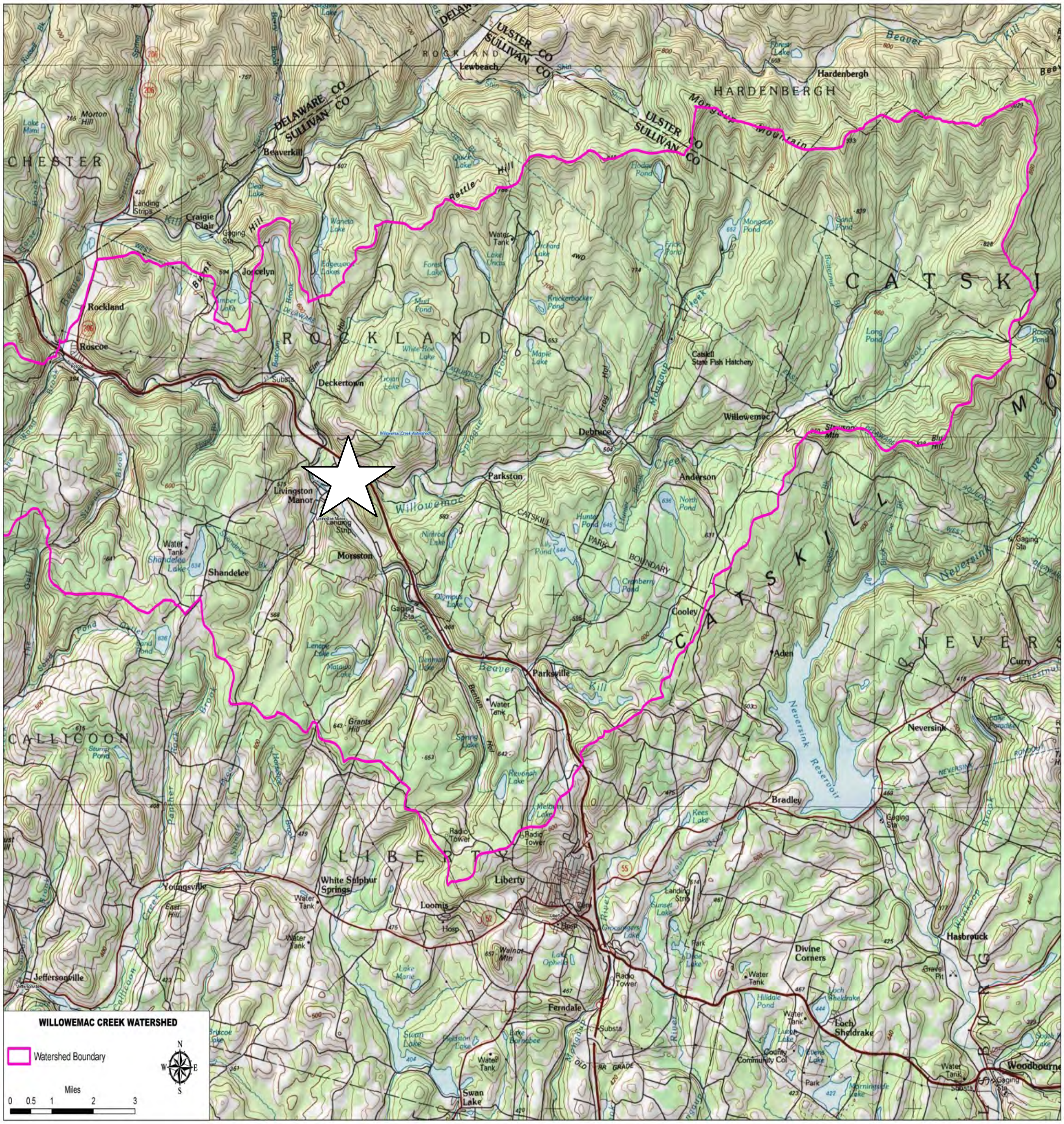
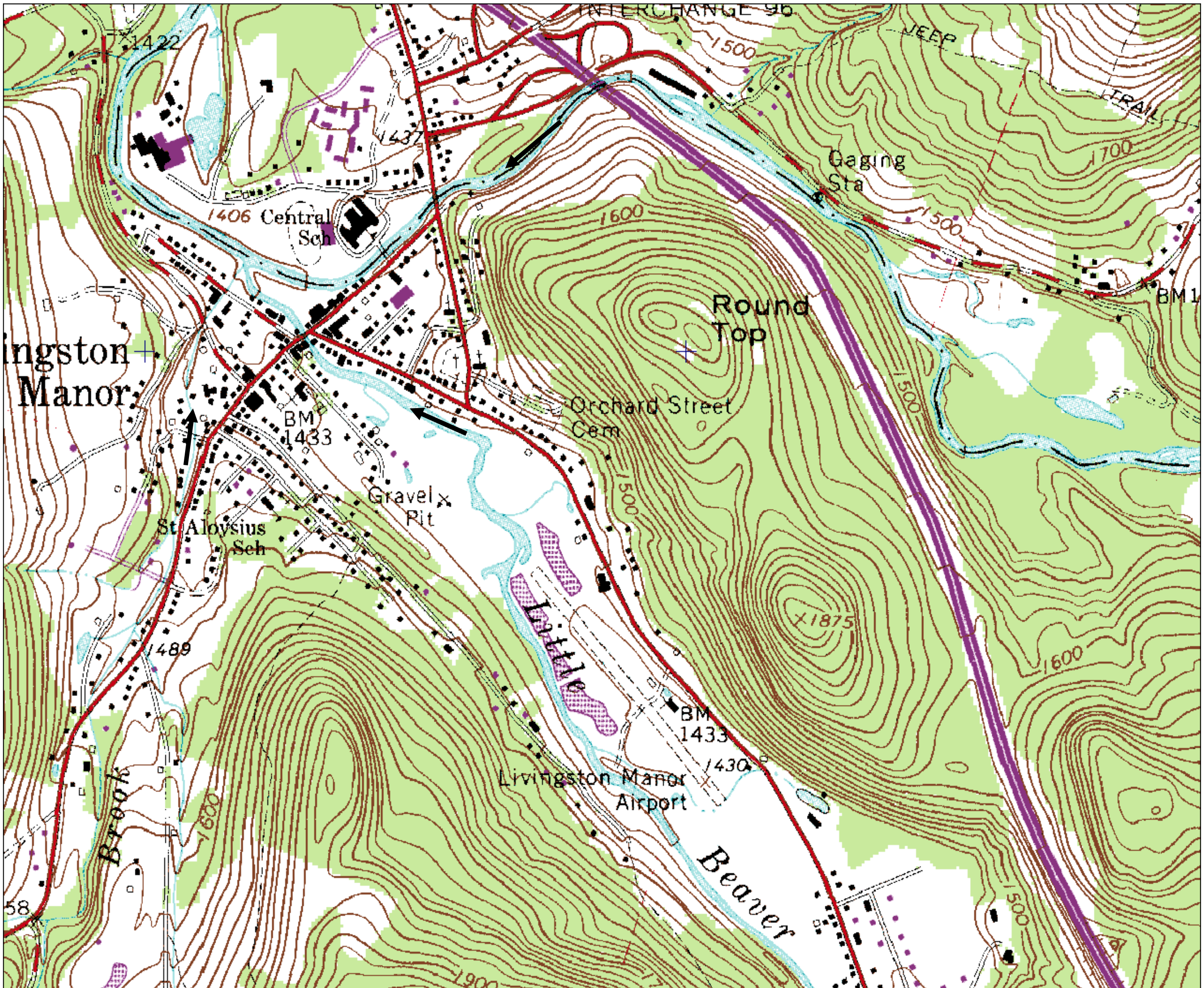


Figure 1.2: Livingston Manor Watershed Boundary



3-D TopoQuads Copyright © 1999 DeLorme Yarmouth, ME 04096 Source Data: USGS 350 ft Scale: 1 : 12,800 Detail: 14-0 Datum: NAD27

← Flow Direction

Figure 1.3: The topography of the Livingston Manor Downtown Area.

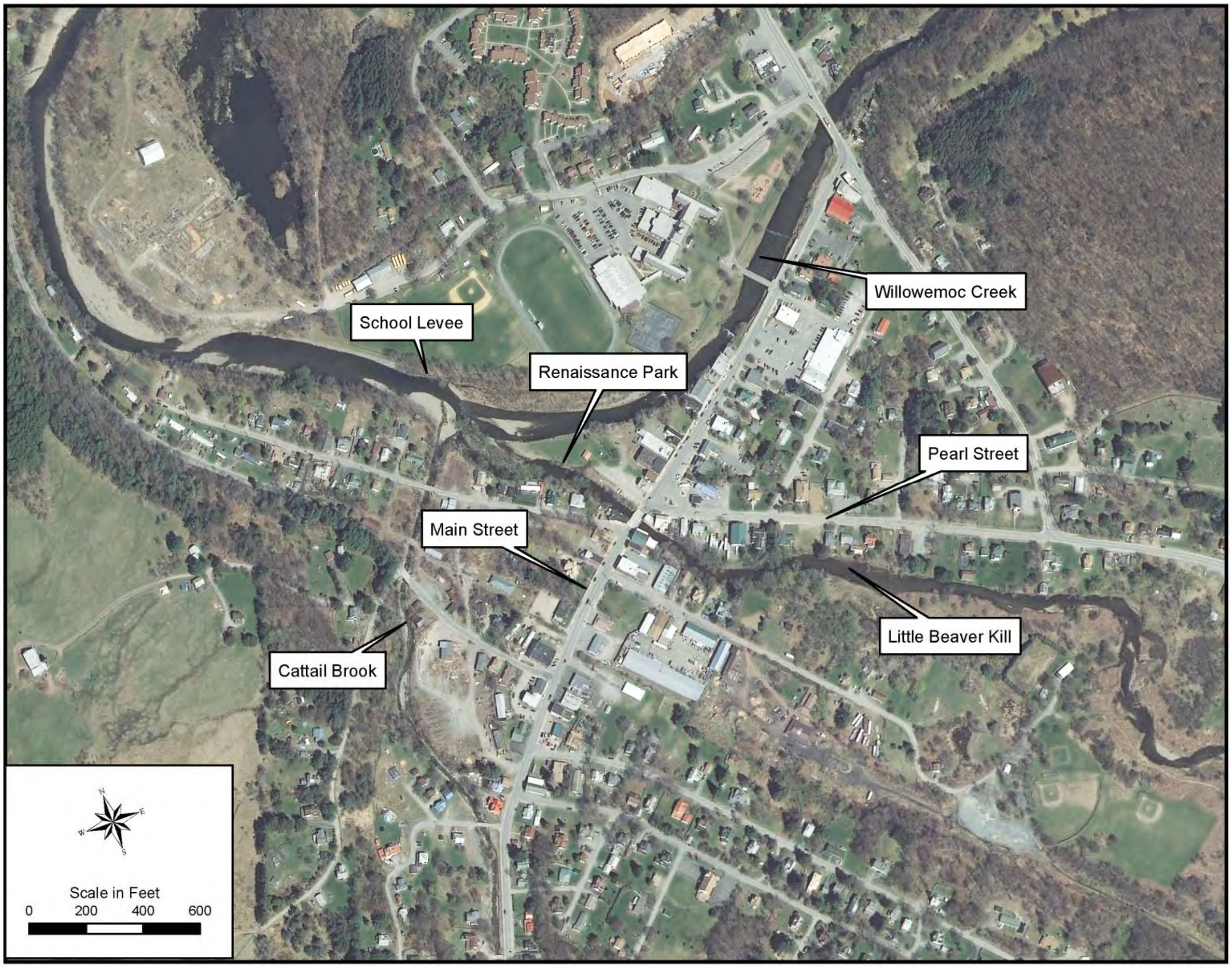


Figure 1.4: Aerial photo of Downtown Livingston Manor with key features noted.

Figure 1.5 Close up aerial view of the confluence of the three streams (Willowemoc, Little Beaver Kill, and Cattail Brook).

1.3 Study and Report Process

The Water Resources Development Act of 1986 (P.L. 99-662) directs the Corps to conduct water resource studies in two phases: the reconnaissance study phase and the feasibility study phase. The reconnaissance study determines whether or not planning to develop a project should proceed to the more detailed feasibility study. This is accomplished through the definition of problems and opportunities consistent with Army policies, the identification of a potential solution including costs, benefits, and environmental impacts, estimating the time and costs for the feasibility study, and an assessment of the level of interest and support of non-federal interests regarding further study.

1.4 Study Purpose and Scope

The purpose of a feasibility study is to ensure the timely and economical completion of a quality feasibility report that is expected to recommend an implementable solution to the identified problems.

This interim feasibility report presents the results of a feasibility level study conducted pursuant to the previously mentioned resolutions and will accomplish the following:

a. Provide a complete presentation of study results and findings so that readers can reach independent conclusions regarding the reasonableness of recommendations
b. Provide a sound and documented basis for decision makers at all levels to judge the recommended solution(s).

This report documents the analysis of existing conditions, without project conditions, plan formulation, and some draft project designs in order to provide recommendations for solutions that reduce recurring flood damages within the community of Livingston Manor, as well as improvements that increase aquatic habitat for ecosystem restoration purposes throughout the study watershed. The evaluations were based on site-specific technical information developed during the course of the study. These included analysis of recent and historical flooding records, hydraulic modeling; and preliminary economic, geotechnical, environmental, and cultural resource investigations.

This feasibility report will detail the following for the study area:

a. Define problems and opportunities.
b. Identify potential solutions.
c. Identify costs and benefits of potential solutions.
d. Present a tentatively selected plan.
e. Discuss items that would be covered in Phase II of the Feasibility Study.

1.5 Prior Studies, Reports and Related Projects

The U.S. Army Corps of Engineers (Corps) was given authority to conduct a reconnaissance study and ensuing feasibility level investigations by the U.S. House of Representatives, Committee on Transportation and Infrastructure Resolution #2495 -- Upper Delaware River Watershed, New York, adopted May 9, 1996. Pursuant to this resolution, the Upper Delaware River Watershed, New York, Reconnaissance Study [905(b) analysis] was initiated in 1996 and completed in 1997. This study identified problems and opportunities within the area focusing on ecosystem restoration and flood risk management issues.

The addendum to the 905b Analysis for the Upper Delaware River Watershed in New York completed and approved in March 2008 indicated that there is sufficient Federal interest to warrant further investigation into flood damage reduction and ecosystem restoration in Livingston Manor, New York. Flooding is a major concern in the hamlet of Livingston Manor. In the last 15 years, Livingston Manor has had six major flood events, including three consecutive 100-year recurrence interval events. The Town of Rockland experienced 88 National Flood Insurance Program claims of over $1.9 million as a result of the September 2004 and April 2005 storms alone. In addition, the quality of trout habitat in the Little Beaver Kill has declined, as summer temperatures regularly exceed good growth for brown trout and exceed lethal thermal limits for brook trout. The Livingston Manor area can no longer support a successful summertime cold-water trout fishery.

The Philadelphia District then proceeded with coordination of a feasibility study with the New York State Department of Environmental Conservation (NYSDEC) as the local sponsor. Based upon further negotiations with NYSDEC, the Project Management Plan (PMP) and a Feasibility Cost Sharing Agreement (FCSA) for a two-phased feasibility study was negotiated. The FSCA was subsequently executed on May 26, 2009.

There are several water resources problems associated with the area surrounding Livingston Manor along the Little Beaver Kill, Willowemoc Creek and Cattail Brook. These problems include flooding, fish habitat impairment, sediment management, as well as loss of floodplain and riparian buffer habitat. The study examined all practicable flood damage reduction and ecosystem restoration alternatives, including, but not limited to structural (floodwalls, levees, wetland creation/restoration, etc) or non-structural (flood proofing, buy-outs, etc.) solutions. Alternatives for this project were developed in accordance with the Corps' Environmental Operating Principles, which aim to foster unity of purpose on environmental issues, reflect a new tone and direction for dialogue on environmental matters, and ensure that employees consider conservation, environmental preservation and restoration in all Corps activities.

Initial study scoping efforts have been coordinated with appropriate Federal, State, and local agencies including the Federal Emergency Management Agency (FEMA) Region II, the New York State Department of Transportation, Sullivan County and the Town of Rockland. In addition to the non federal sponsor (NYSDEC) and the agencies above, there are several non-profit environmental organizations (The Nature Conservancy, Trout Unlimited, and Open Space Institute) interested in participating in the feasibility study to reduce flood damages through the restoration of flood plains and stream habitat at the same time. Future study efforts will be coordinated with other Federal, state and local agencies as well as interested stakeholders.

1.6 Project History

Flooding problems and ecological degradation within the project area have been studied by a number of federal, state, and local agencies over the past 50 years. The following is a list of the prior studies with brief summaries.

Flood Skimming Study, Beaver Kill Creek, Rockland, New York. September 1967. Prepared by U.S. Army Corps of Engineers (USACE). A dam was proposed that would reduce flooding in one third of Rockland.

Open File Report, Flood of July 27-28, 1969. 1969. Prepared by USGS. The flood exceeded all stream flows since 1937 (gage installation date). The flood was greater than the 100-year event and damaged 20 residences, campgrounds, a motel and a sewer treatment plant.

Draft Reconnaissance Report, Livingston Manor and Roscoe, NY. August 1970. Prepared by USACE. The report described flooding problems from Willowemoc Creek upstream of the BeaverKill in Roscoe to two miles upstream of Livingston Manor. In 1969, flood damages totaled $509,000 in Livingston and $37,000 in Roscoe-Rockland. The report proposed levees, channel relocation, a flume and a wall structure to reduce flood damages. The expected cost/benefit ratio of the proposed project was 1.3.

Economic Damage Assessment, Rockland Township. 1976. Prepared by Justin & Courtney, Inc. for USACE. The Little Beaver Kill caused major flooding in Livingston Manor due to a blockage at the Main Street Bridge and upstream ice jams.

Livingston Manor Reconnaissance Report. September 1979. Prepared by USACE. The report documented minor flooding every 2 years and major flooding every 10 to 25 years. Solutions such as upstream reservoirs, major stream relocations and dredging were determined to be uneconomical and environmentally detrimental.

Flood Insurance Study. 1993. Prepared by FEMA. The study indicated that in 1951, a 1,000-foot levee was constructed along the left bank of the Willowemoc Creek below Cattail Brook. It also noted the Willowemoc Creek as a major source of flooding and the construction of a1,600-foot flood wall and levee on the right bank at the High School.

Upper Delaware River Watershed Expedited Reconnaissance Study. 1997. Prepared by USACE. Reported damages from the January 1996 flood which damaged 232 houses, 20 mobile homes, 27 businesses, 3 apartment buildings, and water and sewer treatment plants.

Draft Preliminary Restoration Plan for Little Beaver Kill Trout Habitat. 2003. Prepared by The Bioengineering Group, Inc. for USACE. The plan involved restoration of a section of the Little Beaver Kill that had been thermally degraded. It included a 2,600 foot channel realignment, bank stabilization, floodplain wetland creation, borrow pit filling, and establishment of forested riparian buffer.

Beaver Kill – Willowemoc Watershed Initiative 1994-2002. 2003. Prepared by Trout Unlimited. An assessment of trout habitat in the Beaver kill and Willowemoc watersheds using applied hydrogeomorphic analysis.

Livingston Manor Airport-Mitigation Site Evaluation. 2004. Prepared by LU Engineers for NYSDOT. Discussion of the restoration of 800 yards of the Little Beaver Kill and creation of wetlands adjacent to the existing gravel pits. No significant flood reduction benefits were anticipated.

Pre-Disaster Mitigation Grant. 2005. Prepared by FEMA. A grant for the removal of 15 properties with repetitive flood damages. DRBC analyzed FEMA's National Flood Insurance Program for a total of 40 repetitive loss properties and 5 severe repetitive losses.

Feasibility Analysis Report. 2005. Prepared by McFarland-Johnson, Inc. The report indicated that a dry lake bed with storage volume of 700 acre-feet would be needed to provide protection from a 100-year return-period flood. A downstream levee was still considered necessary.

Flood Mitigation/Ecosystem Restoration Feasibility Study, Potential Study Concepts. 2006. Prepared by McFarland-Johnson, Inc. for the Town of Rockland. The study identified potential flood mitigation solutions that included: floodwater storage and stream restoration on the airport property; a flood wall and levee setback with channel relocation and riparian restoration along Pearl Street; stream relocation at the gravel pits; floodplain storage and wetland creation at poultry plant site; expansion of the main street bridge with restoration of the floodplain; levee removal at the high school; additional culvert installation at Covered Bridge Road; and floodwater storage and wetland creation through modification of existing impoundments in the Little Beaver Kill watershed (e.g., Matawa Lake).

New York State Hazard Mitigation Plan. 2006. Prepared by URS for FEMA. The purpose of this study was to document the maximum flooding elevations that occurred as a result of the heavy rains during the week of June 25, 2006.

Initial Appraisal Report. 2006. Prepared by USACE. Following flooding damages of $1.9 million in the Town of Rockland in September 2004 and April 2005, the report suggested solutions for the future. The structural solutions included channel improvements, floodwater bypassing, and modification of detention basins. Nonstructural solutions included flood proofing, raising structures, buyouts, floodplain restoration, and wetland creation.

Technical Support for Feasibility Study. 2007. Prepared by McFarland-Johnson for USACE. Study collected existing stream channel cross section data and recommended stability and hydrology and hydraulics analysis.

Addendum to Upper Delaware River Watershed Expedited Reconnaissance Study of 1997. 2008. Prepared by USACE. The reexamination of the Upper Delaware River Watershed in New York State to identify problems, needs and opportunities for improvements relating to local flood damage reduction, ecosystem restoration, water quality, and watershed management.

Multi-Jurisdictional Study for the Delaware River Basin. 2008. Prepared by USACE. A discussion of basin-wide flooding and water resource issues, including the Town of Rockland. Determined that the Town of Rockland does not want a structural flood damage reduction project that adversely impacts the natural values of the area.

2.0 Problem Identification

2.1 Problem Analysis

The Livingston Manor area has been subject to both local and widespread damage caused by the flooding of lands and property adjacent to its streams. Three waterways and their associated watersheds reach a confluence at the southern end of Livingston Manor. These waterways are the Willowemoc Creek, Little Beaver Kill Creek, and Cattail Brook. Repetitive flooding in Livingston Manor begins at a 5-year return-period flood interval for Little Beaver Kill Creek.

The area has a long history of flooding dating back to the late 1800s. Significant flooding also occurred in June 1969 and 1973. The Livingston Manor watersheds, like many others in the nation have been impacted by flooding because people live, work, travel, and recreate in floodplains, and because their land use activities have increased the runoff from watersheds and changed the hydraulics of the floodplain itself. As illustrated on the 2006 FEMA floodplain map (Figure 2.1), most of the Town lies within the 100-year floodplain.

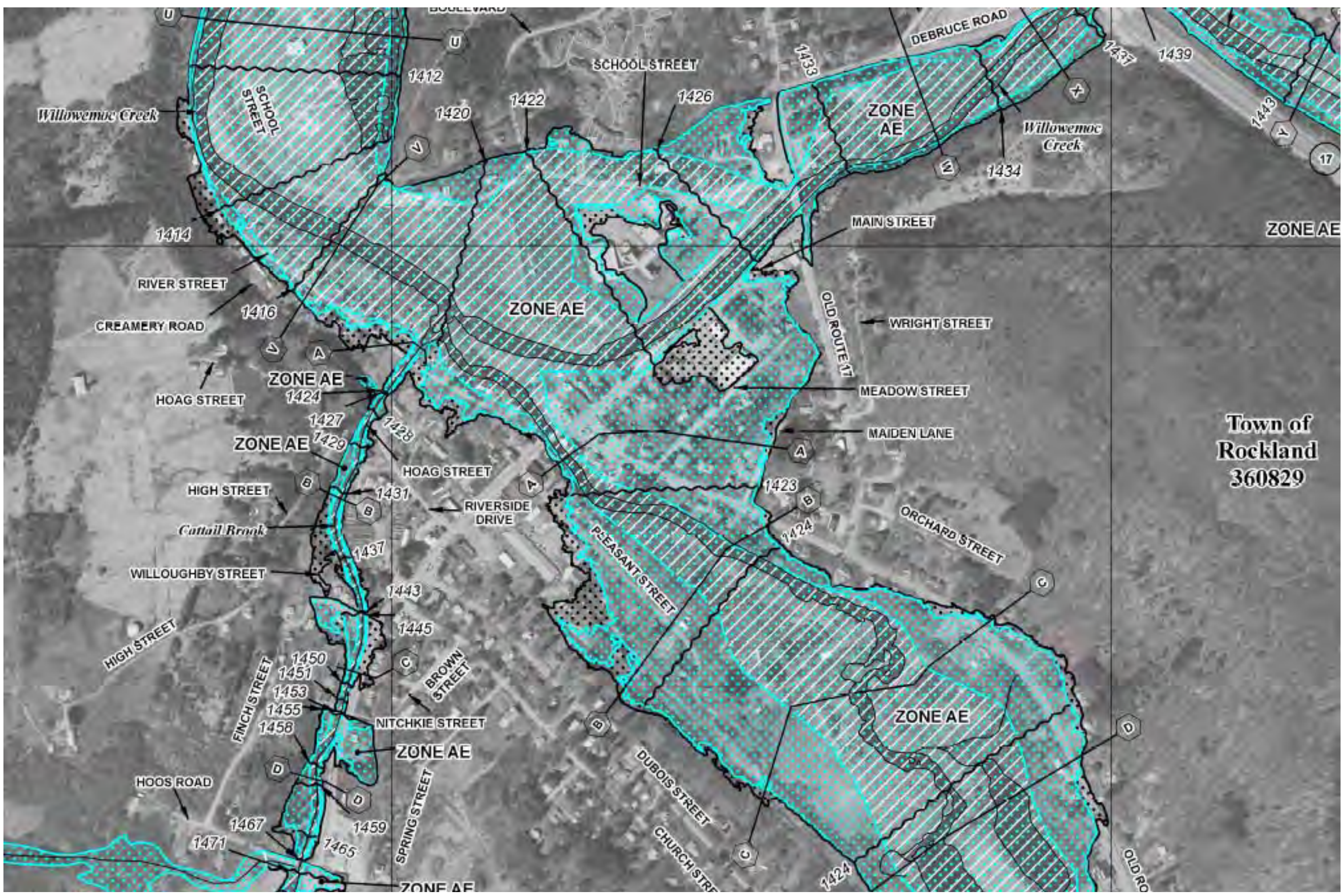


Figure 2.1: FEMA floodplain map depicting the 100-yr floodplain.

Flood events typically occur when storms move across the area with long duration or intense rainfalls. These storms are of two general types; storms of tropical origin (hurricanes) or storms of extra-tropical origin such as thunderstorms and northeasters. The movement of warm moist air into contact with surrounding air of lower temperature produces the violent thunderstorms and intense precipitation of the summer months and the northeasters of the cool months. The latter are of coastal origin and are accompanied by severe winds and heavy precipitation. When these storms are both slow moving (long duration) and intense, the worst flooding events are likely to occur. Other floods are caused by combinations of storms, snowmelt, and ice jams.

2.1.1 Recent Flood Events

In the past 20 years, the Livingston Manor area has been inundated by numerous flood events. For example, in 1996, flooding occurred in both January and November resulting in damaged roads, bridges, bridge piers and abutments, and several retaining walls. Total damage in 1996 to Sullivan County infrastructure was $5.5 million and damage to private property was $4.4 million. Major flooding also occurred in the subsequent years of 2004-2006. These three consecutive years of flooding was unprecedented and resulted in widespread damage to public and private property.

The June 2006 flood event was a major event for the Delaware River Watershed. This event was the result of extremely heavy rainfall over the Delaware River Basin from June 24 to 28. The National Weather Service data indicates that 6 to15 inches of rain fell in the Schuylkill, Lehigh, and upper Delaware River watersheds during the period. During the evening of June 27, National Weather Service flash flood warnings were in effect for nearly all counties in the Pennsylvania and New York portions of the basin. The highest flows in recorded history were observed during the June 2006 storm event at various USGS gages located on streams and tributaries in the upper portion of the study area watershed. The normal reading on the stream gauge on the downstream main stem Beaver Kill Creek at Cooks Falls is 185 cubic feet per second (cfs). During the June 2006 storm, this gauge was recorded at 45,900 cfs before the gauge station submerged and malfunctioned. Normal flow on the adjacent West Branch of the Neversink River in Claryville is 50 cfs. For this event it was recorded at 8,000 cfs before the gauge was inundated. On July 1, 2006, President Bush declared a major disaster for the State of New York triggering the release of federal funds to help communities recover from the severe storms and flooding in June 2006.

As recently as September 2012, approximately 5-7 inches of rain fell within 24 hrs, and the Cattail Brook overtopped its banks causing widespread property damage within Livingston Manor, including the loss of three bridges.

2.1.2 Damages to Flood Prone Areas

Impacts to Livingston Manor from flooding have been widespread and severe. Extensive damage to local infrastructure and private homes has occurred as a result of flooding. Six devastating floods have occurred in the area in the last 15 years (Jan 1996, December 2000, September 2004, April 2005, June 2006, and September 2012). Reported damages from the last three consecutive floods that were at, or above, the 100-year return-period are below:

September 2004: $770,000
April 2005: $1,000,000
June 2006: $4,000,000

The last two of these events were floods of record (April 2005 and June 2006), with June 2006 now considered the “flood of record” for the Delaware River Watershed. After the 2005 flood event, FEMA approved and is currently implementing a Voluntary Acquisition buyout of 15 homes at cost of $1.8 million. Of this amount, $1.45 million of this was provided by FEMA. Local interests are still responsible for their share of $360,000. The June 2006 event resulted in the first recorded flood fatality. A 15-year old girl drowned as her house collapsed into Cattail Brook.

Other losses associated with flooding events in the area have been streambank erosion and channel migration. Both of these have resulted in threats to public facilities, utility lines, and private and commercial structures.

Various areas of Livingston Manor are more susceptible to flooding than others. Some of the areas frequently impacted by flooding include Main St. Park (Figure 2.2), Main St. Bridge area (Figures 2.3 - 2.5), Pearl St. (Figure 2.6), and the Cattail Brook area (Figures 2.7 and 2.8).

Figure 2.2: The Main Street Park area at the confluence of the Willowomec and Little Beaver Kill creeks.

Figure 2.3: Looking upstream from the Main St. Bridge at an area normally impacted by flooding events.

Figure 2.4: Looking downstream at the Main St. Bridge, an area normally impacted by flooding events.

Figure 2.5: Aerial view of Main St. Bridge.

Figure 2.6: Pearl Street during 2006 flood event.

Figure 2.7: A house located on the Cattail Brook.

Figure 2.8: Cattail Brook looking downstream to confluence with Willowemoc Creek.

2.1.3 Ecological Impacts of Flooding

The detrimental impacts of the persistent and widespread flooding in the vicinity of Livingston Manor are not only damages to buildings and infrastructure. The flooding has also resulted in ecological degradation of the streams and riparian areas. The ecological problems include the scouring of habitat, channel instability, debris in the streams, thermal pollution, erosion and deposition, and wetland/floodplain losses.

Wetlands have been lost along the streams for a number of reasons including the construction of dams for recreational impoundments, residential development, and agriculture. This loss of wetlands has resulted in the elimination of two of the major functions that wetlands serve, which are sediment removal and wildlife habitat. Since the wetlands are not present to filter and retain sediment during out of bank flood events, much of it remains in the stream and increases turbidity, which can severely degrade the fish habitat. Many semi-aquatic and terrestrial organisms also rely on wetlands as a specialized habitat and cannot relocate once the wetlands have been eliminated.

Wetlands, as well as upland riparian areas, typically provide a vegetative cover for streams that helps to regulate the water temperature by shading out sunlight. This helps to maintain the cooler water temperatures that are required by native and sport fish such as trout. When the wetland and riparian vegetation is removed, the temperatures in the streams become too warm to sustain fish populations, especially in the summer months. Thermal stress caused by high summer water temperatures in the Willowemoc and Lower Beaverkill represent a limiting factor for trout populations in the lower and mid river system in many years (Trout Unlimited, 2003).

The ecological impacts also result in secondary economic impacts in the project area. Since fishing is a major tourist industry in Sullivan County, the health of the streams and the fish populations are essential to the economic well being of the region. The increased turbidity and the thermal pollution that have resulted from the loss of wetlands and riparian vegetation have made long sections of the streams inhospitable for local fish populations.

Another secondary economic impact related to ecological conditions is the exacerbation of floods due to wetland loss. Wetlands act like a sponge that provides natural flood storage during storm events. When they are eliminated and this storage capacity is taken away, the flood levels and damages downstream worsen. Resolution of these ecological issues is a high priority of the NYSDEC and stakeholder organizations such as The Nature Conservancy and Trout Unlimited.

2.2 Problem and Opportunity Identification

The problems identified in the Livingston Manor (Little Beaver Kill, Cattail Brook, and Willowemoc Creek Watersheds) are:

- Recurring flood damages to the commercial and residential areas of Livingston Manor and the Town of Rockland.
- Streambank erosion along Cattail and Little Beaver Kill within Livingston Manor.
- Degraded fish habitat in the watershed as a result of the scouring of stream beds and banks and loss of wetlands and riparian vegetation.
- Loss of fish habitat due to flooding, industrial activities (past dredging of stream), and stream encroachment by infrastructure (e.g., bridges).
- Invasive species (e.g., Japanese knotweed) colonizing streambanks and other natural areas.

There are opportunities in the Livingston Manor watersheds to:

- Reduce flooding damages in the Livingston Manor area.
- Restore degraded stream channels in the watershed.
- Move sewer infrastructure out of the floodplain.
- Restore the natural floodplain at the former Poultry Plant.
- Reduce frequent flooding in the Town of Rockland.
- Improve recreation along the world renowned trout fishery.
- Remediate a stream in an area dug for gravel pits.
- Improve water quality, which will reduce filtration and treatment costs.
- Improve unique bird watching opportunities along the waterfront.
- Restore degraded trout breeding habitat which can reduce the restocking frequency.
- Improve trout habitat to increase tourism revenue ($9M – 1994)
- Restore wetlands for flood water storage, sediment filtration, and wildlife habitat.
- Create a management plan for invasive species in the watershed.
- Improve water quality and aquatic habitat for imperiled native freshwater mussels.

