LOCAL FLOOD ANALYSIS

FOR THE

EAST BRANCH/MAIN STEM OF THE NEVERSINK

This document was prepared for the Towns of Denning and Neversink under the supervision of the Denning Neversink Flood Advisory Committee with funding provided by Sullivan County Soil and Water Conservation District's Stream Management Program through contract with New York City Environmental Protection

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June 2016

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Purpose and Scope

The Towns of Neversink and Denning, situated along the banks of the Neversink River, have experienced severe flooding in recent years. This has led to a heightened awareness of the damage that can occur from flooding. Residents, businesses, and other stakeholders desire to build community resilience and protect community assets from future flood damage. In order to access new funding assistance to meet those goals, a hydraulic analysis of the main population areas of Denning and Neversink is underway. As with Stream Management Planning in the New York City watershed region since 1997, this effort is funded through local County Soil & Water Conservation Districts by NYC Environmental Protection. A Committee of residents, local officials and technical staff from the funders was created to administer the Local Flood Hazard Mitigation Analysis. Those members from Town of Neversink were: Keith Stryker, Code Enforcement Officer, James Stengal, Planning Board Chair. Jim Marion served on the Committee member until he passed away in late 2014. From Denning: Mark Boncek, ZBA Chair, Bill Bruning, retired Supervisor, and currently, Greg Vurckio, a Town Council member; and Aaron Bennett from Ulster County Department of Environment.

Staff members of Sullivan County SWCD's Rondout Neversink Stream Program included Brian Brustman, Karen Rauter, Stacie Howell; from NYC DEP: Mark Vian, Phil Eskeli and Emily Smith. From Barton and Loguidice: Wendell Buckman, P.E. and Shaun McAdams.

The purpose of this Local Flood Hazard Mitigation Analysis (LFA) document is to provide a detailed assessment of the flooding characteristics in the Towns of Neversink and Denning. The focus area of the analysis extends from the Denning Road bridge crossing of the East Branch of the Neversink (approximately two and a half miles upstream of the Ulster-Sullivan County line) to the confluence of the East and West Branches of the Neversink Frost Valley Road bridge; the focus area then continues on the main stem of the Neversink, approximately one half mile downstream of the Halls Mills Covered Bridge.

This LFA document describes the existing flood hazards within the focus area, identifies existing infrastructure elements in the community that are at risk for flood damage, recognizes potential alternatives aimed at reducing flood impacts, and describes an implementation plan for prioritized alternatives. The analysis is based on an initial flood study completed by FEMA, and is supported by additional field-derived data reflecting current river- and floodplain conditions. This document includes a review of available information pertinent to the hydrologic and hydraulic functions of the Neversink and engineering analysis required to assess the flooding characteristics within the focus area. In addition, reach specific stream stability restoration goals from the Upper Neversink Stream Management Plan have been included in the Appendices, as well as General Recommendations for best practices when managing the stream for flood hazard mitigation.

II. Site Description

County: Sullivan & Ulster Counties

Village/Town: Towns of Neversink & Denning

USGS Quadrangle Map: Claryville

River/stream: Neversink River (East Branch & Main Stem)

Stream Classification: C with (T) Standards (East Branch)
B with (T) Standards (Main Stem)

Focus Area Length: 6.4 miles
(3.5 miles of the East Branch and 2.9 miles of the Main Stem)

Drainage area: The drainage area at the downstream limits of the focus area is approximately 68 square miles.

Gages: There are three gaging stations in proximity to the focus area: one on the East Branch (at a Denning Road Bridge crossing); one on the West Branch Neversink at County Bridge 157 Frost Valley Road (approximately one half mile upstream of the confluence of the East and West Branches) and a third on the main stem (0.9 miles downstream of the focus area (at the Halls Mills Covered Bridge).

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III. Methods

III.A. Approach

An evaluation of flooding in the Neversink watershed was developed from available information, data collected from field reconnaissance, and engineering computations. The basis for the evaluation was FEMA's hydraulic model developed in 2013 to update previous Flood Insurance Studies (FISs). FEMA's Effective Hydraulic Model was performed in the US Army Corps of Engineers' HEC-RAS software. Barton & Loguidice D.P.C. (B&L) reviewed and modified the FEMA Effective Model in order to capture the existing flood regime of the East Branch and the main stem of the Neversink River and its tributaries within the defined project area. This adapted model is referred to as the "Duplicate Model."

Using this refined model informed by existing FEMA modeling and corrected by inputs from field data and observations of the stream/floodplain network, B&L modeled a range of flood flows (1.25-, 2-, 10-, 25-, 50-, 100-, and 500-year flood events) within the project area. The outputs of these model runs graphically document flood profiles, identifying water surface (flood) elevations and lateral flood extents (inundation widths) within the project area corresponding to each flood flow. Using Geographic Information Systems (GIS), topographic mapping (supported by LiDAR-derived contour data) and aerial imagery overlays to depict inundation zones, at-risk structural elements (including residential properties, infrastructure elements, etc.) were identified for each flood stage modeled. Defining the inundation limits and affected infrastructure elements corresponding to each modeled flood stage provides the fundamental basis for identifying mitigation alternatives based upon prioritized assessment of the severity and extent of impacts associated with each modeled flood event.

One of the dominant local perceptions is that flooding through the study area is caused or exacerbated by sediment filling in the channels. In order to further understand this issue and be able to evaluate alternatives as they relate to sediment transport, B&L conducted a field-analysis to evaluate sediment transport characteristics through the project reaches of the Neversink and its East and West Branches. Methods utilized include the FLOWSED/POWERSED models (informed by empirical field data collected from 21 river sections), to evaluate both sediment transport competence (mobilization) and capacity (conveyance) through the project reach. Findings were used to provide a comparative analysis of the sediment transport regime at various locations through the project reach, providing insight as to where imminent changes in channel form during a flood, likely caused by rapid sediment deposition, may lead to an elevated risk to infrastructure and other elements of interest. Ultimately, the findings of the sediment transport analysis will be used to evaluate opportunities where bank stabilization and channel modifications can be used in tandem to protect streamside infrastructure, properties, and resources by balancing sediment transport and reducing the risks associated with abrupt changes in channel form that often accompany flood events.

III.A.1 Hydrology

The hydrology for the existing FEMA models was developed utilizing current information fromthe gage stations located on the East Branch and the main stem of the Neversink. The total drainage area at the downstream limits of the project area is approximately 68 square miles. There are three gaging stations in proximity to the focus area: one on the East Branch (at a Denning Road Bridge crossing); one on the West Branch Neversink at County Bridge 157 Frost Valley Road (approximately one half mile upstream of the confluence of the East and West Branches) and a third on the main stem (0.9 miles downstream of the focus area (at the Halls Mills Covered Bridge).

FEMA utilized a Log Pearson Type III statistical evaluation of historic flood elevations recorded at these gage stations to determine the peak discharges for the 10, 25, 50, 100, & 500 year flood events. Results of this evaluation were reviewed by B&L to confirm that the corresponding discharge values determined by FEMA are consistent with actual, current flood conditions. As a means of validating the FEMA gage analysis, discharge values associated with Tropical Storm Irene (2011) and the flood of 2012) were compared with, and found to closely mimic, those actually experienced during these events. Using FEMA’s analysis of larger floods, B&L developed discharge values corresponding to the 1.25, and 2 year floods, providing a means for evaluating the river’s flood- and sediment transport regimes during these smaller, more frequently-occurring events.

Table 1 - Peak Discharges (cfs)

Location	Recurrence Interval (years)						
	1.25	**2**	**10**	**25**	**50**	**100**	**500**
Near the Upstream Limit of Project Area – East Branch Neversink USGS Gage No. 01434017	1,720	2,340	4,170	5,510	6,730	8,070	11,400
WB Neversink USGS Gage No. 01434498	3,670	5,860	12,000	15,600	18,600	21,800	30,000
Downstream limits of Project Area – Main Stem Neversink USGS Gage No. 01435000	4,090	6,530	13,300	17,300	20,700	24,200	33,200

III.A.2 Duplicate Hydraulic Model

The hydraulic assessment is used to evaluate and predict water elevations, identify flood prone areas, and evaluate mitigation strategies to minimize future flood damage and protect water quality. FEMA developed an updated hydraulic analysis for the Neversink Watershed in 2013.

