TOWN OF OLIVE LOCAL FLOOD ANALYSIS

FLOOD ENGINEERING ANALYSIS REPORT
HAMLETS OF BOICEVILLE AND WEST SHOKAN
TOWN OF OLIVE
ULSTER COUNTY, NEW YORK

Prepared for:

Cornell Cooperative Extension of Ulster County
3130 Route 28
Shokan, NY 12481

For the Town of Olive, NY

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Letter From the Town of Olive's Local Flood Advisory Committee

Dear Reader,

On June 10, 2014 the Olive Town Board established the Flood Advisory Committee (FAC) to produce a Flood Mitigation Plan for the Town. A first step in recommending priority strategies and actions for Olive was to conduct Local Flood Analysis, which was made possible with funding from the Ashokan Watershed Stream Management Program.

To that end, the Committee followed several key values while finding solutions to reduce or remove flood hazards. Solutions must be:

- cost-effective for the Town to build and to maintain
- cost-effective for individuals and businesses directly involved
- maintain, as much as possible, the sense of community and the "flavor" of our business and residential areas
- reviewed in public meetings and be accepted by the community as realistic and desirable
- thoroughly researched and analyzed with proper engineering methods and professional expertise
- implemented with care and economy by professionals experienced in flood hazard mitigation following permitted town-approved plans
- protect our natural resources, especially the streams and wildlife.

Best Regards,

The Town Of Olive Flood Advisory Committee

Table of Contents

1.0 Executive Summary

The Town of Olive has experienced three 3 major flooding events within the last twenty years, the most severe and recent being Hurricane Irene in 2011. These floods have caused significant property loss and severely disrupted community life. This Local Flood Analysis report is the first step in identifying what could be done to reduce or remove causes of flooding and calculate a general cost of the most acceptable solutions. It will be used to inform the residents of the Town of Olive, to guide decision-making by the town, and to provide essential data for projects in the future.

The audience for this analysis includes officials of the Town of Olive, future consultants, future funding agencies, contractors for mitigation projects, and the residents of the town.

The expected outcome of the Town of Olive's Local Flood Analysis (LFA) is an understanding of flooding hazards within the Town's population centers of Boiceville and West Shokan and to identify the highest priority flood mitigation solutions for these hazards. This understanding is captured in the Local Flood Analysis report (LFA) and the solutions presented in the LFA were driven by the Town's Flood Advisory Committee's (FAC) decisions on recommendations developed using engineering and geomorphic technical analyses. These solutions were then vetted by the FAC, the Town Board and the community using each solution's benefit to cost ratio, impact to the community's character, influence on existing and future economic opportunities and public safety as prioritization metrics.

The LFA is a standalone report that summarizes all of the work undertaken to identify and prioritize flood mitigation solutions as part of the Town's LFA. The community will use the LFA to select the mitigation solutions that will be implemented and identify strategies to move these solutions forward (funding, planning documents, etc.)

The Boiceville Study Area and West Shokan Study Area were the two areas within the Town of Olive that were studied in the LFA and in these two study areas, a total of sixteen (16) flooding hazards were characterized and thirteen (13) mitigation solutions were developed.

In the Boiceville Study Area, seventeen (17) buildings are prone to flooding at moderately occurring flood events (25-year return interval flood). Various mitigation scenarios were evaluated with the proposed three arch Route 28A bridge in place to protect these buildings. The community must decide if: they want to do nothing, protect their community in place or begin moving buildings out of flood prone area. The "do nothing approach" leaves these buildings exposed to future flooding and high flood insurance premiums which suppress the building's property values. Protecting the buildings in place will require significant annual costs to be paid by the Town. Relocating buildings out of the flood prone area will change the character of Boiceville. In the West Shokan Study Area, no flood inundation hazards were found under clear water conditions (i.e. no obstructions) or during obstructed conditions. However, there are several locations where erosion hazards will lead to significant road and bridge closures and major impediments to emergency response times. The erosion hazard condition at the Watson Hollow Bridge should be addressed immediately as well as the failing road embankment along Watson Hollow Road downstream of the bridge. Permanent monitoring stations are recommended to be established at areas sensitive to obstructions that could exacerbate existing erosive conditions.

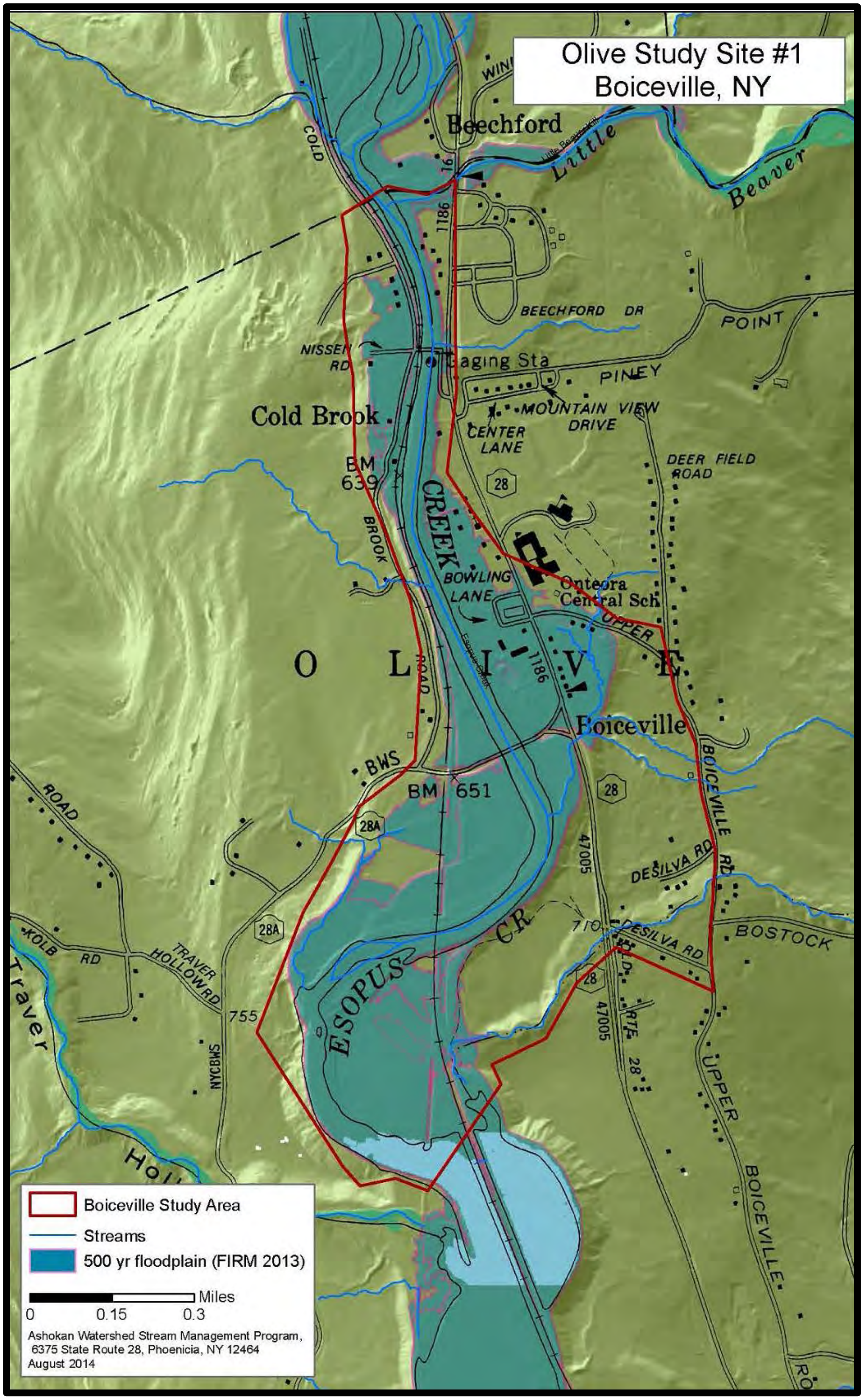
2.0 Statement of Purpose and Scope

Major floods have become more frequent, and government resources for recovery have decreased. These floods have caused significant property loss and severely disrupted community life. While a single property owner cannot take on the tasks necessary to reduce or remove flood hazards of this magnitude, the Town can.

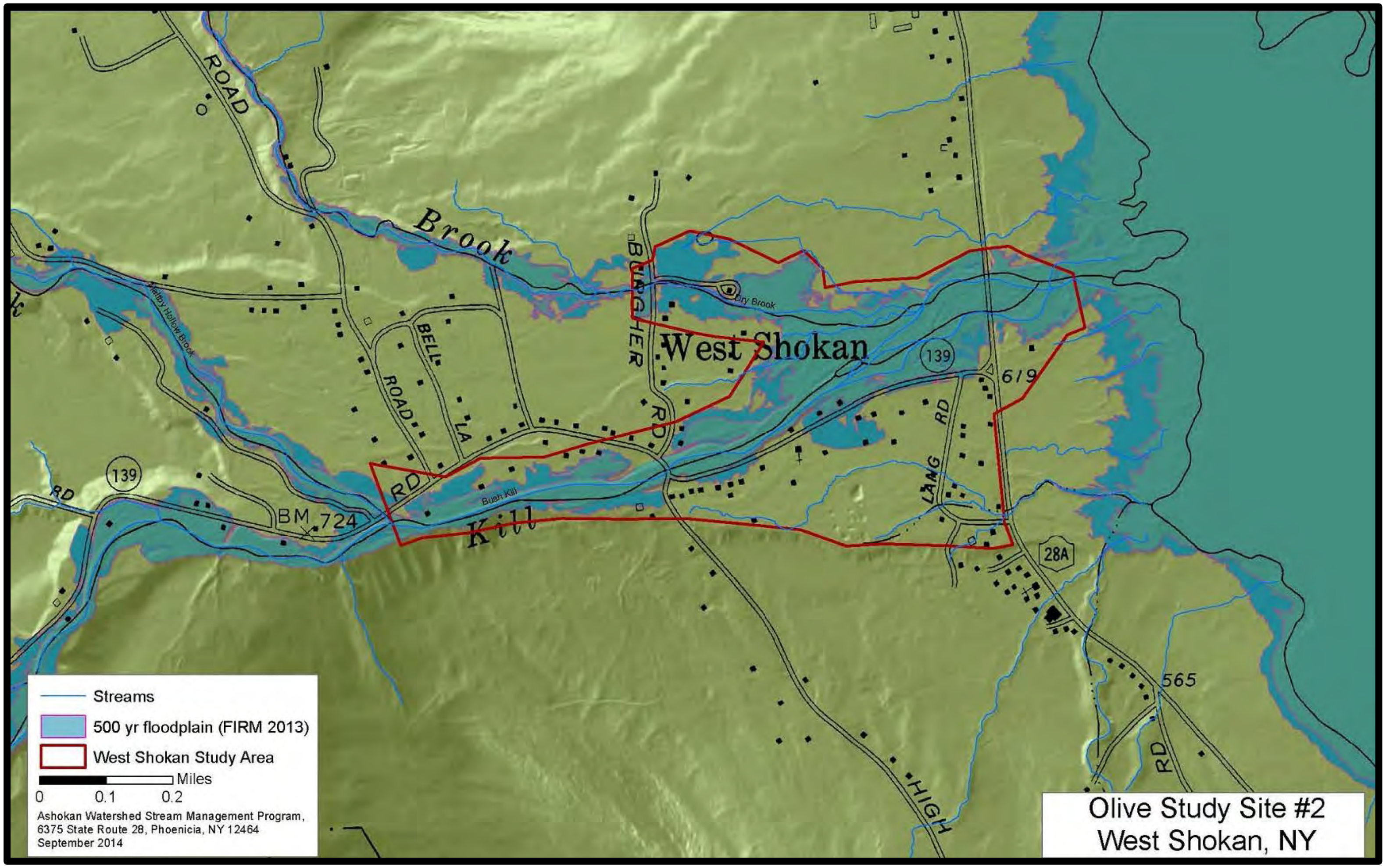
The primary concerns that are driving this project are:

- Concern for the safety of Town residents and visitors
- Repeated damage to buildings and public infrastructure
- Disruption of community life during repairs and clean-up
- Increasing cost of flood insurance (required by mortgage lenders) that becomes an economic burden on our local citizens, reducing property values and driving some businesses to close
- Continued damage to natural resources, especially stream banks and beds.

The two study areas for the Town of Olive's LFA are in the Boiceville hamlet (referred to as the Boiceville Study Area) and the second area in the West Shokan hamlet (referred to as the West Shokan Study Area). The Boiceville Study Area extends from the Town Boundary to approximately 2.3 river miles downstream on Esopus Creek, which is approximately 1.2 miles downstream of the Route 28A Bridge near the Esopus-Ashokan Reservoir confluence.


Olive Study Site #1
Boiceville, NY
Beechford
Little
Beaver
BEECHFORD DR
POINT
NISSEN RD
Gaging Sta
PINEY
Cold Brook
MOUNTAIN VIEW DRIVE
CENTER LANE
DEER FIELD ROAD
BM 639
CREEK
BROOK
BOWLING LANE
Onteora Central Sch
UPPER
O L I V E
Boiceville
BWS
BM 651
BOICEVILLE RD
DESILVA RD
ESOPUS CR
BOSTOCK
KOLB RD
TRAVER HOLLOW RD
Traver
755
NYCBWS
UPPER BOICEVILLE
Boiceville Study Area
Streams
500 yr floodplain (FIRM 2013)
Miles
0 0.15 0.3
Ashokan Watershed Stream Management Program,
6375 State Route 28, Phoenicia, NY 12464
August 2014

The West Shokan Study Area extends approximately 1.2 miles upstream of the Bushkill-Ashokan Reservoir confluence to the confluence with Maltby Hollow Brook on the Bushkill, and on Dry Brook, from its confluence with the Bushkill to approximately 0.7 miles upstream of the confluence.



Both study areas are located within the New York City Department of Environmental Protection (DEP) Ashokan Reservoir's watershed. Since DEP provides drinking water to New York City, the incoming water quality to the Ashokan Reservoir is an important management strategy. Both study areas are located in an area with a town-adopted Stream Management Plan (SMP) (CCEUC 2007). The SMP is a managerial document that guides water quality preservation and enhancement. There are five long term goals of an SMP: Flooding and Erosion, Water Quality, Aquatic Ecology, Recreation and Management Coordination). The SMP includes a physical assessment to provide a baseline characterization of the watershed which will inform improvements of these goal areas. The LFA utilized the SMP's data and management strategies while developing LFA solutions to ensure continuity between the two management plans.

3.0 Local Flood Analysis Methodology Summary

Flood hazard mitigation strategies for the Town of Olive were developed from an adapted methodology presented in the Local Flood Analysis's Scope of Work. This protocol included collecting existing electronic and hard copy data from town, county, state and federal governments to characterize the causes of flooding in the Town. If this information was insufficient, then a Data Gap Analysis was completed that provided recommendations of what and how additional information should be collected in order to explain the Town's flooding hazards. These recommendations were presented to the Flood Advisory Committee (FAC) for approval. The FAC is a group of individuals, appointed by the Olive Town Board with technical advisors from the Ashokan Watershed Stream Management Program, the Catskill Watershed Corporation, NYC Department of Environmental Protection and NYS Department of Conservation. The FAC's purpose is to act as a representation of the community and involved agencies to discuss, vet and approve of flood mitigation solutions.

Next, a series of existing hydraulic modeling runs were completed to identify flood hazards. There were two categories of flood hazards that were identified in this LFA. The first is an inundation flood hazard where flood waters submerge important areas to the community. The second hazard category are areas sensitive to floodwater obstructions that could worsen flood conditions. These areas were referred to as flood debris hazards. Once an initial round of modeling runs was completed, the results were presented to the FAC and the Town of Olive Board. During these presentations, additional areas important to the community were identified and information about historical flooding damage was collected.

Over the course of several meetings, preliminary flood mitigation strategies were developed. These strategies were hydraulically modeled to understand their efficacy (benefits) in reducing or eliminating flood hazards. If a strategy was beneficial and realistic, the cost of implementing it was estimated. The mitigation strategies and their preliminary benefit to cost ratios (BCR) were presented to the FAC to understand if the community would consider their implementation. Then, using preliminary BCR's and other prioritization metrics, the mitigation strategies were ranked and the strategies most feasible to the FAC were selected to be further analyzed for implementation. The most feasible implementation strategies are presented in the Local Flood Analysis report along with their supporting prioritization metrics. The LFA has identified the highest priority strategies that have formed the Town's road map for flood resiliency.

3.1 Data Gap Analysis Summary and Purpose

Data was collected during the "windshield site visit" in April 2015 and from soliciting several data sources. Collected data can be seen in Appendix Figure A-1. This is considered "existing" data. The goal of collecting existing data was to be able to sufficiently characterize flooding hazards in the LFA boundary without the need of more detailed field surveys which could be time consuming. The data was categorized into four main subjects for each study area and are as follows:

- Watershed characteristics that influence flood hazards and water quality
- Hydrology and hydraulic models
- Known flooding hazards in the study areas
- Existing flood related ordinances and town plans

Next a Data Gap Analysis was completed on the existing data to identify preliminary flooding hazards. Preliminary flooding hazards include areas that are inundated by floodwaters up to a 500-year return interval flood (500-year). Preliminary flooding hazards also include locations where high water velocities destabilize streambanks or streambeds, causing debris to enter the water body that create or worsen flooding hazards downstream. These flooding hazards were referred to as "preliminary" because it was unknown at the time if these hazards were important to the community and therefore warranted further analysis.

Using computer programs HEC-RAS (version 4.1.0, RAS) and ArcGIS (version 10.1), the location of preliminary flooding hazards were identified in the two Study Areas and placed on maps. The Flood Advisory Committee (FAC) flooding hazards and public flooding hazards were digitized using ArcGIS and placed on the preliminary flooding hazard maps allowing for their location to be compared. If a FAC flooding hazard or a public flooding hazard were in the same location as a preliminary flooding hazard then the flooding hazard was deemed important to the community and therefore warranted further analysis. Also, if a FAC flooding hazard or a public flooding hazard were in the same location as a preliminary flooding hazard it meant there was sufficient data to satisfactorily characterize the hazard using only existing data. If the FAC or public flood hazards could not be satisfactorily explained then there was a "gap" in the existing data. These gaps were filled using field collected data or subsequent requests of information from the FAC or the public.

3.2 Data Gap Analysis Approach

The Data Gap Analysis used a series of geomorphic assessments, hydraulic modeling runs and public meetings to characterize the flooding hazards within the LFA boundary.

Rapid Geomorphic Assessment

A Terrace and Floodplain Terrain (TAFT) map was created for the assessment to understand the relationship between the rivers' (Esopus Creek, Bushkill and Dry Brook) and their floodplains within and proximal to the Study Area. The relationship between stream and floodplain is often used to identify reach-based causes of potential flood hazards. A "reach" is a term that describes a certain section of a river; therefore reach-based hazards are caused by the condition of the river upstream or downstream of the hazard location. Three common conditions that cause reach-based hazards are listed below.

1. A river's ability to flood into proximal terrestrial areas (floodplain) which causes flood inundation hazards if there is infrastructure within this area.

2. The geomorphic successional stage of a water body (a surrogate for stream stability) which can be used to identify reach-based causes of erosion hazards.

3. A river's historic and future channel migration patterns which can predict reach-based causes of erosion hazards if the river's alignment is moving towards sensitive areas.

A TAFT map (Figure 1) is created by developing a vertical datum of the average daily water surface elevation (ADWSE) profile through a study area. Next, this vertical datum is subtracted from the digital terrain model (DTM) of the surrounding land forms. The resultant datum is divided into intervals usually defined by flood water depths above the ADWSE (i.e. the water depth above the ADWSE during a 2-year return interval flood, 10-year return interval flood, etc.). These intervals show the location and size of the approximate 2-year floodplain, 10-year floodplain, etc. on one map.

The TAFT map can also be used as a guide to mitigate future flood hazards by restricting development in low lying floodplain areas. By keeping these areas clear of buildings or other sensitive infrastructure, rivers can naturally migrate into low lying floodplains or send floodwaters into these areas thereby avoiding hazards to existing buildings, roads, and bridges.

Existing Stream Feature Inventory (SFI) Data Collection and Review

SFI data characterizes streams and rivers in the Stream Management Plan for each study area. Data was collected by the Ashokan Stream Management Program in the field using GPS equipment and a GIS database. SFI data was used to characterize the following information pertinent to the LFA: stream stability, location of the water pollution sources, debris jams, obstructions and bridge/culvert crossings.

FAC Meetings and Public Meeting Data Collection

The first public FAC meeting was held on April 14th, 2015. Maps of the study area were printed to allow participants to identify flood locations in the Study Area. Tables were also created that were used to collect the following information: hazard type, frequency of hazard occurrence and the hazard's impact to the participant and the hazard's impact to the community. This information was then supplemented with additional hazard information collected during a subsequent FAC meeting. There were a total of 52 submitted hazards. The hazards were then reviewed to understand their cause and character. Typically, flooding hazards fall into one of the following groups.

- **Riverine Flood Hazard:** A location where overflow from a river, stream or creek channel (damages assets and often results in a federal disaster declaration. This type of flooding generally occurs more than six hours after peak rainfall.

- **Flash Flood Hazard:** A location where a rapid and extreme flow of high water overflows from a river, stream or creek channel into a normally dry area beginning within six hours of an intense rainfall event. Ongoing flooding can intensify to flash flooding in cases where intense rainfall results in a rapid surge of rising flood waters i.e. a minor flooding event rapidly becomes a larger flooding event after another burst of intense rain.

- **Stormwater Flood Hazard:** A location where damage to asset occurs resulting from insufficient capacity of private or municipal stormwater drainage infrastructure. This includes ditches, catch basins and piping systems.

- **Debris Jam Flood Hazard:** A location where damage to assets occurs resulting from flooding or erosion that is caused by debris reducing the capacity of water corridors, bridges, culverts or stormwater drainage infrastructure. Debris can be wood, bedload (stones moved by water in streams) or manmade (sofas, car parts).

- **Erosion Hazard:** Eroding Banks that threaten public or private infrastructure. Threatened infrastructure is near an actively eroding bank (notable movement of bank over the last five years) and the rate of erosion could threaten infrastructure within the next five years.

- **Ice-Jam Flood Hazard:** A location where damage to assets occur resulting from flooding or erosion caused by ice jams. An ice jam is an accumulation of ice that acts as a natural dam and restricts flow of a body of water. Ice jams may build up to a thickness great enough to raise the water level and cause flooding.

- **High Groundwater Level Flood Hazard:** An area where damage occurs in areas not connected to recognizable drainage channels. Through a combination of infiltration and surface runoff (sheet flow) water may accumulate and cause flooding problems generally in concave basins.

- **Unknown Flooding Hazard:** The cause of flooding is not known.

Existing Hydraulic and Hydrologic Model Data Collection and Review

The Flood Insurance Study (FIS) (FEMA (1) 2013) for Ulster County was revised in December 2013. The revisions included an updated hydrologic and hydraulic study for the Ashokan Reservoir watershed. Hydrologic (HEC-HMS) and hydraulic (HEC-RAS) models were developed as part of the FIS revision in order to update the Federal Emergency Management Agencies (FEMA) Flood Insurance Rate Maps (FIRM) for the Ashokan Reservoir watershed. The modeling efforts were contracted through FEMA and supported by DEP (FEMA contract # HSFEHQ-09-D-0369).

The two LFA Study Areas are located within the updated FEMA modeled Ashokan Reservoir watershed and the pertinent electronic hydraulic models (HEC-RAS version 4.1) were obtained. The models and their supporting reports were reviewed. Two hydraulic models were developed for the West Shokan Study Area and one hydraulic model for the Boiceville Study Area. The first West Shokan Study Area model starts at the Bushkill-Ashokan Reservoir confluence and extends 4.9 miles upstream (referred to as the Bushkill model) and the second model begins at the Dry Brook-Bushkill confluence and extends 3.3 miles upstream (referred to as the Dry Brook model). The hydraulic model for the Esopus Creek Study area begins at the Esopus Creek-Ashokan Reservoir confluence and extends 23.3 miles upstream (referred to as the Esopus model).

A rainfall runoff model (HEC-HMS) was developed for the entire Ashokan Reservoir watershed to calculate flood discharges whose discharge values for the 10-year, 25-year, 50-year, 100-year and 500-year return interval floods were input into the HEC-RAS models. Calibration runs were completed for some models to increase the accuracy of the calculated water surface profiles. These runs were done for models where there were known high water mark elevations and known discharges. The Bushkill model and Esopus model had calibration runs completed.

Several assumptions in the hydraulic models were reviewed to ensure the models accurately capture existing conditions since several years have passed since they were developed. If model conditions accurately capture the existing conditions, then the calculated floodwater elevations were assumed to be accurate. These assumptions will be explained in each Study Area's results section.

Water Depth Maps
Hydraulic results were exported from the duplicated HEC-RAS models and converted into water surface elevation files using the HEC-GeoRAS tool in ArcGIS. A water surface elevation raster was created for the following return interval floods: 10-year, 25-year, 50-year, 100-year and 500-year. The topography of the study areas was obtained and converted into a raster file format. The topography raster was subtracted from each water surface elevation raster. The resultant raster represents the depth of water over the topography. Water Depth Maps created as part of the Data Gap Analysis were considered preliminary because they show isolated inundation areas. An isolated inundation area is an area that modeling results show to be inundated but is physically separated from the continuous flood area by high topography. Isolated inundation areas (areas that are shown to have water in them from modeling results but are physically disconnected from the river/stream and therefore do not realistically convey water) were removed from the water depth map and presented in subsequent sections.

Benefit to Cost Ratio
One critical component of the LFA is determining the benefit to cost ratio (BCR). The BCR is a mathematic term that divides the dollars of benefit achieved by a flood mitigation project by the dollars of cost it will take to implement the flood mitigation project. FEMA's Benefit to Cost Analysis software program (version 5.1.0) was used to calculate the BCR's for this project. To quantify the achieved dollar benefit for buildings or homes that are damaged by flood hazards, a field investigation was completed to assess the following information: Highest Adjacent Grade elevation (HAG); height from HAG to the first floor (the first habitable floor); foundation type (slab, pier, etc.); basement type (if applicable); number of stories; and if the building was a residence or business (business type). Other information to quantify the achieved dollar benefit was obtained from the municipality or county. For example, lost revenue due to flooding damage, labor hours or equipment costs to clean up debris from a flood, etc. Specific information that was used to calculate the BCRs for the Study Areas will be outlined in subsequent sections.

3.3 Data Gap Analysis Results: Boiceville Study Area

3.3.1 Rapid Geomorphic Assessment

The average daily water surface elevation (ADWSE) profile for the Study Area was created from measuring the water surface elevation of the Esopus when the 2009 LiDAR survey was completed. The TAFT map was extended 2,000' upstream of the Study Area to characterize the portion of the river leading into the study area. Two thousand feet is 10.5 times the bankfull width (bankfull width is 197') (USGS 2015) which is an adequate distance to characterize an adjacent reach.

The TAFT map in Appendix Figure A-2 and in Figure 1 shows two general relationships between the Esopus and its floodplains within the Study Area. A 300' average valley width begins at the upstream Study Area boundary and extends approximately 3,000' downstream to the Boiceville Market area. In this section of the Esopus, there are nominal increases in floodplain width between the 2-year floodplain and 100-year floodplain which means most of the floodwaters are being contained within the river corridor. This constriction causes fast moving water and erosive conditions during flooding. At the Boiceville Market, the valley widens to 1,600' reducing its flood water speed and erosive energy. The Boiceville Market and other buildings are located within the 10-year to 25-year floodplain (8.5' -10.5' ADWSE). These valley widths are notably narrower and wider than the range of valley widths noted in the Upper Esopus Stream Management Plan that are upstream of the Study Area which range from 656'-1,300'.

A much larger valley width is present 200' upstream of the Study Area (floodplain width is 1,950') where a low lying floodplain (2.5'-6.5' above ADWSE) on both sides of the Esopus exists. Other areas of low lying floodplain exist downstream of the railroad bridge crossing of the Esopus. There are other smaller areas of lower floodplain in the Study Area where the Little Beaver Kill and an unnamed tributary meet the Esopus. These floodplains were probably created by the deposit of alluvial material from the tributaries and do not pose a flooding hazard since there is no infrastructure in these areas.

Upstream of the project site, the low lying floodplain (2.5'-6.5' above ADWSE) is a location where the historic river alignment has migrated. The thin blue lines shown on the TAFT map in the right bank floodplain are very close to the ADWSE meaning that at some point in the past, the Esopus' alignment ran through the floodplain and has since migrated towards the left bank and State Route 28. As such, a reach-based erosion hazard due to channel migration is high in this location.

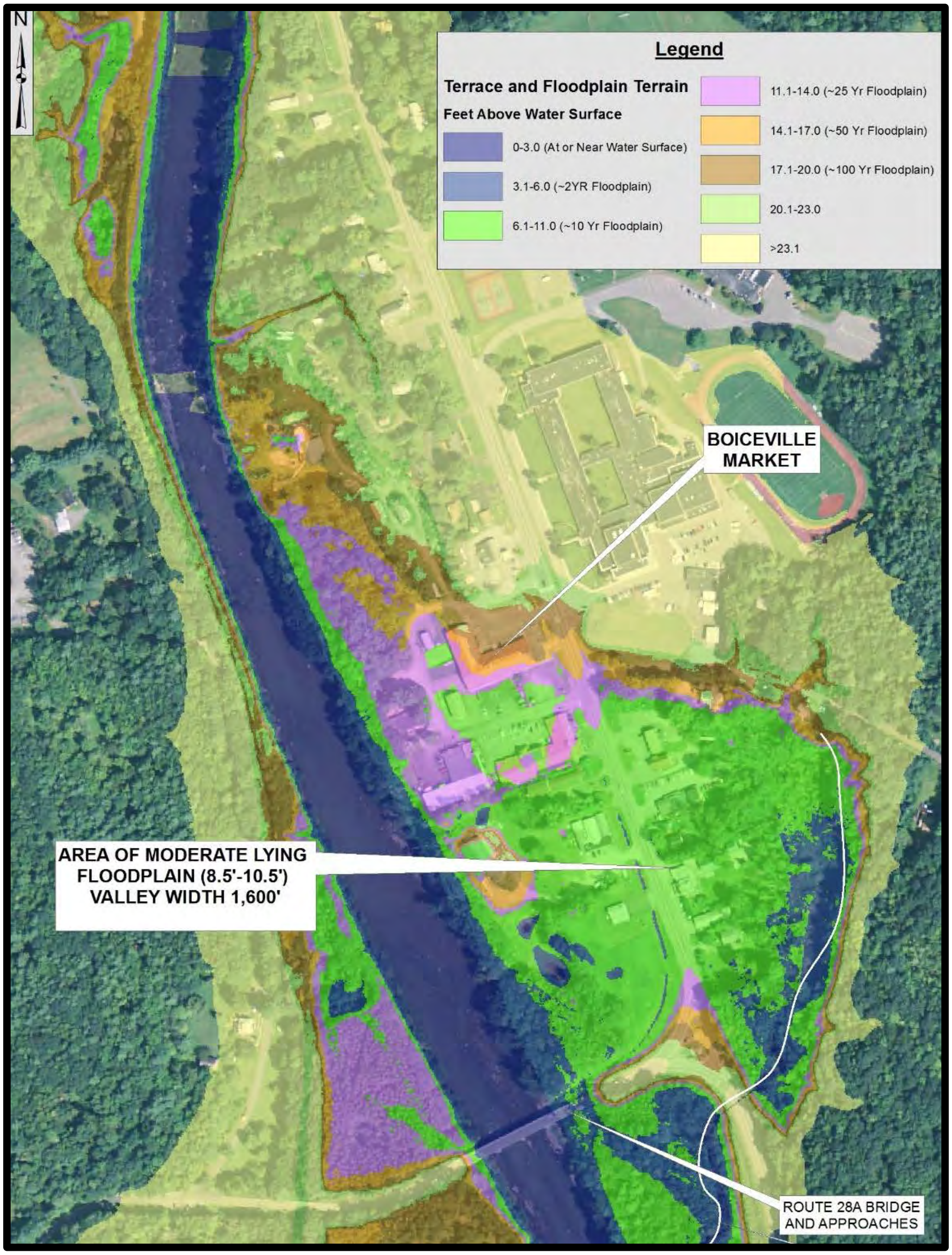


Figure 1: Terrace and Floodplain Terrain Map of Boiceville Mitigation Area

Erosion hazards due to the lateral migration of the Esopus are unlikely through much of the study area where the flooding extents are limited by the narrow valley walls (300' +/- wide). Conversely, in areas with wider floodplains, the possibility for channel migration is more likely. For example, it is possible that the historic Esopus alignment (pre-European settlement) ran through the area between the Boiceville Market and Fire House Co. #5 since there is moderate lying floodplain on the east bank. However, since the floodplain height is 8.5'-10.5' above ADWSE, the probability of this erosion hazard occurring is low because only large floods can reach this height and the area is protected by the Route

28A bridge approaches. Just downstream of the Route 28A bridge along the east bank, the TAFT map shows a thin blue line that is more parallel with the present day Esopus alignment than it is parallel with the present day unnamed tributary alignment. This could indicate the location of a historic Esopus alignment channel. If the Route 28A approaches are widened, this historic alignment should be taken in consideration since it is within reason that the Esopus may try to recapture parts of its historic alignment creating an erosion hazard. At the low lying floodplain 800' downstream of the bridge, the Esopus becomes anabranched (multithread) which is an indication of where a combination of sediment deposition and channel migration has occurred.

3.3.2 Esopus Creek Stream Feature Inventory (SFI) Review

SFI data was collected between 2005-2006 to develop the Upper Esopus Stream Management Plan recommendations. This Plan divided the Esopus into 21 reaches and a GIS survey was completed which mapped important stream features. Relevant SFI data was reviewed to identify and explain potential flood hazards.   Pertinent SFI data included: eroding banks, depositional features, debris jams, etc. The SFI mapped 192 eroding banks in the watershed with up to 56% of stream banks in certain reaches in the watershed actively eroding. Several locations where entire hillsides are failing were documented. This information shows there is a source of debris (sediment and logs) which could create flood hazards in the Study Area. It was assumed that a constant source of debris would be transported to the Study Area for the development of sustainable mitigation practices. If these eroding banks and failing hillsides are stabilized or the debris trapped upstream, then this assumption would need to be changed.

In the Study Area there was little SFI data that documented any concern for flooding hazards as shown on the TAFT map (Appendix Figure A-2). SFI features that were notably lacking were the dearth of deposition features which would suggest infilling that can exacerbate flooding hazards. Since this information was collected almost 10 years ago, this should be confirmed during the field investigations.

There is an eroding bank between the railroad bridge and Route 28A bridge but there is little infrastructure proximal to this bank so this hazard was deemed of little importance. Upstream of Study Area adjacent to the low lying floodplain (2.5'-6.5' above ADWSE), the left bank has been protected by a revetment. The protection was probably installed to protect the road and homes from an erosion hazard and the status of this revetment is unclear. This hazard was included in this assessment because of the level of consequence this hazard poses and it may be warranted to extend the Study Area's boundaries. This stream feature supports the TAFT findings which predicted there would be a high probability of an erosion hazard occurring in this area since the Esopus was migrating to the left (east). Outside the study area there are three large woody debris mapped SFI features in the Study Area which could cause localized flood hazards or erosion hazards and should be assessed during the field investigations.

The Upper Esopus Stream Management Plan was also reviewed to identify and to understand the conditions that may cause potential flooding hazards. The Esopus Creek channel alignment has changed little over the last several decades in and around the Boiceville Study Area. The only notable change occurred near the upstream limits of the study area (in the low lying floodplain area as noted above) where it has shifted towards the left bank over the last several years. There is a several thousand foot right bank rip rap revetment leading up to the Boiceville Market protecting the adjacent railroad which is located high above on the hillside and is not inundated by the 100-year flood. The structural status of this revetment was found to be stable and therefore the revetment does not impact flooding hazards in the Boiceville Study Area.

3.3.3 Public Flooding Hazards and FAC Flooding Hazards

Ten (10) of the fifty-two (52) FAC or public flooding hazards are located in the Boiceville Study Area. The most common public flooding hazard or FAC flooding hazard group was stormwater (four), followed by overbank flooding (three) and debris jams (two) as seen in Appendix Figures A-3 through A-5. Three of the four stormwater hazards (hazard #6, #7 and #8) are near the unnamed tributary that flows to the east of the Boiceville Market. It is unclear if the hydraulic capacity of the culvert under State Route 28 causes the tributary to flood or if backwater from the Esopus causes the flooding. The fourth stormwater hazard (hazard #0) is located at the Route 28A bridge. The bridge's influence on flood water surface elevations is being modeled using the US Army Corps of Engineer's hydraulic modeling software (HEC-RAS) and will be discussed in subsequent chapters.

The three overbank flooding hazards are located at the Boiceville Market and are explained by the TAFT map in Figure 1 which shows these buildings to be located in a moderate lying floodplain (8.5'-10.5' above ADWSE) connected to the Esopus. This floodplain begins to flood around the 25-year return interval storm. The debris jams at hazard #3 and hazard #4 were not marked on the SFI inventory and will be explored in the field investigations to characterize if they could potentially cause flooding hazards. The last hazard is an eroding bank (hazard #5). This was not marked in the SFI inventory and it will be measured and its potential impacts assessed during the field investigation.

3.3.4 Hydraulic and Hydrologic Model Review: Hydrology

The peak discharges for the 10, 25, 50, 100 and 500 year return interval floods used in the Esopus Creek preliminary FEMA HEC-RAS model were developed as part of the County's Flood Insurance Study (36111CV0001B). A rainfall runoff model was used to calculate these peak discharges. The model was calibrated to the August 2011, October 2005 and September 2011 flood events by matching the calculated discharges to the measured discharge at USGS stream gage at Coldbrook located in Boiceville along the Esopus (USGS gage #01362500) which is located 2,300' upstream of the LFA boundary as seen in Figure 2. The calculated discharge after calibration for the August 2011 event (73,166 cfs) and the measured discharge at the USGS gage (75,800 cfs) were nearly identical (3% difference) as seen in Figure 3 (FEMA 2012). From the calibrated model, a flood discharge curve was developed. The rainfall runoff model's flood discharge curve was then compared to the flood discharge curve calculated using a Bulletin 17B statistical analysis at the USGS Coldbrook stream gage (station skew, Weibell Plotting method) and the results can be seen in Table 1. It appears the rainfall runoff model under predicts most of the flood discharges except the 500-year return interval discharge. The rainfall runoff model over predicts the 500-year event by 7%. Both 500-year discharges are notably higher than the 100-year discharges (roughly 60% and 90% higher for Bulletin 17B and rainfall runoff model respectively). The August 2011 flood was approximately equal to a 75-year return interval storm using the rainfall runoff model and approximately equal to a 50-year return interval storm using the Bulletin 17B method. It is unclear why there is a notable discrepancy between the two flood discharge curves but for the purpose of the LFA, the calibrated values in the Effective FIS will be used.

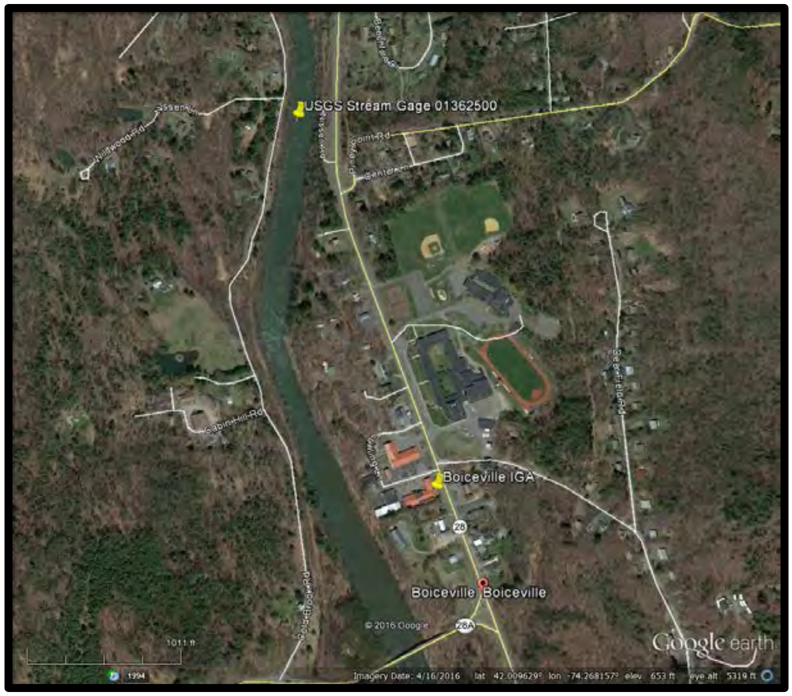


Figure 2: Location of USGS Stream Gage and Boiceville Market

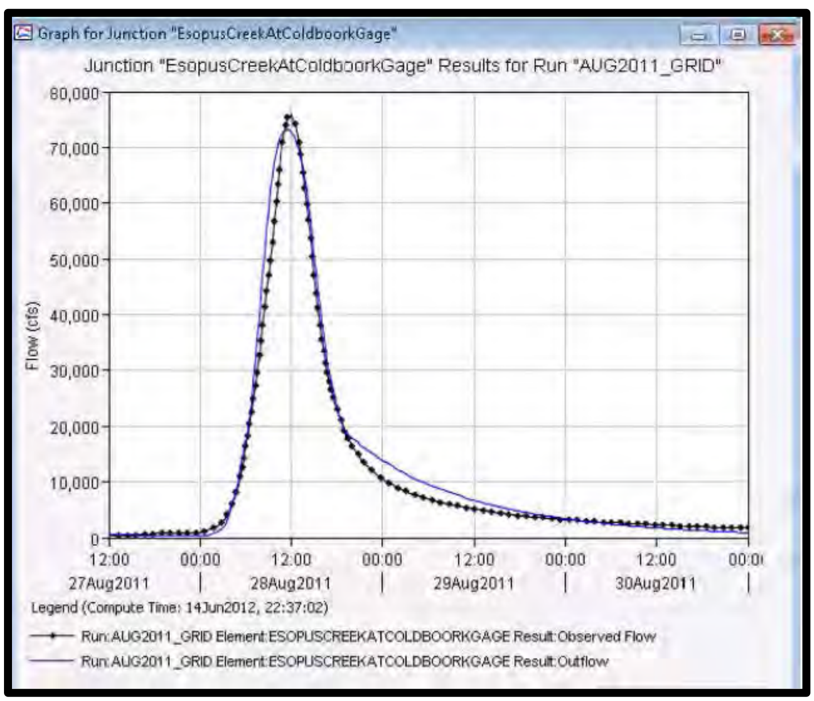


Figure 3: Comparison of Rainfall Runoff Discharges versus Measured Discharge (FEMA 2012)

Table 1: Comparison of Bulletin 17B Flood Discharge Values versus Rainfall Runoff Model Values

Bulletin 17B Flood Discharge Values (cfs)	Flood Return Interval	Rainfall Runoff Model Flood Discharge Values (cfs)
159,128	500-Year	169,597
95,437	100-Year	86,781
74,936	50-Year	63,747
Not Calculated	25-Year	46,736
52,753	20-Year	Not Calculated
39,051	10-Year	30,440

3.3.5 Hydraulic and Hydrologic Model Review: Hydraulics

Several assumptions in the Esopus Creek hydraulic model were reviewed to ensure it accurately captures the existing conditions because the information collected to build the model was collected between 2011 and 2012. The Esopus Watershed Hydraulic Study, New York (Task Order HSFE02-11-J-0001) report was reviewed as well for supportive documentation.

The first reviewed assumption was the appropriateness of the downstream boundary condition. In the HEC-RAS model, a normal depth calculation was used to set the boundary condition at the downstream cross section which is an acceptable approach for non-backwater flow conditions. A review of the DEP Ashokan Reservoir data show that reservoir levels can range from 540' to 590' in elevations. The Esopus channel bottom is lower than 590' for several hundred feet upstream of the Ashokan Reservoir-Esopus confluence meaning that several of the most downstream cross sections in the model would be filled with reservoir water creating a backwater condition. Therefore, the normal depth calculation is not the optimal downstream boundary condition. However, the hydraulic report does not address how the boundary condition was selected nor how reservoir levels may influence the boundary condition. The Boiceville Study Area is located approximately a mile upstream (river slope 0.005ft/ft) of the Ashokan-Esopus confluence so it is assumed that any backwater effect from the Reservoir is negligible and the river is flowing under non-backwater conditions. As such, it is unlikely the uncertainty of the appropriateness of the downstream boundary condition will influence the modeling results in the Boiceville Study Area.

The second assumption checked was the calibration of the model. Several modeling variables can be manipulated to adjust the model's calculated water surface to a known (and measured) high water mark. These variables include ineffective flow area and relative roughness (Manning's "n" values). In the Esopus model, the most downstream high water mark that the model was calibrated to was in the Boiceville Study Area near the Boiceville Market and Fire House Company #5 (see Figure 4), about 1.0 mile upstream of the reservoir. This high water mark was surveyed after the 2011 floods (75,800 cfs). The Esopus model's variables were then adjusted until the calculated water surface was within 0.5' of the surveyed water surface elevation at Fire House Co. #5 (FEMA 2012) which is acceptable difference. However, at the USGS Coldbrook stream gage located 2,300' upstream, the difference is 3.0' as seen in Figure 5 (FEMA 2012) which is not an effective calibration. Since the model was calibrated using high water marks within the LFA boundary and appears to be more conservative/overestimates, the model is assumed to be reliable.

Figure 4: High Water Mark at Fire House Co. #5 (The line between light and dark bricks)

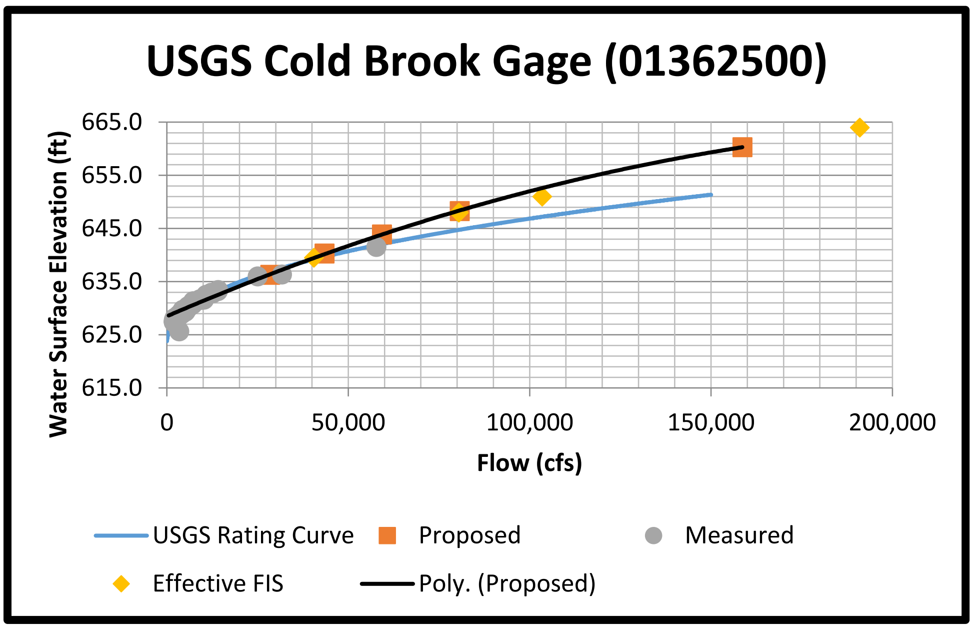


Figure 5: Comparison of Measured Discharges and Modeled Discharge in FEMA Models (FEMA 2012)

The third reviewed assumption was the application of ineffective flow areas (inundated areas where the velocity of water is assumed to be zero). Areas in an ineffective flow area do not convey water longitudinally and therefore are not used in the calculations for water surface elevations. Figure 6 shows the cross section from the Esopus model through the Boiceville Market Area. The green hatch areas are ineffective flow areas. Flood waters inundate the area around the Boiceville Market area (between station 800 and 1000) starting at the 25-year flood event. The cross section shows that this area does not convey flood waters. The TAFT Map in Figure 1 shows that the Route 28A bridge approaches jut out and forms an east to west high location. This obstruction blocks that conveyance of floodwaters running north to south and the use of ineffective flow areas in the Study Area are appropriate. Lateral flow direction is considered negligible.

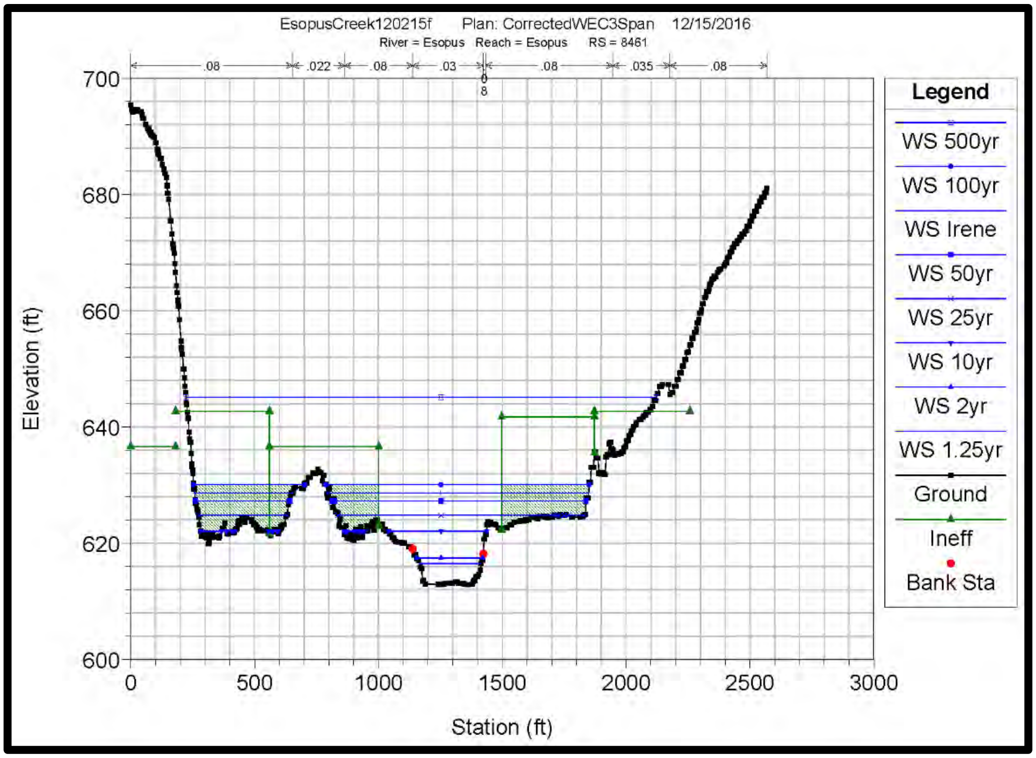


Figure 6: HEC RAS Cross Section through the Boiceville Market Area. Areas with green hatch are Ineffective Flow Areas near the Market.

The last reviewed assumption was the topography used to build the model. Several cross sections were surveyed in the Study Area from stream top of bank to top of bank after the 2011 floods and spliced into the 2009 LIDAR information to create the cross sections used in the hydraulic model. The FAC felt that there were no notable changes in topography in the Study Area which means the topography is acceptable. This assumption was reinforced by comparing the recently surveyed channel (winter 2014/15) sections obtained as part of the Route 28A bridge replacement work with the channel sections in the duplicate HEC-RAS model. The only notable change in topography occurred near the bridge. There is an increase in channel bed elevation near the bridge since the survey information for the duplicate model was obtained (Figure 7). This increase is slight, when compared to the overall water depth during the 10-year flood (average water depth 10') and the 100-year water depth (average water depth 20'). Therefore, the topography in the duplicative HEC-RAS model was updated with the newer survey data and the remaining topographic information was determined to be acceptable.

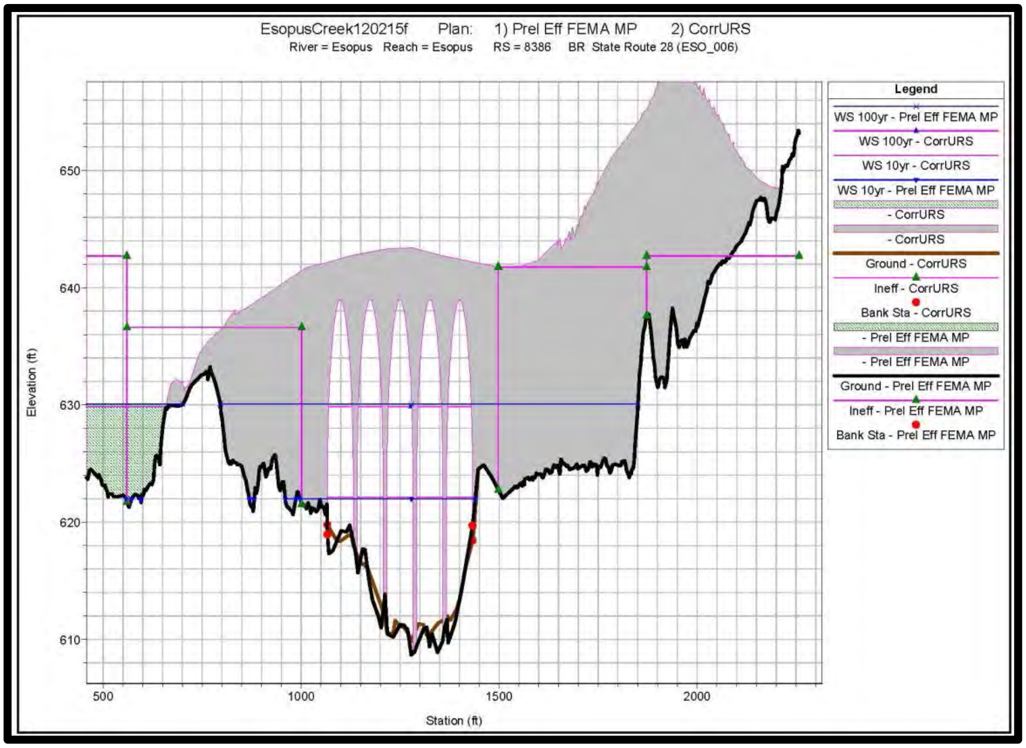


Figure 7: Cross Section of Duplicated and Corrected Model. Note Slight Changes in Channel Topography

3.3.6 Preliminary Water Depth Maps

Preliminary water depth maps were created for the standard 10-year, 25-year, 50-year and the 100-year flood events. General comments for each map are noted below:

<u>10-Year Return Interval Flood (Appendix Figure A-6):</u> Floodwaters are generally contained within the Esopus channel banks. Over bank flooding appears to only occur immediately upstream and downstream of the Route 28A (Five Arch) bridge. There is some inundation predicted to the east of State Route 28 along the unnamed tributary but no overland connection is visible. The map was edited after the FAC was consulted to understand flooding in this area.

<u>25-Year Return Interval Flood (Appendix Figure A-7):</u> Notable increase in flooding in the Boiceville Market area. It appears there are “threads” that connect the Esopus to the floodplain. A thread is located between the Sewage Treatment Plant and the Market and just to the south of the treatment plant. Shallow water depths are present over State Route 28 (1.1’-2.5’) and floodwaters begin to surround the Boiceville Market Building (0.1’-1.0’). It appears overbank flooding occurs on the right bank across from Fire House Company #5 upstream of Route 28A but not downstream of Route 28A. Fire House Company #5 is completely surrounded by water (depth 0.1’-2.5’). The map was edited after the FAC was consulted to understand flooding in this area.

<u>50-Year Return Interval Flood (Appendix Figure A-8):</u> Flooding extents remain relatively unchanged except for downstream of Route 28A along the right bank. The ground elevation around the Market is under water (1.1’-2.5’). The first floor elevation of the Market is between 0.5’ and 1.0’ above the ground elevation so it is assumed there is water in the Boiceville Market building during this flooding event. All the businesses in this area have the same depth of water in them except for the building to

the north of the Boiceville Market which is mostly dry. There is more water depth over State Route 28 (2.6’-4.5’) and most of the buildings between it and the unnamed tributary to the east have between 2.6’ to 6.5’ water depth around them. The map was edited after the FAC was consulted to understand flooding in this area.

100-Year Return Interval Flood (Appendix Figure A-9): Flooding in the Boiceville Market, Fire House Company #5 and State Route 28 area is deep (>8.5’). The business to the north of the Market has water surrounding it and most likely enters the building. There is now water in the floodplains, upstream and downstream of Route 28A along both banks. The map was edited after the FAC was consulted to understand flooding in this area.

500-Year Return Interval Flood (Appendix Figure A-10): In general, the 500-year water surface elevation is twelve feet higher than the 100-year water surface elevation which is an unusually large difference between the two flood frequencies. Flooding in the entire area surrounding the Boiceville Market including the business to the north is deeper than 8.5’. State Route 28 is under water beginning at the Route 28A intersection to the school. There is a distinct high area about 100’ wide, parallel with State Route 28 starting adjacent to the school. All buildings to the west of this high area are under 6.6’ to 8.5’ of water.

3.3.7 Water Quality Assessment Data Review

The SFI data identified 192 eroding banks and over 150 fine sediment sources along with many failing hillsides in the Esopus Creek watershed. Sediments (silts/clays) that are present in these locations will be transported downstream into the Study Area during flood conditions causing water quality concerns. There are few sources of fine sediments in the Study Area that would further contribute to water quality concerns.

When overbank flooding occurs several buildings will become inundated starting around the 25-year flood return interval. These are commercial and residential buildings which may contain chemicals and hazardous waste that create water quality concerns. Around the 50-year flood event, floodwaters reach petroleum storage tanks about 200’ northwest of the market (see Figure 8). If these tanks are not anchored properly they can cause water quality and public safety issues.

Figure 8: Petroleum Tanks located Northwest of Boiceville Market

3.3.8 Identified Data Gaps and Proposed Field Methodology

The review of existing data identified several gaps that cannot fully explain existing or potential flood hazards or allow for informed mitigation solutions to be developed. The following outlines the questions that were raised, the methodology used to answer the questions and the results as determined from information collected in the field.

1. What is function of Mount Pleasant and Mount Tremper Flood Control Projects? The FAC was consulted and these facilities were built 60 years ago and do not have an impact on flooding conditions in the Study Area.

2. Are there any deposition features in the Study Area that may have caused infilling? There are no depositional features in the Stream Feature Inventory. The FAC was consulted and field data was collected using a Trimble 6000 handheld GPS device (accuracy <1.0') on July 2015 and using SFI methodology. No depositional areas were found.

3. Besides the submitted erosion hazards and in the SFI, are there any eroding banks of concern in or proximal to the Study Area, for example just upstream? The FAC was consulted and field data was collected using a Trimble 6000 handheld GPS device on July 2015 using SFI methodology. No additional erosion hazards were found.

4. What is the status of the revetment upstream of the low lying floodplain just upstream of the LFA boundary where the Esopus is migrating left (east) (Appendix Figure A-2)? Is this a concern for the FAC? The FAC was consulted and field data was collected using a Trimble 6000 handheld GPS device on July 2015 using SFI methodology. The revetment is being undermined but this is not within the scope of the LFA and therefore should be omitted.

5. Are there buildings along the Little Beaver Kill and are they occupied structures? Is the flooding around them from the Esopus or Little Beaver Kill? The FAC was consulted and there are no homes between State Route 28 and the Esopus Creek. There are no homes upstream of State Route 28 along the Little Beaver Kill that are within a Special Flood Hazard Area (a FEMA delineated floodplain). There are no flooding hazards along the Little Beaver Kill.

6. When, how and where does the flooding for stormwater hazards #6, #7 and #8 occur (Appendix Figure A-3)? Are there constrictions in the floodplain that create these flooding hazards? The FAC was consulted and data was collected using traditional surveying methods for hazard #8 (culvert under State Route 28 and upstream floodplain) in July 2015, hazard #7 (DeSilva Road culvert) in July 2016 and Hazard #6 (culvert under State Route 28) in July 2016. These locations are considered important to the FAC and should be considered in the LFA.

7. Do the debris jams at Hazard #3 and Hazard #4 (Appendix_Figure A-3) cause flooding problems or cause local erosion? The FAC was consulted and field data was collected using a Trimble 6000 handheld GPS device on July 2015 using SFI methodology. Hazard #3 was the old Coldbrook Bridge that was destroyed in the 2011 floods. It is located high up on the floodplain and does not pose a flooding hazard. Hazard #4 is the damaged railroad bridge over the Esopus; it does not pose any flooding hazards in the Boiceville Study Area.

3.4 Data Gap Analysis Results: West Shokan Study Area

3.4.1 Rapid Geomorphic Assessment

Using the same methodology as was used for Esopus Creek, TAFT maps were created for the West Shokan Study Area. The TAFT map was extended 1,800' upstream of the Study Area to characterize the portion of the river leading into the study area. Two thousand feet is 27.0 times the bankfull width (width is 67') (USGS 2015) which is an adequate distance to characterize an adjacent reach.

The TAFT map in Figure 9 depicts a typical relationship between a river that cuts through an alluvial fan and the river's floodplains. The floodplain width is narrower along the beginning of the alluvial fan and the upstream reaches of the Bushkill where the floodplain averages about 400'. Floodplain width increases further downstream (and downslope) along the fan. Near the most downstream bridge on Watson Hollow Road (referred to as the Watson Hollow Road bridge) and close to the halfway point along the fan, the floodplain width expands to approximately 1,750'. The floodplain width exceeds 4,000 feet as it approaches the confluence with the Ashokan Reservoir near Route 28A.

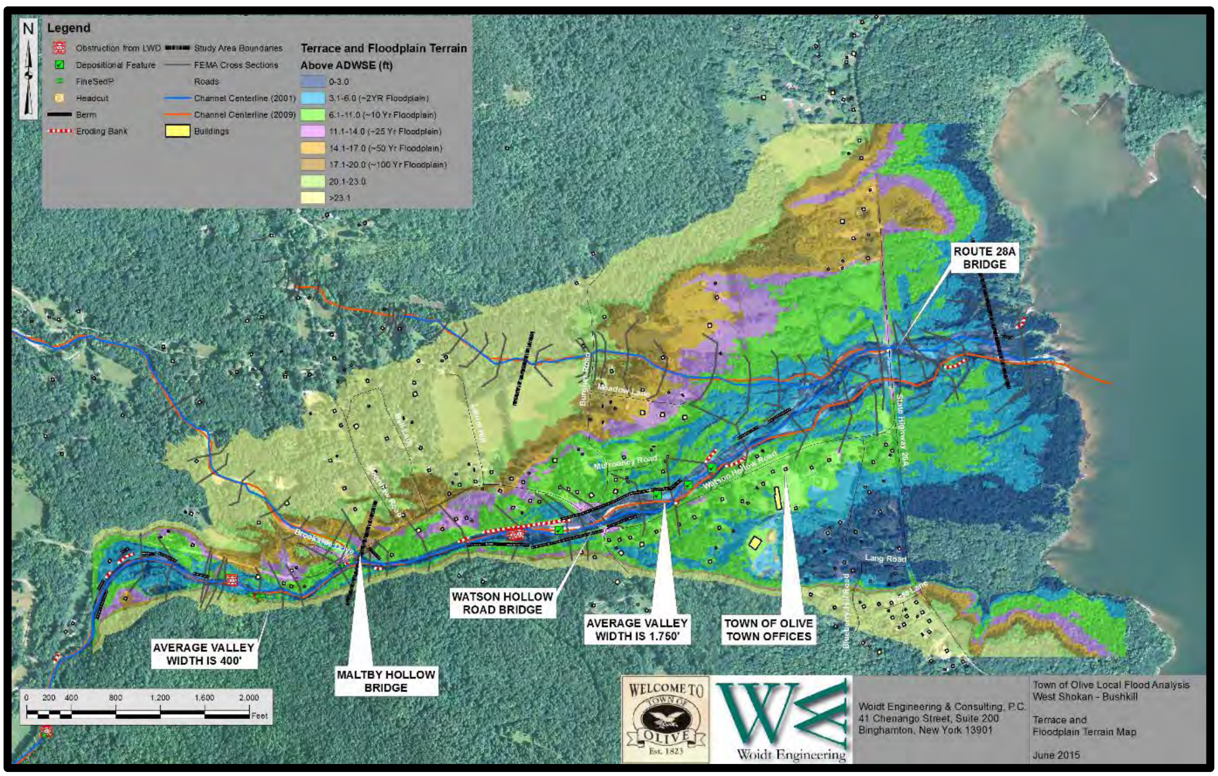


Figure 9: Terrace and Floodplain Terrain Map of West Shokan Study Area

Another alluvial fan characteristic is the amount of low lying area that is close to the channel bottom elevation. Using the TAFT map, this characteristic is shown in blue (area between 0.1'-6.0' above the ADWSE). There are long blue threads (0.1'-6.0' above the ADWSE) that parallel the present day channel alignments (both the Bushkill and Dry Brook). These threads represent historic alignments of the Bushkill and Dry Brook. This characteristic is first observed near the Watson Hollow Road Bridge and continues downstream towards the reservoir. Two recent channel alignments were digitized on aerial photography taken in 2001 and again in 2009 to capture the change in channel alignment over the course of eight years. The 2001 and 2009 Bushkill alignments begin to diverge downstream of the

Watson Hollow Road Bridge and notably separate adjacent to Olive's town offices. It is at this point that the 2009 alignment takes a dramatic turn to the south. It is reasonable to assume that over the last millennium the Bushkill and Dry Brook alignments have traversed back and forth across the alluvial fan's low lying floodplain (area shown in blue in Figure 9 on previous page).

Potential flood hazards exist in this Study Area because it is reasonable that the Bushkill or Dry Brook could avulse (change direction) and reoccupy their historic alignments in the low lying floodplains areas. Potential flood hazards exist where there are buildings or other sensitive infrastructure located in these areas. If the channels were to avulse and follow historic flow paths, land that had been normally dry could become suddenly inundated and the land adjacent to these flow paths could be eroded. There are several existing locations exposed to these types of potential flood hazards. The first is east of the town offices along Lang Road where there are several buildings in a blue area as seen in the TAFT map. A blue area is an area vertically proximal to the Average Daily Water Surface Elevation (ADWSE). There is a blue thread that extends up the valley slope (to the west) towards Watson Hollow Road that could be a historic flow path. The most western portion of this blue thread (closest to Watson Hollow Road) will be investigated during field investigations to confirm if this potential flood hazard exists. Another potential hazard is located parallel with Watson Hollow Road, 300' northeast of the Town Hall. A blue thread runs parallel with the road until it meets Route 28A where it ends. This thread ends at the road, probably due to the embankment fill that was used to build the road. This was assumed since immediately downstream of the road, the blue thread continues. If the Bushkill were to avulse and run along this thread, it could pose an erosional hazard at this section of road.

This TAFT map also can be used as a guide to mitigate future flood hazards by restricting development in low lying floodplain areas (areas in blue). These areas may be prone to future channel migration or water inundation. By keeping these areas clear of buildings or other sensitive infrastructure, the channels can naturally migrate and would not pose a hazard to buildings.

3.4.2 Bushkill Stream Feature Inventory Review

Review of Stream Feature Inventory (SFI) data confirmed preliminary conclusions that the West Shokan Study Area is located within an alluvial fan with dynamic channel movement that can create both reach wide and site specific-flooding hazards. Table 2 summarizes the number and length of measured features that are potential flood hazards in the Study Area.

Table 2: Type and Quantity of Flood Hazards as mapped by the SFI

Feature Type	Number of Observations	Length (ft)
Depositional Features	4	N/A
Fine Sediment Sources	2	N/A
Eroding Banks	9	1,820
Obstruction Caused By Large Woody Debris	2	N/A

The West Shokan Study area is located within the Bushkill Stream Management Plan area. The Plan identified a distinct break between the lower and upper reaches of the West Shokan Study Area in terms of the relationship between sediment transport and sediment storage. In the lower reaches there is more sediment deposition and storage and the stream becomes braided with multiple flow pathways. This description aligns well with the previous findings that the West Shokan Study Area has the potential for multiple reach-based flood hazards, primarily erosion and channel migration that could change inundation extents.