Goals, Objectives, and Constraints

The goals of the Upper Delaware River Watershed, Livingston Manor Study are to reduce the occurrence of frequent flooding damages within the community of Livingston Manor, NY and improve aquatic habitat conditions for trout populations in the watersheds of Willowemoc Creek and the Little Beaver Kill Creek. The objectives of the study include:

- Reduce flooding damages in the Livingston Manor area for the less than 20-year storms by 2016.
- Reduce flooding damage along Main Street and Pearl Street in downtown Livingston Manor by 2016.
- Reduce the water surface elevation of storm floods along Pearl Street in Livingston Manor by 2016.
- Restore approximately one mile of ecologically degraded stream channel along the LBK at the old airport site by 2016.
- Improve water quality in Cattail Brook and the LBK in the Town of Rockland by 2016.
- Restore degraded riparian buffers with native vegetation by 2016.

- Eradicate invasive plant species in riparian buffer areas by 2016.

The study has numerous constraints associated with it. The following are constraints of the study:

- Ecosystem restoration options must not increase community flooding.
- Flood reduction strategies and structures must not further degrade trout habitat.
- Minimize the relocation of structures from downtown Livingston Manor.
- Flood reduction strategies may not impact federally listed endangered species.
- Flood reduction strategies must be acceptable to the non-federal sponsor and community.

3.0 Existing Conditions

3.1 Site Description

3.1.1 Climate

The project area drainage basin lies predominantly in Sullivan County, New York. Descriptions below for the climate in Sullivan County were taken, in part, from the 1989 Soil Survey of Sullivan County, New York.

Winters are cold and summers are warm in Sullivan County. The climate in the area is of the humid continental type. Valley areas in the south and east parts of the county are somewhat warmer and upper slopes and mountaintops are somewhat colder. Precipitation is generally heavy and evenly distributed throughout the year. In summer, it falls primarily during thunderstorms. Heavy rains from slow moving thunder storms occasionally cover the entire area and cause severe flooding. Table 3.1 provides historic precipitation and temperature data for the Livingston Manor project area. On average, the warmest month is July with the highest recorded temperature (99 degrees Fahrenheit) recorded in 1953 and 1988. January is the average coolest month of the year with the lowest temperature (-26 degrees Fahrenheit) on record occurring in 1963 (The Weather Channel, 2010).

The total annual precipitation averages 50 inches. Overall, rainfall is well distributed throughout the year. Thunderstorms occur approximately 31 days each year, with most occurring in summer. The average seasonal snowfall exceeds 70 inches. The greatest snow depth at any one time during the period of record was 48 inches. On the average, 58 days of the year have at least 1 inch of snow on the ground. The average relative humidity in mid-afternoon is about 60 percent with humidity at its highest during nights. The sunshine is experienced approximately 60 percent of the time possible during the summer and 35 percent of the time possible in winter (United States Department of Agriculture, 1989).

Potential impacts to environmental resources, particularly water resources, through changes in climate have increasingly become an important topic to discuss. The Intergovernmental Panel on Climate Change concluded that observed climate records and projections provide evidence that freshwater resources are vulnerable and may be strongly impacted and have wide ranging consequences on ecosystems and human societies (Bates et al, 2008). Observed evidence from around the world shows natural systems are being affected regionally with emphasis on temperature increases (Intergovernmental Panel on Climate Change, 2007). A United States Geological Survey study of the projected implications of climate change in the Delaware River watershed showed that with increasing median temperatures in the Beaver Kill and Willowemoc watershed, an increase in winter flows, decreased summer base flows and earlier runoff events were expected (Ayers et al, 1994). In responding to climate change at the regional level, integrated watershed management strategies include protecting and restoring natural systems, recognizing water quantity and water quality linkages, coordinating land and water resources management, and others (Brekke et al, 2009). In an effort to combat climate change at the local level in the state of New York, a partnership between local communities and the State are formed. Any county, city, village or town can join this partnership called "Climate Smart Communities". The objective of the partnership is to reduce greenhouse gas emission and save taxpayer dollars. Sullivan County is on the New York State list of climate smart communities (New York State Department of Conservation, 2010d).

Table 3.1: Monthly Precipitation and temperature averages for Livingston Manor, New York (The Weather Channel, 2010)

Month	Average High Temp.	Average Low Temp.	Mean Temp.	Record High Temp.	Record Low Temp.	Average Precipitation
January	31 ^oF	11 ^oF	21 ^oF	62 ^oF (2007)	-21 ^oF (1981)	3.77 inches
February	34 ^oF	13 ^oF	23 ^oF	73 ^oF (1954)	-26 ^oF (1963)	2.87 inches
March	43 ^oF	21 ^oF	32 ^oF	82 ^oF (1986)	-8 ^oF (1967)	3.77 inches
April	54 ^oF	32 ^oF	43 ^oF	89 ^oF (1976)	-3 ^oF (1982)	4.30 inches
May	66 ^oF	43 ^oF	55 ^oF	91 ^oF (1979)	19 ^oF (1986)	4.87 inches
June	74 ^oF	51 ^oF	63 ^oF	92 ^oF (2005)	31 ^oF (1986)	4.84 inches
July	79 ^oF	56 ^oF	68 ^oF	99 ^oF (1988)	38 ^oF (1988)	4.67 inches
August	78 ^oF	54 ^oF	66 ^oF	95 ^oF (2001)	34 ^oF (1986)	4.29 inches
September	70 ^oF	47 ^oF	58 ^oF	99 ^oF (1953)	24 ^oF (1974)	4.48 inches
October	59 ^oF	36 ^oF	47 ^oF	84 ^oF (1986)	15 ^oF (1972)	4.00 inches
November	46 ^oF	28 ^oF	37 ^oF	80 ^oF (1982)	2 ^oF (1951)	4.21 inches
December	35 ^oF	18 ^oF	26 ^oF	65 ^oF (2001)	-16 ^oF (1980)	3.86 inches

3.1.2 Air Quality

Air pollution originates from various sources including industry, motor vehicles, energy facilities, and many other human activities. Air pollution has the potential to harm human health and damage ecosystems. The Clean Air Act of 1970, last amended in 1990, required the United States Environmental Protection Agency (USEPA) to set National Ambient Air Quality Standards (NAAQS) for wide-spread pollutants from numerous and diverse sources considered harmful to the environment and public health (United States Environmental Protection Agency, 2010b). The USEPA has set NAAQS standards for six "criteria" pollutants including carbon monoxide (CO), lead (Pb), nitrogen dioxide (NO_2), Ozone (O_3), particulate matter (PM), and sulfur dioxide (SO_2).

The Department of Environmental Conservation implements the state and federal air pollution control and monitoring programs in the State of New York. Air quality is monitored by the Division of Air Resources. Air quality monitoring is conducted by placing air monitors at various locations within the state. More than 80 ambient air quality continuous and manual monitoring sites exist across the state. Direct real time measurements include gaseous criteria pollutants (ozone, sulfur dioxide, oxides of nitrogen, carbon monoxide), $PM_{2.5}$ (particulate matter with less than 2.5 microns diameter), and meteorological data. Collected data is compiled into ambient air quality reports and are provided to the public and technical community. The EPA's "Green Book" identifies those areas of the country and the criteria pollutants that persistently exceed the national ambient air quality standards and are designated non-attainment. From 1980 through 2010, Sullivan County New York has been within attainment standards established by USEPA (United States Environmental Protection Agency, 2010a).

An Air Quality Index (AQI) developed by the USEPA is published daily for regions in New York as a means of reporting air quality to the general public. The state has been broken down into eight "Air Quality Health Advisory" regions. Sullivan County is located within Region III known as the Lower Hudson Valley advisory region. The AQI tells how clean or polluted the air is, and what associated health effects might be a concern (Table 3.2). It was created as an easy way to correlate levels of different pollutants to one scale; the higher the AQI value, the greater the health concern. When levels of ozone and/or fine particles are expected to exceed a higher threshold AQI value, an Air Quality Health Advisory is issued which alerts sensitive groups to take necessary precautions (New York State Department of Conservation, 2010a). In the Earth's lower atmosphere, near ground level, "bad" ozone is formed when pollutants emitted by motor vehicles, power plants, industrial boilers, refineries, and other sources react chemically in the presence of sunlight and is a harmful air pollutant. Fine Particle pollution (Particulate Matter) in the air includes a mixture of solids and liquid droplets. Some particles are emitted directly; others are formed in the atmosphere when other pollutants react. Those less than 2.5 micrometers in diameter are so small that they can enter the lungs, potentially causing serious health problems. The forecasting season for ozone is from May through September, whereas, fine particulate sampling is conducted year round.

Table 3.2: New York Air Quality Index Table
(New York State Department of Conservation, 2010a)

Air Quality Index Values (when AQI is in this range….)	Levels of Health Concern (air quality conditions are…….)	Cautionary Statement (per Air Quality level……..)
0 to 50	Good	Air quality is considered satisfactory and air pollution poses little or no risk
51to 100	Moderate	Air quality is acceptable. Some pollutants may pose a moderate health concern for a very small number of people who are unusually sensitive.
101 to 150	Unhealthy for sensitive groups	Member of sensitive groups may experience health effects. General public not likely affected.
151 to 200	Unhealthy	Everyone may begin to experience health effects; members of sensitive groups may experience more serious effects.
201 to 300	Very unhealthy	Health alert, everyone may experience more serious health effects
301 to 500	Hazardous	Health warnings of emergency conditions. The entire population is more likely to be affected.
FINE PARTICLES		
Air Quality Values	Levels of Health Concern	Cautionary Statements
0 to 50	Good	None
51to 100	Moderate	Unusually sensitive people should consider reducing prolonged or heavy exertion.
101 to 150	Unhealthy for sensitive groups	People with heart or lung disease, older adults, and children should reduce prolonged or heavy exertion.
151 to 200	Unhealthy	People with heart or lung disease, older adults, and children should avoid prolonged or heavy exertion. Everyone else should reduce prolonged or heavy exertion.
201 to 300	Very unhealthy	People with heart or lung disease, older adults, and children should avoid all physical activity outdoors. Everyone else should avoid prolonged or heavy exertion.
301 to 500	Hazardous	People with heart or lung disease, older adults, and children should remain indoors and keep activity levels low. Everyone else should avoid all physical activity outdoors.
OZONE		
Air Quality Values	Levels of Health Concern	Cautionary Statements
0 to 50	Good	None
51to 100	Moderate	Unusually sensitive people should consider reducing prolonged or heavy exertion.
101 to 150	Unhealthy for sensitive groups	Active children and adults, and people with lung disease, such as asthma, should reduce prolonged or

		heavy exertion outdoors.
151 to 200	Unhealthy	Active children and adults, and people with lung disease, such as asthma, should avoid all exertion outdoors. Everyone else, especially children, should reduce prolonged or heavy exertion outdoors.
201 to 300	Very unhealthy	Active children and adults, and people with lung disease, such as asthma, should avoid all outdoor exertion. Everyone else, especially children, should avoid prolonged or heavy exertion outdoors.
301 to 500	Hazardous	Everyone should avoid all physical activity outdoors.

3.1.3 Topography, Geology and Soils

The topography, geology, and soils of the project and surrounding areas within Sullivan County have been exhaustively studied and catalogued by the U.S. Department of Agriculture, Soil Conservation Service in cooperation with Cornell University Agricultural Experiment Station. The information provided in this topography section was taken from the 1989 Soil Survey of Sullivan County, New York.

As described in the 1989 Sullivan County soil survey, Sullivan County lies mainly within the Appalachian Plateaus province, which is divided into several sections. The northern one-third of the county consists of the Catskill section. The largest part of the county is the Southern New York section just south of the Catskill Mountains. This part is a deeply dissected plateau that slopes gently to the southwest. The southeast edge of this plateau is bounded by a fairly steep, prominent escarpment. The highest elevations in the county are in the Catskill section and include mountain elevations of 3,051 feet, 2,985 feet and 3,118 feet. Relief in this area is commonly steep. South of the Catskill Mountains in the Southern New York section, elevations range from about 2,000 feet in the north part to about 1,200 feet in the south part. The lowest elevation in this section is approximately 480 feet. Relief is generally steeper in the west part of this section and less steep in the central and south areas except for valley sides of the Delaware River and the lower Neversink River. A small part of southeastern Sullivan County lies in the Ridge and Valley province. In the Ridge and Valley section, elevations range from about 1,780 feet at the north to about 1,200 feet at the south end. The lowest point in this section is approximately 380 feet.

Bedrock underlying all physiographic areas of Sullivan County is of sedimentary origin. The bedrock formations are oldest at the southeast edge of the county next to Orange County and become progressively younger in a northwesterly direction toward Delaware County. The overall project area is located within the Catskill Formation of Middle and Upper Devonian age rock. The Beaver Kill basin is underlain by this bedrock (Reynolds, 2000). These rocks are mainly red and grayish brown sandstone and shale and include the Stony Clove and Katsburg Formations and the undifferentiated Hamilton Group. The Livingston Manor project area is within the Lower Katsburg bedrock formation (Dsd) with portions of the watershed falling within the Upper Katsburg bedrock formation (Djwh).

Approximately 10,000 years ago, Sullivan County was completely glaciated during the last ice age known as the Wisconsin Glaciation. Much of the county is therefore covered by glacial till, an unsorted mixture of sand, silt, clay, and rock fragments. Glacial till covers approximately 92 percent of the area within the Beaver Kill basin (Reynolds, 2000). Depth of this material in the county ranges from just a few inches on hilltops to several hundred feet in some valleys. Swartswood, Lackawanna, and Wellsboro soils are examples of soils that formed in glacial till. Other common glacial deposits include glacial outwash, which is coarse sandy and gravelly material deposited by meltwater flowing from the glacier. These deposits occur as outwash plains or as small rounded hills, ridges, or terraces along valley sides. Tunkhannock, Chenango, and Red Hook soils are examples of soils that formed in glacial outwash. Most of the fine sand, silt and clay particles in glacial meltwater settled out in lakes or ponds. These lacustrine deposits occur in several parts of the county but are most extensive in the valleys of the Shawangunk and Basher Kills. Scio, Raynham, and Wallington soils formed in these deposits. The glaciation of Sullivan County also resulted in many small shallow lakes that gradually filled with partly decomposed plant material. The remnants of these glacial lakes, now filled with peat or muck, are scattered throughout the county. Carlisle and Palms soils formed in these deposits (United States Department of Agriculture, 1989).

Map unit delineation on a soil map represents an area dominated by one major kind of soil or an area dominated by several kinds of soil. A map unit is identified and named according to the taxonomic classification of the dominant soil or soils. There are approximately 122 major soil mapping units in Sullivan County, New York. Of these, approximately 55 are found within the project area. The types of work and land disturbance expected in the proposed study would be located within open water and floodplain areas. Table 3.3 lists those soil series and mapping units typically found within these landforms of the project area (United States Department of Agriculture, 1989).

Table 3.3: Project area soil series and mapping units

SOIL SERIES	MAJOR MAP UNIT	MAP UNIT SOIL NAME	RATING
Barbour Series	Bb	Barbour loam	All areas are Prime Farmland
Bash Series	Bs	Bash Silt loam	Prime Farmland if drained
Cheshire Series	CsB	Cheshire channery loam, 3-8 % slopes, stony	All areas are Prime Farmland
Cheshire Series	CsF	Cheshire channery loam, 35-60 % slopes, stony	Not Prime Farmland
Fluvaquents	Fu	Fluvaquents-Udifluvents complex, frequently flooded	Not Prime Farmland
Lackawanna Series	LaD	Lackawanna channery loam, 15-25 % slopes	Not Prime Farmland
Pompton Series	PmA	Pompton gravelly fine sandy loam, 0-3 % slope	All Areas are Prime Farmland

Suncook Series	Sn	Suncook fine sandy loam	Farmland of Statewide Importance
Tunkhannock Series	TkA	Tunkhannock gravelly loam, 0-3 %slopes	All areas are Prime Farmland
Udorthents	Ud	Udorthents, smoothed	Not Prime Farmland
Wellsboro Series	WeC	Wellsboro gravelly loam, 8-15 % slopes	Farmland of Statewide Importance

3.1.4 Prime and Unique Farmland

Prime Farmlands, as described in the 1989 Soil Survey for Sullivan County, New York include:

> "*The U.S. Department of Agriculture defines prime farmland as the land that is best suited to producing food, feed, forage, fiber, and oilseed crops. It has the soil quality, growing season, and moisture supply needed to produce a sustained high yield of crops while using acceptable farming methods. Prime farmland produces the highest yields and requires minimal amounts of energy and economic resources, and farming it results in the least damage to the environment. An area identified as prime farmland must be used for producing food or fiber or must be available for those uses. Thus, urban and built-up land and water areas are not classified as prime farmland.*"

Unique Farmlands, as described by the United States Department of Agriculture's (USDA) Soil Surveys include:

> *"Unique farmland is land other than prime farmland that is used for the production of specific high-value food and fiber crops. It has the special combination of soil quality, location, growing season and moisture supply needed to produce sustained high quality and/or high yields of a specific crop when treated and managed according to modern farming methods. Examples of such crops are citrus, olives, cranberries, fruit and vegetables."*

The general criteria for prime farmland include: favorable temperature and growing-season length, a generally adequate and dependable supply of moisture from irrigation or precipitation, acceptable levels of acidity or alkalinity, permeability to air and water, and few or no rocks. Prime farmland is not flooded during the growing season, excessively erodible, and is not saturated with water for long periods of time. The slopes generally range from 0 to 8 percent. The Sullivan County survey area contains about 39,000 acres of prime farmland that represents about 6.2 percent of the total acreage in the survey area. The majority of the prime farmlands are located in the west-central part of the county. The soil map units that make up prime farmland only in the Sullivan County survey area are listed in Table 3-4. Some soils in Table 3-4 are classified as prime farmland if certain limitations of the soil are overcome. The measures needed to overcome the limitations of these soils are given in parentheses after the name of the map unit (United States Department of Agriculture, 1989). As per coordination with the Sullivan County Soil District, no prime agricultural soils in the Livingston Manor project area will be affected by proposed work.

Table 3.4: Sullivan County Prime Farmland Soils

Map Symbol	Soil Name
Bb	Barbour loam
Bs	Sash silt loam (where drained)
ChA	Chenango gravelly loam, 0 to 3 percent slopes
ChB	Chenango gravelly loam, 3 to 8 percent slopes
LaB	Lackawanna channery loam, 3 to 8 percent slopes
LeB	Lewbeach silt loam, 3 to 8 percent slopes
LoB	Lordstown silt loam, 3 to 8 percent slopes, stony
Pe	Philo silt loam
PrnA	Pompton gravelly fine sandy loam, 0 to 3 percent slopes
PrnB	Pompton gravelly fine sandy loam, 3 to 8 percent slopes
Po	Pope silt loam, occasionally flooded
Pp	Pope very fine sandy loam, rarely flooded
Ra	Raynham silt loam (where drained)
Re	Red Hook sandy loam (where drained)
RhA	Riverhead sandy loam, 0 to 3 percent slopes
RhB	Riverhead sandy loam, 3 to 8 percent slopes
SaB	Scio silt loam, 2 to 6 percent slopes
TkA	Tunkhannock gravelly loam, 0 to 3 percent slopes
TkB	Tunkhannock gravelly loam, 3 to 8 percent slopes
UnA	Unadilla silt loam, 0 to 2 percent slopes
UnB	Unadilla silt loam, 2 to 6 percent slopes
VaB	Valois gravelly sandy loam, 3 to 8 percent slopes
Wa	Wallington silt loam (where drained)

3.1.5 Land Use, Recreation and Tourism

Land use in the county ranges from vast open space areas such as the Upper Delaware Scenic and Recreational River and Catskill Park to densely populated areas and farming communities (Sullivan County Division of Public Works, 2010). Sullivan County is approximately seventy eight percent forested making it one of the most forested counties in the state (Sullivan 2020 Volume II: The Toolbox, 2005). Non forested areas of disturbance within the county are associated primarily with residential uses and active agriculture. Land uses in the county include vacant lands, commercial, recreational, industrial, conservation, and agricultural such as row crops, orchards, livestock and others.

Sullivan County was officially formed in 1809. Timber was abundant within the county and was in great demand during that time period. Timber rafting was the first major industry in Sullivan County. The construction of the Delaware and Hudson Canal system in 1828 resulted in exponential population growth and the transition to the tanning industry throughout the mid-1800. As a result of the landscape change (removal of trees) and depletion of forests associated with timber harvesting and tanning, the tanning and timber harvesting industries diminished. The county transitioned to the tourism industry in the late 1800's which was viable until the mid-1900. During this period, numerous resorts and hotels prospered. Sullivan County resorts offered a fresh and clean countryside with amenities such as fishing, golf, skiing, and other forms of entertainment for many people coming from metropolitan areas such as New York City. Factors that resulted in the decline of the tourism industry in the 1960's included inexpensive air travel, proliferation of air conditioning, and the growth of suburbia. Presently, tourism is still the primary industry within the county.

The Sullivan County economic policy is to redefine its image as a tourism destination by capitalizing on natural and scenic features, the arts and culture, and adventure and recreational sports found within the county. The 2020 Sullivan County tourism goal states "Create a diversified tourism industry with a balanced mix of year-round activities that include eco-tourism and recreational venues, agri-tourism, casinos, hotels and resorts, and the cultural arts" (Sullivan 2020 Volume II, 2005).

Sullivan County offers museum and historic sites, antique shops, art galleries, and golf courses as opportunities and attractions. The county maintains The Delaware and Hudson Canal Linear Park, Lake Superior State Park, Minisink Battleground Park, Stone Arch Bridge Historical Park, Livingston Manor Covered Bridge Park, Sullivan County Museum, and Fort Delaware Museum of Colonial History. The Upper Delaware River and the Catskill Mountains also provide for outdoor activities such as horseback riding, boating, camping, and eagle watching. Hunting, fishing, and hiking are major recreation activities in the area. More than one hundred reservoirs, ponds, and lakes, in the county are available for water sports. The Delaware River provides opportunities for canoeing and fishing and is designated a wild and scenic river.

The Sullivan County area lays claim to being the "birthplace of fly-fishing in the United States" largely because of trout fishing on the 27-mile-long Willowemoc Creek which flows between Livingston Manor and Roscoe, New York, where it intersects the Beaver Kill. The streams are stocked annually by the State of New York. All of the stocked fish (1 million pounds each year) for the Catskills as well all the reservoirs in the New York City water supply come from the Catskill Fish Hatchery just northeast of Livingston Manor in DeBruce, New York. The Catskill Fly Fishing Center and Museum is on the northern edge of Livingston Manor and is located near the Willowemoc Creek. Trout fishing in the Beaver Kill and Willowemoc watershed contributed nearly 10 million dollars to the Town of Rockland in 1994 alone (Conyngham and Gillespie, 2003).

3.1.6 Hazardous, Toxic and Radioactive Waste

Hazardous, Toxic and Radioactive Wastes (HTRW) are defined as any "hazardous substance" regulated under the Comprehensive Environmental Response Compensation and Liability Act (CERCLA§103) of the United States Code (42 U.S.C. §9603). Hazardous substances regulated under CERCLA include: 1) "hazardous wastes" under Section 3001 of the Resource Conservation and Recovery Act (RCRA), 2) "hazardous substances" identified under Section 311 of the Clean Air Act, 3) "toxic pollutants" designated under Section 307 of the Clean Water Act, 4) "hazardous air pollutants" designated under Section 112 of the Clean

Air Act, and 5) "imminently hazardous chemical substances or mixtures" that the Environmental Protection Agency (EPA) has taken action on under Section 7 of the Toxic Substance Control Act.

A database search of HTRW locations in the study area was completed by Environmental Data Resources for the USACE Philadelphia District in 2006. The purpose of the database searches and reports was to identify potential HTRW sources as a preface to future, focused site identification and investigations.

Table 3.5 presents the category of HTRW and the number of sites that the database searched identified as being within the study area. Note that these numbers should be considered to be approximate values as there was some interpretation as to where the sites fell relative to the floodplain. Often times there are more than one address or report for a given site number, particularly where there were spill or release reports in the database.

A review of the database search indicated that a majority of the identified sites were related to oil spills, primarily due to heating oil system overfilling or system failures. These are relatively small spills and due to the locations (in or near homes or commercial properties) are likely to have been properly remediated. Additionally, since they are located in or near private properties, they are not likely to be in areas considered for project activities. Although no specific HTRW sites were identified within the areas proposed for modification or excavation, further investigation of these areas is strongly recommended to better characterize the materials and to sample and analyze materials for chemical constituents and concentrations.

Table 3.5: HTRW Sites in the Project Area

Category	Number of Sites
RCRA Small Quantity Waste Generator	1
Facility Index System (FINDS)	4
Leaking Storage Tanks (LTANKS)	3
Historic Leaking Storage Tanks (HIST LTANKS)	3
Underground Storage Tank (UST)	1
Historic Underground Storage Tank (HIST UST)	2
Aboveground Storage Tank (AST)	1
Historic Aboveground Storage Tank (HIST AST)	1
Hazardous Waste Manifest (MANIFEST)	1
New York State Spills Information (NY SPILLS)	17
New York State Historic Spills Information (NY HIST SPILLS)	8
State Pollutant Discharge Elimination System (SPDES)	1

In December 2006, a Geologist and Environmental Specialist from the USACE Philadelphia District performed a preliminary investigation of the existing site conditions in the Livingston Manor area. This investigation was conducted to observe and evaluate the environmental conditions in the vicinity of Cattail Brook, Little Beaver Kill Creek and

Willowemoc Creek that could require remedial activities if a flood risk management solution was constructed. Accessibility of the proposed work areas was also evaluated in the event an investigation is required to evaluate the subsurface conditions.

Areas of potential modification in support of flood-related work with possible HTRW interests would include the poultry production property (chemicals, fuel utilities and a discolored seep area), the airport property (chemical, fuel and deicer products) and any properties that were subjected to fuel spills.

It is possible that the properties within the study areas could be subjected to spills, leaks, etc. during normal operations or extraordinary circumstances. Such issues would have to be dealt with by the State or local authorities prior to moving forward with the project.

3.1.7 Wild and Scenic Rivers

Congress created the National Wild and Scenic Rivers System in 1968 to preserve the free flowing conditions of certain rivers with outstanding natural, cultural, and recreational values for the enjoyment of present and future generations. The Wild & Scenic Rivers Act 1968 PL 92-542 classifies rivers as wild, scenic, or recreational. Wild rivers are rivers or sections of rivers that are free of impoundments and generally inaccessible except by trails. Scenic rivers are rivers or sections of rivers that are free of impoundments, contain watersheds and shorelines largely primitive and undeveloped but are accessible in places by roads. Recreational rivers are rivers or sections of rivers readily accessible by roads or railroads, may have some shoreline development, and may have past impoundments or diversions.

On November 10, 1978, a 73 mile segment of the Delaware River from the confluence of the East and West Branches below Hancock, New York, to the existing railroad bridge downstream of Cherry Island in the vicinity of Sparrow Bush, New York was designated The Upper Delaware Scenic and Recreational River. This segment includes parts of five counties to include Sullivan County, New York. The Beaver Kill and Willowemoc Creek drain the northwest part of the county, flowing westward into Delaware County and eventually into the East Branch of the Delaware River. The project area is not a wild and scenic river but is found within the watershed of the Upper Delaware River.

3.1.8 Aquatic Resources and Wetlands

3.1.8.1 Surface Waters

As described in the Sullivan County (1989) Soil Survey, most of Sullivan County is drained by the Delaware River or its tributaries. A small area located in the east part of the county flows into the Hudson River drainage system. The Beaver Kill and Willowemoc Creek drain the northwest part of the county, flowing westward into Delaware County and eventually into the East Branch of the Delaware River. Streams draining the west and south parts of the County include Hankins Creek, Callicoon Creek, and Ten Mile River. The Mongaup River drains a large part of the central and south parts of the County. The Neversink River flows from Ulster County into the northeast part of Sullivan County, continues southward through the towns of Fallsburg, Thompson, and Forestburg and then flows into Orange County. The Basher Kill drains much of the town of Mamakating in the east part of the county. The Shawangunk Kill, Homowack Kill, and Rondout Creek drain some extreme east parts of the county and eventually flow into the Hudson River.

Generally, the streams in Sullivan County have cut deeply into the landscape and have steep valley sides and relatively narrow flood plains. Livingston Manor is located at the confluence of the Little Beaver Kill, Cattail Brook, and the Willowemoc Creek. The project area is located within the drainage basin of the Delaware River. Little Beaver Kill originates in hills northeast of Parksville, NY. The Little Beaver Kill flows to the west and joins the Willowemoc Creek. The Willowemoc subsequently discharges into the mainstem Beaver Kill in the village of Roscoe, NY. Reynolds (2000) referenced a study of hydrogeological factors that affect stream flows in Catskill streams and other areas. Of the 13 Catskill streams studied, the Beaver Kill and Willowemoc Creek had the highest mean annual discharges. It was concluded that dry weather flows of these stream are sustained by groundwater being discharged primarily from sandstone members of the Catskill Formation bedrock underlying the basin.

Waters of the State of New York are provided a water quality classification based on existing and expected best usages with standards of quality and purity established for all classifications. The classification system has been developed by the New York State Department of Environmental Conservation. Stream classifications of water bodies in the project area are classified as C (TS) according to the NYSDEC. Streams classified as C (T) or higher are subject to NYSDEC's Protection of Waters permit program. The "T" designation indicates that the waters are suitable for trout, and the "TS" designation indicates the waters are suitable for trout spawning. Table 3.6 shows the State classification and standard associated with the three main stream systems within the project area.

Table 3.6: New York State water body classification for primary waters in the project area

Stream Name	Classification	Standard Designation
Little Beaver Kill	B (Best usage for swimming, other recreation, and fishing)	T (Trout waters)
Willowemoc Creek	C (Best usage for fishing)	TS (Trout waters suitable for spawning)
Cattail Brook	B (Best usage for swimming, other recreation, and fishing)	TS (Trout waters suitable for spawning)

Overall, the surface water quality of the Little Beaver Kill and Willowemoc Creek are very good to excellent. Seasonal high water temperatures and thermal stress is the main water quality concern and the main limiting factor affecting aquatic species and trout production in the 100 square mile project study area. Although many factors play a part in increases in water temperatures and the subsequent stress on aquatic species in the project area, the major overlying concerns include impacts from heated road runoff, loss of riparian and instream cover, stream gravel mining activities, sedimentation, unstable stream channel geometry, stormwater management, and floodplain loss (New York State Department of Environmental Conservation, 2002; Conyngham, J and N. Gillespie, 2003).

3.1.8.2 Stream Habitat and Stability

The current stream stability and subsequent habitat availability in the Little Beaver Kill and Willowemoc Creeks has been the result of numerous anthropogenic and natural impacts over time in the watershed and specifically the project area. Encroachments into flood plains, stream gravel mining, straightening and armoring of channels, transportation system development (railroads and road systems), infrastructure and bridge construction and maintenance, poor stormwater management, increased flows, and drought are but a few of the impacts that have helped create and presently define the stream system seen today in the project study area. In an assessment of basin geomorphology and fluvial processes in the Beaver Kill-Willowemoc watershed, Conyngham and Gillespie, (2003) noted the following findings:

- Uppermost watershed sites show generally good to excellent habitat, with low width/depth ratios and high pool distribution.
- Width/depth ratios increase significantly as drainage area increases—although some increase is to be expected, the rate of increase in this parameter exacerbates the system’s vulnerability to thermal extremes. Bedrock exercises local controls at specific sites.
- Incised, trapezoidal channels and lack of thalweg (deepest thread of the channel, holding the lowest base flow) characterize the lower system (associated with high width/depth ratios). The channel width at extreme low flows is essentially the same as it is at bankfull flows, and the entrenchment ratio is low. This geometry has negative implications for thermal stress, homogenous hydraulics, and very high velocities during high flow events.
- Lack of pool habitat in the lower Beaver Kill—the longitudinal profiles, aerial photographs, and car/foot surveys show a decreasing distribution of true low-gradient, low velocity, deep pool structures as drainage area increases.
- Coarsening of substrate—average size of river substrate should decrease as one descends the channel system and gradients decrease. In the Beaver Kill/Willowemoc system the opposite is true.
- Presence of chute cutoffs, split channels, and truncated meanders, affecting width/depth ratios and channel slopes in the lower system.
- A high presence of bank armor characterizes certain reaches, particularly in the lower system.

- Associated with loss of floodplains, infrastructure encroachment, bank armoring, and gravel mining. The channel planform and sinuosity have been affected by avulsions and meander truncation.
- The lowest section of the river may be rebuilding a stable geometry due to increased sediment supply and grade control at the mouth of the system.
- Surveys indicate multiple instances of gravel deltas or hardened, channelized sections at tributary mouths, limiting or eliminating fish passage in the lower discharges of summer droughts and fall spawning periods.
- Significant portions of the original floodplain throughout the middle and lower reaches of the system have been compromised or eliminated by presence of road beds, rail beds, bridges, fill, berms, or incision of reaches of stream bed. Low entrenchment ratios in areas with well-developed floodplains (now abandoned and functioning as terraces) are strong indicators of incision.
- Impacts are largely absent in the upper system, locally present in middle reaches, and prevalent in lower sections of the Beaver Kill and many of its tributaries. The level of impact in the lower system is moderate, due to the system's large substrate. High width/depth ratios and trapezoidal channels exacerbate climatic thermal stress. Fisheries restoration goals should be to improve biological conditions in moderate years and reduce thermal stress in extreme years by narrowing overwide channels, restoring cross-sectional complexity, and restoring tributary mouths for fish passage and thermal refuges.