The detailed HEC-RAS model developed by FEMA for the Main Stem and East Branch of the Neversink River does not extend to the upstream limits of the study area. An approximate model extended from the detailed model past the limits of the study area. The approximate study was used and enhanced with additional data to extend the detailed HEC-RAS model to the study limits. In addition to the cross sections in the FEMA model (surveyed in 2013), an additional twenty-one (21) cross sections obtained during our sediment transport analysis were also added to the model to provide the most complete and up-to-date model possible. A detailed evaluation of the duplicate hydraulic model was completed to investigate obstructions, ineffective flows, and verify geometry throughout the model. The final step was to model the inundation limits from Tropical Storm Irene. During our initial public meeting we gathered information regarding what was actually observed during the event and compared this to our model. This provided us a with a real-world calibration of the model. The end result was our existing conditions “Duplicate Effective Model” that was used to compare potential mitigation alternatives.

III.B. Field Reconnaissance

Field data was collected from 21 locations along the main stem and East Branch of the Neversink River. Field data collected at each location included an analysis of prevailing sediment particle size distributions in the river's bed (pebble counts) and adjoining depositional gravel bars (bar samples). Cross sections and longitudinal profiles of the river channel were surveyed at each location to inform hydraulic conditions at each sampling location. This information was used to evaluate the effectiveness of the river at various points to transport sediment (gravel) when in flood.

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III.C. Sediment Transport Modeling

Field data collected from 21 study locations along the East Branch and main stem was utilized to evaluate sediment transport through the project reach, both in terms of competence (the ability of the river to mobilize the available sediment from a static state) and capacity (or the ability of the river to convey the available sediment load once mobilized).

Competence is evaluated through comparative analysis of the relationship between the composition of the prevailing river substrate (bed material) and the force exerted upon those sediment particles by the action of water flowing along the river channel (shear stress). As shear stress increases, the size of sediment particle able to be mobilized by the flow also increases. In the most general of terms, by comparing the shear stress at each study location (derived from the surveyed cross section and longitudinal profile) to the sediment particle size distribution of the river bed at that site, a determination is made as to whether the shear stress exerted on the bed is greater than, less than, or relatively equal to that required to mobilize the sediment available.

At locations where shear stress significantly exceeds that required to mobilize the sediment, the river is said to be *over-competent*, and bed scour will occur. This can lead to the channel becoming deeper and, eventually, to bank collapse. Conversely, in scenarios where shear stress is less than that required to mobilize sediment, aggrading conditions (sediment deposition) will result. This can lead to a channel that is filled with sediment, leading to higher inundation levels and channel migration as the river seeks flow routes around the obstructions. A stable river section, which mobilizes the available sediment load without excessive scour or deposition, maintains a relative balance between available shear stress and that necessary to mobilize sediment particles comprising the river bed.

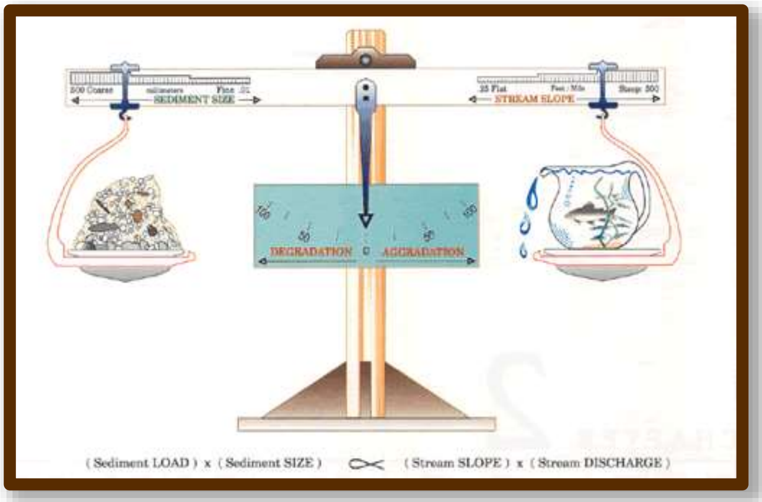

Image courtesy: Dave Rosgen (Wildland Hydrology)

Transport capacity describes the river's ability to pass (convey) the volume of sediment coming from upstream through a given channel section. The FLOWSED / POWERSED model ~~models~~ ~~were~~was utilized to evaluate sediment capacity at each study location, by comparing channel hydraulics of the study section to those of a representative 'stable' river section. Reference sediment rating curves were used to establish sediment transport rates for each section, based upon the overall condition of the contributing upstream reach and the anticipated volume of sediment derived from adjoin stream reaches of 'Good/Fair' versus 'Poor' condition (in terms of bed and bank stability). Similar to the evaluation of competence, those sections which exhibit excess transport capacity (are able to convey more sediment than that delivered from upstream) tend to degrade (scour), whereas those that lack sufficient capacity tend to deposit sediment and aggrade. A stable river section has sufficient capacity to both mobilize and convey the sediment load without aggrading or degrading. This model is used to assess the current transport capacity and whether the stream is likely to aggrade or degrade from incoming sediment in the next bed mobilizing event. It does not specifically tell us if, and to what degree the channel has aggraded or degraded in the past, which can only be assessed through repeat channel surveys.

Results of the sediment transport analysis revealed the following trends along the course of the East Branch and main stem within the project area:

- Of 15 study sections along the East Branch:
  - 10 locations were determined to be actively aggrading (depositing excess sediment)
  - 3 were found to be degrading
  - 2 were determined to be relatively stable
- Of 6 study sections along the main stem Neversink:
  - 4 locations are aggrading
  - 1 exhibits degrading conditions
  - 1 was determined to be relatively stable

Determination of aggrading conditions at 14 of 21 locations along the East Branch and main stem supports the general consensus of the community that the river, over time, has been filling with sediment. This is partly due to the existing hydraulic conditions in various places in the river—including backwater conditions caused by bridge spans at the numerous road crossings that restrict the river at higher flows--and partly due to a high supply of sediment coming from stream bank and hillslope erosion, both within the study area and from upstream watersheds. Although measures to manage sediment sources are not specifically included in this LFA program, ongoing efforts by the Rondout/Neversink Stream Management Program are specifically aimed at treating bank and hillslope erosion, and will reduce the excessive sediment loading to the Neversink system.

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III.D. Public Outreach

A series of public presentatons were held to gain input and share information with the community members during the process of conducting the analysis. The meetings were structured as follows:

- *Meeting #1* – This meeting was used to inform the community of the LFA process. We also utilized this meeting to verify the existing HEC-RAS model. To do this we showed the residents the inundation developed by Irene in our model and compared it to what the public actually experienced during the storm.
- *Meeting #2/3* – We presented our alternative modeling to the public and the results of modeling and used the opportunity further educate on the functionality of the model and its benefits as a tool for planning. River process, river stability, and sediment transport concepts were also presented, as well as the distinction between natural stream channel design and traditional dredging.
- *Meeting #4* – This meeting was used to present the results of the BCA and to discuss the limitations they pose to implementing proposed solutions that were modelled.
- *Town Board Meetings* – Once accepted by the Town Boards, the Local Flood Analysis will serve to make them eligible for future funding opportunities available within the NYC watershed region.