3.4.3 Public Flooding Hazards and FAC Flooding Hazards

As noted in the Esopus Creek section of this memo, there were a total of 52 submitted existing hazards at the first public and FAC meeting, 11 of which are located in the West Shokan Study Area as seen in Appendix Figure A-12 through A-15 (the remaining hazards are outside both Study Areas). The most common existing hazard type was erosion or erosion/overbank flooding (six) followed by debris jams or debris/stormwater (five). Notably there are no overbank flooding hazards that were identified in the West Shokan Study Area. As shown in Appendix Figures A-12 through A-15, there are very few buildings (1 or 2) that are within the 100 year floodplain which is probably why there were no submitted overbank flooding hazards.

The valley slope along an alluvial fan is much flatter than the steeper headwaters draining to the fan. Stream slope is a key component for calculating shear stress (the physical process of moving a submerged object in a fluid). If the slope decreases (in this example the valley slope is used as a surrogate for the energy slope) an object that was moved by water in the steeper headwaters would cease to be carried by the water in the flatter alluvial fan valley slope. This physical process leads to deposition (cessation of movement) of bedload (gravels, cobbles and boulders) in certain locations along the alluvial fan. Deposited bedload can build up over time and form obstructions to flow redirecting flow towards stream banks and causing erosion. The redirection of water into a stream bank caused by an obstruction is an example of a site-based cause of an erosion failure mechanism. Other site-based causes include log jams that also redirect water into unwanted locations.

During subsequent FAC meetings and field investigations, it will be determined if the submitted hazards were caused by either site-based causes or reach-based causes. This distinction is important for developing an informed design of how to mitigate these hazard types. For example, debris can be manipulated to accumulate in certain areas and not others mitigating unwanted flow deflections. If the hazards are reach-based caused, then removing the infrastructure out of the way of the migrating channel or developing a mitigation solution that extends further upstream or downstream of the hazard location are preferred solutions.

3.4.4 Hydraulic and Hydrologic Model Review: Hydrology

The peak discharges for the 10, 25, 50, 100 and 500 year return interval floods used in the Bushkill, Dry Brook and Maltby Hollow preliminary FEMA HEC-RAS models were developed as part of the County's Flood Insurance Study (36111CV0001B). A rainfall runoff model was used to calculate these peak discharges. For the discharges in the FEMA study, the model was calibrated to the August 2011, October 2005 and September 2011 flood events by matching the calculated discharge to the measured discharge at the USGS stream gage along the Bushkill in West Shokan (USGS gage #01363382) as seen in Figure 10. The calculated discharge after calibration for the August 2011 flood event (7,027 cfs) and the measured discharge at the USGS gage (6,240cfs) differed by 13% as seen in Figure 11 (FEMA 2012). Calibration was not completed in the Dry Brook or Maltby Hallow watershed.

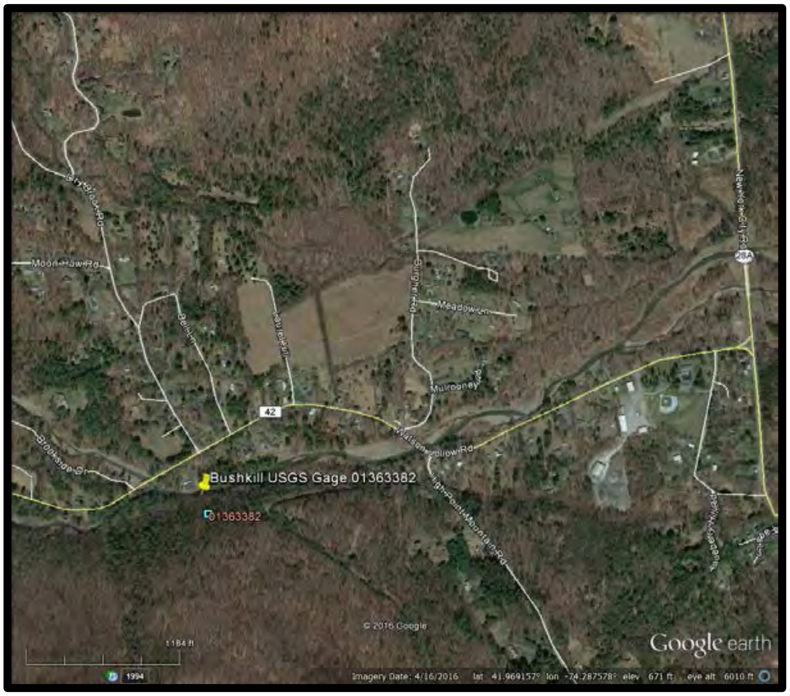


Figure 10: Location of USGS Stream Gage along Bushkill at West Shokan (01363382)

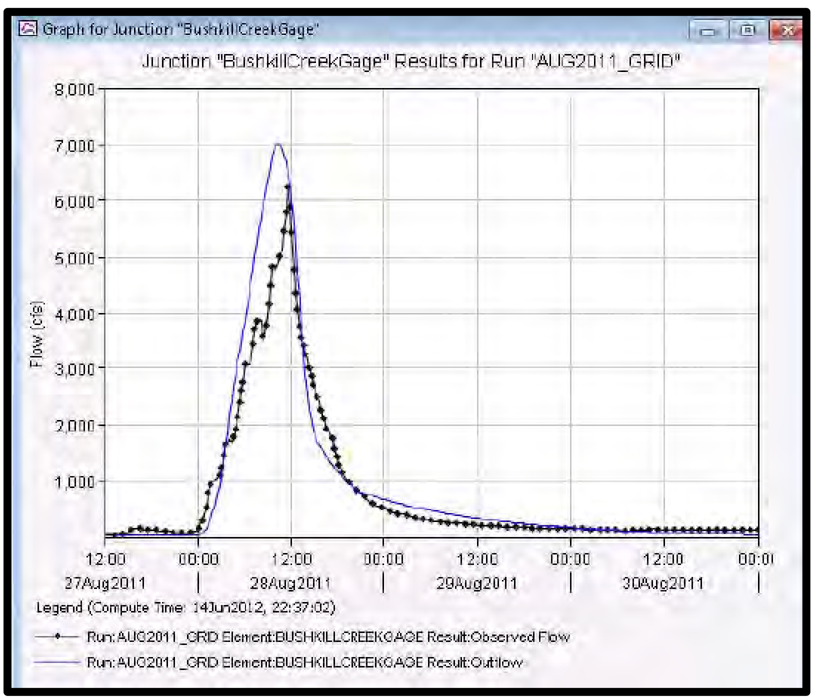


Figure 11: Comparison of Rainfall Runoff Discharges versus Measured Discharge (FEMA 2012)

A calibration run was completed only for the Bushkill model to increase the accuracy of the calculated water surface elevation profiles using the August 2011 flood discharge. The results were compared to known water surface elevations at the USGS stream gage (#01363382 Bushkill below Maltby Hollow Brook at West Shokan).

3.4.5 Hydraulic and Hydrologic Model Review: Hydraulics

The effective FEMA HEC-RAS model was obtained and duplicated and the preliminary FIS (#36111CV001B) was reviewed.

The first reviewed assumption was the appropriateness of the downstream boundary condition which was normal depth calculation (slope of 0.0113ft./ft.). As discussed in section 3.3.5, the Bushkill empties into the reservoir approximately 1,110' downstream of the Route 28A bridge over the Bushkill. The fluctuating reservoir levels influence on hydraulics is not discussed in the FIS. Since the most downstream area of interest in the LFA boundary is located more than a thousand feet upstream, has a channel bed elevation greater than 606' and is on a relatively steep slope (>1%), it is unlikely reservoir levels impact hydraulics in the study area.

The second assumption checked was the calibration of the model. None of the three models were calibrated to any measured discharges (FEMA (2) 2013). The Bushkill modeling results were only compared to measured water surface elevations at USGS #01363382 downstream of the Maltby Hollow and Bushkill confluence. These numbers compared reasonably well during discharges less than 5,000 cfs (less than a 50-year return interval flood) but the difference increased with larger events (>2.0'). Note, the discharges are erroneously listed in Table 15 in the FEMA report and are for the Bushkill upstream of the Bushkill/Maltby Hollow confluence, not for the gage which is located downstream of the confluence. Since there are no calibration data nor enough peak annual discharge data to complete a Bulletin 17B analysis (a statistical analysis using a Log Pearson III distribution), the discharges and the model are considered adequate for this exercise.

The third assumption checked ineffective flows and Manning's "n" values and all seemed adequate.

The last reviewed assumption was the topography. Supplemental cross sections were surveyed in the West Shokan Study Area from stream top of bank to top of bank after the 2011 floods and spliced into the 2009 LIDAR information to create the cross sections used in the HEC-RAS hydraulic models for the Bushkill and Dry Brook. Eight cross sections were surveyed along the Bushkill and five cross sections were surveyed along Dry Brook. Due to the depositional nature of an alluvial fan it was recommended cross sections be resurveyed to see if there have been notable changes in topography. Notable changes in the topography could change inundation extents during flood conditions. A section near critical infrastructure such as the fire house near the Town offices (HEC RAS section 3395) and near Watson Hollow Road Bridge (HEC RAS section 4690) were recommended to be resurveyed.

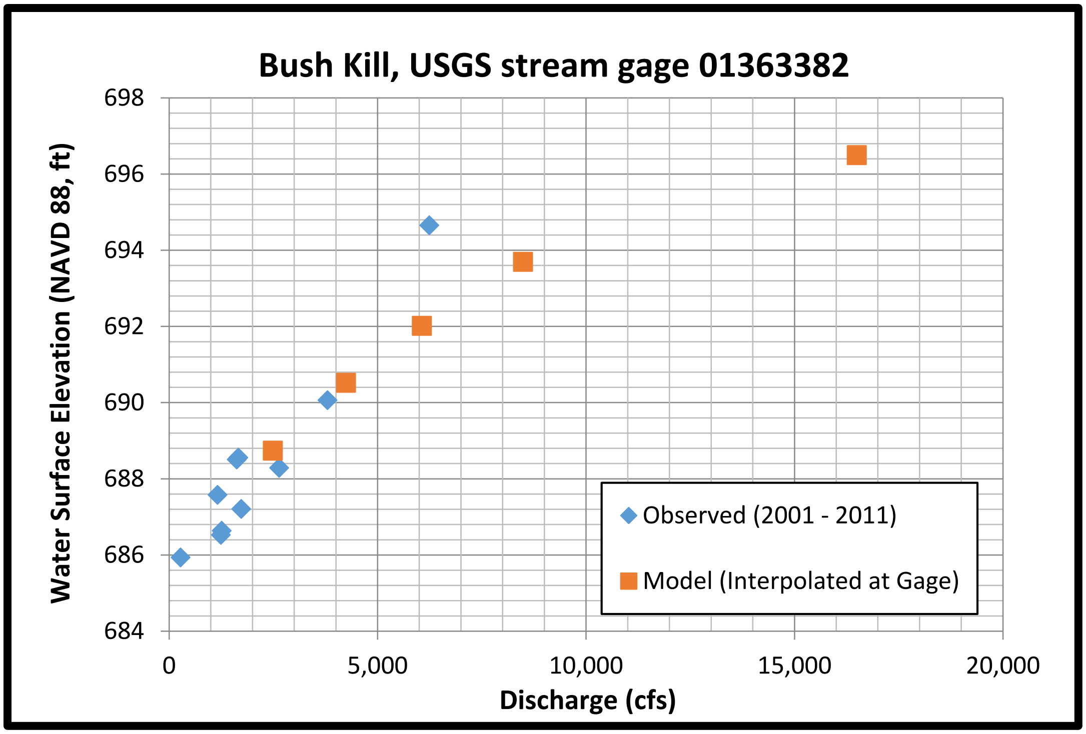


Figure 12: Comparison of Modeled Water Surface Elevations vs. Measured Water Surface Elevations.

3.4.6 Preliminary Water Depth Maps

Preliminary water depth grid maps were made for the standard 10-year, 25-year, 50-year, 100-year and 500-year flood events. General notes for each map are made below:

10-Year Return Interval Flood (Appendix Figure A-16): Floodwaters are generally contained within the Bushkill and Dry Brook channels. Over bank flooding appears to only occur to the north of the Bushkill near the confluence with Dry Brook. This overbank flooding could be the exchange of floodwaters between the two streams. Also, the confluence area between the two streams is inundated (section 2721) but there is high area between this location and Route 28A. All bridges and culverts along the Bushkill and Dry Brook are able to pass the 10-year flood. The map was edited after the FAC was consulted to understand flooding in this area.

25-Year Return Interval Flood (Appendix Figure A-17): Floodwaters continue to be contained within the main channels of the Bushkill until section 4564 where they begin to spread out. It does not appear that any buildings are within the inundation area. The area just upstream of the Route 28A bridge is almost completely inundated. All bridges on the Bushkill are able to pass the 25-year flood with minor backwater influence. The culvert along Burgher Road along Dry Brook is overtopped during the 25 year flood and causes backwater conditions. The map was edited after the FAC was consulted to understand flooding in this area.

50-Year Return Interval Flood (Appendix Figure A-18): Flooding extents do not appear to inundate any roads or buildings along the Bushkill during this flood. There does appear to be a connection between overbank flooding and adjoining floodplain at section 1167 in the Dry Brook model. There is a home near this section that may be at risk of flooding. The area upstream of Route 28A is completely inundated. All bridges on the Bushkill are able to pass the 50-year flood. The culvert along Burgher Road along Dry Brook causes the road to overtopped by a 0.5’ of water. The map was edited after the FAC was consulted to understand flooding in this area.

<u>100-Year Return Interval Flood (Appendix Figure A-19):</u> Flooding extents inundate several buildings along the Bushkill but no roads. The building along Watson Hollow Road near the Town Office is inundated by 0.6’ of water. Two homes between the Bushkill and Mulrooney Road are also inundated but it appears there is a berm between the Bushkill and these homes so in the refined Water Depth map, these buildings may not be inundated if the berm keeps the 100-year floodwaters away from these homes. Along Dry Brook, no buildings are inundated and one road (the Burgher Road crossing over Dry Brook) is overtopped by more than a 1.0’ of water. The map was edited after the FAC was consulted to understand flooding in this area.

<u>500-Year Return Interval Flood (Appendix Figure A-20):</u> The depth grid shows flooding has not crossed the Watson Hollow Road but the FIRM map shows that several buildings near the town offices are inundated during this flood event. This contradiction is due to the cross section in the model not being extended far enough to capture the full floodplain width. This will be adjusted per direction of the FAC. The buildings just north of this area across the road are inundated with up to 4.0’ of water. The buildings south of Mulrooney Road have a 1.0’-4.0’ of water around them. The culvert along Burgher road is overtopped by greater depths. The map was edited after the FAC was consulted to understand flooding in this area.

Water Quality Assessment Data Review

There is very little overbank flooding during the 100-year flood and 1-2 homes may be inundated during this event. Pollution concerns from these residential buildings, which may contain chemicals and hazardous waste, are low since there is such few in number. At the 500-year event, more buildings are inundated including the Public Works buildings near the Town Offices. These buildings more than likely contain pollutants that would cause water quality concerns. However, the inundation frequency of these areas is very low.

There were six erosion hazards submitted by the public and the FAC. It is unclear if these erosion hazards are eroding banks which would provide a sediment source for water quality concerns or if the hazards are potential erosion hazards at bridge abutments. This will be clarified during subsequent FAC meetings and field investigations. Once the SFI data becomes available it will be reviewed to determine if there are other water quality concerns in the Study Area.

3.4.7 Identified Data Gaps and Proposed Field Methodology

The review of existing data identified several gaps that cannot fully explain existing or potential flood hazards or allow for informed mitigation solutions to be developed. The following outlines the questions that were raised, the methodology used to answer the questions and the results.

1. When were the stream spoil berms built (near the Town offices) and do they serve a purpose? The FAC was consulted and field data was collected using a Trimble 6000 handheld GPS device on July 2015 using SFI methodology. These were debris piles made by stream work completed by the US Army Corps of Engineers in 1985 and do not serve a purpose. These features do not protect infrastructure so they should be omitted from the LFA.

2. Near Hazard #5, is there a man-made feature that separates the low lying area between the Bushkill and Mulrooney Road? The FAC was consulted and field data was collected using a Trimble 6000 handheld GPS device (accuracy <1.0') on July 2015 using SFI methodology. This is a manmade berm built to protect the homes to the north and it should be considered in the LFA's recommendation for protection.

3. Is the potential flood hazard (the blue thread) on the south shore of the Watson Hollow Road bridge real? A total station survey was completed on July 2015 that measured the elevation profile of this depression and compared it to the channel elevation profile of the adjacent Bushkill. The elevation of the flow path and the road profile suggest that during the construction of the road, fill was placed in a historic flood path isolating it from the Bushkill. It is unlikely the Bushkill's flood waters will be able to inundate this path due to the height of the road. This potential flood hazard should be omitted.

4. Is the potential flood hazard (the blue thread) that runs parallel along Watson Hollow Road heading towards Route 28A real? A total station survey was completed on July 2015 to compare the Bushkill elevation profile with the elevations of the old flow path profile. The elevations between the two profiles suggest that floodwaters could occupy this flow path and it is a possibility that the Bushkill could migrate into this flow path which could then damage Route 28A. This flood hazard should be considered in the LFA.

5. What is the history of stream management practices in the Study Area? In particular: bank protection, channel excavation, bridge repair particularly on the Bushkill and how have they fared over time? The FAC was consulted and it is understood that overall stream management activities have been completed in the Study Area in recent memory. Most recently was a dredging and bulldozing exercise completed by the US Army Corps of Engineers in 1985 to remove debris. There was large wood removal in this area after Tropical Storm Irene as well.

6. How many houses were impacted by the culvert backing up on Burgher Road (hazard #0)? The FAC was consulted and several homes were isolated when the road overtopped. This hazard should be considered in the LFA.

7. Are there any buildings the FAC is aware of in the 100 year floodplain that are not shown? The FAC was consulted and no other buildings were known. During the July 2015 field visits, no other buildings were observed.

8. Are the erosion hazards along Watson Hollow Road or near the bridge abutments? The FAC was consulted and field data was collected using a Trimble 6000 handheld GPS device on July 2015 using SFI methodology. There were several vertical and lateral instabilities mapped during the field visits. These were deemed important and were considered in the LFA.

9. Which cross sections should be resurveyed? A section near critical infrastructure such as the fire house near the town offices (cross section Busk_04) and near the 1st Watson Hollow Bridge (Busk_07x) are recommended to be resurveyed. A total station survey was completed on July 2015 to collect the information and was inputted into the duplicative HEC-RAS model to correct it.

10. Cross section 3000 in the Bushkill model was not extended far enough and this could show more or less area being inundated around the Town Office. Should this be corrected in the model to see if the 500-year water surface elevation drops? HEC-GeoRAS was used to extend the cross section.

4.0 Boiceville Study Area

4.1 Watershed Characteristics that Impact Flooding Hazards

4.1.1 Topography and Climate

The Esopus Creek watershed begins roughly 28 miles away in the headwaters at Winnisook Lake and drains 191 mi^2 leading to the Study Area. The watershed drains rugged Catskill terrain with 21 peaks over 3,000 feet with the highest peak being Slide Mountain (4,180'). The channel elevation at the downstream extent of the Study Area where the Esopus meets the reservoir is 576'. This creates a steep gradient as water and sediment make a quick descent to and through the Study Area. The average channel slope is 1.5% and is classified as a mountainous stream and the majority of the valley widths range from 656' to 1,300' (CCEUC 2007). The climate in the watershed is characterized as humid continental with the amount of precipitation varying based on orographic lifting (at increasing elevations, more rainfall occurs). Annual precipitation varies from 36" to 60", elevation dependent. This elevation gradient, combined with the potential for large intense rainstorms, can transport water and debris (rocks and trees) into the Study Area quickly creating flooding hazards.

4.1.2 Surficial Geology

The underlying bedrock of the watershed consists mostly of sandstones, siltstones and shales (CCEUC 2007) and was "mined and scraped" by several rounds of ice ages over the last 1.3 million years. The bedrock was broken and pushed by ice sheets, some which were several thousand feet thick. Once the ice began to melt, the mined rocks (ranging in size from sands to boulders) were deposited into features that ranged upwards of hundreds of feet thick. These features, consisting of mostly sands, gravels and cobbles, were highly erodible since they lacked the cohesive properties typically found with compacted silts and clays. Melting glacial waters carried these materials downstream until they formed unconsolidated deposits. These unconsolidated highly erodible features (glacial outwash) are found lining most of Esopus Creek (CCEUC 2007).

4.1.3 Anthropogenic

The Esopus Creek watershed has been altered by human behavior (anthropogenic). European settlement of the watershed began in the 1700's and by the late 1800's, 80%-90% of the original forests were gone (Kudish 2000) for tanneries and kiln enterprises. The loss of original forest cover increased the amount of rainfall runoff from the stripped lands while decreasing the vegetation that held fragile soils together causing the land to erode. The increased amount of water and sediments rushed down the mountains slopes into the river valleys below. The resulting intersection of this wall of water and sediments at the valley floor caused the streams there to undergo severe changes due to increased rain runoff and the denuded stream banks consisting of highly erodible glacial outwash. Typical changes during this kind of instability are steep eroding stream banks, narrower water corridors (i.e. little to no connection to low lying floodplains) and often poor water quality.

Present day streams and rivers in the watershed are in some phase of recovery from the anthropogenic impacts. For example, the Stream Management Plan's baseline characterization was completed in 2005-2006 and showed river sections upstream of the Study Area had upwards of 26% to 53% of their stream banks actively eroding. Sands, gravels and cobbles (referred to as sediments), exposed by eroding banks and unstable streams, are moved downstream and deposited in certain areas. This condition, referred to as "infilling", results in the space that once was occupied by water now being occupied by these transported sediment. This often results in higher water surface elevations during flooding events because there is inadequate space within the river to move floodwaters.

Recent anthropogenic activities influencing the creek are infrastructure encroachments into the active floodplain. An example of this is the Route 28A (Five Arch) bridge approaches along the eastern stream bank which cut off upstream and downstream floodplains as seen in the TAFT map in Appendix Figure A-2.

4.1.4 Flooding History

The flow gage data was obtained from the USGS stream gage located upstream of the Boiceville Market (ID# 01362500). The top five historic flood events are listed below.

Table 3: Top Five Recorded Discharges at USGS Stream Gage #01362500

Rank	Year	Discharge (cfs)
1	2011	75,800
2	1980	65,300
3	1951	59,600
4	2005	55,200
5	1933	55,000

The discharges used in the HEC-RAS model were reviewed to determine the flood return interval of the discharges shown in Table 4. A return interval is a statistical term that describes the frequency a certain discharge will occur. For example, a 10-year return interval flood will statistically occur once in ten years. The discharges for the study area used in the HEC-RAS model are shown in the Table 4 below. The largest flood recorded at this station was the 2011 flood. This event was between the 50-year and the 100-year return interval flood. A FEMA Schedule Bulletin 17B analysis of the USGS stream gage (#01362500) data was completed using the Weibell plotting method and the station skew to compare to the discharges used in the duplicated HEC-RAS model. The 2011 flood was determined to be roughly a 75-year flood event. Another recent flood event occurred in 2005 and this flood was roughly a 35-year flood. Both of these flood events caused damage in the Boiceville Market area which further supports that the Market is located in a floodplain that is flooded during moderately sized floods.

Table 4: Flood Discharges From Preliminary FEMA Hydrologic Model

Return Interval	Discharge (cfs)
10-Year	30,440
25-Year	46,736
50-Year	63,747
100-Year	86,781
500-Year	169,597

4.1.5 Floodplain Development Ordinance and Related Town Planning Documents.

The existing Town of Olive floodplain development ordinance was authorized in 1987 (No.3-1987) and updated in September 2016 (No.2-2016). It defines the Statutory Authority and Purpose of the ordinance. Section 97-13 (E) Encroachments defines what activities are allowed within a delineated

FEMA floodplain and FEMA floodway. The ordinance meets the minimum federal standards for development within a delineated FEMA floodplain. The preliminary Flood Insurance Rate Map for the Study Area can be seen in Appendix Figure A-21. The area around the Boiceville Market is within a delineated FEMA floodplain. The Town of Olive does not have an official comprehensive planning document. A draft version was developed in 1975, 1995 and 2011 but none were adopted by the Town Board.

4.2 Boiceville Study Area Local Flood Analysis Summary

To organize the proposed mitigation solutions, the Boiceville Study Area is divided into four mitigation areas and can be seen in Appendix Figure B-1. The Boiceville mitigation area is bordered to the south near the Route 28A bridge over Esopus Creek in the hamlet of Boiceville. This mitigation area primarily focuses on the overbank flooding hazard caused by the Esopus and the associated flooding hazard caused by the Route 28A bridge. It ends approximately 2,500' upstream and includes the floodplains on the east and west stream banks. The second mitigation area is located further upstream on the same unnamed tributary that passes through a culvert under Upper Boiceville Road. The third mitigation area is centered on an unnamed tributary that passes through a culvert on DeSilva Road and then State Route 28 approximately 100 feet downstream. The last mitigation area analyzed was the State Route 28 Ponding mitigation area which focuses on the stormwater flooding hazard caused by an unnamed tributary that passes through a culvert underneath State Route 28 close to its intersection with Route 28A. It is believed that this hazard may flood the homes to the west of the tributary. The western portion of this mitigation area overlaps the eastern portion of the Boiceville mitigation area.

4.3 Boiceville Mitigation Area Summary

This mitigation area includes critically vital infrastructure such as Fire House Company #5, the Boiceville Market and the Sewage Treatment Plant. There are several other businesses and residences that have been damaged due to flooding. The Route 28A bridge is proposed to be replaced within the next five years. The bridge replacement design is ongoing and the LFA analysis was completed in unison with the preliminary bridge replacement design to ensure the proposed design would neither exacerbate existing flooding hazards nor limit future flood mitigation hazards.

4.3.1 Hydraulic Approach

As stated previously, a major change in the Boiceville mitigation area will be the replacement of the Route 28A bridge over the Esopus which is scheduled to be replaced within 5 years. The LFA solutions and Route 28A bridge replacement design were worked on in tandem to ensure the proposed bridge crossing would not impede possible flood mitigation solutions. This process is explained in the 2016 "Town of Olive Local Flood Analysis 28A bridge replacement and Boiceville Study Area Flood Mitigation Strategies" report (WEC 2016). The preferred bridge alternative would match the existing bridge's overall clear span and would feature a revised three span bridge (two support piers) configuration that would obstruct less flow area than the existing bridge configuration.

The presented mitigation solutions assume the three span bridge will be in place. Consequently, the proposed mitigation solution conditions were compared to future "existing conditions" which assumed the proposed three span bridge is in place. The procedures for developing the future "existing conditions" can be reviewed in the WEC 2016 report. The efficacy of the proposed mitigation solutions compare the proposed water surface elevations to the future "existing conditions" water surface elevations.

4.3.2 Existing Hydraulic Conditions and Water Depths

The water depth maps as seen in Figure 13 and (Appendix Figures B-2 through Figure B-7) were developed using the WEC corrected model.

As seen in Appendix Figure B-6, (the 100 year water depth map, there are 17 buildings surrounded by water during the 100-year flood and most of the buildings are shown to have water around the foundations starting at the 25-year flood (Appendix Figure B-3). Figure 13 is a close up of Appendix Figure B-3 and shows there is approximately 1-2' of water in the Boiceville Market (Building B-16) during the 25-year flood. Interviews of community members reported around 2' of water during the 2005 flood which closely matches the 25-year flood water depth map.

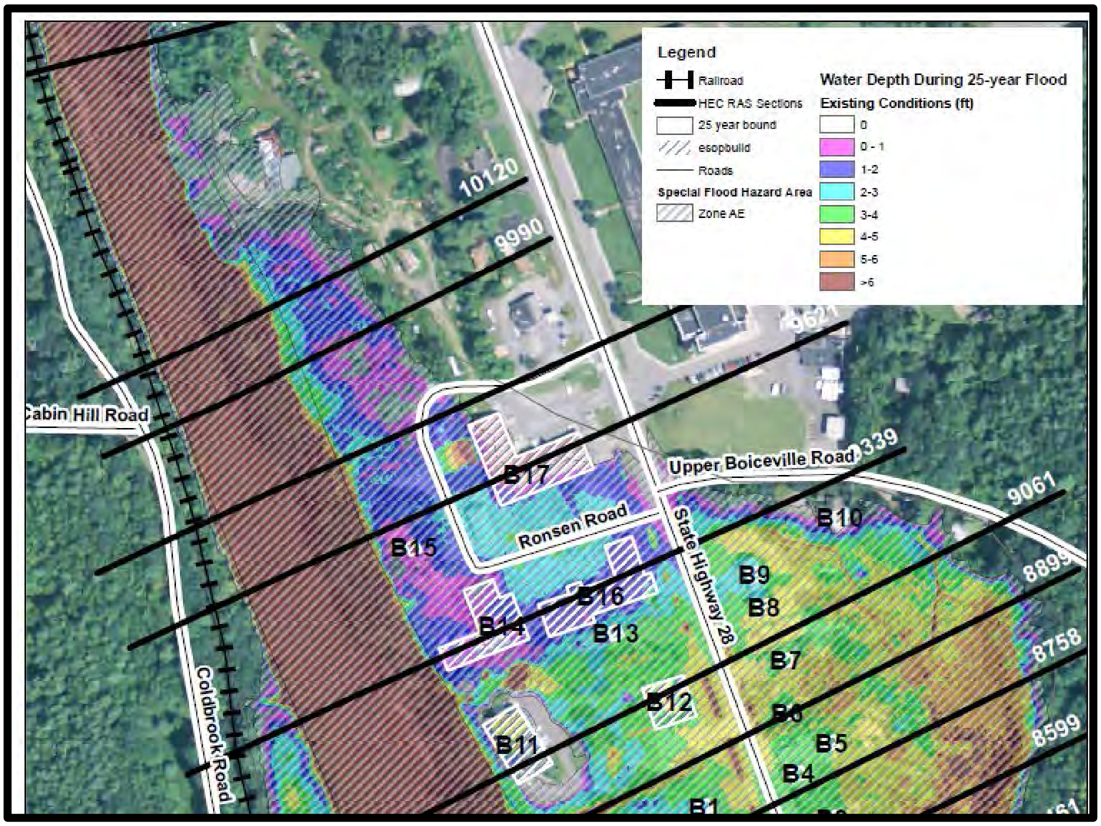


Figure 13: Water Depths Around the Boiceville Market (B-16) during the 25 year flood.

4.3.3 Flood Hazard Mitigation Solution Summary:

The proposed mitigation solutions are presented as separate sections in this report. Each solution contains the following: a description and exhibit of the proposed mitigation activity, a conceptual construction cost, the reduction of water surface elevations at points of interest (POI), benefit to cost ratios, challenges and opportunities for implementation, water quality protection and potential funding sources for each solution.

Only the mitigation solutions that work in tandem with the proposed three-span bridge were included in this report. To avoid confusion from mitigation solution plan names during the LFA process, the original mitigation solution plan names were retained and therefore the plan names may not be in numerical order. A complete list of solutions is presented in Table 5.

Proposed mitigation solutions included Flood Damage Prevention, Property Protection, Structural Projects and Community Pollution Prevention. The lowering of adjacent land, referred to a floodplain bench is an example of a Flood Damage Prevention solution that was modeled and vetted by the FAC. Increasing the clear span (the bridge width) of the three arches bridge (a Structural Project) was modeled to understand the relationship between bridge width and flood water elevation. Property Protection solutions included raising first floor elevations of certain buildings or the potential for buyouts and buyouts with possible relocations.

For each solution a table will be presented outlining the priority metrics for the solution. The metrics are summarized in Table 6 on page 40.

Table 5: List of Preliminary Mitigation Solutions

Mitigation Plan #	Mitigation Plan Description	Hydraulic Analysis?	Benefit Cost Analysis?
1	Proposed four span Route 28A bridge. Grade floodplain bench on eastern stream bank. Floodplain bench would be to the east of B11. Relocate buildings B14 and B15. B1 would remain.	No	No
2	Same as Mitigation Plan #1 but an earthen berm would be placed. B1 would remain.	No	No
3	Proposed four span Route 28A bridge. Grade floodplain bench on eastern stream bank. Floodplain bench would be to the east and west of B11. Relocate buildings B14 and B15. B1 would remain.	No	No
4	Proposed three span Route 28A bridge. Grade floodplain bench on eastern stream bank. Floodplain bench would be to the east of B11. Relocate buildings B14 and B15. B1 would remain.	Yes	Yes
5	Same as Mitigation Plan #4 but a flood protection facility levee (an earthen berm) would be placed. Relocate buildings B1, B14 and B15.	Yes	Yes
6	Proposed four span Route 28A bridge. Grade floodplain benches on eastern and western stream banks. Floodplain bench would be to the east of B11. Relocate buildings B14 and B15. B1 would remain.	No	No
7	Same as Mitigation Plan #4 but completely remove Route 28A bridge and both approaches.	Yes	Yes
8	Proposed three span Route 28A bridge. Grade floodplain bench on eastern stream bank. Floodplain bench would be to the east of B11. Relocate buildings B14, B15 and B1. Raise SR 28 road profile to protect up to 50-year flood.	No	No
9	Proposed three span Route 28A bridge. Install a flood protection levee system only. Relocate buildings B1, B14 and B15	Yes	Yes
9A	Same as Mitigation Plan #9 but completed in two phases. The first phase is to Relocate buildings B1, B14 and B15. The second phase is to build the flood protection system.	Yes	Yes
10	Lower 1,500 linear feet of the Esopus Creek by a depth of 5’ (dredging)	Yes	No

Mitigation Plan #	Mitigation Plan Description	Hydraulic Analysis?	Benefit Cost Analysis?
11	Relocate 28A bridge and waste water treatment plant and install wider floodplain benches than in Mitigation Plans #4, #5 and #7.	Yes	No
12	Town to complete a plan to identify new developable land and zoning changes (if applicable) to relocate buildings out of flood prone areas	Yes	Yes
13	Structural improvements (raise first floor elevations) of qualified buildings.	Yes	Yes

Table 6: Priority Metrics for Mitigation Solutions

Priority Metric name	A "high" score description	A "moderate" score description	A "low" score description
Benefit to Cost Ratio	The 75th or greater percentile of proposed mitigation solutions for the mitigation area	The 50th to 75th percentile of proposed mitigation solutions for the mitigation area	Less than the 50th percentile of proposed mitigation solutions for the mitigation area
Water Quality Protection	>5 chemical or natural occurring water pollution sources mitigated	3-5 chemical or natural occurring water pollution sources mitigated	1-2 chemical or natural occurring water pollution sources mitigated
Community Cohesion Preservation	No or minimal disturbance to existing community layout (1-2 private residences needing relocation)	3-5 private residences needing relocation or 1-2 non anchor businesses needing relocation	>5 private residences need relocation, 1 or more anchor businesses needing relocation,
Ease of Obtaining Permits for Proposed Solution	Little challenges perceived obtaining environmental permits	Little to moderate number of challenges perceived obtaining environmental permits	Moderate to High number of challenges perceived obtaining environmental permits
Economic Impact	Solution has little negative impact or maintains or improves the local economy	Solution has little to moderate negative impact to local economy	Solution has moderate to high negative impact to local economy
Ease of Obtaining Funding	Good confidence that two or more sources of funding could be used to implement solution	Moderate to good confidence that one source of funding could be used to implement solution	Low confidence that funding could be obtained to implement solution
Ease to Acquire Easements	Solution would require 1-2 parcels of land to have an easement	Solution would require 3-5 parcels of land to have an easement	Solution would require >5 parcels of land to have an easement or require a parcel of land with deed restrictions
-Level of Town Effort to Implement Plan	Low level of effort required by town	Moderate level of effort required by town	High level of effort required by town
Numerical Value of Scores	5	3	1

4.3.4 Plan #4 - Floodplain Benches Only

Summary: The floodplain will be lowered starting 350 ft downstream of the existing Route 28A bridge and ending 1,600 ft upstream of the bridge. The average width of this cut area will be 90' and it will be lowered on average 2.5'. This cut will form a floodplain bench which will be seeded with native grasses and lined along the stream bank with willows and other herbaceous native shrubs. The goal of the floodplain bench is to increase the available volume to pass flood waters. The top of the bench will be set at an elevation such that it will be inundated during frequent flood events (less than a 2.0 year flood).

Results: This plan will reduce water surface elevations during the 25-year return flood by on average of 0.3' (~4"). This will eliminate flooding during this return interval flood in the Boiceville Market. This can be observed in the Figure 14 (25-year flood) and in Appendix Figure B-9 (100 year flood). This plan has minimal impact to water surface elevations during moderate to large floods as seen by the continued water depths during the 25-year flood in Figure 14. The difference between the two water surface elevations before and after the mitigation solution remains the same.

Despite the increased conveyance in flood water volume created by the floodplain bench, the buildings in Boiceville remain inundated during moderate and large flood events. These buildings are located in a moderately low lying floodplain (Figure 1) and in an unusually wide part of the valley (1,600' of active floodplain) when compared to the creek upstream (<500' of active floodplain) as described in Section 3.3.1. Floodwaters, when flowing through a constrained area (upstream of Boiceville) flow much faster than the floodwaters at a proximal wider area (at Boiceville). When this happens, water surface elevations tend to rise as the water spreads out into the floodplain. In these cases, increasing flood water conveyance alone may not solve the inundation hazard.

***Benefit to Cost Ratio**:* The cost of construction is estimated to be $2,449,600 (including building relocation which was the sum of all improvement values to the parcels where buildings are proposed to be relocated). The estimate is shown in Appendix Figure B-10. Using the FEMA's BCA version 5.1.0 short form, the preliminary benefit to cost ratio was 0.15 as shown in Table 9 and in the summary reports (Appendix Figures B-11 and B-12). The low preliminary BCR was due to the continued inundation of the buildings beginning at the 25-year return interval flood.

Implementation Challenges and Opportunities: Two buildings (B14, B15) will need to be relocated to complete the floodplain bench construction. One of the buildings is an active business, the other is a vacant building. The proposed floodplain bench also crosses several private land parcels and permanent easements that would need to be obtained to allow the construction and maintenance of the floodplain bench. The floodplain bench would need to be maintained (brush hogged and cleared) to prevent large trees from growing that could reduce flood water conveyance.

***Funding Sources**:* With a low preliminary BCR score (0.15) and continued inundation to buildings, funding for this project will be difficult to obtain.

Water Quality Protection: Continued inundation under proposed conditions will not reduce water quality pollution.

Prioritization:

Table 7: Prioritization Score for Boiceville Plan 4

Priority Metric name	Score	Numerical Value
Benefit to Cost Ratio	Low	1
Water Quality Protection	Low	1
Community Cohesion Preservation	Moderate	3
Ease of Obtaining Permits for Proposed Solution	High	5
Economic Impact	Moderate	3
Ease to Acquire Funding	Low	1
Ease to Acquire Easements	Moderate	3
Level of Town Effort to Implement Plan	Low	1
Total Score		**18**

Table 8: Comparison of Existing and Plan 4 Water Depths in Feet

	100 Year Flood			**50 Year Flood**			**25 Year Flood**		
Point of Analysis	Existing	Plan 4	Delta	Existing	Plan 4	Delta	Existing	Plan 4	Delta
1	5.2	5.1	-0.1	2.2	2	-0.2	0.4	0	-0.4
2	6.6	6.8	0.2	3.1	3.1	0	0.7	0.4	-0.3
3	7	7.2	0.2	3.5	3.5	0	1.1	0.8	-0.3

Table 9: Plan 4 BCR Results

Number of Structures / Work Item	Benefits	Costs
17 (damages avoided)	$368,234	
2 (demo/relocation)		$961,510
Construction		$1,159,090
- Engineering/Design/Survey (12%)		$139,080
- Contingency (15%)		$174,000
Extend Sewer		$155,000
TOTALS	**$368,234**	**$2,449,600**
Benefit to Cost Ratio (BCR)	**0.15**	

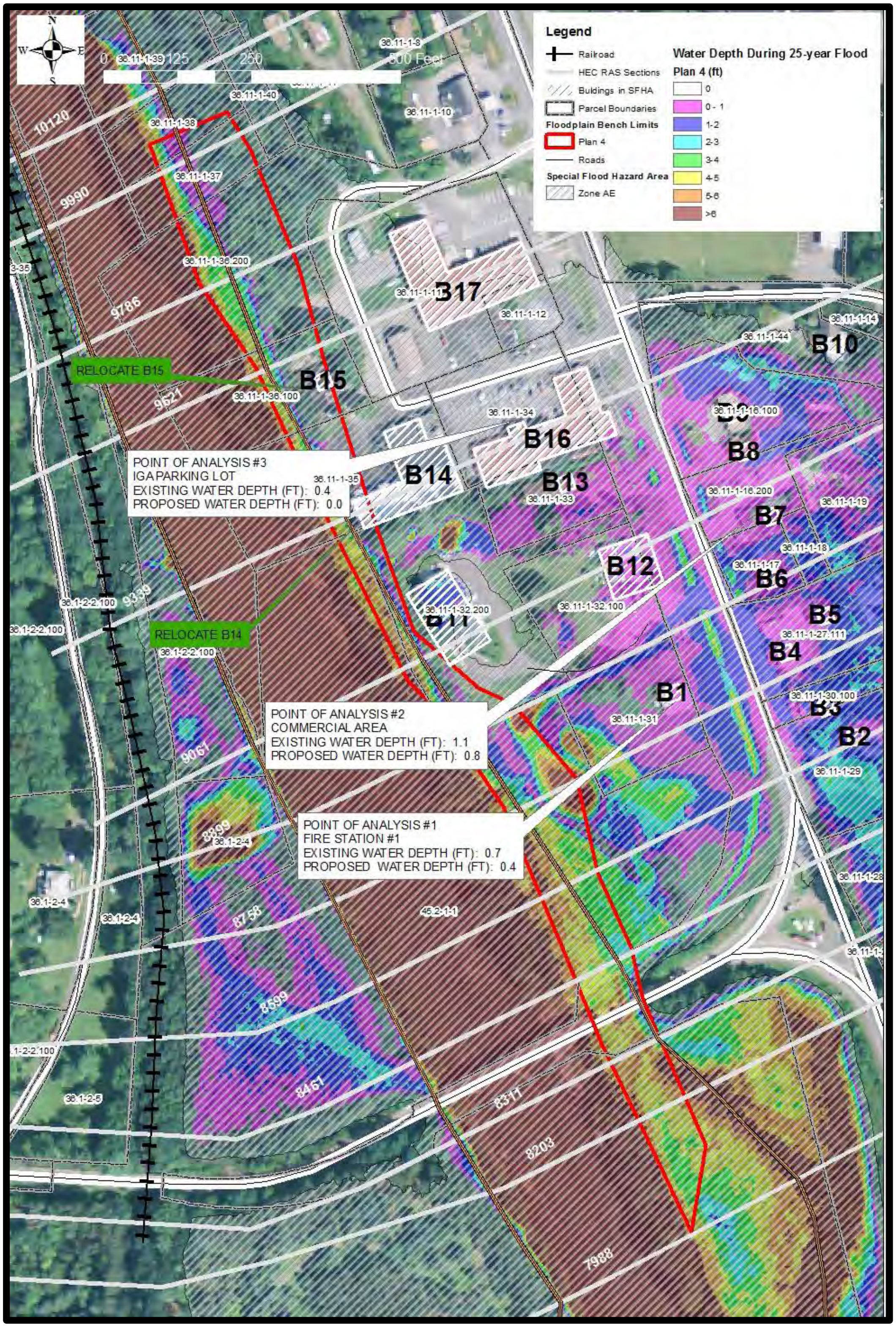


Figure 14: Conceptual Layout of Plan 4

4.3.5 Plan #5 - Floodplain Benches and Flood Levee System

This plan would mirror Plan #4 and include a flood protection facility (an earthen berm) which would protect the majority of buildings from flooding hazards. The alignment of the earthen berm allows the Esopus to flood into its floodplains unimpeded during a moderate flood event (10-year flood event) while minimizing the number of buildings that would need to be relocated.

Buildings B1, B14 and B15 would need to be relocated in order to construct the flood protection facility. Funds are available through CWC and DEP for the purchase of the existing structures and property and assistance with some of the potential relocation costs for these properties.

The proposed flood protection system should meet FEMA certification requirements for flood protection systems to ensure building owners landward of the berm would receive discounts on flood insurance premiums. As such, the elevation of the top of the earthen levee was set to meet NFIP regulation 65.10(b) which states the levee elevation should exceed the BFE (base flood elevation also referred to as the 100-year flood event) by three feet, 3.5' at the upstream end of the levee. The crest of the levee would be 10' wide with three horizontal to one vertical side slopes (for mowing). The base's footprint would be 70' wide where it meets the downstream high ground near the Route 28A and State Route 28 intersection and be 50' wide where it meets upstream high ground northwest of building B17 (Figure 15 on page 48). It would be on average 6' high between the upstream high ground and building B11 and on average 9' high between B11 and the downstream high ground.

To be a FEMA accredited flood levee, besides meeting the height requirements, the levee must protect critical infrastructure landward of the flood protection system. Buildings B1 and B11 (Fire House Company #5 and the wastewater treatment plant, respectively) are the two pieces of critical infrastructure in Boiceville. At building B1, the 500-year flood elevation is 16.5' higher than the 100 year flood elevation. FEMA requires critical infrastructure to be protected to the BFE plus 3' feet freeboard or the 500[1] year flood elevation, whichever is higher. Therefore, it is unrealistic to protect B1 so it should be relocated to an area that is not prone to flooding. Building B11 is so close to the floodway (<15'), it is not possible to put the levee riverward of this building so this building cannot be protected. The levee could be put landward of the building which would require the driveway to building B11 to be graded over the levee. By having the levee landward of the wastewater treatment plant, the levee could be accredited by FEMA (i.e. flood insurance premiums for the landowners landward of the levee would go down) but the treatment plant itself would not be protected.

The levee would tie into the parking lot of building B11. It is assumed that the fill built to the parking lot and the waste water treatment plant was compacted to industry standard to prevent settling which is similar to the compaction rate requirements for FEMA levees. The base of the wastewater treatment plant is 150' wide which is more than double the width of the levee and it is assumed that this is adequate to meet hydrostatic design criteria.

Two pumping stations would be needed to drain the landward side of the levee. The purpose of the pumps is to protect the buildings landward of the levee if interior flooding were to occur at the same time as exterior flooding conditions. To meet FEMA accreditation guidelines, the pumps must keep inlet

[1] As noted in section 3.3.4 and 3.3.5, there is uncertainty with the 500-year discharge and its predicted water surface elevation using the corrected effective hydraulic model but it was assumed that the predicted 500-year water surface elevation is reasonable for use in the LFA.

water depths to a foot or less during the design flooding conditions of the levee (when floodwater elevations match the levee's top elevation). If the levee elevation is exceeded by floodwaters, the pumps are no longer required to meet their design conditions. The first pumping station (Pumping station "A") is located near building B1 where an existing stormwater drainage ditch would be reconfigured to drain underneath the levee in a culvert with flap gate. This pumping station would drain approximately 10 acres west of State Route 28. East of State Route 28, as described in Section 4.6, there is a tributary that flows through a culvert underneath the highway. The tributary features a wetland between it and the highway. Assuming a flap gate is constructed on the culvert under State Route 28 which would cause the tributary to backwater if the flap gate was closed during flooding on the Esopus, it is desirable to avoid flooding the proximal buildings. Under existing conditions, this wetland stores a large volume of water during flooding conditions (a 500-year flood on the tributary) resulting in only one building, B3, being inundated by 0.9' of water (as described in Section 4.6). Therefore with modest grading, a pumping station could keep all the proximal buildings dry when the tributary is flooding. A three foot earthen berm would to be placed between the buildings and wetland to maintain freeboard requirements. The cumulative length of all berms is 1,900'.

Results: The proposed levee provides protection to all landward buildings at the 100-year flood event (Figure 15 on page 48). The additional freeboard above the water surface elevation also protects the buildings from larger flood events. It does not protect from inundation during the 500-year flood since the water surface elevation during this event is notably higher.

Benefit to Cost Ratio: The cost of Plan #5 is estimated to be $3,905,300 (including building relocation, constructing the flood protection system and floodplain benches, engineering costs, etc.). The estimate can be seen in Appendix Figure B-14. Using FEMA's BCA version 5.1.0 short form, the preliminary benefit to cost ratio was 0.63 (Table 12 on page 47) and the summary report can be seen in Appendix Figures B-15 and B-16. The short form BCR does not allow for annual maintenance costs to be included in the BCR calculation but it is assumed the annual costs will not reduce the BCR cost to a degree that would influence a decision about this plan. The BCR includes the relocation of buildings B1, B14 and B15 and their associated demolition costs.

Implementation Challenges and Opportunities: The proposed flood protection system crosses several private land parcels and a NYSDOT right of way. Permanent easements would need to be obtained to allow the construction and maintenance to be completed.

Accrediting a flood levee system can be an arduous task which requires involvement with state and federal governments. The length of time from implementation to end of construction is usually at least 5 years.

A primary benefit would include the reduction of flood insurance premiums since the buildings on the landward side of the levee would be rezoned from a Zone AE to a Zone X. This reduction could exceed 50% savings in annual premiums. Also, buildings landward of an accredited levee system maintain more resale value than buildings in Zone AE.

The flood levee system will require maintenance to remain FEMA accredited such as mowing, engineering inspection, etc. Interior pumping stations also require annual maintenance to ensure the pumps are working properly. The annual maintenance cost is expected to range between $6,400 (3 dollars per linear foot of levee and 700 dollars for pump station maintenance) to $15,000 (2% of the construction cost for levees and pump stations). In case of damage to the levee and pumps, the US Army Corps of Engineers has a Rehabilitation Assistance Program for FEMA accredited levees that costs shares (80% federal, 20% local) the repair cost. The 20% local match can be in-kind contribution i.e. labor, etc.

Funding Sources: The preliminary BCR score of 0.65 does not meet the typical minimal threshold of 1.0 for submission of a grant for FEMA hazard mitigation sources. Neither the CWC FHMIP nor the Ashokan Stream Management Program will fund the construction of a flood protection system. Costs of purchase, structural demolition, and relocation of B1, B14, and B15 may be eligible under the NYCFFBO and the CWC FHMIP. Other potential funding sources may be with State flood hazard mitigation programs. Municipal bonds may be another source of capital to build the berms, but interest costs should be incorporated as part of the cost analysis.

Water Quality Protection: Inundation to the 100-year flood elevation does not exist. Sources of water pollution from seventeen buildings will be substantially mitigated.

Prioritization:

Table 10: Prioritization Score for Boiceville Plan 5

Priority Metric name	Score	Numerical Value
Benefit to Cost Ratio	Low	1
Water Quality Protection	Moderate	3
Community Cohesion Preservation	Moderate	3
Ease of Obtaining Permits for Proposed Solution	Moderate	3
Economic Impact	Moderate	3
Ease to Acquire Funding	Low	1
Ease to Acquire Easements	Low	1
Level of Town Effort to Implement Plan	Low	1
Total Score		16

Table 11: Comparison of Existing and Plan 5 Water Depths in Feet

	100 Year Flood			50 Year Flood			25 Year Flood		
Point of Analysis	Existing	Plan 5	Delta	Existing	Plan 5	Delta	Existing	Plan 5	Delta
1	5.2	0.0	-5.2	2.2	0.0	-2.2	0.4	0.0	-0.4
2	6.6	0.0	-6.6	3.1	0.0	-3.1	0.7	0.0	-0.7
3	7	0.0	-7.0	3.5	0.0	-3.5	1.1	0.0	-1.1

Table 12: Plan 5 BCR Results

Number of Structures / Work Item	Benefits	Costs
15 (damages avoided)	**$2,475,438**	
3 (demo/relocation)		$1,214,510
Construction, materials		$2,118,590
- Engineering/Design/Survey (12%)		$254,220
- Contingency (15%)		$318,000
TOTALS	**$2,475,438**	**$3,905,320**
Benefit to Cost Ratio (BCR)	**0.63**	

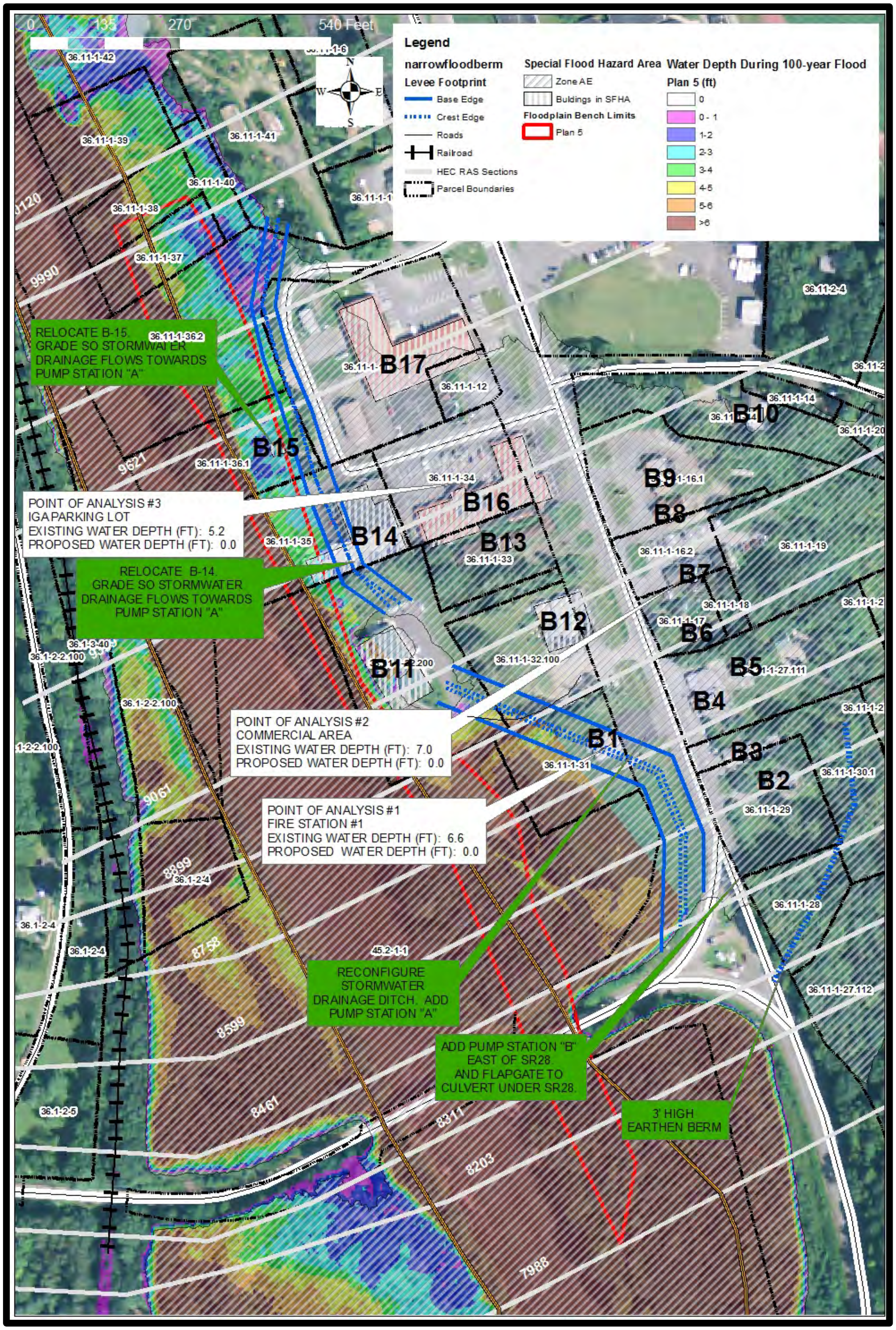


Figure 15: Conceptual Layout of Plan 5

4.3.6 Plan #7-Floodplain Benches and Relocation of Route 28A Bridge

Summary: Plan 7 would also build upon Plan 4 by proposing the removal of the Route 28A bridge crossing and all its' related approach fill. The purpose of Plan 7 is to see what would be the potential reduction to flood water elevations if all the obstructions related to the Route 28A bridge were removed. This includes the bridge, the earthen fill from the bridge eastwards to the Route 28A/State Route 28 "Y" intersection and the fill associated with the approach on the western stream bank. The proposed floodplain bench dimensions are roughly the same as Plan 4. The proposed relocation for the Route 28A bridge crossing could be near the State Route 28 and Piney Point Road intersection or approximately 1,500 ft north of the Winnie Road and State Route 28 intersection.

Results: The proposed actions reduce water surface elevations notably. In Appendix Figure B-3 (25-year flood), note the shallow water depths around all the buildings and inundation to the buildings east of State Route 28 occurs from the backwatering of the Esopus up the unnamed tributary. This could be completely eliminated with installation of a flap gate on the culvert underneath State Route 28. From Figure 16 on page 51, it appears the water around building B12 and B13 could be completely eliminated by filling in a low lying area between the sewage treatment plant and the Boiceville Market. Water depths are still on average greater than 3.0' during the 100-year flood (Appendix Figure B-18) and are over 5' at Point of Analysis #3 (see Table 11 on page 46). This solution will eliminate nuisance flooding up to the 25-year flood but the mitigation area will still be inundated at larger flood events (50-year flood or greater). The water surface elevations during the 500-year flood are reduced by more than seven feet on average, which shows the impact of the bridge crossing on extreme flood events. On average, relocating the bridge reduces the 100-year water surface elevations 1.5'. However, removing the bridge obstructions and increasing floodwater conveyance (floodplain benches) does not solve the flooding problems in Boiceville during more extreme flood events.

Benefit to Cost Ratio: The cost of construction is estimated to be $2,588,000 (including building relocation) and the estimate can be seen in Appendix Figure B-19. Using the FEMA's BCA version 5.1.0 short form, the preliminary benefit to cost ratio was 0.37 (Table 15) and the summary report can be seen in Appendix Figures B-20 and B-21. The construction cost assumed all the costs associated with removing the bridge infrastructure and its approach fill and the required costs to upgrade Cold Brook Road to be the new Route 28A would be part of the Route 28A bridge relocation. The low preliminary BCR was due to the continued inundation of the buildings beginning at the 25-year return interval flood.

Implementation Challenges and Opportunities: Two buildings (B14, B15) will need to be relocated to complete the floodplain bench construction. One of the buildings is an active business, the other is a vacant building. The proposed floodplain bench also crosses several private land parcels and permanent easements would need to be obtained to allow the construction and maintenance to be completed. The Flood Advisory Committee did not believe DEP (the funding agency for the Route 28A bridge rebuild) would consider moving the bridge out of the way without a significant reduction in water surface elevations. Plan 7's floodplain benches alone do notably reduce water surface elevations during moderate and large events but relatively deep water elevations do remain during the 50-year and 100-year flooding events so it is unlikely this activity is feasible. For this reason other interactions that assume the bridge would be removed (such as adding a flap gate to the State Route 28 culvert) were not completed.

Funding Sources: With a low preliminary BCR score (0.37) and continued inundation to buildings, funding for this project will be difficult to obtain.

Water Quality Protection: Continued inundation under proposed conditions beginning approximately when inundation under existing conditions will not reduce water quality pollution.

Prioritization:

Table 13: Prioritization Score for Boiceville Plan 7

Priority Metric name	Score	Numerical Value
Benefit to Cost Ratio	Moderate	3
Water Quality Protection	Low	1
Community Cohesion Preservation	Moderate	3
Ease of Obtaining Permits for Proposed Solution	High	5
Economic Impact	Moderate	3
Ease to Acquire Funding	Low	1
Ease to Acquire Easements	Moderate	3
Level of Town Effort to Implement Plan	Moderate	3
Total Score		22

Table 14: Comparison of Existing and Plan 7 Water Depths in Feet

	100 Year Flood			50 Year Flood			25 Year Flood		
Point of Analysis	Existing	Plan 7	Delta	Existing	Plan 7	Delta	Existing	Plan 7	Delta
1	5.2	3.8	-1.4	2.2	0.9	-1.3	0.4	0.0	-0.4
2	6.6	4.8	-1.8	3.1	2.1	-1.1	0.7	0.1	-0.6
3	7	5.6	-1.4	3.5	2.4	-.9	1.1	0.0	-1.1

Table 15: Plan 7 BCR Results

Number of Structures / Work Item	Benefits	Costs
15 (damages avoided)	$964,667	
2 (demo/relocation)		$961,510
Construction, materials		$1,314090
- Engineering/Design/Survey (12%)		$126,000
- Contingency (15%)		$174,000
Extend Sewer		$139,080
TOTALS	**$964,667**	**$2,588,680**
Benefit to Cost Ratio (BCR)	**0.37**	

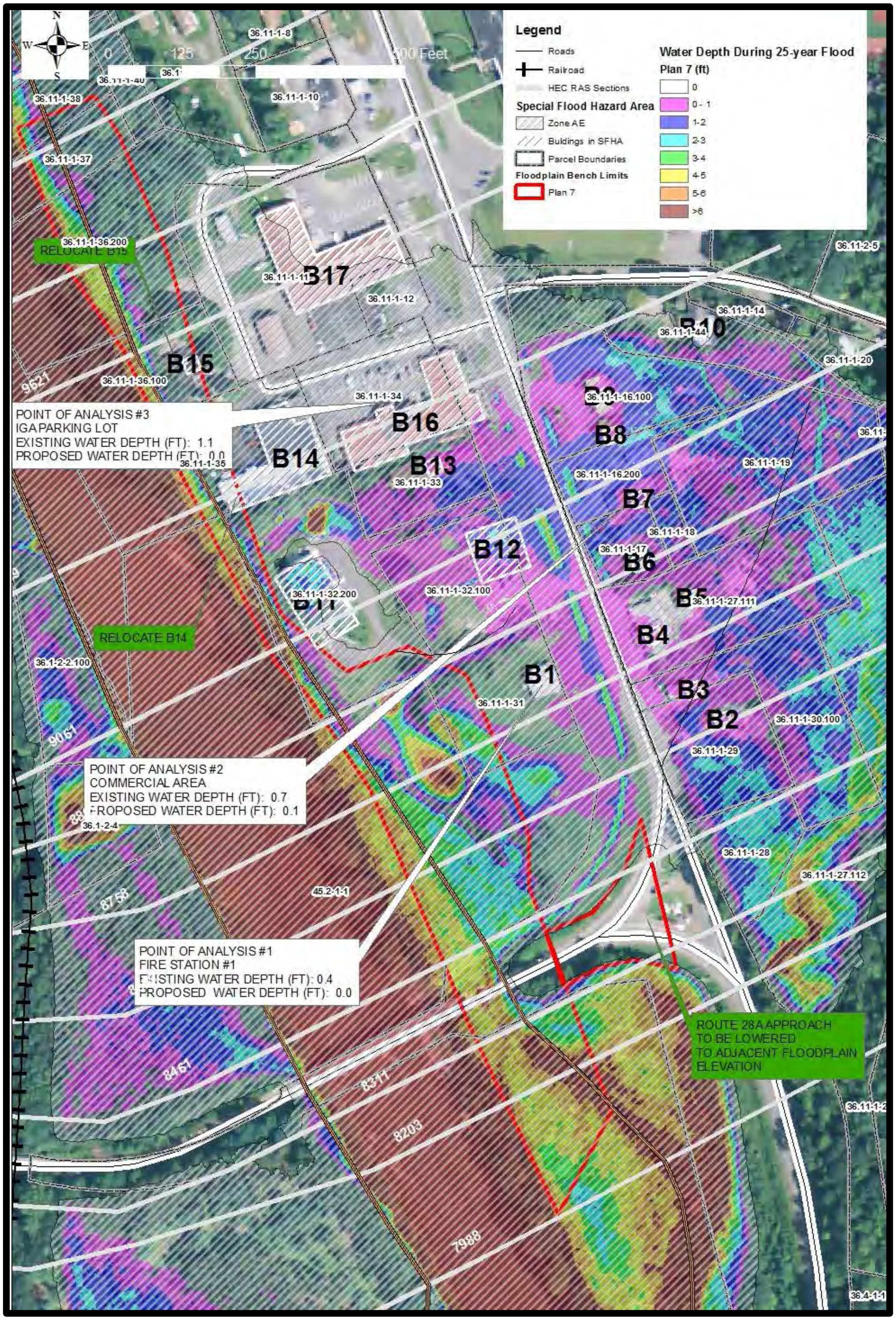


Figure 16: Conceptual Layout of Plan 7

4.3.7 Plan #9 - Flood Levee System Only

***Summary**:* Plan 9 would mirror Plan 5 but would not include floodplain benches. This plan would feature an earthen berm (flood levee system) to be constructed that would protect the majority of buildings from flooding hazards. The alignment of the earthen berm allows the Esopus to flood into its floodplains unimpeded during a moderate flood event (10-year flood event) while minimizing the number of buildings that would need to be relocated.

Buildings B1, B14 and B15 would need to be relocated in order to construct the flood protection facility. Funds are available through CWC and DEP for the purchase of the existing structures and property and assistance with some of the potential relocation costs for these properties.

The proposed flood protection system should meet FEMA certification requirements for flood protection systems to ensure building owners landward of the berm would receive discounts on flood insurance premiums. As such, the elevation of the top of the earthen levee was set to meet NFIP regulation 65.10(b) which states the levee elevation should exceed the BFE (base flood elevation also referred to as the 100-year flood event) by three feet, 3.5' at the upstream end of the levee. The crest of the levee would be 10' wide with three horizontal to one vertical side slopes (for mowing). The base's footprint would be 70' wide where it meets the downstream high ground near the Route 28A and State Route 28 intersection and be 50' wide where it meets upstream high ground northwest of building B17 (Figure 18 on page 56). It would be on average 6' high between the upstream high ground and building B11 and on average 9' high between B11 and the downstream high ground.

To be a FEMA accredited flood levee, besides meeting the height requirements, the levee must protect critical infrastructure landward of the flood protection system. Buildings B1 and B11 (Fire House Company #5 and the wastewater treatment plant respectively) are the two pieces of critical infrastructure in Boiceville. At building B1, the 500-year flood elevation is 16.5' higher than the 100 year flood elevation. FEMA requires critical infrastructure to be protected to the BFE plus 3' feet freeboard or the 500[2] year flood elevation, whichever is higher. Therefore, it is unrealistic to protect B1 so it should be relocated to an area that is not prone to flooding. Building B11 is so close to the floodway (<15'), it is not possible to put the levee riverward of this building, so this building cannot be protected. The levee could be put landward of the building which would require the driveway to building B11 to be graded over the levee.

The levee would tie into the parking lot of building B11. It is assumed that the fill built to the parking lot and the waste water treatment plant was compacted to industry standard to prevent settling which is similar to the compaction rate requirements for FEMA levees. The base of the wastewater treatment plant is 150' wide which is more than double the width of the levee and it is assumed that this is adequate to meet hydrostatic design criteria.

Two pumping stations would be needed to drain the landward side of the levee. The purpose of the pumps is to protect the buildings landward of the levee if interior flooding were to occur at the same time as exterior flooding conditions. To meet FEMA accreditation guidelines, the pumps must keep inlet water depths to a foot or less during the design flooding conditions of the levee. If the levee elevation is

[2] As noted in section 3.3.4 and 3.3.5, there is uncertainty with the 500-year discharge and its predicted water surface elevation using the corrected effective hydraulic model but it was assumed that the predicted 500-year water surface elevation is reasonable for use in the LFA.

exceeded by floodwaters, the pumps are no longer required to meet their design conditions. The first pumping station (Pumping station "A") is located near building B1 where an existing stormwater drainage ditch would be reconfigured to drain underneath the levee in a culvert with flap gate. This pumping station would drain approximately 10 acres west of State Route 28. East of State Route 28, as described in section 4.6, there is a tributary that flows through a culvert underneath the highway. The tributary features a wetland between it and the highway. Assuming a flap gate is constructed on the culvert under State Route 28 (which would cause the tributary to backwater if the flap gate was closed during flooding on the Esopus), it is desirable to avoid flooding the proximal buildings. Under existing conditions, this wetland stores a large volume of water during flooding conditions (a 500-year flood on the tributary) resulting in only one building, B3, being inundated by 0.9' of water (as described in Section 4.6). Therefore with modest grading, a pumping station could keep all the proximal buildings dry when the tributary is flooding. A three foot earthen berm would need to be placed between the buildings and wetland to maintain freeboard requirements. The cumulative length of all berms is 1,900'.