3.1.8.3 Groundwater

The main source of water in Sullivan County is ground water. Ground water is drawn from three kinds of aquifers: bedrock, glacial till, and glacial outwash. The glacial outwash yields the greatest amount of water and provides several public water supplies. The bedrock aquifer is the most commonly used and widely available source of water. Fractures in the rock hold ground water. This kind of aquifer can supply small or moderate amounts of water. Glacial till is generally not a reliable source of water because its yields are low. Three hundred and seventy one wells drilled into the Catskill formation showed well depths ranging from 5 to 960 feet with an average yield of 25 gallons per minute and a range of 0 to 600 gallons per minute (Reynolds, 2000). Surface water from lakes or reservoirs supplies water for several of the larger communities in the county. Springs supply water in small amounts (United States Department of Agriculture, 1989). Groundwater from the Catskill Formation is used for domestic, municipal, and industrial water supplies and generally has excellent water quality without treatment (Reynolds, 2000).

3.1.8.4 Wetlands

The United States Fish and Wildlife Service utilizes a wetland and deepwater habitats classification system developed by Cowardin et al (1979) which places ecologically similar habitats into a hierarchal system that permits wetland classification down to dominance types, which are based on dominant plants or substrates. The system can be used for inventory and mapping for Federal and State wetland inventories. It also has provided a uniformity of wetland terminology. The United States Fish and Wildlife Service use this classification to determine wetland status and trends.

The National Wetlands Inventory project, administered by the U.S. Fish and Wildlife Service, was established to generate information about the characteristics, extent and status of the Nation's wetlands and deepwater habitats. This information is used by Federal, State, and local agencies, academic institutions, U.S. Congress, and the private sector. The Emergency Wetland Resources Act of 1986 directs the Service to map the wetlands of the United States. The National Wetlands Inventory uses information on hydrology, hydrophytes, and hydric soils to delineate wetlands and deepwater habitats in accordance with national photographic, cartographic, and digitizing standards.

The project area watershed has a variety of wetland resources. These wetland resources vary in landscape position, size, vegetation, hydrological condition, and function. Some more notable functions include: stream flow maintenance; sediment retention; diverse wildlife habitats; surface water detention; and nutrient transformation. These functions likely play an important role in project area water quality and flood management. As seen in Figure 3.1, wetlands mapped in the project area are typically hydraulically or physically connected to stream resources. Table 3.7 provides the alpha numeric wetland codes and classification description of each wetland type found in the project area based on data taken from the U.S. Fish and Wildlife Service wetlands mapper. New York State’s freshwater wetlands are protected under the Freshwater Wetlands Act (Article 24) of the Environmental Conservation Law.

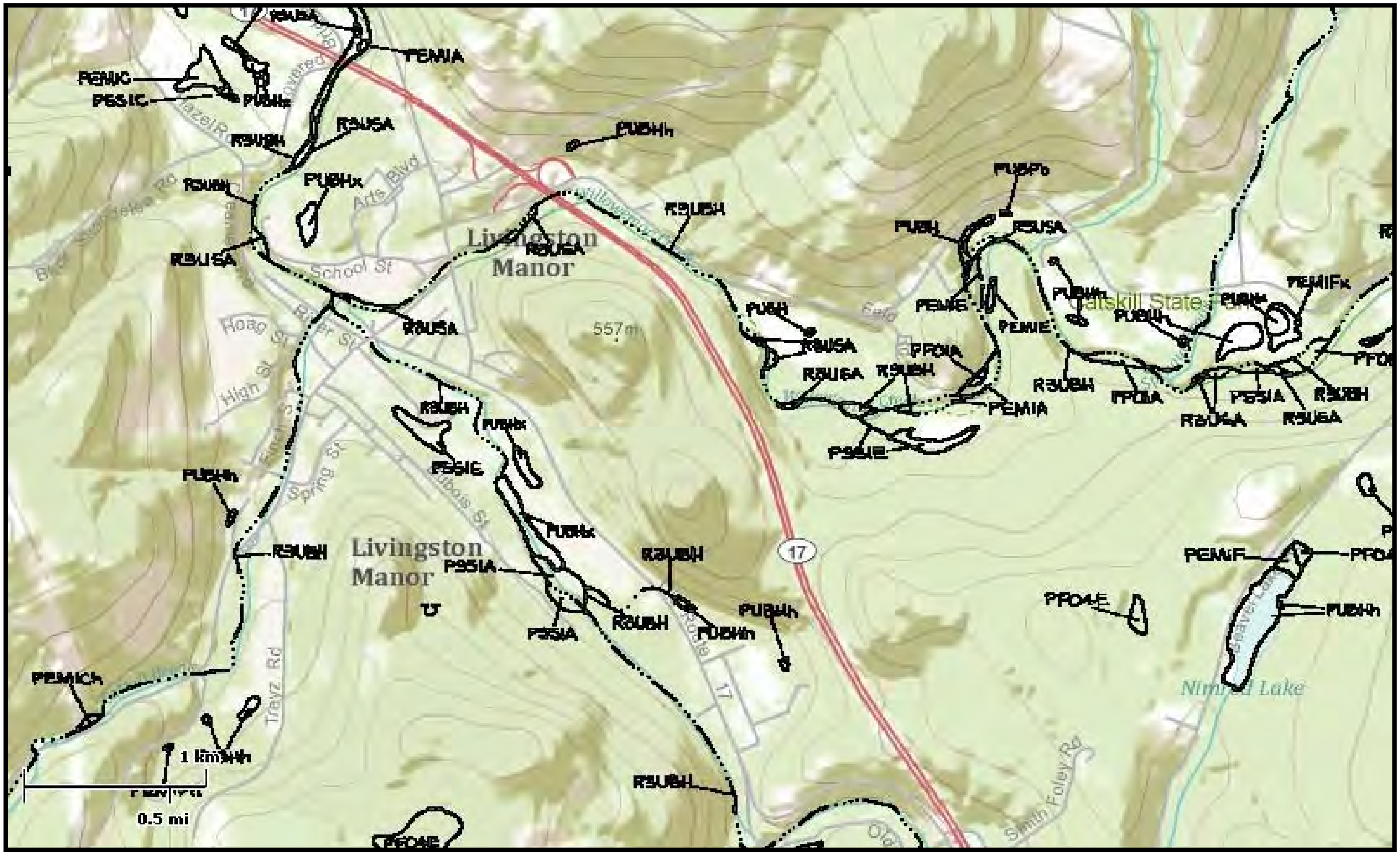


Figure 3.1: U.S. Fish and Wildlife Service National Wetlands Inventory of the types of wetlands found in the Livingston Manor, New York project area

(United States Fish and Wildlife Service, 2010b)

Table 3.7: Livingston Manor project study area wetlands (United States Fish and Wildlife Service 2010b)

Wetland Code	System	Sub-System	Class	Sub-Class	Water Regime	Special Modifier
PEM1A	Palustrine	*	Emergent	Persistent	Temporarily Flooded	*
PEM1C	Palustrine	*	Emergent	Persistent	Seasonally Flooded	*
PEM1E	Palustrine	*	Emergent	Persistent	Seasonally Flooded/ Saturated	*
PEM1Ch	Palustrine	*	Emergent	Persistent	Seasonally Flooded	Diked/ Impounded
PEM1Eh	Palustrine	*	Emergent	Persistent	Seasonally Flooded/ Saturated	Diked/ Impounded
PEM1Fh	Palustrine	*	Emergent	Persistent	Semi-Permanently Flooded	Diked/ Impounded
R3UBH	Riverine	Upper Perennial	Unconsolidated Bottom	*	Permanently Flooded	*
R3USA	Riverine	Upper Perennial	Unconsolidated Shore	*	Temporarily Flooded	*
PUBHh	Palustrine	*	Unconsolidated Bottom	*	Permanently Flooded	Diked/ Impounded
PUBHx	Palustrine	*	Unconsolidated Bottom	*	Permanently Flooded	Excavated
PUBH	Palustrine	*	Unconsolidated Bottom	*	Permanently Flooded	*
PUBFb	Palustrine	*	Unconsolidated Bottom	*	Semi-Permanently Flooded	Beaver
PSS1A	Palustrine	*	Scrub-Shrub	Broad-Leaved Deciduous	Temporarily Flooded	*
PSS1C	Palustrine	*	Scrub-Shrub	Broad-Leaved Deciduous	Seasonally Flooded	*
PSS1E	Palustrine	*	Scrub-Shrub	Broad-Leaved Deciduous	Seasonally Flooded/ Saturated	*
PFO1A	Palustrine	*	Forested	Broad-Leaved Deciduous	Temporarily Flooded	*

3.1.9 Vegetation

The vegetation of the project area watershed reflects the environmental conditions (geology, climate, soils, disease, elevations, and urban development) associated with the physiographic provinces and the disturbance history, both natural and anthropogenic. A wide variety of native and introduced species can be found within forested as well as non-forested areas of the county and project area.

The Catskill Mountains have elevations which range from less than 1,250 feet above sea level (asl) in the valleys to more than 4,000 feet asl on the peaks. Most of the project area is approximately 1,400 feet asl. Nearly 40% of the watershed is protected by inclusion in the Catskills Forest Preserves "forever wild" status. Widespread logging and acid factory-related cutting during the nineteenth century has resulted in mostly even-aged stands. Invasive plants have changed the character and composition of some vegetation communities. The area landscape consists mostly of northern hardwood forest with species such as American beech (*Fagus grandifolia*), Paper birch *(Betula papyrifera)*, red maple (*Acer rubrum*), sugar maple (*Acer saccharum*), black cherry (*Prunus serotina*), quaking aspen (*Populus tremuloides*), eastern hemlock (*Tsuga canadensis*), white pine (*Pinus strobus*), mixed oaks (*Quercus spp.*), black willow *(Salix nigra)*, and American sycamore *(Platanus occidentalis)*. Understory woody plants may include witch hazel (*Hamamelis virginiana*), striped maple *(Acer pennsylvanicum)*, dogwood *(Cornus spp,)*, nannyberry *(Viburnum lentago)*, serviceberry *(Amelanchier canadensis)*, American hornbeam *(Carpinus caroliniana)*, and sumac (*Rhus typhina*) among others. Many species of herbaceous plants such as wildflowers, grasses, sedges, and ferns are found in the project area as well. These are found in the former airfield, former poultry processing plant, and in riparian areas (United States Fish and Wildlife Service 2010a).

In addition to the native tree and understory species listed above, the watershed has become home to various introduced plants which can be extremely aggressive and tend to crowd out native groups. Some common invasive woody and herbaceous vegetation likely to occur within and in the proximity of the project area are provided in Section 3.1.12.

3.1.10 Wildlife Resources

3.1.10.1 Birds

Wildlife species found in the region are based on the various habitat types present. Birds are found at all elevations and some, like the Bicknell's thrush *(Catharus bicknelli)*, are associated with habitat in higher elevations. The project area is located near the Upper Delaware River, Pepacton Reservoir and Catskill Peaks Important Bird Areas, as designated by the Audubon Society. Raptors are common during migration but concentrations are not high compared to other areas of the State (hawk watch sites are found near Oneonta and Port Jervis). However, the Delaware River is an important wintering area for bald eagles *(Haliaeetus leucocephalus)*. Other raptors expected to be found in the area include red-tailed hawk *(Buteo jamaicensis)* red-shouldered hawk *(Buteo lineatus)*, northern goshawk *(Accipiter gentilis)*, Cooper's hawk *(Accipiter cooperii)*, sharp-shinned hawk *(Accipiter* *striatus),* great homed owl *(Bubo virginianus),* barred owl *(Strix varia),* and the eastern screech owl *(Megascops asio)* (United States Fish and Wildlife Service 2010a).

More than 200 species of birds have been documented in the Catskills such as dark-eyed junco *(Junco hyemalis),* warblers such as the black and white *(Mniotilta varia),* black-throated blue *(Dendroica caerulescens),* black-throated green *(Dendroica virens*), blackburnian *(Dendroica fusca),* mourning *(Oporornis philadelphia),* yellow-rumped *(Dendroica Coronata),* Canada *(Wilsonia canadensis),* and yellow *(Dendroica petechia).* In addition, song sparrow *(Melospiza melodia),* eastern kingbird *(Tyrannus tyrannus),* eastern phoebe *(Sayornis phoebe),* mourning dove *(Zenaida macroura),* least flycatcher *(Empidonax minimus),* red-winged blackbird *(Agelaius phoeniceus),* common grackle *(Quiscalus quiscula),* common yellowthroat *(Geothlypis trichas),* wood thrush *(Hylocichla mustelina),* great blue heron *(Ardea herodias),* black-capped chickadee *(Poecile atricapillus),* winter wren *(Troglodytes troglodytes),* golden-crowned kinglet *(Regulas satrapa),* hermit thrush *(Catharus guttatus*), solitary vireo *(Vireo solatarius),* Canada goose *(Branta canadensis),* wood duck *(Aix sponsa),* mallard *(Anas platyrhynchos),* American black duck *(Anas rubripes),* hooded merganser *(Lophodytes cucullatus),* and common merganser *(Mergus merganser)* can be expected to be found in the project area (United States Fish and Wildlife Service 2010a).

3.1.10.2 Mammals

Mammals are common in the Catskills and a few are restricted to the large tracts of forest habitat that remain there. White-tailed deer *(Odocoileus virginianus),* black bear *(Ursus americanus),* coyote *(Canis latrans),* red *(Vulpes vulpes)* and gray *(Urocyon cinereoargenteus)* fox, river otter *(Lontra canadenis),* bobcat (*Lynx rufus),* beaver *(Castor canadensis),* long-tailed weasel *(Mustela frenata),* Mink *(Mustela vision),* woodchuck *(Marmota monax),* eastern chipmunk *(Tamias striatus),* muskrat *(Ondatra zibethicus),* raccoon *(Procyon lotor),* and the opossum *(Didelphis virginiana)* are all found in this region. Various types of moles, like the eastern mole *(Scalopus aquaticus)* and the star-nosed mole *(Condylura cristata),* inhabit this section of the state as do voles, like the meadow vole *(Microtus pennsylvanicus)* and the woodland vole *(Microtus pinetorum).* Red squirrels *(Tamiasciurus hudsonicus)* and gray squirrels *(Sciurus carolinensis)* are commonly seen and there are no less than four species *of* shrews (Soricidae spp.) found in the Catskills. Types of mice, like the white-footed mouse *(Peromyscus leucopus)* and the deer mouse *(Peromyscus moniculatus),* are common in this combination of forests, fields, and urban areas. Other smaller mammals found in the Catskills are the eastern cottontail rabbit *(Sylvilagus floridanus),* little brown bat *(Myotis lucifugis),* big brown bat *(Eptesicus fuscus),* eastern red bat *(Lasiurus borealis),* hoary bat *(Lasiurus cinereus),* and silvered-haired bat *(Lasionycteris noctivagans).* The eastern porcupine *(Erethizon dorsatum)* is also an inhabitant of the area (United States Fish and Wildlife Service 2010a).

3.1.10.3 Reptiles and Amphibians

Common reptiles and amphibians of the Catskills include the timber rattlesnake *(Crotalus horridus),* northern copperhead *(Agkistrodon contortrix),* eastern milk snake *(Lampropeltis triangulum),* smooth green snake *(Liochlorophis vernalis),* northern ringneck snake *(Diadophis punctatus),* common garter snake *(Thamnphis sirtalis),* and the northern redbelly snake *(Storeria occipitomaculata).* Turtles, like the snapping turtle *(Chelydra serpentina),* painted turtle *(Chrysemys picta),* and the eastern box turtle *(Terrapene carolina)* are found here. Northern spring peeper *(Pseudacris crucifer),* bullfrog *(Rana catesbeiana),* gray tree frog *(Hyla versicolor),* green frog *(Rana clamitans),* wood frog *(Rana sylvatica),* northern leopard frog *(Rana pipiens),* pickerel frog *(Rana palustris),* eastern American toad *(Bufo americanus),* red-spotted newt *(Notophthalmus viridescens),* spotted salamander *(Ambystoma maculatum),* northern dusky salamander (Desmognathus fuscus), northern red back salamander *(Plethodon cinereus),* northern spring salamander *(Gyrinophilus porphyriticus),* and the northern two-lined salamander *(Eurycea bislineata)* are found in the Catskills region (United States Fish and Wildlife Service 2010a)**.**

In addition to the bird, mammal, reptile and amphibian species listed above, the watershed has become home to various introduced species which can be extremely aggressive and tend to crowd out or compete with native groups. Some common invasive species that may occur within and in the proximity of the project area are provided in Section 3.1.12.

3.1.10.4 Finfish and Invertebrate Species

A variety of aquatic organisms are found inhabiting aquatic areas encompassing the Little Beaver Kill, Willowemoc, and Cattail Brook watersheds. In general, aquatic organisms found in Catskill streams include invertebrates, mollusks, and fish. As documented by Smith and Kraft (2005) and the USFWS (2010), common fish species identified in the watershed include slimy sculpin *(Cottus cognatus),* rock bass *(Ambloplites rupestris),* smallmouth bass *(Micropterus dolomieu),* largemouth bass *(Micropterus salmoides),* chain pickerel *(Esox niger),* Cyprinidae spp., pumpkinseed *(Lepomis gibbosus),* brown bullhead *(Ameiurus nebulosus*), creek chub *(Semotilus atromaculatus),* fall fish *(Semotilus corporalis),* longnose dace *(Rhinichthys cataractae),* common shiner *(Luxilus cornutus),* fathead minnow *{Pimephales promelas),* American shad *(Alosa sapidissima),* American eel *(Anguilla rostrata),* white sucker (*Catostomus commersoni*), young of year and adult brook trout *(Salvelinus fontinalis),* young of year and adult brown trout *(Salmo trutta),* young of year and adult rainbow trout *(Oncorhynchus mykiss),* Eastern blacknose dace (*Rhinichthys atratulus),* tessellated darter *(Etheostoma olmstedi),* cutlip minnow *(Exoglossum maxillingua),* sea lamprey *(Petromyzon marinus),* and margined madtom *(Norurus insignis).*

Salmonid species play an important ecological and economic role in the region. Three species of trout are found in the Delaware River system including brook, rainbow, and brown. A 2000 creel survey by the New York State Department of Environmental Conservation on the Beaver Kill and its tributaries, including 5.4 miles of the Little Beaver Kill and 4.2 miles of the Willowemoc, revealed brook, brown, and rainbow trout inhabiting most, but not all, tributaries. Maximum summer water temperatures (>70 degrees F) in shallow streams appear to be the limiting factor for trout populations. Very little fishing activity was observed on the Little Beaver Kill during the creel survey, although the stream has been annually stocked with over 2,000 brown trout. The Willowemoc has been annually stocked with over 18,000 brown trout in past years. Wild populations of trout are also present. Public fishing rights have been secured by the New York State Department of Environmental Conservation on both the Little Beaver Kill and Willowemoc, but access is not continuous nor granted for both sides of the waterways within the project area (United States Fish and Wildlife Service 2010a). A 2002 angler use survey for the Beaver Kill watershed showed that 10% of anglers interviewed were from the New York counties of Sullivan, Ulster and Delaware with 42% interviewed visiting from New York – New Jersey metropolitan area. The survey also demonstrated the international significance of the project area with surveyed anglers originating from Puerto Rico, Holland, Poland, Portugal, South Africa, Japan, Yugoslavia, Romania, Canada, and England.

Invertebrates are present in every conceivable biotic habitat, and in most ecosystems they constitute the groups with greatest species richness. Invertebrates are ecologically involved with virtually every biotic process occurring in natural communities, from pollination, herbivory, and predation to soil formation, disease transmission, nutrient cycling and decomposition to name only a few. A host of aquatic invertebrate species can be found within waterways of the region. The Stream Biomonitoring Unit of the New York State Department of Environmental Conservation uses aquatic macro-invertebrates to monitor the water quality of the State's rivers and streams. Macro-invertebrates were collected and identified by the New York State Department of Environmental Conservation during a July 26th, 1994 stream survey of the Little Beaver Kill and its tributaries (New York State Department of Environmental Conservation, 1994a). Table 3.8 summarizes the general classification of the macro-invertebrates species collected during that survey. Of the 12 orders positively identified during the survey, the presence of Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) in a sample are the Orders most often recognized as being associated good water quality and used to make educated assumptions on the general condition of a particular water body or sampling location. The 1994 Little Beaver Kill Watershed survey confirmed the presence of approximately 21 Families, 31 genera, and 39 species within these three Orders. A July 27th 1994 survey of the Willowemoc Creek in Sullivan County confirmed the presence of approximately 19 Families, 31 genera, and 35 species within these three Orders (New York State Department of Environmental Conservation, 1994b).

Table 3.8: Summary of the New York State Department of Environmental Conservation 1994 survey of the macro-invertebrate community inhabiting the Little Beaver Kill watershed, located in Sullivan County, New York.

Phylums	Sub-Phylums	Classes	Orders	Families	Genera
4	1	5	12	44	78

3.1.11 Threatened and Endangered Species

Endangered species are those whose prospects for survival are in immediate danger because of a loss or change of habitat, over-exploitation, predation, competition or disease. Threatened species are those that may become endangered if conditions surrounding the species begin or continue to deteriorate.

A review of data on Federally-listed species protected pursuant to the ESA reveals extant and extirpated populations of northern monkshood *(Aconitum noveboracense), a* threatened species in the region. While no records were found for the project area, occurrences have been reported within 5 miles. This includes a 1983 record south east of the project site and another record approximately 5 miles south, found in 1989, but neither population was found during surveys in 2004. The northern monkshood is also a State-listed threatened species. Another State-listed species is the ensiform rush *(Juncus ensifolius).* This endangered species, like the northern monkshood, has been found in the region but not the project area. A survey in 2004 found this species less than 5 miles from the project site. While no longer Federally-listed, the State-listed endangered bald eagle has been observed in the project area. In addition, several bald eagle nests are found in the region and are at least 10 miles from the project site. Eagle foraging along larger streams and rivers is becoming more common in the Catskills (United States Fish and Wildlife Service 2010a).

A user defined search was conducted on the New York State Department of Conservation (2010c) Nature Explorer website to obtain lists of rare species and significant natural communities that are listed in the databases of the New York State Natural Heritage Program. A search was conducted for Sullivan County, New York and the general watershed limits of the study area used as the search criteria. Table 3.9 lists the species and communities shown as being within the defined search areas.

Table 3.9: Rare species and significant natural communities list for Sullivan County, New York and project area watershed
(New York State Department of Conservation, 2010c)

Group Community	Species		Protection Status	
	Common Name	**Scientific Name**	**State**	**Federal**
Birds	Bald Eagle	*Haliaeetus Leucocephalus*	Threatened	NA
	Henslow's Sparrow	*Ammodramus henslowii*	Threatened	NA
	Least Bittern	*Ixobrychus exilis*	Threatened	NA
	Pied-billed Grebe	*Podilymbus podiceps*	Threatened	NA
	Sedge Wren	*Cistothorus platensis*	Threatened	NA
Reptiles	Bog Turtle	*Glypyemis muhlenbergii*	Endangered	Threatened
	Timber Rattlesnake	*Crotalus horridus*	Threatened	NA
Amphibians	Hellbender	*Cryptobranchus alleganiensis*	Special Concern	NA
Butterflies and Moths	Karner Blue	*Plebejus Melissa samuelis*	Endangered	Endangered
Beetles	Appalachian Tiger Beetle	*Cicindela ancocisonemsis*	NA	NA
	Cobblestone Tiger Beetle	*Cicindela marginipennis*		NA
Mussels and Clams	Brook Floater	*Alasmidonta varicosa*	Threatened	NA
	Dwarf Wedgemussel	*Alasmidonta heterodon*	Endangered	Endangered
Animal Assemblages	Bat Colony	NA	NA	NA
Flowering Plants	Hooker's Orchid	*Platanthera hookeri*	Endangered	NA
	Jacob's Ladder	*Polemonium vanbruntiae*	Rare	NA
	Northern Monk's-hood	*Aconitum noveboracense*	Threatened	Threatened
Ferns and Fern Allies	Blunt-lobe Grape Fern	*Botrychium oneidense*	Endangered	NA
Uplands	Beech-Maple Mesic Forest	NA	NA	NA
Freshwater Nontidal Wetlands	Dwarf Shrub Bog	NA	NA	NA
	Spruce-Fir Swamp	NA	NA	NA

3.1.12 Invasive Species

The Catskill Regional Invasive Species Partnership (CRISP) is a cooperative partnership that promotes prevention, early detection, rapid response and broader control of invasive plant species to protect the natural resources in the Catskill Region. Members of the partnership include: the Catskill institute for the environment, the Catskill Center for Conservation and Development, New York State Department of Environmental Protection, New York State Department of Environmental Conservation, the Nature Conservancy, among others. CRISP conducts public outreach, management activities, and supports research about ecological impact and effective controls of invasive plant species (Catskill Regional Invasive Species Partnership 2010). Table 3.10 provides a CRISP compiled list of invasive plant species affecting the Catskill Mountain Region.

Table 3.10: Invasive plant species in the Catskill Mountain Region

Regional Status			
Common Name	**Scientific Name**	**Form**	**Habitat Area**
Approaching the Region (Not yet detected)			
Brazilian Water Weed	*Egeria densa*	Aquatic	Lakes, rivers
European Frog-bit	*Hydrocharis morsus-ranae*	Aquatic	Lakes, rivers
Kudzu	*Pueraria Montana var. lobata*	Vine	Uplands
Limited Distribution			
Pale swallow-wort	*Cynanchum rossicum*	Vine	Uplands
Glossy buckthorn	*Frangula alnus*	Shrub	Open uplands, wetlands
Giant hogweed	*Heracleum mantegazzianum*	Herb	Open uplands, riparian areas
Eurasian water milfoil	*Myriophyllum spicatum*	Aquatic	Lakes, rivers
Mile-a-minute	*Polygonum perfoliatum*	Vine	Uplands
Limited Distribution but Established			
Tree of heaven	*Ailanthus altissima*	Tree	Uplands
Black swallow-wort	*Cynanchum louisiae*	Vine	Uplands
Burning bush	*Euonymus alatus*	Shrub	Uplands
Japanese stilt grass	*Microstegium vimineum*	Grass	Forested uplands
Water chestnut	*Trapa natans*	Aquatic	Lakes, rivers
Widespread			
Norway maple	*Acer platanoides*	Tree	Forested uplands
Garlic mustard	*Alliaria petiolata*	Herb	Forested uplands
Japanese barberry	*Berberis thunbergii*	Shrub	Forested uplands
Asiatic bittersweet	*Celastrus orbiculatus*	Vine	Uplands
Spotted knapweed	*Centaurea stoebe ssp. micranthos*	Herb	Open uplands
Autumn/Russian olive	*Elaegnus umbellate, E. angustifolia*	Shrub	Open uplands
Japanese/Giant knotweed	*Fallopia japonica, F. sachalinensis*	Herb	Riparian areas, uplands
Bush honeysuckle	*Lonicera spp.*	Shrub	Uplands
Purple loosestrife	*Lythrum salicaria*	Herb	Wetlands
Common reed	*Phragmites australis*	Grass	Wetlands
Buckthorn	*Rhamnus cathartica*	Shrub	Open uplands
Multiflora rose	*Rosa multiflora*	Shrub	Open uplands

Many species of non-native invasive plants and animals are known to be currently established in the project area, especially along waterways. Japanese knotweed, garlic mustard, common reed, and purple loosestrife are common plants. Didymo or *Didymosphenia geminata* is a noxious slimy plant also known as "rock snot" that has been found in Catskill streams. Also present in the watershed is zebra mussel *(Dreissena polymorpha),* quagga mussel *(Dreissena bugensis),* finger nail clam *(Sphaeracea spp.),* mud snail *(Bithynia tentaculata),* flathead catfish *(Pylodictis olivaris),* and hemlock wooly adelgid *(Adelges tsugae)*. Japanese knotweed appeared to be the most ubiquitous invasive species in the project area (United States Fish and Wildlife Service 2010a).

3.1.13 Cultural Resources

The prehistory of the Northeast United States is conventionally divided into Paleoindian, Archaic, Woodland and Contact cultural periods. These periods are further divided into sub-periods or phases based upon distinguishing cultural, technological, or economic changes.

3.1.13.1 The Paleoindian Period (12,500 - 10,000 BP)

The term Paleoindian has been used since the 1930s to describe the earliest known inhabitants of North America who most likely arrived to this continent across the Bering Strait during its Pleistocene terrestrial exposure. There is no firm beginning date of the Paleoindian period, but it is generally held that occupation in the Northeast began around 12,500 BP (Before Present) during the late Wisconsin glacial period and lasted until around 10,000 BP during the early Holocene. Paleoindians dispersed throughout the continent and ultimately occupied a wide range of physiographic areas.

The Paleoindian culture is marked by an artifact assemblage that includes distinct projectile point types known as fluted points typically manufactured of high quality, cryptocrystalline chert and traditionally viewed as projectiles used for hunting large migratory mammals. Spurred end scrapers, side scrapers, and spokeshave gravers, which would have been used to process such game, are also diagnostic of the Paleoindian period (Ritchie 1980). Subsistence strategies may have been focused on diverse resources including seeds, nuts, birds, fish, and small mammals that would have been abundant in early Holocene watershed features.

The end of the Paleoindian period is still poorly understood and some researchers believe that the demise of this culture may have been caused by rapidly changing forest environments, perhaps forcing a northward movement of populations who left no clear descendant cultures (Snow 1980). However, other researchers have viewed early Holocene settlement patterns as locally stable with cultural continuity from the Paleoindian period to well into the Early Archaic sub-period (Custer 1996).

3.1.13.2 The Archaic Period (10,000 – 3000 BP)

The term "Archaic" was first used in North American archaeology by William A. Ritchie in 1932, who described a culture in the Northeast that had not developed ceramic technology and was dependent on hunting, gathering, and fishing (Treichler 1991). The Archaic period is generally divided into the Early, Middle and Late subperiods, and a Terminal Archaic occurring at the end of the Late Archaic. In general, the Early Archaic (10,000 – 8000 BP) cultures represented an adjustment to changing post-Pleistocene conditions although settlement patterns during this period appear to represent the same preferences for site location as in the preceding Paleoindian period. The Middle Archaic subperiod, which lasted from 8000 BP to 6000 BP, is viewed as a time of dramatic change in the subsistence strategies employed by hunters and gatherers in the Northeast and Mid-Atlantic. The Late Archaic sub-period (6000-3000 BP) beheld the development of regional complexity, as populations rapidly increased and the cultural patterns that were established during the Middle Archaic were elaborated upon and intensified. The Terminal Archaic, which some researchers date from 3700-2700 BP, is a transitional period that sees a change in the subsistence and settlement system and the introduction of new tool types.

3.1.13.3 The Woodland Period (3000 BP – AD 1600)

Although the Woodland period is generally distinguished among Early, Middle and Late subperiods in the Northeast, the Early and Middle Woodland in the Mid-Atlantic region have been treated together because of fewer temporal and cultural distinctions in the region. In general, the Early Woodland subperiod is signaled by the appearance of new cultural traits, namely the widespread use of ceramics, and intensification of older traits, including mortuary ceremonialism, which were carried over from the Late and Terminal Archaic (Ritchie 1980). Although the beginning the Early Woodland subperiod is generally marked at 3000 BP, there is inevitable overlap of several hundred years with the Terminal Archaic. During the Late Woodland (AD 1000-1600), which lasted up until European contact, the adoption of horticulture had an integral part in population growth and subsistence and settlement systems and saw the establishment of large villages in mostly riverine settings.

3.1.13.4 The Contact Period (AD 1600 – 1800)

Archaeological sites of historic period are marked by objects of European manufacture, in very small quantities at first, but in greater numbers at later times until nearly all of the imperishable material is that bought from traders. For much of the State the date of the first visible European influence is about 1550 A.D., but trade goods appear earlier near the coast and later in the Delaware River Valley.

The coming of the white man resulted in marked changes in Indian life. European diseases - smallpox, tuberculosis, and many others - had a devastating effect on a population which had never developed immunity to them. Competition for land and trade led to the constant wars of the early historic period and a general breakdown of the old order.

When the first Dutch, English and Swedish settlers arrived in what is now Sullivan County, they met with bands of Native Americans who were descendents of the Unami and Munsee speaking groups who inhabited the Delaware and Hudson River Valleys for centuries. These aboriginal groups were known as the Lenni Lenape, or “original people”. The arrival of the Europeans in the 17th century forced the Lenape westward, eventually settling in Ontario, Canada, New York, Missouri, Wisconsin, Kansas and Oklahoma (Conway 2009).

3.1.13.5 European Influence and History

In 1716, Johannes Hardenbergh purchased a large tract of land know as the Hardenbergh Patent in what is today Sullivan, Ulster and Delaware Counties from the Chief of the Native Americans living in the area. Timber was abundant in the area, and soon great logs were being floated down the Delaware River for use in the growing ship building industry in Philadelphia (Frisbie 1996).

Shares in the Hardenbergh patent changed hands frequently; however, prior to 1790 there were few people in the area except the Mamakating, Lumberland, Cochecton and Neversink districts. It was then that Robert Livingston, who had purchased five-sixteenths of the densely forested Hardenbergh patent with others, pushed the location of men on their lands by either sale or lease, and by 1800 there were more than 3,000 inhabitants of the county (Frisbie 1996).

Samuel F and John P. Jones founded the village of Monticello in 1804, with brother John felling the first tree and brother Samuel instrumental in the construction of the Newburgh-Cohechton Turnpike. The turnpike was the first improved road in the area that connected the Hudson River with the Delaware River, and one of two infrastructure improvements that helped to detach the southwestern corner of Ulster County as its own County chartered in 1809. The County name was chosen to honor Major General John Sullivan who, along with Brigadier General James Clinton, led an American campaign against the Loyalists and the Iroquois in 1779 and drove them out of the area (Conway 2009).

The other improvement was the building of the Delaware and Hudson Canal which opened in 1828. The canal was conceived to carry Pennsylvania coal to the Hudson River for transport to New York City. By 1850 the population of Sullivan County increased to more than 25,000 residents. The canal was also instrumental in a second industry of the County: Tanning (Frisbie 1996).

The hemlock trees in Sullivan County produced superior leather products. Approximately forty tanneries sprung up across the county, each with its own immigrant community, mostly from Ireland who came specifically to work the trade. The tanning industry thrived till the end of the 1880s when the hemlock trees were depleted (Conway 2009).