IV. Flood Mitigation

IV.A. General

As shown through the modeling and historic events, the studied project reach (East Branch and Main Stem of the Neversink in the Claryville area) is susceptible to flooding during large storm events. Alternatives for mitigation alternatives are characterized under the following categories:

- **Property Protection:** These types of alternatives include measures that either provide structural measures to protect existing buildings, residences, and infrastructure elements from flood impacts, such as flood levees, diversions, floodwalls, etc., or to remove them from the flood inundation zone through raising building elevations, relocation, or abandonment of properties.
- **Flood Damage Protection and Planning:** These types of alternatives include stream and/or floodplain modifications intended to reduce flood elevations. These approaches are *oftentimes, but not entirely*, most · applicable in areas where sufficient lateral area adjacent to the active channel and floodplain are available to implement such measures. In addition to reduction in flood risk and associated hazards, these alternatives, including such measures as floodplain reconnection, installation and protection of streamside buffers, and natural channel restoration, provide a wide range of additional benefits to the community. Benefits include improved aesthetics, recreational opportunities, water quality, and elevated property values. When compared to more structurally-engineered alternatives, these modifications provide greater flood mitigation benefits to the system as a whole by reducing flood velocities, reducing bank erosion and mass failures, and minimizing changes in channel form upstream and downstream by balancing the sediment transport regime. Funding sources such as Catskill Watershed Corporation (CWC) are available to support flood mitigation projects that incorporate approaches such as natural channel and/or floodplain restoration.

- **Natural Resource Protection:** These types of alternatives do not directly address flood stages or direct flood impacts, but instead address elements that frequently contribute to or exacerbate flood elevations. They include: debris ~~management~~blockages at culverts and bridges; bed-load, large woody debris; bank stabilization; and landslide remediation. These approaches can also include out-of-channel projects intended to restore the natural hydrologic regime through increasing groundwater infiltration, stormwater detention and storage, and reducing flood surges associated with excessive overland runoff. Rondout Neversink Stream Program through Sullivan County SWCD is a potential source for funding these multi-purpose restoration projects.
- **Structural Projects:** These types of alternatives provide structural protection to critical infrastructure elements, such as utilities, bridges, roadway embankments, and culverts. Because of the localized nature of many of these types of projects, these approaches are best implemented in conjunction with one or more additional mitigation alternative approaches, such as replacing, retrofitting, or re-sizing bridges and culverts, etc.
- **Emergency Response and Services:** These types of alternatives do not directly address flood impacts, per se, but establish adequate response measures from Emergency Services agencies to provide affected residents with safety, shelter, and adequate supplies to offset the impacts to health, personal safety, and impacts to quality of life that result from flood events.
- **Community Pollution Prevention:** These types of alternatives identify and secure, either through structural, relocation, or other means, elements within the community that pose potential pollution and/or toxic risks to people, property, and the environment when inundated during a flood.

The alternatives evaluated by the hydraulic model below largely focus on structural and flood damage protection through projects that reduce flood elevations and subsequent impacts to structures and roadways. The alternatives evaluated are presented starting upstream and working downstream through the project area but in no order of importance or priority.

IV.B. Areas of Interest

IV.B.1 Denning Road Dam near Red Hill Road

The small private dam that crosses the East Branch of the Neversink just upstream from the Denning Road Bridge near the intersection with Red Hill Road was identified as a potential contributor to flooding. The influence of the dam on flooding in the area was unknown. To fully compare the effects of the dam, an alternative was developed that removed the dam entirely. The alternative restored the grade of the channel. The reduction of flood elevations was approximately 0.5 ft for storms with a recurrence interval larger than 10-years. The influence of the removal was only observed approximately 700-800 feet upstream. This impacts the owner of the dam and 2 other houses upstream and across the road. Refer to Appendix A for the reduction in water surface elevations at each of the houses impacted.

While there is localized benefit from this alternative, it would not provide widespread benefits throughout the project area. The current owner of the dam was present for the presentation during which the model was discussed and though he did not return to see the results of the model at the later meeting, his desire to retain the dam in place was noted. Following Irene, he made an investment to repair the dam and expand on the stone walls intended to protect the driveway which has suffered repeated flood damage.

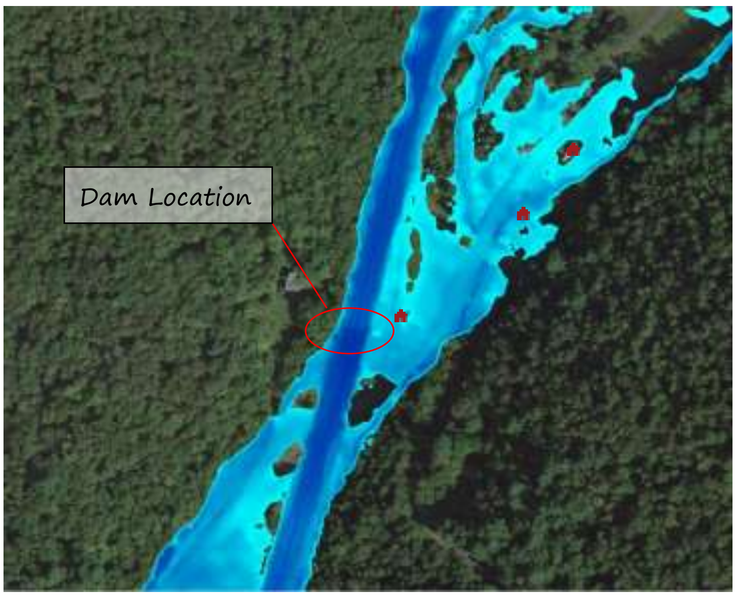


Figure 6 - Inundation Area during a 10 year event – Existing Conditions

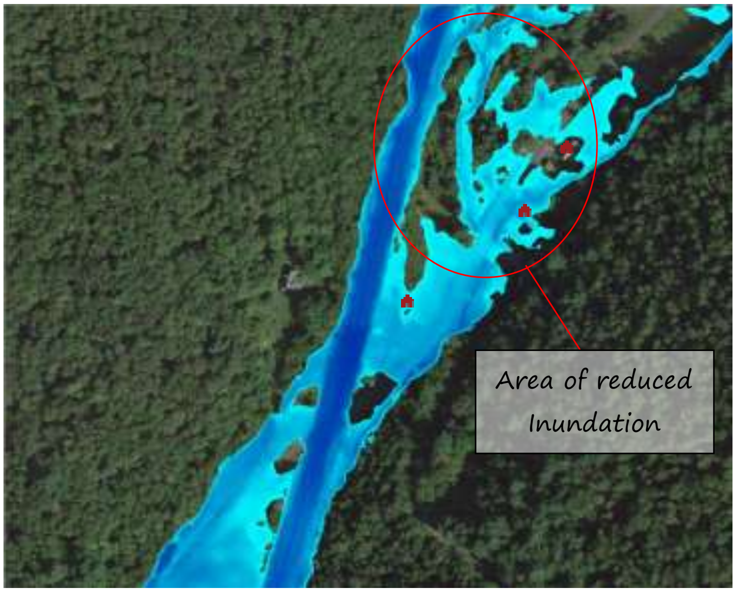


Figure 7 - Inundation Area during a 10 year event – Proposed Conditions

IV.B.2 "Double Bridge" at Town Hall

The influence of the existing truss bridge and the temporary bridge installed next to it was identified as a potential constriction along the East Branch of the Neversink. The presence of two bridges aligned at different orientations presented a location where a significant amount of energy was lost in the model resulting in backwater elevations upstream. The bridge was slated for replacement in 2015 and an initial concern was the size of the bridge being proposed by Ulster County. The replacement bridge being constructed by the County was modeled compared to the existing two bridge condition:

Flow	Existing WSE (ft)	Proposed WSE (ft)
1.25-yr storm	1695.07	1694.94
2-yr storm	1696.22	1695.88
10-yr storm	1698.63	1697.83
25-yr storm	1699.92	1698.83
50-yr storm	1700.58	1699.43
100-yr storm	1701.30	1700.05
500-yr storm	1700.58	1701.55

The proposed low beam elevation of the new bridge is 1699.84. The improved opening results in backwater elevations that are reduced by approximately 1 foot for the larger storms. The freeboard, or distance between the low beam and the water surface, for the 50-year storm is 0.4 feet. A storm between the 25- and 50-yr flows would inundate the approach roadway southwest of the bridge. It appears that the flow is getting over to Saw Mill Road at an upstream cross section which is inundating the southwest approach. The berm upstream of the bridge in the left floodplain is overtopped between the 25 and 50-year storms.