Results: The proposed levee provides protection to all landward buildings at the 100-year flood event (Figure 18 on page 56). The additional freeboard above the water surface elevation also protects the buildings from larger flood events. It does not protect from inundation during the 500-year flood since the water surface elevation during this event is notably higher. The proposed activities increase velocity modestly (<0.2 ft/sec as seen in Table 18 on page 55) which does not increase erosional concerns at the waste water treatment plant which is armored by large stone (Figure 17 on page 55).

Benefit to Cost Ratio: The cost of Plan #9 is estimated to be $2,548,600 (including building relocation, constructing the flood protection system, engineering costs, etc.) and the estimate can be seen in Appendix Figure B-23. Using the FEMA's BCA version 5.1.0 short form, the preliminary benefit to cost ratio was 0.97 (Table 19 on page 55). The summary report can be seen in Appendix Figures B-24 and B-25. The short form BCR does not allow for annual maintenance costs to be included in the BCR calculation but it is assumed the annual costs will not reduce the BCR cost to a degree that would influence a decision about this plan. The BCR includes the relocation of buildings B1, B14 and B15 and their associated demolition costs.

Implementation Challenges and Opportunities: The proposed flood protection system crosses several private land parcels and a NYSDOT right of way. Permanent easements would need to be obtained to allow the construction and maintenance to be completed.

Accrediting a flood levee system can be an arduous task which requires involvement with state and federal governments. The length of time from implementation to end of construction usually is at least 5 years. The Federal Emergency Management Agency (FEMA) website contains a "Levee Resources Library", which can be accessed online at https://fema.gov/fema-levee-resources-library.

A primary benefit would include the reduction of flood insurance premiums since the buildings on the landward side of the levee would be rezoned from a Zone AE to a Zone X. This reduction could exceed 50% savings in annual premiums. Also, buildings landward of an accredited levee system maintain more resale value than buildings in Zone AE.

The flood levee system will require maintenance to remain FEMA accredited such as mowing, engineering inspection, etc. Interior pumping stations also require annual maintenance to ensure the pumps are working properly. The annual maintenance cost is expected to range between $6,400 (3 dollars per linear foot of levee and 700 dollars for pump station maintenance) to $15,000 (2% of the construction cost for levees and pump stations). In case of damages to the levee and pumps, the US Army Corps of Engineers has a Rehabilitation Assistance Program for FEMA accredited levees that costs shares (80% federal, 20% local) the repair cost. The 20% local match can be in-kind contribution i.e. labor, etc.

Funding Sources: The preliminary BCR score of 0.97 does not meet the typical minimal threshold of 1.0 for submission of a grant for FEMA hazard mitigation sources; however, it is close to the threshold and may improve if a long form BCA is completed to support a funding grant application. Neither the CWC FHMIP nor the Ashokan Stream Management Program will fund the construction of a flood protection system. Costs of purchase, structural demolition, and relocation of B1, B14, and B15 may be eligible under the NYCFFBO and the CWC FHMIP. If these buildings were to be addressed as described in Plan #9A, the BCR would become 1.89, which may increase opportunities for grant funding. Other potential funding sources may be with State flood hazard mitigation programs. Municipal bonds may be another source of capital to build the berms, but interest costs should be incorporated as part of the cost analysis.

Water Quality Protection: Inundation to the 100-year flood elevation does not exist. Sources of water pollution from seventeen buildings will be substantially mitigated.

Prioritization:

Table 16: Prioritization Score for Boiceville Plan 9

Priority Metric name	Score	Numerical Value
Benefit to Cost Ratio	Moderate	3
Water Quality Protection	Moderate	3
Community Cohesion Preservation	Moderate	3
Ease of Obtaining Permits for Proposed Solution	Moderate	3
Economic Impact	Moderate	3
Ease to Acquire Funding	Low	1
Ease to Acquire Easements	Low	1
Level of Town Effort To Implement Plan	Low	1
Total Score		18

Table 17: Comparison of Existing and Plan 9 Water Depths in Feet

	100 Year Flood			50 Year Flood			25 Year Flood		
Point of Analysis	Existing	Plan 9	Delta	Existing	Plan 9	Delta	Existing	Plan 9	Delta
1	5.2	0.0	-5.2	2.2	0.0	-2.2	0.4	0.0	-0.4
2	6.6	0.0	-6.6	3.1	0.0	-3.1	0.7	0.0	-0.7
3	7	0.0	-7.0	3.5	0.0	-3.5	1.1	0.0	-1.1

Table 18: Comparison of Existing and Plan 9 Water Surface Elevation and Velocity

	100 Year Flood					
	Water Surface Elevation (ft)			Velocity (ft/sec)		
Cross Section	Existing	Plan 9	Delta	Existing	Plan 9	Delta
9339	631.95	631.48	-0.47	19.51	19.66	0.15
9061	632.53	632.08	-0.45	15.65	15.67	0.02
8899	632.37	631.98	-0.39	14.77	14.76	-0.01

Figure 17: Looking Upstream at Rip Rap Embankment at Waste Water Treatment Plant (Building B11)

Table 19: Plan 9 BCR Results

Number of Structures / Work Item	**Benefits**	**Costs**
15 (damages avoided)	2,475,438	
3 (demo/relocation)		1,214,510
Construction, materials		1,050,090
- Engineering/Design/Survey (12%)		126,000
- Contingency (15%)		158,000
TOTALS	**2,475,438**	**2,548,600**
Benefit to Cost Ratio (BCR)	**0.97**	

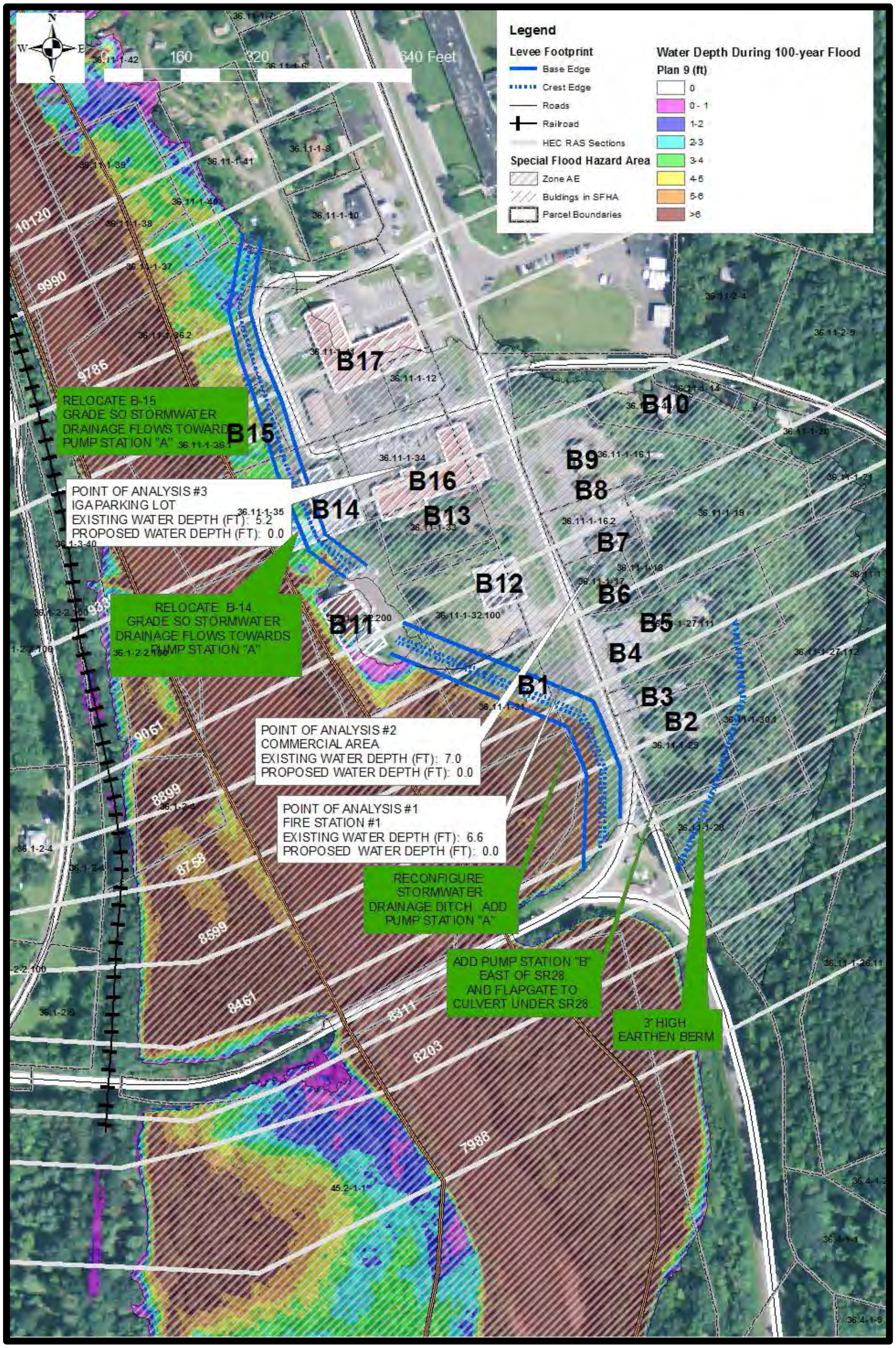


Figure 18: Conceptual Layout of Plan 9

4.3.7 Plan #9A - Flood Levee System Only

Summary: Plan 9A would mirror Plan 9 but is broken into two phases to increase the Benefit to Cost Ratio to improve the competiveness of a grant application for federal or state funding sources. Buildings B1, B14 and B15 would be relocated using funds available through CWC and DEP for the purchase of the existing structures and property and assistance with some of the potential relocation costs for these properties. Once this activity is completed, the Town could then seek and apply for funding to build the remainder of the planned work.

The proposed flood protection system should meet FEMA certification requirements for flood protection systems to ensure building owners landward of the berm would receive discounts on flood insurance premiums. As such, the elevation of the top of the earthen levee was set to meet NFIP regulation 65.10(b) which states the levee elevation should exceed the BFE (base flood elevation also referred to as the 100-year flood event) by three feet, 3.5' at the upstream end of the levee. The crest of the levee would be 10' wide with three horizontal to one vertical side slopes (for mowing). The base's footprint would be 70' wide where it meets the downstream high ground near the Route 28A and State Route 28 intersection and be 50' wide where it meets upstream high ground northwest of building B17 (Figure 20 on page 61). It would be on average 6' high between the upstream high ground and building B11 and on average 9' high between B11 and the downstream high ground.

To be a FEMA accredited flood levee, besides meeting the height requirements, the levee must protect critical infrastructure landward of the flood protection system. Buildings B1 and B11 (Fire House Company #5 and the wastewater treatment plant, respectively) are the two pieces of critical infrastructure in Boiceville. At building B1, the 500-year flood elevation is 16.5' higher than the 100 year flood elevation. FEMA requires critical infrastructure to be protected to the BFE plus 3' feet freeboard or the 500[3] year flood elevation, whichever is higher. Therefore, it is unrealistic to protect B1 so it should be relocated to an area that is not prone to flooding. Building B11 is so close to the floodway (<15'), it is not possible to put the levee riverward of this building so this building cannot be protected. The levee could be put landward of the building which would require the driveway to building B11 to be graded over the levee.

The levee would tie into the parking lot of building B11. It is assumed that the fill built to the parking lot and the waste water treatment plant was compacted to industry standard to prevent settling which is similar to the compaction rate requirements for FEMA levees. The base of the wastewater treatment plant is 150' wide which is more than double the width of the levee and it is assumed that this is adequate to meet hydrostatic design criteria.

Two pumping stations would be needed to drain the landward side of the levee. The purpose of the pumps is to protect the buildings landward of the levee if interior flooding were to occur at the same time as exterior flooding conditions. To meet FEMA accreditation guidelines, the pumps must keep inlet water depths to a foot or less up during the design flooding conditions of the levee (when floodwater elevations match the levee's top elevation). If the levee elevation is exceeded by floodwaters, the pumps are no longer required to meet their design conditions. The first pumping station (Pumping station "A") is located near building B1 where an existing stormwater drainage ditch would be

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[3] As noted in section 3.3.4 and 3.3.5, there is uncertainty with the 500-year discharge and its predicted water surface elevation using the corrected effective hydraulic model but it was assumed that the predicted 500-year water surface elevation is reasonable for use in the LFA.

reconfigured to drain underneath the levee in a culvert with flap gate. This pumping station would drain approximately 10 acres west of State Route 28. East of State Route 28, as described in section 4.6, there is a tributary that flows through a culvert underneath the highway. The tributary features a wetland between it and the highway. Assuming a flap gate is constructed on the culvert under State Route 28 (which would cause the tributary to backwater if the flap gate was closed during flooding on the Esopus), it is desirable to avoid flooding the proximal buildings. Under existing conditions, this wetland stores a large volume of water during flooding conditions (a 500-year flood on the tributary) resulting in only one building, B3, being inundated by 0.9' of water (as described in Section 4.6). Therefore, with modest grading, a pumping station could keep all the proximal buildings dry when the tributary is flooding. A three foot earthen berm would to be placed between the buildings and wetland to maintain freeboard requirements. The cumulative length of all berms is 1,900'.

Results: The proposed levee provides protection to all landward buildings at the 100-year flood event (Figure 20). The additional freeboard above the water surface elevation also protects the buildings from larger flood events. It does not protect from inundation during the 500-year flood since the water surface elevation during this event is notably higher. The proposed activities increase velocity modestly (<0.2 ft/sec as seen in Table 22 on page 60) which does not increase erosional concerns at the waste water treatment plant which is armored by large stone (Figure 19 on page 60).

Benefit to Cost Ratio: Under scenario 9A, the buyout and potential relocation costs for buildings B1, B14 and B15 have not been included as project costs assuming they were funded separately under the CWC FHMIP and NYCFFBO. The cost of Plan #9A is estimated to be $1,169,000 (Appendix Figure B-27). Since buildings B1, B14 and B15 have been removed, the benefits also have been reduced to $2,209,200. Using FEMA's BCA version 5.1.0 short form, the preliminary benefit to cost ratio was 1.89 (Table 23 on page 60, Appendix Figures B-28 and B-29). The short form BCR does not allow for annual maintenance costs to be included in the BCR calculation but it is assumed the annual costs will not reduce the BCR cost to a degree that would influence a decision about this plan.

Implementation Challenges and Opportunities: The proposed flood protection system crosses several private land parcels and a NYSDOT right of way. Permanent easements would need to be obtained to allow the construction and maintenance to be completed.

Accrediting a flood levee system can be an arduous task which requires involvement with state and federal governments. The length of time from implementation to end of construction usually is at least 5 years. The Federal Emergency Management Agency (FEMA) website contains a "Levee Resources Library", which can be accessed online at https://fema.gov/fema-levee-resources-library.

A primary benefit would include the reduction of flood insurance premiums since the buildings on the landward side of the levee would be rezoned from a Zone AE to a Zone X. This reduction could exceed 50% savings in annual premiums. Also, buildings landward of an accredited levee system maintain more resale value than buildings in Zone AE.

The flood levee system will require maintenance to remain FEMA accredited such as mowing, engineering inspection, etc. Interior pumping stations also require annual maintenance to ensure the pumps are working properly. The annual maintenance cost is expected to range between $6,400 (3 dollars per linear foot of levee and 700 dollars for pump station maintenance) to $15,000 (2% of the construction cost for levees and pump stations). In case of damages to the levee and pumps, the US

Army Corps of Engineers has a Rehabilitation Assistance Program for FEMA accredited levees that costs shares (80% federal, 20% local) the repair cost. The 20% local match can be in-kind contribution i.e. labor, etc.

Funding Sources: The preliminary BCR score of 1.89 does meet the typical minimal threshold of 1.0 for submission of a grant for FEMA hazard mitigation sources. This BCR score may improve if a long form BCA is completed to support a funding grant application. Neither the CWC FHMIP nor the Ashokan Stream Management Program will fund the construction of a flood protection system. Costs of purchase, structural demolition, and relocation of B1, B14, and B15 may be eligible under the NYCFFBO and the CWC FHMIP. Other potential funding sources may be with State flood hazard mitigation programs. Municipal bonds may be another source of capital to build the berms, but interest costs should be incorporated as part of the cost analysis.

Water Quality Protection: Inundation to the 100-year flood elevation does not exist. Sources of water pollution from seventeen buildings will be substantially mitigated.

Prioritization:

Table 20: Prioritization Score for Boiceville Plan 9A

Priority Metric name	Score	Numerical Value
Benefit to Cost Ratio	High	5
Water Quality Protection	Moderate	3
Community Cohesion Preservation	Moderate	3
Ease of Obtaining Permits for Proposed Solution	Moderate	3
Economic Impact	Moderate	3
Ease to Acquire Funding	Low	1
Ease to Acquire Easements	Low	1
Level of Town Effort To Implement Plan	Low	1
Total Score		20

Table 21: Comparison of Existing and Plan 9A Water Depths in Feet

	100 Year Flood			50 Year Flood			25 Year Flood		
Point of Analysis	Existing	Plan 9	Delta	Existing	Plan 9	Delta	Existing	Plan 9	Delta
1	5.2	0.0	-5.2	2.2	0.0	-2.2	0.4	0.0	-0.4
2	6.6	0.0	-6.6	3.1	0.0	-3.1	0.7	0.0	-0.7
3	7	0.0	-7.0	3.5	0.0	-3.5	1.1	0.0	-1.1

Table 22: Comparison of Existing and Plan 9A Water Surface Elevation and Velocity

	100 Year Flood					
	Water Surface Elevation (ft)			Velocity (ft/sec)		
Cross Section	Existing	Plan 9	Delta	Existing	Plan 9	Delta
9339	631.95	631.48	-0.47	19.51	19.66	0.15
9061	632.53	632.08	-0.45	15.65	15.67	0.02
8899	632.37	631.98	-0.39	14.77	14.76	-0.01

Figure 19: Looking Upstream at Rip Rap Embankment at Waste Water Treatment Plant (Building B11)

Table 23: Plan 9A BCR Results

Number of Structures / Work Item	Benefits	Costs
12 (damages avoided)	2,209,230	
Construction, materials		920,000
- Engineering/Design/Survey (12%)		111,000
- Contingency (15%)		138,000
TOTALS	**2,209,230**	**1,169,000**
Benefit to Cost Ratio (BCR)	**1.89**	

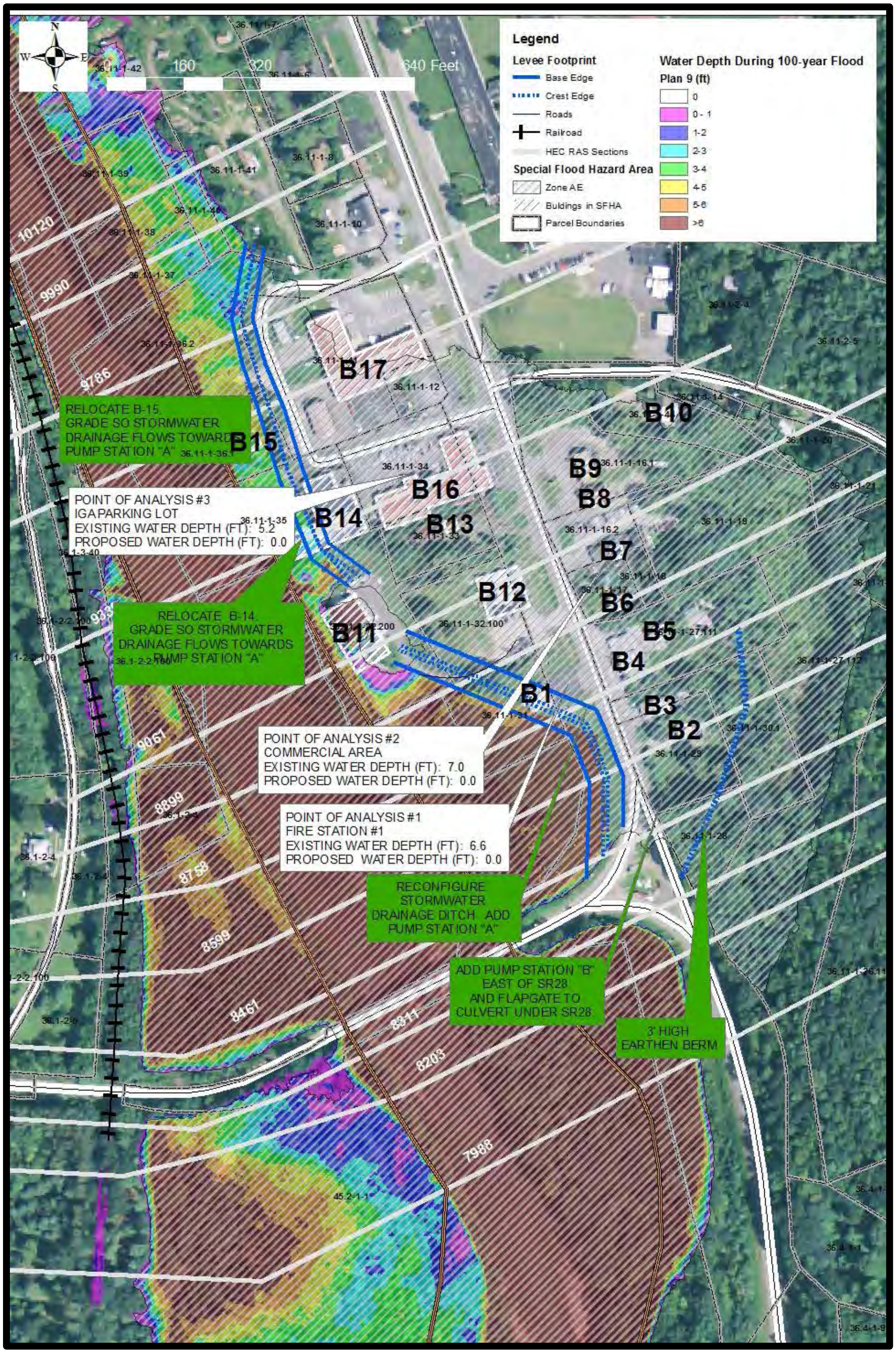

Figure 20: Conceptual Layout of Plan 9A

4.3.8 Plan #10 - Dredging

Summary: The purpose of mitigation solution Plan 10 is to reduce floodwater elevation reduction by lowering the Esopus Creek channel bottom. This practice is commonly referred to as dredging. Dredging was a common flood mitigation strategy for decades since it was believed that lowering the river bottom would also lower flood water elevations. The proposed dredging extents start at the Route 28A bridge crossing and extends 1,500 feet upstream. The proposed creek bottom would be lowered 5' which is roughly the amount of water depth around many buildings during the 100-year flood. The dredging activities would create a 5' deep trench that is 110' wide along the channel bottom and 130' wide on top. Since a drinking water reservoir is located less than a mile downstream, it was assumed protecting water quality conditions would be required while completing the dredging activities. Per site observations, the material to be dredged would consist mostly of gravel size or larger material. This size of material would not need a complex dewatering system and could be immediately hauled off site. Some sands and silty material would also be excavated and would need an onsite dewatering system to remove water from the material before it is hauled off site. Porous geotubes have been proposed as the preferred dewatering method. Once all the material is hauled off site, the construction site would be stabilized with seed and mulch.

Results: As seen in Figure 21 on page 64 (25-year flood) and Appendix Figure B-30 (100-year flood) inundation still occurs starting at the 25-year flood event for most buildings. Flooding would occur from Esopus floodwater directly from overbank flooding on the Esopus and backwater up the unnamed tributary that flows underneath State Route 28. The Boiceville Market would be dry during the 25-year flood and on average the flooding depths would be reduced by a half foot around the remaining buildings. There is less water surface reductions during the larger floods (50-year and 100-year) as seen in Table 25.

***Benefit to Cost Ratio*:** The cost of construction is estimated to be $3,231,500. Using the similar water surface reductions in Plan 4 (Table 8 on page 42) as a guide and comparing the construction costs between Plan #4 ($2,015,000), it is reasonable to judge that the preliminary benefit to cost ratio for Plan #10 would be at or lower than Plan 4's BCR (0.14). Using this guidance, a BCR was not completed for Plan #10 because it is assumed the Plan 10 BCR will be low enough to realize that Plan 10 is not financially justifiable.

Implementation Challenges and Opportunities: The major challenge for this proposed activity will be acquiring environmental permits. Dredging has fallen out of favor for permitting agencies such as the NYSDEC and USACE unless there are justifiable financial incentives or public safety reasons. The main concern these agencies have is the impact to the aquatic environment. Excavating material from the creek destroys macro invertebrate habitat and fish habitat such as spawning redds. Another concern is the sustainability of the gains achieved through dredging. A dredging trench will fill in with gravels and cobbles being transported through the dredged area from upstream sources. As the trench fills in, the benefits gained are reduced requiring ongoing dredging, another reason why the permitting agencies do not favor dredging in streams.

Funding Sources: With an assumed low BCR score (less than 0.14) the proposed activity would not be competitive for a FEMA application. It is unlikely New York State or NYCDEP funding would be available. Municipal bonds may be the only source of capital to complete these activities. Dredging activities would need to be repeated because the excavated trench would fill in with sediments being transported from upstream requiring additional financial resources.

Water Quality Protection: Inundation under proposed conditions continues. Water pollution from the inundated areas will continue.

Prioritization:

Table 24: Prioritization Score for Boiceville Plan 10

Priority Metric name	Score	Numerical Value
Benefit to Cost Ratio	Low	1
Water Quality Protection	Low	1
Community Cohesion Preservation	High	5
Ease of Obtaining Permits for Proposed Solution	Low	1
Economic Impact	Moderate	3
Ease to Acquire Funding	Low	1
Ease to Acquire Easements	High	5
Level of Town Effort To Implement Plan	Low	1
Total Score		18

Table 25: Comparison of Existing and Plan 10 Water Depths in Feet

	100 Year Flood			50 Year Flood			25 Year Flood		
Point of Analysis	Existing	Plan 10	Delta	Existing	Plan 10	Delta	Existing	Plan 10	Delta
1	5.2	5.2	0.0	2.2	2.1	-0.1	0.4	0.0	-0.4
2	6.6	6.4	-0.2	3.1	2.8	-0.3	0.7	0.2	-0.5
3	7	7.0	0.0	3.5	3.2	-0.3	1.1	0.5	-0.6

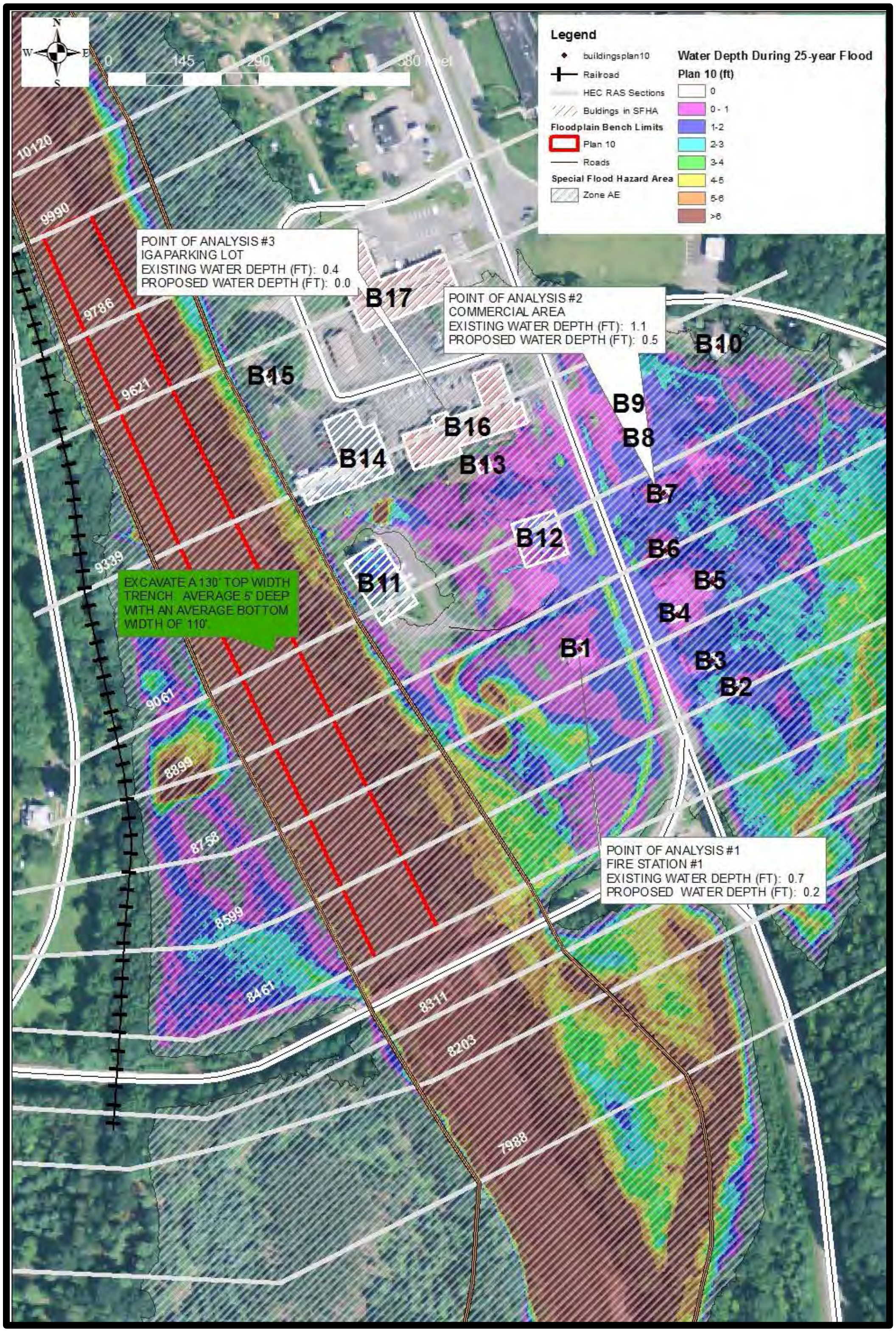

Figure 21: Conceptual Layout of Plan 10

4.3.9 Plan #11 - Relocate Route 28A Bridge and Waste Water Facility.

Summary: The purpose of mitigation solution Plan 11 is to investigate the removal of all potential obstacles to flood water conveyance. As seen in the Terrace and Floodplain Terrain map in Figure 1, the wastewater treatment plant (B11) is a notable fill spot in the floodplain. This fill spot is one of three obstacles that also constrain the width of the proposed floodplain benches, the other two being building B14 and B15. The proposed activities for Plan 11 completely remove buildings B11, B14 and B15 and widen the floodplain bench through this area from 100' on average to 190' to demonstrate what the maximum reduction of water surface elevations could be assuming no obstructions. The width of Plan 11's floodplain bench is governed by the Boiceville Market. Since the market is the main anchor business in the Boiceville mitigation area, it is assumed to stay in place. The excavation depth will remain the same for the benches as seen in Plans 4 and 5, on average 2.5'

***Results*:** As seen in Figure 22 on page 67 (25-year flood) and Appendix Figure B-31 (100-year flood), inundation still occurs starting at the 25-year flood event for most buildings. Flooding would occur from Esopus floodwater directly from overbank flooding on the Esopus or backwater up the unnamed tributary that flows underneath State Route 28. The Boiceville Market would be dry during the 25-year flood and on average the flooding depths would be reduced by a half foot around the remaining buildings. There are less water surface reductions during the larger floods (50-year and 100-year) as seen in Table 27. It is possible to eliminate flooding completely during the 25-year flood for all buildings by installing a flap gate to the culvert under State Route 28 and filling in low areas. Again, during larger flooding events, the buildings would remain inundated.

Benefit to Cost Ratio: Using the similar water surface reductions in Plan 4 (Table 8 on page 42) as a guide and understanding that relocating the waste water treatment plant will result in considerable cost (cost of construction in 2010 was $12 million dollars), it is reasonable to judge that the preliminary benefit to cost ratio for Plan 11 would be at or lower than Plan 4's BCR (0.14). Using this guidance, a BCR was not completed for Plan 11 because it is assumed the Plan 11 BCR will be low enough to know that Plan 11 is not financially justifiable.

Implementation Challenges and Opportunities: There may not be suitable locations for relocating the wastewater treatment plant given the required elevation the plant needs to be able to receive wastewater under gravity flow. Two buildings (one an active business, B15, the other a vacant commercial building, B14) would need to be relocated. Also, the floodplain benches would cross several private parcels so temporary and permanent easements would need to be obtained to construct and maintain the benches. In addition, the proposed bridge to replace the existing bridge has been approved by DEP and will be constructed proximal to the existing bridge so this plan may not be realistic to implement.

Funding Sources: With an assumed low BCR score (less than 0.14) the proposed activity would not be competitive for a FEMA application. It is unlikely state or NYCDEP funding would be available since the major cost of the project would be relocating a multimillion dollar sewage treatment plant that was just built. In addition, the proposed activities do not fully solve the flooding problems.

Water Quality Protection: Inundation under proposed conditions continues. Water pollution from the inundated areas will continue.

Prioritization:

Table 26: Prioritization Score for Boiceville Plan 11

Priority Metric Name	Score	Numerical Value
Benefit to Cost Ratio	Low	1
Water Quality Protection	Moderate	3
Community Cohesion Preservation	Moderate	3
Ease of Obtaining Permits for Proposed Solution	High	5
Economic Impact	Moderate	3
Ease to Acquire Funding	Low	1
Ease to Acquire Easements	Low	1
Level of Town Effort To Implement Plan	Low	1
Total Score		18

Table 27: Comparison of Existing and Plan 11 Water Depths in Feet

	100 Year Flood			50 Year Flood			25 Year Flood		
Point of Analysis	Existing	Plan 11	Delta	Existing	Plan 11	Delta	Existing	Plan 11	Delta
1	5.2	3.9	-1.3	2.2	1.2	-1.0	0.4	0.0	-0.4
2	6.6	5.2	-1.4	3.1	2.1	-1.0	0.7	0.0	-0.7
3	7.0	6.3	-0.7	3.5	2.9	-0.6	1.1	0.5	-0.6

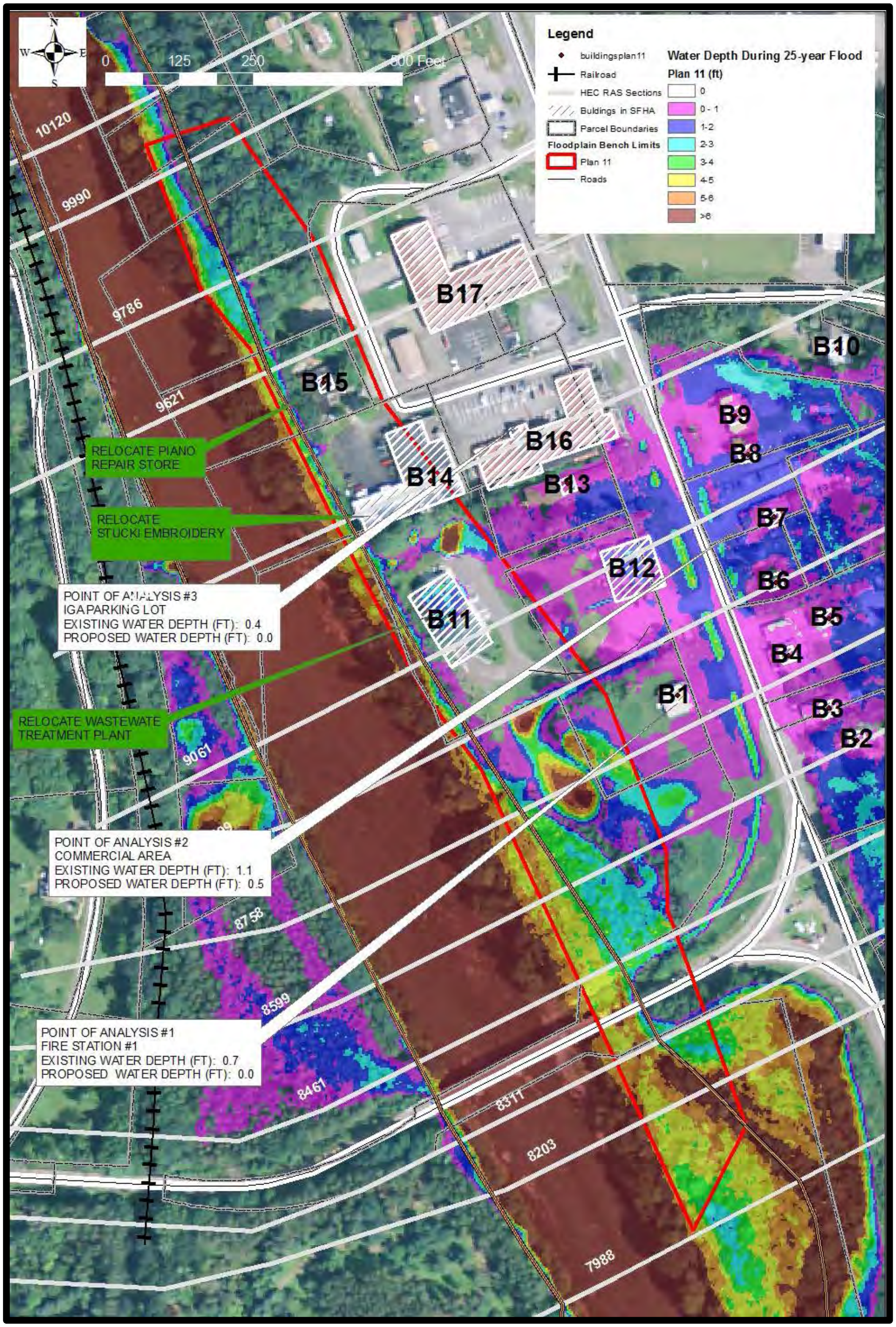

Figure 22: Conceptual Layout of Plan 11

4.3.10 Plan #12 - Planning and Relocation

Summary: The Town could pursue community planning that identifies future economic growth centers and critical community facility locations outside of flood prone areas. There are three tools that are available to the Town in order to reduce its flood losses. These include the voluntary flood buyout programs, planned relocation of businesses and residences, and a community planning process to help guide these decisions. The NYCFFBO and CWC FHMIP are designed to help communities move critical facilities, anchor businesses, residences, and other businesses to areas outside the floodplain.

The highest priority building type to relocate is the critical community facility. Fire House Company #5 (Building B1) in Figure 22 on page 67, is a critical community facility that becomes isolated by floodwaters during moderate flood events, thus posing a public safety risk. The other critical community facility located within the study area is the waste water treatment plant (B11) which was built to be flood resistant and is not a priority at this time.

The second highest priority building(s) type that is considered for relocation with planning are the identified anchor businesses. An anchor business is defined as a business that if damaged or destroyed would immediately impair the health and/or safety of a community. Examples of these businesses are gas stations, grocery stores, doctor's offices or pharmacies. The Boiceville Market and Boiceville Pharmacy (B16) (Tax Parcel ID 36.11-1-34), and the Maverick West building (B7) (Tax ID 36.11-1-16.200) a professional medical office, are anchor businesses that can be relocated.

The third type of building(s) eligible as flood hazard mitigation projects are individual properties that have experienced or may experience significant damage from flooding. This analysis shows that seventeen buildings located in the Boiceville mitigation area will be inundated during moderate flood events (25-year return interval flood). It is also noteworthy that some of these structures have had flood damage twice within the last 15 years (2005 and 2011). Per NYCFFBO rules, an inundation damaged property is eligible for the NYCFFBO if, 1) it has been substantially damaged, 2) or based on analysis, is likely to be substantially damaged in a flood with a high probability of recurrence (greater than 1% annual chance recurrence), or 3) has been identified by FEMA as a repetitive losses or severe repetitive loss property. Substantially damaged means that flooding has caused structural damage of 50% or more of the building value. If a property meets any of these criteria then the property could be eligible for buyout or buyout with relocation.

The Town has the option to support flood buyout with or without relocation. The Town supports relocation within the Town when possible, and will work with the property owner to assist with relocation. For the buyout programs, the Town will consider, on a case by case basis, all properties in the LFA study area, within the 500-year floodplain. To be eligible, all properties must meet the substantial damage criteria, and have a willing buyer, willing seller, and town approval.

There are several underutilized suitable parcels for relocating anchor businesses and other private buildings suitable for development in the vicinity of Boiceville. It is recommended that the Town pursue funding under the CWC Sustainable Communities Planning Program to identify and plan for the development of relocation properties.

Results: Implementation of this plan would gradually reduce the number of buildings being threatened by future flood inundation. The relocation of buildings would change the character of Boiceville by physically relocating them away from the business district. The Town recognizes the property owner may not wish to relocate within the Town. The Town may support flood buyout with or without relocation. However, the Town supports relocation within the Town of Olive when possible. The Town will work with the property owner to assist with relocation.

Benefit to Cost Ratio: The relocation cost was calculated using the town taxable value (2013 assessment year) for the particular parcel the building is located on. If multiple buildings exist on the property, the town taxable value was divided equally between the buildings. Using the FEMA's BCA version 5.1.0 short form, a preliminary BCR of 0.62 was calculated as shown in Table 28. The BCR report can be seen in Appendix Figures B-32 and Figure B-33. From parcel data for building B1, (Fire Company #5) the value of the building was assumed to be $230,000.

Table 28: Plan 12 BCR Results

Number of Structures / Work Item	Benefits	Costs
15 (damages avoided)	$3,313,936	
Relocation Costs		$5,341,600
- Demolition Costs (10%)		$534,160
TOTALS	**$3,313,936**	**$5,875,760**
Benefit to Cost Ratio (BCR)	**0.62**	

***Implementation Challenges and Opportunities*:** There may be community resistance to changing the hamlet's character by moving buildings to new locations. This step, should they choose to move and protect their property values, will ensure that they will not be flooded again. .

Funding Sources: The NYC Funded Flood Buyout Program (NYCFFBO) and the CWC's Flood Hazard Mitigation Implementation Program (FHMIP) provide resources for buyout and relocation of buildings within the LFA area. Additionally, the CWC's Sustainable Communities Grant Program is available to communities that wish to update their zoning, ordinances, and planning efforts to better accommodate flood hazard mitigation measures.

Water Quality Protection: Floodwater inundation and the water pollution sources would continue until these buildings were relocated out of the flood zone.

Prioritization:

Table 29: Prioritization Score for Boiceville Plan 12

Priority Metric name	Score	Numerical Value
Benefit to Cost Ratio	Moderate	3
Water Quality Protection	High	5
Community Cohesion Preservation	Low	1
Ease of Obtaining Permits for Proposed Solution	High	5
Economic Impact	Moderate	3
Ease to Acquire Funding	High	5
Ease to Acquire Easements	High	5
Level of Town Effort To Implement Plan	Moderate	3
Total Score		30

4.3.11 Plan #13 - Structural Interventions (Property Protection)

Summary: There are several buildings in the flood prone area of Boiceville that can be either structurally changed to raise the first floor elevation and/or relocate mechanics (furnace, water heater, etc.) out of basements. The buildings that are structurally able to be elevated have either crawl spaces or have existing basements (finished or unfinished). Table 30 shows the buildings that can potentially be elevated to avoid continued damage from flood inundation. Buildings built on slabs would likely need to be completely demolished and then rebuilt. In general, raising a building that is constructed on a slab will require demolishing the existing building, constructing an earthen pad to place the new building on (to raise the new slab higher than floodwaters) and then constructing the new building. To avoid filling in the floodplain and causing unwanted negative impacts to flood waters, it is recommended that buildings with slabs be relocated.

Results: Implementation of this plan would lead to construction within the flood prone areas as the eligible buildings are lifted and a higher foundation is built. The foundation would allow for floodwaters to pass through using flood vents. Six of the seventeen buildings located within the flood prone area are structurally eligible to have both their first floor elevations and the building mechanics (boilers, water heaters, etc.) raised. Building B17 has its first floor elevation (finished basement) below the Base Flood Elevation (BFE) but the majority of its business is conducted on the 2nd floor. The finished basement area could be removed and added to the 2nd floor or as an additional floor. The basement of this structure could be wet floodproofed at a fairly minimal cost, which would allow the space to be used for parking and storage as needed.

Benefit to Cost Ratio: The opinion of probable construction cost to raise these structures is summarized in Table 30 and a detailed construction cost estimate can be seen in Appendix Figure B-34. The cost of relocating the finished basement in building B17 to the 2nd story or higher was assumed to be the same as lifting the entire first floor.

The buildings have been proposed to be elevated to 2.0' above the 100 year water surface elevation (known as the BFE). Using the FEMA's BCA version 5.1.0 short form, the preliminary BCR of 0.49 was calculated (Table 31). The BCA printout report can be seen in Appendix Figures B-35 and B-36.

***Implementation Challenges and Opportunities*:** When buildings are lifted, utilities and ingress/egress also need to be changed to match the higher first floor elevation. This may pose challenges to the buildings east of State Route 28 where the distance between the highway and the entranceways is short, which may be challenging in making the buildings accessible. The eight buildings that have been built on slabs will be very difficult and expensive to raise and would likely need to be demolished and relocated on higher ground.

Funding Sources: Following a Presidentially declared disaster, FEMA's Hazard Mitigation Grant Program offers property protection grants to buildings with a high BCR score such as building B4 or building B8. FEMA's Flood Mitigation Assistance Grant Program is a program made available to States with the purpose of reducing risk of flood damages to structures that are insured under the NFIP. The Catskill Watershed Corporation's (CWC) FHMIP also has funding available, up to 75% of the total cost, to assist with elevating qualified buildings.

Water Quality Protection: Raising buildings will improve water quality by removing some of the water pollution sources from floodwaters but some buildings and activities cannot be elevated, therefore some water pollution sources will exist as long as those building remain.

Table 30: Summary Opinion of Probable Construction Costs

Building ID	**Basement Type**	**Opinion of Probable Construction Cost**
B2	Unfinished	$61,400
B4	Unfinished	$191,560
B6	Unfinished	$81,920
B7	Crawl	$259,840
B8	Unfinished	$71,920
B14	Crawl	$665,600
B17	Finished	$1,468,000

Table 31: Plan 13 BCR Results

Number of Structures / Work Item	**Benefits**	**Costs**
7 (damages avoided)	$1,496,115	
7 (wet floodproofing)		$2,800,240
TOTALS	**$1,496,115**	**$2,800,240**
Benefit to Cost Ratio (BCR)	**0.53**	

Prioritization:

Table 32: Prioritization Score for Boiceville Plan 13

Priority Metric name	**Score**	**Numerical Value**
Benefit to Cost Ratio	Moderate	3
Water Quality Protection	Moderate	3
Community Cohesion Preservation	Moderate	3
Ease of Obtaining Permits for Proposed Solution	High	5
Economic Impact	Moderate	3
Ease to Acquire Funding	Moderate	3
Ease to Acquire Easements	High	5
Level of Town Effort To Implement Plan	High	5
Total Score		30

4.4 Upper Boiceville Road Mitigation Area Summary

Upper Boiceville Road mitigation area contains one location of interest. This is the stream crossing of Upper Boiceville Road over an unnamed tributary to the Ashokan Reservoir. It is located approximately one mile southeast of the Boiceville Market as seen in Figure 23 below. There is a community concern that this town road that crosses a perennial stream can be overtopped during a flooding event. This condition would make the road impassable and could damage the crossing, requiring the road to be closed for a long period until it is repaired or replaced. This is a community concern because Upper Boiceville road is the auxiliary north to south traffic corridor if State Route 28 is impassable due to an emergency such as a traffic accident or flooding near the State Route 28 and Route 28A intersection. If the Upper Boiceville Road crossing is closed, it could cause lengthy detours and added travel time for emergency response vehicles, commerce and daily commuters.

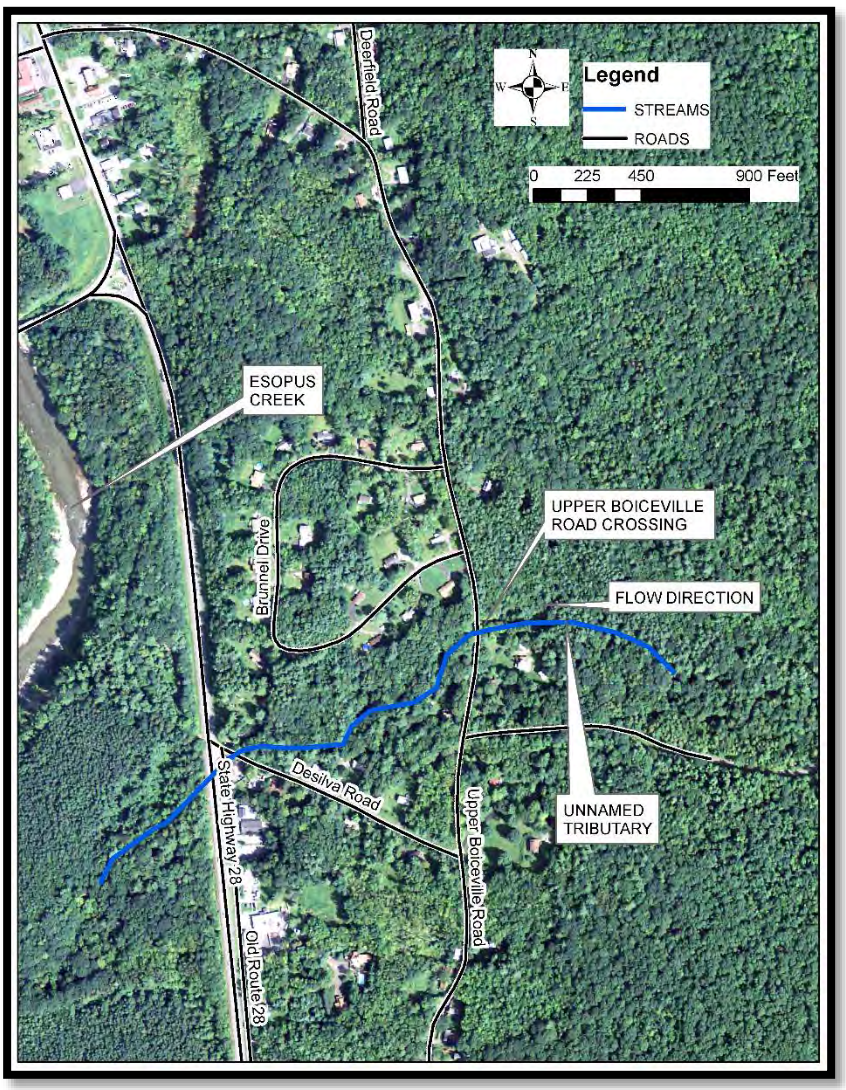

Figure 23: Location Map of Upper Boiceville Road

4.4.1 Hydraulic Approach

Hydrology: The unnamed tributary is an ungaged stream which means there is no available discharge data to complete a flood discharge frequency analysis. The drainage area of the unnamed tributary is 2.01 square miles (see drainage area map - Appendix B-37). As such, flood discharges were developed using the Soil Conservation Service (SCS) Unit hydrograph method imbedded in the proprietary HydroCAD, Version 10.0 software package. Curve Numbers (CN) values were estimated from review of land use, aerial photography and Ulster County Soil Mapping. Predominant soil types consist of Hydrologic Soil Group C/D soils for the inflow area of the drainage area. Land cover primarily consists of wooded areas.

The 24 hour precipitation values for the 2, 10, 25, 50, 100 and 500-year return interval storms were obtained from the Northeast Regional Climate Center (NRCC) precipitation data for the project vicinity.

Lag time's (T_{lag}) for the inflow hydrographs were computed utilizing the Miller-Folmar methodology from NRCS procedures, as defined below:

$$T_{lag} = L^{0.65}/180.5$$

Where T_{lag} = Lag time, in hours

L = Longest hydraulic length of watershed, in feet

The individual peak discharge values for the tributary are shown in Table 33.

Table 33: Flood Discharges for Return Intervals on Upper Boiceville

Return Interval (Years)	Discharge (cfs)
2	130
10	289
25	425
50	561
100	726
500	1,257

Channel topographic data was collected by a laser survey and floodplain topography was obtained from the 2009 LiDAR survey. The information was joined and then input into a USACE HEC-RAS hydraulic model. Cross section locations can be been in Appendix Figure B-38. Relative roughness values were developed from site observation and published values.

4.4.2 Existing Hydraulic Conditions and General Site Conditions

The HEC-RAS model was run for the six discharges. The crossing can be seen in section view in Figure 24 and shows that the bridge is overtopped starting at the 50-year return interval storm assuming unobstructed flow. The crossing can be seen in profile view in Appendix Figure B-39. Site observations show the upstream abutments are failing (as seen in Figure 25 and in Appendix Figure B-40) due to material failure and scour along the abutment toe or both.

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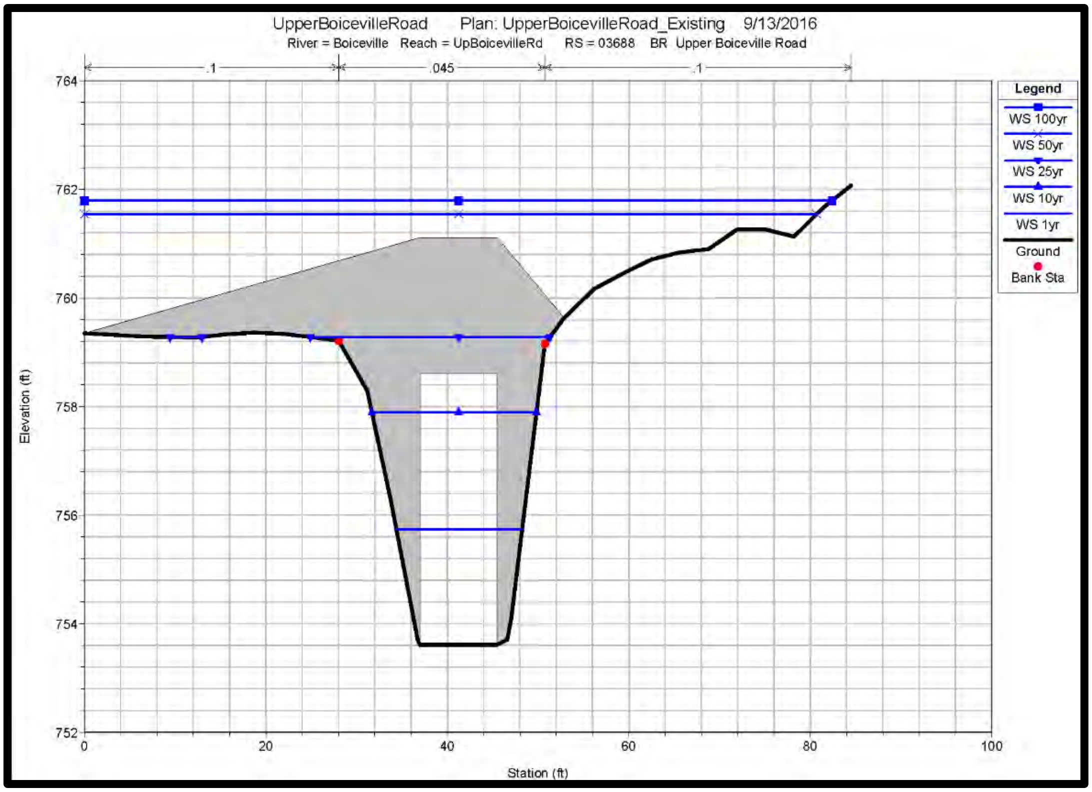


Figure 24: Section View of Existing Upper Boiceville Road Crossing

Figure 25: Looking Downstream at Upper Boiceville Road Bridge

4.4.3 Plan #14 - Three Sided Box Culvert

Summary: The Upper Boiceville Road hazard mitigation solution design criteria was to pass the 50-year flood event which matches the NYS Department of Transportation's design criteria for principal arterials. This design criteria included a foot of freeboard (height between 50-year water surface elevation and top of culvert) to pass floating debris. To avoid complications with the road's vertical curve profile, maintaining the existing road profile's elevation was desirable.

Results: Increasing the clear span from 7' to 12' will pass the 50-year storm and meet the desired freeboard requirements. The proposed dimensions will also pass the 100-year storm. Increasing the clear span 5' does not appear to have notable construction constraints since there is adequate space on either side of the existing bridge to widen the crossing. The proposed crossing can be seen in section view in Figure 26 below and in profile view in Appendix Figure B-41. The proposed structure would be a three sided box culvert (natural stream channel bottom) with concrete wing walls.

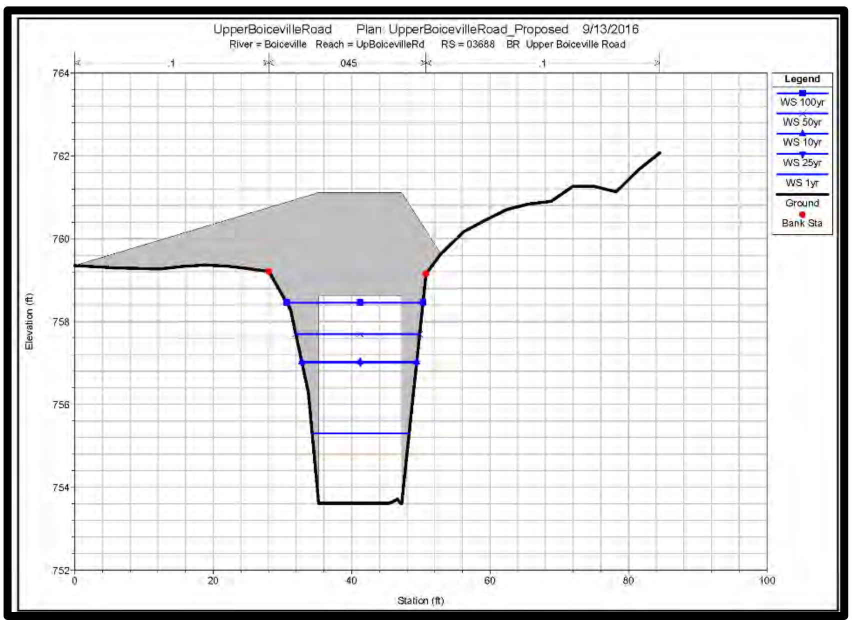


Figure 26: Proposed Cross Section at Upper Boiceville Road Crossing

Benefit to Cost Ratio: The conceptual construction cost estimate for replacing the Upper Boiceville Road Bridge with a three sided box culvert (design life of 50 years) is $132,100 and a detailed construction cost estimate can be seen in Appendix Figure B-42. In addition to the upfront capital costs the assumed annual maintenance costs was $750 (paving, abutment repair, etc.). This costs is rolled into the final mitigation project cost which is $142,451.

The value of Upper Boiceville Road to the community is an axillary north to south route towards Shokan and Kingston if State Route 28 is closed. Using FEMA's BCA Version 5.1.0's frequency damage assessment tool, the preliminary benefit to cost ratio was calculated assuming State Route 28 was closed just north of the Route 28A/State Route 28 intersection and Upper Boiceville Road was needed as the primary north to south transportation corridor. Due to water depth and velocity occurring at the 50-year event and the existing structural condition of the crossing, it was assumed the crossing would be damaged beyond repair and would need to be closed until it was replaced and the assumed time for replacing the bridge (closure length) was 120 days. The detour starts at the closure and requires a vehicle to travel northwards to Mt. Tremper, turn north on State Route 212, turn southeast onto Wittenberg Road, continue on Yankeetown Road until it joints with State Route 28. The length of detour was measured at 10.5 miles and estimated to take an additional 20 minutes of time. A 2013 NYSDOT Roadway Traffic County Hourly Report counted an average weekday daily traffic (AWDT) count of 5,325 vehicles traveling southbound on State Route 28 between 4/23/13 and 4/29/13. This AWDT count was used for the BCA traffic trips per day.

Per Figure 13 (page 37), State Route 28 is inundated with water during the 25-year flood event (probability of this flood event is 0.04 occurring any given year) on the Esopus and is assumed closed. The Upper Boiceville Road bridge is damaged beyond repair during the 50-year flood event (probability of this flood event is 0.02 occurring any given year) on the unnamed tributary. The probability of these two independent events occurring around the same time as each other is 0.008. This probability was converted into a recurrence interval for the BCA. The preliminary BCR was 7.7 (Table 34) and the summary report can be seen in Appendix B-43 and B-44.

Table 34: BCA Input and Results for Upper Boiceville Road Plan #14 Using Damage-Frequency Assessment

Project Useful Life	50 Years
Annual Maintenance Costs	$750
Estimated Number of 1-Way Traffic Trips	5,325
Additional Time Per One-Way Trip	20 minutes
Number of Additional Miles	10.5
DPW Road Detour Cost (Existing Conditions)	$2,500
Days Road Would be Closed (Existing Conditions)	120
Mitigation Benefits	$1,097,063
Mitigation Costs	$142,451
Benefit to Cost Ratio	7.7

Implementation Challenges and Opportunities: There are no driveways or utility conflicts that would interfere with the project. Upper Boiceville Road could be reduced to one lane while one half of the crossing was built and then the lane would be switched to finish the other half of the crossing.

Funding Sources: This project has a high BCR and may be eligible for funding through the Catskill Watershed Corporation's Flood Hazard Mitigation Program, the Ashokan Watershed Stream Management Program's SMIP funding, or FEMA hazard mitigation grants after a Presidential disaster declaration.

***Water Quality Protection*: Not Applicable**

Prioritization:

Table 35: Prioritization Score for Upper Boiceville Road Plan #14

Priority Metric name	Score	Numerical Value
Benefit to Cost Ratio	High	5
Water Quality Protection	Low	1
Community Cohesion Preservation	Moderate	3
Ease of Obtaining Permits for Proposed Solution	High	5
Economic Impact	High	5
Ease of Funding	High	5
Ease to Acquire Easements	High	5
Level of Town Effort To Implement Plan	High	5
Total Score		34

4.5 DeSilva Road Mitigation Area Summary

DeSilva Road Mitigation Area contains one area of interest. There are two crossings of an unnamed tributary underneath DeSilva Road and State Route 28 as seen in Figure 27. This area is located downstream of the Upper Boiceville Road crossing as described in section 4.4 and is located approximately 0.5 mile southeast of the Boiceville Market. DeSilva Road is a town road connecting Upper Boiceville Road to the east and State Route 28 to the west.

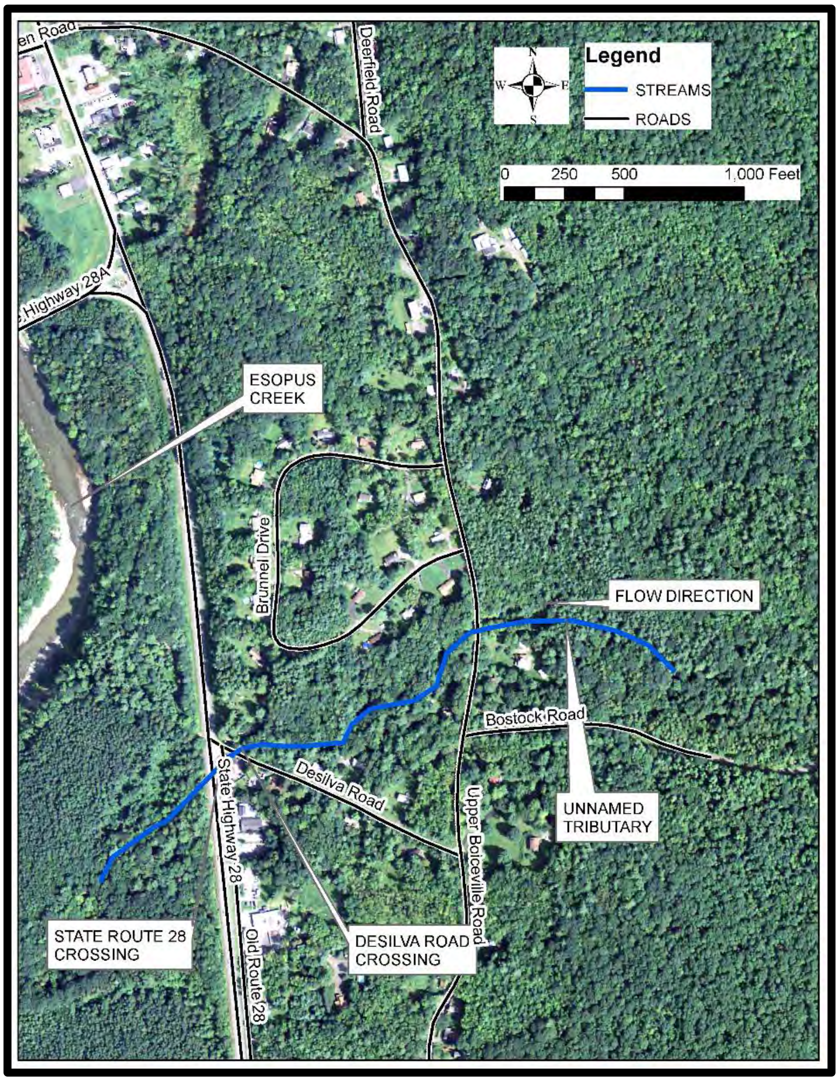


Figure 27: Location Map for DeSilva Mitigation Area

4.5.1 Hydraulic Approach

Hydrology: Since the drainage area upstream of DeSilva Road is essentially the same drainage area for Upper Boiceville Road~~,~~ the discharges from Upper Boiceville Road were used for DeSilva Road.

Hydraulics: Channel topographic data was collected by a laser survey and floodplain topography was obtained from the 2009 LiDAR survey. The information was joined and then input into the USACE HEC-RAS hydraulic model. Cross section locations can be been in Figure 28. Relative roughness values were developed from site observation and published values.

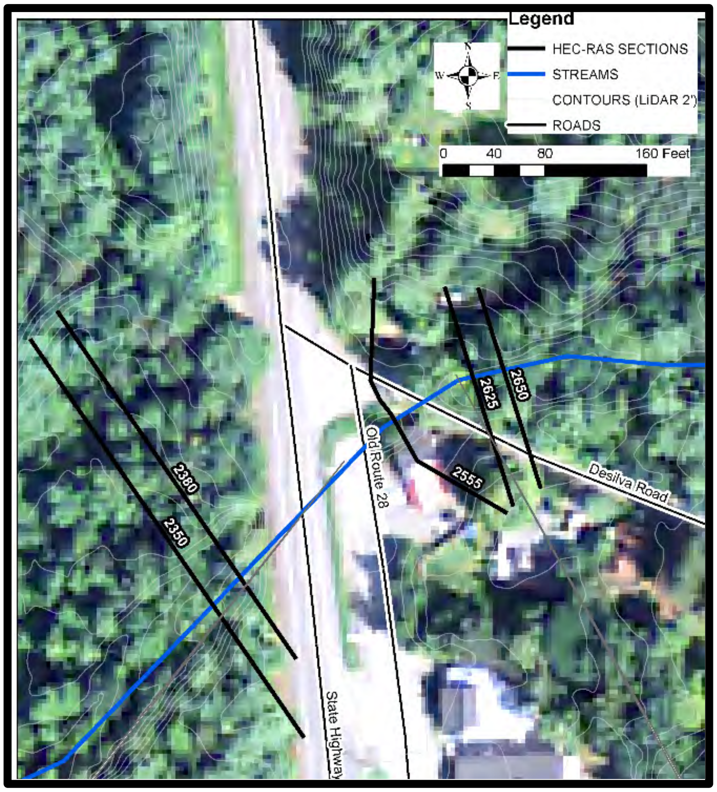


Figure 28: Location of Surveyed Cross Section for DeSilva Mitigation Area

4.5.2 Existing Hydraulic Conditions and General Site Conditions

The HEC-RAS model was run for the six discharges. The DeSilva Road crossing can be seen in section view in Figure 29 and in Figure 30. This culvert is overtopped by a 1.0’ of water starting at the 25-year flood. The State Route 28 crossing can be seen in section view in Figure 31 and in Figure 32. This crossing is overtopped by 0.2’ of water starting at the 50-year flood. The crossings can be seen in profile view in Appendix Figure B-45. Typical hydraulic design standards for town roads such as DeSilva Road is the 10-year flood and the existing hydraulic conditions meet this standard. State Route 28’s design criteria were not met. Site observations showed both crossings’ wingwalls and headwalls appear to be structurally intact as seen in Figure 30 and Figure 32. In Figure 32 note there is a transition between the arch culvert on the upstream end of the State Route 28 crossing and the four sided box culvert on the downstream end which reduces hydraulic efficiency.