With the depletion of the trees by both the timber and tanning industries, Sullivan County had to look to another industry in order to sustain itself. In the 1840s the area turned to tourism. Tanneries and logging camps were replaced with hotels and boarding houses built by private developers to accommodate visitors who flocked to the riverside for its beauty and recreational opportunities touted by writers and painters of the era, and the completion of the Monticello & Port Jervis Railroad in 1871 brought tourists and thus, prosperity to the rest of the county (Conway 2009).

Tourism continued to thrive until the early 1900s when the promise of clean air and clean water shifted from recreation to a possible cure for tuberculosis. The construction of several treatment facilities, most notably the Loomis Sanitarium, soured the “freshness” of the area and diminished the tourist trade. However, this did not deter many middle and working class New York City residents of Jewish descent, who began frequenting the Catskill mountain resorts from the 1920s to the 1970s (Falk 2012).

In February 2010, A.D. Marble & Company cultural resource professionals conducted Phase IA Historic Resources Investigations to document known and expected architectural and archaeological resources within the Area of Potential Effect (APE) for the ten potential alternatives for flood damage reduction and ecosystem restoration in the hamlet of Livingston Manor, Sullivan County, New York. The focus of the investigation was to identify those resources listed, eligible, or potentially eligible for listing in the National Register of Historic Places (National Register). Based on the results of the investigation, further work will be required to assess possible impacts to architectural and archaeological resources once the preferred alternative is selected.

3.1.14 Infrastructure and Transportation

Sullivan County contains numerous primary, secondary, and tertiary roadways with limited railroad and air transportation options. Of the 9 state routes (17, 17B, 42, 52, 52A, 55, 55A, 97, and 206) and one U.S. Route (209) found in the County, State Route 17 is the main artery of travel between the northern and southern portions of the county. As part of a major ongoing New York State Department of Transportation project, State Route 17 is scheduled to become part of Interstate 86 (Sullivan County Division of Public Works, 2010). As part of this highway construction, the Parksville Interchange is being constructed upstream of Livingston Manor along the Little Beaver Kill headwaters. In addition, Sullivan County maintains a highway system of approximately 140 routes. Sullivan County maintains approximately 400 miles of roads and 100 bridges. Livingston Manor contains numerous secondary and tertiary roads and bridges. In addition, two State Route 17 bridge overpasses cross Willowemoc both upstream and downstream of Livingston Manor. Old Route 17 passes directly through the city limits as does County Road 149. One active railroad remains in Sullivan County along with 8 airports of which only one is public. No active railroads or airports are in or near Livingston Manor.

3.1.15 Socioeconomic Conditions

Table 3.11 displays comparative population data for Livingston Manor, Sullivan County and New York State. Livingston Manor is a census designated place (CDP) as established by the

United States Census Bureau. A CDP is a populated area (a concentration of population) that is delineated each decennial census for statistical purposes by the United States Census Bureau.

Table 3.11: Town, County, and State Population by decennial census from 1960 through 2000
(U.S. Census Bureau, 2010)

Location	1960	1970	1980	1990	2000
New York	16,782,000	18,237,000	17,557,000	17,990,455	18,976,457
Sullivan County	45,272	52,580	65,155	69,277	73,966
Livingston Manor	2,080	1,522	1,436	1,482	1,355

As of the census of 2000 (Table 3.12), Livingston Manor, New York had a population of 1,355 people, 515 households, and 330 families residing in the CDP. The racial makeup of the CDP was 85.4% White, 6.2% African American, 0.1% Native American, 1.0% Asian, 5.1% from other races, and 2.2% from two or more races. Hispanic or Latino of any race was 11.8% of the population. The population density was 437.6 per square mile (168.8/km^2). There were 619 housing units at an average density of 199.9/mi^2 (77.1/km^2).

The population in the CDP was spread out with 31.8% under the age of 18, 7.4% from 18 to 24, 26.0% from 25 to 44, 21.7% from 45 to 64, and 13.1% who were 65 years of age or older. The median age was 35.2 years. For every 100 females there were 94.1 males. For every 100 females age 18 and over, there were 90.5 males.

Of the 515 households, 33.8% had children under the age of 18 living with them, 41.4% were married couples living together, 16.1% had a female householder with no husband present, and 35.9% were non- families. Twenty eight percent of all households were made up of individuals and 11.8% had someone living alone who was 65 years of age or older. The average household size was 2.62 and the average family size was 3.21.

The median income for a household in the CDP was $27,159, and the median income for a family was $29,167. Females had a median income of $24,375 versus for $22,250 males. The per capita income for the CDP was $13,047. About 26.1% of the population and 22.0% of families were below the poverty line, including 41.6% of those under age 18 and 10.0% of those ages 65 or over.

Table 3.12: 2000 year partial census data comparison for Livingston Manor, Sullivan County, and New York State

	Livingston Manor		Sullivan County		New York State	
Subject	**Number**	**% of Total**	**Number**	**% of Total**	**Number**	**% of Total**
GENERAL CHARACTERISTICS						
Total population	1,355	100.0 %	73,966	100.0 %	18,976,457	100.0 %
Male	657	48.5 %	37,643	50.9 %	9,146,748	48.2 %
Female	698	51.5 %	36,323	49.1 %	9,829,709	51.8 %
Median age (yrs)	35.2	(X)	38.8	(X)	35.9	(X)
Under 5 years	107	7.9 %	4,355	5.9 %	1,239,417	6.5 %
18 years and over	924	68.2 %	55,514	75.1 %	14,286,350	75.3%
65 years and over	178	13.1 %	10,584	14.3 %	2,448,352	12.9 %
RACE						
One race	1,325	97.8 %	72,585	98.1 %	18,386,275	96.9 %
White	1,157	85.4 %	63,103	85.3 %	12,893,689	67.9 %
Black or African American	84	6.2 %	6,292	8.5 %	3,014,385	15.9 %
American Indian and Alaska Native	2	0.1 %	197	0.3 %	82,461	0.4 %
Asian	13	1.0 %	825	1.1 %	1,044,976	5.5 %
Native Hawaiian and Other Pacific Islander	0	0.0 %	29	0.0 %	8,818	0.0 %
Some other race	69	5.1 %	2,139	2.9 %	1,341,946	7.1 %
Two or more races	30	2.2 %	1,381	1.9 %	590,182	3.1 %
Hispanic or Latino (of any race)	160	11.8 %	6,839	9.2 %	2,867,583	15.1 %
SOCIAL CHARACTERISTICS						
Population 25 years and over	785	(X)	50,228	(X)	12,542,536	(X)
High school graduate or higher	532	67.8 %	38,275	76.2%	9,916,212	79.1 %
Bachelor's degree or higher	64	8.2 %	8,367	16.7 %	3,433,212	27.4 %
Civilian veterans (civilian population 18 years and over)	122	13.3 %	7,788	14.0 %	1,361,164	9.5 %
Foreign born	52	3.9 %	5,875	7.9 %	3,868,133	20.4 %
Speak a language other than English at	165	13.5 %	9,921	14.2 %	4,962,921	28.0 %

home (population 5 years and over)						
ECONOMIC CHARACTERISTICS						
In labor force (population 16 years and over)	571	60.1	33,330	60.2 %	9,046,805	61.1 %
Mean travel time to work in minutes (workers 16 years and over)	25.2	(X)	29.3	(X)	31.7	(X)
Median household income in 1999 (dollars)	27,159	(X)	36,998	(X)	43,393	(X)
Median family income in 1999 (dollars)	29,167	(X)	43,458	(X)	51,691	(X)
Per capita income in 1999 (dollars)	13,047	(X)	18,892	(X)	23,389	(X)
Families below poverty level	74	22.0 %	2,143	11.6 %	535,935	11.5 %
Individuals below poverty level	347	26.1 %	11,559	16.3 %	2,692,202	14.6 %
HOUSING CHARACTERISTICS						
Household population	1,349	99.6 %	69,141	93.5 %	18,395,996	96.9 %
Group quarters population	6	0.4 %	4,825	6.5 %	580,461	3.1%
Average household size	2.62	(X)	2.50	(X)	2.61	(X)
Average family size	3.21	(X)	3.05	(X)	3.22	(X)
Total housing units	619	100.0 %	44,730	100.0 %	7,679,307	100.0 %
Occupied housing units	515	83.2 %	27,661	61.8 %	7,056,860	91.9 %
Owner-occupied housing units	273	53.0 %	18,834	68.1 %	3,739,166	53.0 %
Renter-occupied housing units	242	47.0 %	8,827	31.9 %	3,317,694	47.0 %
Vacant housing units	104	16.8 %	17,069	38.2 %	622,447	8.1 %
Median housing value (dollars)	80,300	(X)	93,300	(X)	148,700	(X)

HOUSING CHARACTERISTICS (cont)						
Median monthly owner costs with mortgage (dollars)	873	(X)	1,068	(X)	1,357	(X)

Median monthly owner costs Not mortgaged (dollars)	415	(X)	416	(X)	457	(X)
(X)- Data unavailable or not applicable.						

Vacancy rates, or housing units not lived in on a permanent basis, are used as a potential indicator of distressed regions. In 2000, Sullivan County had a vacancy rate of 38.2% and Livingston Manor had a vacancy rate of 16.8%. These high vacancy rates are likely attributed to seasonal tourism in which many homes are used as vacation homes or rented seasonally.

Although recreation and tourism are important economic considerations for Sullivan County, agriculture represents one of the largest economic sectors in the County, with the combined output value of agriculture exceeding $60,000,000 in 2004. Sullivan County is a leading supplier of specialty poultry products to the New York Metropolitan Area (Sullivan County, New York, 2010) New York State Agricultural Districts no.'s 1 and 4 are mapped within Sullivan County. Although a substantial amount of agricultural lands are mapped, changes in technology, urban sprawl, and the vacation industry have resulted in the number of farms decreasing over the past few decades (Sullivan County Division of Public Works, 2010).

3.1.16 Environmental Justice

Executive Order 12898, entitled "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations." This EO directs Federal agencies "to make achieving environmental justice part of its mission by identifying and addressing, as appropriate disproportionately high and adverse human health or environmental effects of programs, policies, and activities on minority populations and low income populations in the United States…." The purpose of this order is to avoid the disproportionate placement of adverse environmental economic, social, or health impacts from Federal actions and policies on minority and low-income populations. In order to prevent the potential for discrimination and disproportionately high and adverse effects on specific populations, a process must identify minority and low-income populations that might be affected by the implementation of a proposed action or alternatives.

As defined by the "Environmental Justice Guidance Under NEPA" (CEQ, 1997), "minority populations" includes persons who identify themselves as Asian or Pacific Islander, Native American or Alaskan Native, black (not of Hispanic origin), or Hispanic. Race refers to Census respondents' self-identification of racial background. Hispanic origin refers to ethnicity and language, not race, and may include persons whose heritage is Puerto Rican, Cuban, Mexican, Central or South American.

A minority population exists where the percentage of minorities in an affected area either exceeds 50 percent or is meaningfully greater than in the general population. Low-income populations are identified using the Census Bureau's statistical poverty threshold, which is based on income and family size. The Census Bureau defines a "poverty area" as a census tract with 20 percent or more of its residents below the poverty threshold and an "extreme poverty area" as one with 40 percent or more below the poverty level.

As of the census of 2000, there were 1,355 people residing in Livingston Manor, New York. The racial makeup of this census designated place was 85.4 percent White, 6.2 percent African American, 1.0 percent Asian, 0.1 percent Native American or Alaskan, 2.2 percent from two or more races and 5.1 percent some other race. The median income for a household in the CDP was $29,159 and the median income for a family was $29,167. The per capita income was $13,047. About 22.0 percent of families and 26.1 percent of the population were below the poverty level. The project area is considered a "poverty area" but is not considered to be one of a minority population.

3.2 Hydrologic and Hydraulic Analyses

In order to accurately identify and evaluate the flooding problems, hydrologic and hydraulic models were developed for Willowemoc Creek, Little Beaver Kill Creek, and Cattail Brook within the study area using the latest existing data which was supplemented and updated as necessary. This analysis reflects the existing conditions or the without project condition of the study area. These models were then used to recreate and understand different flooding events and to assess the effectiveness of various flood reduction alternatives.

3.2.1 Background

The Willowemoc Creek, Little Beaver Kill Creek, and Cattail Brook all flow through and converge within Livingston Manor, NY. At the confluence, they have drainage areas of approximately 65 square miles (Willowemoc), 30 square miles (Little Beaver Kill), and 7 square miles (Cattail), with a combined drainage area of 102 square miles.

From a hydraulic standpoint, the study area for this effort extends downstream from the confluence of the three streams approximately 2 miles. The total drainage area at this point is approximately 104 square miles.

Figure 4.1 is an orthophotographic image made available through the United States Department of Agriculture (USDA), dated 2006, overlaid with streams and pertinent geographic information that detail the surrounding area.

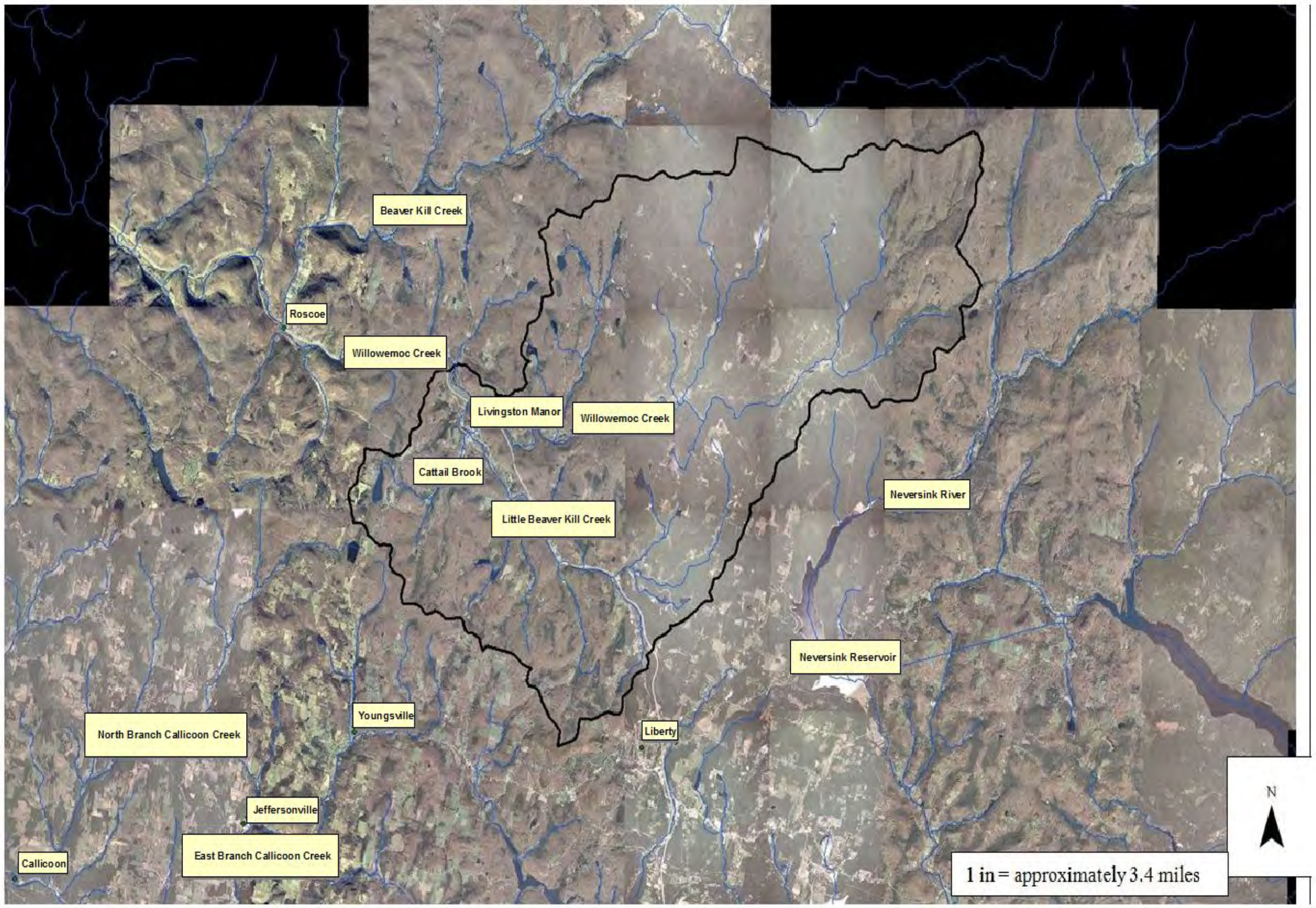


Figure 3.2: Study area for the hydrologic and hydraulic analyses.

3.2.2 Discharge Frequency Analysis

A discharge frequency analysis was conducted in order to determine the magnitudes of flow associated with given annual chance of exceedance (ACE). The ACE is defined as that (level of) event that has a particular chance of being equaled or exceeded in any year (i.e., the yearly chance of a given size flood or larger occurring). It is the inverse of the return period multiplied by 100 —i.e., a flood with an ACE of 1% is the 100-year return-period flood.

The frequency discharges for Willowemoc Creek and Little Beaver Kill were based on a statistical analysis of USGS Stream Gage 01419500 (Willowemoc Creek near Livingston Manor, NY) and Gage 01420000 (Little Beaver Kill near Livingston Manor, NY). However, since gage records were discontinued at the Willowemoc and Little Beaver Kill gages in 1973 and 1981, respectively, it was necessary to extrapolate the readings at these gages especially for the major rain events in 1996, 2004, 2005 and 2006. Data from a gage which still exists and generates readings, Gage 1420500 (Beaver Kill Creek at Cooks Falls), was used for the extrapolation. The frequency discharges for Cattail Brook were also derived using the Willowemoc, Little Beaver Kill and Beaver Kill gauges.

The locations of the three gages relative to Livingston Manor are shown in Figure 4.2 and pertinent data for the gages is provided in Table 4.1.

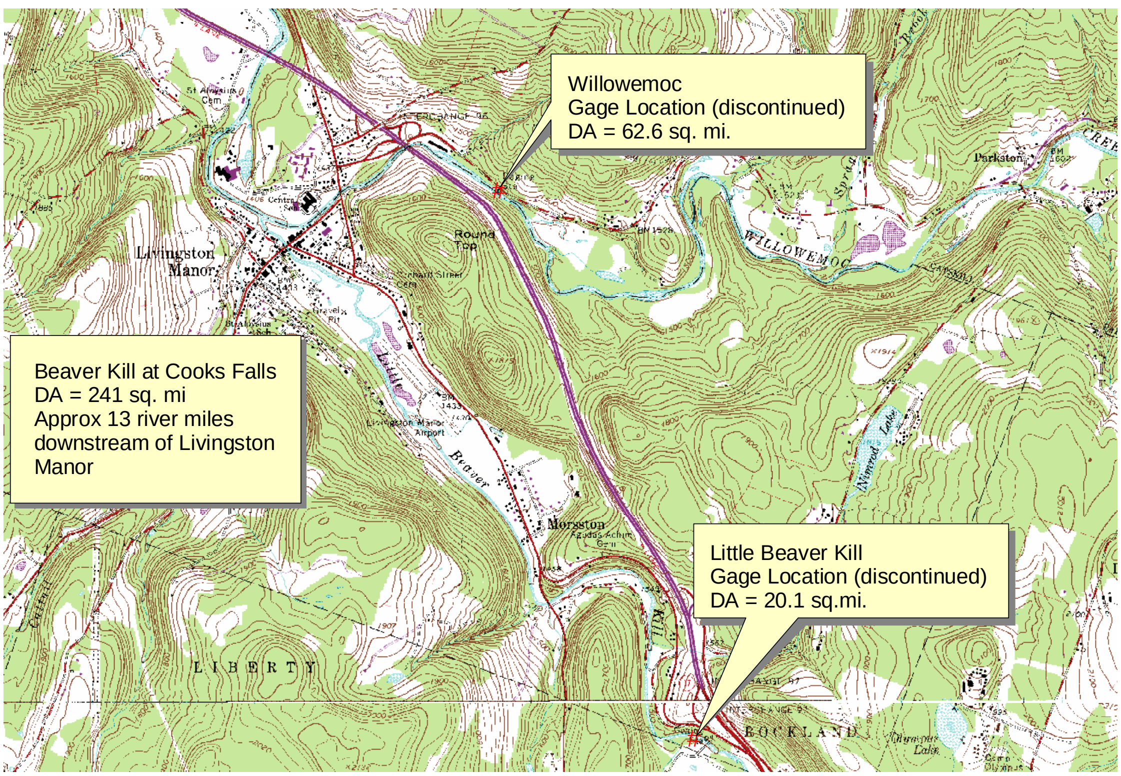


Figure 3.3: Locations of USGS stream gages in the study area.

Table 3.13: USGS Stream Gage Data

Gage	Drainage Area (sq mi)	Period of Record
01419500 Willowemoc	62.6	08-11-1938 12-21-1973
01420000 Little Beaver Kill	20.1	02-12-1925 05-12-1981
1420500 Beaver Kill	241	03-28-1914 07-23-2008

A statistical analysis of the available stream gage data was performed and the frequency discharges for the Willowemoc, Little Beaver Kill and Cattail Brook were prorated to various locations in Livingston Manor. Additional information on this analysis can be found in the Hydrologic and Hydraulic Analysis in Appendix A.

3.2.3 Hydrologic Model

The runoff of the Willowemoc Creek and its tributaries was quantified using the USACE Hydrologic Engineering Center's Hydrologic Modeling System (HEC-HMS), version 3.4. HEC-HMS is a generalized rainfall runoff computer program. The model allows the assessment of proposed reservoir modifications and can be used by the locals for land use planning. The modeled watershed is shown in Figure 4.3. The watershed was divided into 86 sub-basins for the area of interest. A large number of sub-basins increases the accuracy of the model and reduces the effort required to modify the model for various proposed solutions.

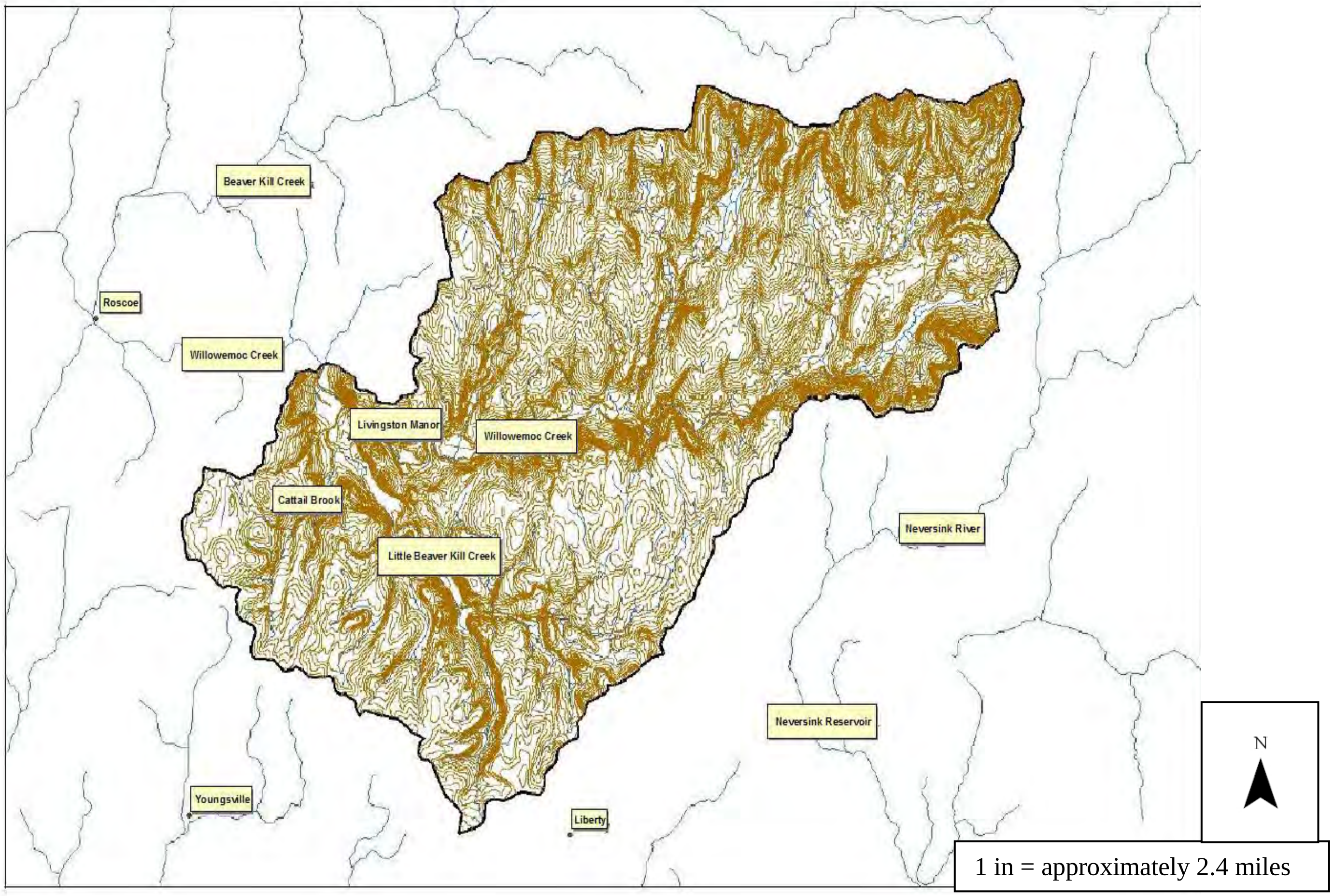


Figure 3.4: HEC-HMS Modeled Watershed

Storage areas within the modeled watershed were analyzed to determine their relative effects on downstream flows. The lakes that were modeled are:

- Denman Lake
- Lenape Lake
- Lilly Pond
- Matawa Lake
- Mongaup Pond
- Nimrod Pond
- Orchard Lake
- Paramount Pond
- 2nd Pond @ Parksville
- Tanzman Lake
- Shandelee Lake

The locations of all modeled reservoirs are shown in Figure 4.4.

A detailed description of the hydrologic analysis can be found in the Hydrologic and Hydraulic Analysis in Appendix A.

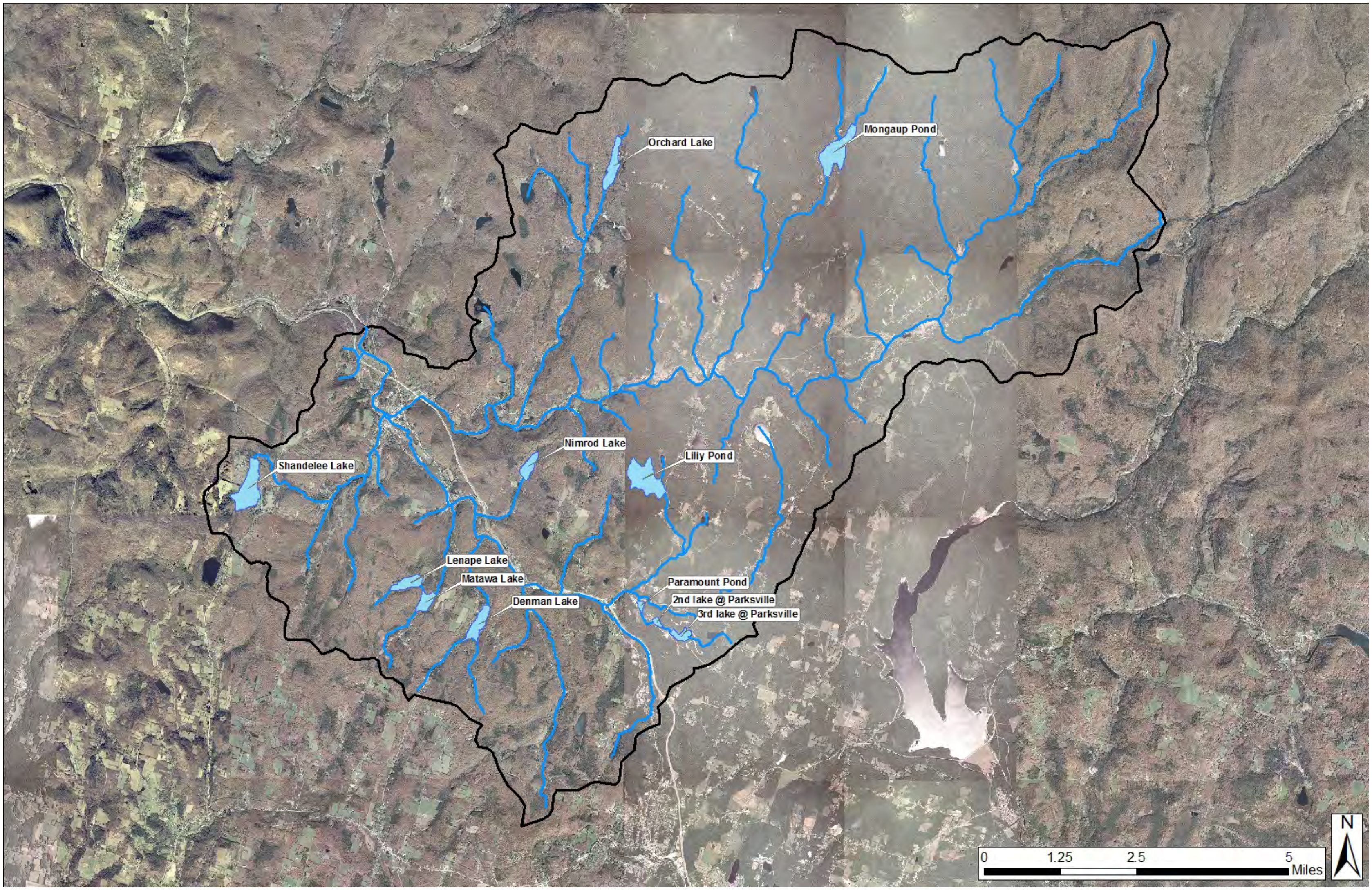


Figure 3.5: Modeled Reservoirs

3.2.4 Hydraulic Model

The frequency discharges were transformed into water surface elevations (wsel) with the USACE Hydrologic Engineering Center's River Analysis System (HEC-RAS) version 4.1.

Three primary HEC-RAS models were created within the area of interest. Willowemoc Creek was modeled for 14,641 linear feet (lf), Little Beaver Kill Creek for 6,972 lf, and Cattail Brook for 5,975 lf.

Portions of Livingston Manor along the Willowemoc Creek are protected by levees on both the left and right overbanks. However, for some events the levees are flanked at the upstream end and/or overtopped. Under such conditions the water surface elevations in the main channel of the Willowemoc are not the same as the water surface elevations in the "back channels" behind the levees. The Willowemoc floodplain was analyzed with three models: a main stem Willowemoc model and two back channel models. The back channel on the right overbank is labeled, "channel behind the school" and the back channel on the left overbank is labeled, "channel behind the levee on the LOB". The limits of the five HEC-RAS models were set to encompass all known damage locations and all locations of possible hydraulic solutions.

The main stem Willowemoc HEC-RAS model required the use of 62 cross sections and 5 bridge crossings. These bridges include:

- Covered Bridge Road
- Route 17 Bridge below Livingston Manor
- Foot Bridge leading to High School
- Old Route 17
- Route 17 Bridge above Livingston Manor

The channel behind the school has no bridges and required 24 cross-sections. The channel behind the levee on the left overbank has no bridges and required 11 cross-sections.

The levees and wall along the Willowemoc are modeled as lateral structures. The levees' elevations, which were field surveyed, determine the discharges for the two back channel models and correspondingly the flow that remains in the main channel of the Willowemoc Creek downstream of the diversion points. As such, the modeling of the levees is critical to accurate water surface elevations throughout Livingston Manor.

Hydraulically the levees were assumed not to fail during overtopping and interior water surface elevations were assumed not to exert a backwater effect on the levee. However, these levees do not appear to have been maintained or to meet USACE requirements and failures of portions of the levee could occur.

An example of the cross sections created for the HEC-RAS modeling of Willowemoc Creek is provided in Figure 4.5. Two foot contours are shown. The remaining cross section figures for Willowemoc Creek, as well as the cross sections for Little Beaver Kill and Cattail Brook, are provided in Appendix A.

The Little Beaver Kill HEC-RAS model required the use of 30 cross sections and 1 bridge, which was the Main Street bridge.

The Cattail Brook HEC-RAS model required the use of 37 cross sections and 7 bridges crossings. These bridges include:

- River Street
- An Access Road approximately 198 feet upstream
- Creamery Road
- Finch Street
- A Private Road approximately 469 feet upstream
- Hoos Road
- Main Street (County Road 149)

The five HEC-RAS models were run with the frequency discharges as determined in the hydrologic analysis. The hydraulic performance of the lateral structures in diverting water out of the main Willowemoc channel to the two back channels was assessed. Knowledge of levee performance is required because of the complex interaction between the main stem Willowemoc and the two back channels as mediated by the lateral structures. For example, raising a levee would reduce flow into a back channel but it would also increase the flow in the Willowemoc downstream of what was once a diversion point. The frequency water surface profiles are the basis for calculating economic damages.

A detailed description of the hydraulic analysis can be found in Appendix A.