The concept of a detention pond was briefly discussed, but was determined not to be feasible given the volume of flow that comes down the East Branch of the Neversink. For example a 2-3 acre detention pond would fill in a matter of minutes during a 10-year storm event. Once the detention pond is filled, it would offer no reduction in peak discharges. This concept was not explored further.

While the model showed that conditions are improved with the proposed bridge design, there is still flooding along the south approach. This flooding is what shuts down the road to vehicular traffic and results in water traveling down Denning Road towards the center of Claryville. To address this issue, an option to raise the road out of the floodplain was evaluated. This was combined with 1) a 60foot long bypass culvert to carry under Denning Road the water coming from Saw Mill Road when higher flows overtopped the berms, and 2) stream channel modifications downstream of the bridge, including a 100 foot wide floodplain bench along the south bank of the river where the Town Hall currently sits, and a smaller bench in front of the failed slope along the north bank to mitigate erosion. This last treatment would also reduce velocities at the toe of the failed slope, allowing the bank to be stabilized. In order to accommodate the floodplain bench downstream of Denning Road, the Town Hall would have to be relocated to facilitate this project. While a major project, this reduces flood elevations significantly and reduces the risk for several houses in this segment for floods with a recurrence interval greater than 50 years. Refer to Appendix A for the reduction in water surface elevations at each of the houses impacted.

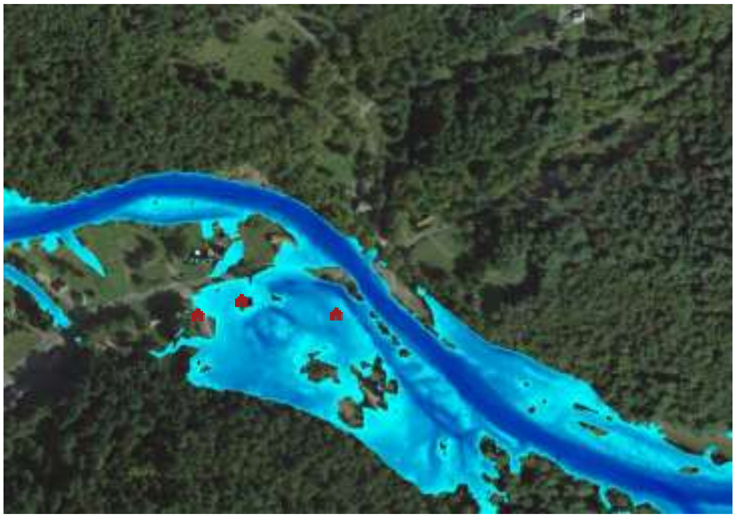


Figure 8 - Inundation Area during a 25 year event – Existing Conditions

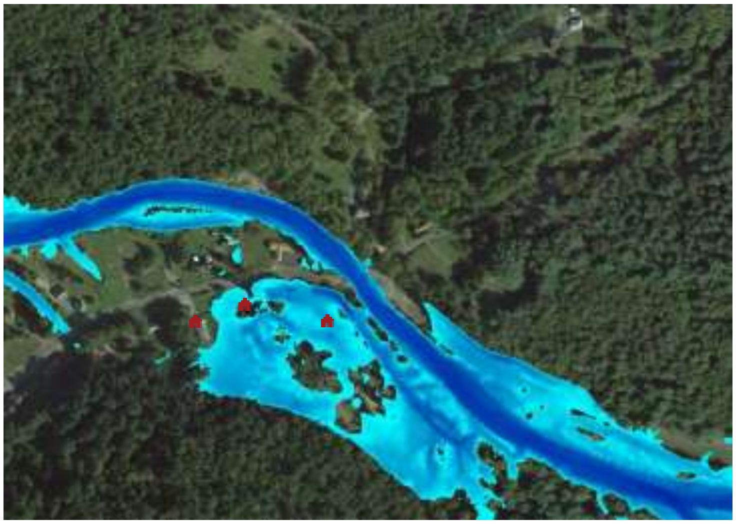


Figure 9 - Inundation Area during a 25 year event – Proposed Conditions

IV.B.3 DOT Stacked Stone Wall DS of County Line/"Wellington Site"

The area of concern is a 2600 foot length of stream beginning just upstream of the DOT stacked stone wall on Sullivan County Road 19 to a point just upstream of the Frost Valley Road Bridge. This reach of the stream was identified for several concerning features. The wall itself is being eroded along the toe, the stream is overly wide and braided, and appears to have experienced significant aggradation. In addition, this site was previously dredged following Tropical Strom Irene and the section along the stacked rock wall partially restored before being significantly reworked again by the September 2012 flood. The alternative evaluated at this site would reestablish the channel dimensions of the stream utilizing the data collected through the sediment transport model and the principles of natural channel design. By establishing the correct channel dimensions, there are three primary benefits. 1) The stream's ability to transport the gravel is brought into balance with what is delivered from upstream. This prevents the large scale aggradation of material that is currently observed at this location. 2) By establishing a channel form that is in balance, the stream becomes more stable. This means that the large migrations of the stream from one bank to the other will be less likely to occur. There will be floodplain area between the DOT wall along Denning Road and the stream. This floodplain area will provide conveyance during larger storms reducing the impact to properties and stabilizing the toe in front of the DOT wall. 3) The development of a natural channel section and improved stream slope results in the reduction of water surface elevations in this reach. The benefits of this project help meet multiple objectives. By stabilizing the stream, not only can a decrease in water surface elevations be achieved, but the volatility of the stream in this stretch is reduced leading to a more sustainable solution than traditional dredging and bank stabilization approaches. Refer to Appendix A for the reduction in water surface elevations at each of the houses impacted.