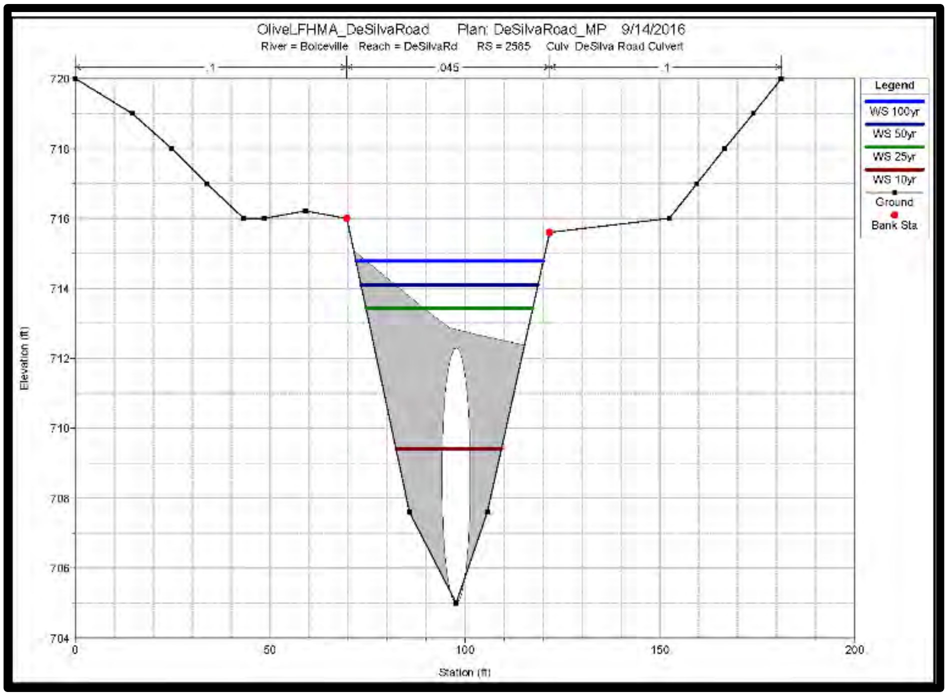


Figure 29: Section View of Existing Hydraulic Conditions at DeSilva Road Crossing

Figure 30: Looking Downstream at DeSilva Road Crossing

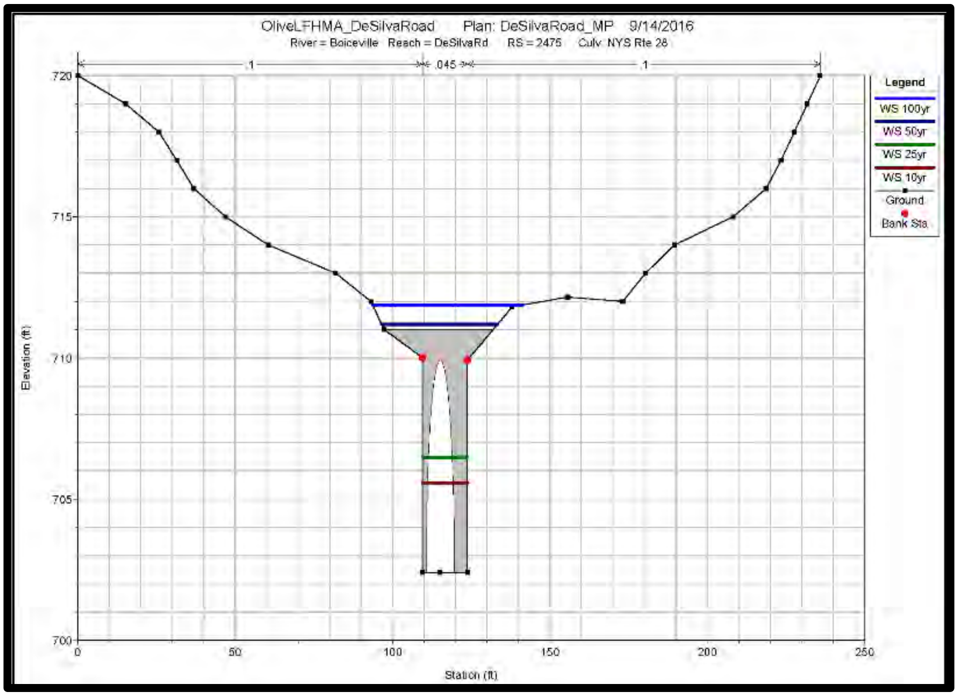


Figure 31: Section View of Existing Hydraulic Conditions at State Route 28 Crossing

Figure 32: Looking Upstream at State Route 28 Crossing

4.5.3 Plan #15 - Wider Clear Span Three Sided Box Culvert

Summary: The DeSilva Road hazard mitigation solution design criteria was to pass the 50-year flood event at the State Route 28 crossing which matches the NYS Department of Transportation's design criteria for principal arterials. Since DeSilva Road met typical design standards for town roads, (passing the 10-year flood) no changes at this crossing were required. The design criteria for the State Route 28 crossing included a foot of freeboard (height between 50-year water surface elevation and top of culvert) to pass floating debris. To avoid complications with the road's vertical curve profile, maintaining the existing road profile's elevation was desirable.

Results: Replacing the existing arch with a three sided box culvert (natural stream channel bottom) with concrete wing walls and concrete head wall with a clear span of 10 feet (7.5' rise) will pass the 50-year flood with a freeboard greater than one foot as seen in Figure 33. The profile under proposed conditions can be seen in Appendix Figure B-46. To note, a clear span of 12 feet was the narrowest clear span that would pass the 100-year flood event. Neither the 10 foot wide nor the 12 foot wide box culvert would improve the hydraulic condition at the DeSilva Road crossing.

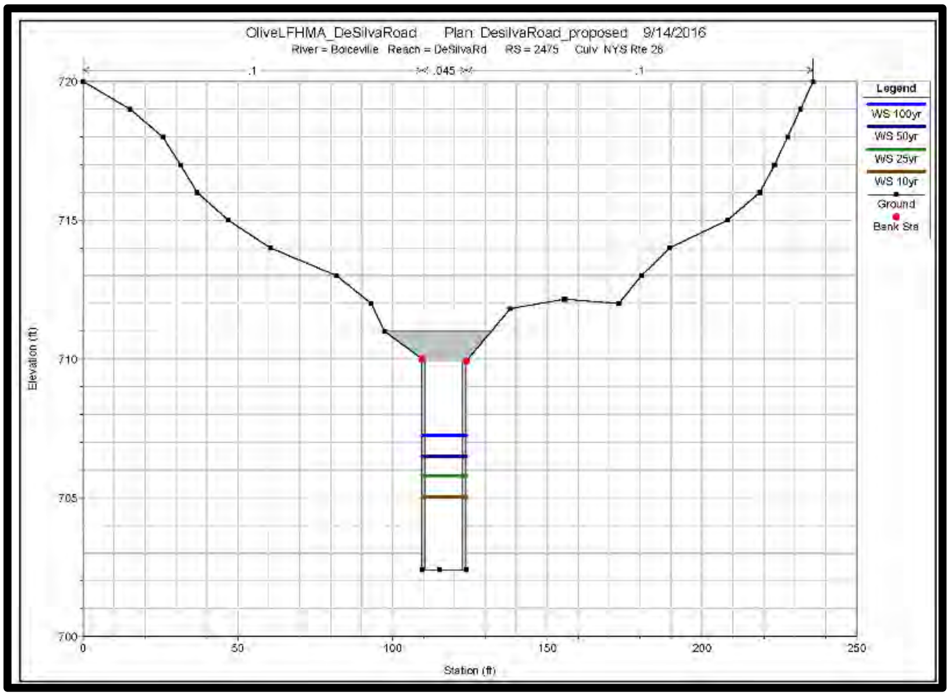


Figure 33: Proposed Cross Section at State Route 28 Crossing

Benefit to Cost Ratio: The conceptual construction cost estimate for replacing the DeSilva Road crossing with a 3 sided box culvert is $297,200 and a detailed construction cost estimate can be seen in Appendix Figure B-47.

Using FEMA's BCA Version 5.1.0's frequency damage assessment tool, the preliminary benefit to cost ratio was calculated assuming State Route 28 was at the crossing of the tributary. Due to water depth (0.2') and velocity occurring at the 50-year event, only modest clean up would be needed. During the 100-year flood event, it was assumed the crossing would be damaged beyond repair and would need to be closed until it was replaced. Assumed closure length was 120 days. The detour starts at the closure and requires a vehicle to travel northwards to Mt. Tremper, turn north on State Route 212, turn southeast onto Wittenberg Road, continue on Yankeetown Road until it joints with State Route 28. The length of detour was measured at 10.5 miles and estimated to take an additional 20 minutes of time. A 2013 NYSDOT Roadway Traffic County Hourly Report counted an average weekday daily traffic (AWDT) count of 5,325 traveling southbound on SR 28 between 4/23/13 and 4/29/13. This AWDT count was used at the BCA traffic trips per day. The preliminary BCR was 4.88 (Table 36) and the summary report can be seen in Appendix Figure B-48 and Figure B-49.

Table 36: BCA Input and Results for DeSilva Mitigation Area Plan #15-Crossing Under State Route 28

Project Useful Life	50 Years
Annual Maintenance Costs	$750
Estimated Number of 1-Way Traffic Trips	5,325
Additional Time Per One-Way Trip	20 minutes
Number of Additional Miles	10.5
DPW Road Detour Cost (Existing Conditions)	$2,500
DPW Road Clean Up (Existing Conditions-50-Year RI, 100-Year RI)	$4,500,$0
Days Road Would be Closed (Existing Conditions-50-Year RI, 100-Year RI)	1,120
Mitigation Benefits	$1,501,701
Mitigation Costs	$307,551
Benefit to Cost Ratio	4.88

Implementation Challenges and Opportunities: DeSilva Road could be closed without much disturbance to traffic due to low traffic volumes and proximal short detours. Since the road profile can be maintained, there will be negligible impact to adjacent driveways or the intersection with State Route 28.

Funding Sources: This project has a high BCR and may be eligible for funding through Catskill Watershed Corporation's Flood Hazard Mitigation Implementation Program, the Ashokan Watershed Stream Management Program's SMIP funding, or FEMA hazard mitigation grants after a Presidential disaster declaration. Since the existing crossing meets typical NYSDOT design standards for principle arterials, this project may not be seen as a high priority.

Water Quality Protection: Not Applicable

Prioritization:

Table 37: Prioritization Score for DeSilva Road Plan #15

Priority Metric name	Score	Numerical Value
Benefit to Cost Ratio	High	5
Water Quality Protection	Low	1
Community Cohesion Preservation	Low	1
Ease of Obtaining Permits for Proposed Solution	High	5
Economic Impact	Low	1
Ease of Funding	High	5
Ease to Acquire Easements	High	5
Level of Town Effort To Implement Plan	High	5
Total Score		28

4.6 State Route 28 Ponding Mitigation Area Summary

This mitigation area is located 100’ due east of the State Route 28 and Route 28A intersection as seen in Figure 34. There is an unnamed tributary running from north to south which flows under State Route 28 where it eventually joins the Esopus a couple hundred feet downstream. There are two flooding hazard concerns that are caused by the tributary’s floodwaters. The first is the stormwater hazard at the crossing under State Route 28 which is believed to be undersized causing flooding into the adjacent homes and businesses to the west of the tributary and east of State Route 28. The second flooding hazard concern is when the Esopus’ water levels are high due to flooding and how this may result in a rise in the tributary’s floodwaters if a later rainstorm causes flooding on the tributary. The FAC suggested there may be up to six buildings that could be impacted from these flooding hazards. The buildings can be seen in Appendix Figure B-2 (buildings B2 through B7) which shows the buildings are not inundated by floodwater during the Esopus' 10-year flood event. Compare Appendix Figure B-2 (10-year flood on the Esopus) to Figure Appendix B-3 (25-year flood on the Esopus) which shows inundation around the buildings during the 25-year flood event is caused by overbank flooding from the Esopus.

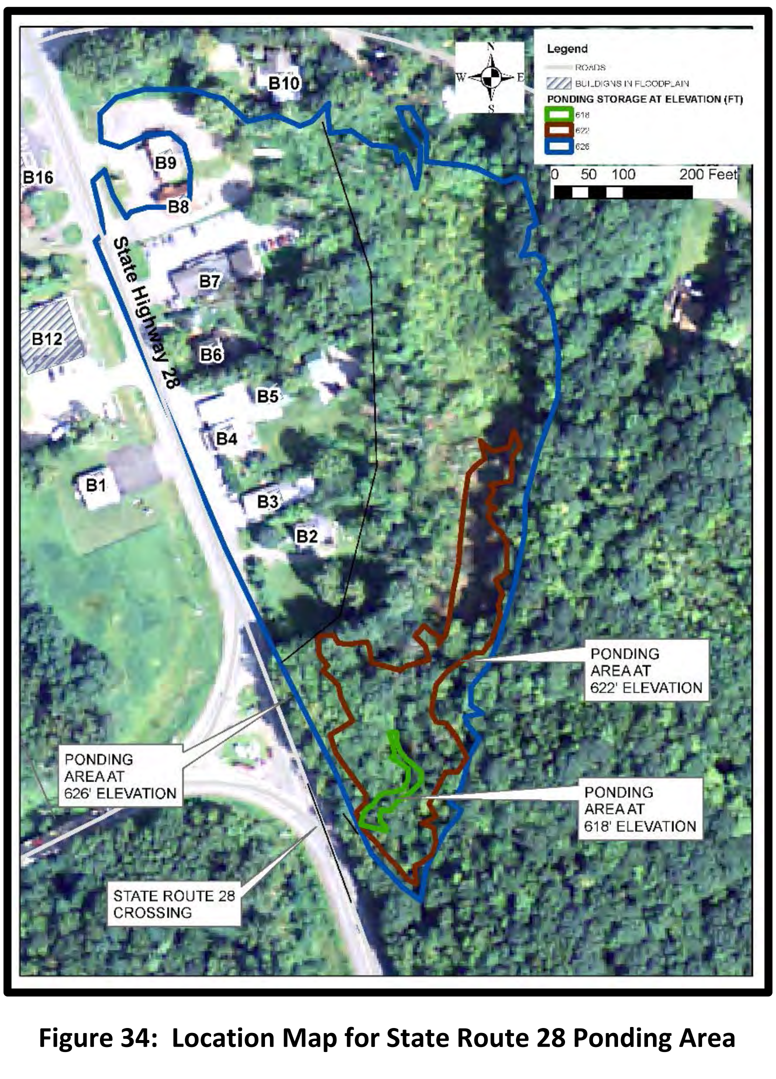


Figure 34: Location Map for State Route 28 Ponding Area

4.6.1 Hydraulic Approach

***Hydrology**:* The unnamed tributary is an ungaged stream which means there is no available discharge data to complete a flood discharge frequency analysis. The respective drainage area of the unnamed tributary is 0.65 square miles (as seen in Appendix Figure B-50). As such, flood discharges were developed using the Soil Conservation Service (SCS) Unit hydrograph method imbedded in the proprietary HydroCAD, Version 10.0 software package. Curve Numbers (CN) values were estimated from review of land use, aerial photography and Ulster County Soil Mapping. Predominant soil types consist of Hydrologic Soil Group C/D soils for the inflow areas of the two drainage areas. Land cover primarily consists of wooded areas.

The 24 hour precipitation values for the 2, 10, 25, 50, 100 and 500-year return interval storms were obtained from the Northeast Regional Climate Center (NRCC) precipitation data for the project vicinity. The individual peak discharge values for the tributary are shown in Table 38.

Table 38: Flood Discharges for Unnamed Tributary to State Route 28 Ponding Area

Return Interval (Years)	Discharge (cfs)
2	98
10	199
25	282
50	363
100	459
500	760

Channel topographic data and crossing dimensions were collected by a laser survey and floodplain topography was obtained from the 2009 LiDAR survey. The information was used to calculate a stage volume curve and the information was input into HydroCAD model.

Water Surface elevations for several flood events on the Esopus were obtained from the Corrected WEC HEC-RAS model and can be seen in Table 39. The development of the Corrected WEC HEC-RAS model is described in the 2016 “Town of Olive Local Flood Analysis 28A bridge replacement and Boiceville Study Area Flood Mitigation Strategies” report (WEC 2016). Since the flooding of the homes occurs via Esopus overbank flooding beginning at the 25-year flooding event, only the 2-year and 10-year water surface elevations were used in this analysis because these are the studied flood events on the Esopus whose water elevations could influence the unnamed tributary’s water surface elevations.

Table 39: Water Surface Elevations on Esopus to Determine Backwater Effect on State Route 28 Ponding Area

Return Interval (Years)	Water Surface Elevation On the Esopus (Cross Section 8250, in ft)
2	616.7
10	621.1

4.6.2 Existing Hydraulic Conditions and General Site Conditions

Summary: The existing hydraulic conditions are summarized in Table 40. Table 40 shows negligible difference between the water surface elevations in the ponding area under free discharge conditions and when the Esopus has a 2-year flood. When the Esopus has a 10-year flood occurring, there is a notable difference between these water surface elevations and under free discharge conditions. The results show that the water surface elevation on the Esopus does influence the pond's water surface elevation. Table 41 shows the basement type, Height of Adjacent Grade (HAG) and First Floor Elevations (FFE) of the buildings in the ponding area. If there is a 10-year flood on the Esopus creek and a 500-year flooding event were to occur, this would lead to inundation of one building's (B9) first floor elevation by 0.9'. The probability that this would occur is 0.0002 (once in 5,000 years) therefore this is not considered a flood hazard. Please note, at house B2, there would be 0.6' of water around the house during the 10-year Esopus, 100-year tributary flood condition. However, it is believed the mechanics in the house are elevated to the first floor elevation and therefore would not be damaged by flooding. In all other buildings, the mechanics are located at the first floor elevation. The results of this analysis show no flooding hazards exist from the tributary's floodwaters at the State Route 28 Ponding Mitigation Area.

Table 40: Water Surface Elevation Results In State Route 28 Ponding Area

Water Surface Elevation in Pond Upstream of SR 28 Crossing					
Condition		Storm Return Interval			
	10-yr	25-yr	50-yr	100-yr	500-yr
Free Discharge (No Tailwater)	619.78	620.9	621.74	622.80	625.60
Esopus 2-yr WSEL (Tailwater)	619.9	620.9	621.79	622.84	625.61
Esopus 10-yr WSEL (Tailwater)	622	622.7	623.4	624.3	625.9

Table 41: First Floor Elevations and Highest Adjacent Grade of Buildings Near State Route 28 Ponding

Building ID	Basement Type	Height of Adjacent Grade (ft)	First Floor Elevation (ft)
B2	Unfinished	623.7	627.7
B3	Slab	625	625
B4	Unfinished	625	626
B5	Slab	625	626
B6	Unfinished	626	628.5
B7	Crawl	625.4	626.4

Results**:** Not Applicable, no flooding hazard exists

Benefit to Cost Ratio: Not Applicable, no mitigation solution presented

Implementation Challenges and Opportunities: Not applicable

Water Quality Protection: Please refer to discussion in section 4.1 on page 34 about water quality pollution sources caused by over bank flooding and backwater effects from the Esopus.

Prioritization: Not Applicable, no flooding hazard exists

5.0 West Shokan Study Area

5.1 Watershed Characteristics that Impact Flooding Hazards.

5.1.1 Topography and Climate

The Bushkill watershed drains 19.4 mi^2 to the study area beginning at its furthest point 7.2 miles away at Mombaccus Mountain (elevation 2,631'). The Bushkill watershed drains rugged Catskill terrain with the highest elevation occurring at High Point which lies southwest of the West Shokan Study area at elevation 3,400'. The channel elevation at the downstream extent of the West Shokan Study Area near where the Bushkill meets the Ashokan reservoir is 586'. This creates a steep gradient as water and sediment make a quick descent to the Study Area. The average channel slope is 5.0% and is classified as a mountainous stream. A review of the 2013 United States Geological Service (USGS) West Shokan, NY topographic map show the headwaters of the Bushkill consisting of narrow and steep valleys which drain to a flat and wide valley in the Study Area. This flat wide valley is an alluvial fan which starts about 1.0 mile upstream of the Maltby Hollow/Bushkill confluence along Maltby Hollow Creek and 0.25 miles upstream of the Maltby Hollow/Bushkill confluence along the Bush Kill. The average channel slope in the alluvial fan is 2% which is a notable decrease than the average channel slope in the steeper headwaters.

An alluvial fan is a fan or cone shaped sediment deposit built up by streams. Alluvial fans are a notable geomorphic feature in flood mitigation planning because sediments (sands, gravels and cobbles) are expected to deposit along an alluvial fan and infilling may occur. Infilling results in the space that once was occupied by water that is now occupied by deposited sediments. This often results in higher water surface elevations during flooding events because there is now inadequate space within the river to move floodwaters.

The climate in the watershed is characterized as humid continental with the amount of precipitation varying based on orographic lifting (at increasing elevations, more rainfall occurs) and annual precipitation varies from 36" to 60" elevation dependent. This elevation gradient combined with the potential for large intense rainstorms can transport water and debris (rocks and trees) into the Study Area creating flooding hazards quickly.

5.1.2 Surficial Geology

The underlying bedrock of the watershed consists mostly of sandstones, siltstones and shales (CCEUC 2007) and was "mined and scraped" by several rounds of ice ages over the last 1.3 million years. The bedrock was broken and pushed by ice sheets, some ice sheets were several thousand feet thick. As the glaciers receded, the mined rocks (ranging in size from sands to boulders) were deposited into features that ranged upwards of hundreds of feet thick.

In the Bushkill watershed, the dominant surficial geology feature is unsorted glacial sediment commonly referred to as glacial till. These features are a heterogeneous mix of silts, sands, gravels and cobbles and are compacted. Glacial till is not as erodible as glacial outwash since the silts and clays provide cohesive strength. However, once exposed to moving water the silts and clays become suspended in the water solution creating turbidity problems. Also if a stream bank consisting of glacial till becomes overly steepened by erosion along the stream bank toe, it will fail in large sections causing erosion hazards and ongoing turbidity issues. Sediments from the last ice age's glacial outwash and continued erosion of the glacial till lining valley floors are probably the main source of sediments that have created the alluvial fan in the Study Area.

5.1.3 Anthropogenic

The Ashokan Reservoir watershed has been altered by human behavior (anthropogenic). European settlement of the watershed began in the 1700's and by the late 1800's, 80%-90% of the original forests were gone (Kudish 2000) for tanneries and kiln enterprises. The loss of original forest cover increased the amount of rainfall runoff from the stripped lands while decreasing the vegetation that held fragile soils together causing the land to erode. The increased amount of water and sediments rushed down the mountains slopes into the river valleys below. The resulting intersection of this wall of water and sediments at the valley floor caused the streams there to undergo severe changes due to increased rain runoff and the denuded stream banks consisting of highly erodible glacial outwash. Typical changes during this kind of instability are steep eroding stream banks, narrower water corridors (i.e. little to no connection to low lying floodplains) and often poor water quality.

Continued anthropogenic activities in the Study Area influence the Bushkill and its tributaries by either controlling their channel alignments or separating their floodplains from the channel. Long stretches of rip rap were observed during the windshield survey in an attempt to prevent the creeks and streams from moving into unwanted areas as seen in Figure 35 below. Stream spoil berms were observed in multiple locations. A stream spoil berm is a man-made feature created by excavating material from the stream and dumping them along the side of the stream. The berm's original purpose could have been to prevent floodwaters from entering sensitive areas or to lower the creek bed elevation in an attempt to reduce floodwater elevation or a combination of the two. The size of the vegetation growing on the stream spoil berms is an indicator of how old the berms may be (less than 25 years). Due to the geological and geomorphic nature of alluvial fans which are traditionally areas where large amounts of sediment deposition occur and where channel alignment migration often occurs, it is anticipated more human interventions will be needed to protect sensitive infrastructure from flood hazards.

Figure 35: Looking upstream of the Maltby Hollow Brook Bridge at rip rap revetment. Note stream spoil berms upstream of revetment on left bank

Figure 36: Looking upstream on Bushkill adjacent to Town Offices.
Looking at right bank stream spoil berms.
Note the tree diameter on berm is smaller than tree diameters landward

5.1.4 Flooding History.

The flow gage data was obtained from the USGS stream gage (ID# 01363382) located on the Bushkill just downstream of its confluence with Maltby Hollow Brook. This gage has been recording peak discharges for 14 Water Years (beginning in 2000). The top five flood events are listed below.

Table 42: Top five recorded discharges at USGS Stream Gage #0136382

Rank	Year	Discharge (cfs)
1	2011	6,240
2	2005	3,800
3	2006	3,300
4	2010	2,640
5	2007	1,730

The discharges used in the HEC-RAS model were reviewed to determine the flood return interval of the discharges shown in Table 42. A return interval is a statistical term that describes the frequency a certain discharge will occur. For example, a 10-year return interval flood will statistically occur once in ten years. The discharges for the study area used in the HEC-RAS model are seen in Table 43. The largest flood recorded at this station was the 2011 flood. This event was approximately a 50-year return interval flood. There was no reported damage caused by inundation from overbank flooding in the West Shokan Study Area but there were several locations that needed repair from erosion after the 2011 flood.

Table 43: Flood Discharges From Preliminary FEMA Hydrologic Model

Return Interval	Discharge (cfs)
10-Year	2,485
25-Year	4,239
50-Year	6,058
100-Year	8,484
500-Year	16,492

5.1.5 Floodplain Development Ordinance and Related Town Planning Documents

Please refer to section 4.1.5 on page 35. The Bushkill Study Area is located within the Town of Olive.

5.2 West Shokan Study Area Local Flood Analysis Summary

The West Shokan Study Area was broken into several mitigation areas to organize the proposed mitigation solutions as seen in Figure 37 below. The mitigation areas were separated by the major water body flowing through them. The first mitigation area (the Bushkill Mitigation area) starts at the confluence of the Bushkill with the Ashokan Reservoir and extends upstream to the confluence with Maltby Hollow Brook approximately 7,500 feet upstream (including the bridge). Five hazards were identified in this area. The second mitigation area is Maltby Hollow Brook starting at the confluence with the Bushkill and extending 800' upstream. The only hazard in the Maltby mitigation area was the Maltby Hollow Bridge which carries County Route 42 over Maltby Hollow Brook. The final area (Dry Brook mitigation area) starts at the confluence of Dry Brook with the Bushkill and extends approximately 3,200 feet upstream. The only hazard that was identified in the Dry Brook mitigation area was the crossing of Burgher Road over Dry Brook. It is believed that this hazard may flood the homes to the west of the tributary. The eastern portion of this mitigation area overlaps the eastern portion of the Bushkill mitigation area.

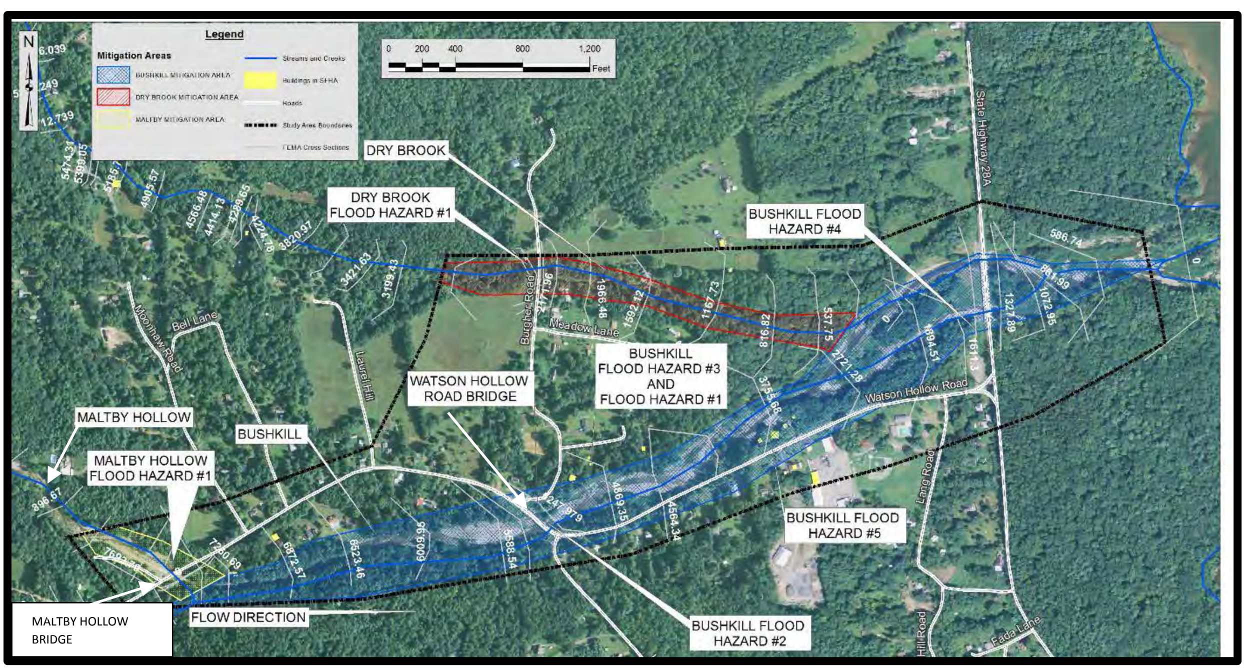


Figure 37: Location map of the three mitigation areas in The West Shokan Study Area

5.3 Bushkill Mitigation Area Summary

Five flooding hazards were identified from the submitted FAC flooding hazards, public flooding hazards and from the data gap analysis in the Bushkill mitigation area. The cause of all these flooding hazards is the buildup of debris (logs or stone) deposited during times of high flow. As discussed in section 3.4.1 on page 25, the Bushkill mitigation area is within an alluvial fan and is prone to deposition of gravels, cobbles and logs. The flooding hazards are locations where buildup and the consequential obstruction could cause undesirable rises in flood water elevations that could inundate homes, bridges or roads. Also, the community was concerned the obstructions could also cause undesirable changes in the speed of water (velocity) that could remove stream bank material (erode) causing bridges or roads to fail.

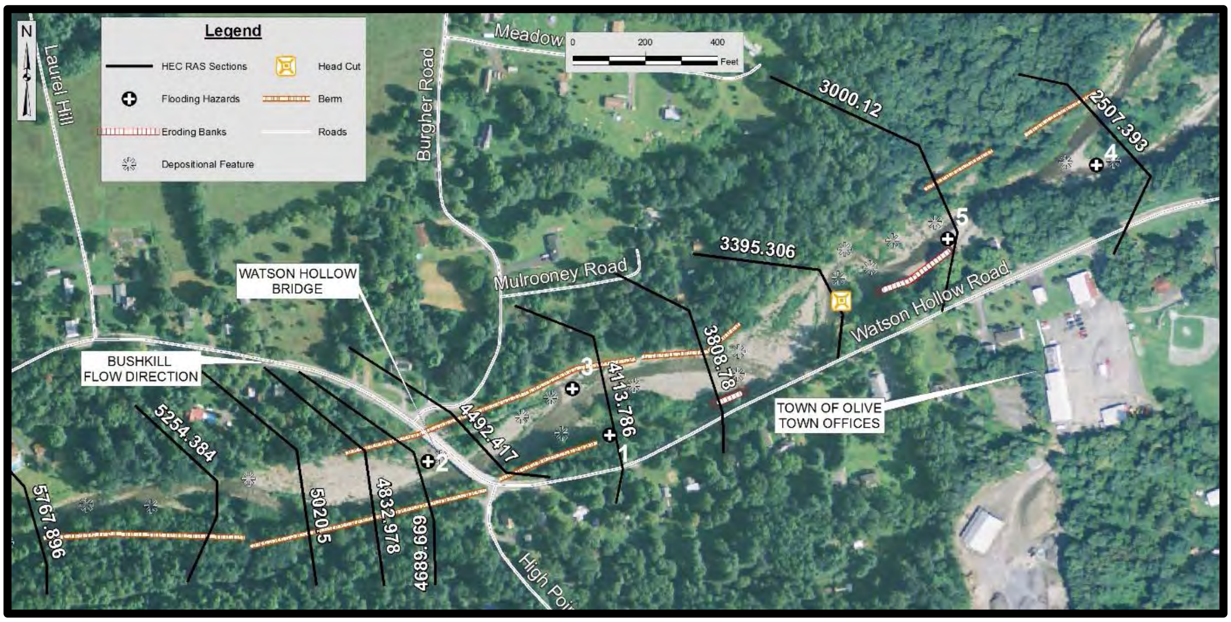


Figure 38: Location Map of Cross Sections Used in the Hydraulic Analysis and Flood Hazards

5.3.1 Hydraulic Approach

The duplicated FEMA HEC-RAS model as described in section 3.4.5 was corrected using supplemental cross sections to ensure the topographic data in the model was up to date. The following sections in Figure 38 were resurveyed: 4832, 4689, 4492 and 3000 (decimal values excluded). Section 5020 was a new section for the corrected model to inform potential mitigation solutions. The general cross section geometry appears to have changed little although there are some channel modifications observed such as seen in stations 360 and 440 in Figure 39 (along the left bank looking downstream). However this change was deemed minor therefore it was determined that no additional cross sections in the Bushkill mitigation area would need to be resurveyed for the mitigation analysis. The corrected HEC-RAS model was used to calculate “existing conditions”.

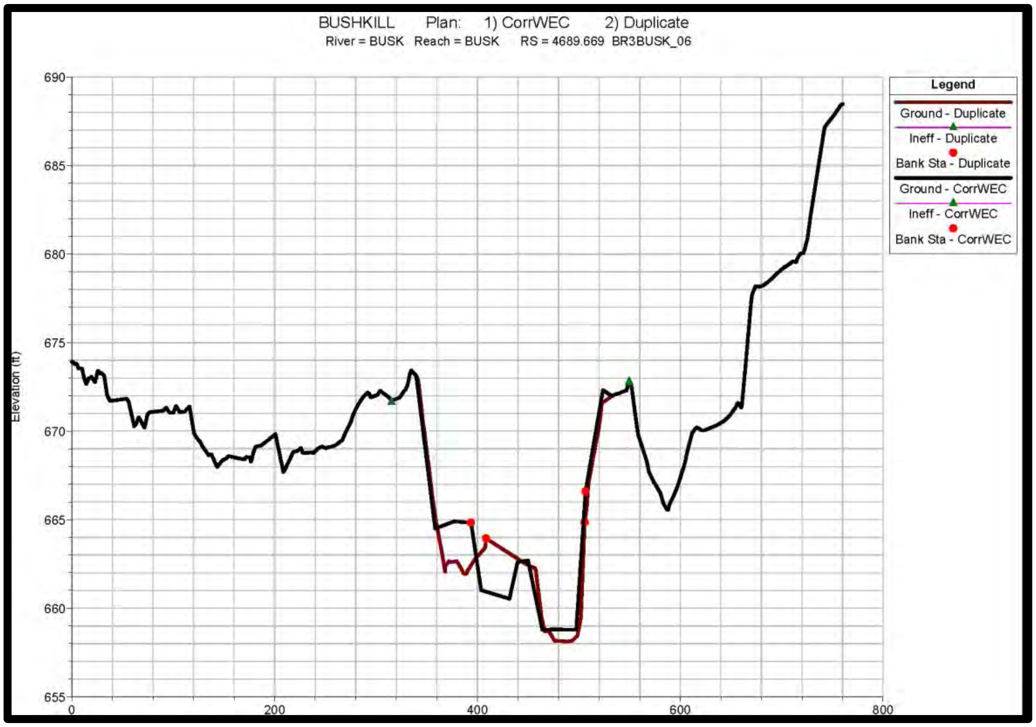


Figure 39: Section View of the Corrected and Duplicated Topography in the Bushkill

5.3.2 Existing Hydraulic Conditions and Water Depths

As seen in Appendix Figures A-16 through A-20, the Bushkill's water depth maps, there is only one home that is inundated by floodwaters and this occurs at the house shown in Figure 43 (page 98) Building B100 is inundated at the 100-year flood by 0.6' of water. There will be some damage at this building but the cost will be modest and occurs so infrequently that this was not considered a flooding inundation hazard. As such, flood inundation hazards under clear water conditions (i.e. no obstruction) do not exist in the Bushkill mitigation area. The flood hazards listed in sections 5.3.3 through 5.3.7 were modeled under obstructed conditions, i.e. water surface elevations were calculated assuming part of the Bushkill was blocked. If the resulting water surface elevations caused a flood inundation hazard, then a conceptual mitigation solution was developed.

5.3.3 Flood Hazard #2 - Watson Hollow Bridge

Summary: The Watson Hollow Road crossing over the Bushkill is a vital transportation route for the citizens who live in the hamlet of West Shokan. If the bridge were to be rendered unusable, the residents of 183 homes would need to make a one hour detour of sixty miles to access eastern travel destinations such as Shokan or Kingston for emergency services, provisions, school and work. If this bridge were rendered unusable for long periods of time because it was damaged beyond repair and needed to be replaced, the financial hardships to the several hundred residents living west of the bridge would be severe.

The left side of the Watson Hollow Bridge (looking downstream) is filled with sediments from a large depositional feature (gravel/cobble bar). This blockage has reduced flood conveyance volume along the left bank and forced most of the flood flows along the right bank. With more water being forced along the right bank, the speed of water (velocity) has increased, resulting in erosion of the Bushkill's channel bottom. Evidence of the erosion can be seen in Figure 41. Figure 40 shows there is only 6' of freeboard (the space between the bottom of the bridge and the channel bottom) along the left bank. Figure 41 shows that there is over 14' feet of freeboard along the right bank. Figure 41 also shows the channel bottom has eroded enough that the bottom of the bridge abutment is hanging in air and that the rip rap (large stone protection) has been compromised (there are many large stones missing). This condition should be noted by the county and corrected immediately before the condition worsens.

The concern is if this bridge were to be compromised, it would leave 183 homes without quick access to emergency services. The most common reasons for the bridge to become compromised are the overtopping of the bridge or abutment failure due to ongoing erosion.

Figure 40 Looking Downstream at Watson Hollow Bridge

Figure 41: Looking at Right Bank at Watson Hollow Bridge

This flood hazard mitigation solution modeled a large obstruction upstream of the bridge to calculate the change in water surface elevation and water velocity. The FAC selected an obstruction size that would block 50% of the bridge opening area assuming a larger obstruction blocking more of the opening area would be removed before the next flood. The obstruction was modeled on the left bank because there is a large gravel bar forming here with woody vegetation growing on it. These conditions are conducive for a naturally occurring obstruction to form on the left side of the creek as opposed to the right side of the pier which is open to flow.

Results: Figure 42 shows the obstruction at the upstream side of the Watson Hollow Road crossing over the Bushkill. This obstruction was 720 square feet which blocked roughly 50% of the 1,450 square feet opening underneath the bridge. The obstruction caused a rise in all water surface profiles; however, none exceeded the deck elevation meaning that all floodwaters occurring at the 100-year flood and during more frequent floods pass under the bridge as shown in Figure 42. The water surface profile can be seen in Appendix Figure B-51. The water velocities through the bridge increase with the obstruction (see Table 44). This is more notable during a moderate flood event (the 10-year flood) and less so during the larger flood events (100-year).

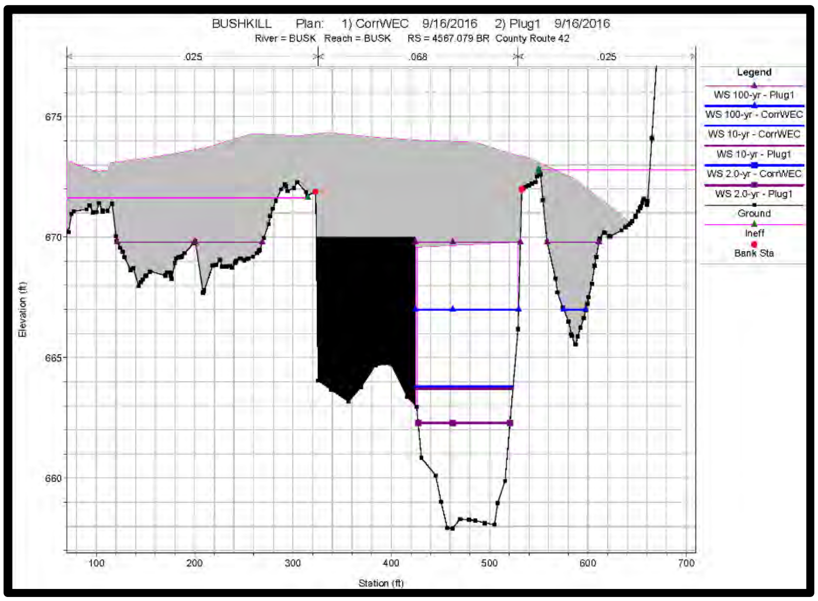


Figure 42: Hydraulic Results of Clear Water and Obstructed Conditions

Table 44: Hydraulic Results of the Clear Water Condition vs. Obstructed at Watson Hollow Bridge

Point of Interest	**10 Year Velocity**			**100 Year Velocity**		
	Plug 1	Corrected	Difference	Plug 1	Corrected	Difference
5254	6.38	6.52	-0.14	9.15	9.05	0.1
4832	5.86	6.96	-1.1	6.75	9.65	-2.9
4689*	6.92	5.23	1.69	9.57	9.32	0.25
4113	5.65	5.65	0	6.45	6.45	0
3395	7.98	7.98	0	9.72	9.72	0
All Values in Feet/Sec						
*Cross Section Located Upstream Next to Bridge						

A sizable obstruction at the Watson Hollow Road crossing over the Bushkill does not cause inundation hazards but does increase the water velocity through the bridge. This is noteworthy considering the already compromised right bank abutment. Since no inundation hazards occur at this mitigation solution, no conceptual design or BCR was completed.

The proposed mitigation solution would be part of the debris management strategy (stable alluvial fan channel design and engineered sediment depositional areas and engineered log debris entrainment areas). This would begin ~200' upstream of the Watson Hollow Bridge and end 100' downstream of Potential Flood Hazard location #4. Since this solution does not solve an inundation flood hazard it is not considered part of the LFA scope and therefore needs to be addressed under a different program.

Benefit to Cost Ratio: Not Applicable, no mitigation solution developed.

Implementation Challenges and Opportunities: Not Applicable, no mitigation solution developed.

Funding Sources: The solution's design and construction budget for protecting the Watson Hollow Bridge is not covered under the LFA program. However, other resources such as the Ashokan Watershed's Stream Management SMIP grants or New York Rising Community Reconstruction Program funds could be used to address this erosion hazard.

Water Quality Protection: Not Applicable, no mitigation solution developed

Prioritization**:** Not Applicable, no mitigation solution developed

5.3.4 Flood Hazard #5 - Homes Along Watson Hollow Road

Summary: Between the Bushkill and Watson Hollow Road there are three homes located proximal to the Town of Olive town offices located on the Bushkill's right bank. One of these homes is within the Special Flood Hazard Area (B100 in Figure 44) and has a first floor elevation (FFE) at approximately 628. The home is inundated (0.5') during the 100-year return interval flood. The other homes FFE are approximately a foot higher and they are located 100' upstream (west) and 100' downstream (east) of B100. The FAC is concerned that the inundation depth could rise rapidly if an obstruction were to form, blocking floodwater flow near cross section 3000 as shown in Figure 44 (on page 99).

In addition to this concern, the Bushkill has migrated away from its recent centerline and moved towards the right bank. Evidence of this can be seen in the inundated tree in Figure 43. This tree would not have grown in the middle of the river and it is leaning, suggesting the supportive soil has been washed away. The channel migration has also created a headcut. A headcut is a relatively sudden change in elevation or a knick point in a stream. For example, the headcut in the area where the Bushkill has migrated features a drop of more than 5' over a distance of 40' whereas along the Bushkill's centerline there was a drop of about a foot over the same distance. The headcut and the presence of faster moving waters along the right bank pose a concern to the stream bank protection (rip rap) that is protecting the three homes along the bank. Headcuts migrate upstream and this headcut could undermine the scour protection of these homes and could cause an erosion hazard to the homes.

Figure 43: Looking at Right Bank near the Homes.
Note Mature Vegetation in the Center of the Bushkill

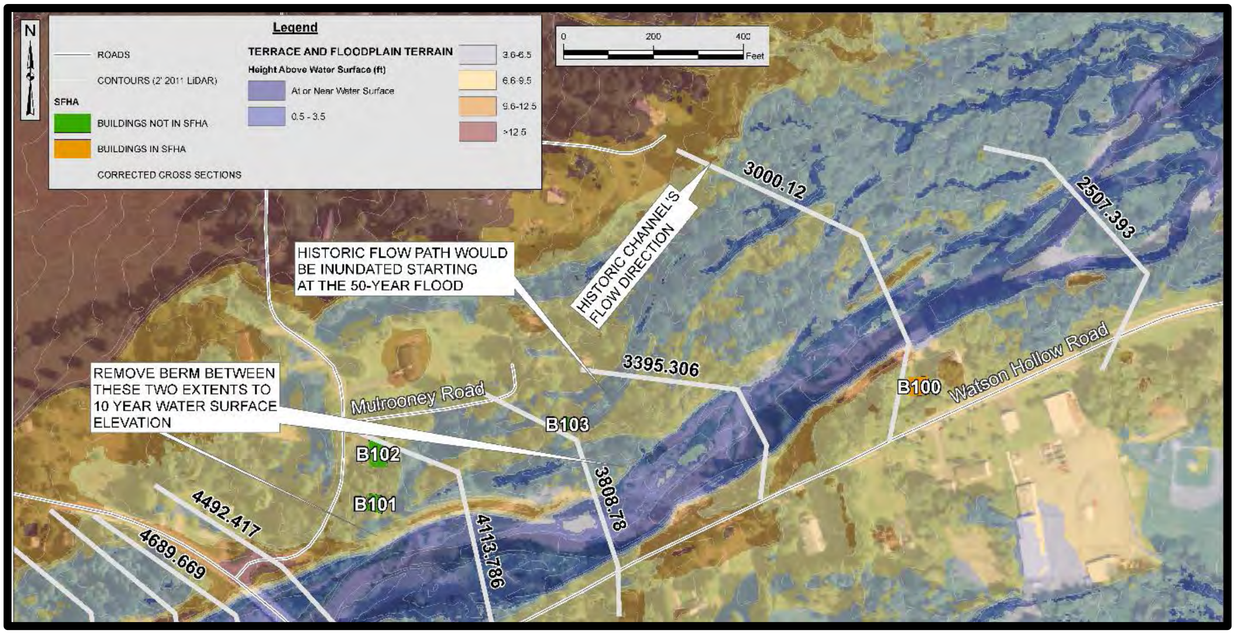


Figure 44: Location Map of Cross Sections and Buildings Near Flood Hazard #3 and #5

An obstruction was modeled in the duplicated HEC-RAS model by inserting an obstruction along the left bank (the area most prone to debris accumulation). The obstruction's size was increased until a moderate flood (the 25-year) began to inundate the home (FFE=642.5) which also means the 100-year flood would then cause moderate damage. The FAC considered it realistic that an obstruction could block approximately 50% of the active channel. Any larger obstruction would more than likely be removed. Therefore, a flooding hazard under obstructed conditions occurs if an obstruction blocking 50% or less of the active channel results in a rise in water surface elevation (WSEL) inundating building B100 during the 25-year return interval flood.

Results: A left bank obstruction was added to section 3000 at station 162 and increased towards the right bank until the desired rise of the 25-yr WSEL was achieved. The resulting obstruction that achieved this rise ended at station 667 (a length of 500') as seen in Figure 45. The channel is approximately 60% blocked between bank stations, and approximately 73% between the stations of 159 and 874 where the 25-yr WSE reaches the extents of the cross section. The water surface profile comparison between clear water and obstructed water can be seen in Appendix Figure B-52 and in Table 45 on page 100.

The obstruction size exceeded the threshold to consider Hazard #5 a flood hazard. Appendix Table B-53 does show that velocities increase because of the obstruction which will cause further destabilization of the area causing the head cut as discussed in the summary to migrate upstream posing an erosion hazard to the homes along the right bank.

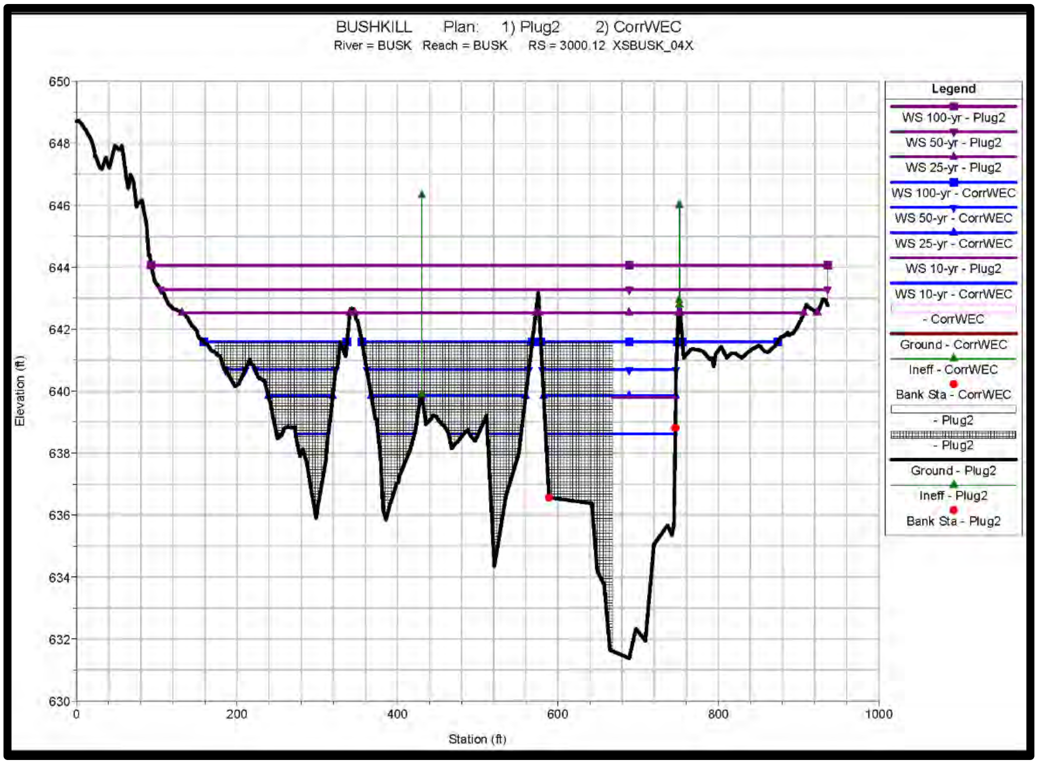


Figure 45: Section View of Plugged Cross Section for Hazard #2

Table 45: Water Surface Elevations for Hazard #2

Point of Interest	25 Year Water Surface Elevation			100 Year Water Surface Elevation		
	Plug 2	Corrected	Difference	Plug 1	Corrected	Difference
4689	666.31	666.31	0	Plug 2	Corrected	Difference
4113	657.91	657.46	0.45	668.31	668.31	0
3395	644.8	642.86	1.94	659.98	659.78	0.2
3000*	642.53	639.84	2.69	646.97	644.91	2.06
All Values in Feet						
*Cross Section Located Adjacent to Building B100 on Watson Hallow Road						
(Height of Adjacent Grade is 641.0, First Floor Elevation is 642.5)						

Benefit to Cost Ratio: Not Applicable, no mitigation solution developed.

Implementation Challenges and Opportunities*:* Not Applicable, no mitigation solution developed.

Funding Sources: The solution's design and construction budget for protecting the Watson Hollow Road Bridge is not covered under the LFA program. However, other resources such as the Ashokan Watershed's Stream Management SMIP grants or New York Rising Community Reconstruction Program funds could be used to address this erosion hazard.

Water Quality Protection: Not Applicable, no mitigation solution developed

Prioritization: Not Applicable, no mitigation solution developed

5.3.5 Flood Hazard #3 and #1: Man-made Levee and Erosion Hazards to Watson Hollow Road

Summary: This site is located 450' downstream of the Watson Hollow Bridge along the left bank. There is a man-made berm at this site as seen in Figure 46 below (hazard #3 in Figure 38, page 93). The preliminary FIRM (Map# 36111C0410E) does not show this feature so it is not a certified FEMA levee. It appears this feature was built to provide flood protection from the Bushkill for three homes that are north of the berm between the Bushkill and Mulrooney Road as seen in Figure 38 on page 93. It is unclear if this berm was engineered and built following good construction practices (engineered fill, compaction, etc.) It appears the berm is being maintained by evidence of recent mowing. However, small woody vegetation is starting to grow which is contra-indicated for the maintenance of flood protection facilities.

The riverward side of the earthen berm is protected from erosion using rip rap. This can be seen with the evidence of large stones along the rock toe in Figure 47. In some locations large stones are missing and could have rolled out of place and been buried. The FAC's concern is that if this berm fails, then the adjacent homes could be flooded. The FAC is also concerned that the berm has cut off floodplain access resulting in increased velocities and water surface elevations proximal to the berm. If this is true and the problem is corrected, it could reduce water velocities along Watson Hollow Road (Hazard #1 in Figure 38 on page 93) alleviating the existing erosion of the road embankment and along the berm itself.

Figure 46: Photo Taken at Photo Point #4. Looking Downstream at Man Made Berm

Figure 47: Photo Taken at Photo Point #4
Looking Upstream at Man-made Berm and Missing Large Stones

To model a berm failure and to see what its impacts are to water velocities and water surface elevations, the ground was lowered in the model to below the 10-year WSEL (the lowest flood modeled). This was completed for section 4113 (seen in Figure 48) and section 3808 (seen in Appendix Figure B-54).

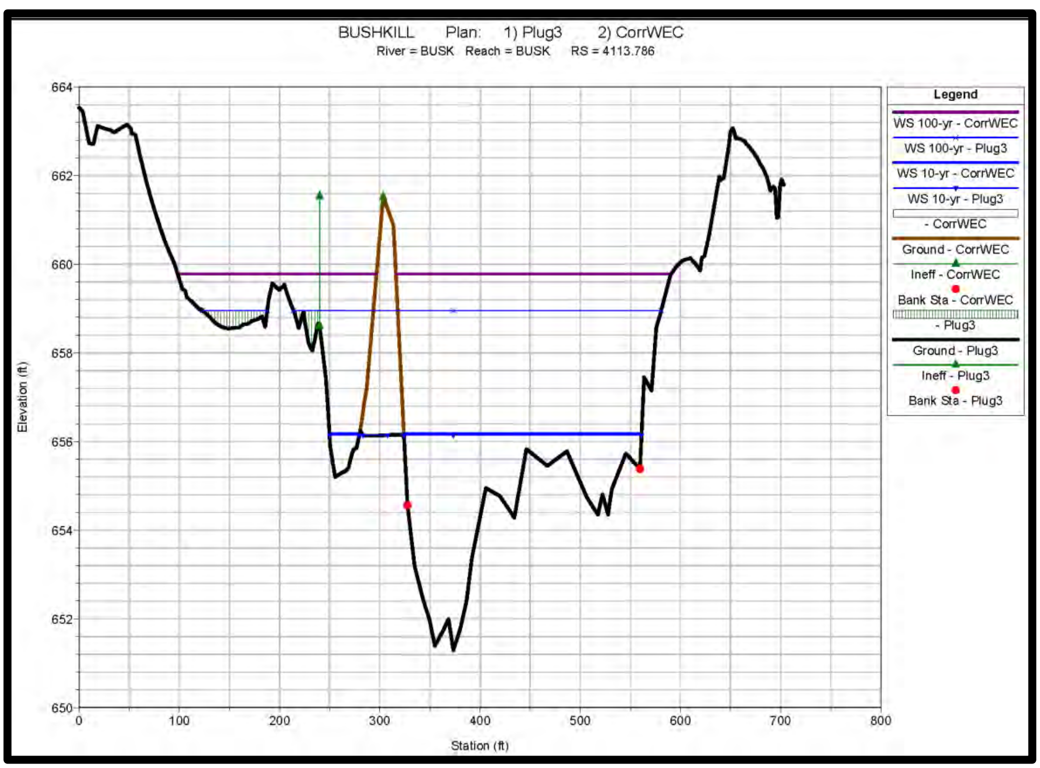


Figure 48: Cross Section View of Existing Conditions and Failed Berm (or Removed Berm) Conditions

Results: The removal of the berm does lower the 100-year water surface elevation (WSE) notably, (0.9') at the 100-year flood and modestly at the 25-year flood (0.3'). The reason for this decrease is with the berm removed, a historic flow channel can receive floodwaters, which had been blocked off by the berm as seen in Figure 44 on page 99. This increases the area available for flow and reduces WSEL as shown in Table 46. As shown in Table 47 (page 104), the 100-year WSEL is below the highest adjacent grade (HAG) of buildings B101-B103 when the berm is removed meaning the berm is not needed to prevent inundation against the 100-year flood. Interestingly, the 500-year WSEL overtops the berms at sections 4113 and 3808 (661.6' and 656.5' respectively) so the berm only protects the buildings for a flood between the 100-year and 500-year flood. Removing the berm does lower the 500-year WSEL at sections 4113 and 3808 to 661.1' and 655.1' respectively. This means buildings B101 and B102 are not inundated with or without the berm and building B103 has 1.4' less water depth if the berm is removed during the 500-year flood.

There is a notable reduction in water velocities in section 3808 during the 25-year and 100-year floods, 0.47 ft/sec and 1.44 ft/sec when the berm is removed as seen in Table 46. Removing the berm will reduce the erosive energy along the Watson Hollow road embankment, which is important since eroding banks along the road were observed and mapped as seen in Appendix Figure A-11. However there are increases in water velocities immediately upstream and downstream of the berm breached cross sections due to floodwaters expanding and contracting as they flow into and out of wider areas.

If the berm were to fail, there are no inundation hazards to buildings B101 and B102. Building B103 would be inundated by more water for flood events between the 100-year and 500-year flood which is so infrequent that it is not considered a hazard. Therefore, it can be concluded that inundation hazards do not exist at this mitigation site.

Table 46: Velocity Under Existing and Berm Removed Conditions for Hazard #3

Point of Interest	**25 Year Velocity Ft/sec**			**100 Year Velocity Ft/sec**		
	Corrected	Berm Removed	Difference	Corrected	Berm Removed	Difference
4832	7.83	7.83	0	9.65	9.65	0
4689	6.58	6.58	0	9.32	9.32	0
4492	7.09	7.10	-0.01	9.66	9.84	0.18
4113*	5.70	5.72	-0.02	6.45	6.45	0
3808*	7.89	7.42	-0.47	11.44	10.00	-1.44
3395	8.38	8.67	0.29	9.72	10.21	0.49
*Lowered Unaccredited Berm at sections 3808 and 4113 down to 10 year water surface elevation)						

Table 47: Water Surface Elevations Under Existing and Breached Berm Conditions for Hazard #3

Point of Interest	25 Year Water Surface Elevation			100 Year Water Surface Elevation		
	Corrected	Breached Berm	Difference	Corrected	Breached Berm	Difference
4832	668.15	668.15	0	670.54	670.54	0
4689	666.31	666.31	0	668.31	668.31	0
4492	663.34	663.33	-0.01	664.97	664.88	-0.09
4113*	657.46	657.19	-0.27	659.78	658.95	-0.83
3808*	651.94	651.91	-0.03	653.33	651.94	-1.39
3395	642.86	642.76	-0.1	644.91	644.68	-0.23
All Values in Feet						
*Lowered Unaccredited Berm at sections 3808 and 4113 down to 10 year water surface elevation)						
HAG Elevations: B101-663.0, B102-664.0, B103-653.2						

The proposed mitigation solution would be part of the debris management strategy (stable alluvial fan channel design and engineered sediment depositional areas and engineered Large Wood entrainment areas). This would begin ~200’ upstream of the Watson Hollow Bridge and end 100’ downstream of Potential Flood Hazard location #4. Since this solution does not solve an inundation flood hazard it is not considered part of the LFA scope therefore needs to be addressed under a different program.

***Benefit to Cost Ratio**:* Not Applicable, no mitigation solution developed.

Implementation Challenges and Opportunities: Not Applicable, no mitigation solution developed.

***Funding Sources*:** Resources such as the Ashokan Watershed’s Stream Management SMIP grants or New York Rising Community Reconstruction Program funds could be used to address this hazard.

***Water Quality Protection**:* Not Applicable, no mitigation solution developed

Prioritization: Not Applicable, no mitigation solution developed

5.3.6 Flood Hazard #4 - Erosive Damage to Route 28A Southern Approach

Summary: This site is located 920 feet upstream of the 28A bridge crossing. A historic flow channel exists along the right bank and is separated from the active flood waters by a gravel berm as seen in Figure 49 It appears the berm was created from side-casted gravels and cobbles when the Bushkill was dredged last and is similar to the side case berm seen in Figure 50 below. It is likely this berm was not engineered and not built following good construction practices (engineered fill, compaction, etc.)

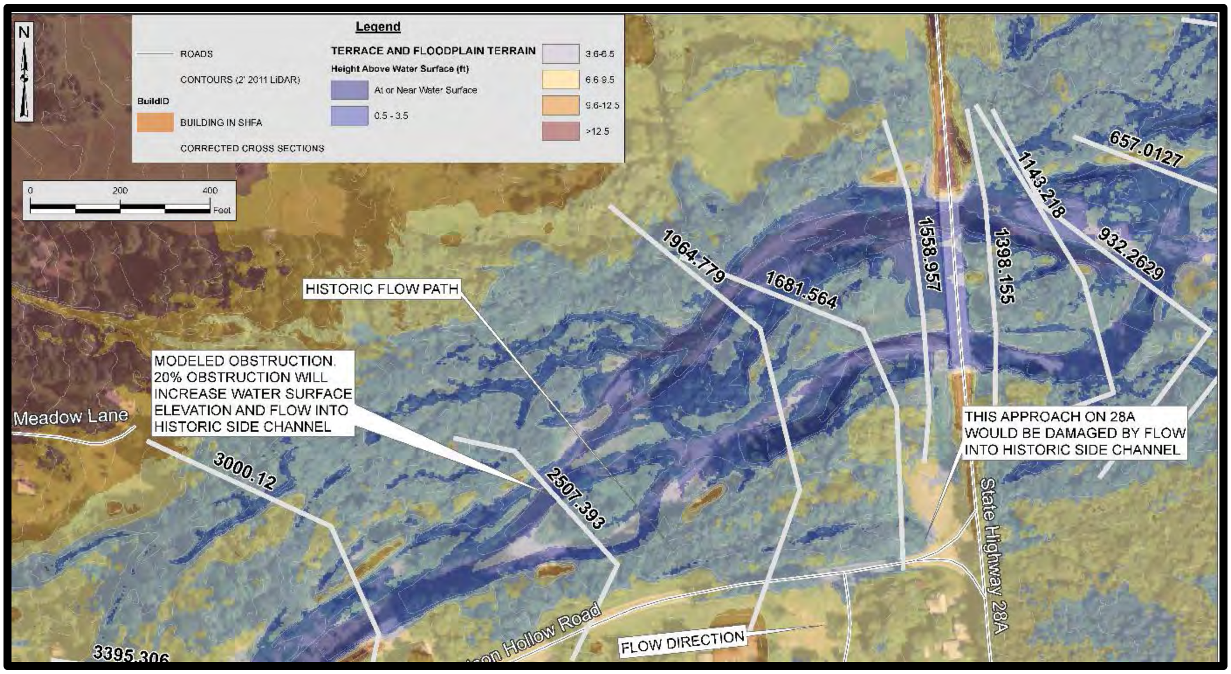


Figure 49: Location Map of Hazard #4

Large log obstructions and sediment obstructions have begun to form at this location. The concern is that continued growth of these obstructions could raise water elevations and increase velocities along the side cast berm. These two potential conditions could cause the side-cast berm to fail and moving water could reoccupy the historic flow channel. At the downstream end of the historic flow channel is the Route 28A parking lot and the Route 28A bridge approach. Neither of these facilities are protected against fast moving water and could become damaged if the side-cast berm fails, allowing the Bushkill to reoccupy its historic flow path.

Figure 50: Looking Downstream at Side Cast Berm

The obstruction was modeled in the duplicated HEC-RAS model by inserting an obstruction along the left bank (the area most prone to debris accumulation). The obstruction's size was increased until a moderate flood (the 10-year) overtopped the berm and floodwaters could enter the historic side channel leading to possible damage at the parking area pulloff at the Route 28A southern bridge approach and the approach itself. This damage would occur more frequently with the obstruction in place since there is less area for water to flow through in the Bushkill, requiring more water to flow in the side channel towards an area of Route 28A which is not protected against fast moving water. An obstruction could cause the Bushkill to migrate into the historic channel which would cause increase the amount of damage to the southern Route 28A approach since the majority of the water would be aimed there. The FAC considered it realistic that an obstruction could block approximately 50% of the active channel. Any larger obstruction would more than likely be removed.

Results: An obstruction was inserted at station 200 and ended at station 235 resulting in blocking 113 square feet of the channel area (458 square feet channel area). The obstruction blocks 25% of the channel resulting in the 10-year WSEL to rise and enter the historic flow channel as seen in Figure 51. This means that a relatively small amount of blockage could shift more water towards the southern Route 28A approach leading to its damage.

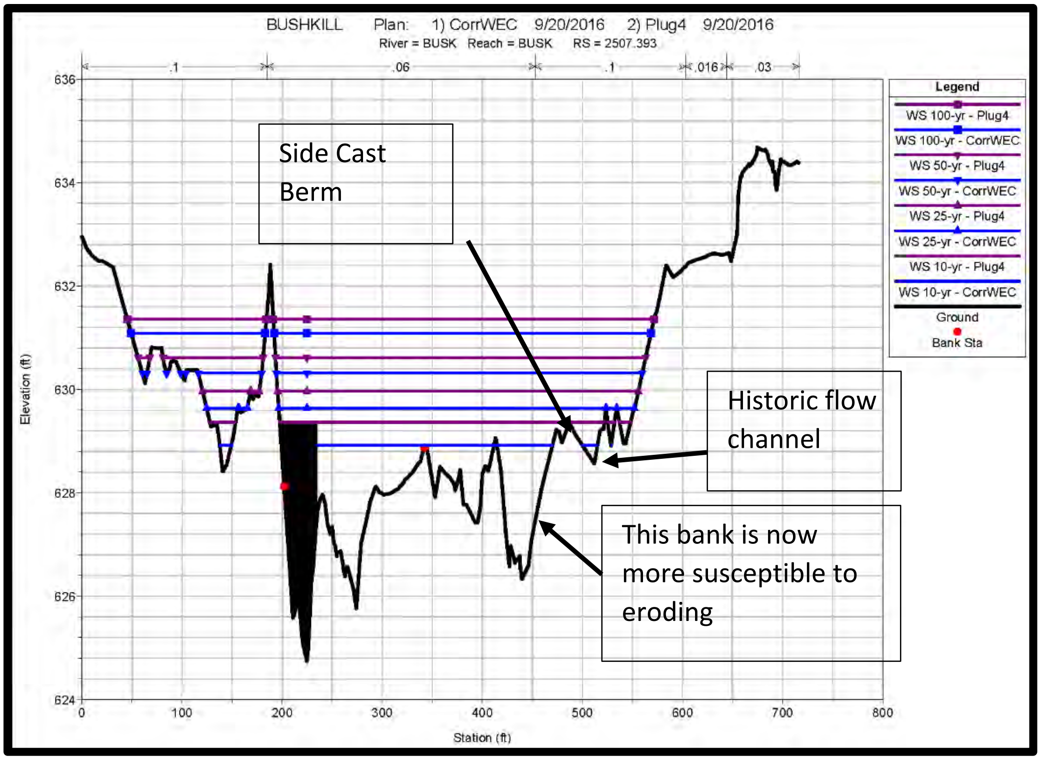


Figure 51: Section View of Plugged Cross Section for Hazard #4

The rise in water surface elevation does go away before the Route 28A bridge as seen in profile in Appendix Figure B-55. The obstruction does not cause an inundation hazard at the 28A bridge and its approach but would cause an erosion hazard at the southern approach pull out.