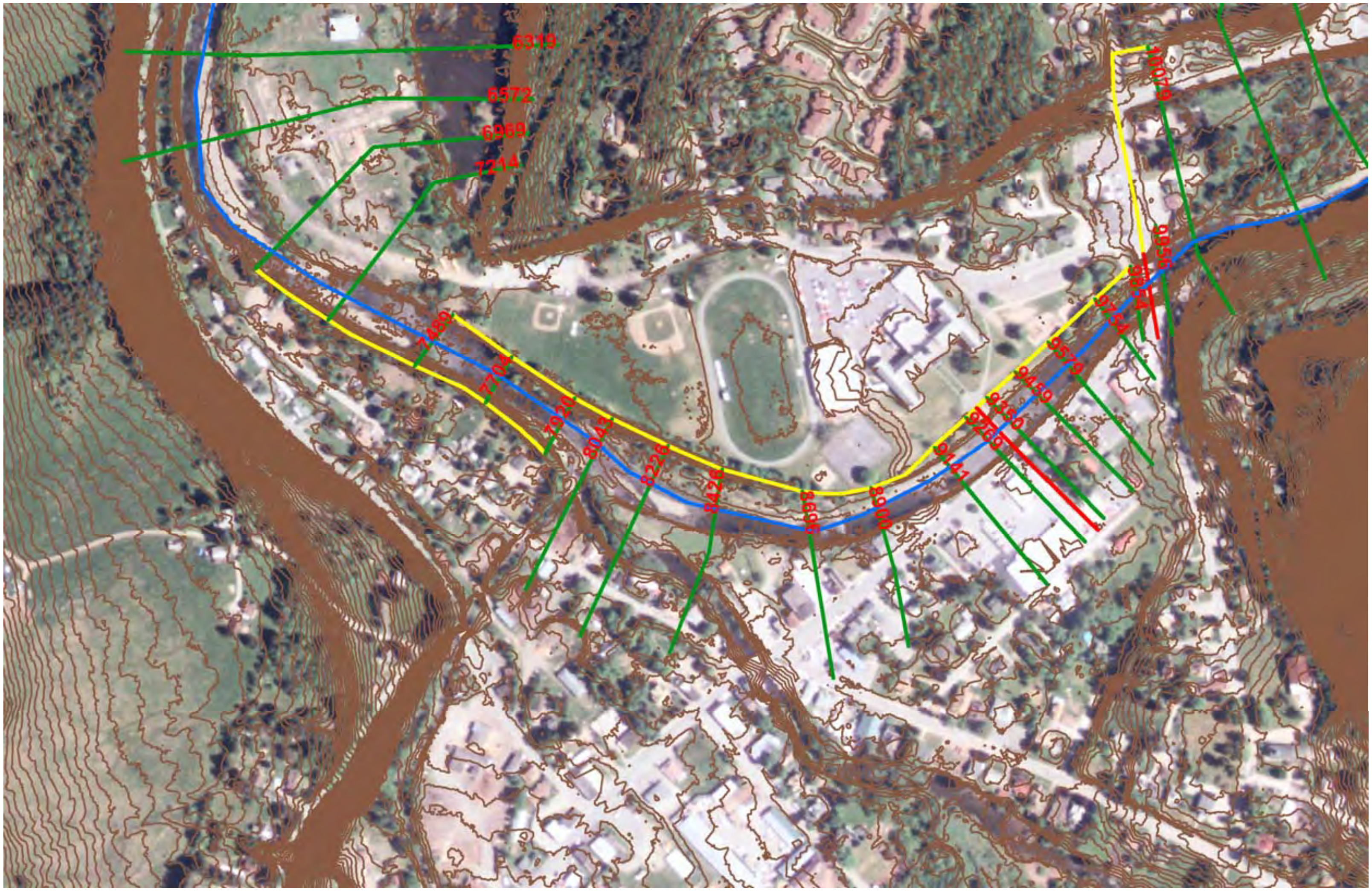


Figure 3.6: Example of the cross sections created for the HEC-RAS modeling of the Willowemoc Creek

3.3 Economic Model/Flood Damage Analysis

Structures within the area of interest were surveyed and values were assigned to each structure. Structures were grouped into economic reaches to ensure an accurate spatial distribution of the damages (Figures 4.6 – 4.8). A hydraulic cross-section was assigned to each economic reach as means of correlating the water surface elevation-frequency results with the surveyed structures. Average annual damages were calculated for each reach. The majority of the damage is located along Little Beaver Kill Creek.

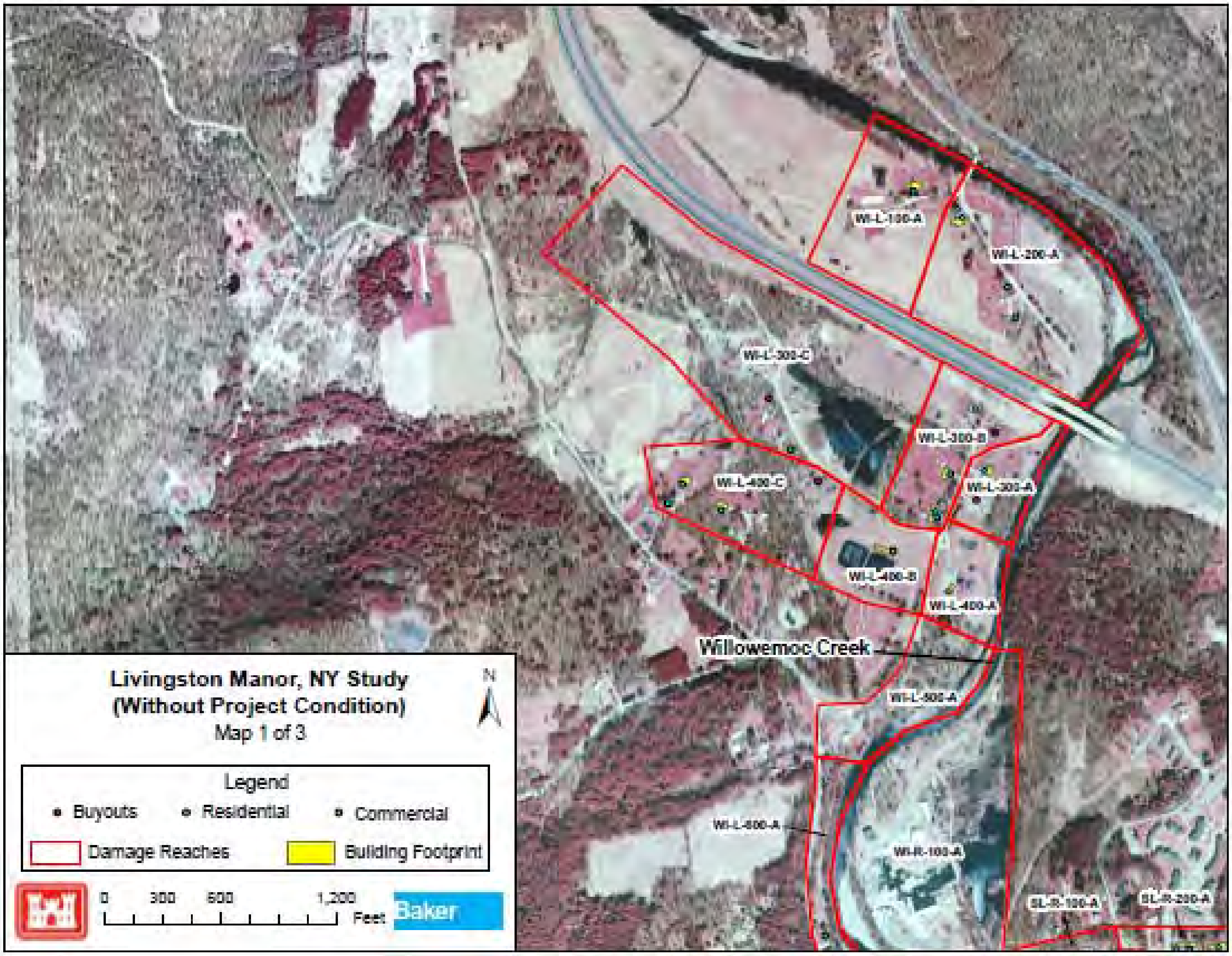


Figure 3.7: Economic Damage Reaches (Route 17 area).

Figure 3.8: Economic Damage Reaches (Downtown area).

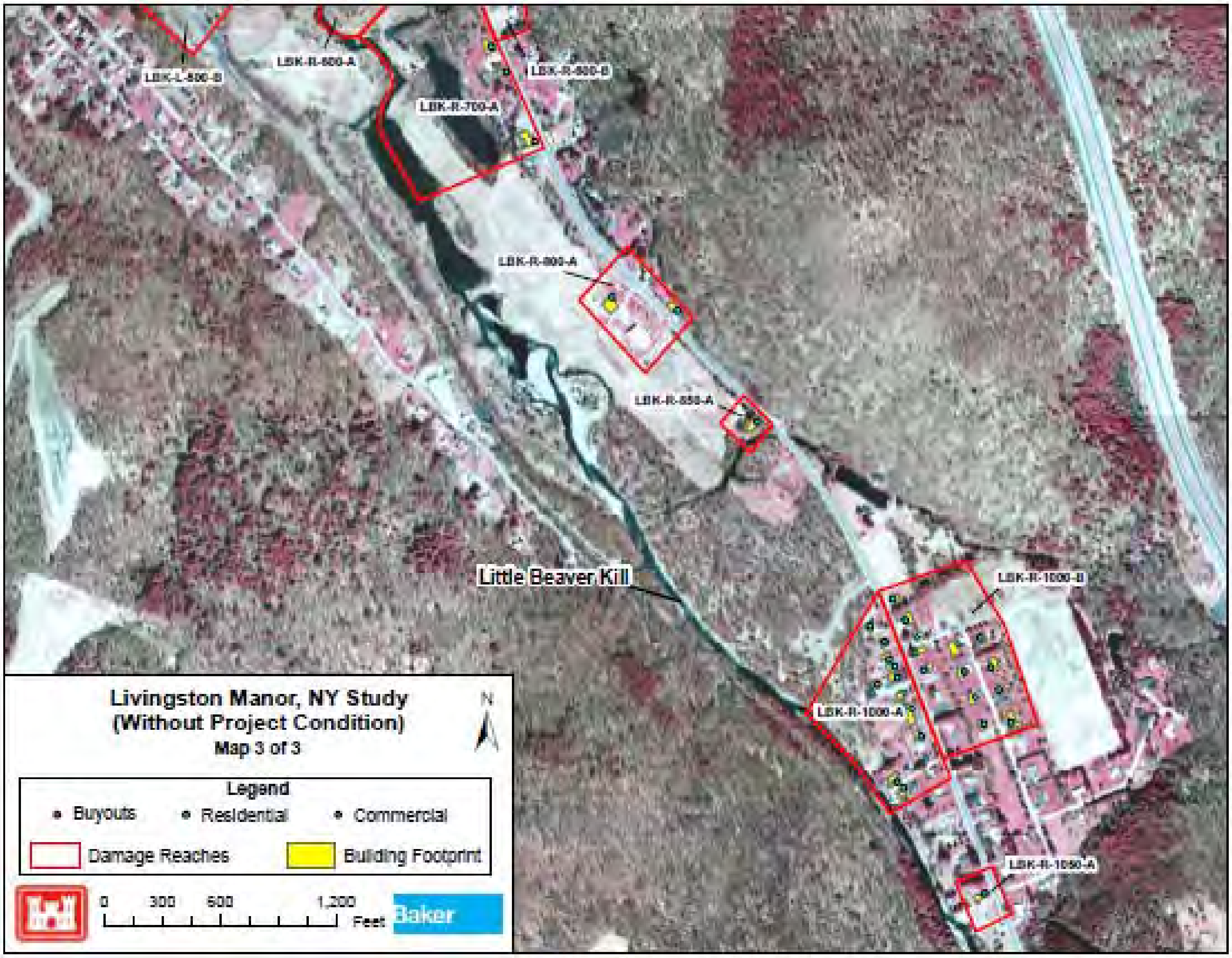


Figure 3.9: Economic Damage Reaches (Airport area).

4.0 Plan Formulation

4.1 Problems, Goals, Objectives and Criteria

The Federal objective in making investments in flood risk management is to contribute to the National Economic Development (NED), consistent with protecting the Nation's environment, and / or to the National Ecosystem Restoration (NER). Contribution to NED is achieved by increasing the net value of the nation's output of goods and services, expressed in monetary units. NED contributions must also consider the environmental effects of proposed changes on ecological, cultural, and aesthetic attributes of natural and cultural resources. Contribution to the NER is achieved by increasing the net value to the nation's output of significant habitat, expressed in habitat units. Plans formulated during this study were evaluated based on their contribution to NED, consistent with protection of the nation's environment, and their contribution to NER.

The optimum level of flood risk management that can be justified will be determined by analysis. Risk management measures must function without causing adverse effects in other areas (primarily downstream). When an NED plan is identified, the risk or uncertainty associated with the plan, that is, the magnitude of residual damages or potential effects associated with failure above flood design levels, will be determined by analysis. The plan should be complete and not require additional future improvements other than normal Operation and Maintenance (O&M). The plan must be realistic, state-of-the-art, and in compliance with sound engineering practice.

The NED objective is maximization of the economic worth of alternative plans. For flood risk management projects, this objective relates to a plan's capability to manage flood risk by comparing the plan's economic benefits with the project cost on an annualized basis. The amount that a project's economic benefits exceed the project cost is defined as net benefits. In the plan formulation process, the plan that yields the greatest net benefits best meets the NED objective.

The relationship of benefits to costs is expressed in terms of a benefit-cost ratio (BCR). Flood risk management benefits are the monetary savings or benefits due to damages prevented, reduction in the cost of emergency services, and reduction of economic disruption. These project benefits are subsequently annualized to represent an annual benefit applicable for the period of analysis. The project cost, which includes the construction, or first cost, the interest (opportunity cost) on the first cost during construction, the O&M costs, and the interest to amortize the project cost over the period of analysis are also annualized to represent an annual project cost applicable for the period of analysis. The annual benefits and the annual costs are then related in a ratio of benefits to costs. To be economically feasible, a plan must ultimately have greater benefits than costs or, more specifically, a BCR greater than 1.0, based on the current applicable Federal interest rate.

Recommendations should seek to provide a plan that reasonably maximizes net benefits, unless certain provisions can be applied to supersede this criterion. One such provision allows a locally preferred plan (LPP) to be selected as the recommended plan, if the plan yields greater net benefits than any smaller scale alternative. Recommended plans that are less costly than the NED Plan would be cost-shared on the same basis as the NED Plan. In the absence of special legislation, Federal participation in a recommended plan that is more costly than the NED Plan would be limited to the Federal share of the NED Plan, unless the increased cost is deemed worthy of warranting Federal participation, and is specified as such in the exception. Cost sharing may then be calculated on the same basis as the NED Plan.

Aquatic ecosystem restoration was recognized as a Corps mission in 1996, thereby allowing investigation of alternatives and implementation of aquatic ecosystem restoration projects to be cost-shared between the Federal government and the local sponsor. Plans formulated for restoration vary from those formulated for flood risk management in that 1) they make environmental improvement an objective, 2) the ultimate design is self-maintaining, 3) restoration science is relatively new and unproven, and 4) policy constraints differ.

In order to determine the NER plan, alternative plans are considered, costs are developed and outputs/benefits are defined. Traditional benefit-cost analysis is not possible with non-monetary benefits or outputs. Therefore, cost-effectiveness/incremental cost analysis (CE/ICA) is used to determine the NER plan. The recommended plan should be the justified alternative and scale having the maximum of monetary and non-monetary (habitat units) beneficial effects over monetary and non-monetary costs. (In other words, it is the plan that provides the most for the money). This plan occurs where the incremental beneficial effects just equal the incremental costs or, alternatively stated, where the extra environmental value is just worth the extra costs.

In some instances, plans may be formulated to meet several different types of objectives. NED and NER plans are commonly combined together into one plan known as the Combined Plan. Combined Plans may not produce the greatest number of benefits in either category; there are trade-offs that are considered. However, they do produce benefits to both categories, and are often more efficient than two projects formulated independently for different, single purposes. Also, there may be opportunities to include features to address additional, secondary, purposes such as recreation. For Combined Plans, costs are allocated to each purpose. The costs are then compared to the benefits to determine the effectiveness of the plan relative to each purpose.

The following sections list the planning goals, objectives and criteria used for this study to formulate and evaluate Federal interest in alternative plans to address flood risk management and associated ecosystem restoration.

4.1.1 History of Past Flooding and Ecological Degradation

The severe, repetitive, damaging floods in the Livingston Manor area have been documented since the late 1800's with significant events recorded in June 1969, June 1973, January 1996, November 1996, September 2004, April 2005 and June 2006. These floods caused millions of dollars in damage to homes, businesses, and infrastructure and resulted in Federal disaster declarations. Typical damages include inundation of residential and commercial structures, as well as erosion of roads, retaining walls, bridge piers and abutments. From the January, 1996 storm alone, Sullivan County reported infrastructure damages of $5,500,000 and property damages of $4,400,000. Approximately 20 miles of county roads suffered severe damage to shoulders, pavement, embankments, and drainage systems. Immediate repairs were needed for at least 20 bridges and their adjacent roadways, including 2 which were destroyed.

There are several water resources problems associated with the area surrounding Livingston Manor along the Little Beaver Kill, Willowemoc Creek and Cattail Brook. The study area is famous for the excellent fishing found in its streams. Brown, rainbow, and brook trout are the dominant sport fish. These streams serve as spawning and nursery areas for larger stocked streams and reservoirs and they are stocked annually to supplement natural trout populations. However, these fisheries are threatened by environmental degradation through destruction of in-stream habitat and increased turbidity as the result of bank and channel erosion, poor sediment management, flooding, and flood recovery efforts. The loss of wetlands and riparian buffers in the study area has also been cited as a concern because of the loss of associated benefits such as improved water quality, flood protection, and quality fish and wildlife habitat.

4.1.2 Planning Goals

General Goals

- Make investments in flood risk management to contribute to the NED, consistent with protecting the Nation’s environment or to NER.
- Where feasible, manage flood risk in the study area.

Study-Specific Goals

- Reduce damages from frequently recurring flooding within the community.
- Identify opportunities for, and feasible methods of, flood risk management and related ecosystem restoration in the study area.
- Improve aquatic habitat conditions for sustainable native trout populations.

4.1.3 Planning Objectives

General Objectives

- Address the specific needs and concerns of the general public within the study area.
- Be flexible to accommodate changing economic, social, and environmental patterns and changing technologies.
- Integrate with and complement other related programs within the study area.
- Provide information to the public on existing and predicted flood risk in the study area; provide information on flood risk management measures.

Study-Specific Objectives

- Prevent flood damages for the study area communities.
- Evaluate specific structural and nonstructural methods to manage flood risk in the study area.
- Evaluate flood risk management-related ecosystem restoration measures in the study area.

4.1.4 Planning Criteria

General Planning Criteria

Technical

- Plans must be sound, safe, acceptable engineering and environmental solutions.
- Plans must be in compliance with good engineering and environmental practice, taking into account low risk of failure, and the safety of human lives and property.
- Plans must be realistic and must not rely on future research and development of key components, although they should contain a monitoring component to assess success and identify corrective actions as appropriate.
- Plans must be consistent with existing local plans for flood risk management.
- Plans must be complete and not depend on future projects to provide the necessary flood protection.
- The 1% ACE (100-year) flood flow water surface elevation should not increase more than 0.2 foot with a structural flood risk management alternative in place.

Economic – National Economic Development

- The recommended plan must be economically feasible; i.e., the plan’s benefits must exceed the cost of the plan.
- Alternative plans should be evaluated using the current Federal interest rate and price levels over a 50-year period of analysis.
- Annualized costs must include the cost of operation, maintenance, repair, rehabilitation, and replacements.
- Plans must be efficient. They must represent optimal use of resources in an overall sense.
- Plans must consider avoiding impacts. Where this is not possible, minimization should next be considered, followed by mitigation or replacement, if justified.

- Where opportunities exist to enhance significant environmental resources, the plan should incorporate all justified measures.

Economic – National Ecosystem Restoration

- The project should restore ecosystem structure, functions, and values.
- The project should result in improved environmental quality.
- The improvement should be of great enough national significance to justify Federal expenditure.
- The measures taken to improve environmental quality should result in a more naturalistic and self-regulating system.
- The measures should reestablish, to the extent possible, a close approximation of predevelopment conditions.

Environmental and Social

- Evaluate structural, nonstructural, and restoration measures in accordance with guidelines established by the National Environmental Policy Act of 1969 (Public Law 91 190), as amended, and the Principles and Guidelines for Water and Related Land Resources Implementation Studies, as developed by the U.S. Water Resources Council, dated July 1983.
- Promote the protection and enhancement of areas of natural beauty and human enjoyment.
- Protect areas of valuable natural resources.
- Protect quality aspects of water, land, and air resources in the watershed.
- Protect against possible loss of life and hazards to health.
- Promote safety.
- Preserve and enhance social, cultural, educational, and historical values within the project area.
- Minimize and, if possible, avoid the displacement of people and destruction or disruption of community cohesion.

In addition, all Corps civil works projects must be in compliance with the agency's Environmental Operating Principles (EOP) and Doctrine.

- Strive to achieve environmental sustainability.
- Recognize the interdependence of life and the physical environment.
- Seek balance and synergy among human development activities and natural systems by designing economic and environmental solutions that support and reinforce one another.

- Continue to accept corporate responsibility and accountability under the law for activities and decisions under our control that impact human health and welfare and the continued viability of natural systems.
- Seek ways and means to assess and mitigate cumulative impacts to the environment; bring systems approaches to the full life cycles of our processes and work.
- Build and share an integrated scientific, economic, and social knowledge base that supports a greater understanding of the environment and impacts of our work.
- Respect the views of individuals and groups interested in Corps activities, listen to them actively, and learn from their perspective in the search to find innovative win-win solutions to the Nation's problems that also protect and enhance the environment.

Study-Specific Planning Criteria

- Make sure plans recognize the presence and number of historic structures; avoid or minimize impacts to historic character through retrofit measures. Assure compliance with Section 106 of the National Historic Preservation Act.
- Recognize the historic and current function of the streams in the lives of the study area communities and avoid severing the communities' connections to these streams. Recognize the streams as a visual, recreational, and economic resource to the communities.
- Take past and current planning and management efforts into account in formulation of new flood risk management measures. Recognize previously identified limitations on the feasibility and suitability of large structural water control projects on the streams.
- Recognize the various existing landforms in the study area that were not constructed nor maintained as flood risk management measures, but are currently depended on to function in that role.
- Account for potential contaminated sites in the development of flood risk management measures. Avoid changes to existing landforms that would increase flows into or from potentially contaminated areas.
- Recognize on-going human activities and land-usage in identification of potential sites and measures for flood risk management-related ecosystem restoration.

4.2 Plan Formulation Approach

An array of potential solutions is available for consideration to address flooding issues. Most options were addressed by the Corps in the July1997 *Upper Delaware River Watershed, New York, Expedited Reconnaissance Study Section 905(b) (WRDA 86) Analysis* and the Addendum, which was completed in February 2008. The current study revisits the previously identified options using updated information, including surveys, mapping and modeling in the assessment, as well as considering new or modified alternatives.

The Corps worked with the local sponsor and cooperating agencies to establish a plan formulation approach for the Interim Feasibility Study for Livingston Manor, reflecting the Corps' Planning Guidance, Strategic Plan, Environmental Operating Principles, and Collaborative Planning Guidance.

Corps guidance and planning initiatives have been coordinated with the study team to establish the plan formulation approach. This effort was undertaken to establish and coordinate an agreed-upon process that would be followed for plan development.

Taken as a whole, the plan formulation approach recognizes the need to balance flood risk management and ecosystem restoration opportunities with other social and environmental needs within the study area. In addition to the no action alternative, as represented by the without project future condition, the broad range of alternatives is discussed below.

4.2.1 Range of Alternatives

A general description of the range of alternatives evaluated is provided in the section below. The approach to developing a comprehensive plan is to separately identify and evaluate the over-arching regional management measures, and the more localized measures necessary to address specific problems or opportunities. The watershed measures and local measures will be identified for possible implementation for the overall study area, either separately or in combination with other alternatives.

The individual structural and nonstructural measures have initially been developed separately as features to address flood damages, and ecosystem restoration needs. Once the evaluation of these features has been undertaken, the measures will be evaluated to identify features that are complementary and could be combined together.

4.2.1.1 Structural Measures

Structural measures consist of structures designed to control, divert, or exclude the flow of water from the flood-prone areas to the extent necessary to reduce damages to property, hazards to life or public health, and general economic losses.

4.2.1.2 Nonstructural Measures

Nonstructural measures are those activities that can be undertaken to move what is being damaged out of harm's way, rather than attempting to alter the movement of water. Nonstructural measures include a variety of techniques, including land-use controls to limit future development in the flood hazard areas, acquisition or relocation of flood-prone development, and retrofit of existing structures.

4.2.1.3 Ecosystem Restoration

Ecosystem restoration measures seek to restore the functional outputs of important habitats within the study area. Restoring wetlands can also provide localized flood risk management by slowing the speed of floodwaters, absorbing the force of flow, detaining floodwaters, and filtering out suspended solids. Through these actions, wetlands have the potential to lower flood heights and reduce the erosive potential of the water.

4.2.2 Floodplain Management Plan

It should also be acknowledged that in addition to identifying a recommended plan for Federal participation, it is also possible to identify alternatives, which if not implemented by the Federal government, could be recommended as elements that could be locally implemented and considered as part of a Floodplain Management Plan (FPMP) or an expanded FPMP. As part of any Corps flood risk management project, a requirement for project implementation is that a FPMP be in place within one year of signing the Project Partnership Agreement (PPA) with a non-Federal construction partner. This study helps to identify alternatives that have local support that could comprise elements of an expanded FPMP, such as land development regulation. Although part of any future Corps flood risk management project, a FPMP will not be produced as part of this Interim Feasibility Study.

4.2.3 Iterative Approach

The planning process for the study has followed the Corps' six-step, iterative planning process:

1. Specify Problems and Opportunities
2. Inventory and Forecast Conditions Without Project
3. Formulate Alternative Plans
4. Evaluate Alternative Effects
5. Compare Alternative Plans
6. Select Recommended Plan

For the Interim Feasibility Study for Livingston Manor, this six-step procedure will be followed, with the formulation, evaluation and comparison steps (Steps 3-5) repeated iteratively in each of the three Cycles described below. (This process has been performed for Cycle 1-Screening of Measures and a portion of Cycle 2-Initial Assessment of Alternative Measures) Each phase of investigation develops alternative measures to an increased level of detail to determine whether the alternative measures should be considered further, or eliminated. The three phases of analysis include the following:

- Cycle 1 – Screening of Measures
- Cycle 2 – Initial Assessment of Alternative Plans
- Cycle 3 – Incremental Alternative Plan Development and Assessment

The following sections provide a summary of the approach to this iterative process. Cycle 1 is a screening of flood risk management and ecosystem restoration measures to address water resource needs in the study area relative to the Principles and Guidelines. Cycle 2 of the iterative planning approach includes evaluating alternative design storm conditions and spatial extent of protection to select the most appropriate scale (storm discharge or spatial extent) for the measure. Cycle 3 of the analysis is to develop comprehensive alternative plans for the study area by developing combinations of the different alternatives. For the Interim Feasibility Study, a consistent terminology is used for describing alternatives, based upon the level of detail, and refinement. These terms generally are: 1) measures, 2) alternatives, and 3) alternative plans. The term “measure” is used in the screening process when describing the types of solutions that are available for flood risk management and are concept-level in detail. Measures are single features or activities which address the planning objectives. The term “alternative” represents a specific plan for an area, with specific design objectives, which represent a single risk management measure. The term “alternative plan” is defined as combinations of one or more measures, which can be integrated together, or varied by location to accomplish the desired objectives of flood risk management, and ecosystem restoration.

4.2.3.1 Cycle 1 - Screening of Measures

The screening of the full array of potential measures was performed to identify the specific measures that could potentially address the identified problems and opportunities. The Screening of Measures was undertaken in several parts. First, a full range of measures was evaluated qualitatively to determine if they are appropriate solutions to the identified ecosystem restoration and flood risk management problems. Each measure was then evaluated relative to evaluation criteria of completeness, effectiveness, efficiency, and acceptability derived from the Principles and Guidelines for Water and Land Related Resources Implementation Studies (P&G).

While Cycle 1 did not include a formal assessment of the with and without project conditions, the screening assumed that measures could eliminate the without project damages if the continued assessment of the alternative measures and plans is appropriate. If the pool of damages was insufficiently large to justify a measure, the continued assessment of that measure was considered to not be financially prudent.

A comparison was made of the estimated annual costs of local structural measures to the without project existing Average Annual Damages (AAD) of affected development to help guide assessments of cost effectiveness and economic efficiency; and to determine if the measures were likely to meet the P&G requirement for cost efficiency. For flood risk management measures, the benefits must exceed the costs. In general, if the annual cost of a measure significantly exceeds the maximum amount of damage that could be prevented, it was clear that the measure will not meet the standards for cost efficiency.

In evaluating the cost efficiency of structural and nonstructural alternatives, preliminary layouts and costs were developed. These preliminary costs were compared to the AAD in the protected reaches.

Ecosystem restoration measures were identified based on site-specific needs and opportunities. These measures are developed so that they can potentially address the needs for both ecosystem restoration and flood risk management. The Cycle1 Screening filters the suite of possible solutions to those measures that are consistent with the evaluation criteria of completeness, effectiveness, efficiency, and acceptability, and identifies measures for more refined evaluation during the Cycle 2 assessment.

4.2.3.2 Cycle 2 - Initial Assessment of Alternative Plans

Cycle 2 of the iterative formulation initiated a preliminary concept-level design of the more limited range of alternatives and analyses of economic issues. This includes preliminary design of alternatives at various scales, dimensions or levels of risk management. Each alternative was compared to the without project condition. (In Cycle 3, more detailed structural alternative layouts and cross sections will be developed using the best available topography and geotechnical data). Nonstructural alternatives were developed considering groups of structures with similar levels of flood risk, such as all structures within the 50% ACE (2-year) or 20% ACE (5-year) floodplains. Preliminary benefit analyses were performed for each of these flood risk management alternatives. In the second half of Cycle 2, incremental cost and benefits of increasing levels of risk management will be compared to identify which alternatives maximize NED benefits and to identify appropriate scales for further consideration. Also at this point, the study will evaluate the environmental effects of each alternative to avoid or minimize undesirable environmental impacts and to maximize economic efficiency. This does not involve detailed design and development of management plans but will be of sufficient detail to ensure that potential costs will be considered in the plan evaluation process.

Ecosystem restoration opportunities will be developed in sufficient detail to allow the costs of stand-alone restoration measures to be quantified. Ecosystem outputs will be evaluated using the Habitat Evaluation Procedures (HEP), a method used to document the quality and quantity of available habitat for selected wildlife species under different conditions. A Cost Effective/Incremental Cost Analysis (CE/ICA) will be performed to identify a NER Plan that provides the most cost-effective level of environmental outputs. Where alternative restoration measures also affect the frequency or extent of flood damage, the NED benefits will be calculated and incorporated into the analysis. The benefits will be calculated using the same manner as the flood risk management measures.

4.2.3.3 Cycle 3 - Incremental Alternative Plan Development and Assessment

The third cycle of the analysis will be to develop comprehensive alternative plans for the study area by developing combinations of the different alternatives. This will most likely involve identifying the combination with the most cost-effective watershed flood risk management alternative and the most cost-effective ecosystem restoration and structural and nonstructural flood risk management alternatives. Nonstructural measures will be considered both on a community and study area-wide (watershed) basis to identify potential NED solutions.

In areas where either structural or nonstructural alternatives may efficiently address the problems, multiple combined flood risk management plans will be developed. The NED Flood Risk Management Plan will incorporate the most cost-effective approach for these areas, based on the highest net economic benefits in excess of costs.

The addition of ecosystem restoration alternatives to the plans requires an assessment of the combined cost of implementation. Costs will be allocated to the ecosystem restoration and flood risk management purposes using the Separable Costs-Remaining Benefits (SCRB) method. Because ecosystem restoration benefits are measured in habitat units, not dollar values, the SCRB allocation will assume that the dollar value of NER benefits for an alternative is equal to the separable costs for that alternative developed in Cycle 2. Because some combined NED/NER Plans may provide significant cost savings relative to the individual alternatives, the Combined Multi-Purpose Plans may provide higher net excess benefits than the NED Flood Risk Management Plan.

The most cost-effective plan will be selected by comparing the single-purpose NED or NER plans to any multi-purpose plans to verify that the final selected plan meets NED/NER criteria. To ensure that the selected plan still meets NED/NER criteria after implementation of watershed measures, the most cost-effective local plans will be evaluated in combination with the watershed plan.

4.3 Description of Measures

4.3.1 Description of Flood Risk Management Measures

Section 4.5 presents a description of the watershed, structural, nonstructural and ecosystem restoration measures for flood risk management and ecosystem enhancement. A discussion of the watershed measures is provided first. Watershed measures are implementable outside the boundary and authority of individual municipalities, and include techniques such as large-scale flood forecasting and warning, and reservoir management. Structural measures, which seek to redirect or restrain the flow of floodwaters, are then described. The following sections describe nonstructural options, grouped into the categories of land use and regulatory measures; building retrofit measures; and land acquisition measures. This is followed by a description of ecosystem restoration measures and a description of potential ecosystem restoration opportunities in the study area.

4.3.2 Watershed Measures

4.3.2.1 Flood Warning System

The process of notifying local residents of impending floods can be divided into flood forecasting, warning, and preparedness planning. It is important to note that an effective flood warning system is an important element of other flood risk management measures, helping to protect human life and to ensure correct operation of gates, pumps and closure structures.

Forecasting and warning is primarily a program of the National Weather Service (NWS). While flood forecasting and warning are generally regional in nature and, thus, appropriately handled by agencies with larger jurisdictions, flood preparedness and planning are a local responsibility and part of the All Hazard Mitigation Plan currently required by FEMA. Upon request, and within available funding, the Corps can provide technical assistance and access to data for all applicable sections of the planning process, including but not limited to flooding hazards.

4.3.2.2 Reservoir Management

This technique involves planned methods by which existing reservoirs can be used for multiple purposes, including flood risk management, water supply, recreation, and power generation, while achieving the primary purposes of those facilities. For example, volume in a water supply reservoir can be drawn down in anticipation of forecast spring flooding from snowmelt. The reduction in volume allows for greater retention of floodwaters, which in turn restores the reservoir to its target volume. If multiple reservoirs are present in a watershed, coordination must be used to identify and achieve the multi-use objectives. Typically such coordination would require the involvement of multiple municipalities or counties.