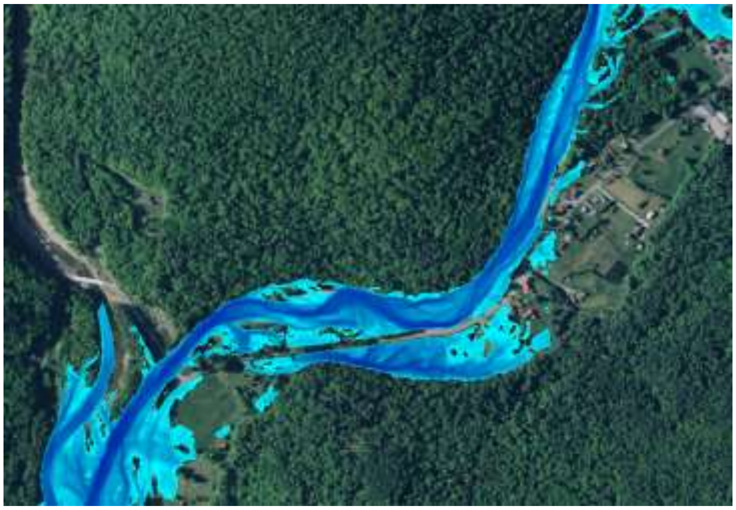


Figure 10 - Inundation Area during a 25 year event – Existing Conditions

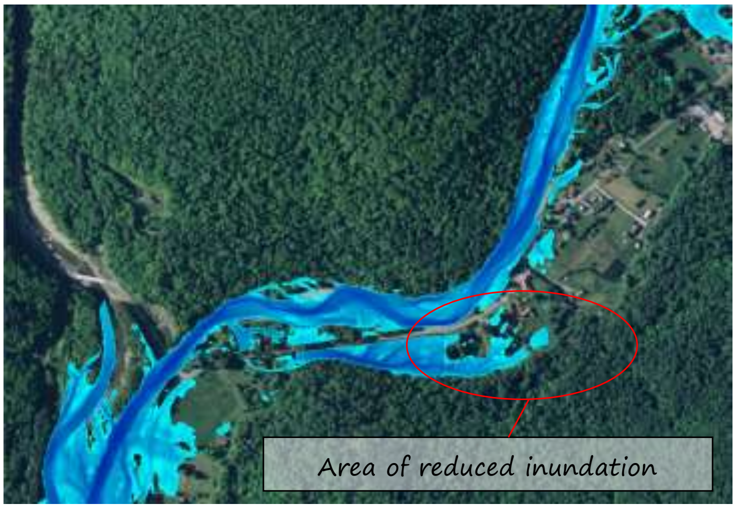
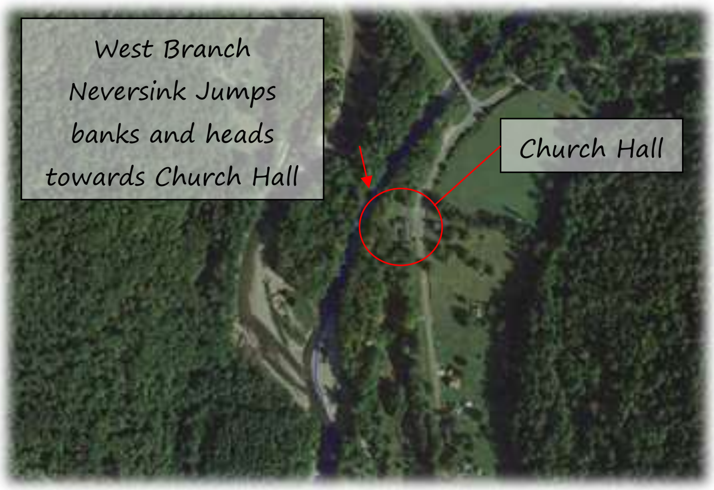


Figure 11 - Inundation Area during a 25 year event – Proposed Conditions

IV.B.4 Church Hall/Downstream of Frost Valley Bridge

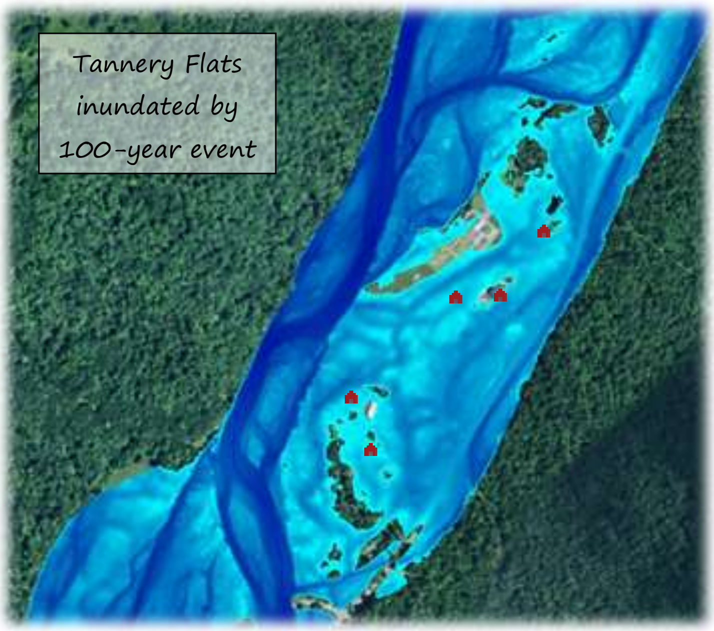


The area of concern begins downstream of the Frost Valley Road Bridge and upstream of the confluence of the East and West Branches of the Neversink. Here, during large storm events, the West Branch of the Neversink River breaches the divide between the two branches, and partially spills into the East Branch channel before the true junction. The additional volume of flow in the East Branch channel potentially raises flood elevations at the church hall and in the floodplain downstream. An alternative was evaluated that looks at increasing the height of the "peninsula" between the two branches until the true junction about 750 feet downstream of the church hall. This would prevent flow from the West Branch of the Neversink from jumping into the East Branch until the true confluence. This alternative provides localized benefit to the church hall and adjacent buildings. Flood elevations are reduced by over 1 foot in the area immediately adjacent to the channel for all storms over the 10-year. Due to the localized nature of the benefits, another option at this location would be raising church hall above flood elevation.

Figure 12 - Inundation Area during a 10 year event – Existing Conditions

Figure 13 - Inundation Area during a 10 year event – Proposed Conditions

IV.B.5 Tannery Flats



The Tannery Flats area is generally low lying and either in or immediately adjacent to the historic floodplain**.** One option that was considered at this location was to utilize existing cutoff channels to improve conveyance. This option explored enlarging one of the channels to a 50' bottom width, set at approximately the 1.25 year. A decrease in flood elevations of 0.1-0.2 feet was seen for the 50 & 100 year storms only in the vicinity of the improved channel itself. No additional benefit was observed upstream or downstream. The reason this overflow channel provides little benefit is that, during flood flows, the area at the outlet of the proposed channel is already in flood stage, and there is no place for the arriving water to go. Regardless of the size of the channel created, the conveyance through the Tannery Flats area is restricted by flooding already occurring at the downstream end of the flats.

Given the limited benefits of the first option, the preferred solution at this location would likely be elevating the first floor of the houses above the 100-year flood elevation. Some of the houses in the Tannery Flats area are located above this elevation and these houses have not experienced the damage of the houses with first floors at lower elevations. To get above the 100-year flood elevation, houses would have to be raised by approximately 1.5 feet.

IV.B.6 Hunter Road and Hunter Road Bridge

Hunter Road crosses the main stem of the Neversink River on a 196 foot long 2 span bridge, and then parallels the river through the floodplain for a distance of 1900 feet before turning west and up the valley wall. At the low point in the road, a culvert carries floodplain back-channel flows from north to south under the road in to a wetland on the south side of the road. Flood at this location resulted in a fatality in 2010 when a motorist entered the flooded roadway and was swept downstream. Our model indicates that Hunter Road is overtopped in events below the 10-year storm. Due to the volume water flowing across the floodplain, simply increasing the size of the existing culvert crossing near the spur to the covered bridge would not prevent the roadway from overtopping. To prevent roadway inundation, the roadway must be raised in excess of 3 feet in some low areas. A detailed survey of the roadway would be required to verify the quantities and locations of fill. Increasing the roadway elevation, adding a series of four 6 foot culverts and increasing the size of the existing culverts from 30 feet to 40 feet and 3feet to 10 feet could raise the road above the 100-yr flood elevation, while avoiding an increase in flood elevations upstream or downstream while. Refer to Appendix A for the reduction in water surface elevations at each of the properties impacted. The estimated project cost would be approximately $2.5M. To clarify potential regulatory limitations, impacts on protected wetlands down-valley of Hunter Road would also have to be evaluated.