The proposed mitigation solution would be part of the debris management strategy (stable alluvial fan channel design and engineered sediment depositional areas and engineered Large Woody Debris entrainment areas). This would begin ~200' upstream of the Watson Hollow Bridge and end 100' downstream of Potential Flood Hazard location #4. Since this solution does not solve an inundation flood hazard, it is not considered part of the LFA scope therefore needs to be addressed under a different program.

Benefit to Cost Ratio: Not Applicable, no mitigation solution developed.

Implementation Challenges and Opportunities*:* Not Applicable, no mitigation solution developed.

Funding Sources*:* The solution's design and construction budget for protecting the Route 28A approach is not covered under the LFA program. However, other resources such as the Ashokan Watershed's Stream Management SMIP grants or New York Rising Community Reconstruction Program funds could be used to address this erosion hazard.

Water Quality Protection*:* Not Applicable, no mitigation solution developed

Prioritization**:** Not Applicable, no mitigation solution developed

5.3.7 Plan #5 - Bushkill Debris Removal

Summary: It may be difficult to achieve funding sources for the proposed bridge crossing as discussed in section 5.5.3. While these funding sources are being secured, it would be optimal to establish permanent monitoring stations at cross sections 4832, 4689, 300 and 2507 as seen in Figure 38 (page 93) in Section 5.3. After notable flood events, at a regular time interval (annual) or whichever comes first, the monitoring stations would be surveyed. The topographic data would then be compared to the data obtained in 2015. When the obstruction blocks 40% or more of the cross sectional area, the municipality should remove the obstruction.

Results: Not Applicable. Existing hydraulic conditions would remain.

Benefit to Cost Ratio: Not Applicable.

Implementation Challenges and Opportunities: There may be permitting challenges to complete these activities. However, most of the obstruction would be removed above the average daily water surface elevation therefore not disturbing the river bed. These activities are more favorable to permitting agencies than a complete "dredging" of the stream. The results of the LFA can also accompany a permit application showing the permitting agencies the importance of this activity which is required to prevent damage to a piece of critical infrastructure.

Funding Sources: The Catskill Watershed Corporation has resources available for stream debris removal, other than gravel, but only after storm events. Also, SMIP may fund critical activities to protect infrastructure.

Water Quality Protection*:* Not Applicable

Prioritization: Not Applicable

5.4 Dry Brook Mitigation Area Summary

There is one flooding hazard located in the Dry Brook mitigation area located at the Burgher Road crossing over Dry Brook as seen in Figure 52. The culvert there was a public flooding hazard and a FAC flooding hazard because there is a concern that it is frequently inundated isolating seven homes to the north of the crossing.

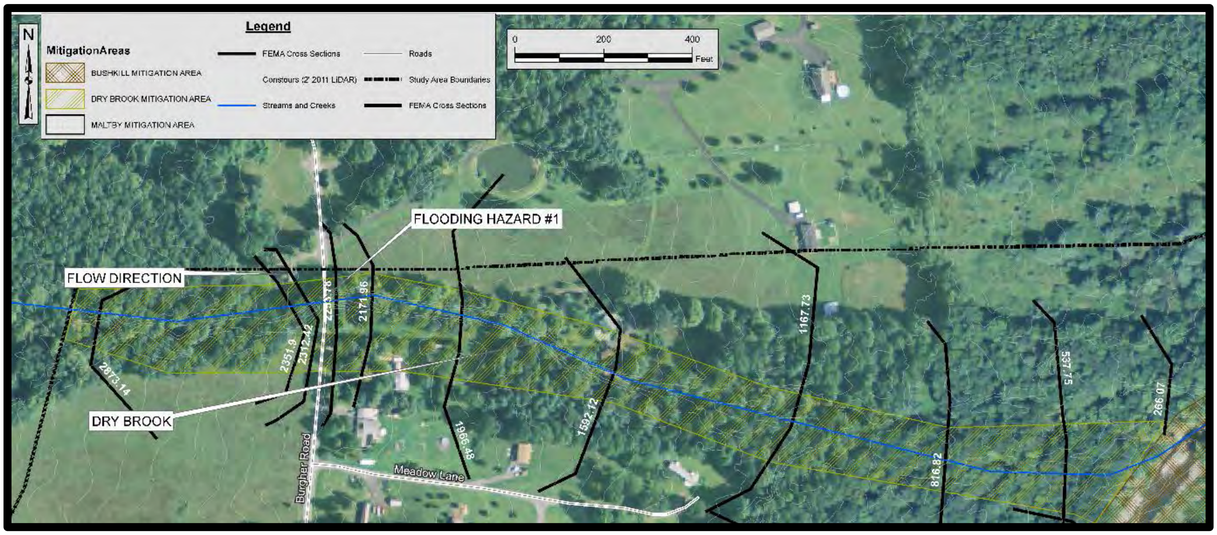


Figure 52: Location Map of Dry Brook Mitigation Area and Hazard #1

5.4.1 Hydraulic Approach

The duplicative FEMA HEC-RAS model for Dry Brook did not need correction. The model was run under existing conditions to understand the frequency Burgher Road was inundated.

5.4.2 Existing Hydraulic Conditions and Water Depths

The existing crossing is a corrugated metal arch culvert with a 7.7ft rise and 12.2 ft span. The lowest elevation along the road profile is 672.7’ and is underwater during the 25-year flood event and larger flood events which is shown in Figure 53 below. The existing water surface profile can be seen in Appendix Figure B-56.

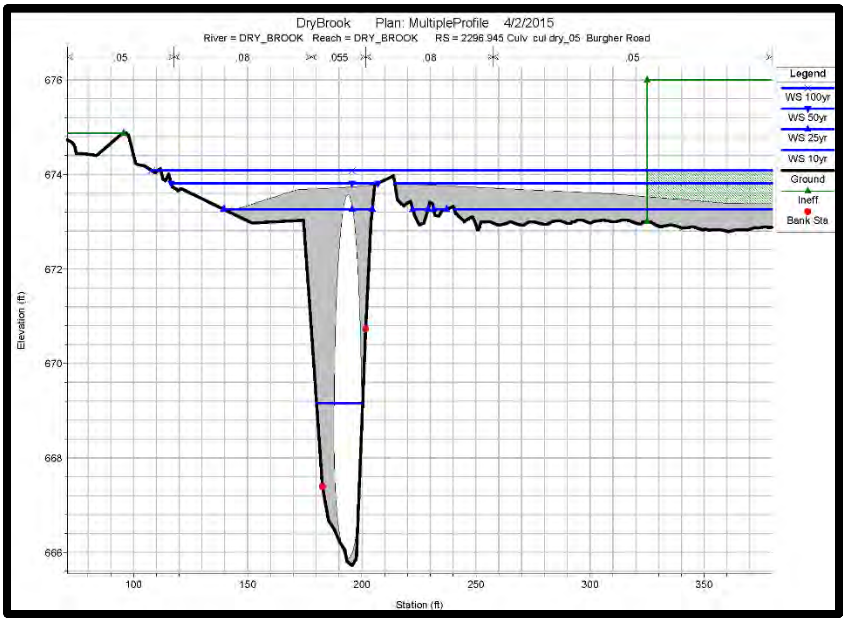


Figure 53: Section View of Existing Hydraulic Conditions at Burgher Road

5.4.3 Plan #16 - Burgher Road Crossing

Summary: The existing arch culvert is overtopped during the 25-year flood and is presumably not damaged severely enough that the crossing would need to be closed. However, the road is submerged during the 50-year flood by 1.3' of water with channel velocities of 5.2 ft/sec. It is assumed that this culvert would be damaged beyond repair during this flood event. This would isolate the seven homes north of the crossing since there is not another vehicle road out of this area. Given that these homes would be isolated if the crossing were to be closed for a long period of time, the FAC would like to see 50-year flood pass through a proposed culvert and the road be designed so that it would not be damaged during the 100-year flood.

Results: The proposed crossing that passed the 50-year flood was a 7.7 foot rise, 18 foot span three sided box culvert. It was desirable to maintain the road profile hence maintaining the same vertical rise. There is enough cover over the crossing and the road to use a three sided box culvert. This box culvert passes the 50-year flood and has water depth and slower channel velocities during the 100-year flood as seen in Figure 54 and Table 48. The water surface profile can be seen in Appendix Figure B-57.

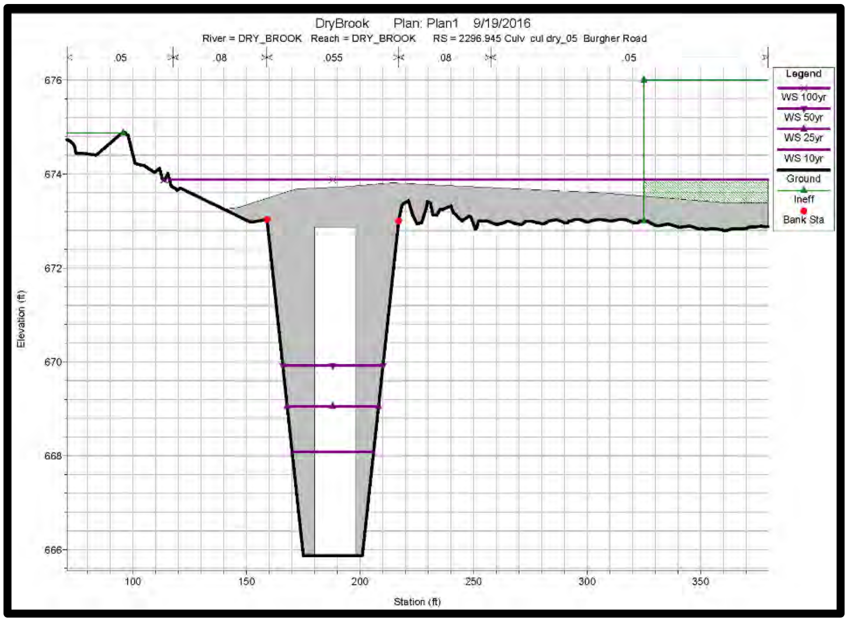


Figure 54: Section View of Hydraulic Conditions Under Proposed Conditions at Burgher Road

Table 48: Hydraulic Conditions Under Existing and Proposed Conditions at Burgher Road

Condition	Existing	Proposed
Water Depth Over Road at 25-Year Flood (ft)	0.76	-3.45
Water Velocity During 25-year Flood (ft/sec)	4.72	4.72
Water Depth Over Road at 50-Year Flood (ft)	1.31	-2.58
Water Velocity During 50-year Flood (ft/sec)	5.2	3.19
Water Depth Over Road at 100-Year Flood (ft)	1.58	1.38
Water Velocity During 100-year Flood (ft/sec)	6.36	3.33

***Benefit to Cost Ratio**:* Since the FEMA BCA software version 5.1.0 does not have an input if a road is closed and there is no other detour option, a delay of 5 hours was assumed for private transportation with a 0.5 mile detour. Road would be closed for 0.5 day after a 25 year flood for clean up by the municipal department of public works. Burgher Road would be damaged beyond repair starting at a 50-year flood event because of water depths (>1.25') and water velocity (<5ft/sec) and it would be 60 days before road could be replaced. The 100-year flood does overtop the proposed crossing so it is assumed the road would be closed for a half day after a 100-year flood for cleanup. The proposed crossing would not be damaged during this event because velocities are much less and road embankment would be sufficiently armored. The planning level construction cost for this project is $94,000 and a detailed cost estimate can be seen in Appendix Figure B-58. The BCR was found to be 0.39 and can be seen in Table 49 below and output report summary in Appendix Figure B-59. One of the limitations of the BCA software is the lack of options it gives to the user to account for the complete lack of access of emergency response. It should be noted that the seven homes north of the crossing would be completely isolated from emergency response which should increase the importance of this project.

Table 49: BCA Inputs and Results for Dry Brook Mitigation Solution Plan #16 Burgher Road Crossing Replacement

Project Useful Life	50 Years
Annual Maintenance Costs	$400
Estimated Number of 1-Way Traffic Trips	14
Additional Time Per One-Way Trip	5 hours
Number of Additional Miles	1
DPW Road Detour Cost (Existing Conditions)	$500
DPW Road Clean Up (Existing Conditions-25-Year RI, all other RI)	$500,$0
Days Road Would be Closed (Existing Conditions-25-Year RI, all other RI)	0.5,60
DPW Road Detour Cost (Proposed Conditions-100-Year RI, all other RI))	$500,0
DPW Road Clean Up (Proposed Conditions-100-Year RI, all other RI)	$500,0
Days Road Would be Closed Proposed Conditions 100-Year RI, all other RI)	0.5,0
Mitigation Benefits	$38,753
Mitigation Costs	$99,720
Benefit to Cost Ratio	0.39

Implementation Challenges and Opportunities: There are driveways to the north and south (<20') of the crossing. This would prevent the proposed crossing from being built offset and parallel with the existing crossing because the horizontal curve needed for the crossover from the Burgher Road to the proposed crossing would interfere with the driveways. For this reason, it was assumed the proposed crossing would occupy some of the existing footprint of the crossing.

Funding Sources: The BCA score is too low to make a competitive FEMA mitigation grant; however, the CWC's Flood Hazard Mitigation Implementation Program or Ashokan Watershed Management SMIP grants may be applied for because of the threat these homes could be isolated from emergency services.

Water Quality Protection: Not Applicable

Prioritization:

Table 50: Prioritization Score for Dry Brook Plan #16

Priority Metric name	Score	Numerical Value
Benefit to Cost Ratio	Low	1
Water Quality Protection	Low	1
Community Cohesion Preservation	High	5
Ease of Obtaining Permits for Proposed Solution	High	5
Economic Impact	Moderate	3
Ease to Acquire Funding	Moderate	3
Ease to Acquire Easements	High	5
Level of Town Effort To Implement Plan	High	5
Total Score		28

5.5 Maltby Hollow Mitigation Area Summary

The Maltby Hollow mitigation area begins at the confluence and extends upstream approximately 400' as seen in Figure 55. There is one flood hazard in this area which was submitted by the FAC and by the public and this is located at the Watson Hollow Road crossing over Maltby Hollow. This will be referred to as the Maltby Hollow Bridge. The concern is that this crossing could be prone to obstruction formation that could either elevate flood waters that would inundate the bridge or cause high velocities that could erode bridge abutments and the approaches. This is a critical crossing because there are dozens of homes west of the crossing that would face a long detour if this bridge was damaged.

Figure 55: Location Map of Maltby Hollow Mitigation Area

5.5.1 Hydraulic Approach

The duplicated FEMA HEC-RAS model as described in section 3.4.5 was corrected using supplemental cross sections to ensure the topographic data in the model was up to date. The following sections in Figure 55 were resurveyed: 176, 303 and 626 (decimal values excluded). Section 537 was a new section for the corrected model to inform potential mitigation solutions. The general cross section geometry appears to have gone through drastic changes since the 2009 LiDAR was obtained. Figure 56 is a typical cross section that captures these changes. Another exhibit in Appendix Figure B-60 shows the change in topography in plan view. Figure 56 and Figure Appendix B-60 show that when the LiDAR was surveyed, there were two channels upstream of the Maltby Hollow Bridge with a notable topographic feature separating the two between stations 180 to 240 as shown in Figure 56. This was not observed when the survey information was obtained in the summer of 2015.

Since there was notable difference in geometry, the corrected model's water surface profile is different than the duplicate model's water surface profile as seen in Appendix Figure B-61. A summary table comparing the two models can be seen in Table 51. It is assumed that some channel modification had occurred between the time the LiDAR and supplemental cross sections were surveyed in 2011 (post tropical storm Irene) which were used to develop the HEC-RAS model and when the summer 2015 data was collected. Since the corrected model contains more up to date topographic information, this model was used as the “existing conditions model”.

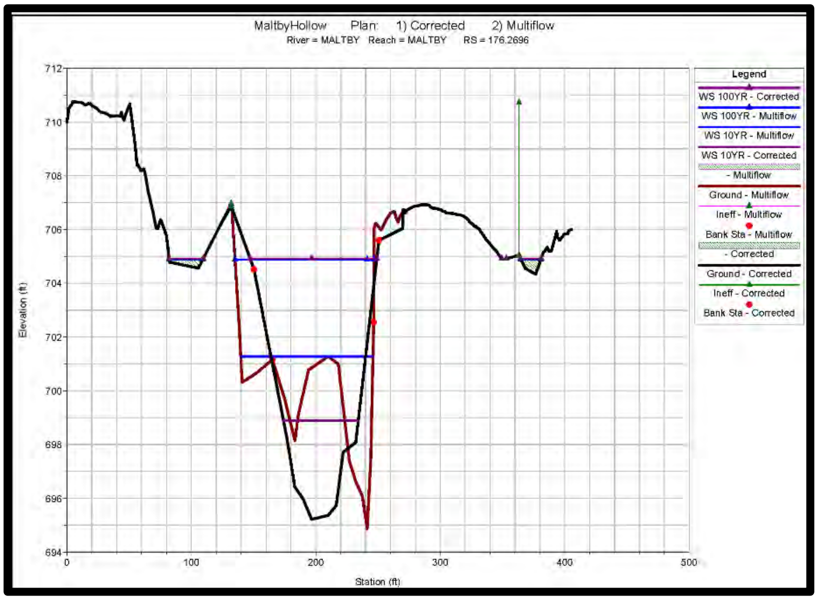


Figure 56: Section View of 2011 and 2015 Topographic Conditions

Table 51: Hydraulic Conditions of Duplicated Model and Corrected Model

Cross Section	**10 Year Water Surface Elevation**			**100 Year Water Surface Elevation**		
	Corrected	Duplicate	Difference	Corrected	Duplicate	Difference
924	721.43	721.43	0	724.55	724.55	0
626	712.09	713.31	-1.22	715.85	716.27	-0.42
537	710.37	N/A	N/A	713.15	N/A	N/A
303	704.07	705.44	-1.37	706.85	707.39	-0.54
176	698.89	701.27	-2.38	704.91	704.88	0.03
40	695.19	695.19	0	699.22	699.22	0
All Values in Feet						

The FAC was concerned that an obstruction would inundate the bridge causing damage that would force the bridge to close. This is a serious concern given the number of people (estimated to be several hundred) who live west of the bridge. The associated vehicle trips (687 Average Annual Daily Traffic) (ULTC 2014) would face an hour plus detour to get to frequently traveled points east.

The large topographic feature seen in Figure 56 and Appendix Figure B-60 could have been a large gravel bar that had formed during high flows. It is also possible that large trees could have been caught up on this gravel bar so it is realistic that an obstruction could form upstream of the bridge. Also, the Ashokan Watershed Stream Management program was completing the Stream Feature Inventory of Maltby Hollow during the LFA to map sources of debris in the watershed. However, with an understanding of the surficial geology, anthropogenic impacts and the stability of the watershed in the neighboring Bushkill watershed (where 13% of all stream banks are eroding) (AWSMP 2015), it is reasonable to assume that another obstruction could form at the Maltby Hollow crossing that shares similar watershed characteristics to the Bushkill.

The FAC considered it realistic that an obstruction could block approximately 50% of the active channel. Any larger obstruction would more than likely be removed. Therefore, a flooding hazard is defined when an obstruction blocking 50% of the active channel results in flooding conditions that could damage the bridge beyond repair in a flood event less than or equal to a 100-year return interval flood.

5.5.2 Existing Hydraulic Conditions and Water Depths

Under clear water conditions, the Maltby Hollow Bridge passes the 100-year flood. The bridge opening is 520 square feet and a 50% blockage would be 260 square feet. Figure 57 shows the size of the obstruction (station 183 to station 210). The resulting water surface rise overtops the approach road at the 50-year flood event with 0.5' of water. During the 100-year flood event the road is overtopped by 2.0' of water which can be seen in Figure 57 and summarized in Table 52. Channel velocities are notably higher under obstructed conditions as seen in Table 52. A water surface profile comparison can be seen in Appendix Figure B-62. It is reasonable to believe that during the 50-year flood event that the bridge would be damaged but could be repaired resulting in some road closure. It is also reasonable to believe that the bridge could be damaged beyond repair during the plugged 100-year flooding event which would close the road for a longer period of time given the water depth over the road and channel velocities.

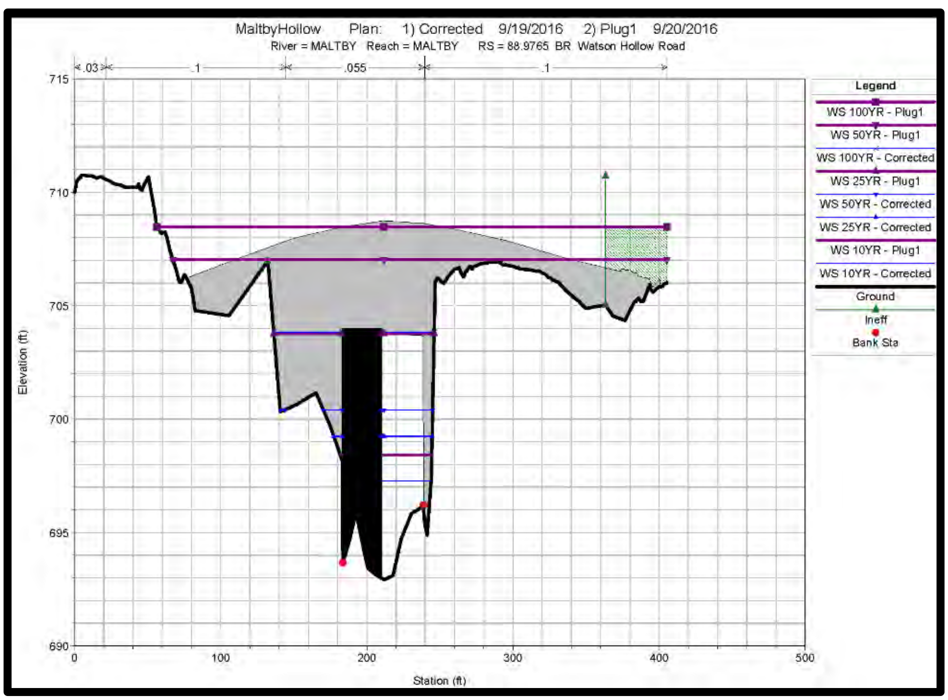


Figure 57: Section View of Plugged Conditions at Maltby Hollow Bridge

Table 52: Hydraulic Results Under Clear Water and Obstructed Conditions

	Existing Conditions			Plugged		
Flood Return Interval	Water Surface Elevation (ft)	Water Depth (ft)	Channel Velocities (ft/sec)	Water Surface Elevation (ft)	Water Depth (ft)	Channel Velocities (ft/sec)
10YR	697.26	-9.25	7.21	698.84	-7.67	13.5
25YR	699.24	-7.27	7.5	703.84	-2.67	10.31
50YR	700.41	-6.1	8.73	707.03	0.52	12.09
100YR	703.84	-2.67	7.84	708.47	1.96	12.9
Lowest Road Profile Elevation on Bridge Approach 706.51’						

5.5.3 Flood Hazard Mitigation Solution Summary: Plan #17-Maltby Hollow Crossing

Summary: The existing bridge could be damaged beyond repair by an obstruction forming at the bridge. Given the sensitivity of this crossing due to the large amount of people who would be required to make over an hour long detour, the proposed crossing should pass the 100-year flood with the obstruction in place. The proposed bridge crossing's clear span would need to be increased from 55' feet to 100' to improve the amount of area available to convey flood waters. Due to the clear span width, a possible bridge design was modeled as a two span concrete bridge with a center pier. The existing bridge alignment could be approximately maintained if it was acceptable to reduce Maltby Hollow Bridge to one lane during construction. The proposed crossing would also feature stream stabilization measures (scour protection) that would protect the stream from erosion and also protect the bridge and abutments.

Results: The proposed crossing would pass the 100-year flood and smaller floods as seen in Figure 58 and summarized in Table 53. A water surface profile comparison can be seen in Appendix Figure B-63.

It was assumed the right bank's (looking downstream) topography would remain roughly the same while the left bank would be moved approximately 30' to the east and laid back to a stable 2 horizontal to 1 vertical slope. The proposed road profile would match the existing road profile. The right bank could also be laid back (while the left bank remains roughly the same) to a stable slope but this would be constrained by Brookside Drive which would need to be reconfigured.

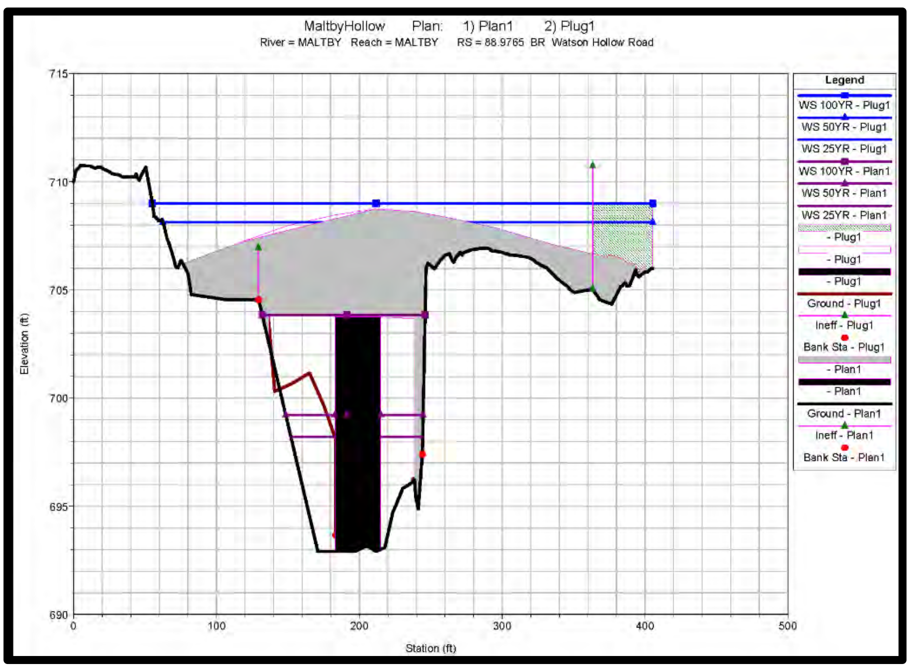


Figure 58: Section View of Existing and Proposed Maltby Hollow Bridge

Table 53: Hydraulic Results of Existing and Proposed Conditions at Maltby Hollow Bridge

	Plugged			Proposed (Plan 1)		
Flood Return Interval	Water Surface Elevation (ft)	Water Depth	Channel Velocities	Water Surface Elevation (ft)	Water Depth (ft)	Channel Velocities (ft/sec)
10YR	698.84	-7.67	13.5	699.22	-7.29	9.03
25YR	703.84	-2.67	10.31	698.21	-8.3	10.03
50YR	707.03	0.52	12.09	699.22	-7.29	10.37
100YR	708.47	1.96	12.9	703.84	-2.67	4.37
Lowest Road Profile Elevation on Bridge Approach 706.51'						

Benefit to Cost Ratio: It was assumed the bridge would be damaged and would need to be closed for 14 days to make the repairs after a 50-year flood before reopening and the bridge would be closed for 180 days after a 100-year flood. After the mitigation activity, the road would need to be closed for a half day to complete inspections of the bridge.

The proposed detour would start on the west end of the bridge and head west along Watson Hollow Road toward Peekamoose Road and State Route 55A in Wawarsing. The detour would then take US-209 north towards Kingston and then take head north on State Route 213 towards Olivebridge where it would meet Route 28A heading northbound towards West Shokan and Watson Hollow Road. The detour would be 60 miles in length and take approximately 80 minutes. Per the 2013 traffic count along Watson Hollow Road, between 28A and High Point Mountain Road (station ID 8230) the average annual daily traffic count is 687 (UCTC 2013).

The construction cost for the proposed bridge was $1,428,300 and a detailed construction cost estimate can be found in Appendix Figure B-64. The BCR was 1.11 (Table 54) and the BCA summary report can be found in Appendix Figure B-65.

Table 54: BCA Results for Maltby Hollow Plan #17

Project Useful Life	50 Years
Annual Maintenance Costs	$750
Estimated Number of 1-Way Traffic Trips	687
Additional Time Per One-Way Trip	1 hr 20 minute
Number of Additional Miles	60
DPW Road Detour Cost (Existing Conditions-10YR,25YR, 50YR, 100YR)	$0,$500,$1,000,$1,000
DPW Road Clean Up (Existing Conditions-10YR,25YR, 50YR, 100YR)	$0,$500,$0,$0
Days Road Would be Closed (Existing Conditions-10YR,25YR, 50YR, 100YR)	0,0.5,14,180
DPW Road Detour Cost (Proposed Conditions-100-Year RI, all other RI))	$1000,0
DPW Road Clean Up (Proposed Conditions-100-Year RI, all other RI)	$1000,0
Days Road Would be Closed Proposed Conditions 100-Year RI, all other RI)	0.5,0
Mitigation Benefits	$1,602,929
Mitigation Costs	$1,438,651
Benefit to Cost Ratio	1.11

Implementation Challenges and Opportunities: The bridge could be built upstream of the existing bridge parallel with the existing road alignment but this would require configuring the driveway that is west of the crossing. The north half of the bridge could be built while reducing Watson Hallow to one lane of traffic. Then, while the remaining existing bridge is demolished, the traffic could be shifted on the new bridge and the rest of the proposed bridge could be built. This approach would require less reconfiguration of the road and reduce the amount of area that would need to be acquired to build the project.

Funding Sources: With a BCR over 1.0, the project would qualify for FEMA Hazard Mitigation Grant Program. However, under existing clear water conditions, the bridge is not prone to damage and FEMA often uses clear water conditions to qualify/quantify hazard damage. Therefore, the Town may want to look towards State, CWC, and SMIP resources to pay for the bridge protection project.

Water Quality Protection: Not Applicable

Prioritization:

Table 55: Prioritization Score for Maltby Hollow Plan #17

Priority Metric Name	Score	Numerical Value
Benefit to Cost Ratio	High	5
Water Quality Protection	Moderate	3
Community Cohesion Preservation	Moderate	3
Ease of Obtaining Permits for Proposed Solution	Moderate	3
Economic Impact	High	5
Ease to Acquire Funding	Moderate	3
Ease to Acquire Easements	Moderate	3
Level of Town Effort To Implement Plan	High	5
Total Score		30

5.5.4 Plan #2 - Maltby Hollow Debris Removal

Summary: It may be difficult to achieve funding sources for the proposed bridge crossing as discussed in 5.5.3. While these funding sources are being investigated, it would be optimal to establish permanent monitoring stations at cross sections 176 and 303 as seen in Figure 55 on page 114. After notable flood events, or at a regular time interval (annual), whichever comes first, the monitoring stations would be surveyed. The topographic data would then be compared to the data obtained in 2015. When the obstruction blocks 40% or more of the cross sectional area, the municipality should remove the obstruction.

Results: Not Applicable. Existing hydraulic conditions would remain.

Benefit to Cost Ratio: Not Applicable because this is a maintenance strategy.

Implementation Challenges and Opportunities: There may be permitting challenges to complete these activities. However, most of the obstruction would be removed above the average daily water surface elevation therefore not disturbing the river bed. These activities are more favorable to permitting agencies than a complete "dredging" of the stream. The results of the LFA can also accompany a permit application showing the permitting agencies the importance of this activity. This activity is required to prevent damage to a piece of critical infrastructure.

Funding Sources: The Catskill Watershed Corporation has resources available through its "Stream Debris Removal Program" and only following storm events. Also the Ashokan Watershed Stream Management Program may fund critical activities to protect infrastructure.

***Water Quality Protection*:** Not Applicable

Prioritization: Not Applicable

6.0 Summary and Recommendations

6.1 Summary

There are two study areas: Boiceville, with inundation hazards, and West Shokan, with erosion hazards.

Boiceville

In the Boiceville mitigation area, this analysis showed that seventeen buildings are prone to flooding at moderately occurring flooding events (25-return interval flood). Various mitigation scenarios were evaluated with the proposed three arch Route 28A bridge in place to protect these buildings.

An analysis conducted for this LFA assessed all options vetted by the consultants, the community and the Flood Advisory Committee. Some alternatives, such as those to improve the conveyance of flood flows (Plan 4, 10) did not provide significant flood elevations reductions and were not prioritized in this plan. Other alternatives (Plan 5, 10, 11) were deemed impractical and also are not considered as potential options. Plan 9, 9A, 12 and 13 received the most attention as potentially viable options to mitigate flood hazards and improve community resiliency and are further considered in the recommendations and implementation strategy.

Each of these options has their advantages and disadvantages.

1. Do nothing
   If the Town takes no action then individual property owners are left to their own resources to recover after future flood events. Flood insurance premiums are rising and are projected to rise sharply over the next decade. Current property owners may not be able to afford flood insurance. The sale of properties within the FEMA delineated floodplain could be suppressed by the cost of flood insurance required by lenders as a condition of a mortgage. Repetitive, uninsured losses can result in owners closing their businesses or abandoning their homes.

2. Protect in place with a Levee
   A levee built to NFIP standards can reduce flood insurance costs (at a savings of 50% or more), reduce flood damages in frequent flood events, protect property values and maintain the character of Boiceville. As conceptualized by this study, a levee would not protect against the 500 yr. flood and funding for the construction may be difficult to obtain. Annual maintenance costs and the regular requirement to meet certification standards would be an on-going responsibility of the Town. The time required to design, acquire property and permits, construct and certify a levee may be an issue for some property owners seeking relief. Highly unlikely but in the realm of possibility, federal and state policies on levees may change which could impact future construction standards, maintenance costs, levee certification and flood insurance premiums.

3. Buyouts and or Relocations
   Relocating out of a floodplain will permanently solve the flooding problems of the property owner but the availability of a site to relocate, the cost of relocation, disruption to a business and community can be obstacles to relocations. A flood buyout without relocation may be attractive to some property owners but this can affect the local economy, tax base and community character. In some cases, where relocation, elevation and floodproofing are not feasible, buyout may be the primary option.

4. Elevations and Floodproofing
   For some structures, it may be possible to either elevate the entire structure or parts of the structure such as its utilities. Increasingly, funding is becoming available for these options, however this approach typically requires a design engineer to ensure that the structure will withstand the stress of elevation. Not all structures, such as structures built on a slab foundation, can be elevated, and access and aesthetics can be an issue. Elevation can reduce flood insurance costs, but may not eliminate all future losses. Floodproofing, either to prevent water from entering a structure (dry floodproofing) or allowing waters to flow through lower parts of the structure such as a crawlspace (wet floodproofing), may be feasible depending on the type and use of the structure. The services of a design engineer are typically required to ensure the modifications are practical and meet NFIP regulations and building codes. Floodproofing may only reduce damages and may require regular maintenance and an operation plan.

The information provided in this report offers guidance to how the community may wish to proceed in addressing the flooding challenges. The Town may choose to implement a combination of more than one option listed above. A strategy for implementing the LFA is provided after the review of the recommendations.

The proposed replacement of the Upper Boiceville Road crossing in the Upper Boiceville mitigation area is technically feasible, financially justifiable and is needed to ensure continuous east to west access in the event that State Route 28 is impassible.

West Shokan

In the West Shokan Study Area, no flood inundation hazards were found under clear water (no obstructions) or obstructed conditions. However, there are notable locations where existing conditions and obstructed conditions cause erosion hazards, some of which could cause road and bridge closures that would require lengthy detours and pose major impediments to emergency response times. The erosion hazard condition at the Watson Hollow Bridge should be addressed immediately as well as the failing road embankment along Watson Hollow Road downstream of the bridge. Permanent monitoring stations are recommended to be established at areas sensitive to obstructions exacerbating erosive conditions.

In the Dry Brook mitigation area, the Burgher Road crossing is inundated at moderate flood levels (25-year flood) and it is reasonable to expect it would be damaged and in need of repair at a 50-year flood. The crossing's replacement using FEMA's BCA toolkit is not financially justifiable but if this crossing were to be closed for a long period of time, it would isolate the residents to the north which should make this crossing an important project for the Town to consider.

The Maltby Hollow Bridge passes the 100-year flood under clear water conditions. However, under obstructed conditions, it is reasonable to assume the bridge is damaged during a 50-year flood resulting in a short closure of the road. It is assumed that the bridge would be damaged beyond repair during a 100-year flood. A long term closure would create lengthy detours that would pose major impediments to emergency response times and quality of life to the hundreds of residents who live upstream of the bridge. The project is financially justifiable. Permanent monitoring stations are recommended to be established at areas sensitive to obstructions exacerbating erosive conditions.

6.2 Recommendations

Recommendations for Both Study Areas*:*

There are a wide variety of mitigation measures that can protect public and private properties from flood damage. While this study did look at several of the most desirable broad mitigation actions (see Table 56 on page 129), these projects often take long periods of time and can be very costly. In these study areas, particularly in the hamlets where many structures are at risk of flooding, elevations, and/or wet/dry floodproofing should be explored. Additionally, residents and businesses that exist within the regulatory floodplain (1% annual risk, FEMA-mapped Special Flood Hazard Area) should be encouraged to carry flood insurance and make appropriate damage claims when flooding does occur. While carrying flood insurance will not prevent damage, it will help get property owners back on their feet quickly post-flood.

The following actions are recommended:

1. The Town should seek to assist in the elevation or relocation of the most flood-vulnerable properties to areas outside of the floodplain where there is owner interest and funding available through federal, state, or local sources, such as the voluntary NYC-Funded Flood Buyout Program (NYCFFBO), or the Catskill Watershed Corporation's (CWC) Flood Hazard Mitigation Implementation program (FHMIP).

   All habitable structures that have the potential to receive 3 feet or more of floodwater against the structure should be considered a high priority for mitigation by the Town. Owners of these properties are encouraged to seek input from the Town on possible mitigation actions. Figure 59 was provided by the NYSDEC's Division of Floodplain Management, and indicates that once the first floor of a structure is inundated with 4' of floodwater, it is likely to become "substantially damaged". For detailed information on this subject, refer to Section 5R of FEMA's "ENGINEERING PRINCIPLES AND PRACTICES for Retrofitting Flood-Prone Residential Structures."

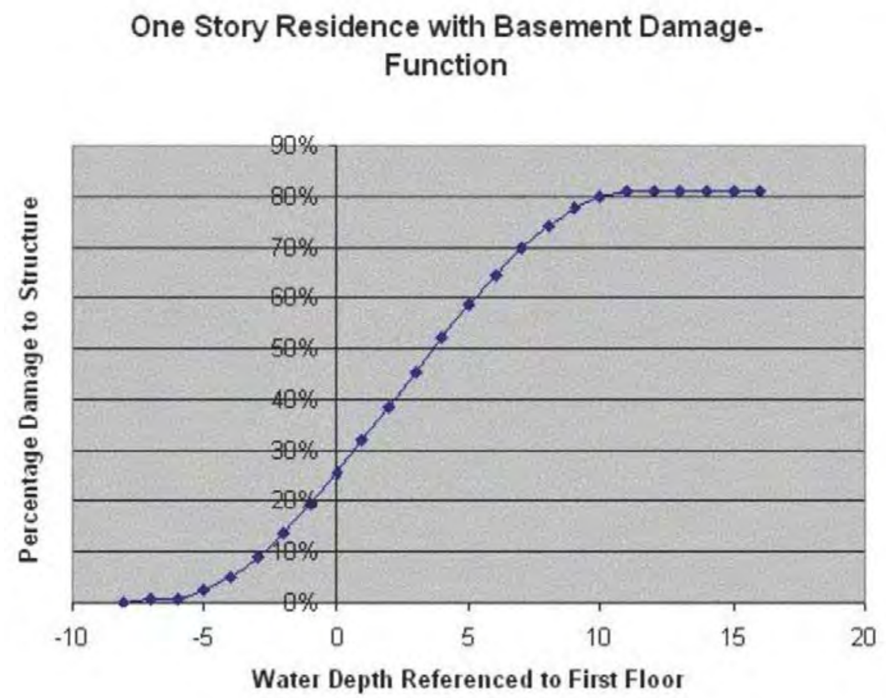


Figure 59: Estimate of Percent Damage to a Structure Based Upon Depth of Inundation

2. The Town should prevent any new development in the floodplain and floodway. The Town should continue to enforce its flood law, ensure all new construction meets all NFIP criteria, and consider the potential impact of flooding on proposed activities in the floodprone areas.

3. Not all homes and businesses in the floodplain get flooded. Conversely, properties that are not in a regulated floodplain can and do flood. Residents and businesses can better prepare themselves by investing in individual property improvements. These measures may include:

   a. Elevation - Home elevation involves the removal of the building structure from the basement and elevating it to a height such that the first floor is located at least 2 feet above the level of the 1% annual risk flood. The basement area is then abandoned and filled no higher than the existing grade. Utilities and appliances in the basement are relocated to the first floor or installed from basement joists or similar mechanism at an elevation no less than 1 foot above the BFE. Elevation of homes can be implemented on a case-by-case basis as property owners approach the Town about mitigation. For detailed information on this subject, refer to Section 5E of FEMA's "ENGINEERING PRINCIPLES AND PRACTICES for Retrofitting Flood-Prone Residential Structures."

   b. "Dry" Floodproofing (Keeps Floodwaters from Entering) - Areas below the flood height remain watertight. Walls may be coated with compound or plastic sheathing and window and vent openings must be permanently closed or covered. Floodproofing should only extend 2-3 feet above the top of the concrete foundation as building walls and floors cannot withstand the pressure of deeper water. Dry floodproofing is not allowed by FEMA for new or substantially improved or damaged residential structures located in the SFHA. A structural engineer should always determine whether the wall and floor systems can resist the hydrostatic and other loads. An operation and maintenance plan may be required for dry floodproofing in some situations. For detailed information on this subject, refer to Section 5D of FEMA's "ENGINEERING PRINCIPLES AND PRACTICES for Retrofitting Flood-Prone Residential Structures."

Examples include:

- Installation of watertight shields for doors and windows
- Reinforcement of wall to withstand floodwater pressures and impact forces generated by floating debris
- Use of membranes and other sealants to reduce seepage of floodwaters through walls and wall penetrations
- Installations of drainage collections systems and sump pumps to control interior seepage and manage hydrostatic pressure on the slab and walls
- Installation of check valves to prevent the backflow of floodwaters or sewage flows through drains
- Anchoring of the building resist floatation and lateral movement.

c. "Wet" Floodproofing (Allows Floodwaters to Pass Through) - Wet floodproofing allows floodwater into a building, thus equalizing interior and exterior water pressure with the goal of preventing the collapse of walls, uplift of floors and mobilization of smaller structures. Wet floodproofing should only be used as a last resort, and if considered, furniture and electrical appliances should be moved or elevated above the flood height elevation. The NFIP allows wet floodproofing only in in limited situations. As with dry floodproofing techniques, developing a wet floodproofing strategy requires site-specific evaluations that may necessitate the services of a design professional. For detailed information on this subject, refer to Section 5W of FEMA's "ENGINEERING PRINCIPLES AND PRACTICES for Retrofitting Flood-Prone Residential Structures."

d. Construction of Property Improvements (Barriers, Floodwalls, and Earthen Berms) - Such structural projects can be used to prevent shallow flooding. There may be properties where implementation of these measures will serve to protect structures, however local floodplain development ordinances must not be compromised. For detailed information on this subject, refer to Section 5F of FEMA's "ENGINEERING PRINCIPLES AND PRACTICES for Retrofitting Flood-Prone Residential Structures."

e. Other Best Practices to Mitigate Flood Damage from Flooding

- Relocate valuable belongings above the 1% annual risk flood elevation to reduce the damage caused during a flood
- Relocate or elevate water heaters, heating systems, washers, and dryers to a higher floor or to at least 12 inches above the BFE. A wooden platform of pressure-treated wood can serve as the base
- Anchor fuel tanks to the wall or floor with noncorrosive metal strapping and lag bolts
- Install a backflow valve to prevent sewer backup into the home

- Install a floating floor drain plug at the lowest point of the lowest finished floor
- Elevate the electrical box or relocate it to a higher floor and elevate electric outlets to at least 12 inches above the 1% annual risk flood elevation

4. Local officials should promote, and eligible property owners (properties within the 0.2% annual risk floodplain) should be encouraged to take advantage of the tank anchoring / relocation program through the Catskill Watershed Corporation.

5. The Town should undertake actions to identify and remove vacant/abandoned structures in the floodplain to prevent potential flooding hazards.

Recommendations for the Proposed Mitigation Solutions

Table 56 summarizes the prioritization of the proposed mitigation solutions which have been reviewed by the FAC. During the review of the mitigation solutions, several standalone recommendations were developed. A standalone recommendation is a recommendation that is supported by the results of multiple proposed mitigation solutions or general best floodplain management practices. The three standalone solutions are as follows:

1. Relocate Building B1 (Fire House Company #5) since it is a critical facility and cannot be protected by any proposed mitigation solution.
2. The Town should consider how future development in the Boiceville Mitigation Area will impact the proposed flood mitigation solutions or create potential hazards or water quality concerns (i.e. unanchored fuel tanks or other hazardous material).
3. Any proposed building development within the Boiceville Mitigation Area should meet state building codes for construction in a FEMA floodplain while not causing deleterious impacts under flood conditions to neighboring buildings.

The FAC then will select which mitigation strategies and standalone recommendation to present to the Town Board to improve the Town's flood resiliency as described in Section 7.0, the local flood mitigation implementation plan.

Table 56: Prioritization Results for Town of Olive Local Flood Analysis

Plan ID	Plan Name	Prioritization Score	BCR
B04	Boiceville Plan #4 - Floodplain Benches	18	0.15
B05	Boiceville Plan #5 - Flood Levee Protection System and Floodplain Benches	16	0.63
B07	Boiceville Plan #7 - Relocate 28A Bridge and Floodplain Benches	22	0.37
B09	Boiceville Plan #9 - Flood Levee Protection System	18	0.97
B09A	Boiceville Plan #9 - Two Phased Flood Levee Protection System	20	1.89
B10	Boiceville Plan #10 - Dredging	18	Not Calculated
B11	Boiceville Plan #11 - Relocate 28A Bridge and Waste Water Treatment Plant	18	Not Calculated
B12	Boiceville Plan #12 - Planning and Relocation	30	0.62
B13	Boiceville Plan #13 - Structural Improvements (Property Protection)	30	0.53
UB1	Upper Boiceville Road Plan #14 - Upper Boiceville Road Crossing	34	7.7
DS1	DeSilva Road Plan #15 - SR 28 Crossing	28	4.88
DB1	Dry Brook Plan #16 - Burgher Road Crossing	28	0.39
MB1	Maltby Hollow Plan #17 - Maltby Hollow Bridge	30	1.11

7.0 Local Flood Mitigation Implementation Strategy

To increase the Town of Olive's flood resiliency, an implementation strategy for the flood hazard mitigation recommendations as described in sections 4.0 through 6.0 are outlined in Table 57. This implementation strategy has been informed by scientific and engineering evaluation, vetting by several meetings with the Flood Advisory Committee and by incorporating feedback from the public and Town Board. The strategy contains standalone recommendations and flood mitigation plans. A standalone recommendation is a flood resiliency strategy that was common in several flood mitigation plans. The flood mitigation plans were discussed in sections 5.0 and 6.0 and are presented in Table 56.

The Town of Olive's Flood Advisory Committee (FAC) has prioritized the standalone recommendations and flood mitigation plans The FAC recommends to the Town of Olive's Town Board that the implementation of each flood resiliency strategy be followed in order as presented in the Plan (Table 57). Reference notes have been included for each strategy so the reader can refer back to the text to understand the strategy's background, flood mitigation efficacy, and potential funding sources.

Table 57: Local Flood Mitigation Implementation Plan

Flood Resiliency Strategy	Strategy Name	Note
1	Relocate Fire House #5	No flood protection system can be designed to protect this facility to FEMA standards. It is also within the footprint of the flood protection levee system (section 4.3.7)
2	Boiceville Plan #12 - Planning and Relocation	The Town must make a decision to protect the hamlet of Boiceville in place or begin to relocate buildings out of harm's way. If the town chooses the latter, several buildings are eligible for relocation/buyout (section 4.3.10). The Town should undergo a planning exercise to identify areas that could be rezoned for building relocation and identify what if any future growth should occur in flood prone areas. The first priority group of eligible buildings that could be relocated are the three anchor businesses (Boiceville Market, Boiceville Pharmacy, and the Maverick West Health Building). The second priority group of eligible buildings are buildings B14 and B15 within a potential flood protection facility. This activity may also be undertaken at the same time as #6 "Structural Improvements"
3	Upper Boiceville Road Plan #1 - Upper Boiceville Road Crossing	This is a critical alternative route to State Route 28 and the crossing is in structurally "fair" condition and is prone to flood damage (Section 4.4).
4	Bushkill and Maltby Hollow Debris Removal	Establishing permanent monitoring sections will allow the Town to understand if these water bodies are filling with obstructions that could lead to worsened flooding conditions (Sections 5.5.4 and 5.3.7).

Table 57 Continued: Local Flood Mitigation Implementation Plan

Flood Resiliency Strategy	Strategy Name	Note
5	Dry Brook Plan #1 – Burgher Road Crossing	This culvert can be damaged to the point of needing repair during moderately sized flooding events. This would isolate several homes leaving them with no vehicular access (Section 5.4)
6	Boiceville Plan #13 - Structural Improvements (Property Protection)	Depending on the results of Flood Resiliency Strategy #2 (Plan #12) some buildings are best for the community to remain where they are. In this case, they should be protected (elevated with wet floodproofing) to prevent future flood damage (Section 4.3.11)
7	Boiceville Plan #9 - Flood Levee Protection System	If the Town chooses to protect the hamlet of Boiceville in place, then as part of Flood Resiliency Strategy #2, Buildings B14 and B15 relocation should be prioritized in relocation (Section 4.3.7). As the funding for this system is the primary obstacle, an effort to find funding can be initiated early after completion of the LFA.
8	Maltby Hollow Plan #1 - Maltby Hollow Bridge	This crossing would be inundated by floodwaters during a very large flood event. If this would occur than emergency response times would increase to unacceptable levels and several hundred people would need to make a 60 mile detour if traveling to West Shokan.

8.0 References

Ashokan Water Stream Management Program (AWSMP). 2015. Bushkill Stream Management Plan.

Cornell Cooperative Extension of Ulster County (CCEUC). 2007. Upper Esopus Creek Management Plan Volume I Summary of Findings and Recommendations.

FEMA 2012. Hydrologic Analysis Technical Support Data Notebook. Task Order HSFE02-10-J-0001 for Ashokan Reservoir Watershed Hydrologic Study, New York. FEMA Contract No. HSFEHQ-09-D-0369

FEMA (1). 2013. Flood Insurance Study Ulster County, NY.

FEMA (2). 2013. Hydraulic Analysis Technical Support Data Notebook. Task Order HSFE02-11-J-0001 for Esopus Watershed Hydraulic Study, New York. FEMA Contract No. HSFEHQ-09-D-0369.

Kudish, M. 2000. The Catskill Forest. A History.

Ulster County Transportation Council (UCTC). 2013 Traffic Monitoring Report. 2014

Woidt Engineering and Consulting (WEC). 2016. “Town of Olive Local Flood Analysis 28A bridge replacement and Boiceville Study Area Flood Mitigation Strategies”.

9.0 Acronyms

ADWSE	Average Daily Water Surface Elevation
BCA	Benefit to Cost Analysis
BCR	Benefit to Cost Ratio
BFE	Base Flood Elevation
CWC	Catskill Watershed Corporation
DEC	New York State Department of Environmental Conservation
DEP	New York City Department of Environmental Protection
FAC	Flood Advisory Committee
FEMA	Federal Emergency Management Agency
FIS	Flood Insurance Study
FHMIP	Flood Hazard Mitigation Implementation Program
HEC-RAS	Hydraulic Engineering Center River Analysis Software
NFIP	National Flood Insurance Program
NYCFFBO	New York City Funded Flood Buyout Program (voluntary)
SFHA	Special Flood Hazard Area
SFI	Stream Feature Inventory
SMP	Stream Management Plan
SMIP	Stream Management Implementation Program
TAFT	Terrace and Floodplain Terrain
USGS	United States Geological Survey

APPENDIX A

A-1 GIS Inventory List
A-2 Boiceville Study Area Terrace and Floodplain Terrain Map
A-3 Boiceville Study Area Publically Submitted Flood Hazards (Index Map)
A-4 Boiceville Study Area Publically Submitted Flood Hazards (North Map)
A-5 Boiceville Study Area Publically Submitted Flood Hazards (South Map)
A-6 Boiceville Study Area Water Depth Map- 10-Year Return Interval Flood
A-7 Boiceville Study Area Water Depth Map- 25-Year Return Interval Flood
A-8 Boiceville Study Area Water Depth Map- 50-Year Return Interval Flood
A-9 Boiceville Study Area Water Depth Map- 100-Year Return Interval Flood
A-10 Boiceville Study Area Water Depth Map- 500-Year Return Interval Flood
A-11 Bushkill Study Area Terrace and Floodplain Terrain Map
A-12 Bushkill Study Area Publically Submitted Flood Hazards (Index Map)
A-13 Bushkill Study Area Publically Submitted Flood Hazards (South Map)
A-14 Bushkill Study Area Publically Submitted Flood Hazards (North Map)
A-15 Bushkill Study Area Publically Submitted Flood Hazards (East Map)
A-16 Bushkill Study Area Water Depth Map- 10-Year Return Interval Flood
A-17 Bushkill Study Area Water Depth Map- 25-Year Return Interval Flood
A-18 Bushkill Study Area Water Depth Map- 50-Year Return Interval Flood
A-19 Bushkill Study Area Water Depth Map- 100-Year Return Interval Flood
A-20 Bushkill Study Area Water Depth Map- 500-Year Return Interval Flood

Inventory of Data

Federal Emergency Management Agency (FEMA)

Task Order for Ashokan Reservoir Watershed Hydrologic Study, NY August 2012
Task Order for Esopus Watershed Hydraulic Study, NY June 2013
FEMA Preliminary Effective Hydraulic Model
FEMA Flood Insurance Map Number 36111C0245E
FEMA Flood Insurance Study Number 36111CV001B
FEMA Preliminary Effective Hydraulic Model GIS Shapefiles (cross section locations, etc.)

Ulster County Planning Department

County Parcel Data GIS Shapefile
County Building GIS Shapefile (Building size, Value of Building)
County Roads GIS Shapefile

New York City Department of Environmental Protection

2009 LiDAR
2001 and 2009 Land Use and Land Classification (LULC) data

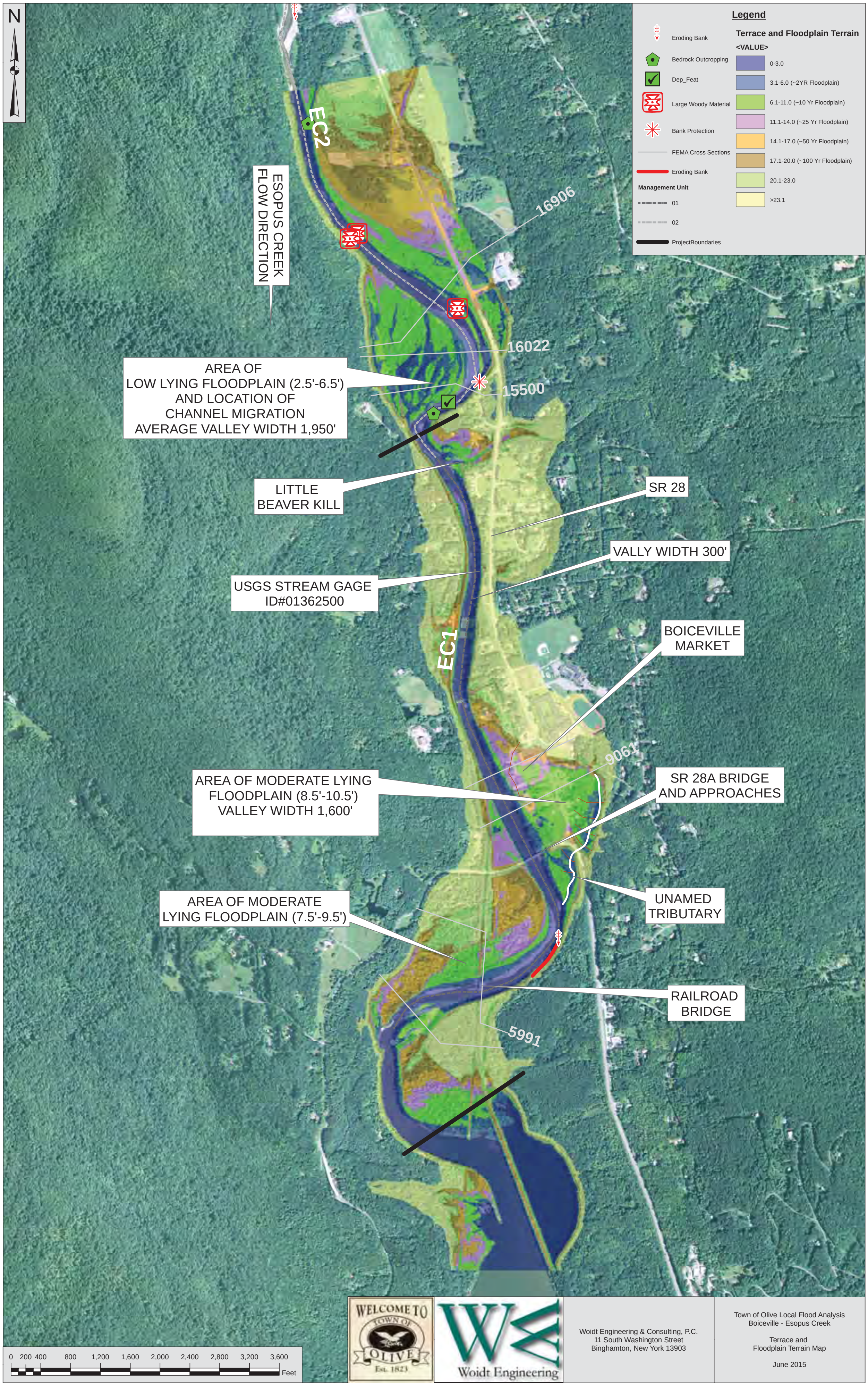
New York State Department of Environmental Conservation

Hydrography GIS Shapefiles (River lines)

Drainage Area (Watershed Boundary) GIS Shapefile

Ashokan Stream Management Program/Ulster County Soil and Water

Stream Inventory Feature Data (SFI)
Upper Esopus Creek Stream Management Plan 2007
2009 2' Contours Created From 2009 LiDAR
Public and Flood Advisory Committee Submitted Hazard Locations (GIS Shapefile and Hard Copy Maps)



N
Legend
Eroding Bank
Bedrock Outcropping
Dep_Feat
Large Woody Material
Bank Protection
FEMA Cross Sections
Eroding Bank
Management Unit
01
02
ProjectBoundaries
Terrace and Floodplain Terrain
<VALUE>
0-3.0
3.1-6.0 (~2YR Floodplain)
6.1-11.0 (~10 Yr Floodplain)
11.1-14.0 (~25 Yr Floodplain)
14.1-17.0 (~50 Yr Floodplain)
17.1-20.0 (~100 Yr Floodplain)
20.1-23.0
>23.1
EC2
ESOPUS CREEK FLOW DIRECTION
16906
16022
15500
AREA OF LOW LYING FLOODPLAIN (2.5'-6.5') AND LOCATION OF CHANNEL MIGRATION AVERAGE VALLEY WIDTH 1,950'
LITTLE BEAVER KILL
SR 28
VALLY WIDTH 300'
USGS STREAM GAGE ID#01362500
EC1
BOICEVILLE MARKET
9061
AREA OF MODERATE LYING FLOODPLAIN (8.5'-10.5') VALLEY WIDTH 1,600'
SR 28A BRIDGE AND APPROACHES
UNAMED TRIBUTARY
AREA OF MODERATE LYING FLOODPLAIN (7.5'-9.5')
RAILROAD BRIDGE
5991
0 200 400 800 1,200 1,600 2,000 2,400 2,800 3,200 3,600
Feet
WELCOME TO TOWN OF OLIVE Est. 1823
Woidt Engineering
Woidt Engineering & Consulting, P.C.
11 South Washington Street
Binghamton, New York 13903
Town of Olive Local Flood Analysis
Boiceville - Esopus Creek
Terrace and Floodplain Terrain Map
June 2015

N
Legend
Boiceville Streams
Boiceville Hazard Locations
Dam Hazard
Debris Jam
Debris Jam/Stormwater
Erosion
Erosion/Debris Jam
Erosion/Overbank Flooding
Overbank Flooding
Stormwater
Buildings within SFHA
Flood Hazard Limits
1.0% Annual Chance Flood
0.2% Annual Chance Flood
Boiceville Roads
Esopus Creek
Coldbrook Road
Little Beaver Kill
Route 28
Beechford Drive
Mountain Valley Road
Riga Lane
Nissen Road
Piney Point Road
Center Lane
State Highway 28
Cabin Hill Road
Deerfield Road
Sunset Mountain Road
MATCH LINE - MAP NORTH
MATCH LINE - MAP SOUTH
Brunnel Drive
Bostock Road
Desilva Road
Old Route 28
Upper Boiceville Road
Hope Road
Traver Hollow Road
State Highway 28A
Traver Hollow Stream
0 1 2 3 4 5 6 7 8 9 10 11
0 200 400 800 1,200 1,600 2,000 2,400
Feet
WELCOME TO TOWN OF OLIVE Est. 1823
Woidt Engineering
Woidt Engineering & Consulting, P.C.
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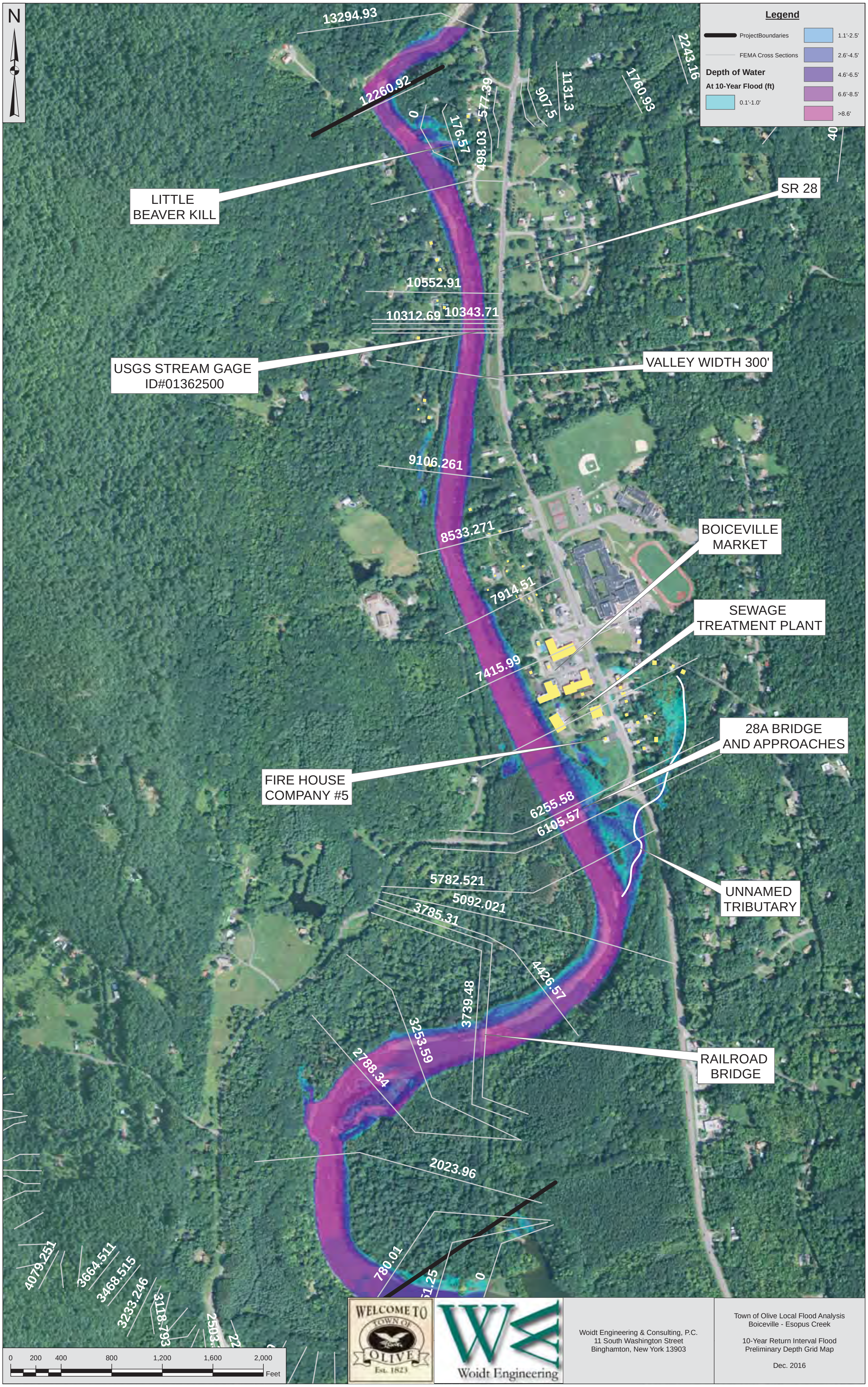
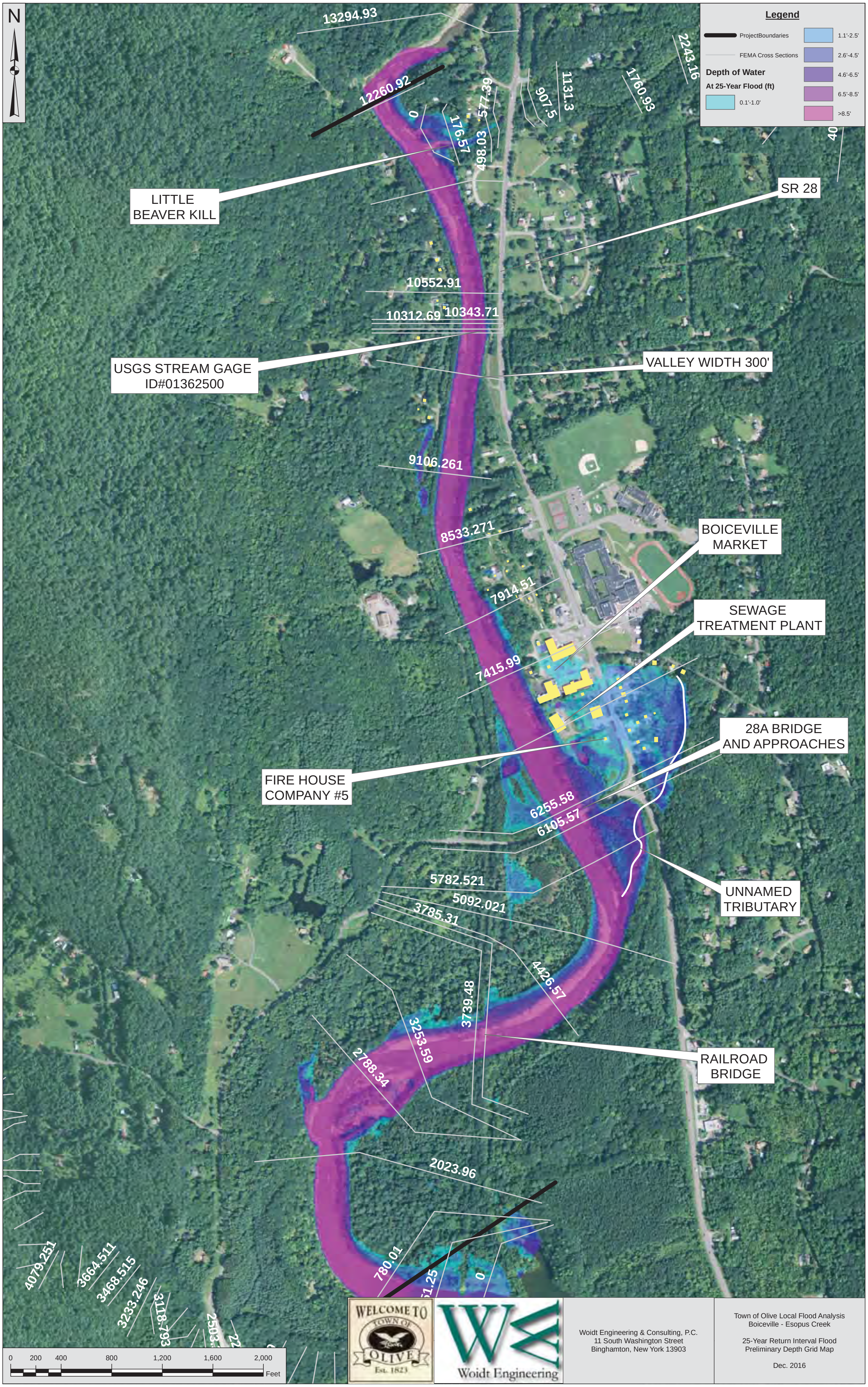
FEMA FIS - Floodplain Mapping
May 2015