4.3.3 Structural Measures

4.3.3.1 Levees and Floodwalls

In general, floodwalls and levees function within the limits of their design to confine flood flows to the existing channel footprint, prevent breakout of floodwaters, and provide protection against flooding. Interior drainage facilities are often required to handle stormwater that ponds behind the barriers. Levees and floodwalls can be combined with closure structures, such as stoplog closures and gate closures, which are manually installed over roadways, bridges, and railways prior to flooding to provide a continuous barrier against flooding to a pre-determined elevation. Levees are earthen embankments, whereas permanent floodwalls are usually built out of concrete or sheetpile, and temporary floodwalls can be constructed out of a variety of materials. Temporary floodwalls are stored as reusable segmented sections that are then put in place and attached to each other in anticipation of the arrival of floodwaters. Typically, temporary floodwalls can take the place of sandbag floodwalls. They can also be used to augment permanent flood barriers such as berms or levees. Permanently installed, deployable flood barriers can also be used. These barriers can be constructed to deploy automatically when floodwaters reach the structure, using hydrostatic pressure to raise the barrier into place.

4.3.3.2 Channel Modification

Channel modification involves widening, deepening or straightening of existing channels, creation of new channels, and the modification of highway and railroad bridges that constrict the channel. Dredging involves mechanical removal of shoaled or deposited material (sediment) from river and tributary beds.

4.3.3.3 Dams or Flow Detention

Flood control dams can have a permanent pool of water behind them, or they may be designed to not retain a permanent pool. This second kind is known as a dry dam. Both types are designed to allow regular passage of water through them and to form a flood pool behind them during heavy rainfall events. Behind dry dams, the land reserved for the temporary flood pool can host compatible uses, such as farming or recreation, when a pool is not present. Since dry dams do not require a permanent pool, they may be more acceptable to the local community.

A typically smaller form of flow detention, known as detention basins, are used to attenuate the peak flow rate of run-off by temporarily storing large volumes of stormwater, then releasing them at a controlled rate of flow. This alternative was considered as a means to create flood storage areas in the floodplain by enclosing a large area with a dike. During floods, the floodwaters would overflow into the storage area. Stored floodwaters would then be released slowly through a downstream outlet. Placing flood control storage areas in the floodplain would require an extensive amount of land to achieve any measurable water surface elevation reductions.

4.3.3.4 Dam Removal

Dam removal would remove controls on downstream flows from former impoundment areas. The technique is used to restore natural flow to rivers, potentially reduce flooding on tributaries and areas upstream of the dam. For ecosystem restoration purposes, it can be used to improve the ability of fish to travel upstream to spawning habitats.

4.3.4 Nonstructural Measures

4.3.4.1 Land Use and Regulatory Measures

The measures described below are designed to direct the location and nature of new development and redevelopment to manage risks from flooding and other hazards.

Zoning and Land Use Controls: State and regional regulations and municipal ordinances can be used to restrict development or redevelopment of structures in at-risk areas. The controls may restrict permitted uses, size, density, and structural siting. Examples include required setbacks from riverfronts or other flood-prone areas. If widely applied, such restrictions can help provide a buffer area between development and areas of greatest risk.

New Infrastructure Controls and Landform/Habitat Regulations: Restrictions on the installation of infrastructure or new connections to existing infrastructure in hazard areas can serve to reduce development, while the use of higher infrastructure standards such as recharge basins can reduce flood risk during storms. Landform and habitat regulations can restrict development in floodprone and/or environmentally sensitive areas and promote the function of natural floodplains.

Construction Standards and Practices: Locally adopted, enforceable codes can regulate the use of building materials and design standards to minimize damage from assorted hazards, including high winds, heavy rains, and flooding. Examples include reinforced foundation footings, piers and foundations, roof anchoring, and provision of adequate drainage.

Insurance Program Modifications: In general, this technique consists of modifications to the National Flood Insurance Program (NFIP) to adjust risk classifications and premiums to reflect flooding hazards at current levels. This can be achieved through remapping floodprone areas using the latest available hydrology, topographic mapping, and modeling methods. Accurate classification of flood risk may discourage or reduce development or redevelopment within high-risk areas.

Tax Incentives: This technique provides tax benefits to property owners for various measures to reduce or eliminate future flooding damage. Such measures include retrofits to existing buildings to reduce flood damage and the establishment of conservation easements, land donation arrangements, or other development restrictions on undeveloped land susceptible to flooding.

4.3.4.2 Building Retrofit Measures

Building retrofit measures are designed to protect damageable property from floodwaters by preventing the water from entering a structure, moving the structure out of flood prone areas, elevating the structure above flood elevations, or modifying the structure so that designated portions (e.g., lower floors or basements) are designed to flood without incurring damage. All exterior losses such as damage to grounds, utilities, roads, crops, etc., would be fully sustained in the future. Description of the assorted techniques follows.

Structure Relocation: Structure relocation involves physically picking a structure up and moving it out of the floodplain. As with buyouts, structure relocation can be a very effective means of eliminating losses from flood damage.

Relocation is, in many respects, the most effective method for retrofitting an existing structure to reduce damage. Ideally, the structure would be entirely removed from the hazard area, eliminating any potential for flood damage and adverse environmental effects such as the collapse of on-site waste disposal systems. A building can be relocated to a new site, or if sufficient space is available outside the floodplain, within the existing lot.

Structure Elevation: Structure elevation involves raising the structure in place, such that floodwaters flow beneath the occupied portion of the building. As described in *Selecting Appropriate Mitigation Measures for Floodprone Structures* - FEMA 551, March 2007, "Elevating a structure to prevent floodwaters from reaching living areas is an effective and one of the most common mitigation methods. The goal of the elevation process is to raise the lowest floor to or above the required level of protection. This can be done by elevating the entire structure, including the floor, or by leaving the structure in its existing position and constructing a new, elevated floor within it. The method used depends on the construction type, foundation type, and flooding conditions." This method is most applicable to frame construction. If a basement were present, it would need to be filled in. Structure elevation projects are more appropriate in areas that experience slower moving floodwaters.

Structure Rebuilding: Structure rebuilding involves construction of a new building on the same property instead of elevating, retrofitting, or otherwise modifying the existing building. The new building will be in compliance with local floodplain management requirements, with the main floor above the base flood elevation. This technique can be used when the existing building is in poor condition, has low value, may require special methods or remedial treatments to elevate, or because of its function is not suitable for elevation or other means of retrofit. Structures in the latter category include large non-residential structures such as firehouses. The existing building would be demolished and a new building be constructed, adhering to applicable floodplain management requirements and building codes.

Free-Standing Barriers: Structure perimeter protection is generally provided by a small levee or floodwall. Perimeter protection is more applicable to multi-building installations or small groups of buildings. A berm can be integrated into a landscaping plan to make it less intrusive. The structure must incorporate a method for discharging precipitation falling inside the perimeter, as well as any floodwaters that exceed the design of the structure.

Dry Floodproofing: Dry floodproofing is making a structure "watertight below the level that needs flood protection to prevent floodwaters from entering. A structure can be dry floodproofed using waterproof coatings or impermeable membranes to prevent seepage of floodwater through the walls, installing watertight shields over doors or windows, and installing sewer backup prevention measures" (FEMA, 2007). Because water will be accumulating outside the building, but not inside it, hydrostatic pressure will build up. If a basement is present, it must be specially designed to withstand the hydrostatic pressure, though pressure on all walls and floors must be considered. Applying a waterproof seal to the structure works best with heavily constructed masonry or concrete structures and flood conditions that are relatively brief in duration. Given the hydrostatic pressure against the structure, this technique is limited to areas that will experience less than three feet of flooding. This technique is not allowed under the NFIP for new or substantially improved or damaged residential structures located in the floodplain; however, it is allowed for non-residential structures in the floodplain.

The velocity of flooding is a primary consideration in the evaluation of dry floodproofing for a given structure. The technique is appropriate only for areas with slow flood velocity (less than three feet-per-second or fps), without threat of flash-flooding, and where flooding depths will be less than three feet.

Wet Floodproofing: Wet floodproofing a structure "consists of modifying the uninhabited portions (such as a crawlspace or an unfinished basement) to allow floodwaters to enter and exit. This ensures equal hydrostatic pressure on the interior and exterior of the structure and its supports. Equalized pressure will reduce the likelihood of wall failures and structural damage. Wet floodproofing is not practical for most slab-on-grade structures that have the living space at or near ground level. Whether or not floodproofing is appropriate depends on the flood conditions, the design and construction of the structure, and whether the structure has been substantially damaged or is being substantially improved. However, many industrial or commercial structures could benefit greatly from wet floodproofing techniques" (FEMA, 2007). All utilities need to be elevated or put in a watertight room. FEMA cautions that "(w)et floodproofing does not reduce flood insurance premium rates on residential structures. Premium rates can only be reduced through elevation of the residential structure above Base Flood Elevation. Non-residential structures can reduce flood insurance premium rates through other forms of floodproofing."

The velocity of flooding is a primary consideration in the evaluation of wet floodproofing for a given structure. The technique is appropriate only for areas with slow flood velocity (less than three feet-per-second or fps) and without threat of flash-flooding. Wet floodproofing can be applied to a greater range of flooding depths (including deep flooding over six feet in depth). Thus, if the technique may be indicated for a given building, then a review of flood velocities in specific locations (e.g., at locations of the candidate building) will be required.

Protection of Utilities: The protection of utilities is the management of flood risk to building utilities such as electrical panels, HVAC units, and hot water heaters through in-place protection (placing utilities in flood-proof enclosures) or by elevating utilities above flood height, often by placing utilities in an addition to the original building. Utilities can be enclosed in floodproof concrete chambers or relocated from a flood-prone basement to a location above base flood elevation. The technique is most effective in areas with frequent low-level flooding below the main floor of structures.

Structure Acquisition: Structure acquisition (also known as structure buyout) is described thus: "acquiring and demolishing or simply demolishing a flood-prone structure is the most successful means of ensuring that a structure will not accumulate additional losses from future flood events" (FEMA, 2007). The structure is bought by a public party (such as the local sponsor) using cost-shared funds, and is no longer occupied. The structure is typically demolished and the property may be converted to recreational use. Acquisitions should accomplish the following: *a.* public acquisition and removal of flood-prone structures; *b.* assembly of vacant parcels to preclude development; *c.* prohibitions against new structures in the floodplain, or floodproofing and stormwater management in some limited cases; *d.* creation of recreation or natural wildlife areas and wetlands in appropriate areas; *e.* development of permanent public open space to provide new recreational opportunities; *f.* removal of, or adjustments to, the public infrastructure to eliminate intrusions into the floodplains and to prevent interruption of essential services during floods; and *g.* enforcement of land use controls to prevent redevelopment in acquired areas and establishment of water management standards at un-acquired properties (FEMA, 2007).

4.3.5 Land Acquisition Measures

4.3.5.1 Purchase of Property

Purchase of property is the public acquisition of private developed or undeveloped lands vulnerable to flooding for long-term protection and preservation. Purchase of developed lands requires purchase and removal of buildings. A requirement is the preparation of a plan for the alternate use of the land, which may include recreation or open-space uses.

4.3.5.2 Easements and Deed Restrictions

Easements allow owners to retain full ownership of property but can either restrict certain uses or permit the use of land by the public or particular entities for specified purposes. Easements are generally established as part of the deed restrictions. For purposes of flood risk management, easements may restrict development of flood prone portions of property, or could be used to create flowage areas where floodwaters are directed en route to water bodies or detention basins.

4.3.6 Ecosystem Restoration Measures

4.3.6.1 Floodplain Reclamation/Wetland Restoration

Reclaimed floodplains and wetlands can provide localized flood risk management by slowing the speed of floodwaters, absorbing the force of flow, and detaining floodwaters. Through these actions, floodplains and wetlands can lower flood heights and reduce the erosive potential of the water, thereby minimizing property damage. Floodplain reclamation can be achieved through removal of buildings and flood control structures to allow floodwaters to return. Wetland restoration can expand upon the ecosystem services of existing wetlands by improving hydrology to increase flows and expand flood storage capacity. Habitat enhancements to benefit wildlife can also be incorporated into wetland restoration projects, including control of invasive species to promote the viability of desired native vegetation. Creation of wetlands from former uplands through changes in hydrology can support growth of wetlands vegetation, as well as yield the flood risk management benefits of wetlands, if properly placed within the landscape.

4.4 Evaluation of Measures and Recommendations for Further Screening

A more detailed review under the criteria of completeness, effectiveness, efficiency and acceptability of measures was conducted for Livingston Manor. Description of these criteria is provided below. Structural and nonstructural measures to be eliminated from further evaluation were identified, as well as those measures that are recommended for further evaluation in the next stages of the planning process.

4.4.1 Evaluation Criteria

The evaluation of alternatives was structured to mirror the current Federal Principles and Guidelines for Water Resource Implementation Studies (P&G) assessment criteria that any plan must be complete, effective, efficient and acceptable. The following paragraphs discuss each of these criteria and identify some potential issues considered in the evaluation of the various alternative measures.

4.4.1.1 Completeness

Completeness is the extent to which any alternative accounts for all necessary investments or other actions necessary to achieve the expected benefits. While the plans presented are generally technically complete, environmental regulations are likely to require mitigation for negative environmental effects and for induced flood impacts. The screening of alternatives recognizes that it is necessary to offset any loss of wetlands or in-stream habitats. This includes potential water temperature impacts if levee, floodwall or channel modification plans require the removal of trees and other vegetation. In addition, some of the areas along the streams are used as parkland or open space. Some of the structural measures may require “diversion” of parkland along the river. This diversion of use may require mitigation or replacement.

At some locations, various types of FEMA flood or hazard mitigation funds may have been used to acquire properties subject to flood damage. The use of FEMA funds for these properties includes deed restrictions that would preclude the use of the property for structural flood risk management. Because the screening analysis has not attempted to identify any conflicts with such properties, there is a possibility that the structural alignments are not implementable without considerable revision.

4.4.1.2 Effectiveness

Effectiveness is the extent to which any alternative addresses the problems and opportunities. In general terms, the different measures considered for this screening vary in their effectiveness in addressing flood problems. Some of the structural measures, such as levees and floodwalls, seek to fully eliminate flooding from most events and avoid damage to both property and infrastructure and to avoid disruption of the community. Other measures, such as flood warning systems, are effective in reducing risks to life and easily moved property (cars and furnishings), but do not address the damage to building and infrastructure. The limitations in effectiveness are considered in the evaluation of various measures.

Future detailed assessments of effectiveness for the current study will be based on updated analysis of flood frequency, hydraulic flow lines and flood risk management. In order to comply with current Corps guidance regarding risk and uncertainty (R&U), each of these assessments now require explicit consideration of the uncertainty, or level of confidence, in the data. The various uncertainties will be incorporated into the Flood Damage Reduction Analysis (HEC-FDA) model and used to calculate the expected damage, confidence bands and the risk-based reliability. Such risk-based assessments typically include long-term risks and conditional non-exceedance assessments.

4.4.1.3 Efficiency

Efficiency is the extent to which each alternative represents a cost-effective use of resources. The primary measures of efficiency on a Federal project are the net NED Benefits, NER benefits and the BCR. Nonstructural measures such as building retrofits or acquisition are typically cost-effective for structures with a high average annual probability of significant flood damage. For areas where nonstructural measures appear technically feasible and implementable, the assessments evaluate protection limited to a range of floodplains, including areas with a high frequency of flooding.

4.4.1.4 Acceptability

Acceptability is a measure of the implementability of each alternative with respect to support by the State and local entities and the public and the compatibility of the plans with existing laws, regulations and policies. The greatest concern about acceptability is the potential for levee/floodwall measures to have a negative impact on community character by cutting off the physical and visual connection to the river.

Other potential acceptability issues are related to the possibility of potential fatal flaws in the environmental permitting process or an inability to obtain the necessary lands, easements or relocations. At this time there is insufficient information to identify any such fatal flaws.

4.4.2 Watershed Alternatives

4.4.2.1 Flood Warning System

Flood warning system expansion that increases public receipt of warning information and advance knowledge of hazardous conditions (such as reverse 9-1-1 for floodplain areas) would provide benefits to all of the communities within the study area and is recommended for continued development through joint Federal and local actions.

4.4.2.2 Reservoir Management

Six existing reservoirs that are upstream of Livingston Manor in the Little Beaver Kill watershed were considered for modification for flood risk management purposes. Only reservoirs in the Little Beaver Kill were examined because the majority of the economic damages are along the Little Beaver Kill. Reservoirs in the Willowemoc watershed were not considered because their modification was judged to have a minor effect on damage reduction. This is due to the small drainage areas controlled by those reservoirs relative to the large drainage area of the Willowemoc at Livingston Manor.

The six reservoirs in the Little Beaver Kill watershed were examined to determine if they could be modified to reduce flow along Pearl Street during flood events. The reservoirs were selected based on issues of ownership and the relatively large drainage areas that are located upstream. The six reservoirs and their drainage areas are shown in Figure 4.1.

In order to determine the benefits of modifying the reservoirs for increased storage, the hydrologic model was adjusted to simulate the removal of each upstream watershed to show the maximum possible benefit. This was equivalent to increasing the size of the reservoirs so that they could contain all potential runoff events. Given that this is highly unlikely, the calculated flow reductions should be considered for analytical purposes only.
As shown on Table 4.1, the six reservoirs were assigned an order then each reservoir modification was added to the one previously to present cumulative effects. The effect of each reservoir modification was assessed with a range of 24 hour rainfalls. The information in Table 4.1 can be used to construct flow reduction curves at Pearl Street for each of the alternatives. However, a flow reduction curve was calculated only for Plan D6 because it reflects cumulative flow reductions relative to existing condition. The flow reduction curve was used to transform the existing discharge frequency curve to the D6 with-project discharge frequency curve and the result is shown on Table 4.2. All six dams must be modified to obtain the with-project discharge frequency shown on Table 4.2.

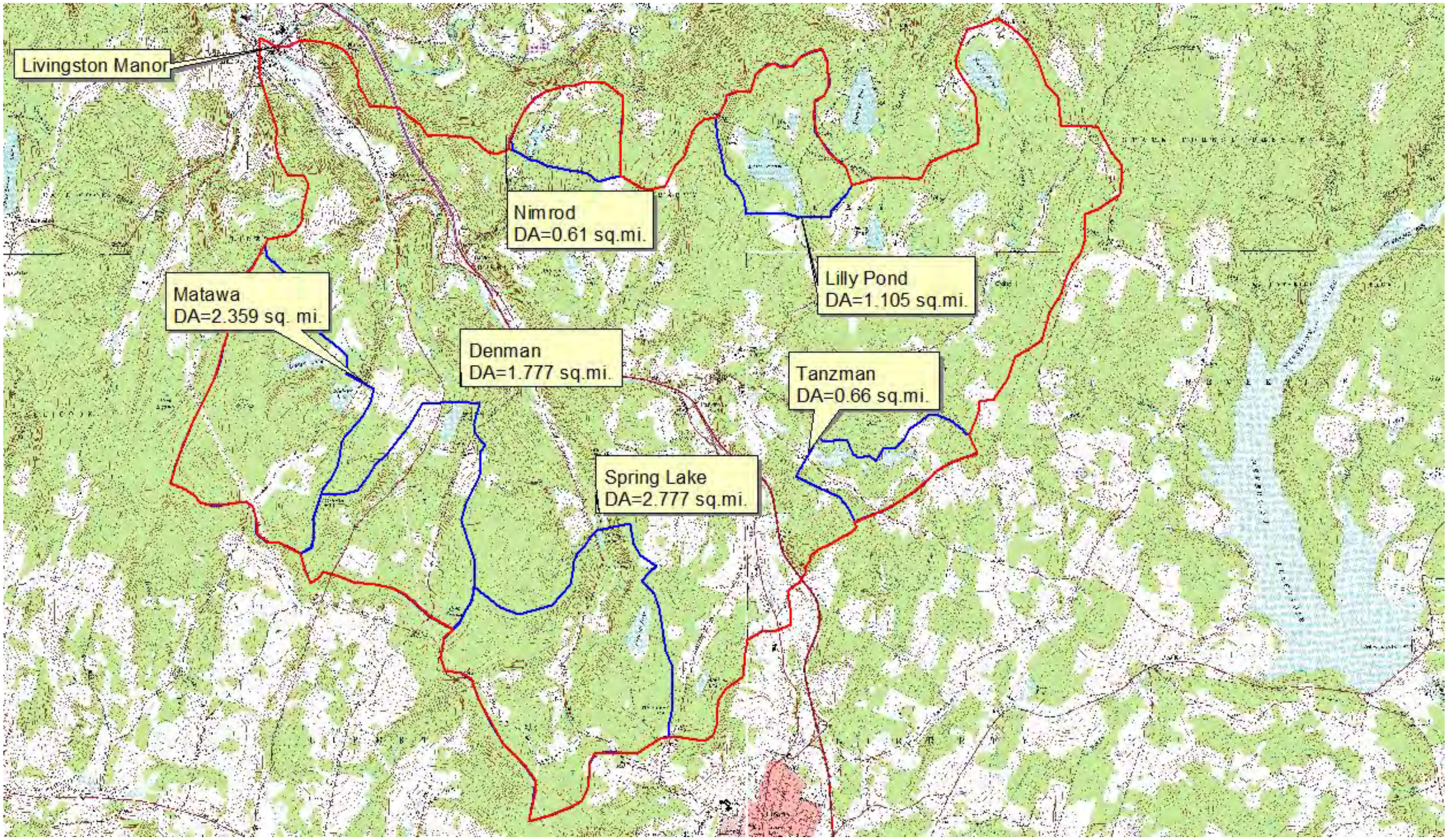


Figure 4.1: Six Reservoirs in the Little Beaver Kill Watershed.

Note: DA=Drainage Area

Table 4.1: Flow Reductions at Pearl Street from Removing the Watershed Upstream of Existing Reservoirs.

Condition	Description	Drainage Area Removed (sq. mi)	Discharge at Pearl Street (cfs)				
			1 inch 24hr Storm	2 inch 24hr Storm	3inch 24hr Storm	5inch 24hr Storm	8 inch 24hr Storm
Existing		NA	85	606	1459	3751	9613
D1	Remove watershed Upstream of: Matawa Dam	2.359	81	598	1448	3729	9155
D2	Remove watershed Upstream of: Matawa, Denman dams	4.136	77	591	1439	3709	8616
D3	Remove watershed Upstream of: Matawa, Denman, Tanzman dams	4.796	76	588	1431	3698	8607
D4	Remove watershed Upstream of: Matawa, Denman, Tanzman, Nimrod dams	5.406	75	585	1427	3685	8324
D5	Remove watershed Upstream of: Matawa, Denman, Tanzman, Nimrod, Lilly Pond dams	6.511	73	583	1425	3682	8318
D6	Remove watershed Upstream of: Matawa, Denman, Tanzman, Nimrod, Lilly Pond dams and, Spring Lake	9.288	67	531	1305	3353	7387

Note: Removing the watershed upstream of the reservoir is equivalent to modifying the dam such that it captures all runoff from the smallest to the largest storm.

Table 4.2: Discharge-Frequency for Reservoir Plan D6 at Pearl Street.

Exceedance Frequency	Event (year)	Discharge (cfs) at Pearl Street	
		Existing	D6
99	1.01	510	446
50	2	1890	1690
20	5	3066	2741
10	10	3976	3508
4	25	5250	4385
2	50	6286	5097
1	100	7392	5859
0.4	250	9002	6967
0.2	500	10318	7929

Note: Drainage Area at Pearl Street is 30.2 sq. mi.

The flows in Table 4.3 apply downstream from the Airport Ponds to the mouth of Little Beaver Kill Creek. The water surface elevations corresponding to the frequency flows of Plan D6 were calculated with the existing (without project) condition hydraulic model and the results are provided in the Hydrologic and Hydraulic Analysis (Appendix A).

4.4.3 Structural Measures

As with the watershed alternatives, the structural measures were primarily focused on Little Beaver Kill because a majority of the economic damages occur in this area. However, two of the measures were located along the Willowemoc Creek. The goal of the structural measures was to reduce the frequency wsels in downtown Livingston Manor. The structural measures include:

- Modification of the school ball field levees along the Willowemoc to lower the wsels at the mouth of Little Beaver Kill. The ball field modifications involved moving the levee landward and lowering the floodplain on the river side of the relocated levee.
- Lowering of Covered Bridge Road under Route 17 along the Willowemoc.
- Replacement of Main Street bridge over the Little Beaver Kill with a wider bridge.
- Lowering of the right overbank of the Little Beaver Kill downstream of Main St.
- Construction of a new reservoir at the Airport Ponds.
- Modifying the outfall structure at the Matawa reservoir.

4.4.3.1 Levees and Floodwalls

Levees and floodwalls are effective flood risk management measures in the following circumstances: *a.* damageable property is clustered geographically; *b.* a high degree of protection, with little residual damage, is desired; *c.* a variety of properties, including infrastructure, structures, contents, and agricultural property, are to be protected; *d.* sufficient real estate is available for levee construction at reasonable economic, environmental, and social costs; and *e.* the economic value of damageable property protected will justify the cost of constructing the new or enhanced levee and floodwalls. In addition, residents must be amenable to any visual effects associated with installation of a permanent levee or floodwall; these structures can block some, or all, of the view of the river, or otherwise reduce access.

The relocation and modification of the ball field levee is intended to lower the water surface elevation of the Willowemoc Creek at the mouth of the Little Beaver Kill Creek. There are two types of modification: moving the levee landward toward the ball field; and moving the levee landward and then lowering the created floodplain approximately 2 feet. The floodplain would be lowered to the elevation of the existing 2-year water surface elevation of the Willowemoc. This would be done to maintain the sediment transport capacity of the Willowemoc. Three different relocation distances were analyzed for the levee: 300, 100 and 50ft.

Due to the limited scope of this Interim Feasibility Study, floodwalls were not analyzed as part of the study. This measure may be analyzed further in future study phases (see Section 4.7).

4.4.3.2 Channel Modification

The first option that was considered for channel modification was along the Willowemoc, downstream of the center of town and the sewer plant, under the Route 17 bridge. The concept was to remove a 30-ft width of the Route 17 road embankment to increase the width of the floodplain. The increased width of the floodplain would allow for more flow area during out of bank flooding events.

The Main Street Bridge over the Little Beaver Kill is constrictive and causes a jump in the water surface across the bridge. This jump occurs even when the water surface does not touch the steel girder. A new wider bridge was the second option considered. It was assumed that the two buildings, upstream and downstream of the bridge on the left side of the creek will be purchased and demolished allowing the bridge's width to be increased by 20 feet. A plan view of the proposed work is shown on Figure 4.2. Initially the new bridge was analyzed assuming a pier, but the majority of bridge modeling simulations assumed that a pier would not be required. In order to protect the fish habitat and to maintain sediment transport capacity, a channel bench approximately 5-feet above the existing channel would be placed under the new portion of the bridge.

Figure 4.2: Plan View of Proposed Widening of Main Street Bridge

The third channel modification option involved lowering the water surface elevation of the Little Beaver Kill. Lowering the water surface energy at the downstream face of the existing Main Street Bridge can lower the water surface elevations on the upstream side of the bridge. One way to lower the energy at the downstream face of the bridge is to lower the channel bank height. The right side of the creek downstream from Main Street would be excavated creating a bench and providing more flow area. A 2-year bench approximately 6 ft above the existing channel was analyzed. Approximately 10 feet of the parking lot downstream of Main Street will need to be taken.

Figure 4.3 is a plan view of the Park with the proposed bench contours shown. The highlighted "Limit of Excavation" shows the extent of the park which must be sacrificed to implement this option. The width of the bench is approximately 25 feet. Trees may be planted at the top of the newer lower banks but the majority of the bench should be planted with native grass or other herbaceous vegetation to allow free flow during flood conditions.

Figure 4.3: Plan View of Bench along Little Beaver Kill Downstream of Main Street Bridge

4.4.3.3 Modeling of Levee and Channel Modification Measures

Various combinations of levee and channel modification measures were considered to reduce damage along the Little Beaver Kill. A total of 26 separate hydraulic modeling simulations were completed. Stage reductions were tabulated at various locations that are shown on Figure 4.4. The combinations of measures that were considered are provided below.

- Modify ball field levees only.
- Modify the bridge only

- Modify bridge and ball field levee.
- Modify floodplain downstream of Main Street only.
- Modify floodplain downstream of Main Street and ball field levee.
- Modify floodplain downstream of Main Street and Main Street Bridge.
- Modify floodplain downstream of Main Street, Main Street Bridge and ball field levee.

Figure 4.4: Locations of tabulated stage reductions.

The results of the hydraulic modeling simulations are provided in the Hydrologic and Hydraulic Analysis (Appendix A). The results provide all of the stage reductions for the various combinations for the 5, 25 and 100 year events. The stage reductions are likely to result in damage reductions, however even a plan with a large drop in water surface elevation may still result in flood water remaining out of bank.

4.4.3.4 Cattail Brook Modeling

When this feasibility study was initiated, it was determined that a with project analysis would not be performed for Cattail Brook because it infrequently exceeded its channel capacity. Even though there had been unprecedented flooding damages on Cattail Brook during a June 2006 event, this event was considered to be abnormal and the average annual damage potential on the brook was considered to be low.

However, on September 18, 2012 another rare rain event (6 inches of rain in a 2 hour period) caused major flooding and damages on Cattail Brook. The flooding was similar to the event that occurred in June 2006, when an intense rain storm coupled with massive tree debris blocked multiple bridges. Because of the debris blockage at Finch Street Bridge, the water jumped out of bank onto County Route 149 (Pearl Street) and flowed towards the center of Livingston Manor as a 2 ft deep torrent causing considerable erosion to the stream banks.

In response to the September 2012 event the non-Federal sponsor (NYSDEC) and the Town of Rockland requested an abbreviated With Project analysis for Cattail Brook. The original HEC-RAS model (reflecting post 2006 conditions) was modified to reflect post September 2012 without project conditions. The September 2012 event destroyed two bridges (Hoos and a private bridge) and caused channel erosion. The private bridge was returned to the status quo ante and Hoos Bridge (a 20ft width) was replaced with a new bridge with a 40ft width. In addition, the bank downstream of Hoos Bridge had the riprap replaced including stepping back the stone to allow expansion of high water. The Town of Rockland indicated that the majority of the channel erosion was repaired such that the post June 2006 channel model is a reasonable representation of the post September 2012 condition. Therefore, the post September 2012 without project model is the post June 2006 existing condition model with Hoos Bridge modeled as a 40ft width span. Figure 4.5 provides an overview of the project area on the Cattail Brook.

Figure 4.5: Overview of Cattail Brook

The following solutions were considered:

A. Divert flow onto the left overbank upstream of Finch Bridge.
   i) Diversion point approx 50 ft upstream of bridge.
   ii) Diversion point approximately 300 ft upstream of bridge.

B. Increase the capacity of Finch Bridge by excavating a bench on the left downstream bank.

C. Increase the capacity of Finch Bridge by excavating a bench on the right downstream bank.

D. Replace Finch Bridge with a 40ft width span.

E. Remove the Private bridge (downstream of Hoos Bridge).

F. Remove old Railroad Bridge (between River and Creamery Roads).

It was determined that Option A had the potential to reduce the flow diversion onto Route 149 (Pearl Street), but at the cost of increased flow and possible increased damage to the houses along Willoughby Street. Therefore, this option was not considered any further. Hydraulic modeling was performed for the other solutions to determine their flood reduction potential.

The hydraulic modeling and analysis determined that the most immediate and effective solution for Cattail Brook will be a combination of the following measures:

1. Replace the existing Finch Street Bridge with a 40 ft span.

2. Demolish the old Railroad Bridge.

3. Encourage and partner with local residents to replant the stream banks of Cattail Brook with native vegetation and create a riparian buffer around the brook. This practice will encourage the stability of the banks and potentially reduce future erosion and loss of mature trees. Various native small trees, shrubs and grasses can be planted along the streambank for erosion control and will enhance the property value. In addition, these planting would also provide important riparian habitat for local wildlife (e.g., birds).

The full analysis of Cattail Brook is provided in the Hydrologic and Hydraulic Analysis (Appendix A).

4.4.3.5 Dams or Flow Detention

Fulton Plan

The first structural flow detention solution consists of a dry dam just upstream of Livingston Manor at the Airport Ponds. This solution is referred to as the Fulton Plan and is named after a local citizen who suggested it. A copy of this report has been shared with Mr. Fulton.

A possible concept plan for the Fulton Plan is shown in Figure 4.6. There is limited storage at the site so the embankment design allows for safe overtopping. This is accomplished with a 5% vegetated exit slope. The embankment across the channel is provided with sufficient freeboard to prevent overtopping. Three variations of the channel outlet were analyzed:

A – Gated structure that releases inflow up to 1600 cfs.

B – Constrictive open channel with a bottom width of 12 ft

C – Constrictive open channel with a bottom width of 5 ft

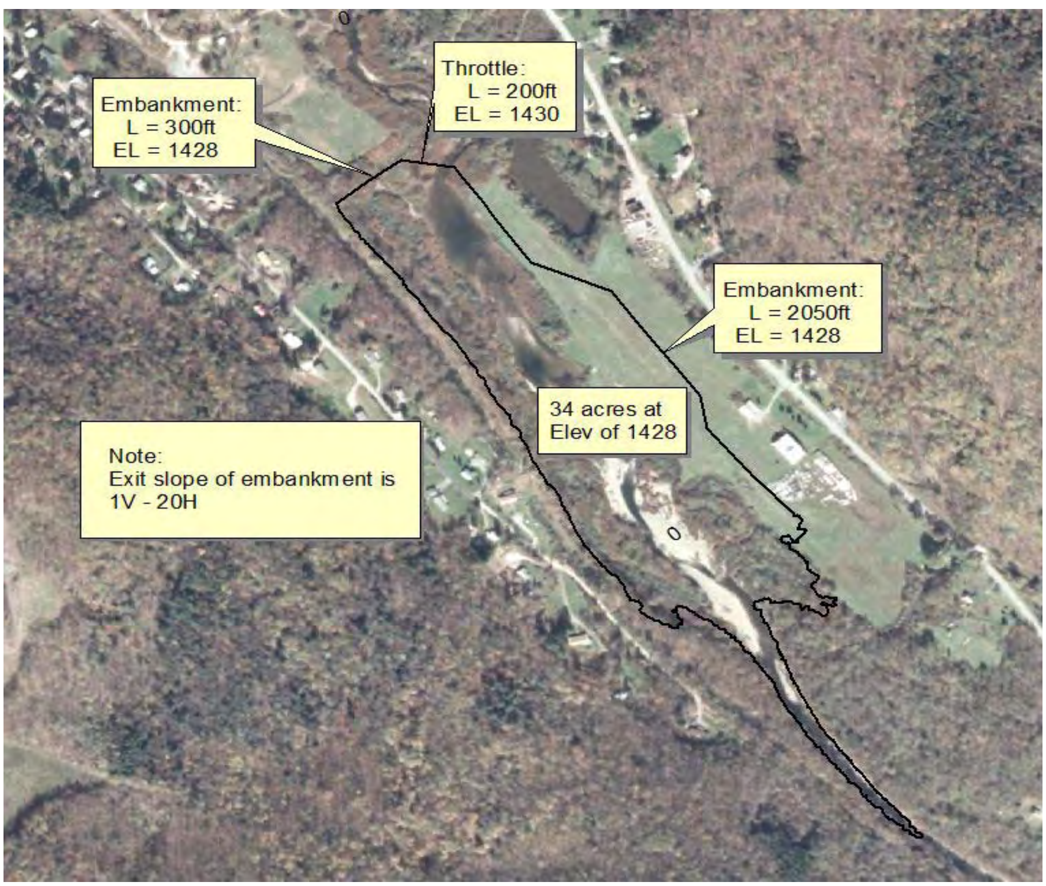


Figure 4.6: Fulton Plan

Hydraulic modeling was performed to simulate the conditions if the 5, 10, 25, 50 and 100 year events were routed through the proposed Fulton Plan detention structure. Flow reductions are shown in Table 4.3.