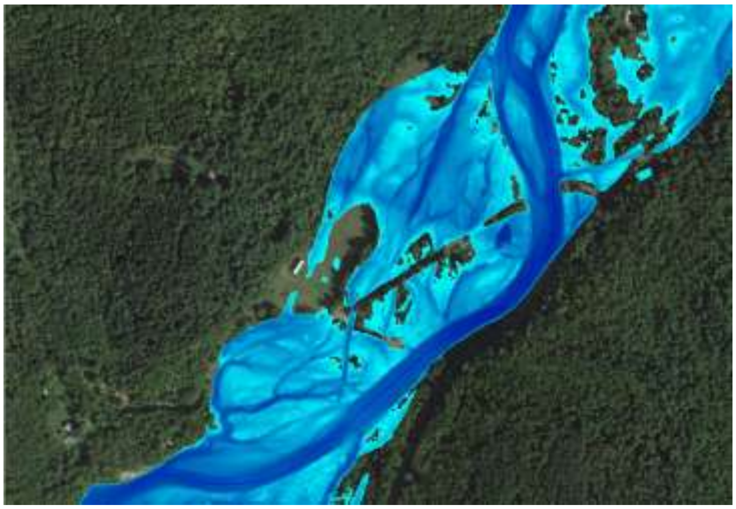


Figure 14 - Inundation Area during a 25 year event – Existing Conditions

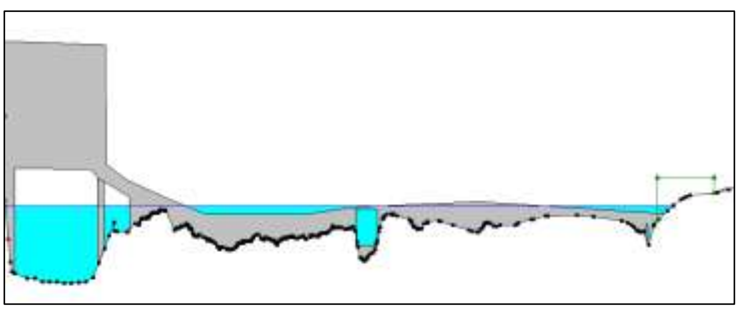


Figure 15 – Existing Road crossing showing covered bridge and 2 existing culverts

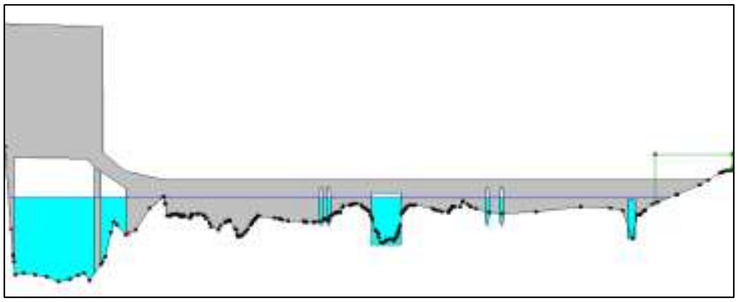


Figure 16 – Proposed raised road with additional floodplain conveyance under road

Given the magnitude of a permanent solution, the interim improvement of a warning system may be the best action to take immediately until a more permanent solution can be fully developed and implemented. This could be as simple as a traffic sign warning of potential flooding ahead or be scaled to more sophisticated systems with flashing lights triggered by water levels as they start to encroach on the roadway.

IV.B.7 Claryville Road near Hunter Road Bridge

Claryville Road just north of its intersection with Hunter Road floods during storm events. During our public outreach, the option of raising Hunter Road at this location a sufficient amount to raise it above the floodplain was suggested. In order to raise Hunter Road above the 100-year event, it would require raising the road by as much as three feet at the lowest area. Since Claryville Road is at the edge of the floodplain, raising the road had no impact on flood elevations. The limiting consideration with this alternative is the scale of the project. To accomplish the elevation goal, Claryville Road would be reconstructed for 2/3 of a mile and raised in elevation by as much as 3 feet. This would lead to Right-of-Way concerns, driveway impacts, and impacts to local drainage such as roadside ditches.

IV.B.8 Fire Hall Culvert/Hillside Runoff

Flow from the hillside behind the Claryville Fire Hall is carried by a swale through a culvert under Denning Road immediately up valley of the fire house. During Hurricane Irene, water backed up behind the culvert and overtopped Denning Road, causing damage to the fire hall. During the storm cleanup, the damaged culvert was replaced with a larger structure. This larger culvert was modeled utilizing a TR-55 and HY-8 analysis to determine if the culvert was still undersized. The current culvert was shown to have adequate capacity to prevent overtopping of the road and meets all NYSDOT requirements for culverts. Therefore no further modifications are proposed at this location.

IV.B.9 Bungalow Brook at Claryville Road

Flooding has been observed by the community at the location where Bungalow Brook crosses through a culvert under Claryville Road. The flooding in the Bungalow Brook area appears to be caused by flow from Bungalow Brook backing up at Claryville Road. A TR 55 analysis of flood discharges at Bungalow Brook was completed to determine peak flows:

2-year	328 cfs
10-year	859 cfs
50-year	1308 cfs
100-year	1620 cfs

A HY-8 culvert analysis was run on the current capacity of the culvert which is approximately 4feet high x 20 feet wide. The original structure is closer to a 5foot high opening, but has filled in with sediment restricting the effective opening. In its current state, the roadway is overtopped by approximately 1foot during a 50-year storm. A proposed crossing would have to be approximately 5feet by 45feet to prevent overtopping during a 50-year storm. This analysis did not evaluate the role of bank erosion observed upstream. Sediment from this bank erosion is being deposited at and under the bridge in part due to the dramatic change in stream slope immediately upstream of the bridge. Without further investigation into increasing the sediment transport capacity of the channel to the downstream end of Claryville Road through careful modification of the stream gradient, the stream is likely to continue to aggrade at the culvert and restrict the opening. A more sustainable long-term solution would likely involve increasing the size of the bridge, bank stabilization upstream, as well as modification of channel gradient in order to maintain adequate sediment transport through the culvert and receiving downstream reaches.

IV.B.10 Debris Blockage at Bridges

A general comment was made during the public meetings regarding the presence of debris in the channel obstructing flow, particularly at bridges. To present a representative model of the effects of debris obstructions at bridges, the bridge downstream of the private dam near Red H~~M~~ill Road was modeled both with and without an obstruction. The representative blockage obstructed approximately 35% of the bridge opening. This blockage increases water surface elevations upstream of the bridge by 9 inches for the 2-year storm, and 6 inches for the 100-year storm. The impact carries up to 800 feet upstream of the bridge for the 100-year storm. The results will be similar at any bridge throughout the model. Implementing a program to remove debris at bridges after a storm event will increase capacity of the channel and reduce the risk for localized flooding.

IV.B.11 Aggradation/Degradation

The sediment transport analysis completed for the project area supported the local consensus that the river is aggrading. During the field reconnaissance, data was collected at 21 sites throughout the East Branch and Main Stem of the Neversink River. Of these 21 sections, 14 (or two thirds) of the sections were aggrading or experiencing deposition. Aggradation is typically the result of over-widened channel conditions or excess sediment supply coming from eroding streambanks upstream. The key to minimizing the deposition is to restore a stable river section to a state that is capable of conveying the appropriate amount of material downstream. In order to accomplish this throughout the corridor, efforts will be made to minimize erosion at streambanks, hillslopes and other sediment sources as well as reshaping the channel form utilizing natural channel design to establish stable sections. The concept of aggradation/degradation was not looked at as a particular alternative to pursue, but rather ~~a concept~~to better understand factors of aggrading and degrading conditions in the stream. This can aid ~~intended for incorporation into all~~when designings ~~and~~ projects throughout the watershed ~~in order~~intended to stabilize the streams and provide improved flood conveyance. The data collected as part of this study in combination with the hydraulic model are key tools to providing the foundation needed to support designs for these types of projects.

Figure 17 – Example Aggrading Section at Station 20+00

Figure 18 – Example Aggrading Section at Station 127+00

Independent of the LFA, the NYCDEP and Rondout Neversink Stream Management Program hasve performed a streambank inventory through the project reaches as well as upstream. This inventory will be used to develop a list of priority bank stabilization projects for the Stream Management Program to address this issue.

V. Benefit-Cost Analysis

A benefit-cost analysis was completed on six of the eleven areas of interest mentioned above. For each of the areas, a project cost was developed and compared to the benefits of the project. The benefits include maintenance of emergency facilities, reduction in flooding at residences, property damage, and loss of life. Each of the Alternatives is summarized below.

V.B.1 Denning Road Dam near Red Hill Road

The removal of the Denning Road Dam near Red Hill Road did not provide wide spread benefits throughout the project area, but it does provide flood reduction benefits to three residences at a relatively low cost. The BCR for this project is 1.55.