N
Legend
Boiceville Streams
Boiceville Hazard Locations
Dam Hazard
Debris Jam
Debris Jam/Stormwater
Erosion
Erosion/Debris Jam
Erosion/Overbank Flooding
Overbank Flooding
Stormwater
Buildings within SFHA
Flood Hazard Limits
1.0% Annual Chance Flood
0.2% Annual Chance Flood
2ft Contours (2009 LiDAR)
Boiceville Roads
Little Beaver Kill
Coldbrook Road
Esopus Creek
Deerhaven Park Road
Wildwood Lane
Nissen Lane
Nissen Road
Bailey Drive
Beechford Drive
Piney Point Road
Mountainview Avenue
Center Lane
State Highway 28
Deerfield Road
Private Road
Cabin Hill Road
Ronsen Road
Upper Boiceville Road
State Highway 28A
MATCH LINE - MAP NORTH
MATCH LINE - MAP SOUTH
0 200 400 800 1,200 Feet
WELCOME TO TOWN OF OLIVE Est. 1823
Woidt Engineering
Woidt Engineering & Consulting, P.C.
11 South Washington Street
Binghamton, New York 13903
Town of Olive Local Flood Analysis
Boiceville - Esopus Creek
Map North
FEMA FIS - Floodplain Mapping
Dec. 2016


N
Legend
Boiceville Streams
Boiceville Hazard Locations
Dam Hazard
Debris Jam
Debris Jam/Stormwater
Erosion
Erosion/Debris Jam
Erosion/Overbank Flooding
Overbank Flooding
Stormwater
Buildings within SFHA
Flood Hazard Limits
1.0% Annual Chance Flood
0.2% Annual Chance Flood
2ft_Contours_(2009_LiDAR)
Boiceville Roads
Coldbrook Road
Esopus Creek
State Highway 28A
State Highway 28
Brunnel Drive
Desilva Road
Old Route 28
Traver Hollow Stream
MATCH LINE - MAP NORTH
MATCH LINE - MAP SOUTH
0
1
4
6
7
8
9
10
0 200 400 800 1,200
Feet
WELCOME TO TOWN OF OLIVE Est. 1823
Woidt Engineering & Consulting, P.C.
11 South Washington Street
Binghamton, New York 13903
Town of Olive Local Flood Analysis
Boiceville - Esopus Creek
Map South
FEMA FIS - Floodplain Mapping
Dec. 2016


N
Legend
ProjectBoundaries
FEMA Cross Sections
Depth of Water
At 10-Year Flood (ft)
0.1'-1.0'
1.1'-2.5'
2.6'-4.5'
4.6'-6.5'
6.6'-8.5'
>8.6'
LITTLE BEAVER KILL
SR 28
USGS STREAM GAGE ID#01362500
VALLEY WIDTH 300'
BOICEVILLE MARKET
SEWAGE TREATMENT PLANT
28A BRIDGE AND APPROACHES
FIRE HOUSE COMPANY #5
UNNAMED TRIBUTARY
RAILROAD BRIDGE
13294.93
12260.92
0
176.57
577.39
498.03
907.5
1131.3
1760.93
2243.16
10552.91
10312.69
10343.71
9106.261
8533.271
7914.51
7415.99
6255.58
6105.57
5782.521
5092.021
3785.31
4426.57
3739.48
3253.59
2788.34
2023.96
780.01
4079.251
3664.511
3468.515
3233.246
3118.793
0 200 400 800 1,200 1,600 2,000 Feet
WELCOME TO TOWN OF OLIVE Est. 1823
Woidt Engineering
Woidt Engineering & Consulting, P.C.
11 South Washington Street
Binghamton, New York 13903
Town of Olive Local Flood Analysis
Boiceville - Esopus Creek
10-Year Return Interval Flood
Preliminary Depth Grid Map
Dec. 2016


N
Legend
ProjectBoundaries
FEMA Cross Sections
Depth of Water
At 25-Year Flood (ft)
0.1'-1.0'
1.1'-2.5'
2.6'-4.5'
4.6'-6.5'
6.5'-8.5'
>8.5'
13294.93
12260.92
0
176.57
577.39
498.03
907.5
1131.3
1760.93
2243.16
LITTLE BEAVER KILL
SR 28
10552.91
10312.69
10343.71
USGS STREAM GAGE ID#01362500
VALLEY WIDTH 300'
9106.261
8533.271
BOICEVILLE MARKET
7914.51
SEWAGE TREATMENT PLANT
7415.99
28A BRIDGE AND APPROACHES
FIRE HOUSE COMPANY #5
6255.58
6105.57
5782.521
5092.021
3785.31
UNNAMED TRIBUTARY
4426.57
3739.48
3253.59
RAILROAD BRIDGE
2788.34
2023.96
780.01
0
4079.251
3664.511
3468.515
3233.246
0 200 400 800 1,200 1,600 2,000 Feet
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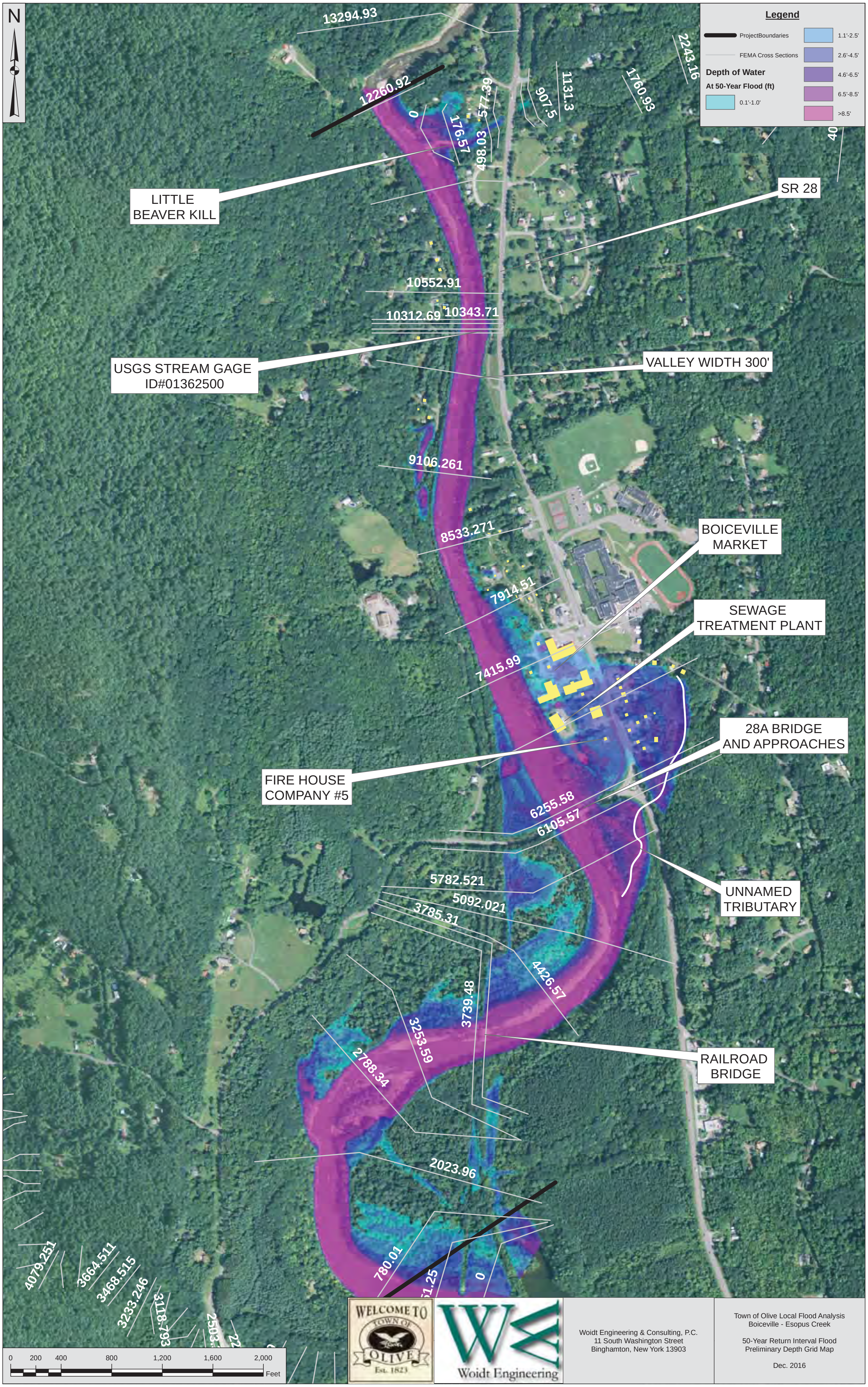
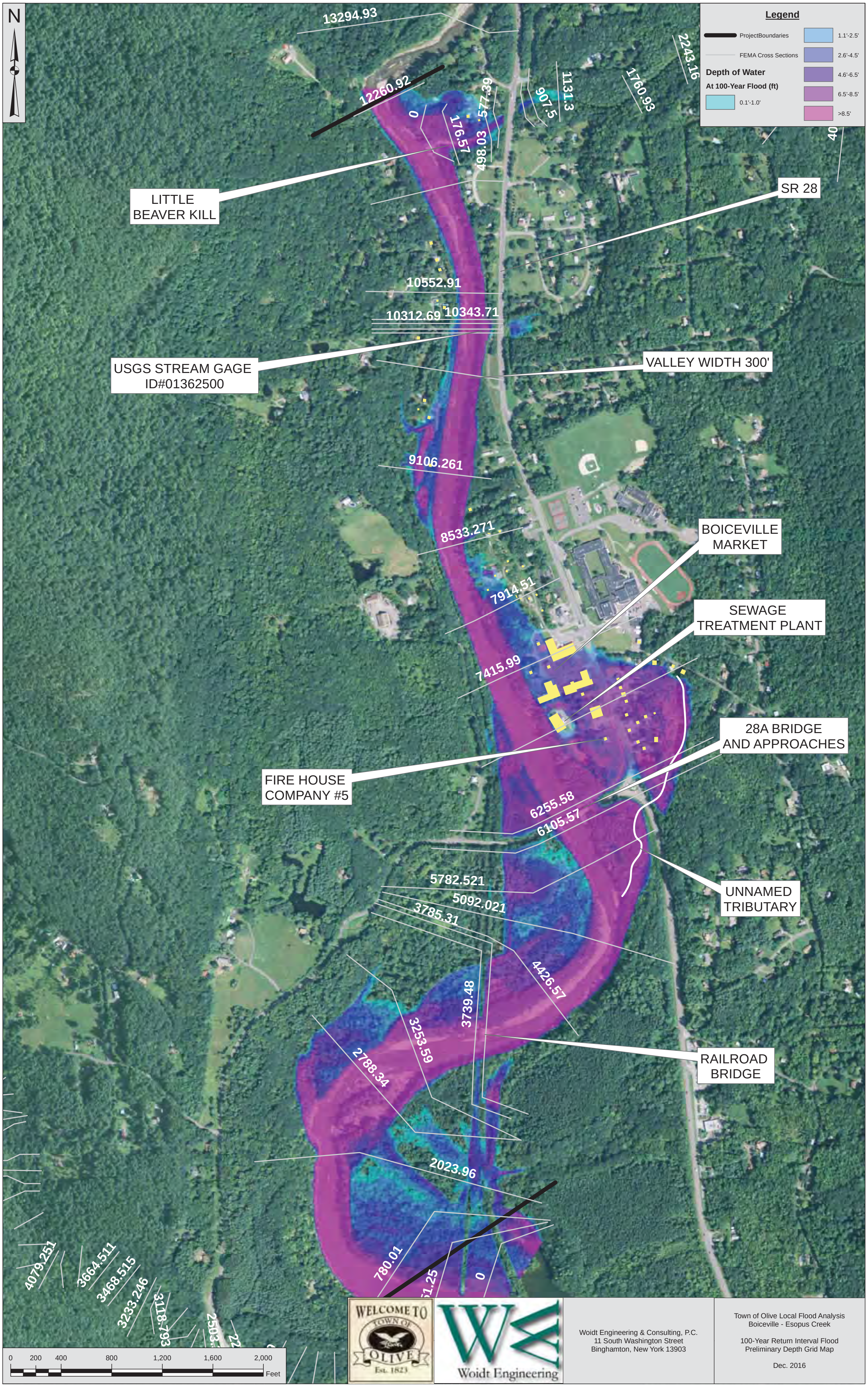
Boiceville - Esopus Creek
25-Year Return Interval Flood
Preliminary Depth Grid Map
Dec. 2016



N
Legend
ProjectBoundaries
FEMA Cross Sections
Depth of Water
At 50-Year Flood (ft)
0.1'-1.0'
1.1'-2.5'
2.6'-4.5'
4.6'-6.5'
6.5'-8.5'
>8.5'
13294.93
12260.92
0
176.57
577.39
498.03
907.5
1131.3
1760.93
2243.16
LITTLE BEAVER KILL
SR 28
10552.91
10312.69
10343.71
USGS STREAM GAGE ID#01362500
VALLEY WIDTH 300'
9106.261
8533.271
BOICEVILLE MARKET
7914.51
SEWAGE TREATMENT PLANT
7415.99
28A BRIDGE AND APPROACHES
FIRE HOUSE COMPANY #5
6255.58
6105.57
5782.521
5092.021
3785.31
UNNAMED TRIBUTARY
4426.57
3739.48
3253.59
2788.34
RAILROAD BRIDGE
2023.96
780.01
0
4079.251
3664.511
3468.515
3233.246
0 200 400 800 1,200 1,600 2,000 Feet
WELCOME TO TOWN OF OLIVE Est. 1823
Woidt Engineering
Woidt Engineering & Consulting, P.C.
11 South Washington Street
Binghamton, New York 13903
Town of Olive Local Flood Analysis
Boiceville - Esopus Creek
50-Year Return Interval Flood
Preliminary Depth Grid Map
Dec. 2016


N
Legend
ProjectBoundaries
FEMA Cross Sections
Depth of Water
At 100-Year Flood (ft)
0.1'-1.0'
1.1'-2.5'
2.6'-4.5'
4.6'-6.5'
6.5'-8.5'
>8.5'
LITTLE BEAVER KILL
SR 28
USGS STREAM GAGE ID#01362500
VALLEY WIDTH 300'
BOICEVILLE MARKET
SEWAGE TREATMENT PLANT
28A BRIDGE AND APPROACHES
FIRE HOUSE COMPANY #5
UNNAMED TRIBUTARY
RAILROAD BRIDGE
13294.93
12260.92
0
176.57
577.39
498.03
907.5
1131.3
1760.93
2243.16
10552.91
10312.69
10343.71
9106.261
8533.271
7914.51
7415.99
6255.58
6105.57
5782.521
5092.021
3785.31
4426.57
3739.48
3253.59
2788.34
2023.96
780.01
0
4079.251
3664.511
3468.515
3233.246
0 200 400 800 1,200 1,600 2,000 Feet
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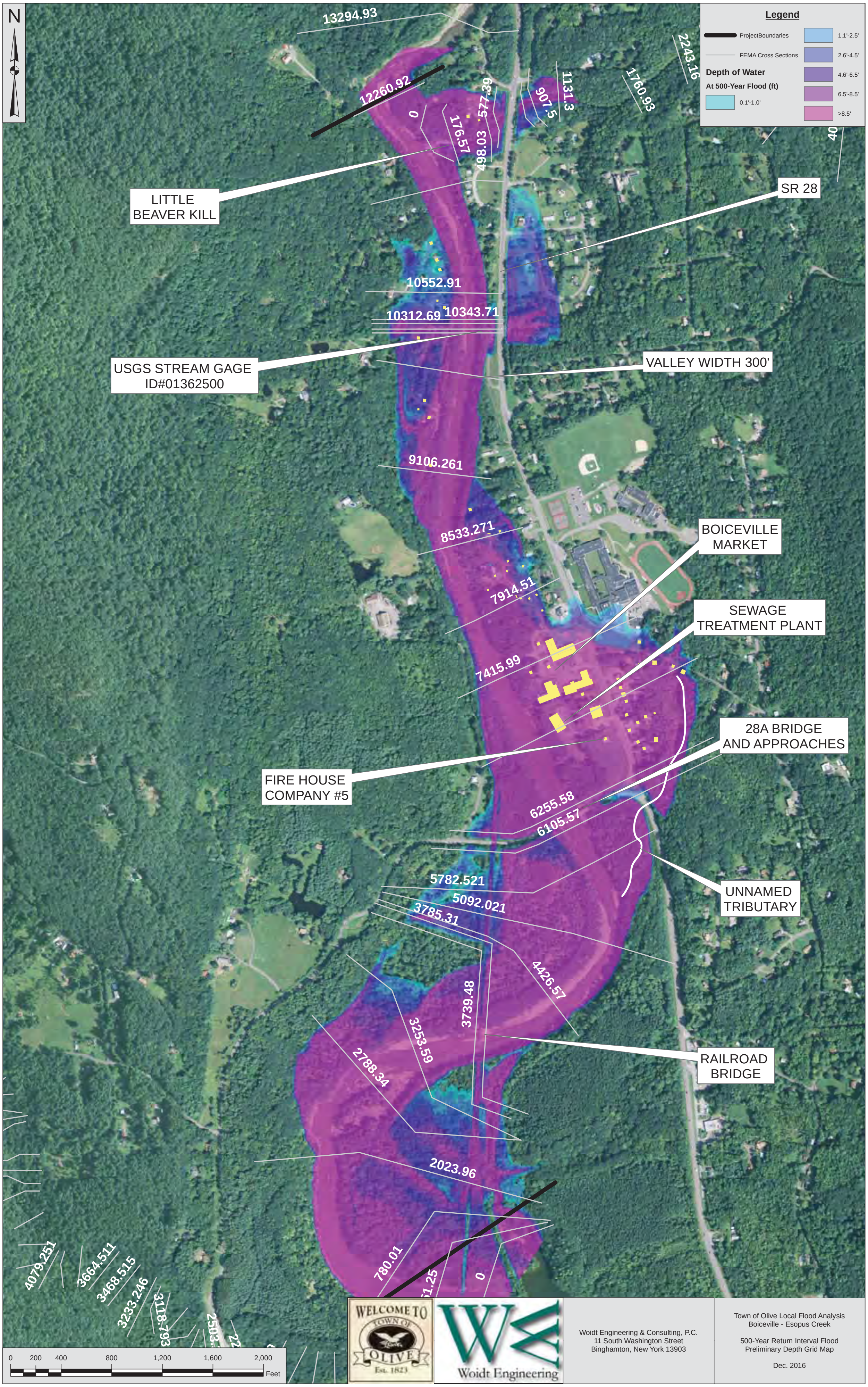
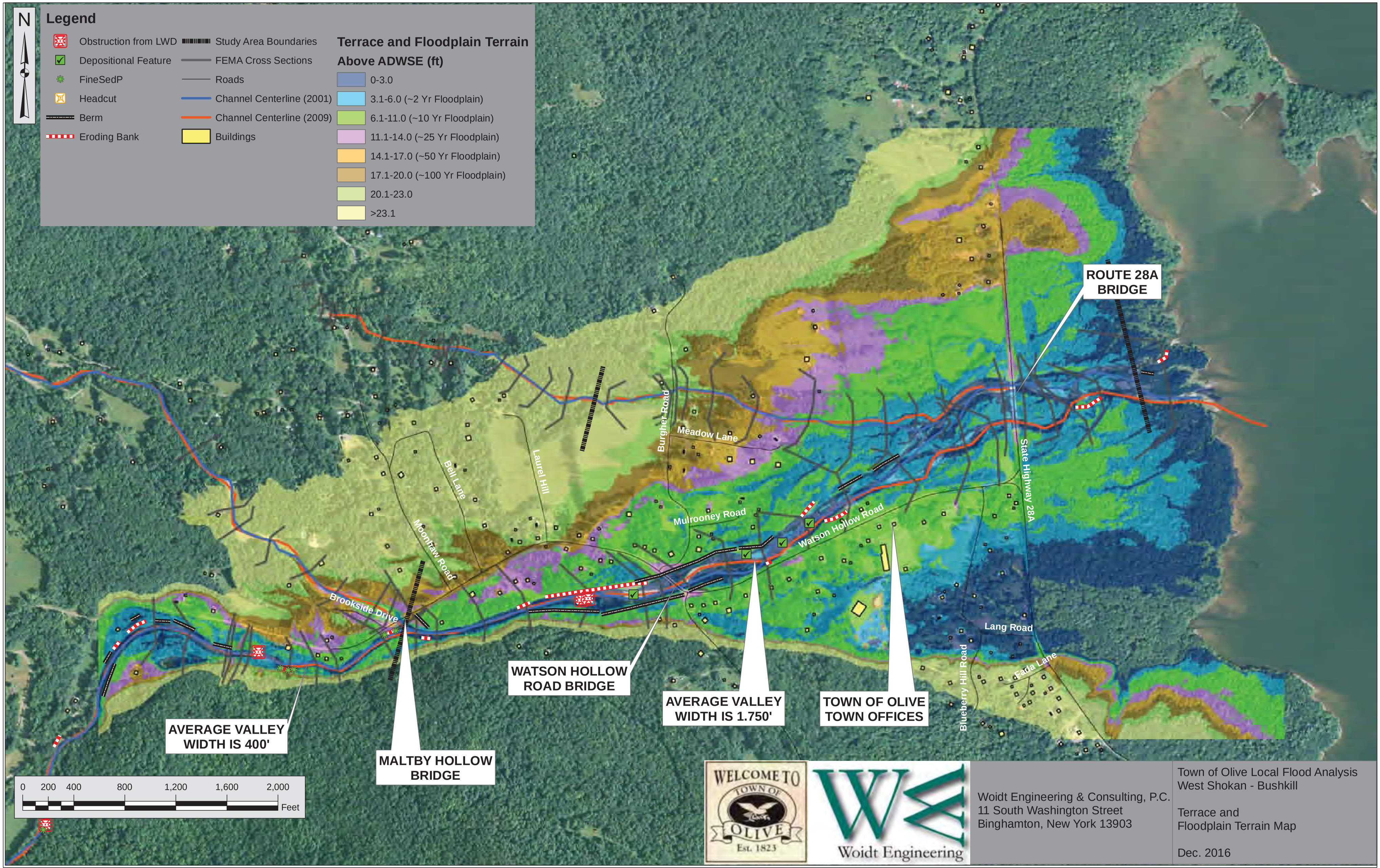
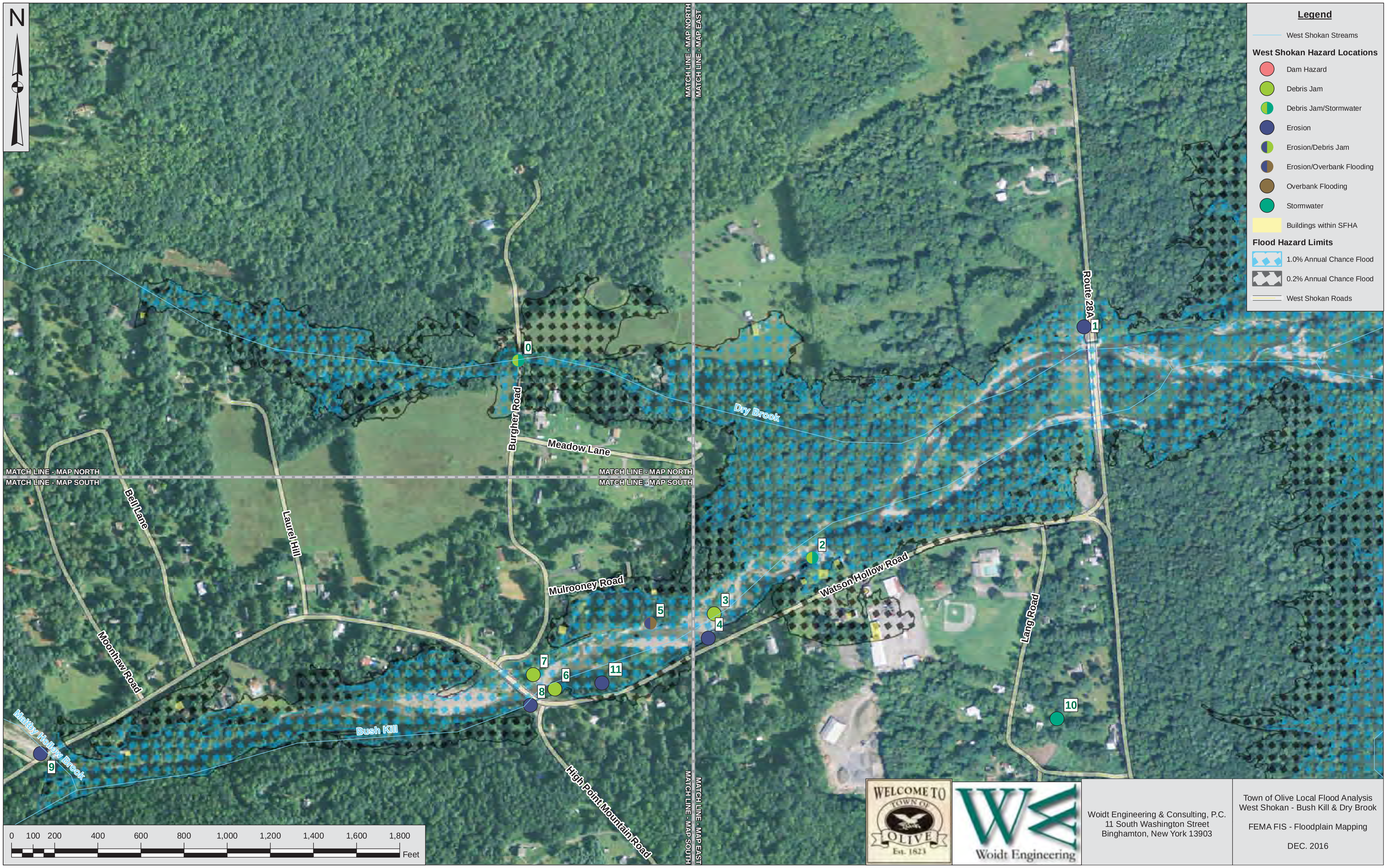
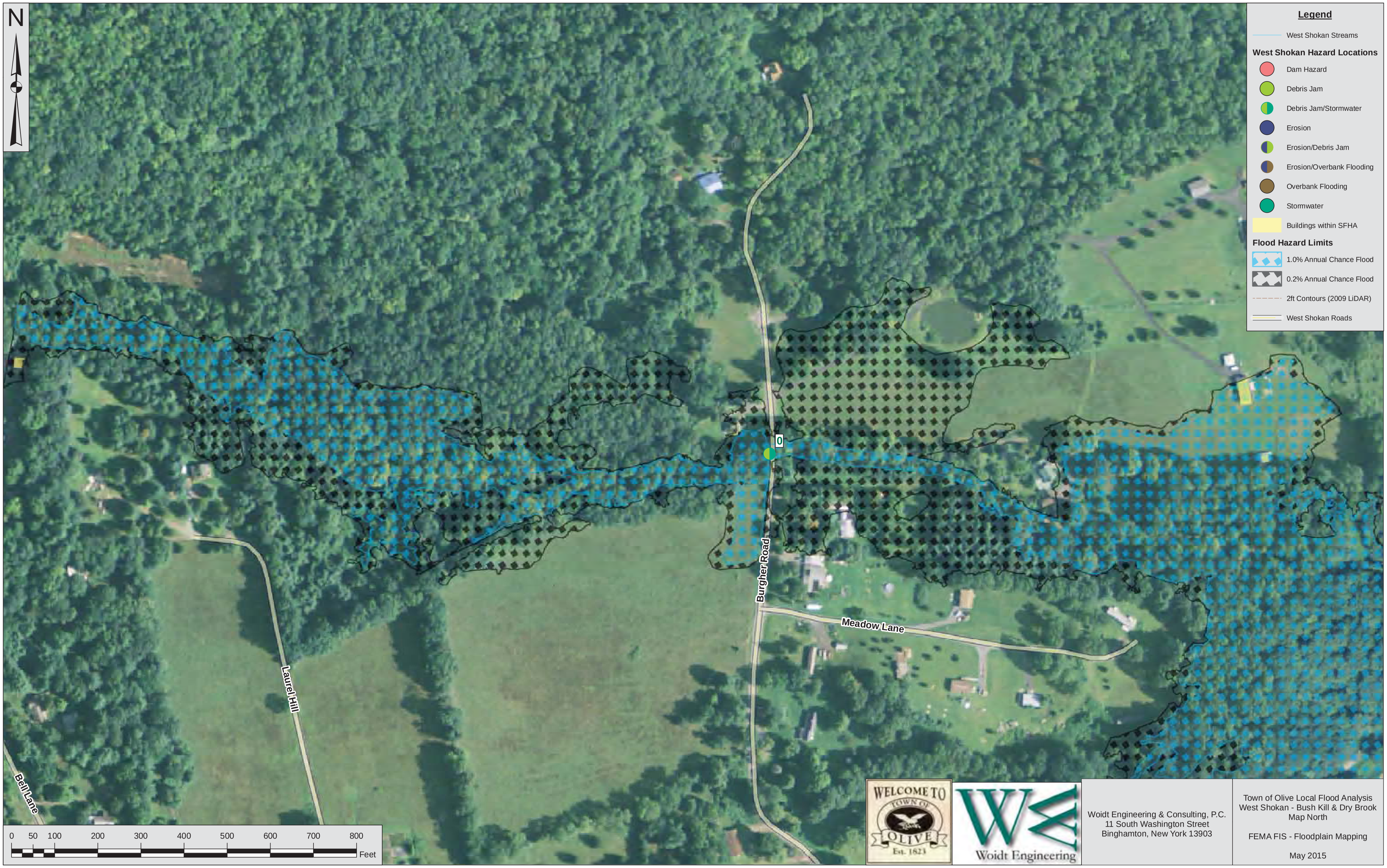
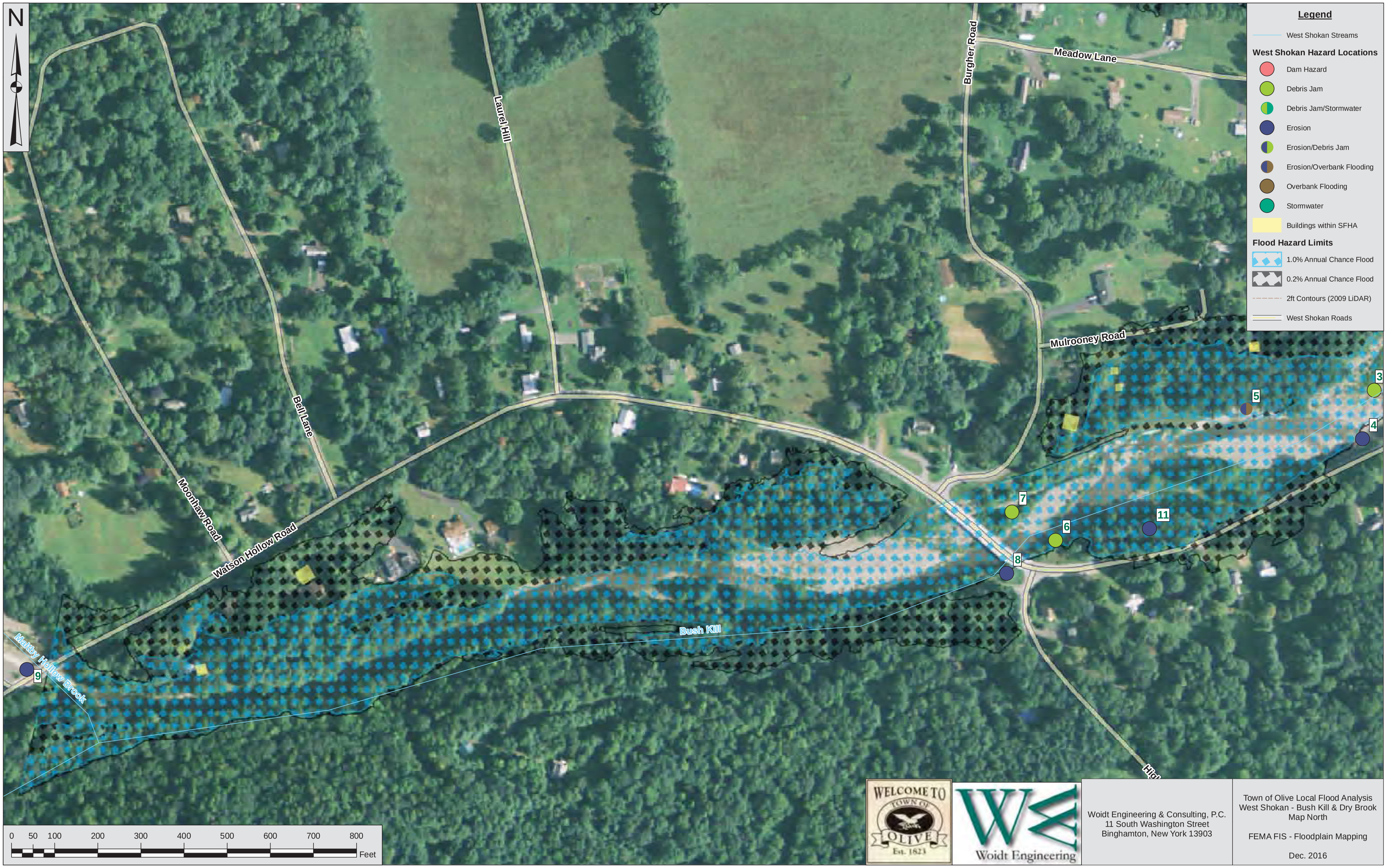
Woidt Engineering & Consulting, P.C.
11 South Washington Street
Binghamton, New York 13903
Town of Olive Local Flood Analysis
Boiceville - Esopus Creek
100-Year Return Interval Flood
Preliminary Depth Grid Map
Dec. 2016

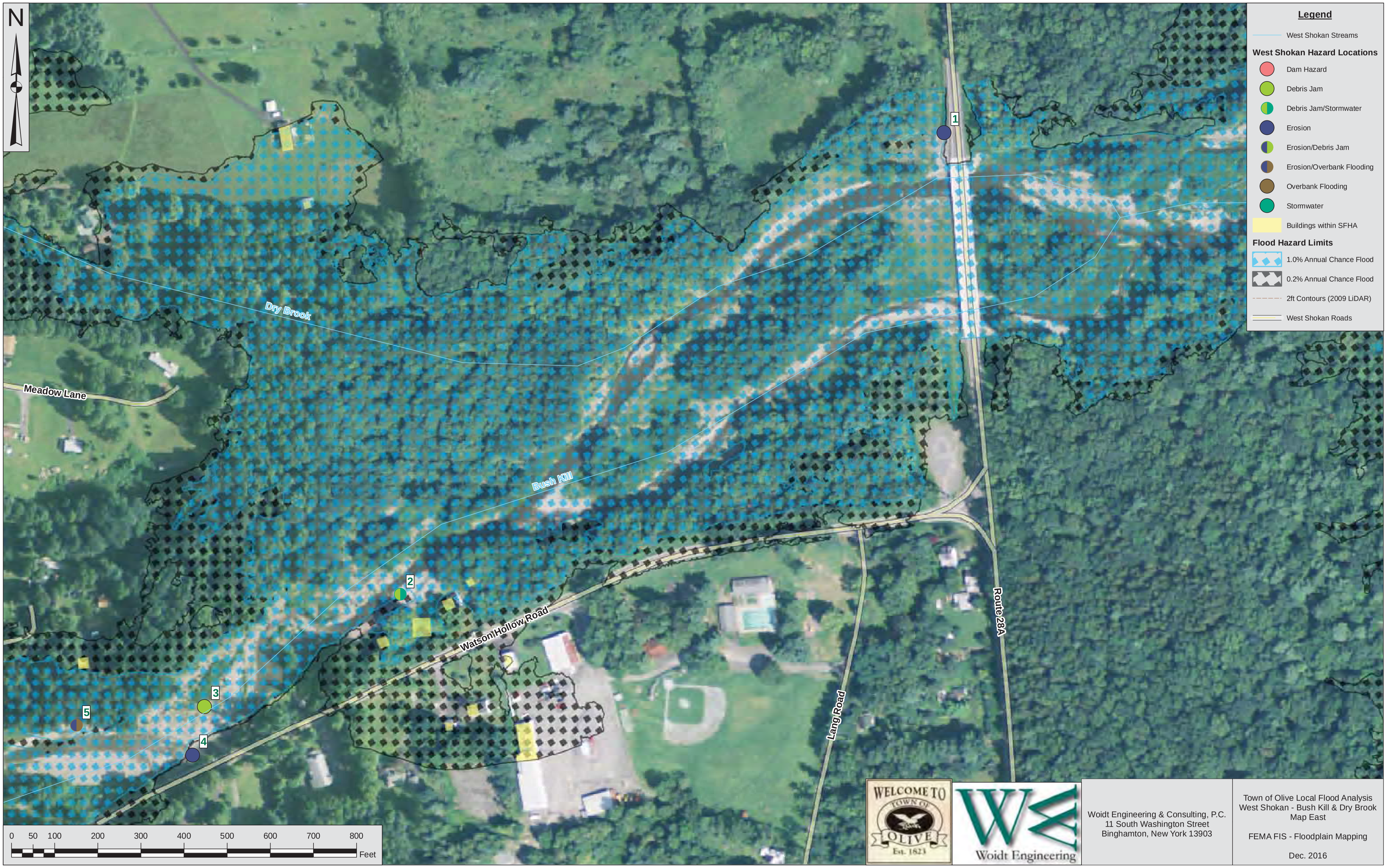

N
Legend
ProjectBoundaries
FEMA Cross Sections
Depth of Water
At 500-Year Flood (ft)
0.1'-1.0'
1.1'-2.5'
2.6'-4.5'
4.6'-6.5'
6.5'-8.5'
>8.5'
13294.93
12260.92
0
176.57
577.39
498.03
907.5
1131.3
1760.93
2243.16
LITTLE BEAVER KILL
SR 28
10552.91
10312.69
10343.71
USGS STREAM GAGE ID#01362500
VALLEY WIDTH 300'
9106.261
8533.271
BOICEVILLE MARKET
7914.51
SEWAGE TREATMENT PLANT
7415.99
28A BRIDGE AND APPROACHES
FIRE HOUSE COMPANY #5
6255.58
6105.57
5782.521
5092.021
3785.31
UNNAMED TRIBUTARY
4426.57
3739.48
3253.59
2788.34
RAILROAD BRIDGE
2023.96
780.01
0
4079.251
3664.511
3468.515
3233.246
3118.793
0 200 400 800 1,200 1,600 2,000
Feet
WELCOME TO TOWN OF OLIVE Est. 1823
Woidt Engineering
Woidt Engineering & Consulting, P.C.
11 South Washington Street
Binghamton, New York 13903
Town of Olive Local Flood Analysis
Boiceville - Esopus Creek
500-Year Return Interval Flood
Preliminary Depth Grid Map
Dec. 2016

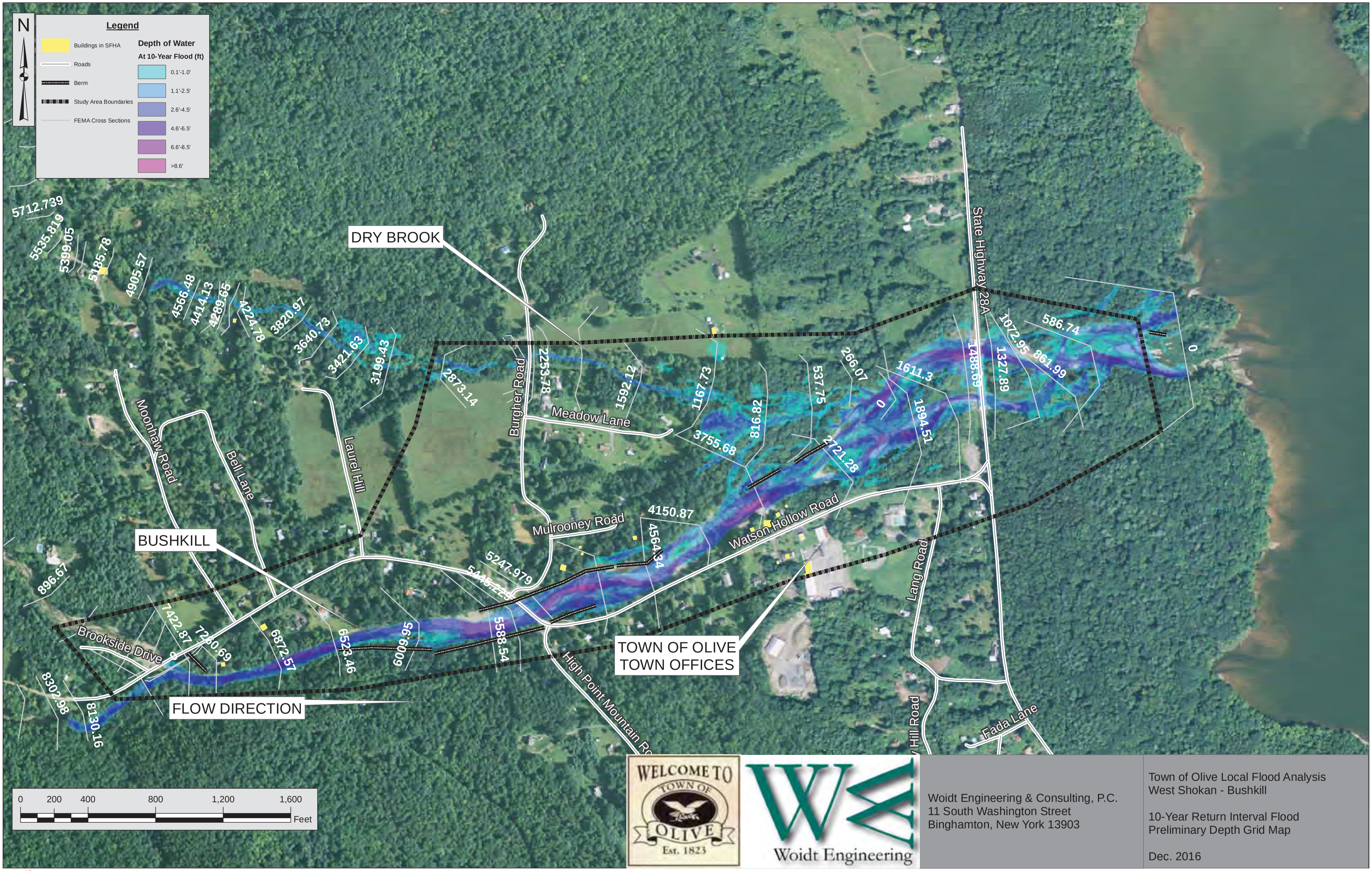

N
Legend
Obstruction from LWD
Depositional Feature
FineSedP
Headcut
Berm
Eroding Bank
Study Area Boundaries
FEMA Cross Sections
Roads
Channel Centerline (2001)
Channel Centerline (2009)
Buildings
Terrace and Floodplain Terrain Above ADWSE (ft)
0-3.0
3.1-6.0 (~2 Yr Floodplain)
6.1-11.0 (~10 Yr Floodplain)
11.1-14.0 (~25 Yr Floodplain)
14.1-17.0 (~50 Yr Floodplain)
17.1-20.0 (~100 Yr Floodplain)
20.1-23.0
>23.1
ROUTE 28A BRIDGE
Burgher Road
Meadow Lane
Laurel Hill
Bell Lane
Moonhaw Road
Mulrooney Road
Watson Hollow Road
State Highway 28A
Brookside Drive
Lang Road
Fada Lane
Blueberry Hill Road
WATSON HOLLOW ROAD BRIDGE
AVERAGE VALLEY WIDTH IS 1.750'
TOWN OF OLIVE TOWN OFFICES
AVERAGE VALLEY WIDTH IS 400'
MALTBY HOLLOW BRIDGE
0 200 400 800 1,200 1,600 2,000 Feet
WELCOME TO TOWN OF OLIVE Est. 1823
Woidt Engineering
Woidt Engineering & Consulting, P.C.
11 South Washington Street
Binghamton, New York 13903
Town of Olive Local Flood Analysis
West Shokan - Bushkill
Terrace and Floodplain Terrain Map
Dec. 2016


N
Legend
West Shokan Streams
West Shokan Hazard Locations
Dam Hazard
Debris Jam
Debris Jam/Stormwater
Erosion
Erosion/Debris Jam
Erosion/Overbank Flooding
Overbank Flooding
Stormwater
Buildings within SFHA
Flood Hazard Limits
1.0% Annual Chance Flood
0.2% Annual Chance Flood
West Shokan Roads
MATCH LINE - MAP NORTH
MATCH LINE - MAP EAST
MATCH LINE - MAP SOUTH
Route 28A
Dry Brook
Burgher Road
Meadow Lane
Bell Lane
Laurel Hill
Mulrooney Road
Watson Hollow Road
Lang Road
Moonhaw Road
Bush Kill
Maltby Hollow Brook
High Point Mountain Road
0
1
2
3
4
5
6
7
8
9
10
11
0 100 200 400 600 800 1,000 1,200 1,400 1,600 1,800 Feet
WELCOME TO TOWN OF OLIVE Est. 1823
Woidt Engineering
Woidt Engineering & Consulting, P.C.
11 South Washington Street
Binghamton, New York 13903
Town of Olive Local Flood Analysis
West Shokan - Bush Kill & Dry Brook
FEMA FIS - Floodplain Mapping
DEC. 2016


N
Legend
West Shokan Streams
West Shokan Hazard Locations
Dam Hazard
Debris Jam
Debris Jam/Stormwater
Erosion
Erosion/Debris Jam
Erosion/Overbank Flooding
Overbank Flooding
Stormwater
Buildings within SFHA
Flood Hazard Limits
1.0% Annual Chance Flood
0.2% Annual Chance Flood
2ft Contours (2009 LiDAR)
West Shokan Roads
0
Burgher Road
Meadow Lane
Laurel Hill
Bell Lane
0 50 100 200 300 400 500 600 700 800
Feet
WELCOME TO
TOWN OF
OLIVE
Est. 1823
Woidt Engineering
Woidt Engineering & Consulting, P.C.
11 South Washington Street
Binghamton, New York 13903
Town of Olive Local Flood Analysis
West Shokan - Bush Kill & Dry Brook
Map North
FEMA FIS - Floodplain Mapping
May 2015


Legend
West Shokan Streams
West Shokan Hazard Locations
Dam Hazard
Debris Jam
Debris Jam/Stormwater
Erosion
Erosion/Debris Jam
Erosion/Overbank Flooding
Overbank Flooding
Stormwater
Buildings within SFHA
Flood Hazard Limits
1.0% Annual Chance Flood
0.2% Annual Chance Flood
2ft Contours (2009 LiDAR)
West Shokan Roads
N
Meadow Lane
Burgher Road
Laurel Hill
Mulrooney Road
Bell Lane
Moonhaw Road
Watson Hollow Road
Maltby Hollow Brook
Bush Kill
3
4
5
6
7
8
9
11
0 50 100 200 300 400 500 600 700 800
Feet
WELCOME TO TOWN OF OLIVE Est. 1823
Woidt Engineering
Woidt Engineering & Consulting, P.C.
11 South Washington Street
Binghamton, New York 13903
Town of Olive Local Flood Analysis
West Shokan - Bush Kill & Dry Brook
Map North
FEMA FIS - Floodplain Mapping
Dec. 2016


N
Legend
West Shokan Streams
West Shokan Hazard Locations
Dam Hazard
Debris Jam
Debris Jam/Stormwater
Erosion
Erosion/Debris Jam
Erosion/Overbank Flooding
Overbank Flooding
Stormwater
Buildings within SFHA
Flood Hazard Limits
1.0% Annual Chance Flood
0.2% Annual Chance Flood
2ft Contours (2009 LiDAR)
West Shokan Roads
Dry Brook
Bush Kill
Meadow Lane
Watson Hollow Road
Lang Road
Route 28A
1
2
3
4
5
0 50 100 200 300 400 500 600 700 800
Feet
WELCOME TO TOWN OF OLIVE Est. 1823
Woidt Engineering
Woidt Engineering & Consulting, P.C.
11 South Washington Street
Binghamton, New York 13903
Town of Olive Local Flood Analysis
West Shokan - Bush Kill & Dry Brook
Map East
FEMA FIS - Floodplain Mapping
Dec. 2016

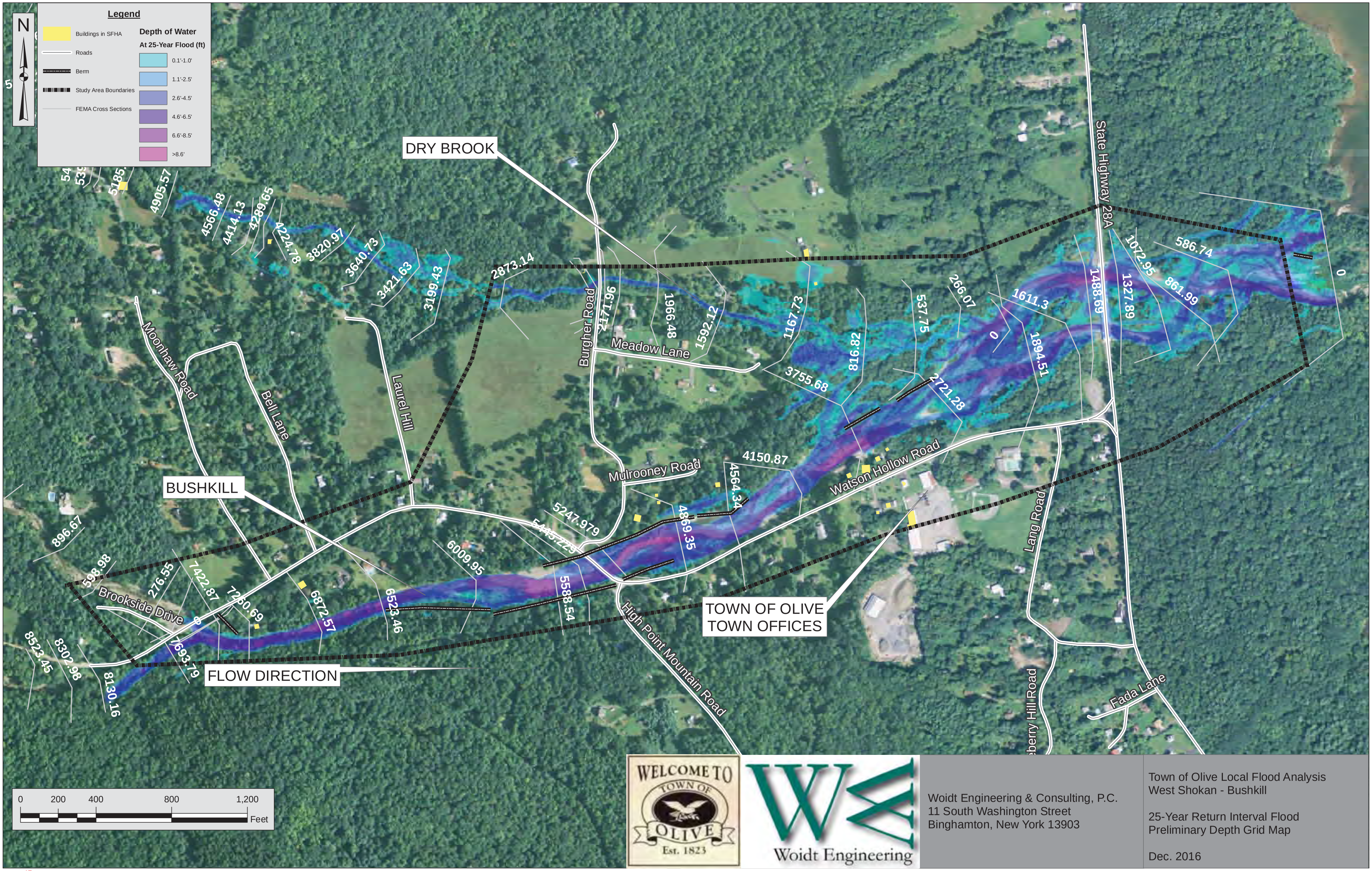


Woidt Engineering & Consulting, P.C.
11 South Washington Street
Binghamton, New York 13903

Town of Olive Local Flood Analysis
West Shokan - Bushkill

10-Year Return Interval Flood
Preliminary Depth Grid Map

Dec. 2016

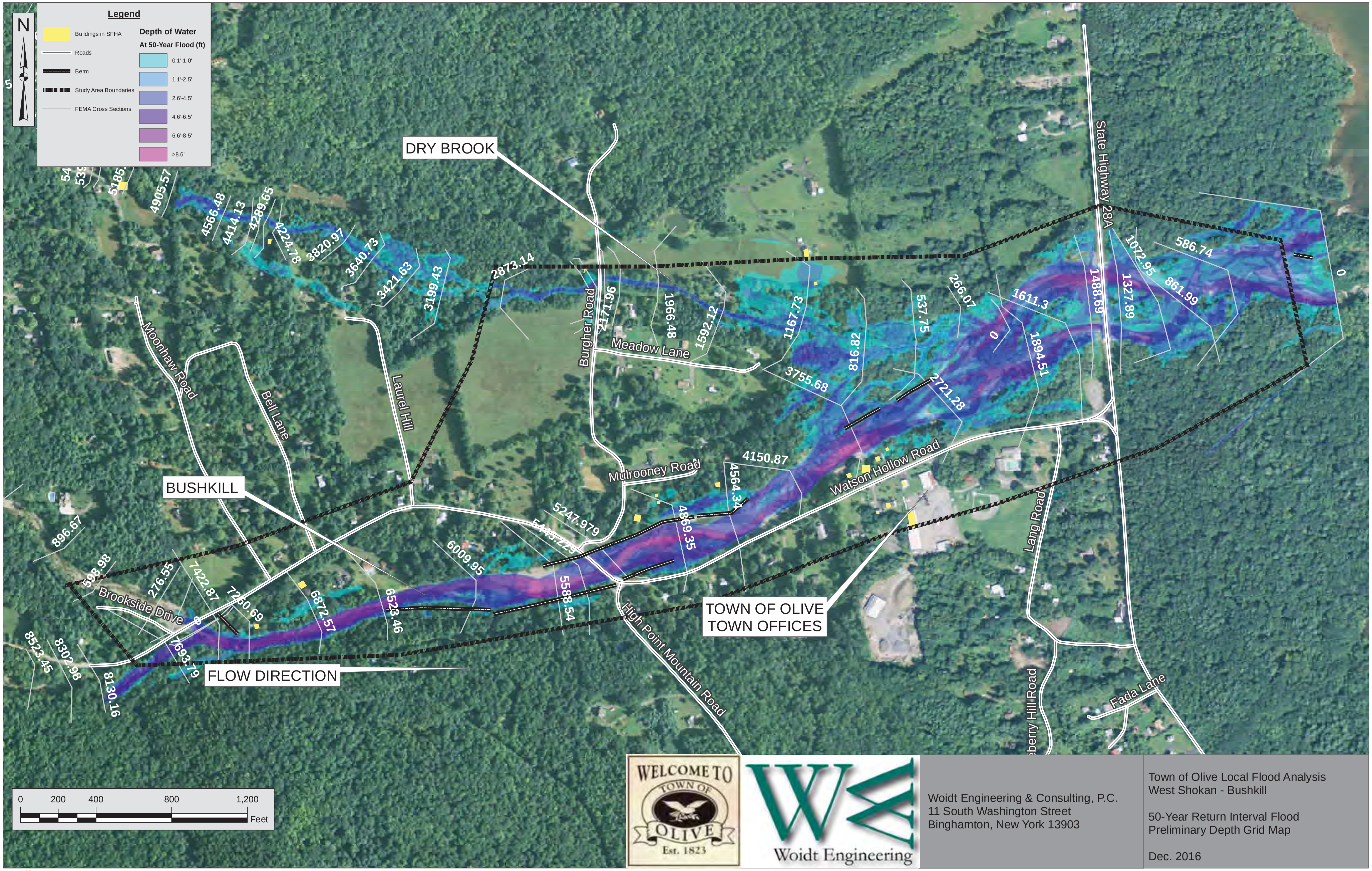


Woidt Engineering & Consulting, P.C.
11 South Washington Street
Binghamton, New York 13903

Town of Olive Local Flood Analysis
West Shokan - Bushkill

25-Year Return Interval Flood
Preliminary Depth Grid Map

Dec. 2016

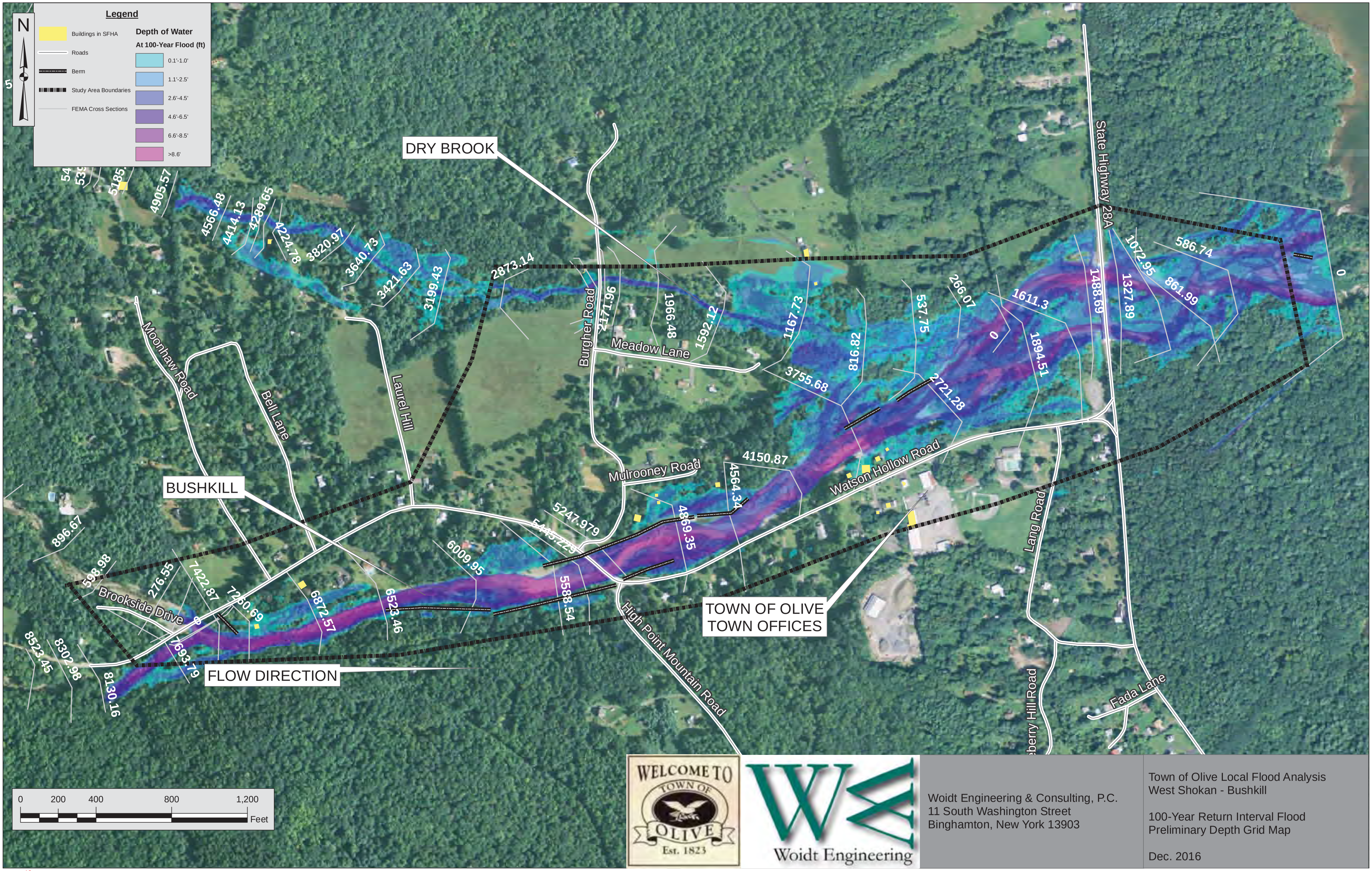


Woidt Engineering & Consulting, P.C.
11 South Washington Street
Binghamton, New York 13903

Town of Olive Local Flood Analysis
West Shokan - Bushkill

50-Year Return Interval Flood
Preliminary Depth Grid Map

Dec. 2016

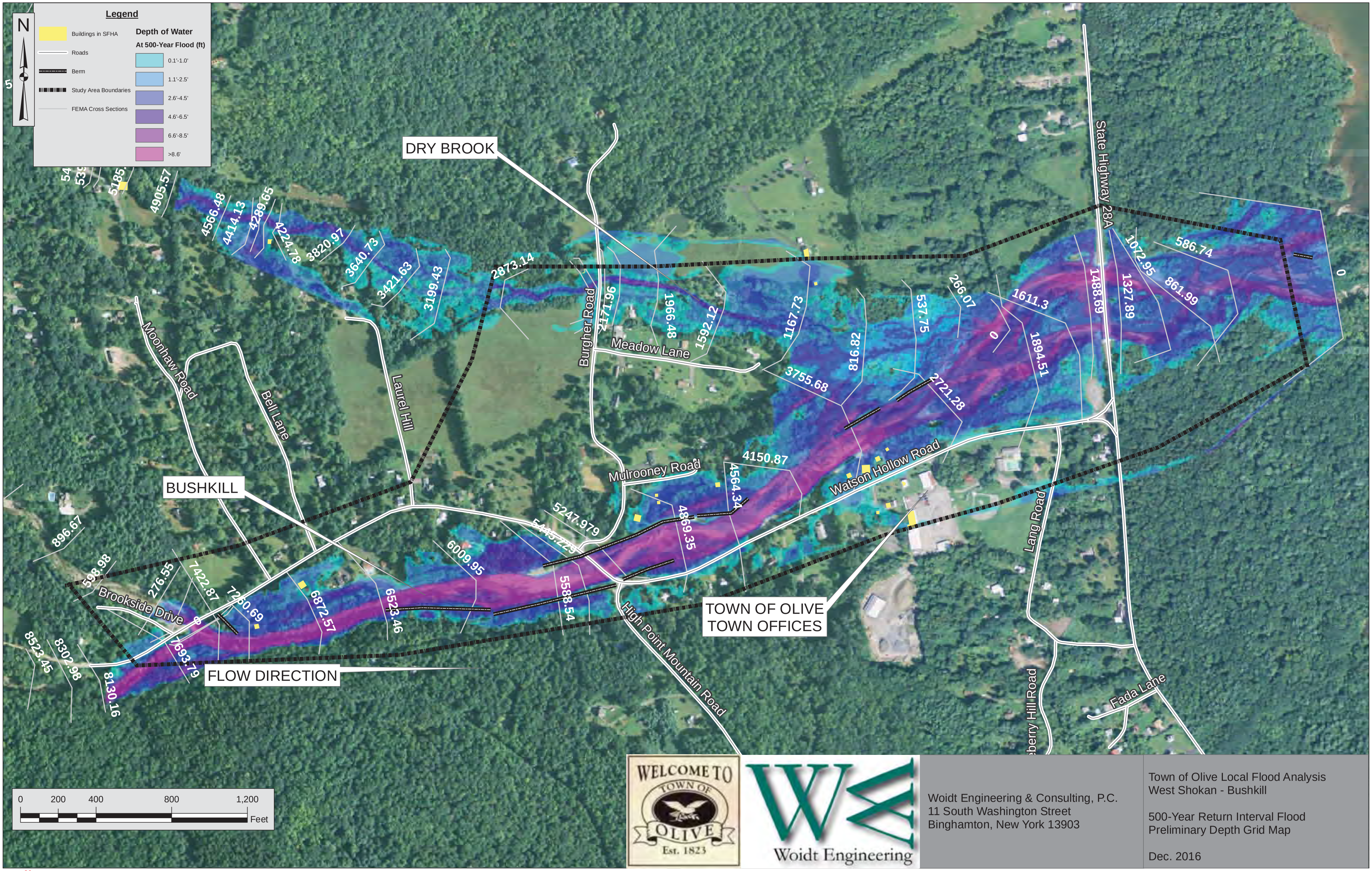


Woidt Engineering & Consulting, P.C.
11 South Washington Street
Binghamton, New York 13903