Table 4.3: Reduced Flows (cfs) from the Fulton Plan.

Condition	Outlet	5 year	10 year	25 year	50 year	100 year
Existing		3017	3921	5172	6218	7292
Fulton Plan -A	Gates, Max Release 1600cfs	2215	3512	5028	6200	7283
Fulton Plan –B	Open channel bottom width 12 ft	2594	3448	4909	6161	7277
Fulton Plan -C	Open channel bottom width 5ft	2535	3512	5044	6197	7282

The flows in Table 4.4 apply downstream from the Airport Ponds to the mouth of Little Beaver Kill Creek. The water surface elevations corresponding to the frequency flows of Fulton Plans A and B were calculated with the existing condition hydraulic model and the results are provided in the Hydrologic and Hydraulic Analysis (Appendix A). (Plan C was not run because the flows are similar to Plan B.)

Matawa Dam

The second structural flow detention solution involves modification of the dam structure at the Matawa reservoir (Figure 4.7). Analysis of this measure was requested by the sponsor because the structure is owned by the Town of Rockland and would not need to be acquired if a project was to be built.

Matawa Dam is a masonry structure constructed in 1949 for water supply. It no longer serves as a water supply and has become a run of river dam with inflow passing uncontrolled over its concrete spillway. The drainage area upstream of the dam is 2.359 sq. mi. with 1.009 sq. mi. controlled by Lenape Dam. The drainage area of the Matawa tributary at its confluence with Little Beaver Kill is 3.22 sq. mi. The drainage area of Little Beaver Kill just downstream of the junction is 28.5 sq. mi.

This measure would involve draining the existing pool and converting the existing structure to a dry dam. Base and moderate flows would be released through a low level outlet and larger flows would be impounded and released gradually after the flows on the Little Beaver Kill return to normal. Dimensions of the structure are provided in Table 4.1.

Figure 4.7: Aerial view of the Matawa reservoir.

Table 4.1: Dimensions of the Matawa Dam (from New York State Inventory of Dams)

Item	Value
Length	120 ft
Height	22 ft
Reservoir Surface Area	26 acres
Normal Storage	240 acre-ft
Maximum Storage	275 acre-ft
Maximum Discharge	215 cfs
Spillway Width	18 ft
Hazard Potential	Low

When a site visit was performed to examine the existing structure, a low level outlet was not observed. A functioning low level outlet would be necessary for this modification to be effective. The outlet would be required to pass base flow for environmental reasons and to quickly drain down the pool after a storm event to make storage available for the next storm event. The analysis assumed an empty reservoir for each storm analyzed. The analysis also assumed that there has been no sediment deposition in the impoundment since dam construction.

Hydrologic modeling was performed to simulate the conditions that would occur during various rainfall events if the Matawa Dam structure was to be modified. Results were tabulated at 3 locations: just downstream of Matawa Dam, on the Little Beaver Kill just downstream of the confluence with the Little Beaver Kill, and at Pearl Street (Figure 4.16). The results are provided in the Hydrologic and Hydraulic Analysis (Appendix A). It was determined that the modification of the dam would have the same effect as the theoretical removal of the watershed that was discussed as Plan D1 in the Reservoir Management Section of this report (Section 4.6.2.2). Hence, this measure alone will not result in a significant reduction in downstream wsels during storm events.

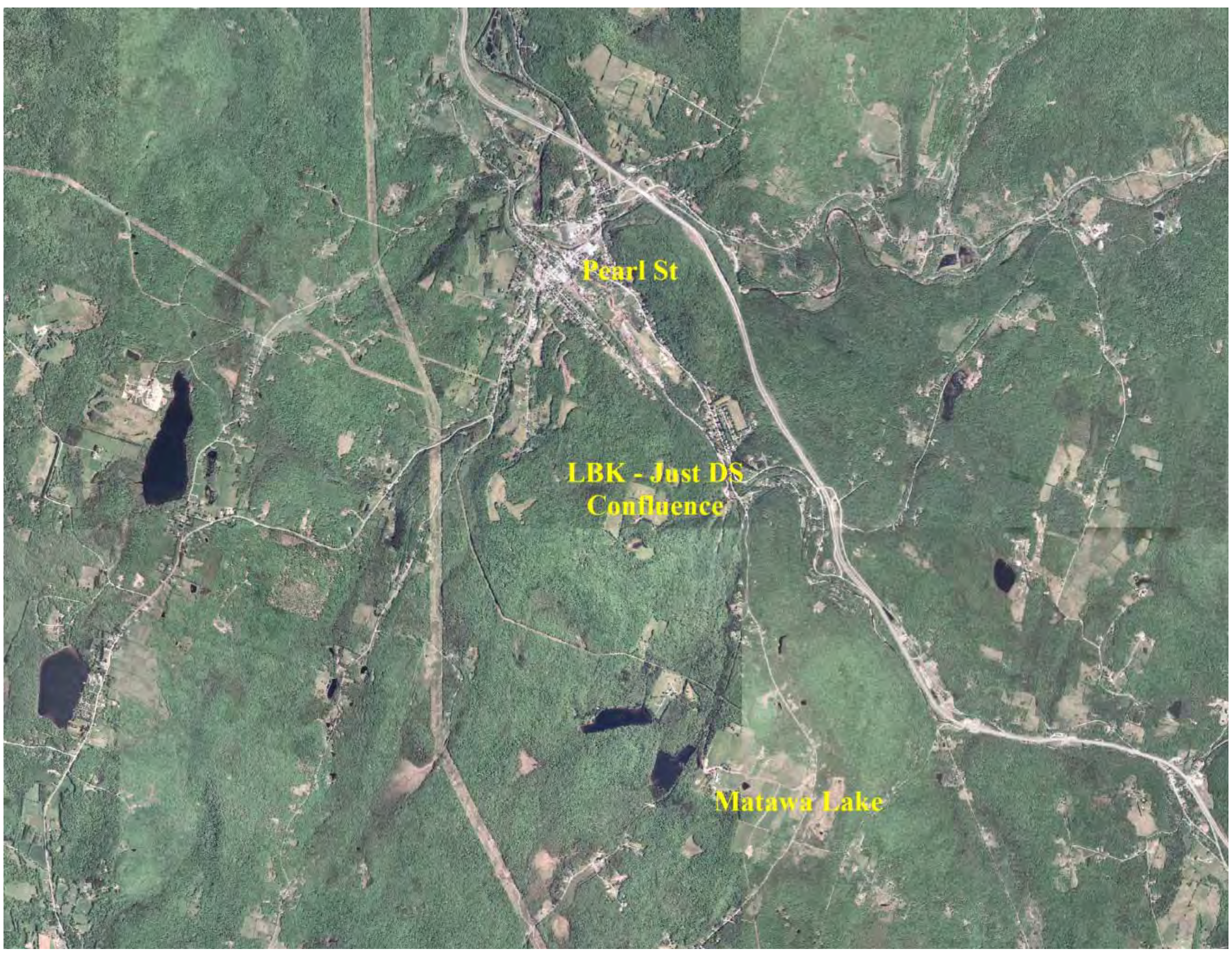


Figure 4.8: Matawa Dam - Discharge Tabulation Locations

4.4.3.6 Combinations of Structural Measures

After the preliminary concept-level designs for the different structural measures were evaluated independently, they were then combined with other measures to create a range of alternatives. These alternatives were evaluated to determine their potential effect on wsels and related damages.

The alternative plans considered were:

Plan A – Remove 30-ft width of Route 17 road embankment downstream of the sewer plant to increase width of the floodplain.

Plan B – Relocation of the ball field levee along the Willowemoc Creek 300 feet landward without lowering the floodplain.

Plan C – Widening of the Main Street Bridge without a pier.

Plan D – Widening of the Little Beaver Kill floodplain downstream of the Main Street bridge and widening of the Main Street Bridge without a pier.

Plan E – Widening of the Little Beaver Kill floodplain downstream of the Main Street Bridge, widening of the Main Street Bridge without a pier, and relocation of the ball field levee along the Willowemoc Creek 50 feet landward with lowering of the floodplain.

Plan F – Fulton Plan detention structure with open channel constriction, bottom width of 12 feet.

Plan G – Fulton Plan detention structure with open channel constriction, bottom width of 12 feet; and widening of the Little Beaver Kill floodplain downstream of the Main Street Bridge.

Plan H – Widening of the Little Beaver Kill floodplain downstream of the Main Street Bridge (with a 2-yr floodplain bench).

Plan I – Widening of the Little Beaver Kill floodplain downstream of the Main Street Bridge and relocation of the ball field levee along the Willowemoc Creek 50 feet landward with lowering of the floodplain.

4.4.4 Nonstructural Measures

Section 4.5.4 discussed potential nonstructural measures that could be implemented in the project area for flood risk management. Although all of the nonstructural measures will be considered for the project area, only the structure acquisition measure has been assessed in any detail at this stage of the feasibility study. This measure, commonly referred to as structure buyout, was given a preliminary evaluation for properties along Pearl Street, Main Street, and Maiden Lane that have historically sustained high flood damages.

The following properties were included in the structure buyout analysis:

41 Main Street
43 Main Street
47 Main Street
49 Main Street
9 Pearl Street
12 Pearl Street
16 Pearl Street
20 Pearl Street
29 Pearl Street
33 Pearl Street
1 Maiden Lane

The results are provided in the preliminary economic analysis below (Section 4.6.5).

4.4.5 Preliminary Alternatives Analysis

Following the screening and evaluation of the structural and nonstructural flood risk management measures, a preliminary alternatives analysis was performed to determine if the proposed solutions were likely to be cost effective and/or result in improved environmental quality. For flood risk management measures to be considered cost effective, the benefits must exceed the costs.

4.4.5.1 Structural Measures

Table 4.2 provides a comparison of the estimated annual costs of the alternative plans and the Average Annual Damages of protected development to determine initial screening BCRs. It also provides the estimated habitat acres that would be restored by the alternatives that have an ecosystem restoration component.

In order to illustrate the flood depth reductions that are anticipated to result from the most beneficial plans, a series of figures were created. Figure 4.9 depicts floodwater depths under the existing or without project conditions. Figures 4.10 through 4.13 depict floodwater depths for the 10 year return period flood for alternatives D, F, G, and H. These alternatives were chosen as the top four because they had the highest net benefits. The 10 year return period flood was chosen because it is at this return frequency that the alternative plans are likely to provide the most benefit.

Figures 4.14 through 4.17 depict the reductions in floodwater depths for plans D, F, G, and H for the 10 year return period flood. They also provide a visual representation of the reduction in floodwater depths for a typical residential property and commercial property in the project area.

Table 4.2: Preliminary Alternatives Analysis Results

STREAM	WITHOUT PROJECT	PLAN A Remove 30-ft width of Route 17 road embankment	PLAN B Move ball field levee along the Willowemoc 300 ft landward; the floodplain is not lowered	PLAN C Main Street Bridge widened without pier	PLAN D Widen LBK floodplain downstream of Main Street Bridge; Main Street Bridge widened without pier	PLAN E Widen LBK floodplain downstream of Main Street Bridge; Main Street Bridge widened without pier; ball field levee relocated 50 ft and floodplain lowered	PLAN F Fulton Plan - detention structure with open channel constriction; existing channel	PLAN G Plan F & Plan H combined	PLAN H Widen LBK floodplain downstream of Main Street Bridge	PLAN I Widen LBK floodplain downstream of existing Main Street Bridge; ball field levee relocated 50ft and floodplain lowered.
ANNUAL DAMAGES										
WILLOWEMOC	$88,850	$84,120	$87,990	$88,850	$88,850	$88,850	$88,850	$88,850	$88,850	$88,850
LEFT LEVEE	$40,130	$40,080	$38,800	$40,130	$40,130	$40,130	$40,130	$40,130	$40,130	$40,130
BEHIND SCH. LEVEE	$99,600	$100,050	$91,020	$99,600	$99,600	$99,600	$99,600	$99,600	$99,600	$99,600
LITTLE BEAVER KILL	$748,500	$748,500	$738,280	$563,800	$495,440	$474,910	$550,600	$527,580	$667,620	$632,760
TOTAL	$977,080	$972,750	$956,090	$792,380	$724,020	$703,490	$779,180	$756,160	$896,200	$861,340
ANNUAL BENEFITS										
TOTAL AAB (AVERAGE ANNUAL BENEFITS)	NA	$4,330	$20,990	$184,700	$253,060	$273,590	$197,900	$220,920	$80,880	$115,740
COST AND BCR										
CONSTRUCTION ESTIMATE	$0	NA	$1,211,000	$3,700,000	$4,357,000	$5,484,000	$3,188,000	$3,845,000	$657,000	$1,784,000
AAC (AVERAGE ANNUAL COST)	$0	NA	$56,372	$172,235	$202,818	$255,280	$148,401	$178,985	$30,583	$83,045
BCR (BENEFIT COST RATIO)	NA	NA	0.37	1.07	1.25	1.07	1.33	1.23	2.64	1.39
NET BENEFITS	NA	NA	-$35,382	$12,465	$50,242	$18,310	$49,499	$41,935	$50,297	$32,695
ESTIMATED HABITAT RESTORATION										
	NA	NA	0	0	0.25 acres riparian	2 acres - riparian	3200'LF Stream channel - 12 acres – riparian 11 acres - wetlands	3200' LF Stream channel - 12 acres – riparian 11 acres - wetlands	0.25 acres riparian	2 acres - riparian

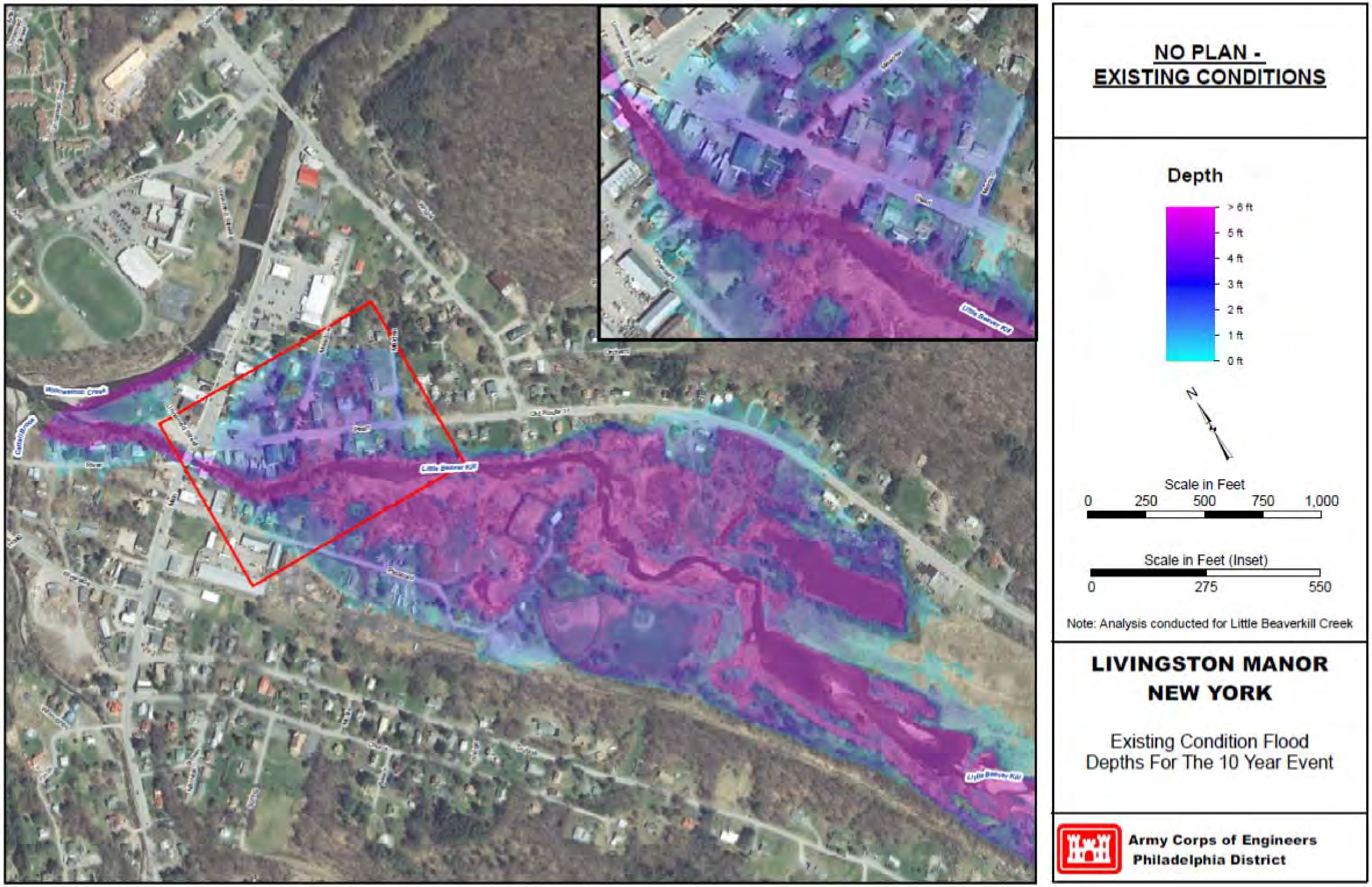


Figure 4.9: Floodwater depths under existing conditions for the 10-year flood.

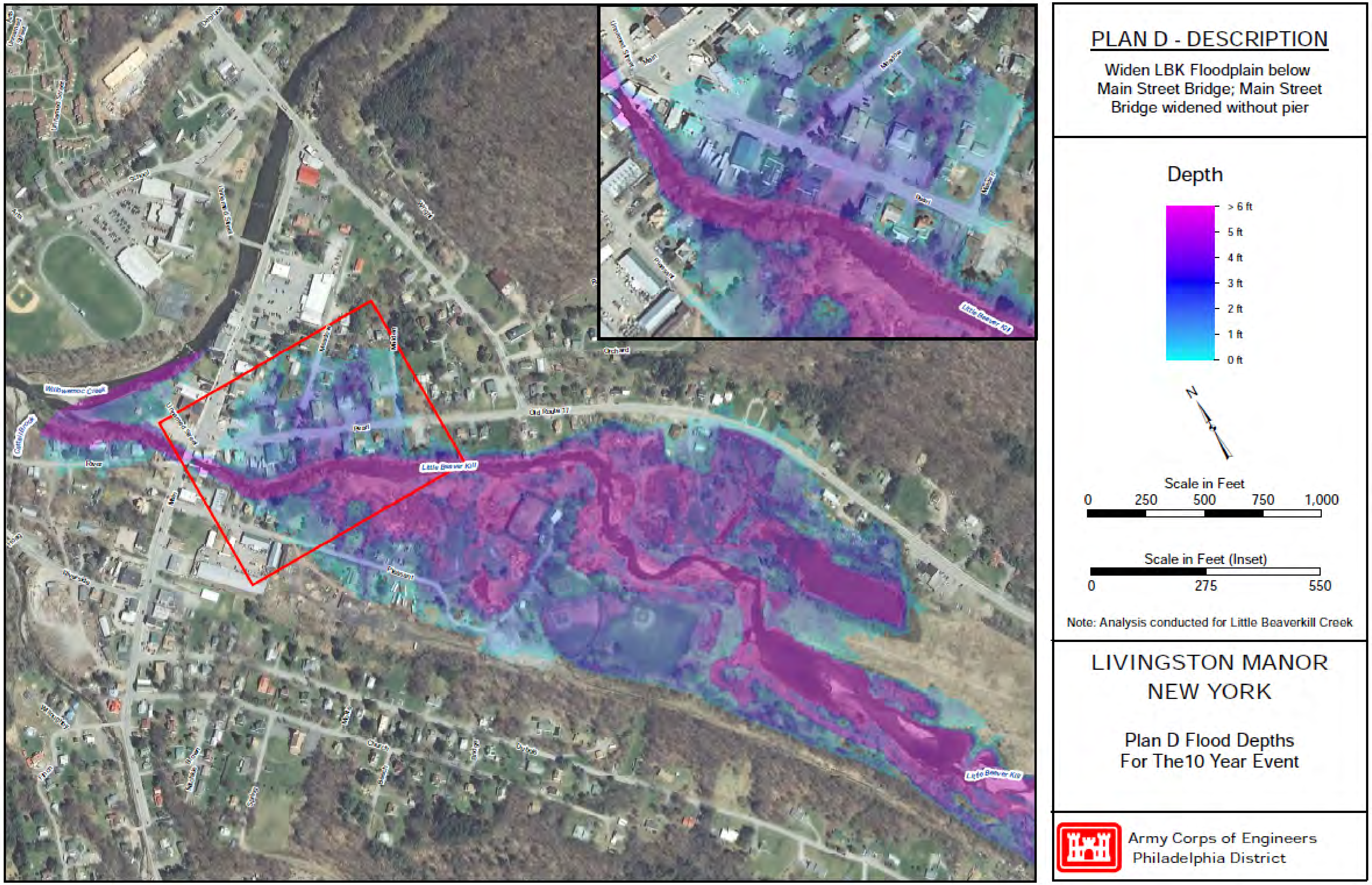


Figure 4.10: Floodwater depths for Alternative Plan D for the 10-year flood.

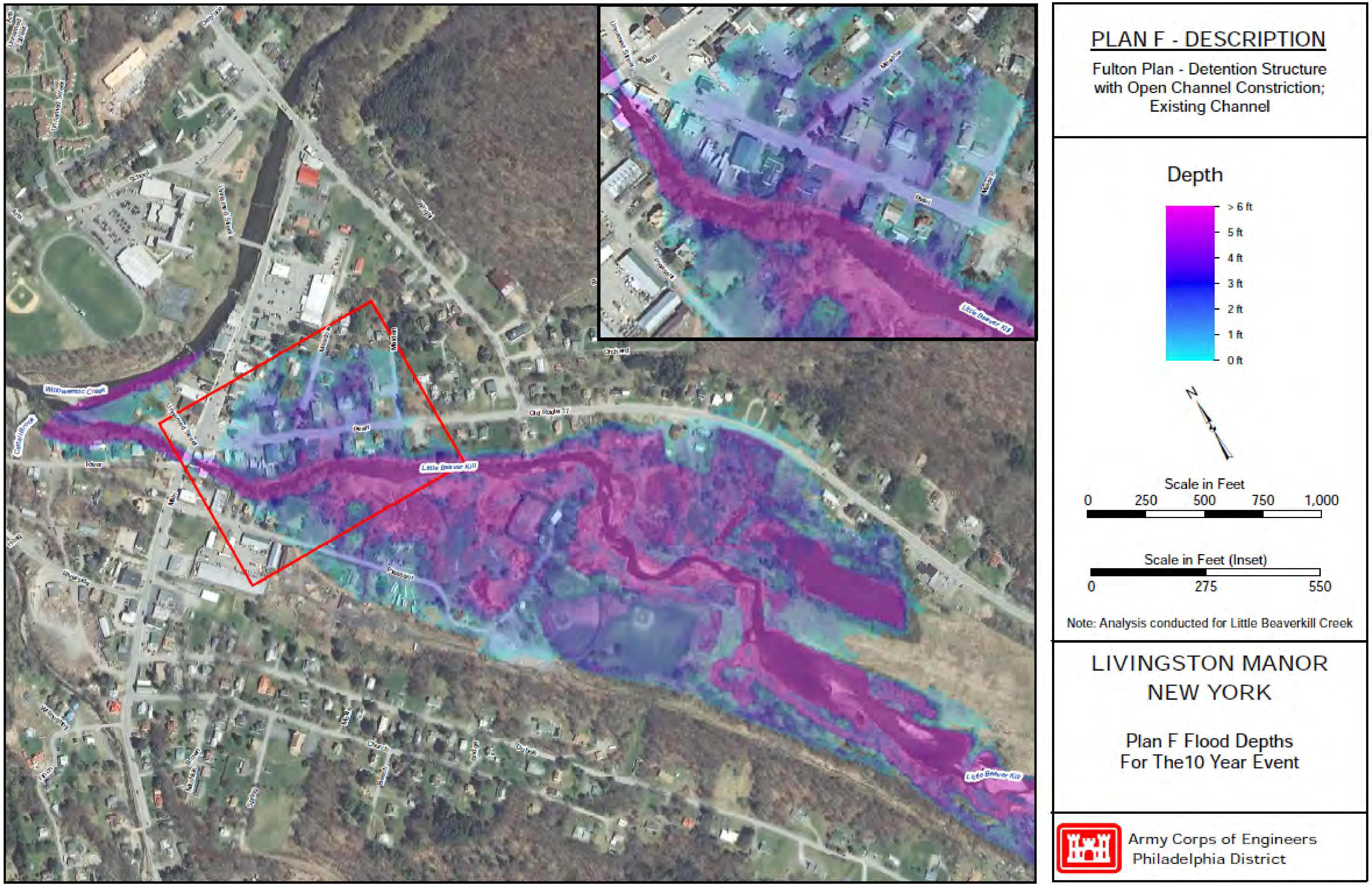


Figure 4.11: Floodwater depths for Alternative Plan F for the 10-year flood.

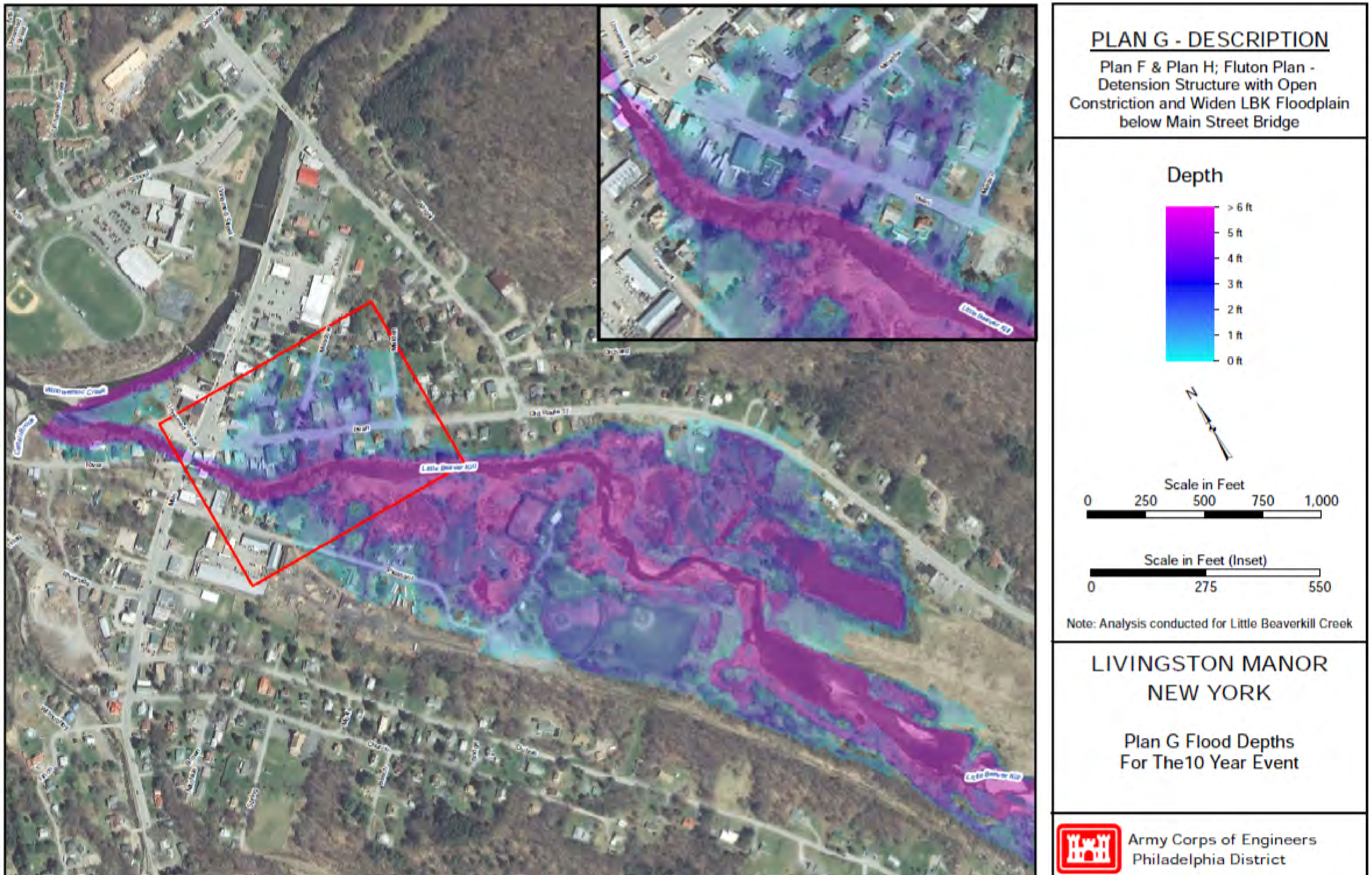


Figure 4.12: Floodwater depths for Alternative Plan G for the 10-year flood.

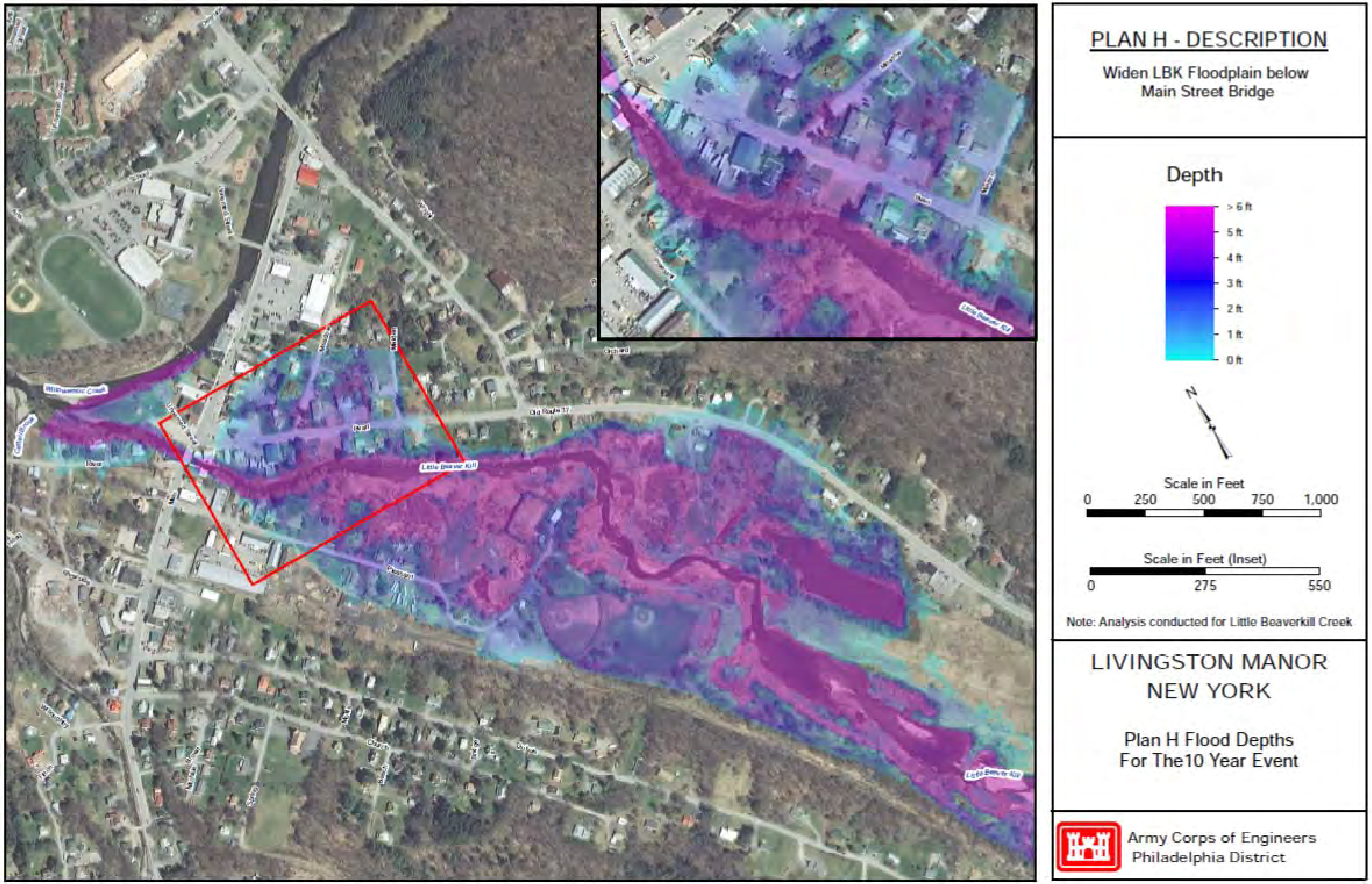


Figure 4.13: Floodwater depths for Alternative Plan H for the 10-year flood.