Summary

Total Project Cost	$97,000
Service Life	50 years
Total Benefits	$150,249
BCR	1.55

V.B.2 "Double Bridge" at Town Hall

The project proposed at the bridge near the Denning Town Hall is a large multifaceted project that includes a new bridge crossing, the creating of flood plain, stabilization of a failed slope, and the relocation of Denning Town Hall. The large capital cost of the project is difficult to overcome within the BCA evaluation. The BCR for this project is 0.19.

<u>Summary</u>

Total Project Cost	$1,750,000
Bridge Crossing	$1,000,000
Floodplain	$300,000
Slope Stabilization	$200,000
Town Hall Relocation	$250,000
Service Life	50 years
Total Benefits	$339,277
BCR	0.19

V.B.3 DOT Stacked Stone Wall DS of County Line/"Wellington Site"

The restoration of the stream channel utilizing natural stream channel design will provide a balanced and stable stream at this location protecting the stacked stone wall and the County Road it supports. The number of residences directly affected is small and the large capital cost of the project is difficult to overcome within the BCA evaluation. The BCR for this project is 0.09.

<u>Summary</u>

Total Project Cost	$1,500,000
Service Life	50 years
Total Benefits	$133,314
BCR	0.09

V.B.4 Church Hall/Downstream of Frost Valley Bridge

The construction of a structure to separate the West Branch from the East Branch at this location would cost in access of $500,000. Since this is more than the value of the Church Hall, by inspection the BCA cannot be above 1 and the BCA analysis was not run. The more realistic approach at this site would be to raise the first floor of the Church above the base flood elevation. The BCR for raising the Church Hall above the Base Flood Elevation is 0.38.

Summary

Total Project Cost	$150,000
Service Life	50 years
Total Benefits	$57,285
BCR	0.38

V.B.5 Tannery Flats

The Tannery Flats area requires approximately 10that structures in the 100-year floodplain be raised so that the first floor elevation is above the base flood elevation. The houses structures can be raised individually or part of a unified project. The BCA analysis is approximately the same for one house as it is for all of the houses. This is The BCR for this project is 1.44.

Summary (per house average)

Total Project Cost	$50,000
Service Life	50 years
Total Benefits	$72,078
BCR	1.44

V.B.6 Hunter Road and Hunter Road Bridge

The Hunter Road site consists of two potential projects. The first is a large capital investment to raise Hunter Road above the flood elevation and replace both culverts as part of the reconstruction. The capital investment is substantial, but the documented loss of life at this location is evaluated as a large benefit. The BCR for the large project is 0.70.

Summary

Total Project Cost	$1,600,000
Service Life	50 years
Total Benefits	$1,121,044
BCR	0.70

A second smaller project consists of installing a warning system to alert drivers when the road is inundated. The cost of this project is relatively low compare due to the benefit. The BCR is 12.85.

Summary

Total Project Cost	$10,000
Service Life	25 years
Total Benefits	$156,501
BCR	12.85

V.B.7 Claryville Road near Hunter Road Bridge

This project consists of raising Claryville Road north of the Hunter Road intersection to prevent overtopping during a storm event. The alternative does not provide any direct benefit to any residence, and there is no documented loss of life. The roadway begin overtopped would restrict emergency vehicle access through this portion of Claryville Road. According to the model, Claryville Road is flooded at the location during a 25 year events. Similarly Denning Road to the north of Claryville is inundated between the 10 and 25 year events. While these routes are restricted, emergency egress is maintained to Claryville via Frost Valley Road. Frost Valley Road within the limits of the model is not overtopped during a 100-year event. With the high capital cost associated with this project, by inspection the BCA cannot be above 1 and the BCA analysis was not run.

V.B.8 Fire Hall Culvert/Hillside Runoff

The culvert was replaced at this site following Irene and no further work is necessary at this site.

V.B.9 Bungalow Brook at Claryville Road

The Bungalow Brook culvert at Claryville Road has been identified as undersized. Proposed measures to reduce flood impacts at this location would include culvert replacement, stabilization of upstream sediment sources (primarily eroding stream banks) and restoration / modification of approximately 400 linear feet of Bungalow Brook to accommodate adequate sediment transport and reduce the risk of culvert obstruction during flood conditions. The benefits include reducing the potential for damage to the two local residents downstream and preventing Claryville Road from being overtopped.

The BCR for the large project is 0.53.

Summary

Total Project Cost	$274,000
Service Life	50 years
Total Benefits	$146,206
BCR	0.53

V.B.10 Debris Blockage at Bridges

Debris blockage at bridges in general was proven to have a negative impact on flooding, especially immediately upstream of the bridges themselves. The concept of removing the debris at bridges should be pursued as a standing post-flood response protocol. The development of specific guidelines outlining when and how the debris should be removed would provide a program that the local highway departments could follow in the wake of a storm.

V.B.11 Aggradation/Degradation

The sediment transport evaluation completed as part of this study provides valuable proof to the perception that the stream is aggrading in a number of locations. No particular project is proposed that explicitly addresses this concern that can be evaluated in the BCA tool. More importantly, all project progress in the drainage basin should be considered with regard to sediment transport concepts and the long term benefits this will have on the basin. Aggradation is typically the result of both post-flood channel widening without regard to naturally stable channel dimensions, and of excess sediment supply from the watershed, which is itself often the result of poor channel and floodplain management practices. The more projects that progress with these concepts in mind, the more stable the stream will become and consequently the more sustainable all of the projects, past or future, will be.

VI. Additional Recommendations

These recommendations are provided to the Denning Neversink Flood Advisory Committee for further consideration.

- Developing an early warning system through a reverse 911 system or similar could be investigated to provide more advanced notice to residents in the event of a flood.
- Fuel tanks throughout the Towns can be elevated above flood stage and anchored to prevent movement or spilling during a flood.
- The advanced warning system suggested for Hunter Road could be pursued for other areas to warn motorists of locally flooded road conditions.
- Investigate the development a Town-wide database of storm damage that could be updated after every storm. This would provide useful data when determining which future projects to pursue; and help in gathering data for grant applications that require Benefit Cost Ratios. The database should include Base Flood elevations at each residence to accompany damage values.
- Implement a program to fund stabilization materials (rock of various sizes, sections of corrugated culvert) to be used for roadway protection during emergency response immediately following a flood.

VII. Summary of Findings

The LFA process provides Claryville and the residents throughout the project area with a valuable tool to make informed decisions within the watershed moving forward. This document is a useful tool that will continue to evolve as projects are completed or as future projects arise. The HEC-RAS model developed for this study is available for future use to evaluate any potential project. Several of the projects proposed in this study are large capital projects that don't ~~produc~~ produce enough benefit to offset their large capital investment, while others are smaller, localized projects where the benefit better suits the expenditure. Only inundation hazards were evaluated as part of this study; where additional flood hazards due to bank erosion have created costs to infrastructure and/or have produced significant negative water quality impacts, these more expensive projects may rise to a priority level that warrants their progression in the future. Three projects were identified as having BCR ratios above 1.0. The potential projects are listed below beginning with the highest BCA.

Project Description	Capital Cost	BCR
Flood Warning System on Hunter Road	$10,000	12.85
Remove Dam near Denning Road	$97,000	1.55
Raise Tannery Flats Houses	$50,000 (per house)	1.44
Hunter Road and Hunter Road Bridge	$1,600,000	0.70
Bungalow Brook at Claryville Road	$274,000	0.53
Church Hall/Downstream of Frost Valley Bridge	$150,000	0.38
"Double Bridge" at Town Hall	$1,750,000	0.19
DOT Stacked Stone Wall/Wellington Site	$1,500,000	0.09

BCAs for the individual mitigation projects evaluated in this study could change as a result of accumulating damages from future floods, as additional knowledge of historical damages comes to light, or as the result of adjustments in the estimated cost of projects. Furthermore, where additional benefits of potential mitigation projects are identified, funding sources other than those dedicated solely to mitigation of inundation risks to public and private property may be identified that make some of these projects feasible.