Town of Olive Local Flood Analysis
West Shokan - Bushkill

100-Year Return Interval Flood
Preliminary Depth Grid Map

Dec. 2016



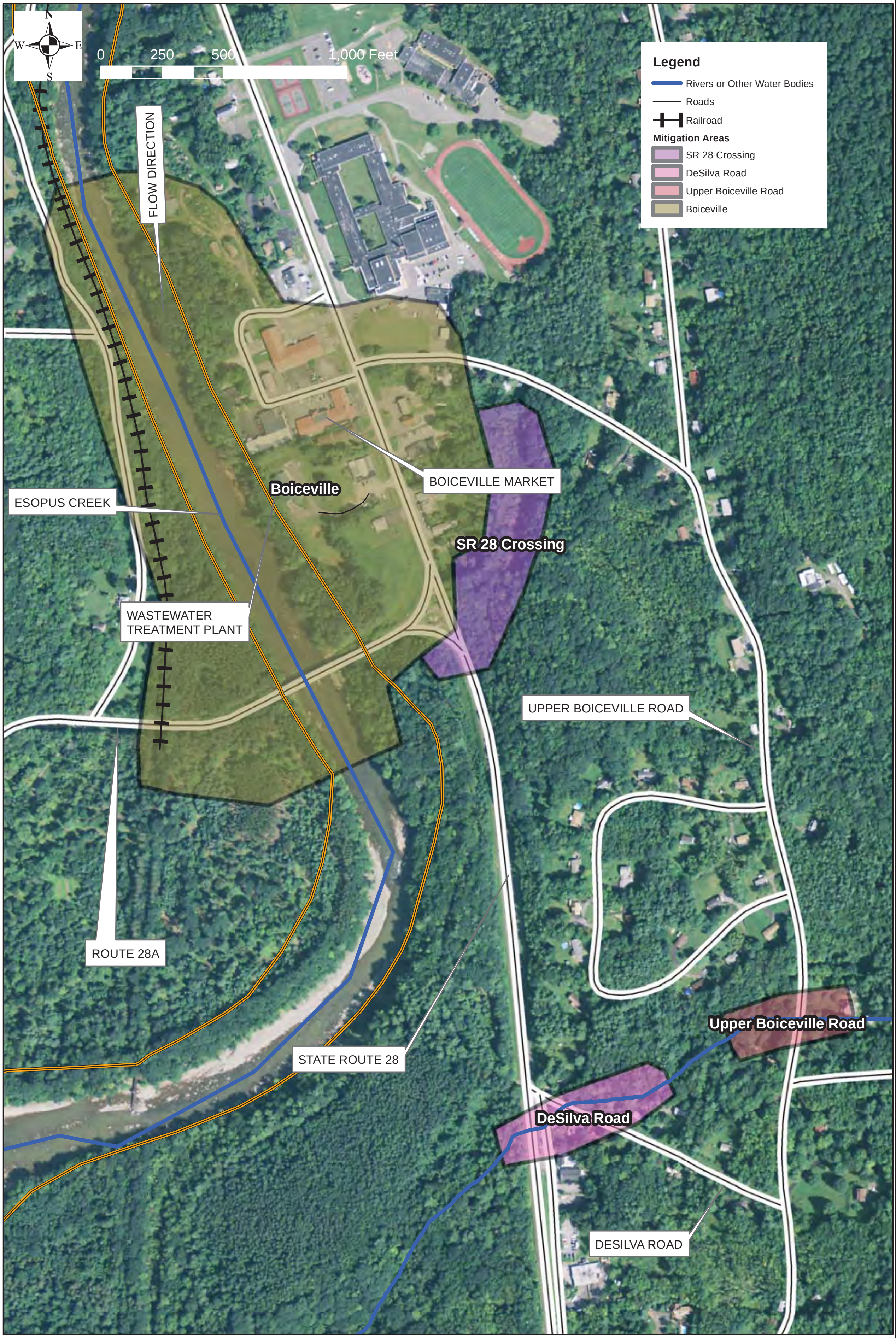
Woidt Engineering & Consulting, P.C.
11 South Washington Street
Binghamton, New York 13903

Town of Olive Local Flood Analysis
West Shokan - Bushkill

500-Year Return Interval Flood
Preliminary Depth Grid Map

Dec. 2016

APPENDIX B



BACKGROUND PHOTO: 2013 NAIP

MITIGATION AREAS IN
BOICEVILLE STUDY AREA

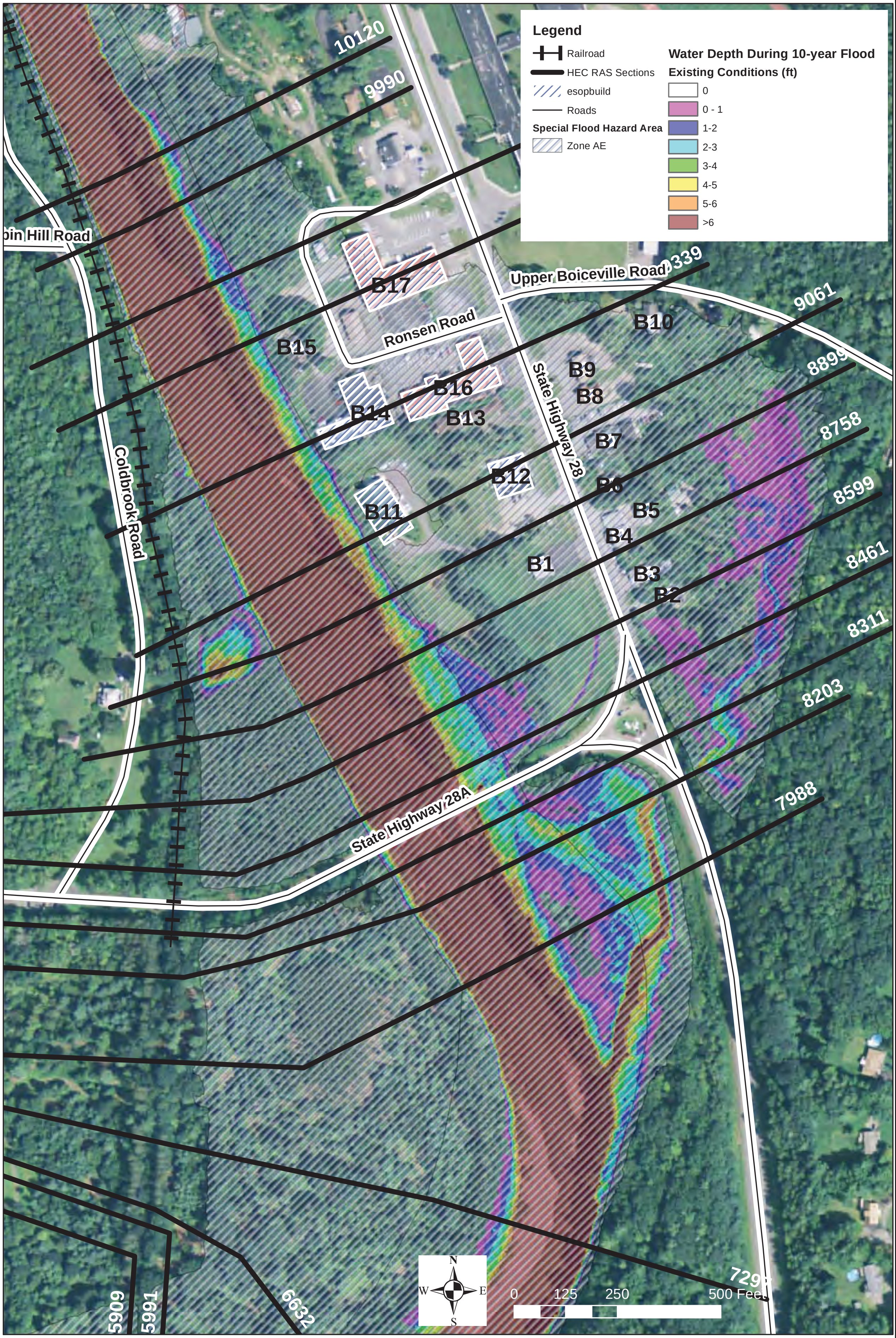
TOWN OF OLIVE
LOCAL FLOOD ANALYSIS

OLIVE, ULSTER COUNTY, NY

DATE: 9/6/16
DESIGNED BY:
DRAWN BY: GDF
CHECKED BY: ::
PROJECT NO:
FIGURE NUMBER: 1

WELCOME TO TOWN OF OLIVE Est. 1823

Woidt Engineering



BACKGROUND PHOTO: 2013 NAIP

EXISTING CONDITIONS WATER DEPTH MAP
10-YEAR RETURN INTERVAL FLOOD

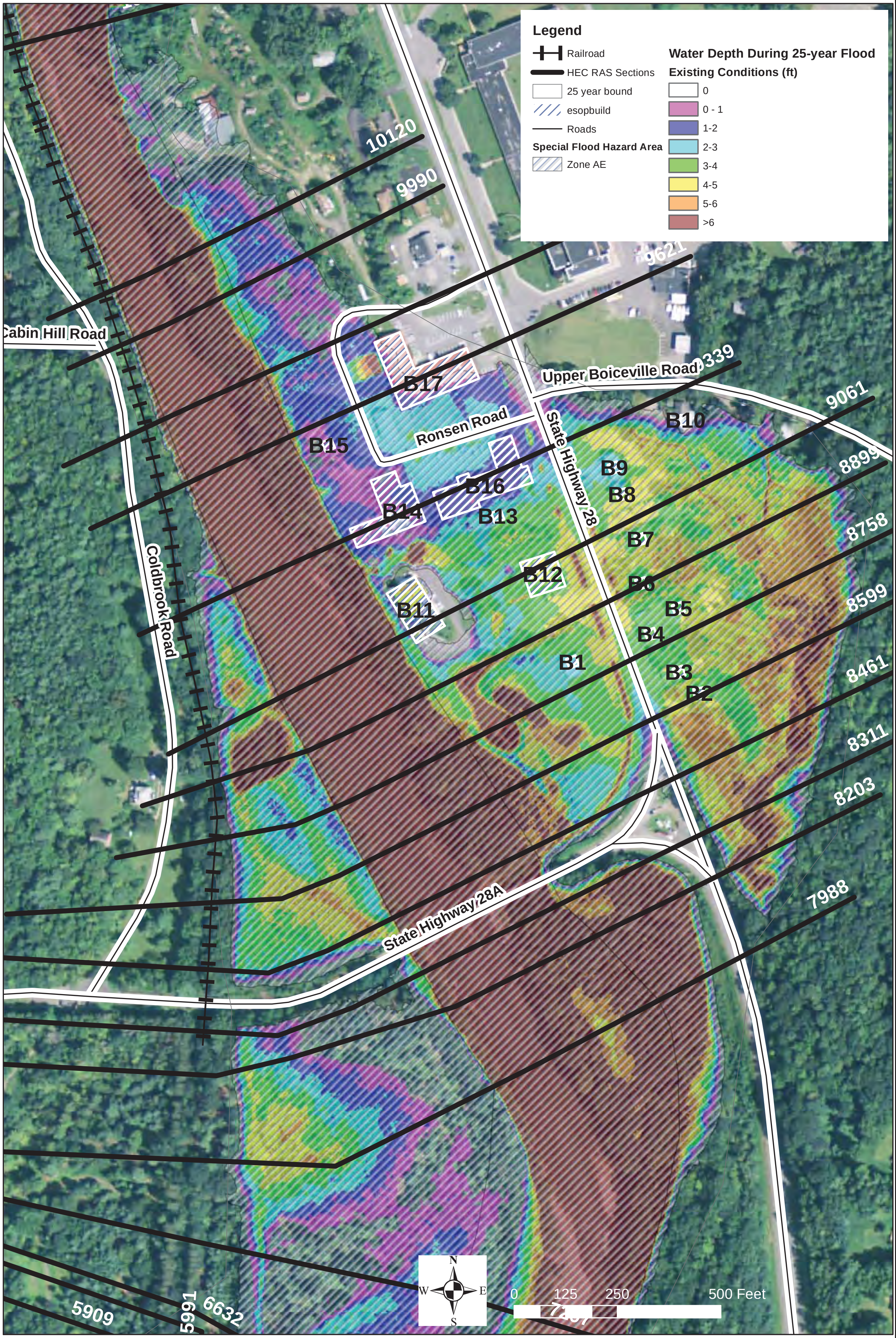
TOWN OF OLIVE
LOCAL FLOOD ANALYSIS

OLIVE, ULSTER COUNTY, NY

DATE: 9/6/16
DESIGNED BY:
DRAWN BY: GDF
CHECKED BY: ::
PROJECT NO:
FIGURE NUMBER: 2

WELCOME TO TOWN OF OLIVE Est. 1823

Woidt Engineering



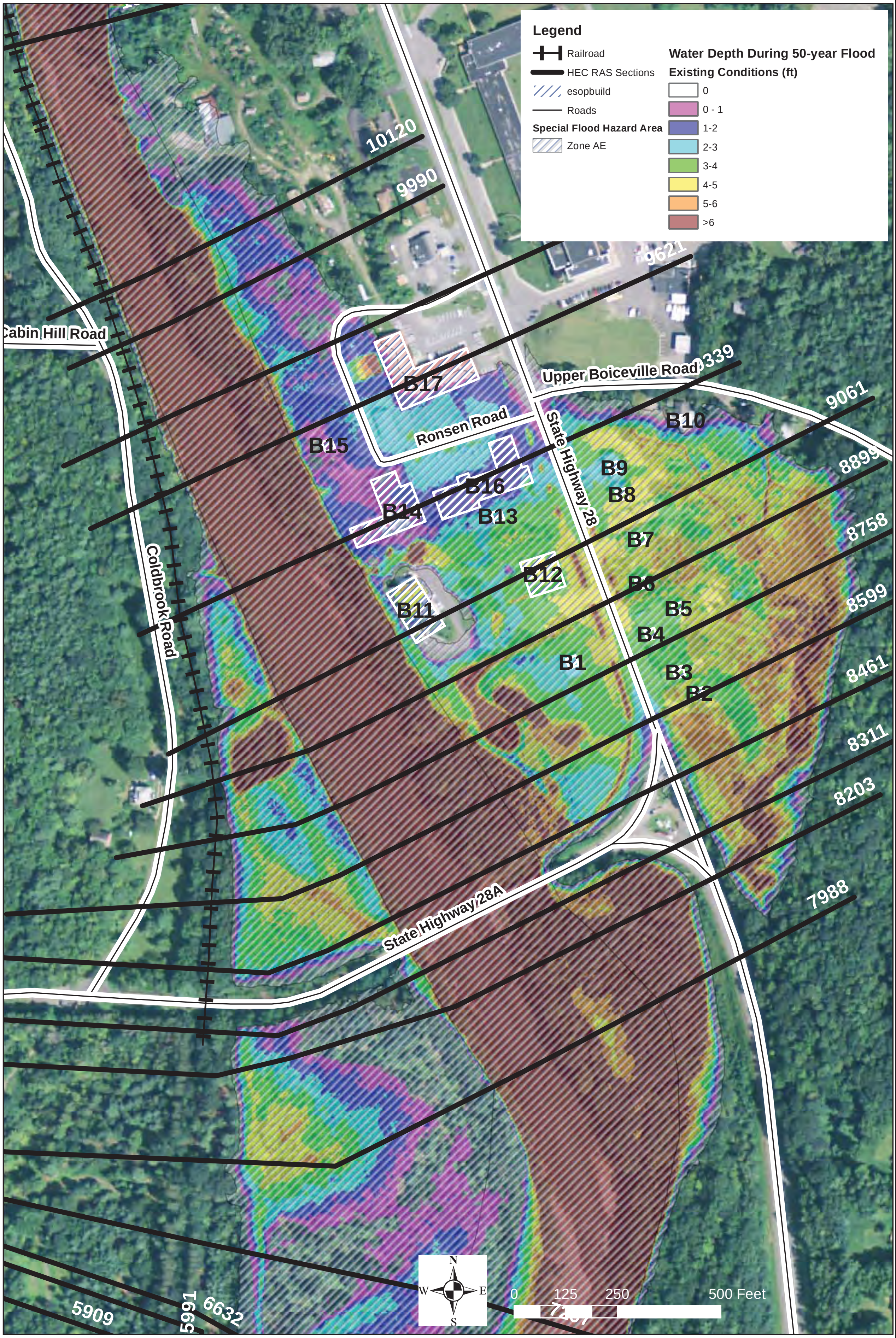
BACKGROUND PHOTO: 2013 NAIP

DATE:	9/6/16
DESIGNED BY:	
DRAWN BY:	GDF
CHECKED BY:	--
PROJECT NO:	
FIGURE NUMBER:	3

EXISTING CONDITIONS WATER DEPTH MAP
25-YEAR RETURN INTERVAL FLOOD

TOWN OF OLIVE
LOCAL FLOOD ANALYSIS

OLIVE, ULSTER COUNTY, NY



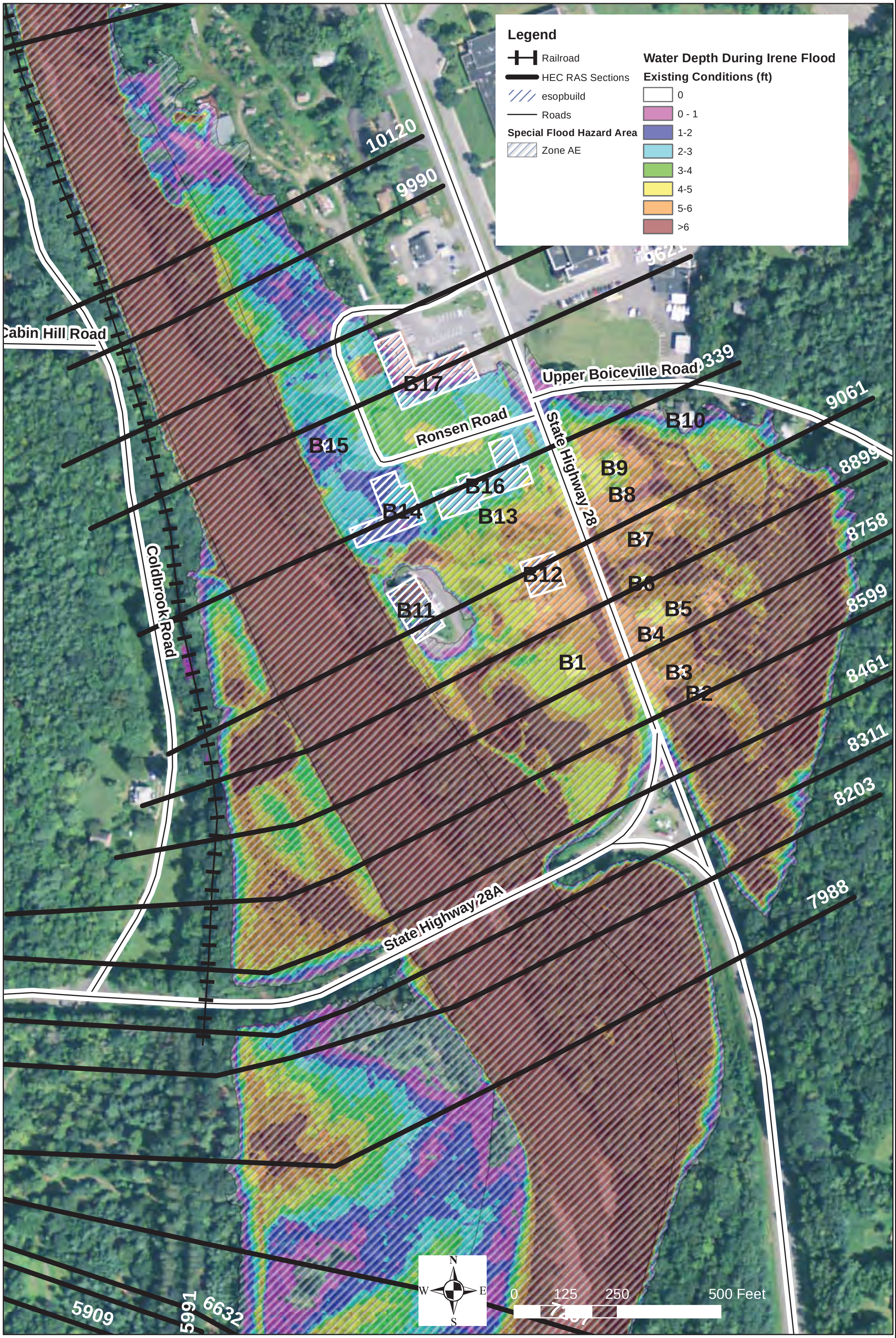
BACKGROUND PHOTO: 2013 NAIP

EXISTING CONDITIONS WATER DEPTH MAP
50-YEAR RETURN INTERVAL FLOOD

TOWN OF OLIVE
LOCAL FLOOD ANALYSIS

OLIVE, ULSTER COUNTY, NY

DATE: 9/6/16
DESIGNED BY:
DRAWN BY: GDF
CHECKED BY: --
PROJECT NO:
FIGURE NUMBER: 4



EXISTING CONDITIONS WATER DEPTH MAP
IRENE FLOOD

TOWN OF OLIVE
LOCAL FLOOD ANALYSIS

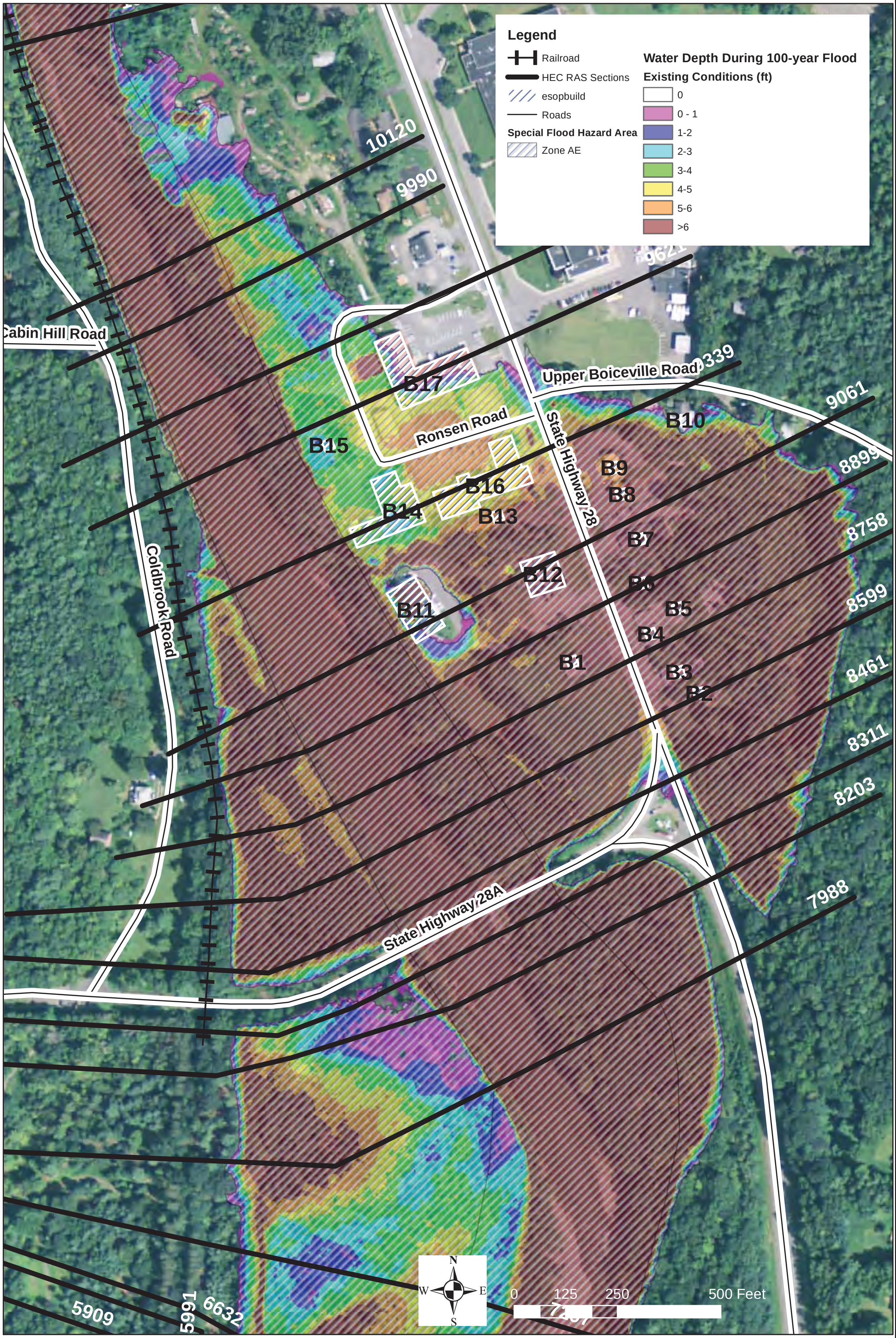
OLIVE, ULSTER COUNTY, NY

BACKGROUND PHOTO: 2013 NAIP

DATE:	9/6/16
DESIGNED BY:	
DRAWN BY:	GDF
CHECKED BY:	::
PROJECT NO:	
FIGURE NUMBER:	5

WELCOME TO TOWN OF OLIVE Est. 1823

Woidt Engineering



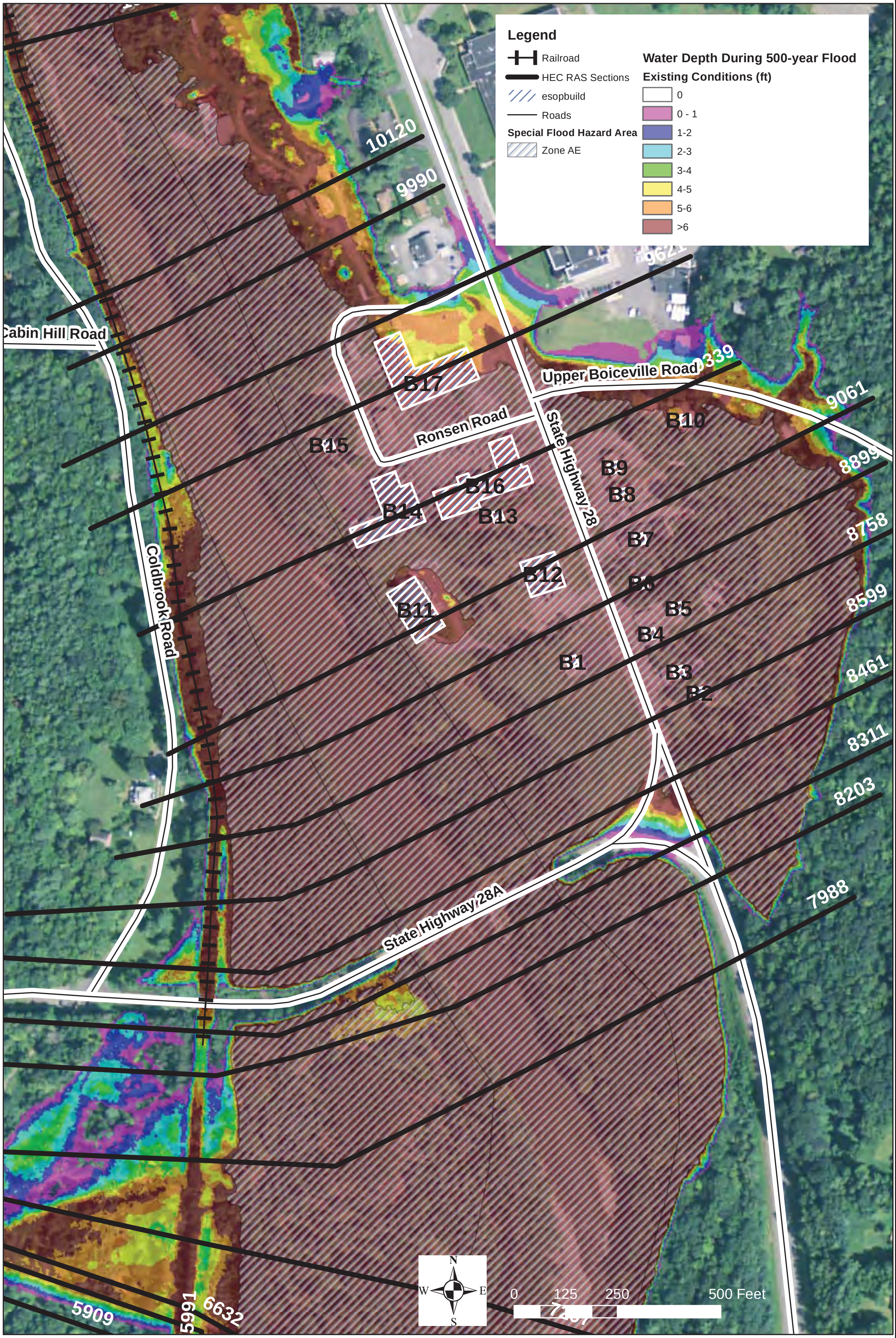
EXISTING CONDITIONS WATER DEPTH MAP
100-YEAR RETURN INTERVAL FLOOD

BACKGROUND PHOTO: 2013 NAIP

TOWN OF OLIVE
LOCAL FLOOD ANALYSIS

OLIVE, ULSTER COUNTY, NY

DATE: 9/6/16
DESIGNED BY:
DRAWN BY: GDF
CHECKED BY: --
PROJECT NO:
FIGURE NUMBER: 6



BACKGROUND PHOTO: 2013 NAIP

EXISTING CONDITIONS WATER DEPTH MAP 500-YEAR RETURN INTERVAL FLOOD

TOWN OF OLIVE
LOCAL FLOOD ANALYSIS

OLIVE, ULSTER COUNTY, NY

DATE: 9/6/16
DESIGNED BY:
DRAWN BY: GDF
CHECKED BY: ::
PROJECT NO:
FIGURE NUMBER: 7

WELCOME TO TOWN OF OLIVE Est. 1823

Woidt Engineering

Title: Property Information Table

Date: 2/14/2017

By: GDF

Structure No.	Address	Property SBL	Size Of Building (SF)	Value (2015) of Building ($/SF)	Demolition Threshold	Residential Building	Building Engineering	Basement Type	Number of Stories	DDF Curve Used	First Floor Elevation	Streabed Elevation	Return Interval 10 Elevation Before Mitigation	Return Interval 50 Elevation Before Mitigation	Return Interval 100 Elevation Before Mitigation	Return Interval 500 Elevation Before Mitigation
B1	4067 RTE 28	36.11-1-31	1978	89.23	50	No	Yes	Slab	One Story	Protective Services	625.8	613.72	623.92	628.89	631.81	645.33
B2	4042 RTE 28	36.11-1-29	1535	59.48	50	Yes	Yes	Pier	Two or More Stories	Residential	627.7	612.76	622.99	628.21	631.14	645.32
B3	4046 RTE 28	36.11-1-30.100	2856	67.09	50	No	Yes	Slab	One Story	Retail-Clothing	625	613.37	623.31	628.38	631.30	645.27
B4	4072 RTE 28	36.11-1-27.111	4789	120.18	50	No	Yes	Pier	One Story	Non-Fast Food	626	613.76	623.82	628.76	631.68	645.29
B5	4072 RTE 28	36.11-1-27.111	2775	56.08	50	Yes	Yes	Slab	Two or More Stories	Residential	626	613.74	623.94	628.91	631.83	645.34
B6	4076 RTE 28	36.11-1-17	2048	107.38	50	Yes	Yes	Pier	Two or More Stories	Residential	628.5	613.61	624.37	629.45	632.37	645.52
B7	4080 RTE 28	36.11-1-16.200	6496	51.6	50	No	Yes	Pier	One Story	Medical Office	626.4	613.79	624.80	629.64	632.48	645.55
B8	4084-4092 RTE 28	36.11-1-16.100	1798	92.49	50	No	Yes	Pier	One Story	Retail-Clothing	627.7	614.02	625.09	629.66	632.38	645.54
B9	4084-4092 RTE 28	36.11-1-16.100	1800	92.38	50	No	Yes	Slab	One Story	Retail-Furniture	626.9	614.12	625.18	629.57	632.21	645.52
B12	4073 RTE 28	36.11-1-32.100	2280	37.28	50	No	Yes	Slab	One Story	Industrial Light	625.9	613.85	624.90	629.68	632.51	645.56
B13	4091 RTE 28	36.11-1-33	4000	50.9	50	No	Yes	Slab	One Story	Hotel	625.9	614.13	625.21	629.55	632.17	645.51
B14	15 Ronsen Rd/RTE 28	36.11-1-35	16640	32.79	50	No	Yes	Pier	One Story	Industrial Light	629.5	614.25	625.33	629.45	631.95	645.47
B15	21 Ronsen Rd	36.11-1-36.100	6450	27.15	50	No	Yes	Slab	One Story	Industrial Light	628.7	614.60	626.02	630.04	632.35	644.41
B16	4099-4103 RTE 28	36.11-1-34	18840	63.22	50	No	Yes	Slab	One Story	Grocery	627.3	614.21	625.29	629.48	632.02	645.49
B17	4115-4125 RTE 28	36.11-1-11	36700	23.97	50	No	Yes	Pile	Two or More Stories	Retail-Furniture	627.8	614.68	626.16	630.15	632.44	644.20

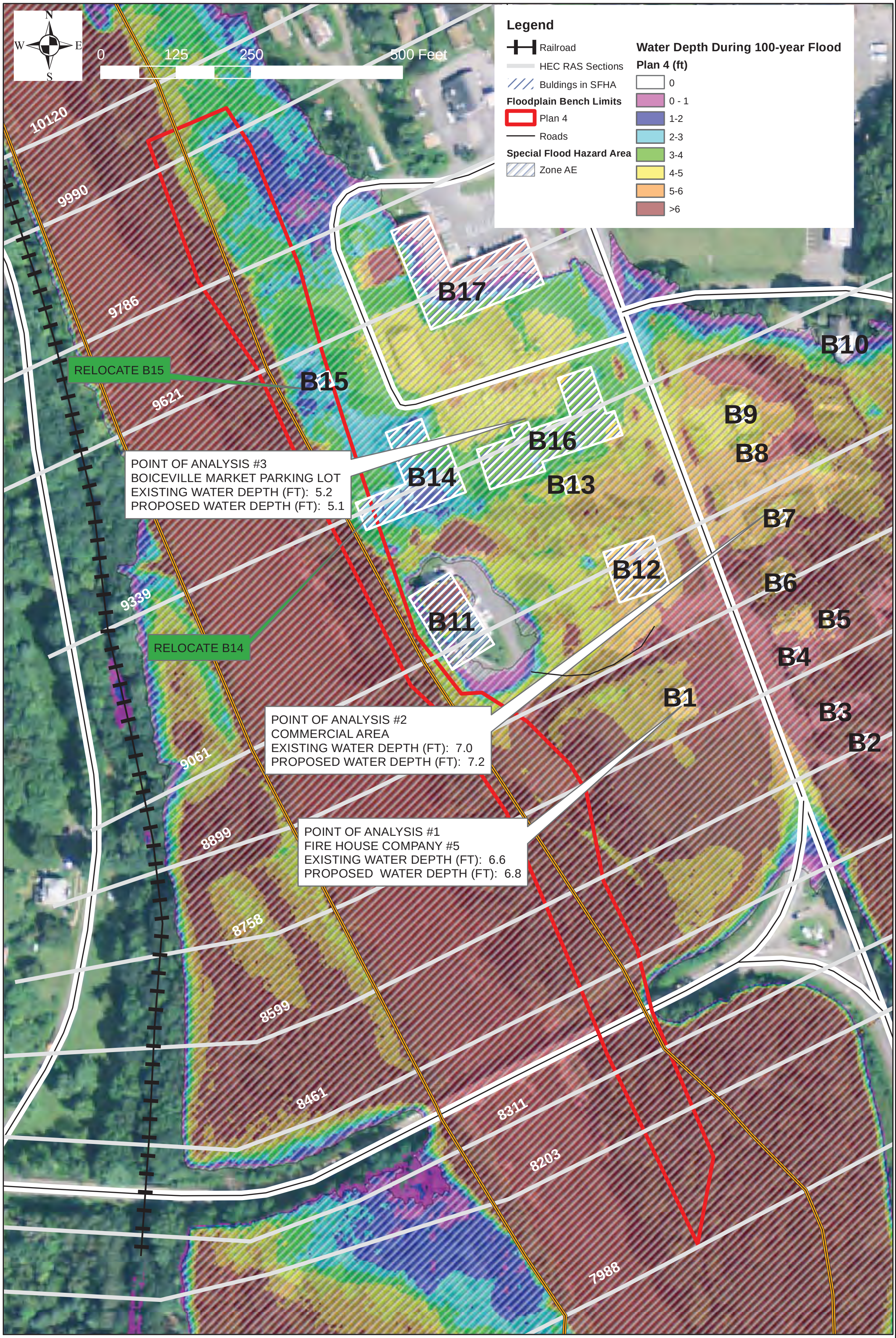


FIGURE NUMBER: 9
PROJECT NO:
CHECKED BY:
DRAWN BY: GDF
DESIGNED BY:
DATE: 9/1/16

Flood Mitigation Strategy: Plan 4
Water Depths at 100-Year Flood

Town of Olive
Location Flood Analysis

Olive, Ulster County, NY

BACKGROUND PHOTO: 2013 NAIP

WELCOME TO TOWN OF OLIVE Est. 1823

Woidt Engineering

TITLE	Opinion of Estimated Construction Cost for Olive LFA Plan 4				
DESIGN LEVEL	Conceptual Design				
DATE	12/29/2016				
BY:	GDF				
CHECKED					
BID ITEM #	ITEM	Unit	Unit Cost	Quantity	Total
1	Mobilization, Demobilization and Restore Site to Pre-Construction Conditions	LS	$206,743	1	$207,000
2	Excavation Bench (Average Depth, width, length 2.5',90.0', 2,000')	CY	$20	16,700	$334,000
3	Haul Excavated Material Off Site	CY	$35	16,700	$585,000
4	Seed and Mulch Site	Acre	$3,250	5	$15,000
5	Procure and Install Silt Fence	LF	$3	2,500	$8,000
6	Procure and Install Biodegradable Erosion Control Fabric	SY	$7.5	1,333	$10,000
7	Demolition of Buildings (10% of B14 and B15 Relocation Value)	LS	$87,410	1	$87,410
8	Relocating Buildings (2015 Building Values for B14 and B15)	LS	$874,100	1	$874,100
9	Extend Sewer From Parcel 36.4-1-39.100 to 36.4-1-45	LF	$250	620	$155,000
				Sub Total	$2,275,600
				Contigency (15%) (Items 1-6)	$174,000
				Engineering, Surveying and Design (12%) (Items 1-6)	$139,080
				Grand Total	$2,449,600

items have been rounded up

Other Benefits

Other Benefits Before Mitigation

No Data

Other Benefits After Mitigation

No Data

Summary Of Benefits

Expected Annual Damages Before Mitigation		Expected Annual Damages After Mitigation		Expected Avoided Damages After Mitigation (Benefits)	
Annual:	$8,479	Annual:	$7,275	Annual:	$1,204
Present Value:	$119,917	Present Value:	$102,888	Present Value:	$17,029

Mitigation Benefits:	$17,029	Mitigation Costs:	$1
Benefits Minus Costs:	$17,028	Benefit-Cost Ratio:	17,029.00

Total Benefits: **$368,234** Total Costs: **$2,449,614** BCR: **0.15**

Project Number: Disaster #: Program: Agency:

State: Point of Contact: Analyst:

Cost Estimate

Project Useful Life (years):	68	Construction Type:	
Mitigation Project Cost:	$0	Detailed Scope of Work:	No
Annual Project Maintenance Cost:	$0	Detailed Estimate for Entire Project:	No
Final Mitigation Project Cost:	$1	Years of Maintenance:	
Cost Basis Year:		Present Worth of Annual Maintenance Costs:	
Construction Start Year:		Estimate Reflects Current Prices:	No
Construction End Year:		Project Escalation:	

No Rows

Title: Proposed Water Surface Elevations Plan #4

Date: 2/10/17

By: GDF

Structure No.	Property SBL	Return Interval 10 Elevation Before Mitigation	Return Interval 10 Elevation After Mitigation	Return Interval 50 Elevation Before Mitigation	Return Interval 50 Elevation After Mitigation	Return Interval 100 Elevation Before Mitigation	Return Interval 100 Elevation After Mitigation	Return Interval 500 Elevation Before Mitigation	Return Interval 500 Elevation After Mitigation
B1	36.11-1-31	623.92	623.85	628.89	628.51	631.81	631.64	645.33	642.97
B2	36.11-1-29	622.99	623.33	628.21	628.10	631.14	631.35	645.32	644.02
B3	36.11-1-30.100	623.31	623.53	628.38	628.26	631.30	631.47	645.27	643.52
B4	36.11-1-27.111	623.82	623.80	628.76	628.48	631.68	631.63	645.29	642.98
B5	36.11-1-27.111	623.94	623.86	628.91	628.51	631.83	631.65	645.34	642.97
B6	36.11-1-17	624.37	624.05	629.45	628.64	632.37	631.72	645.52	642.93
B7	36.11-1-16.200	624.80	624.06	629.64	628.20	632.48	631.26	645.55	644.39
B8	36.11-1-16.100	625.09	624.32	629.66	628.27	632.38	631.17	645.54	645.08
B9	36.11-1-16.100	625.18	624.58	629.57	628.56	632.21	631.32	645.52	645.06
B12	36.11-1-32.100	624.90	624.06	629.68	628.11	632.51	631.16	645.56	644.72
B13	36.11-1-33	625.21	624.63	629.55	628.63	632.17	631.35	645.51	645.06
B14	36.11-1-35	625.33	624.98	629.45	629.02	631.95	631.54	645.47	645.03
B15	36.11-1-36.100	626.02	625.74	630.04	629.83	632.35	632.05	644.41	644.12
B16	36.11-1-34	625.29	624.87	629.48	628.89	632.02	631.48	645.49	645.04
B17	36.11-1-11	626.16	625.89	630.15	629.99	632.44	632.16	644.20	643.94

TITLE	Opinion of Estimated Construction Cost for Olive LFA Plan 5				
DESIGN LEVEL	Conceptual Design				
DATE	2/10/2017				
BY:	GDF				
CHECKED					
BID ITEM #	ITEM	Unit	Unit Cost	Quantity	Total
1	Mobilization, Demobilization and Restore Site to Pre-Construction Conditions	LS	$302,792	1	$303,000
2	Excavation Bench (Average Depth, width and length:2.5',90.0', 2,000)	CY	$20	16,700	$334,000
3	Haul Excavated Material Off Site	CY	$35	16,700	$585,000
4	Seed and Mulch Site	Acre	$3,250	5	$17,000
5	Procure and Install Silt Fence	LF	$3	3,850	$12,000
6	Procure and Install Biodegradable Erosion Control Fabric	SY	$7.5	3,133	$23,500
7	Procure and Install 8' high earthen berm	LF	$215	775	$167,000
8	Procure and Install 10' high earthen berm	LF	$260	575	$150,000
9	Procure and Install Flap Gate at 28 Box Culvert	LS	$110,000	1	$110,000
10	Procure and Install 3' high earthern berm near tributary and wetland	LF	$105	400	$42,000
11	Procure and Install two Pumping stations on each side of SR28 (3.5 acre drainage, minor grading)	LS	$375,000	1	$375,000
12	Demolition of Buildings (10% of B1, B14 and B15 Relocation Value)	LS	$110,410	1	$110,410
13	Existing Property Purchase (2015 Values for B1, B14 and B15)	LS	$1,104,100	1	$1,104,100
				Sub Total	$3,333,100
				Contigency (15%) (Items 1-11)	$318,000
				Engineering, Surveying and Design (12%) (Items 1-11)	$254,220
				Grand Total	$3,905,320

items have been rounded up

Total Benefits:	**$2,475,438**	Total Costs:	**$3,905,314**	BCR:	**0.63**
Project Number:	Disaster #:	Program:	Agency:		
State:	Point of Contact:		Analyst:		

Other Benefits

Other Benefits Before Mitigation

No Data

Other Benefits After Mitigation

No Data

Summary Of Benefits

Expected Annual Damages Before Mitigation		Expected Annual Damages After Mitigation		Expected Avoided Damages After Mitigation (Benefits)	
Annual:	$8,479	Annual:	$1,834	Annual:	$6,645
Present Value:	$119,917	Present Value:	$25,943	Present Value:	$93,974

Mitigation Benefits:	$93,974	Mitigation Costs:	$1
Benefits Minus Costs:	$93,973	Benefit-Cost Ratio:	93,974.00

Total Benefits: **$2,475,438** Total Costs: **$3,905,314** BCR: **0.63**

Project Number: Disaster #: Program: Agency:

State: Point of Contact: Analyst:

Cost Estimate

Project Useful Life (years):	68	Construction Type:	
Mitigation Project Cost:	$0	Detailed Scope of Work:	No
Annual Project Maintenance Cost:	$0	Detailed Estimate for Entire Project:	No
Final Mitigation Project Cost:	$1	Years of Maintenance:	
Cost Basis Year:		Present Worth of Annual Maintenance Costs:	
Construction Start Year:		Estimate Reflects Current Prices:	No
Construction End Year:		Project Escalation:	

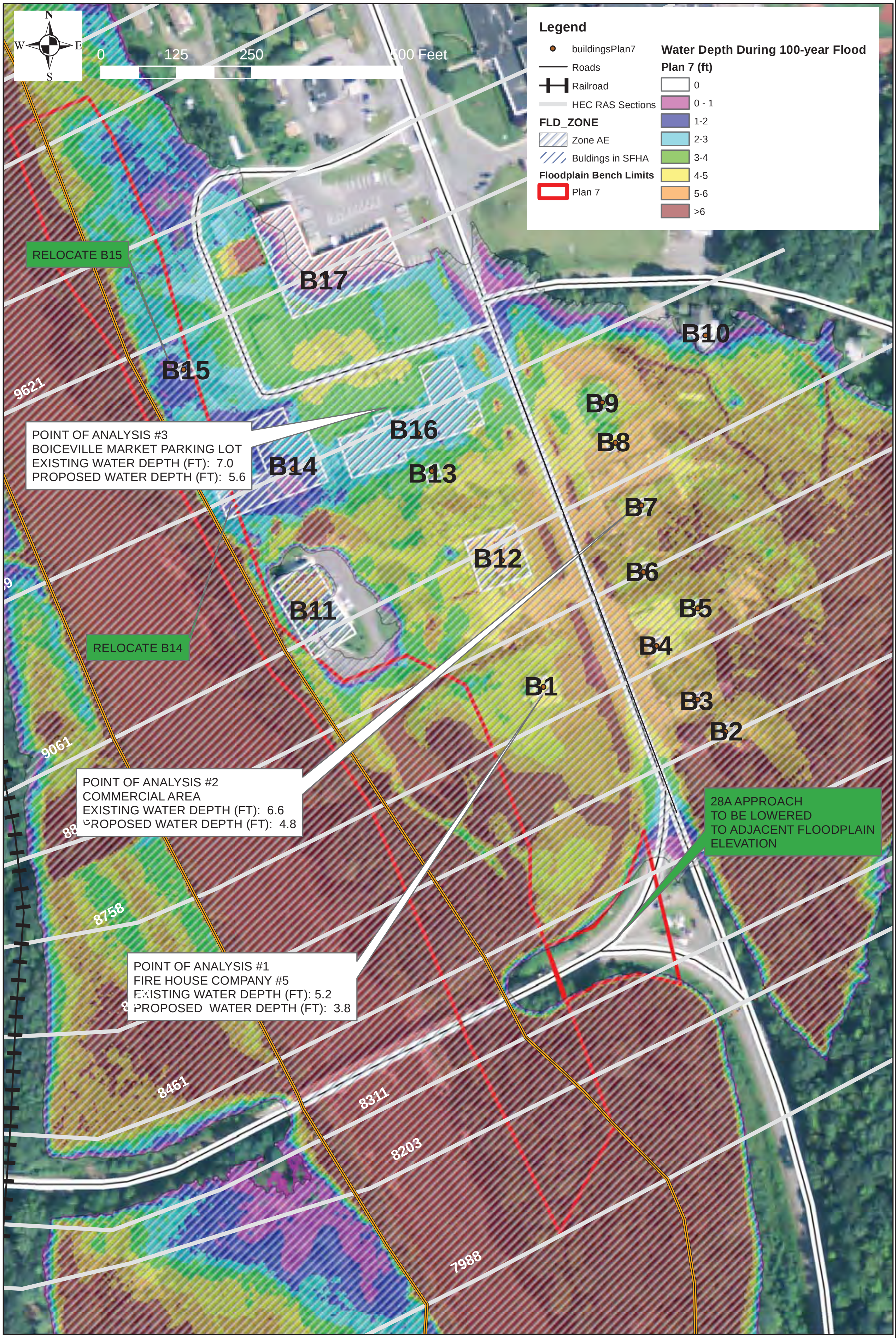
No Rows

Title: Proposed Water Surface Elevations Plan #5

Date: 2/10/17

By: GDF

Structure No.	Property SBL	Return Interval 10 Elevation Before Mitigation	Return Interval 10 Elevation After Mitigation	Return Interval 50 Elevation Before Mitigation	Return Interval 50 Elevation After Mitigation	Return Interval 100 Elevation Before Mitigation	Return Interval 100 Elevation After Mitigation	Return Interval 500 Elevation Before Mitigation	Return Interval 500 Elevation After Mitigation
B1	36.11-1-31	623.92	623.92	628.89	628.89	631.81	631.81	645.33	645.33
B2	36.11-1-29	622.99	622.99	628.21	628.21	631.14	631.14	645.32	645.32
B3	36.11-1-30.100	623.31	623.31	628.38	628.38	631.30	631.30	645.27	645.27
B4	36.11-1-27.111	623.82	623.82	628.76	628.76	631.68	631.68	645.29	645.29
B5	36.11-1-27.111	623.94	623.94	628.91	628.91	631.83	631.83	645.34	645.34
B6	36.11-1-17	624.37	624.37	629.45	629.45	632.37	632.37	645.52	645.52
B7	36.11-1-16.200	624.80	624.80	629.64	629.64	632.48	632.48	645.55	645.55
B8	36.11-1-16.100	625.09	625.09	629.66	629.66	632.38	632.38	645.54	645.54
B9	36.11-1-16.100	625.18	625.18	629.57	629.57	632.21	632.21	645.52	645.52
B12	36.11-1-32.100	624.90	624.90	629.68	629.68	632.51	632.51	645.56	645.56
B13	36.11-1-33	625.21	625.21	629.55	629.55	632.17	632.17	645.51	645.51
B14	36.11-1-35	625.33	625.33	629.45	629.45	631.95	631.95	645.47	645.47
B15	36.11-1-36.100	626.02	626.02	630.04	630.04	632.35	632.35	644.41	644.41
B16	36.11-1-34	625.29	625.29	629.48	629.48	632.02	632.02	645.49	645.49
B17	36.11-1-11	626.16	626.16	630.15	630.15	632.44	632.44	644.20	644.20



BACKGROUND PHOTO: 2013 NAIP

Flood Mitigation Strategy: Plan 7
Water Depths at 100-Year Flood

Town of Olive
Location Flood Analysis

Olive, Ulster County, NY

DATE: 12/26/16
DESIGNED BY:
DRAWN BY: GDF
CHECKED BY: ::
PROJECT NO:
FIGURE NUMBER: 18

TITLE	Opinion of Estimated Construction Cost for Olive LFA Plan 7				
DESIGN LEVEL	Conceptual Design				
DATE	12/29/2016				
BY:	GDF				
CHECKED					
BID ITEM #	ITEM	Unit	Unit Cost	Quantity	Total
1	Mobilization, Demobilization and Restore Site to Pre-Construction Conditions	LS	$206,743	1	$207,000
2	Excavation Bench (Average Depth and width (2.5',90.0') and Length 2,000')	CY	$20	16,700	$334,000
3	Haul Excavated Material Off Site	CY	$35	16,700	$585,000
4	Seed and Mulch Site	Acre	$3,250	5	$15,000
5	Procure and Install Silt Fence	LF	$3	2,500	$8,000
6	Procure and Install Biodegradable Erosion Control Fabric	SY	$7.5	1,333	$10,000
7	Demolition of Buildings (10% of B14 and B15 Relocation Value)	LS	$87,410	1	$87,410
8	Relocating Buildings (2015 Building Values for B14 and B15)	LS	$874,100	1	$874,100
9	Extend Sewer From Parcel 36.4-1-39.100 to 36.4-1-45	LF	$250	620	$155,000
				Sub Total	$2,275,600
				Contigency (15%) (Items 1-6)	$174,000
				Engineering, Surveying and Design (12%) (Items 1-6)	$139,080
				Grand Total	$2,588,680

items have been rounded up

Note: Assume that relocation of 28A bridge and removing approach costs would be part of the 28A bridge program budget and not part of a flood mitigation strategy

Total Benefits: **$964,667**	Total Costs: **$2,588,694**		BCR: **0.37**
Project Number:	Disaster #:	Program:	Agency:
State:	Point of Contact:		Analyst:

Other Benefits

Other Benefits Before Mitigation

No Data

Other Benefits After Mitigation

No Data

Summary Of Benefits

Expected Annual Damages Before Mitigation	Expected Annual Damages After Mitigation	Expected Avoided Damages After Mitigation (Benefits)
Annual: $8,479	Annual: $6,137	Annual: $2,342
Present Value: $119,917	Present Value: $86,789	Present Value: $33,128

Mitigation Benefits: $33,128

Benefits Minus Costs: $33,127

Mitigation Costs: $1

Benefit-Cost Ratio: 33,128.00

Total Benefits: **$964,667** Total Costs: **$2,588,694** BCR: **0.37**

Project Number: Disaster #: Program: Agency:

State: Point of Contact: Analyst:

Cost Estimate

Project Useful Life (years):	68	Construction Type:	
Mitigation Project Cost:	$0	Detailed Scope of Work:	No
Annual Project Maintenance Cost:	$0	Detailed Estimate for Entire Project:	No
Final Mitigation Project Cost:	$1	Years of Maintenance:	
Cost Basis Year:		Present Worth of Annual Maintenance Costs:	
Construction Start Year:		Estimate Reflects Current Prices:	No
Construction End Year:		Project Escalation:	

No Rows

Title: Proposed Water Surface Elevations Plan #7

Date: 2/10/17

By: GDF

Structure No.	Property SBL	Return Interval 10 Elevation Before Mitigation	Return Interval 10 Elevation After Mitigation	Return Interval 50 Elevation Before Mitigation	Return Interval 50 Elevation After Mitigation	Return Interval 100 Elevation Before Mitigation	Return Interval 100 Elevation After Mitigation	Return Interval 500 Elevation Before Mitigation	Return Interval 500 Elevation After Mitigation
B1	36.11-1-31	623.92	623.49	628.89	627.64	631.81	630.35	645.33	638.44
B2	36.11-1-29	622.99	622.7	628.21	627.32	631.14	630.15	645.32	638.35
B3	36.11-1-30.100	623.31	622.99	628.38	627.41	631.30	630.19	645.27	638.49
B4	36.11-1-27.111	623.82	623.42	628.76	627.58	631.68	630.3	645.29	638.52
B5	36.11-1-27.111	623.94	623.49	628.91	627.64	631.83	630.35	645.34	638.43
B6	36.11-1-17	624.37	623.76	629.45	627.86	632.37	630.51	645.52	638.1
B7	36.11-1-16.200	624.80	624.41	629.64	628.53	632.48	630.73	645.55	638.11
B8	36.11-1-16.100	625.09	624.7	629.66	628.78	632.38	630.77	645.54	638.2
B9	36.11-1-16.100	625.18	624.68	629.57	628.7	632.21	630.71	645.52	638.29
B12	36.11-1-32.100	624.90	624.55	629.68	628.68	632.51	630.78	645.56	638.11
B13	36.11-1-33	625.21	624.67	629.55	628.68	632.17	630.69	645.51	638.31
B14	36.11-1-35	625.33	624.65	629.45	628.59	631.95	630.61	645.47	638.42
B15	36.11-1-36.100	626.02	626.14	630.04	630.2	632.35	631.42	644.41	637.44
B16	36.11-1-34	625.29	624.65	629.48	628.61	632.02	630.63	645.49	638.39
B17	36.11-1-11	626.16	626.43	630.15	630.51	632.44	631.58	644.20	637.24

TITLE	Opinion of Estimated Construction Cost for Olive LFA Plan 9				
DESIGN LEVEL	Conceptual Design				
DATE	2/10/2017				
BY:	GDF				
CHECKED					
BID ITEM #	ITEM	Unit	Unit Cost	Quantity	Total
1	Mobilization, Demobilization and Restore Site to Pre-Construction Conditions	LS	$205,837	1	$206,000
2	Seed and Mulch Site	Acre	$3,250	2.6	$8,000
3	Procure and Install Silt Fence	LF	$3	1,500	$5,000
4	Procure and Install Biodegradable Erosion Control Fabric	SY	$7.5	2,000	$15,000
5	Procure and Install 6' high earthen levee	LF	$215	800	$172,000
6	Procure and Install 9' high earthen levee	LF	$240	700	$168,000
7	Procure and Install Flap Gate at 28 Box Culvert and Reconfigure Stormwater Ditch with flapgate	LS	$75,000	1	$75,000
8	Procure and Install 3' high earthern berm near tributary and wetland	LF	$65	400	$26,000
9	Procure and Install two Pumping stations on each side of SR28, (10 acre drainage, minor grading)	LS	$375,000	1	$375,000
10	Demolition of Buildings (10% of B1, B14 and B15 Relocation Value)	LS	$110,410	1	$110,410
11	Existing Property Purchase (2015 Values for B1, B14 and B15)	LS	$1,104,100	1	$1,104,100
				Sub Total	$2,264,600
	items have been rounded up			Contigency (15%) (Items 1-9)	$158,000
				Engineering, Surveying and Design (12%) (Items 1-9)	$126,000
				Grand Total	$2,548,600

Total Benefits: **$2,475,438** Total Costs: **$2,548,614** BCR: **0.97**

Project Number: Disaster #: Program: Agency:

State: Point of Contact: Analyst:

Other Benefits

Other Benefits Before Mitigation

No Data

Other Benefits After Mitigation

No Data

Summary Of Benefits

Expected Annual Damages Before Mitigation		Expected Annual Damages After Mitigation		Expected Avoided Damages After Mitigation (Benefits)	
Annual:	$8,479	Annual:	$1,834	Annual:	$6,645
Present Value:	$119,917	Present Value:	$25,943	Present Value:	$93,974

Mitigation Benefits: $93,974

Benefits Minus Costs: $93,973

Mitigation Costs: $1

Benefit-Cost Ratio: 93,974.00

Total Benefits:	**$2,475,438**	Total Costs:	**$2,548,614**
BCR:	**0.97**		
Project Number:		Disaster #:	
Program:		Agency:	
State:		Point of Contact:	
Analyst:			

Cost Estimate

Project Useful Life (years):	68	Construction Type:	
Mitigation Project Cost:	$0	Detailed Scope of Work:	No
Annual Project Maintenance Cost:	$0	Detailed Estimate for Entire Project:	No
Final Mitigation Project Cost:	$1	Years of Maintenance:	
Cost Basis Year:		Present Worth of Annual Maintenance Costs:	
Construction Start Year:		Estimate Reflects Current Prices:	No
Construction End Year:		Project Escalation:	

No Rows

Title: Proposed Water Surface Elevations Plan #9

Date: 2/10/17

By: GDF

Structure No.	Property SBL	Return Interval 10 Elevation Before Mitigation	Return Interval 10 Elevation After Mitigation	Return Interval 50 Elevation Before Mitigation	Return Interval 50 Elevation After Mitigation	Return Interval 100 Elevation Before Mitigation	Return Interval 100 Elevation After Mitigation	Return Interval 500 Elevation Before Mitigation	Return Interval 500 Elevation After Mitigation
B1	36.11-1-31	623.92	623.92	628.89	628.89	631.81	631.81	645.33	645.33
B2	36.11-1-29	622.99	622.99	628.21	628.21	631.14	631.14	645.32	645.32
B3	36.11-1-30.100	623.31	623.31	628.38	628.38	631.30	631.30	645.27	645.27
B4	36.11-1-27.111	623.82	623.82	628.76	628.76	631.68	631.68	645.29	645.29
B5	36.11-1-27.111	623.94	623.94	628.91	628.91	631.83	631.83	645.34	645.34
B6	36.11-1-17	624.37	624.37	629.45	629.45	632.37	632.37	645.52	645.52
B7	36.11-1-16.200	624.80	624.80	629.64	629.64	632.48	632.48	645.55	645.55
B8	36.11-1-16.100	625.09	625.09	629.66	629.66	632.38	632.38	645.54	645.54
B9	36.11-1-16.100	625.18	625.18	629.57	629.57	632.21	632.21	645.52	645.52
B12	36.11-1-32.100	624.90	624.90	629.68	629.68	632.51	632.51	645.56	645.56
B13	36.11-1-33	625.21	625.21	629.55	629.55	632.17	632.17	645.51	645.51
B14	36.11-1-35	625.33	625.33	629.45	629.45	631.95	631.95	645.47	645.47
B15	36.11-1-36.100	626.02	626.02	630.04	630.04	632.35	632.35	644.41	644.41
B16	36.11-1-34	625.29	625.29	629.48	629.48	632.02	632.02	645.49	645.49
B17	36.11-1-11	626.16	626.16	630.15	630.15	632.44	632.44	644.20	644.20

TITLE	Opinion of Estimated Construction Cost for Olive LFA Plan 9A				
DESIGN LEVEL	Conceptual Design				
DATE	12/29/2016				
BY:	GDF				
CHECKED					
BID ITEM #	ITEM	Unit	Unit Cost	Quantity	Total
1	Mobilization, Demobilization and Restore Site to Pre-Construction Conditions	LS	$83,550	1	$84,000
2	Seed and Mulch Site	Acre	$3,250	0	$0
3	Procure and Install Silt Fence	LF	$3	1,500	$5,000
4	Procure and Install Biodegradable Erosion Control Fabric	SY	$7.5	2,000	$15,000
5	Procure and Install 6' high earthen levee	LF	$215	800	$172,000
6	Procure and Install 9' high earthen levee	LF	$240	700	$168,000
7	Procure and Install Flap Gate at 28 Box Culvert and Reconfigure Stormwater Ditch with flapgate	LS	$75,000	1	$75,000
8	Procure and Install 3' high earthern berm near tributary and wetland	LF	$65	400	$26,000
9	Procure and Install two Pumping stations on each side of SR28, (10 acre drainage, minor grading)	LS	$375,000	1	$375,000
				Sub Total	$920,000
				Contigency (15%) (Items 1-9)	$138,000
				Engineering, Surveying and Design (12%) (Items 1-9)	$111,000
				Grand Total	$1,169,000

items have been rounded up

Total Benefits: **$2,209,230** Total Costs: **$1,169,011** BCR: **1.89**

Project Number: Disaster #: Program: Agency:

State: Point of Contact: Analyst:

Other Benefits

Other Benefits Before Mitigation

No Data

Other Benefits After Mitigation

No Data

Summary Of Benefits

Expected Annual Damages Before Mitigation		Expected Annual Damages After Mitigation		Expected Avoided Damages After Mitigation (Benefits)	
Annual:	$8,479	Annual:	$1,834	Annual:	$6,645
Present Value:	$119,917	Present Value:	$25,943	Present Value:	$93,974

Mitigation Benefits: $93,974

Benefits Minus Costs: $93,973

Mitigation Costs: $1

Benefit-Cost Ratio: 93,974.00

Total Benefits: **$2,209,230** Total Costs: **$1,169,011** BCR: **1.89**

Project Number: Disaster #: Program: Agency:

State: Point of Contact: Analyst:

Cost Estimate

Project Useful Life (years):	68	Construction Type:	
Mitigation Project Cost:	$0	Detailed Scope of Work:	No
Annual Project Maintenance Cost:	$0	Detailed Estimate for Entire Project:	No
Final Mitigation Project Cost:	$1	Years of Maintenance:	
Cost Basis Year:		Present Worth of Annual Maintenance Costs:	
Construction Start Year:		Estimate Reflects Current Prices:	No
Construction End Year:		Project Escalation:	

No Rows

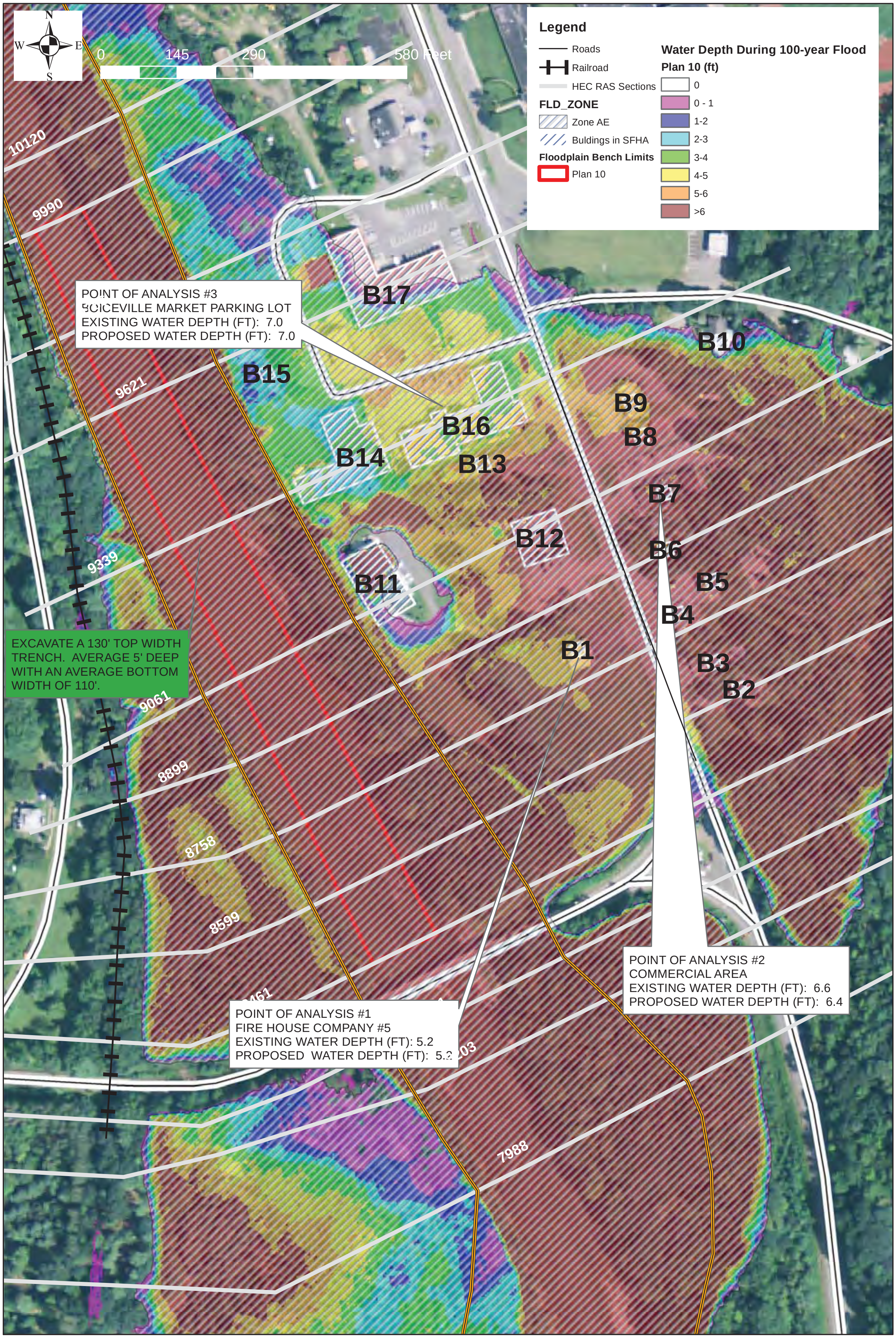


FIGURE NUMBER: 30
PROJECT NO:
CHECKED BY:
DRAWN BY: GDF
DESIGNED BY:
DATE: 12/26/16

Flood Mitigation Strategy: Plan 10
Water Depths at 100-Year Flood

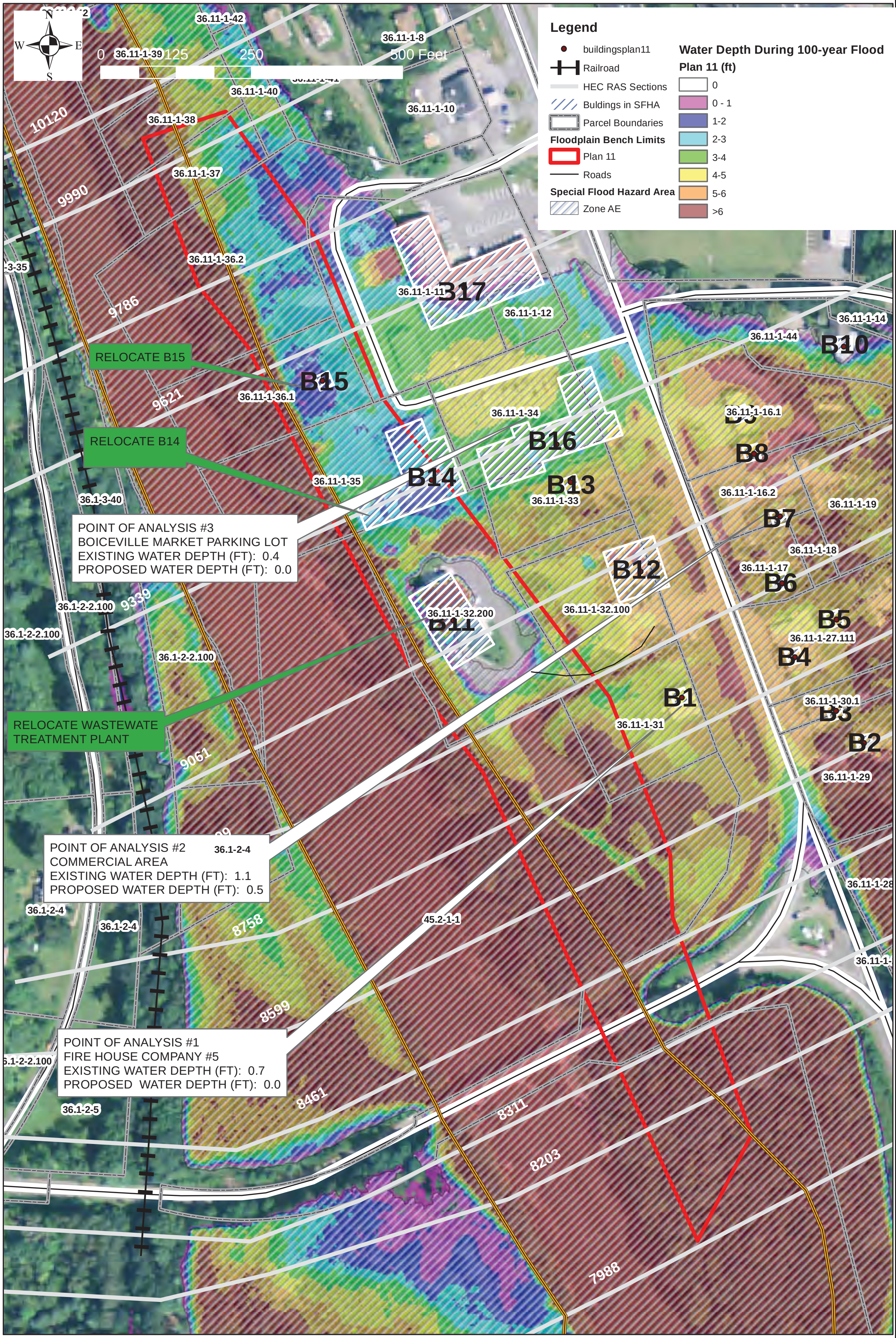
Town of Olive
Location Flood Analysis

Olive, Ulster County, NY

BACKGROUND PHOTO: 2013 NAIP

WELCOME TO TOWN OF OLIVE Est. 1823

Woidt Engineering



BACKGROUND PHOTO: 2013 NAIP

Flood Mitigation Strategy: Plan 11
Water Depths at 100-Year Flood

Town of Olive
Location Flood Analysis

Olive, Ulster County, NY

DATE:	9/1/16
DESIGNED BY:	
DRAWN BY:	GDF
CHECKED BY:	:
PROJECT NO:	
FIGURE NUMBER:	31

WELCOME TO TOWN OF OLIVE Est. 1823

Woidt Engineering

Total Benefits:	**$3,313,936**	Total Costs:	**$5,341,600**	BCR:	**0.62**
Project Number:	Disaster #:	Program:	Agency:		
State:	Point of Contact:		Analyst:		