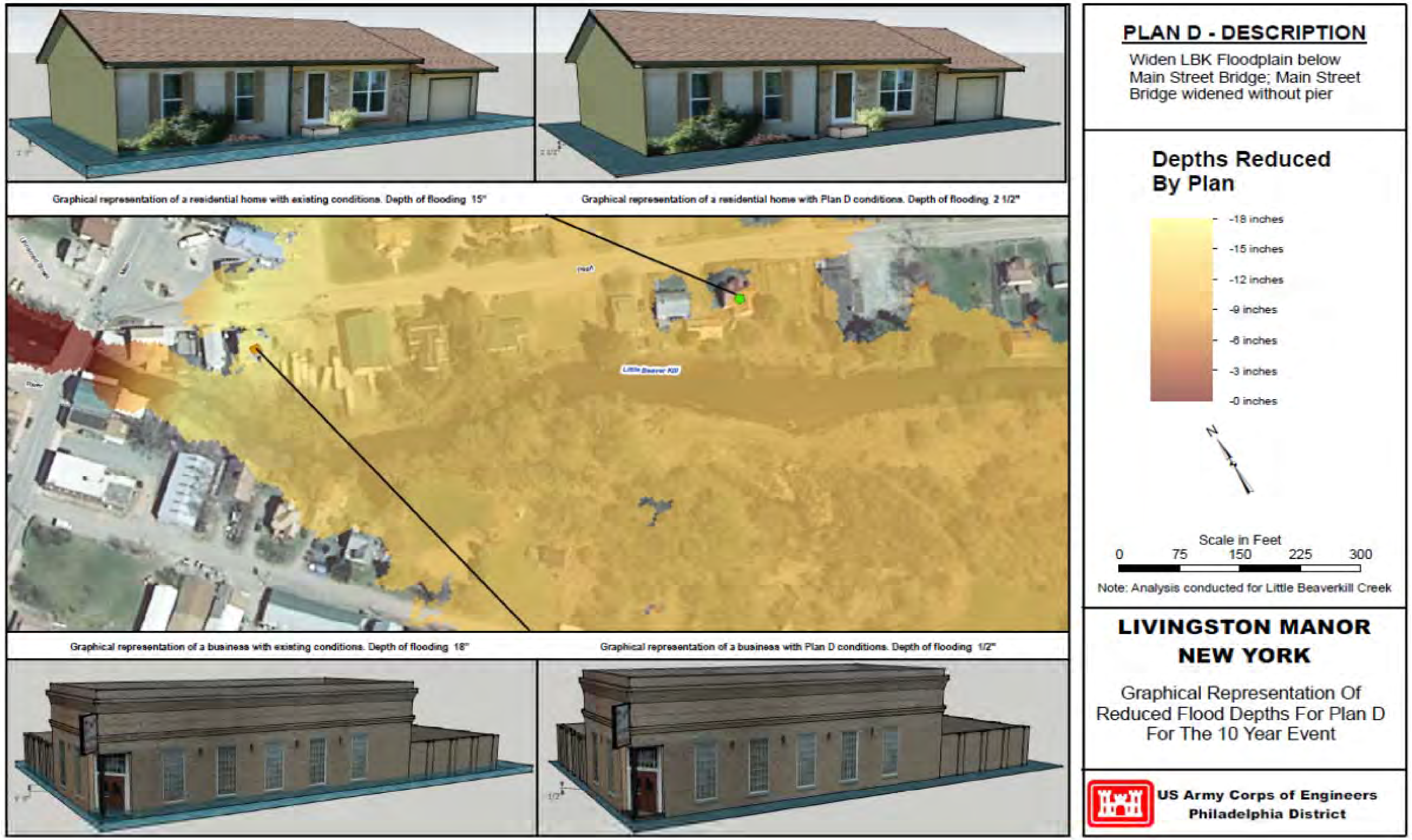


Figure 4.14: Reductions in flood depths for Alternative Plan D for the 10-year flood.

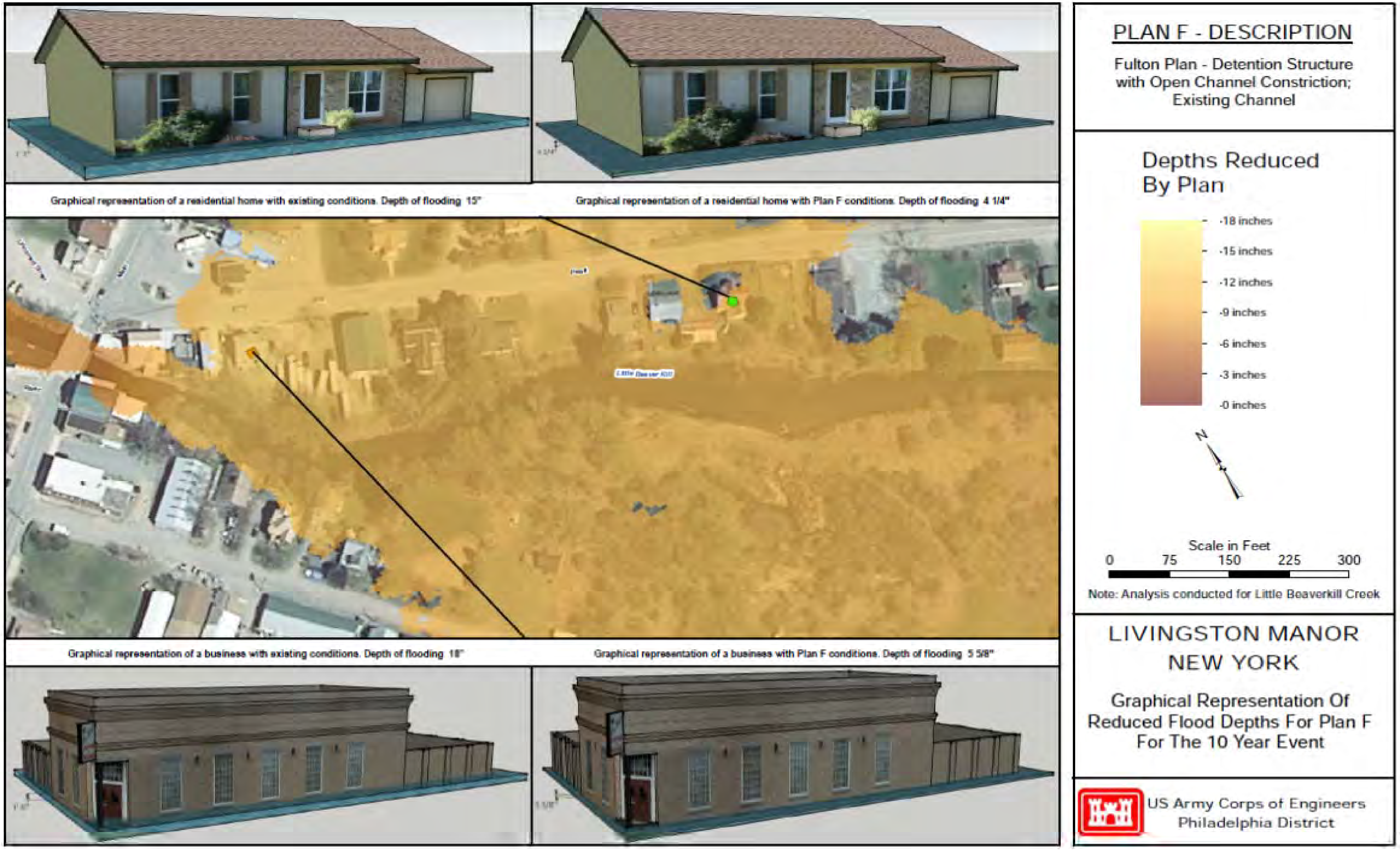


Figure 4.15: Reductions in flood depths for Alternative Plan F for the 10-year flood.

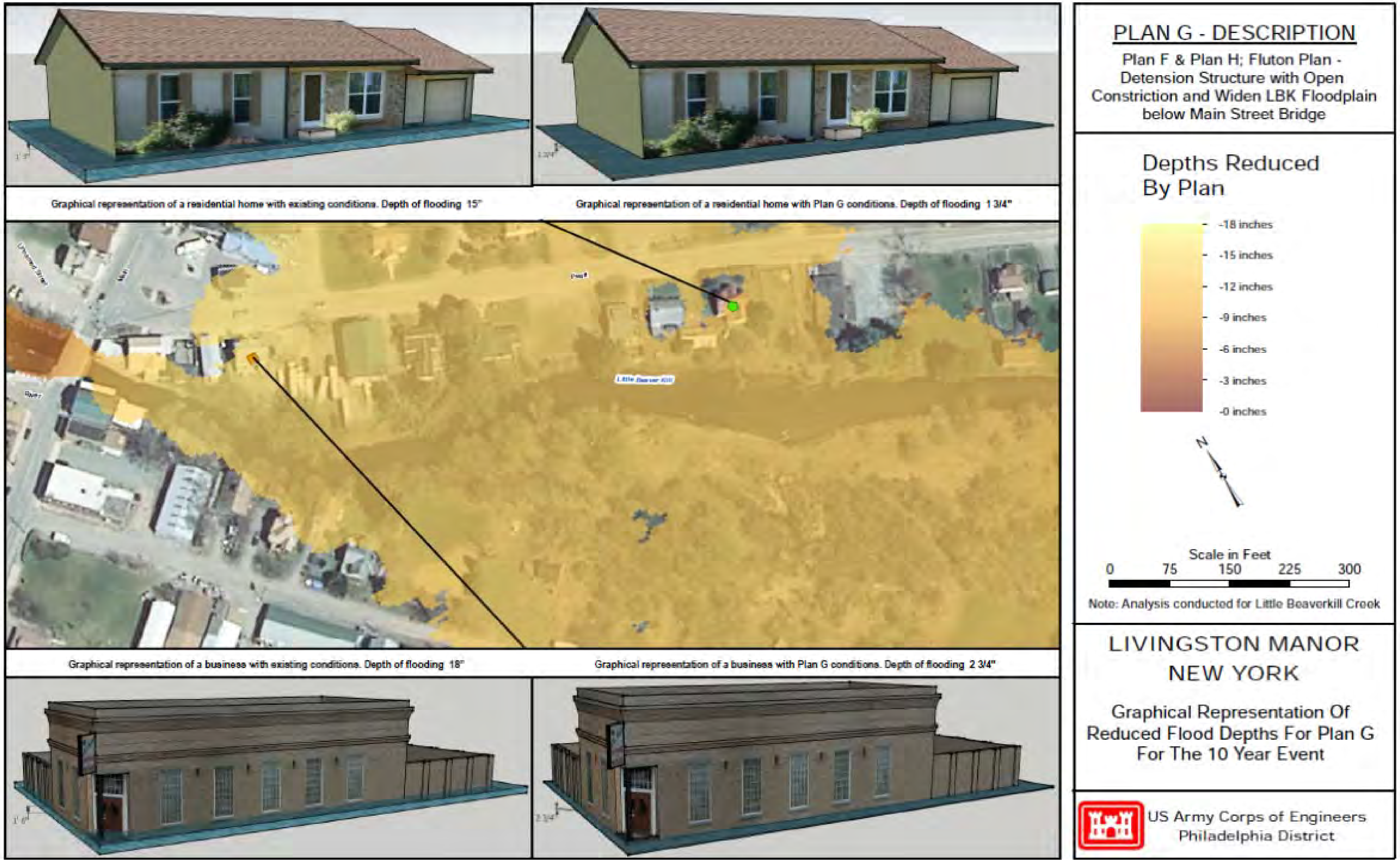


Figure 4.16: Reductions in flood depths for Alternative Plan G for the 10-year flood.

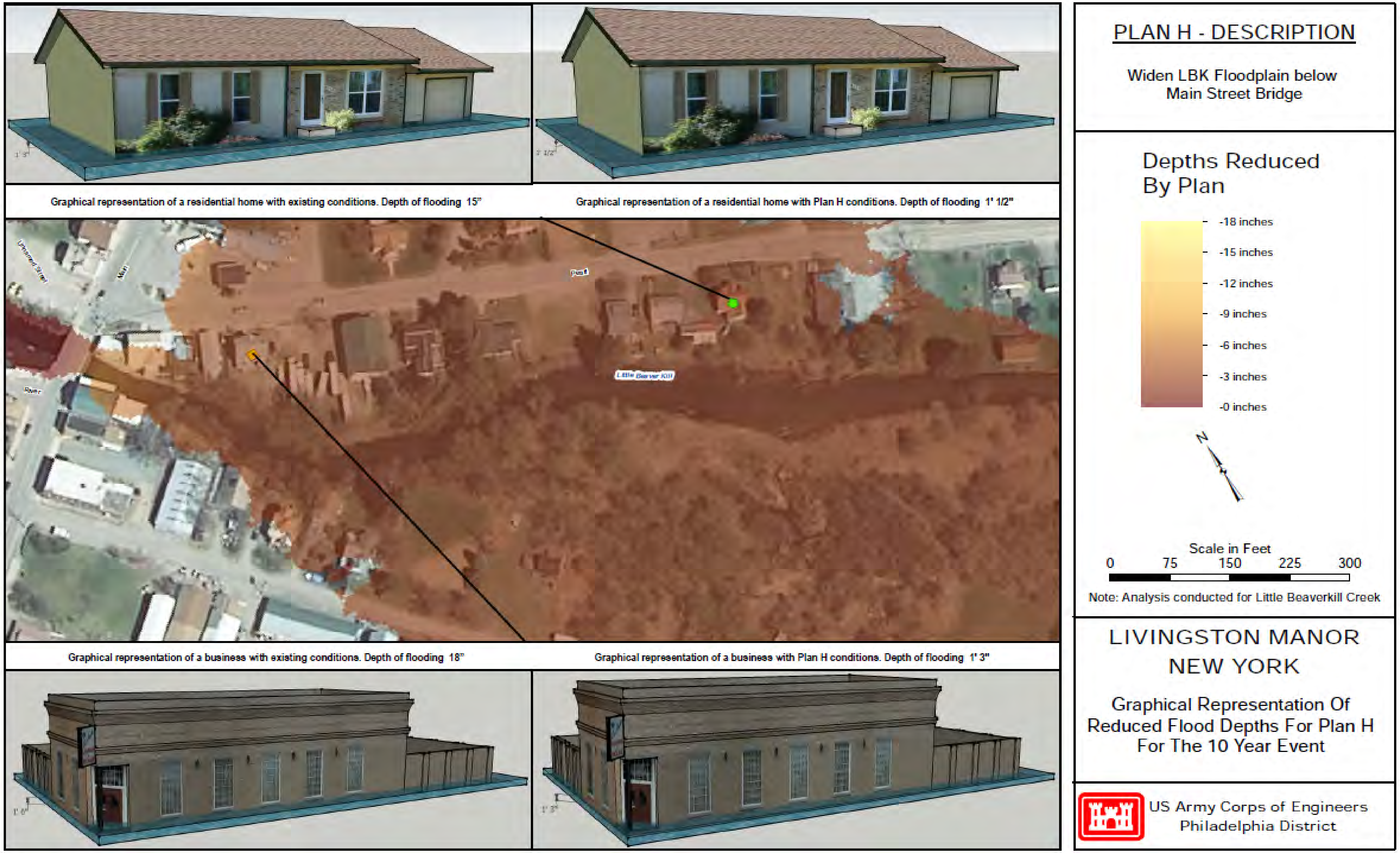


Figure 4.17: Reductions in flood depths for Alternative Plan H for the 10-year flood.

4.4.5.2 Nonstructural Measures

The preliminary economic analysis of the structure buyout measure was performed with the Flood Damage Reduction Analysis (HEC-FDA) software developed by the US Army Corps of Engineers' Hydrologic Engineering Center (HEC). The analysis involved the creation of a model to calculate the Average Annual Damage (AAD) for each structure within the area of interest. The AAD included losses to both the structure and the contents. The content value of each structure was assumed to be the same as the structure value. The model was adjusted to minimize the differences between the computed AAD and the FDA model's calculated AAD for the reaches.

Two scenarios were run through the model to calculate two Benefit Cost Ratios (BCRs). The first scenario only used inputs from the FDA model. The structure value was assumed to be the cost to buyout the structure, so Average Annual Cost (AAC) (1) is the annualization of structure values over 50 years at 4% (Fiscal Year 12 Federal discount rate). A computed AAD was used as the benefit unless the FDA AAD was available for the structure (Table 4.3).

The second scenario used values found from the Sullivan County property assessment data. The market value is an estimate of the likely purchase price if the building were to be sold. Since this is a decent starting estimate for the cost of the buyout, this figure is annualized over a 50 year period at 4% (FY 12 Federal discount rate) to create AAC (2). The assessed value is a rough estimate for the actual worth of the structure, making it a good substitute to replace the overstated structure values. Estimated Annual Damages (EAD) (2) was computed by multiplying the assessed/structure value ratio by the computed EAD (or FDA EAD when available).

To calculate BCR (2), AAC (2) is used as the cost and the benefits used are EAD (2). The assessed values (taken from Sullivan County property assessment data) are more accurate measures of the building's actual value than the structure values are and the market value is a more accurate measure of what the cost of purchasing the structures will be. This maintains the structure damage findings of the FDA model while utilizing more reasonable values. Also, since the cost of purchasing the property is higher than the value of the structure, it more closely accounts for the extra costs the owners will face by purchasing a similar property outside of the floodplain.

Neither of these scenarios considers the costs of appraisals, owners relocating, or the loss of tax revenues to the Town of Rockland. These factors would lead to a lower BCR and should be considered in the next cycle of the feasibility study. There are several pieces of information necessary to carry this analysis into the next cycle and include the reassessment and /or confirmation of the market and structure values. This will require additional coordination with the Town, owners, and realtors.

Additional information about the Economic Analysis can be found in Appendix C.

Table 4.3: Livingston Manor Preliminary Economic Analysis for Potential Buyouts

Reach	Structure	Address	Category	Type	Structure Value	Total Value*	Computed EAD**	FDA EAD	Difference	AAC (1)	BCR (1)	Market Value***	EAD (2)	AAC (2)	BCR (2)
LBK-R-300-B	liv0067	41 Main St	Commercial	CMSNB	565.5	1131	20.66	N/A	N/A	26.33	0.78	153.4	3.64	7.14	0.51
LBK-R-300-B	liv0068	43 Main St	Commercial	CMSNB	611.1	1222	22.97	N/A	N/A	28.45	0.81	455.9	11.14	21.22	0.52
LBK-R-300-B	liv0069	47 Main St	Commercial	CMSWB	629.7	1259	26.77	N/A	N/A	29.31	0.91	207.5	5.74	9.66	0.59
LBK-R-300-B	liv0070	9 Pearl St	Commercial	C1SNB	135.3	270.7	7.72	N/A	N/A	6.30	1.23	N/A	N/A	N/A	N/A
LBK-R-300-B	liv0071	49 Main St	Commercial	C1SNB	138.8	277.6	6.49	N/A	N/A	6.46	1.00	63.85	1.94	2.97	0.65
TOTAL					2081	4161	84.62	83.63	1.2%						
LBK-R-400-A	liv0078	12 Pearl St	Commercial	CMSNB	613.6	1227	119.49	123.3	-3.1%	28.56	4.32	217.1	28.36	10.11	2.81
LBK-R-400-A	liv0079	16 Pearl St	Residential	R2SNB	167.5	334.9	7.43	N/A	N/A	7.79	0.95	99.54	2.87	4.63	0.62
LBK-R-400-A	liv0091	20 Pearl St	Residential	R1SNB	42.44	84.88	3.83	N/A	N/A	1.98	1.94	N/A	N/A	N/A	N/A
TOTAL					823.5	1647	130.75	133.9	-2.3%						
LBK-R-450-B	liv0093	29 Pearl St	Commercial	CMSNB	780.3	1561	129.72	121.8	6.5%	36.32	3.35	151.2	15.04	7.04	2.14
LBK-R-450-B	liv0098	1 Maiden Ln	Residential	R2SNB	83.95	167.9	4.70	N/A	N/A	3.91	1.20	N/A	N/A	N/A	N/A
LBK-R-450-B	liv0099	33 Pearl St	Residential	R2SNB	143.6	287.2	8.21	N/A	N/A	6.69	1.23	166.2	6.18	7.73	0.80
TOTAL					1008	2016	142.63	134.6	6.0%						

Notes and Assumptions:

- All values, EADs, and AACs are in $1,000s
- (**) When available, use FDA EAD as opposed to computed EAD.
- (***) Values taken from Sullivan County Auditor property assessment data. Assessed value is simply 65% of the market value.
- SCENARIO 1: AAC (1) is the annualization of structure values over 50 years at 4% (FY 12 Federal discount rate). Computed or FDA EAD were used as the benefits.
- SCENARIO 2: AAC (2) is used as the cost, but the benefits used are EAD (Assessed). The assessed values (taken from Sullivan County property assessment data) are more accurate measures of the building's actual value than the structure values. EAD (Assessed) was calculated by multiplying the assessed/structure value ratio by the computed EAD (or FDA EAD when available). This maintains the structure damage findings of the FDA model while utilizing more reasonable values.
- Both Scenarios BCRs use FDA EAD as benefits as opposed to computed EAD when the former is available
- The structure values from FDA for the commercial buildings seem overstated, making it hard to say how they relate to market values. It is most likely some combination of overestimated structure values and decreased property values due to flooding that account for the large differences between structure and market values.

4.4.6 Ecosystem Restoration

Ecosystem restoration measures were considered during the screening of measures, but have not yet been taken to the concept-level of design in Cycle 2 (Initial Assessment of Alternative Measures). When the ecosystem restoration measures are more fully developed, they will be evaluated for their completeness, effectiveness, efficiency, acceptability, and significance. Significance is defined according to the following criteria:

- Scarcity – trends and relative abundance of the habitat.
- Connectivity- contributes to the connection of other important habitat pockets.
- Special Status Species- significant contribution to some key life requisite of special status species.
- Plan Recognition contributes to watershed or basin plans.

To be considered for Corps funding, sites are generally required to meet these multiple criteria. Regional or national significance is typically identified based on institutional, public or technical recognition.

A summary of the ecosystem restoration measures that are under consideration is provided below. The four main components include stream restoration through channel realignment and bank stabilization, establishment of a riparian buffer zone to help shade and further stabilize the channel, wetland floodplain creation, and filling of the borrow pits.

4.4.6.1 Channel Re-Alignment and Riverbank Stabilization

Approximately 3,200 linear feet of the Little Beaver Kill would be realigned within the floodway of the existing airport property using the principles of natural channel design. The reach would be designed with flood water attenuation, sediment movement, aquatic instream habitat, riparian cover, and stability as the focal points. To reduce the potential for sedimentation within the active stream channel in this area, a Rosgen Stream Type B is recommended. Stream velocities and slopes would be expected to provide the necessary stream power to pass bedload materials. Channel bed materials will be consistent with bed materials upstream of the project reach. In utilizing this type of design, the risk of erosion and head cutting is increased. As such, the riverbanks would be stabilized using hard (stone) materials for toe protection and in-stream grade-control and flow-deflecting structures (such as rock weirs and bend-way weirs) to maintain channel shape and form and protect the riverbank during flood events. The design would also provide instream and bank habitat diversity during base flow events. In addition, bioengineering, which would include erosion control blankets and native plantings, would be used to stabilize the slopes above the rock toe protection. The upper banks would be bioengineered to tie into riparian buffers existing or created on the site. Finally, as part of this restoration, a sediment analysis would need to be completed since the current airport ponds are capturing sediment and once restored this sediment will be reincorporated into the new stream channel geomorphology.

4.4.6.2 Forested Riparian Buffer Zone

The riparian buffer zone of the Little Beaver Kill in the airport area is limited to a grass/shrub community with a few isolated tree communities. The aquatic habitat can be improved by establishing a minimum 100 foot forested riparian buffer zone along each side of the Little Beaver Kill throughout the proposed project reach totaling approximately 12.0 acres. A vegetative canopy can shade the Little Beaver Kill and help return water temperatures into ranges that support brook trout, rainbow trout, and brown trout during the summer months, provide woody material to the stream reach, cover habitat and food resources for aquatic species, and bank stability with their root systems. The exiting project area includes both native and non-native species. Japanese knotweed (*Polygonum cuspidatum*) is a dominant species in frequently flooded riparian areas and is well established throughout the project reach. The plant out-competes native species by emerging early in the spring and growing very rapidly. The plant is not an obligate hydrophyte, but thrives in the open, frequently disturbed conditions of a low lying flood plain and unstable banks. Establishment of Japanese knotweed can be prevented by monitoring, hand removal of plants found on the site, treatment with glyphosate, and repeated cutting during the growing season to retard stem growth. Planting the site with rapid growing and canopy-forming, deciduous riparian species that are native to the area may also retard establishment of Japanese knotweed in newly planted riparian areas. Species that are currently found on site and can be used in the riparian zone include eastern cottonwood, green ash, silky dogwood, speckled alder, and black willow. Regional or local experts would be consulted in developing planting plans and native species to be used in riparian and wetland restoration areas.

4.4.6.3 Floodplain Wetlands Creation/Filling of the Borrow Pits (Airport Property)

The floodplain of the Little Beaver Kill adjacent to the project site is dominated by meadow grasses. If this floodplain were to be re-graded so that the borrow pits were filled and other areas lowered in elevation it would create conditions that would allow wetlands to re-establish in an area where they likely existed at one time. This could include emergent wetlands, scrub-shrub wetlands, and forested wetlands. The material excavated to create these depression wetlands would be used to fill the borrow pits. Additionally, the depression wetlands would increase flood storage capacity and potentially reduce flooding in Livingston Manor.

Portions of the site were observed to have been filled with construction/demolition debris, old automobile bodies and parts, tires, glass and other materials unsuitable for use in restored wetlands. This material appears to be concentrated near the developed portion of the site (buildings, parking area, and former runway). Further investigation involving construction of soil test pits will be required. The nature of the fill material and the difficulty of removing and properly disposing of it may reduce the suitability of the airport site for wetland creation. The borrow pits will be filled with material excavated during the realignment of the Little

Beaver Kill or offsite borrow material. The fill material in the borrow pits would be capped with topsoil and the borrow pits stabilized with native vegetation.

The development of wetland hydrology and vegetation would require removal of some soil on the premises. The natural groundwater elevation is estimated to be 3-4 feet below the ground surface near the airport runway. Removal of approximately 3-5 feet of surface soil material is anticipated for areas to be included within the wetland creation site. The wetland should incorporate a variety of water regimes to create habitat diversity. Various water regimes would be created by excavating variable amounts of surficial materials to create an uneven surface. The overall design shall be a mosaic of upland and wetland habitats that are re-vegetated utilizing native species. The plan would be to create approximately 11 acres of wetland on the site. The preliminary cost estimate for the restoration of the airport site was $950,000. Note that this cost does not include the construction of berms for possible flood damage reduction and any additional investigation on the quantity or quality of sediment material on site.

4.4.6.4 Floodplain Storage and Habitat Restoration at former Poultry Plant along Willowemoc Creek

The floodplain habitat of the Little Beaver Kill in the former Poultry Plant is currently degraded from past land practices on the site. Excavating fill material from the Poultry Plant site and re-grading the area to create a functioning floodplain forest could provide improved fish and wildlife habitat. In addition, a restored floodplain at this site could provide minor flood storage, but is unlikely to provide much flood damage reduction to the downtown area of Livingston Manor.

The site has great potential for habitat restoration and potential passive recreation (e.g., walking trail) and education for the local community. Additional information is needed from NYDEC on the status of the property from previous land practices and the ability of a new landowner to restore the site. The NYDEC's Division of Environmental Remediation/Hazardous Waste Remediation has not been involved with the property and there has been no application to the NYDEC's Brownfield Program for this property (P. Ferracane, Personal Communication, 2012).

4.4.6.5 Levee Removal or Relocation at the Central High School

Removal of the levee protecting the athletic fields would open available floodplain areas. A riparian buffer would be established along the Willowemoc Creek in this area. Riparian area recommendations for the airport project area would also apply for this and all other riparian area restoration efforts. Riparian cover will provide bank stability, flood water velocity reduction, water temperature reduction for aquatic species, and aquatic and terrestrial habitat. However, discussions between NYDEC and the high school at a meeting held on November 13, 2012 indicted that the high school did not have an interest in moving the levee back from the edge of the Willowemoc Creek (P. Ferracane, Personal Communication, 2012). In addition, Livingston Central School have hired Woidt Engineering to design a repair of the existing berm (E.Weitmann, Personal Communication, 2013).

4.4.7 Tentatively Selected Plan

Based on an evaluation of the various alternatives (Table 4.5), including the environmental impacts, design elements, and estimated costs; and in collaboration with the non-federal sponsor (NYDEC) and the local municipality (Town of Rockland), Plan G (a combination of Plans F and H) was determined to be the tentatively selected plan (Figures 4.18 and 4.19). This plan has strong flood damage reduction benefits; as well as, ecosystem restoration benefits (Table 4.5). The economic results indicate a 1.23 benefit/cost ratio with $41,935 in annual net benefits to the federal government. In addition, this plan restores approximately 3,200 linear feet of natural stream channel, 12 acres of riparian habitat, and 11 acres of wetland habitat to the local community. Plan G provides key flood damage reduction benefits to Livingston Manor. Under Plan G, average annual damages from flooding should decrease by approximately $220,000. Furthermore, since trout fishing is important to the culture and economics of the region, Plan G provides essential benefits desired by the local community. Note that Plan G applies just to the Little Beaver Kill watershed and not Cattail Brook, which was analyzed separately.

Ideally, to get more flood damage reduction benefits, non-structural alternatives (e.g., buyouts) would be combined with the tentatively selected plan; however, due to the preliminary nature of the current non-structural analysis, it would be premature to do that at this point in time of the study. If buyouts do occur, they should be incorporated into the selected plan because if they occur separately or before the federal project is constructed, then the BCRs of structural solutions will need to be re-calculated because some structures will have been removed from the floodplain.

Furthermore, components of the various plans considered could be separated and completed by the non-federal sponsor or Town of Rockland with their own funding. However, this could potentially affect future partnerships with the USACE to implement any plans under this study. Locally-implemented plans could change the existing conditions of the project area and reduce damage benefit calculations. From a federal perspective, this would negatively affect future benefit/cost ratios and net benefits of this study.

Figure 4.18: Plan F - Fulton Plan involving a detention structure and open channel.

Figure 4.19: Plan H – Widening of the Little Beaver Kill floodplain below the Main Street Bridge.

4.5 Conclusions and Future Recommendations

The USACE recommends implementation of Plan G (floodway expansion downstream of Main St. Bridge and the Fulton Plan B). This combination plan provides an array of flood damage reduction measures for the Hamlet of Livingston Manor, while also taking advantage of ecosystem restoration opportunities in the watershed. This plan provides a cost effective return to both the federal government and our non-federal sponsor, while also providing measurable ecosystem restoration benefits.

Due to the limited schedule and funding available, most of the analysis was focused on the Little Beaver Kill watershed. However, after September 18, 2012 storm that resulted in major flooding on Cattail Brook, the hydraulic analysis was expanded to include this watershed. Recommendations for Cattail Brook include replacing the Finch St. Bridge with a longer span and stabilizing the banks of the brook with native vegetation.

Future recommendations and actions include completing Phase II of the feasibility study. The estimated cost of this effort is $400,000 and would need to be cost shared 50/50 with a non-federal sponsor. The additional analysis would include the following:

- Further analysis of potential floodplain storage and ecosystem restoration opportunities at the Poultry Plant.
- Further explore and complete a hydraulic analysis of the floodplain storage and restoration potential at the Sewage Treatment Plant as the infrastructure and levee is relocated further away from the Willowemoc Creek.
- Further explore and complete a hydraulic analysis for the potential restoration and construction of a floodwall/levee on Pearl Street.
- With the recent loss of the Lazy Beagle Restaurant (corner of Main St. and Pearl St.) due to fire damage (Ed Weitmann, personal communication, 2012), we may wish to explore extending the floodway expansion design from downstream of the Main St. Bridge to the area upstream of the Main St. Bridge, previously occupied by the building.
- Further economic analysis of the potential buyout properties in the Town that get repeated damages.
- Further explore various plan combinations that were not included in this report (e.g., combining Plans D (floodway expansion and Main Street Bridge widening) and F (Fulton Plan).
- Further explore restoration options as stand-alone projects (e.g., Fulton Plan without the flood damage berms).

4.6 Project Implementation without Further Study

In lieu of further study, the District may recommend a version of the selected plan (or components of the plan) in this report for implementation under the USACE's Continuing Authorities Program (CAP). The CAP program is a Corps civil works program that is authorized to plan, design, and construct certain types of water resource and ecosystem restoration projects without additional and specific congressional authorization. Additional analysis would be required to support justification under CAP prior to implementation. Furthermore, future funding for CAP projects is uncertain at this time.

Section 205 of the Flood Control Act of 1948 allows flood control projects to be implemented in accordance with current policies and procedures governing projects of the same type which are specifically authorized by Congress. Work under this authority provides for local protection from flooding by the construction or improvement of flood control works such as levees, channels, and dams. In addition, non-structural alternatives will be considered and may include measures such as flood warning systems, raising and/or flood proofing of structures, or relocation of flood prone facilities. The cost share for the 205 authority is 50% federal and 50% non-federal for the feasibility phase; followed by 65% federal and 35% non-federal for the construction phase. In addition, these projects are limited to a Federal cost of $7 million per project.

Section 206 of the Water Resources Development Act of 1996 provides authority for the Corps to investigate, study, modify, and construct projects for aquatic ecosystem restoration. The objective of the 206 authority is the restoration of degraded ecosystem structure, function, and related processes to a less degraded, more natural condition. For this authority, there does not have to be a connection to a previous Federal Project. The non-federal sponsor must demonstrate that the project is cost effective and contributes to an improved environment that is in the general public interest. The cost share for the 206 authority is 50% federal and 50% non-federal for the feasibility phase; followed by 65% federal and 35% non-federal for the construction phase. In addition, these projects are limited to a Federal cost of $5 million per project.

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