In addition to the three projects highlighted above, the Denning Neversink Flood Advisory Committee can pursue other forms of advance warning systems to alert residents and motorists during a flood. Fuel tanks can be secured and other sources of water pollution relocated or reinforced to prevent spills during a flood event.

Action Items:

- ***Fuel tanks can be secured and other sources of water pollution relocated or reinforced to prevent spills during a flood event.***
- ***Implement flooded road warning sign at Hunter Road***
- ***Review Town Building Codes/Floodplain Management***
- ***Investigate further the project at Wellington/DOT Wall***
- ***Identify/Prioritize sediment sources upstream***
- ***Investigate further the project at Bungalow Brook***
- ***Increase documentation of damage and flood elevations during flood events***
- ***Capture the first flood elevation of all relevant structures in the 100-year floodplain as baseline data for potential elevation***
- ***Increase size of Hunter Road culverts as they are replaced***

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APPENDIX A

Property Impact Summary Table

APPENDIX B

HEC-RAS Results

APPENDIX C

Sediment Transport Results

APPENDIX D

General Stream Management Recommendations

Stream Management Program Recommendations

The LFA process highlighted many of the general recommendatiions adopted by Denning and Neversink in their Rondout and Neversink Stream Management Plans. These sections are included here because they describe comprehensive solutions that serve both the Towns of Denning and Neversink and the target audiences of the Rondout and Neversink watersheds.

Flood Protection

The impact of floods on private property, public infrastructure and the quality of life have historically been a primary concern of many watershed stakeholders and continues today, as indicated by the Streamside Landowner Survey (Gilmour 2009). Though the valley is highly prone to flood events due to its local climate, topography and geology, stakeholders can work proactively to reduce or prevent some of their impacts. Flood-related damages and recovery expenses strain local resources and disrupt the fragile economy of the community. The recommendations in the following section represent on-going projects and proposed initiatives which could be implemented to reduce flood impacts.

Selective Stream Gravel Management

Recommended: that an independent stream scientist is funded to create a guidance document with recommendation on how, when and where to scientifically manage problematic gravel deposits with the Rondout Creek watershed.

Notes: Numerous concerns have been expressed regarding current policies and regulations restricting gravel removal. It is the Stream Management Program's role to investigate these issues by advancing discussion with the appropriate regulatory agencies.

Debris Management

Recommended: that a protocol be developed for the inventory of floodplain debris and assistance to municipalities and communities in debris management.

Notes: Develop protocol to ensure responsible floodplain management, including annual clean-up efforts, prevention of illegal dumping, and flood event debris management. ~~The Program Team may need to explore issues of landowner liability for managing large woody debris.~~ Removal of large woody debris would focus on areas that pose a flood hazard to infrastructure and a threat to human welfare.

Post-Flood Technical Assistance

Recommended: to work cooperatively on improving immediate post-flood emergency intervention capabilities through demonstration and training with contractors and local municipalities in scientifically-based stream principles, procedures and methods.

Notes In many areas post-flood work unravels stream systems more than any other non-flood work combined. Using Delaware County SWCD's contractor training workshop as a model, provide local contractors and highway superintendents with training on regional hydraulic relationship curves, natural stream restoration principles and techniques, and identifying best management post-flood intervention techniques.

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Highway Activities and Infrastructure for Water Quality Improvement

Recommended: that the Town and County Highway Departments and NYSDOT integrate geomorphology principles in all new projects and routine maintenance activities related to the Rondout Creek stream system.

Notes: Road/drainage infrastructure improvements are of particular interest to respondents of the Streamside Landowner Survey (Gilmour 2009). Activities related to maintenance of highway infrastructure accounts for the vast majority of stream management activities. Highway activities including maintenance, new construction and flood response, can greatly benefit from consideration of stream process. One possible area for collaboration is the creation of a protocol to evaluate existing culverts and bridges following geomorphic principles, and working together to prioritize and design culverts for retrofitting and replacement where necessary.

Stream Stability Restoration

Recommended: Secure funding commitments for additional unfunded restoration projects on the Rondout Creek as discussed in individual management segments.

Notes: In this Plan, the Project Team identified a number of reaches which are strongly recommended for restoration. Additional restoration sites should be prioritized, ranked and continuing funding sought.

Historic & Current Condition Analysis & Documentation

Recommended: that historical records for precipitation metrics be analyzed so current trends in precipitation amount, intensity, timing of snowmelt and other forces potentially affecting flood frequency and stream flow response can be shared with planners seeking to mitigate their effects.

Flood Response Technical Resources

Recommended: that trained professionals be identified to provide onsite guidance for stream modifications immediately following flooding. Guidelines that integrate stream form and function should be developed for use during post flood response.

Notes: The existing approach to flood management of patching flood damage without stream process knowledge wastes limited funding, may leave localities more vulnerable to future floods and may create liability for already devastated communities. Guidelines for work on flood damaged with minimal stream disturbance would greatly reduce risk of further instability. Stream professionals from Sullivan County Soil & Water Conservation District can provide for rapid and coordinated expert review and guidance on a regional basis during planning, funding, permitting and construction phases of flood remediation.

Flood Damage Prevention Library

Recommended: that the Program Team develop a "one stop shop" for public distribution of National Flood Insurance Program publications; and that an annual notice be published in local newspapers providing notification about the availability of this flood damage prevention library.

Notes: FEMA, the National Association of Floodplain Managers and others have developed extensive materials to assist watershed stakeholders in making sound development decisions related to flooding and flood damage prevention.

Flood Ordinance Review

Recommended: that the Towns of Denning and Neversink conduct a review of current floodplain ordinances and consider adopting revisions that integrate broader community plans, reflect current building codes. It is also recommended that the Towns of Denning and Neversink acquire and utilize geographic information system (GIS) software to assist with floodplain mapping.

Notes: The Sullivan and Ulster County Soil and Water Conservation Districts can provide technical and administrative support to the review process in consultation with NYSDEC and the Sullivan and Ulster County Planning departments respectively.

Community Rating System

Recommended: that the Towns of Denning and Neversink consider participation in the FEMA Community Rating System.

Notes: Municipalities may be able to reduce flood insurance premium rates under the Community Rating System. The Municipalities are strongly encouraged to adopt a "No Rise/Good Neighbor" clause in their revised floodplain ordinance. A "No Rise/Good Neighbor" clause would ~~charge~~ enable townships to develop codes which would prevent new construction from causing a rise in floodwaters.

Notification

Recommended: that the Towns of Neversink and Denning facilitate periodic notification to landowners who have special flood hazard areas (SFHA) located on their property.

Notes: Recent digitization of the real property tax parcels in the NYC watershed, and the development of digital flood maps by NYSDEC can be integrated into a database which would allow for notification of landowners regarding the presence of SFHA on or near their property or business. The database can be used to develop a mailing list of properties with a SFHA present, and periodically a direct mailing can be made to each property owner.

Flood Hazard Education Sessions

Recommended: that the Towns of Denning and Neversink, working with local and state agencies, support periodic training sessions on flood related issues; and that the audience include municipal leaders, code enforcement staff, planning boards, landowners, realtors, lending institutions and others.

Notes: Knowing how to properly manage floodplains is crucial to continued safety and economic sustainability. NYSDEC and the New York State Department of State (NYSDOS) have established education programs geared to local municipalities. Better understanding of flood damage potential, stormwater implications, the NFIP, and use of Federal Insurance Rate Maps will empower local officials to make informed decisions.

Flood Damage Database

Recommended: that the Towns of Denning and Neversink facilitate development of a flood damage reporting system to track types of flooding, their location and the costs associated with flood damage.

Notes: Initially, a database would collect overall records on past floods; then localized flooding occurrences and damages could be documented. Areas with repetitive damage can be prioritized for mitigation because this cumulative cost damage data provides justification for mitigation grant program funding. Training and administrative support would ensure success.