Environmental Benefits

Land Use

Size of Parcel Being Mitigated(sf): in (Acr) 0.00000000

What will the acquired land be used for after the project is finished? 0

Total Land Use Benefits:

Other Benefits

Other Benefits Before Mitigation

No Data

Other Benefits After Mitigation

No Data

Total Benefits: **$3,313,936** Total Costs: **$5,341,600** BCR: **0.62**

Project Number: Disaster #: Program: Agency:

State: Point of Contact: Analyst:

Summary Of Benefits

Expected Annual Damages Before Mitigation	Expected Annual Damages After Mitigation	Expected Avoided Damages After Mitigation (Benefits)
Annual: $8,479	Annual: $0	Annual: $8,479
Present Value: $119,917	Present Value: $0	Present Value: $119,917

Mitigation Benefits: $119,917

Benefits Minus Costs: ($75,583)

Mitigation Costs: $195,500

Benefit-Cost Ratio: 0.61

Cost Estimate

Project Useful Life (years):	68	Construction Type:	
Mitigation Project Cost:	$0	Detailed Scope of Work:	No
Annual Project Maintenance Cost:	$0	Detailed Estimate for Entire Project:	No
Final Mitigation Project Cost:	$195,500	Years of Maintenance:	
Cost Basis Year:		Present Worth of Annual Maintenance Costs:	
Construction Start Year:		Estimate Reflects Current Prices:	No
Construction End Year:		Project Escalation:	

No Rows

Title: Opinion of Probable Construction Cost for Property Protection (Plan #13)

Date: 9/12/2016

Building ID	Unit	Unit Price	B2		B4	Subtotal	B6	Subtotal	B7	Subtotal	B8	Subtotal	B14	Subtotal	B10	Subtotal	B17	Subtotal
			Quantity	Subtotal	Quantity	Subtotal	Quantity	Subtotal	Quantity	Subtotal	Quantity	Subtotal	Quantity	Subtotal	Quantity	Subtotal	Quantity	Subtotal
Lifting House	SF	$15	1,535	$23,025	4,789	$71,835	2,048	$30,720	6,496	$97,440	1,798	$26,970	16,640	$249,600	2,280	$34,200	36,700	$550,500
Building New Foundation	SF	$20	1,535	$30,700	4,789	$95,780	2,048	$40,960	6,496	$129,920	1,798	$35,960	16,640	$332,800	2,280	$45,600	36,700	$734,000
Permitting/Engineering Costs	SF	$5	1,535	$7,675	4,789	$23,945	2,048	$10,240	6,496	$32,480	1,798	$8,990	16,640	$83,200	2,280	$11,400	36,700	$183,500
Total				$61,400		$191,560		$81,920		$259,840		$71,920		$665,600		$91,200		$1,468,000

Total Benefits: **$1,496,115**	Total Costs: **$2,800,240**		BCR: **0.53**
Project Number:	Disaster #:	Program:	Agency:
State:	Point of Contact:		Analyst:

Other Benefits

Other Benefits Before Mitigation

No Data

Other Benefits After Mitigation

No Data

Summary Of Benefits

Expected Annual Damages Before Mitigation		Expected Annual Damages After Mitigation		Expected Avoided Damages After Mitigation (Benefits)	
Annual:	$6,086	Annual:	$1,227	Annual:	$4,859
Present Value:	$86,063	Present Value:	$17,355	Present Value:	$68,708

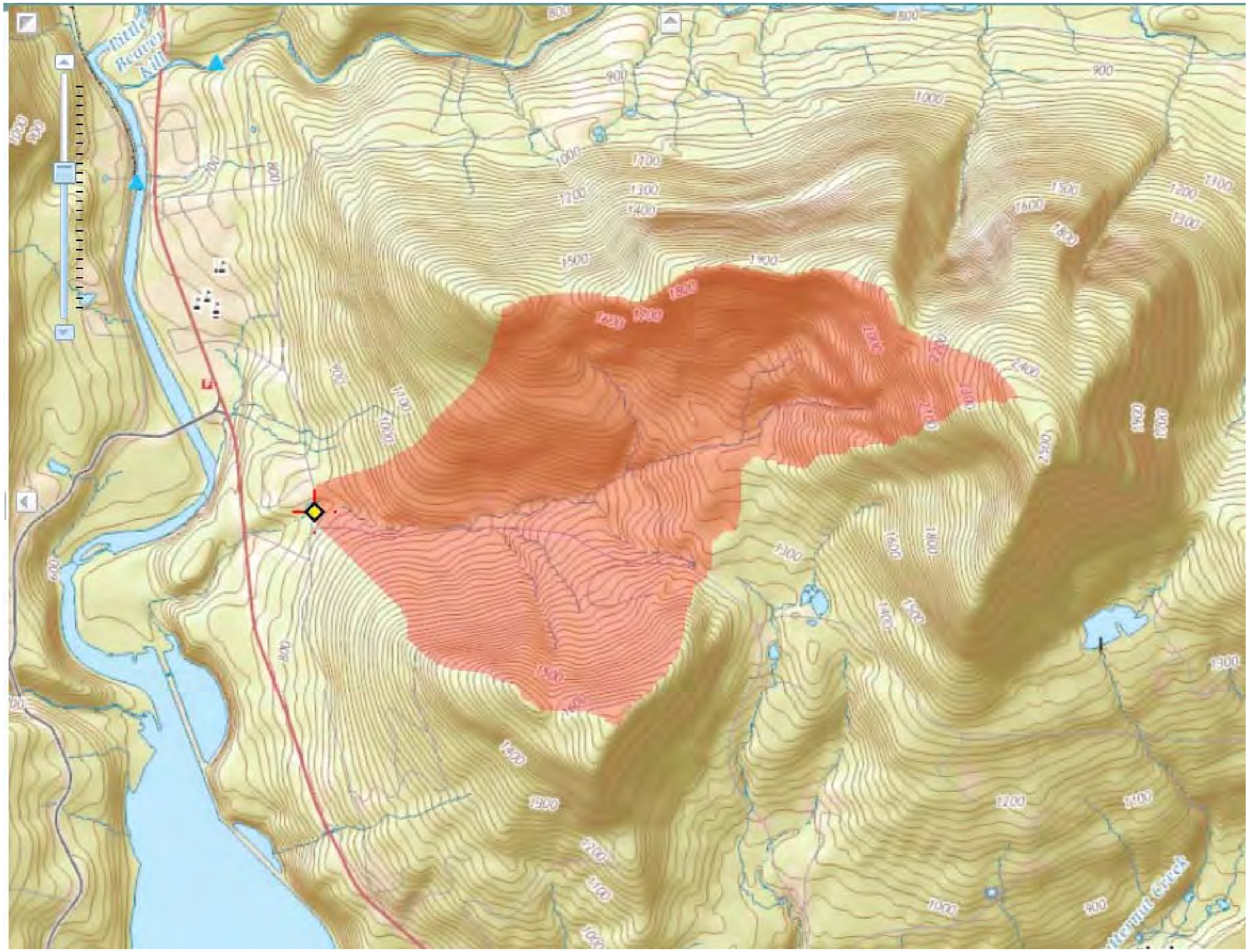
Mitigation Benefits:	$68,708	Mitigation Costs:	$71,920
Benefits Minus Costs:	($3,212)	Benefit-Cost Ratio:	0.96

Total Benefits:	**$1,496,115**	Total Costs:	**$2,800,240**	BCR:	**0.53**
Project Number:	Disaster #:	Program:		Agency:	
State:	Point of Contact:			Analyst:	

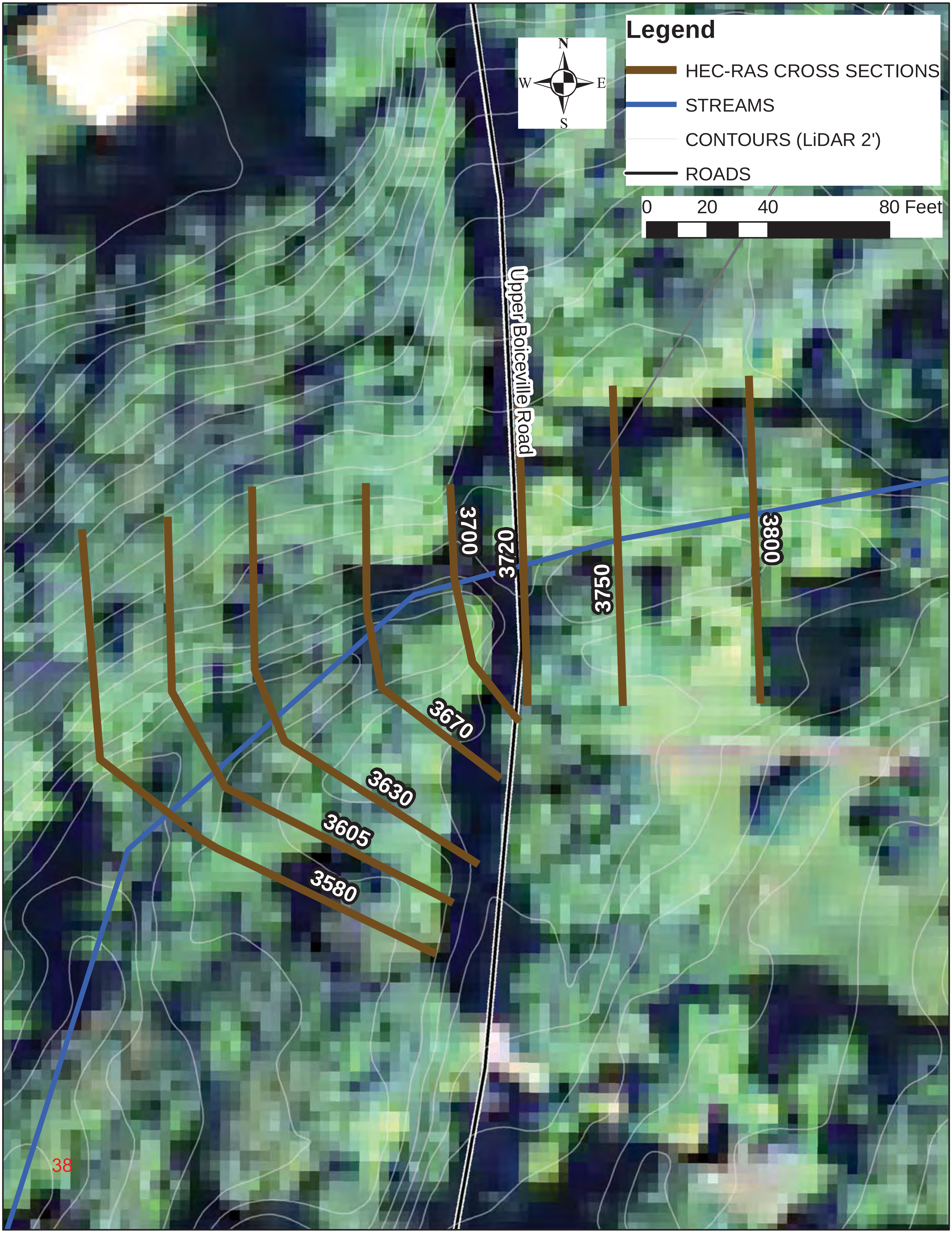
Cost Estimate

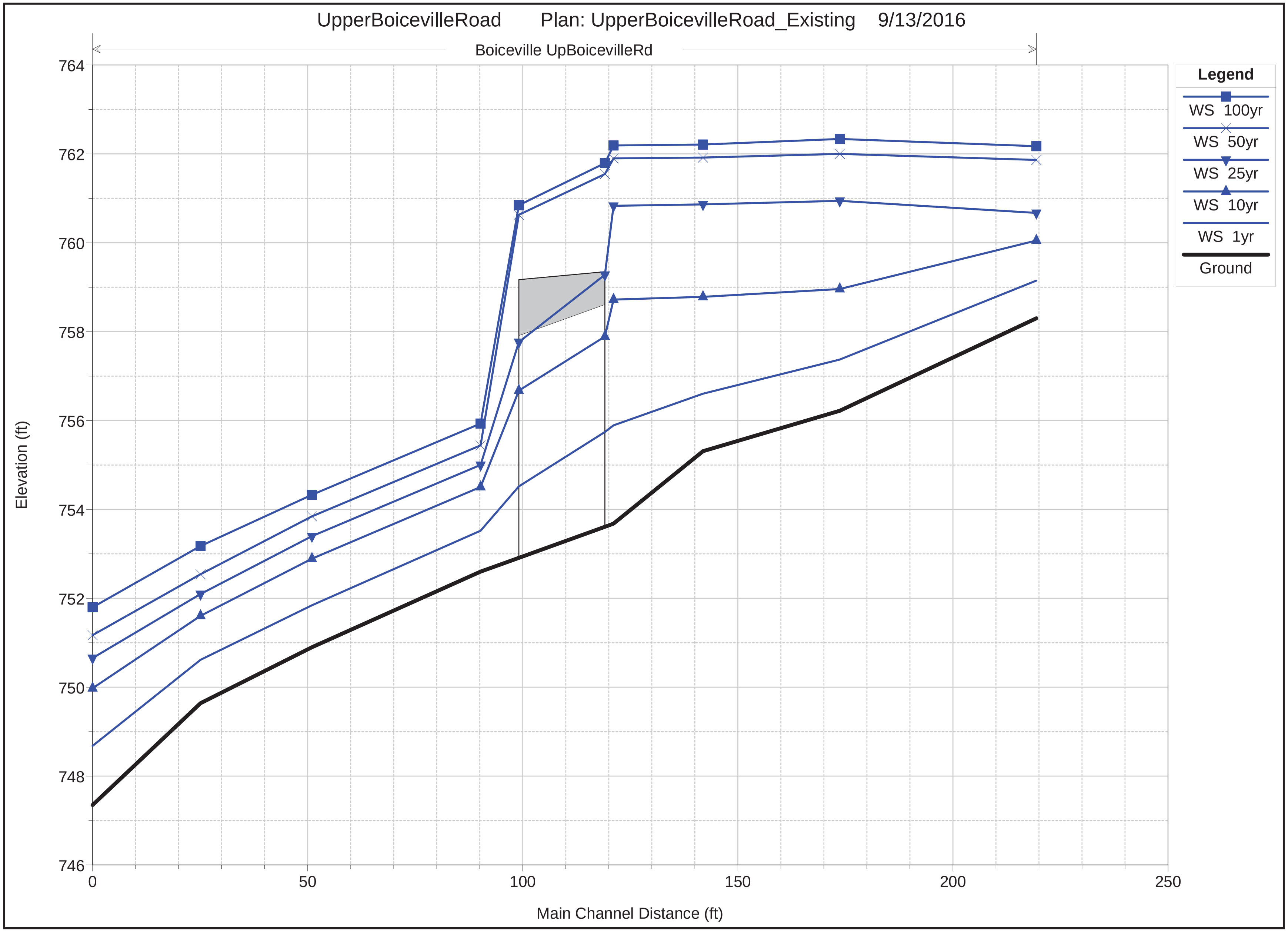
Project Useful Life (years):	68	Construction Type:	
Mitigation Project Cost:	$0	Detailed Scope of Work:	No
Annual Project Maintenance Cost:	$0	Detailed Estimate for Entire Project:	No
Final Mitigation Project Cost:	$71,920	Years of Maintenance:	
Cost Basis Year:		Present Worth of Annual Maintenance Costs:	
Construction Start Year:		Estimate Reflects Current Prices:	No
Construction End Year:		Project Escalation:	

No Rows



Upper Boiceville Road Drainage Map

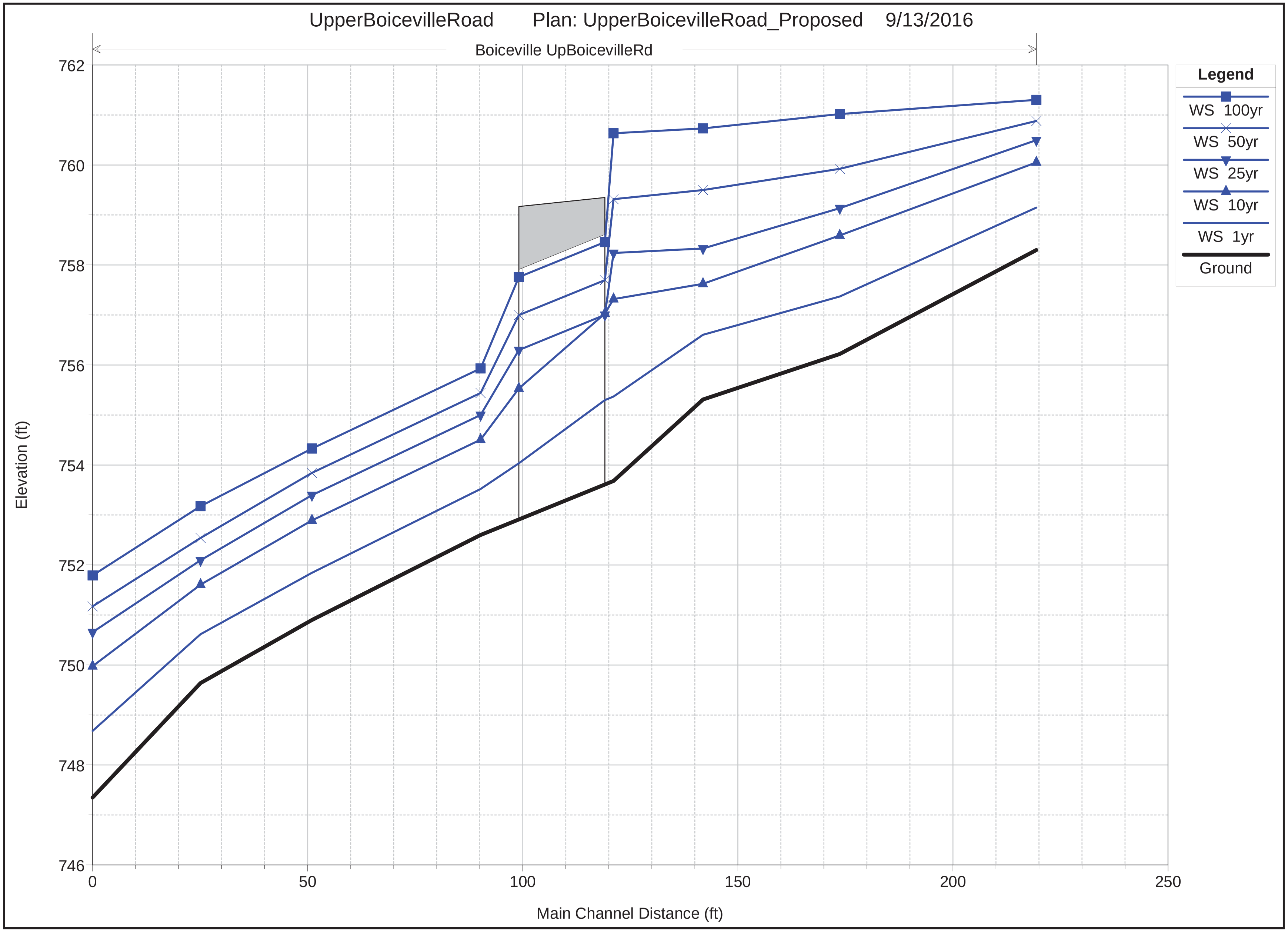

Legend
HEC-RAS CROSS SECTIONS
STREAMS
CONTOURS (LiDAR 2')
ROADS
0
20
40
80 Feet
N
S
E
W
Upper Boiceville Road
3580
3605
3630
3670
3700
3720
3750
3800



UpperBoicevilleRoad Plan: UpperBoicevilleRoad_Existing 9/13/2016
Boiceville UpBoicevilleRd
Legend
WS 100yr
WS 50yr
WS 25yr
WS 10yr
WS 1yr
Ground
Elevation (ft)
764
762
760
758
756
754
752
750
748
746
0
50
100
150
200
250
Main Channel Distance (ft)

Looking Downstream of Right Bank Upper Boiceville Road Abutment

Looking Downstream of Left Bank Upper Boiceville Road Abutment


UpperBoicevilleRoad Plan: UpperBoicevilleRoad_Proposed 9/13/2016
Boiceville UpBoicevilleRd
Elevation (ft)
762
760
758
756
754
752
750
748
746
Main Channel Distance (ft)
0
50
100
150
200
250
Legend
WS 100yr
WS 50yr
WS 25yr
WS 10yr
WS 1yr
Ground

TITLE	Opinion of Estimated Construction Cost for Upper Boiceville Road Crossing				
DESIGN LEVEL	Conceptual				
DATE	6/19/2016				
BY:	GDF				
CHECKED					
BID ITEM #	ITEM	Unit	Unit Cost	Quantity	Total
1	Mobilization, Demobilization and Restore Site to Pre-Construction Conditions	LS	$9,500	1	$9,500
2	Traffic Bypass Control (Upper Boiceville Road is reduced to one lane)	LS	$30,000	1	$30,000
3	Install Silt Fence	LF	$3	200	$600
4	Water Quality Protection (Assume Pump Around)	Day	$1,600	10	$16,000
5	Remove and Dispose of Existing Culvert Under Upper Boiceville Road	LS	$8,500	1	$8,500
6	Procure and Install 25' Long 12' Wide Three Sided Box Culvert for Upper Boiceville Road	LS	$27,000	1	$27,000
7	Procure and Install Stacked Rock Headwalls and Concrete Culvert footer	LS	$9,100	1	$9,100
8	Grade Road and Install 60' of Guardrail	LS	$3,300	1	$3,300
				Subtotal	$104,000
				Contigency (15%)	$15,600
	*Note Boundary Survey is assumed not to be required			Surveying*, Permiting, Engineering (12%)	$12,500
				Grand Total	$132,100

Damage Year:
RI: 250.00
Are Damages In Current Dollars? Yes

Buildings (Days):
Utilities (Days):
Roads (Days): 120.0

DPW Road Detour ($)	$2,500
DPW Clean Up ($)	$0
Total	$9,936,820
Total Inflated	

Volunteers Cost

Number of Volunteers Required:
Cost of Volunteers Time ($/Hour/Person):
Per-Person Cost of Lodging for a Volunteer:
Number of Hours Volunteered/Person:
Number of Days Lodging/Volunteer:
Cost of Volunteers:

Summary Of Benefits

	Expected Annual Damages Before Mitigation	Expected Annual Damages After Mitigation	Expected Avoided Damages After Mitigation (Benefits)
Annual:	$79,493	$0	$79,493
Present Value:	$1,097,063	$0	$1,097,063

Mitigation Benefits: $1,097,063

Benefits Minus Costs: $954,612

Mitigation Costs: $142,451

Benefit-Cost Ratio: 7.70

Cost Estimate

Project Useful Life (years):	50	Construction Type:	
Mitigation Project Cost:	$0	Detailed Scope of Work:	Yes
Annual Project Maintenance Cost:	$750	Detailed Estimate for Entire Project:	No
Final Mitigation Project Cost:	$142,451	Years of Maintenance:	50

Total Benefits: **$1,097,063** Total Costs: **$142,451** BCR: **7.70**

Project Number: Disaster #: Program: HMGP Agency:

State: **New York** Point of Contact: Analyst:

Cost Basis Year:

Construction Start Year:

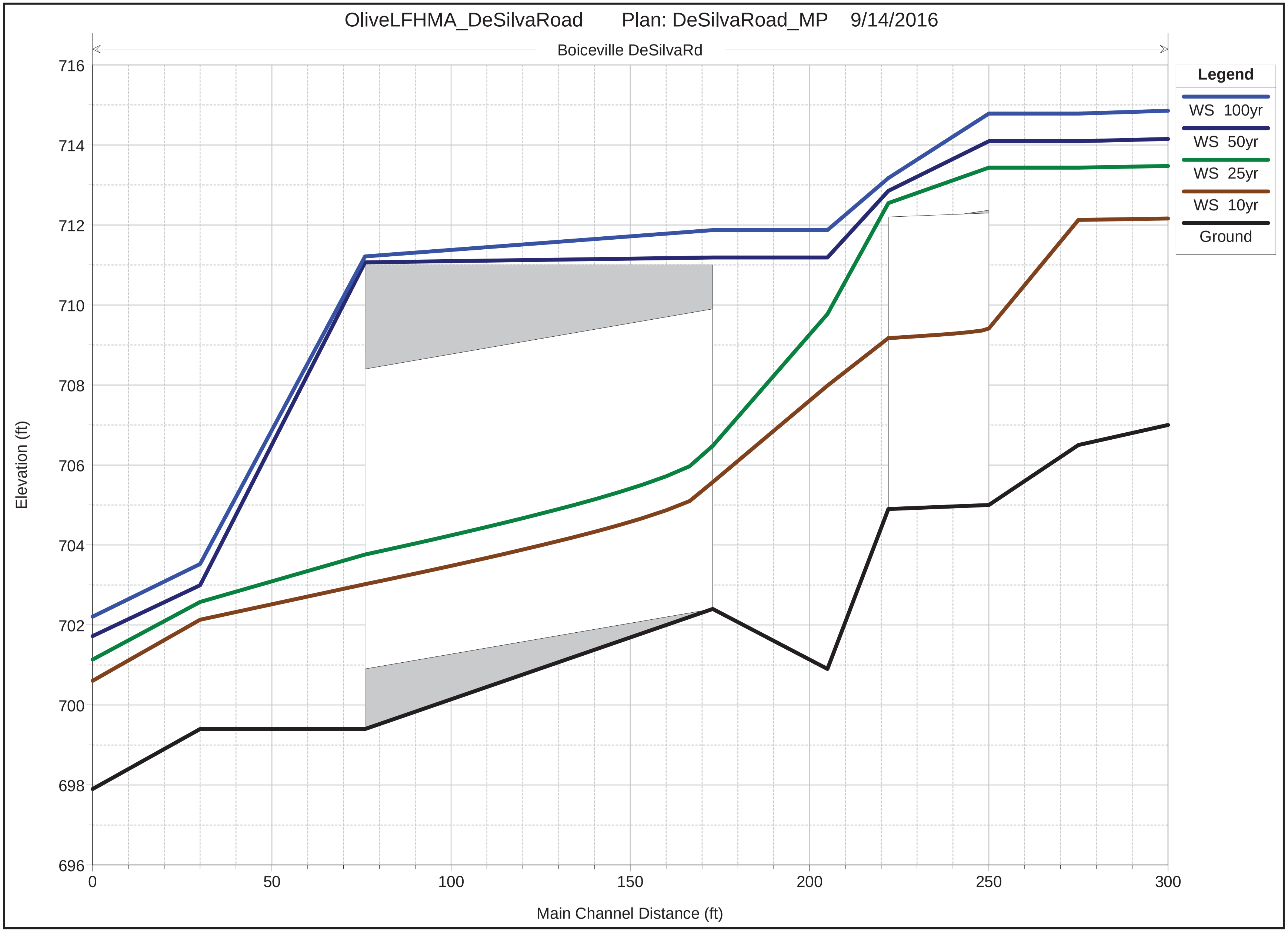
Construction End Year:

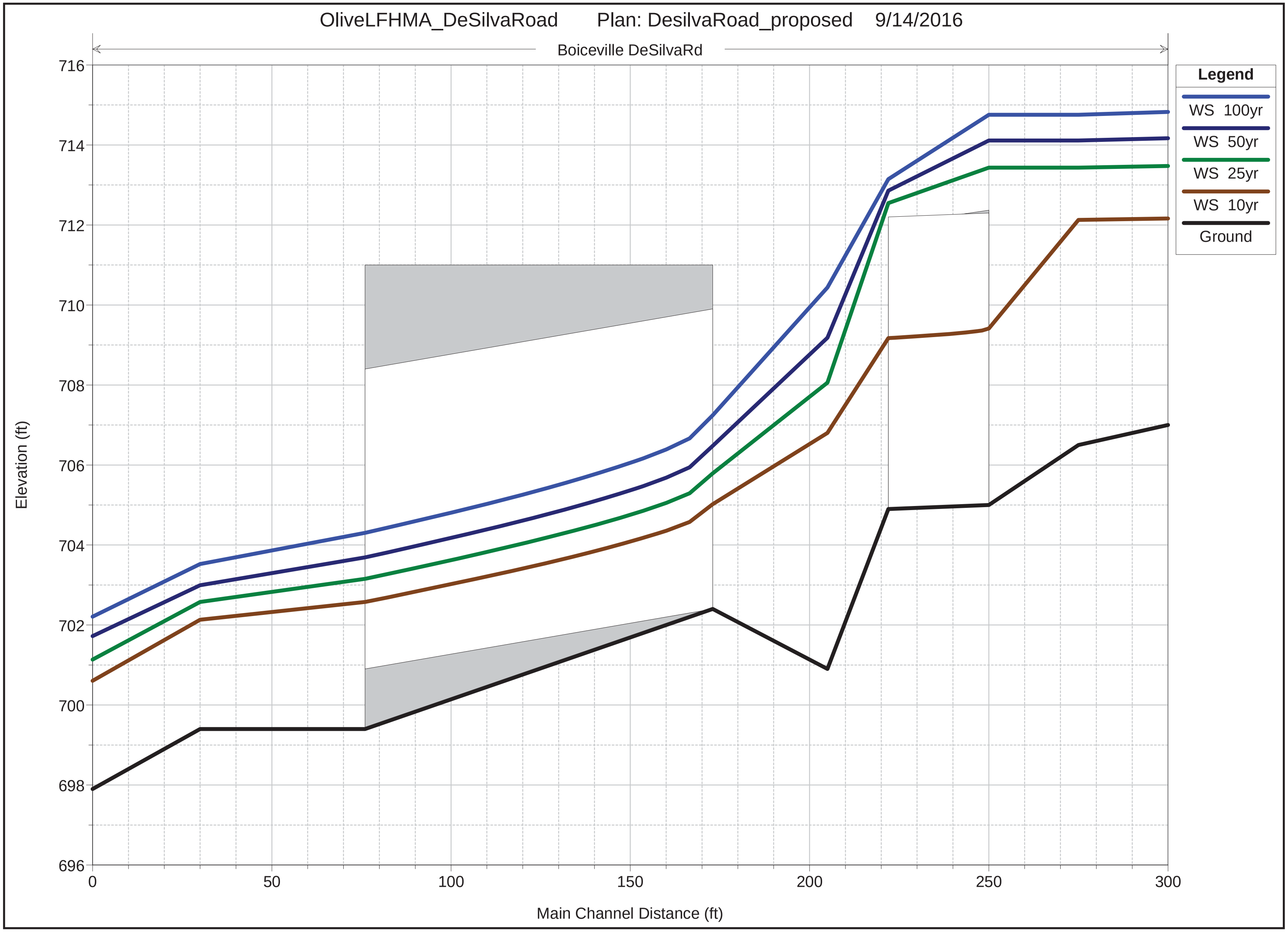
Present Worth of Annual Maintenance Costs: $10,351

Estimate Reflects Current Prices: No

Project Escalation:

Phase and Item	Pub	Hist	Contr	Qty	Unit	Unit Cost	Task Cost
PRE-CONSTRUCTION COSTS							
Lump Sum							$12,500
CONSTRUCTION COSTS							
Lump Sum							$119,600
ANNUAL PROJECT MAINTENANCE COSTS							
Lump Sum							$750
CONSTRUCTION MARKUPS							


OliveLFHMA_DeSilvaRoad Plan: DeSilvaRoad_MP 9/14/2016
Boiceville DeSilvaRd
Legend
WS 100yr
WS 50yr
WS 25yr
WS 10yr
Ground
Elevation (ft)
716
714
712
710
708
706
704
702
700
698
696
0
50
100
150
200
250
300
Main Channel Distance (ft)


OliveLFHMA_DeSilvaRoad Plan: DesilvaRoad_proposed 9/14/2016
Boiceville DeSilvaRd
Legend
WS 100yr
WS 50yr
WS 25yr
WS 10yr
Ground
Elevation (ft)
716
714
712
710
708
706
704
702
700
698
696
0
50
100
150
200
250
300
Main Channel Distance (ft)

TITLE	Opinion of Estimated Construction Cost for DeSilva Road Crossing				
DESIGN LEVEL	Conceptual				
DATE	12/26/2016				
BY:	GDF				
CHECKED					
BID ITEM #	ITEM	Unit	Unit Cost	Quantity	Total
1	Mobilization, Demobilization and Restore Site to Pre-Construction Conditions	LS	$21,300	1	$21,300
2	Traffic Bypass Control (State Route 28 is reduced to one lane)	LS	$45,000	1	$45,000
3	Install Silt Fence	LF	$3	400	$1,200
4	Water Quality Protection (Assume Pump Around)	Day	$1,600	20	$32,000
5	Remove and Dispose of Existing Culvert Under State Route 28	LS	$11,800	1	$11,800
6	Procure and Install 100' Long Three Sided Box Culvert for State Route 28	LS	$90,000	1	$90,000
7	Procure and Install Concrete Headwalls and Concrete Culvert footer	LS	$29,325	1	$29,325
8	Grade Road and Install 60' of Guardrail	LS	$3,300	1	$3,300
				Subtotal	$234,000
				Contigency (15%)	$35,100
	*Note Boundary Survey is assumed not to be required			Surveying*, Permiting, Engineering (12%)	$28,100
				Grand Total	$297,200

Total Benefits: **$1,501,701** Total Costs: **$307,551** BCR: **4.88**

Project Number: Disaster #: Program: HMGP Agency:

State: **New York** Point of Contact: Analyst:

Damage Year:
RI: 100.00
Are Damages In Current Dollars? Yes

Buildings (Days):
Utilities (Days):
Roads (Days): 120.0

DPW Road Detour ($)	$2,500
DPW Clean Up ($)	$0
Total	$9,936,820
Total Inflated	

Volunteers Cost

Number of Volunteers Required:
Cost of Volunteers Time ($/Hour/Person):
Per-Person Cost of Lodging for a Volunteer:
Number of Hours Volunteered/Person:
Number of Days Lodging/Volunteer:
Cost of Volunteers:

Summary Of Benefits

	Expected Annual Damages Before Mitigation	Expected Annual Damages After Mitigation	Expected Avoided Damages After Mitigation (Benefits)
Annual:	$108,813	$0	$108,813
Present Value:	$1,501,701	$0	$1,501,701

Mitigation Benefits: $1,501,701
Benefits Minus Costs: $1,194,150

Mitigation Costs: $307,551
Benefit-Cost Ratio: 4.88

Cost Estimate

Project Useful Life (years): 50
Mitigation Project Cost: $0
Annual Project Maintenance Cost: $750
Final Mitigation Project Cost: $307,551

Construction Type:
Detailed Scope of Work: Yes
Detailed Estimate for Entire Project: No
Years of Maintenance: 50

Total Benefits: **$1,501,701** Total Costs: **$307,551** BCR: **4.88**

Project Number: Disaster #: Program: HMGP Agency:

State: **New York** Point of Contact: Analyst:

Cost Basis Year:

Construction Start Year:

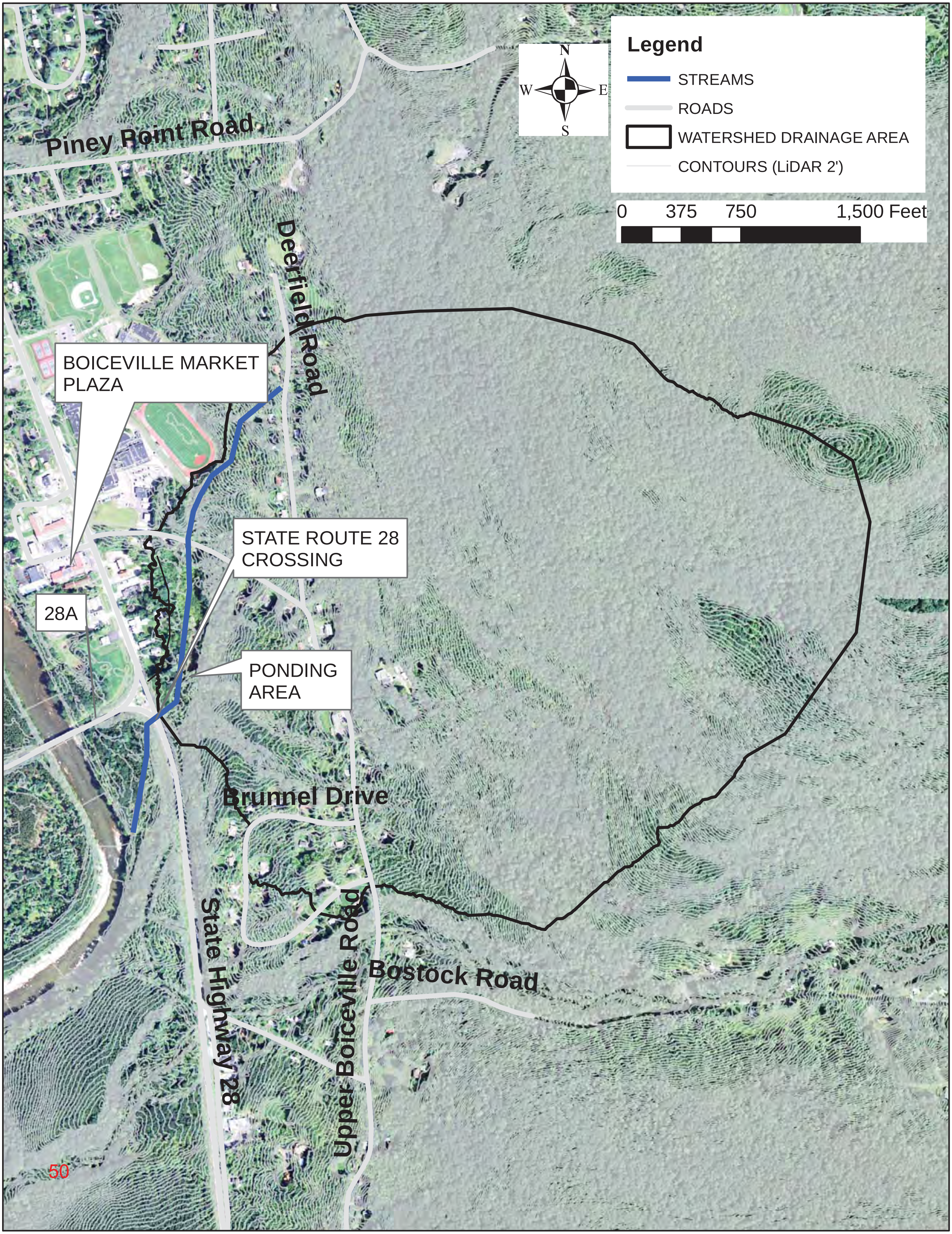
Construction End Year:

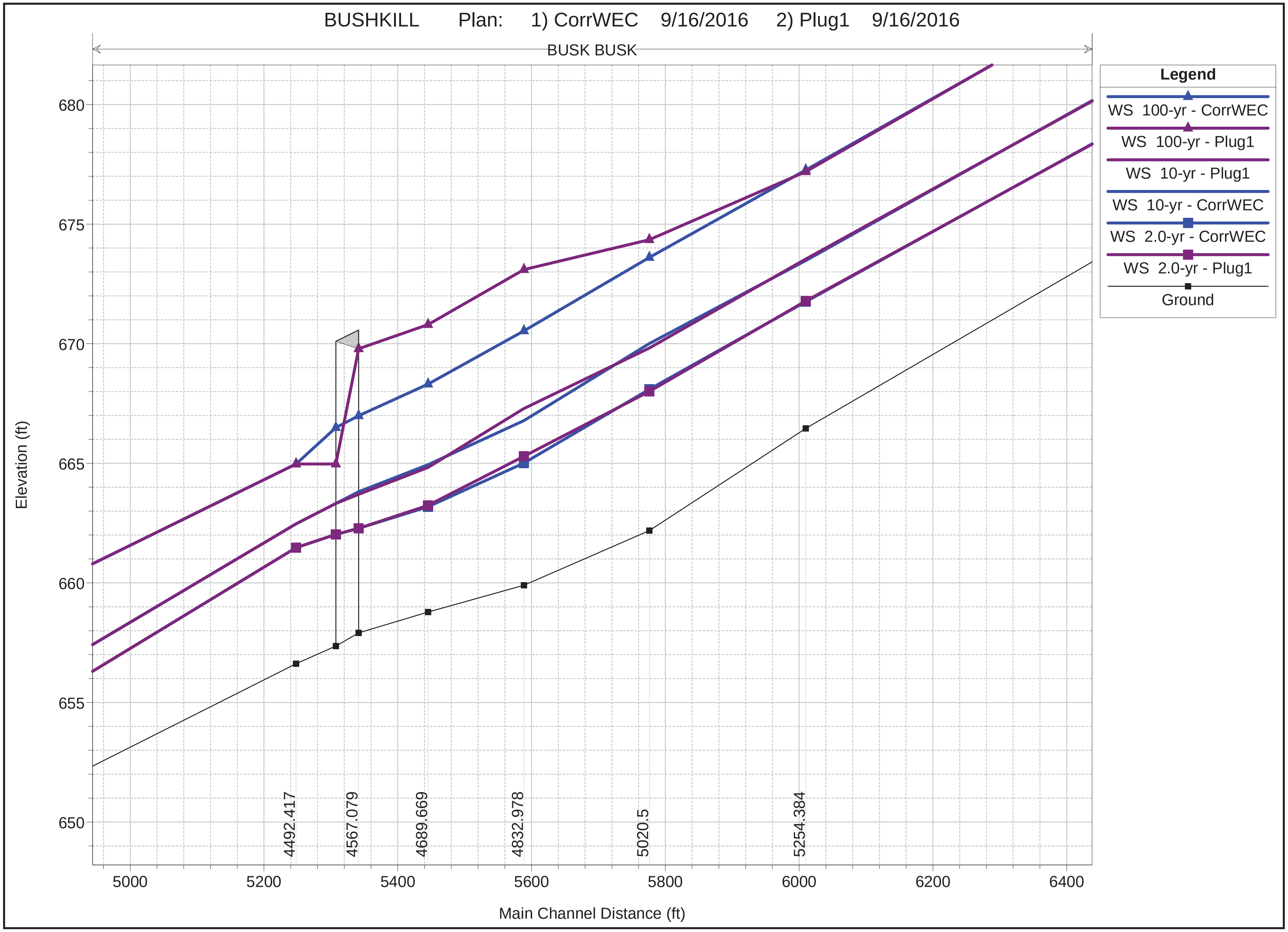
Present Worth of Annual Maintenance Costs: $10,351

Estimate Reflects Current Prices: No

Project Escalation:

Phase and Item	Pub	Hist	Contr	Qty	Unit	Unit Cost	Task Cost
PRE-CONSTRUCTION COSTS							
Lump Sum							$28,100
CONSTRUCTION COSTS							
Lump Sum							$269,100
ANNUAL PROJECT MAINTENANCE COSTS							
Lump Sum							$750
CONSTRUCTION MARKUPS							


Legend
STREAMS
ROADS
WATERSHED DRAINAGE AREA
CONTOURS (LiDAR 2')
N
W
E
S
0
375
750
1,500 Feet
Piney Point Road
Deerfield Road
BOICEVILLE MARKET PLAZA
STATE ROUTE 28 CROSSING
28A
PONDING AREA
Brunnel Drive
State Highway 28
Upper Boiceville Road
Bostock Road
50


BUSHKILL Plan: 1) CorrWEC 9/16/2016 2) Plug1 9/16/2016
BUSK BUSK
Legend
WS 100-yr - CorrWEC
WS 100-yr - Plug1
WS 10-yr - Plug1
WS 10-yr - CorrWEC
WS 2.0-yr - CorrWEC
WS 2.0-yr - Plug1
Ground
Elevation (ft)
680
675
670
665
660
655
650
4492.417
4567.079
4689.669
4832.978
5020.5
5254.384
5000
5200
5400
5600
5800
6000
6200
6400
Main Channel Distance (ft)

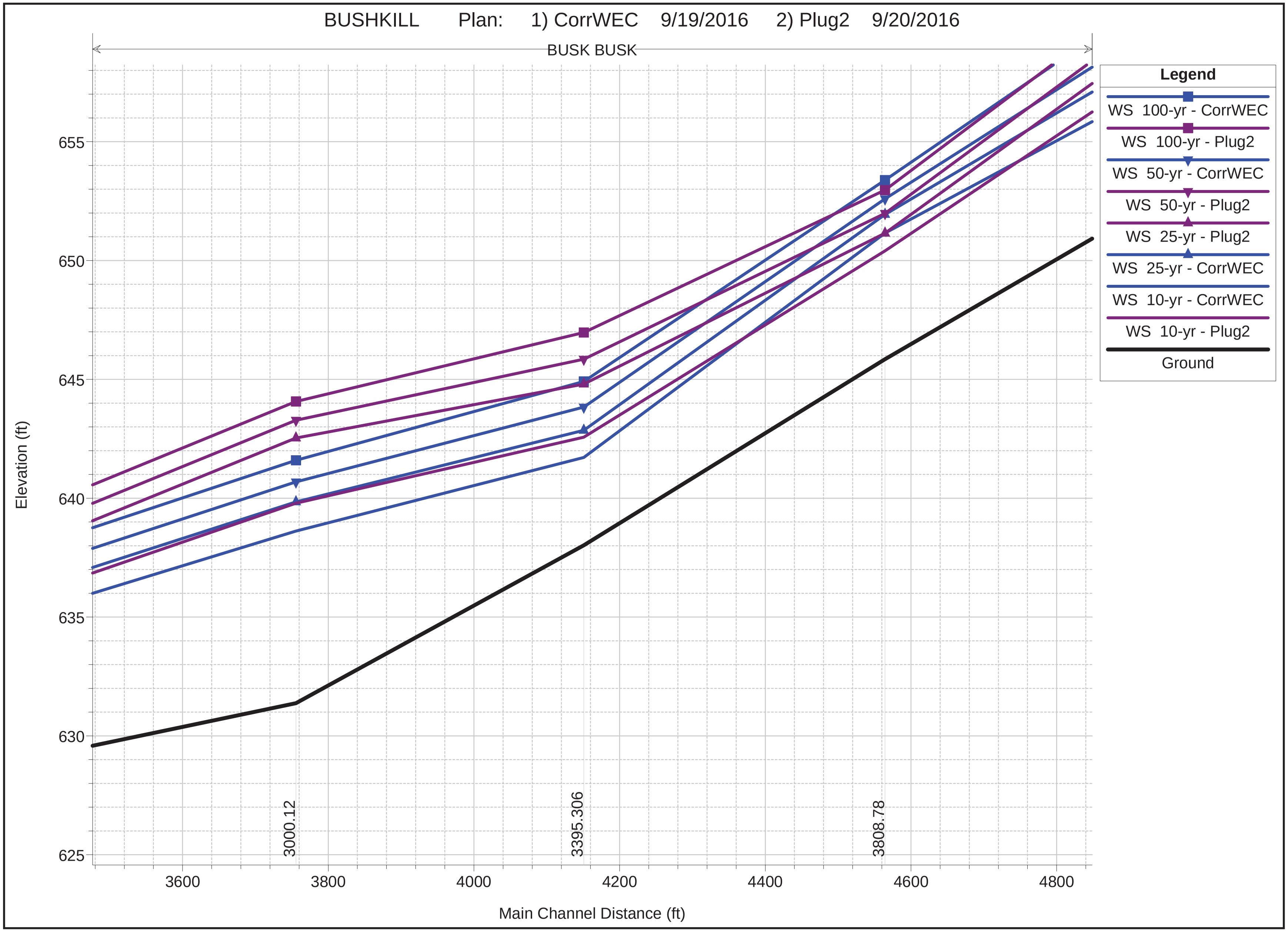

BUSHKILL Plan: 1) CorrWEC 9/19/2016 2) Plug2 9/20/2016
BUSK BUSK
Legend
WS 100-yr - CorrWEC
WS 100-yr - Plug2
WS 50-yr - CorrWEC
WS 50-yr - Plug2
WS 25-yr - Plug2
WS 25-yr - CorrWEC
WS 10-yr - CorrWEC
WS 10-yr - Plug2
Ground
Elevation (ft)
655
650
645
640
635
630
625
3000.12
3395.306
3808.78
3600
3800
4000
4200
4400
4600
4800
Main Channel Distance (ft)

Table: Bushkill Hazard #5 Hydraulic Output

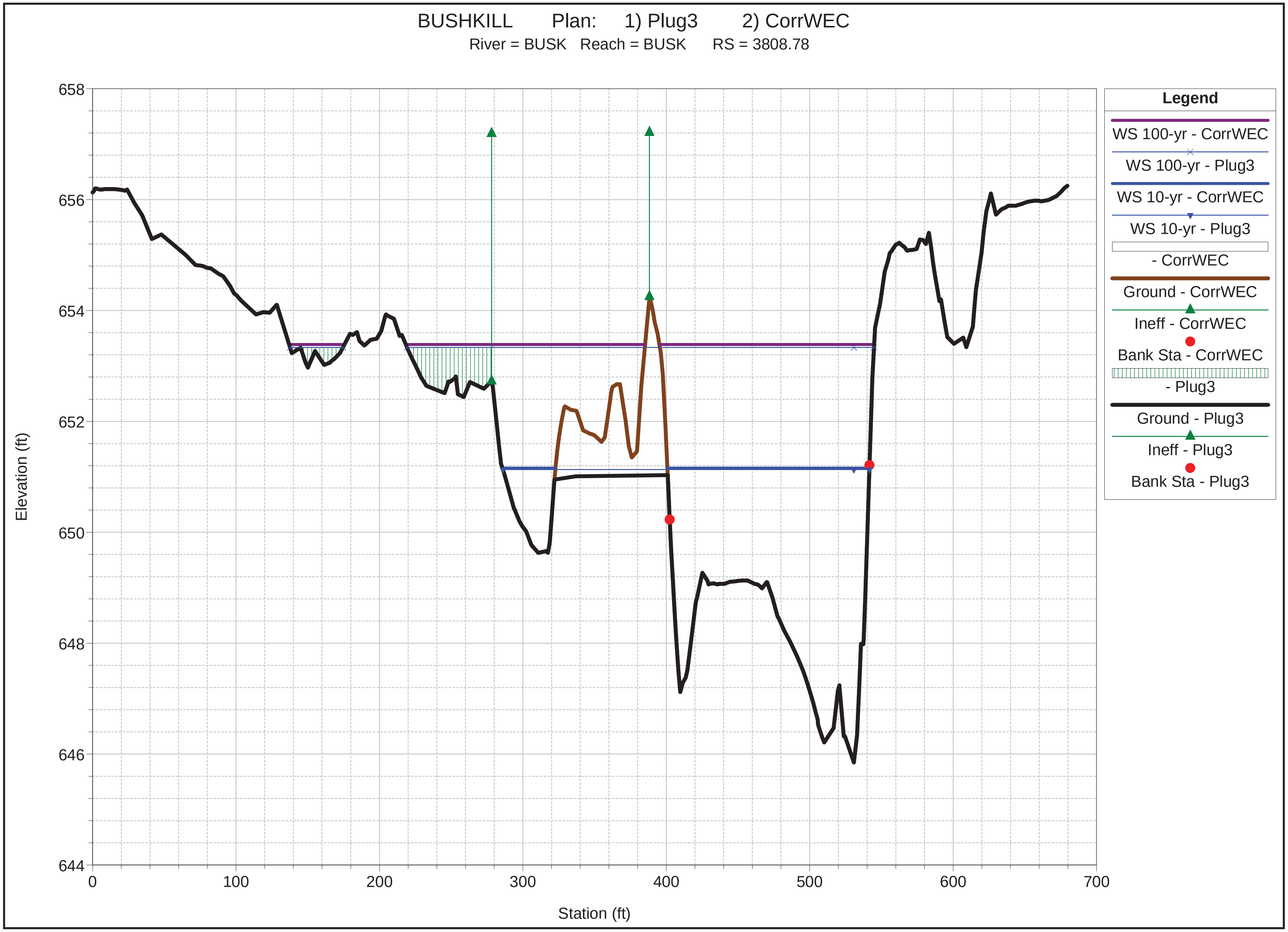
Date: 6/16/16

Point of	25 Year Water Surface Elevation			25 Year Velocity (ft/sec)			100 Year Water Surface Elevation			100 Year Velocity (ft/sec)		
Interest	Plug 2	Corrected	Difference	Plug 2	Corrected	Difference	Plug 2	Corrected	Difference	Plug 2	Corrected	Difference
4689	666.31	666.31	0	6.58	6.58	0	668.31	668.31	0	9.32	9.32	0
4113	657.91	657.46	0.45	4.98	5.7	-0.72	659.98	659.78	0.2	6.19	6.45	-0.26
3395	644.8	642.86	1.94	4.97	8.38	-3.41	646.97	644.91	2.06	6.65	9.72	-3.07
3000*	642.53	639.84	2.69	5.04	4.58	0.46	644.07	641.59	2.48	7.06	6.43	0.63

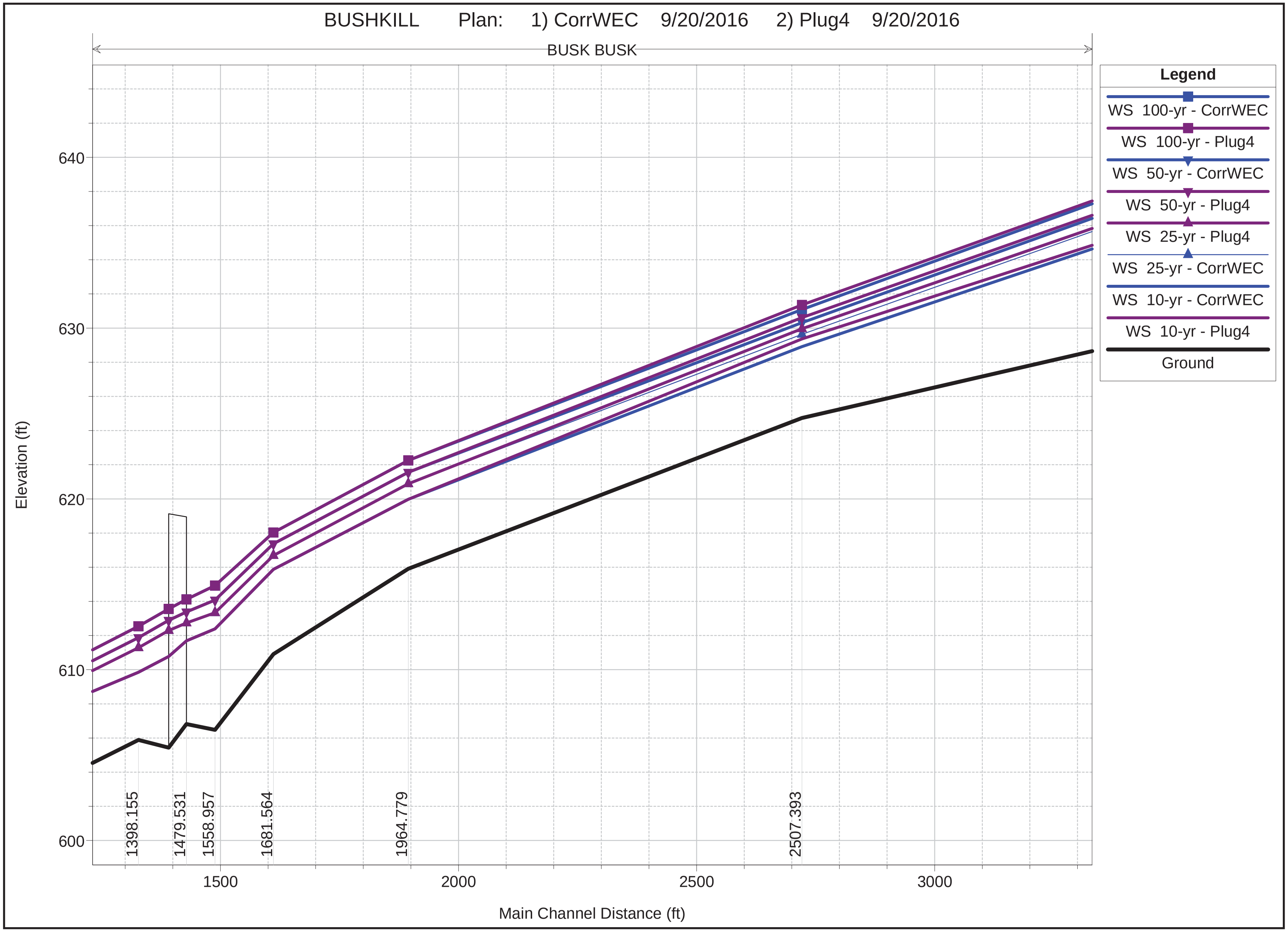
All Values in Feet Unless Noted

*Cross Section Located Adjecent to Building B100 on Watson Hallow Road

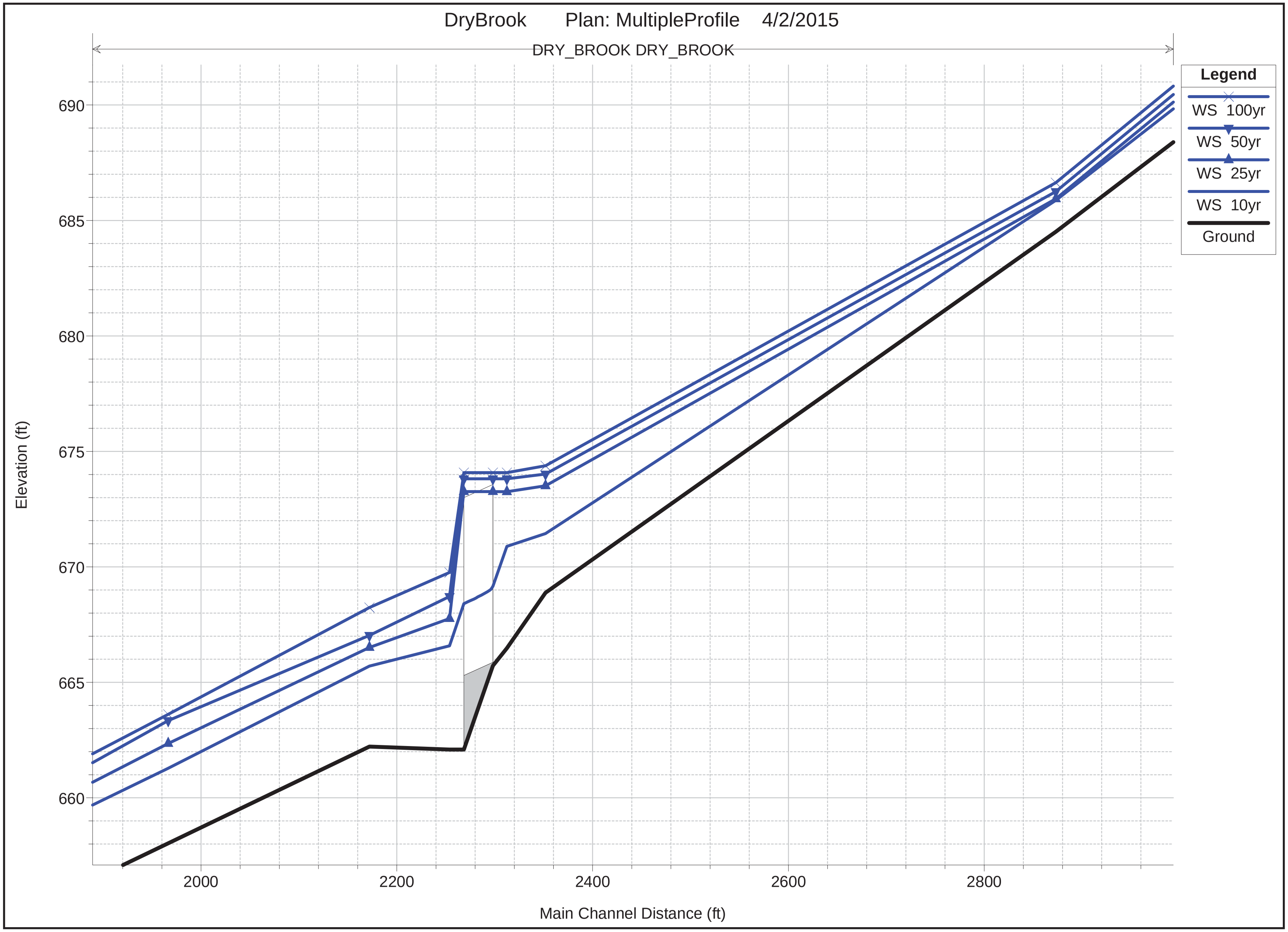
(Height of Adjacent Grade is 641.0, First Floor Elevation is 642.5)



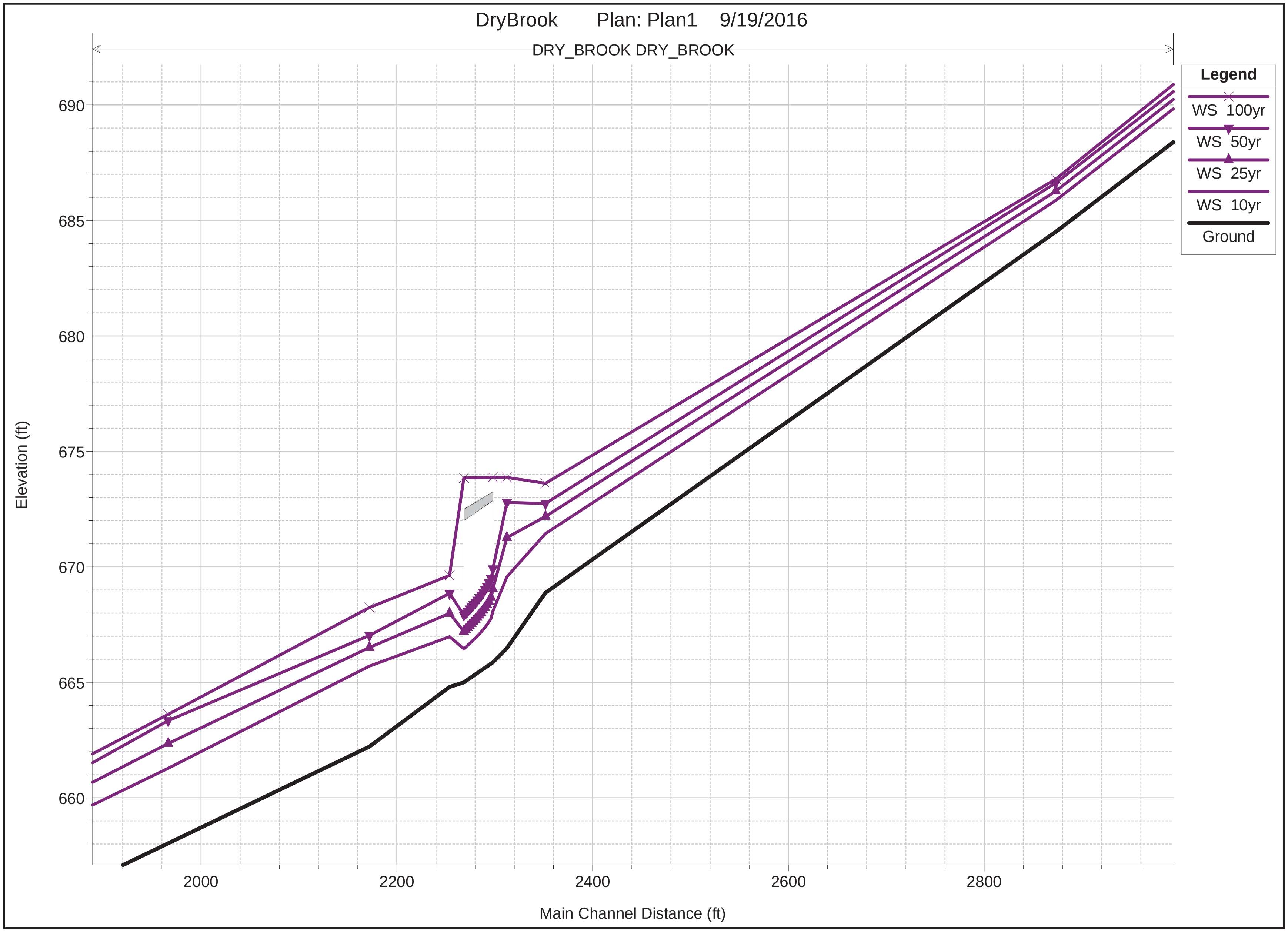
BUSHKILL Plan: 1) Plug3 2) CorrWEC
River = BUSK Reach = BUSK RS = 3808.78
Elevation (ft)
Station (ft)
658
656
654
652
650
648
646
644
0
100
200
300
400
500
600
700
Legend
WS 100-yr - CorrWEC
WS 100-yr - Plug3
WS 10-yr - CorrWEC
WS 10-yr - Plug3
- CorrWEC
Ground - CorrWEC
Ineff - CorrWEC
Bank Sta - CorrWEC
- Plug3
Ground - Plug3
Ineff - Plug3
Bank Sta - Plug3



BUSHKILL Plan: 1) CorrWEC 9/20/2016 2) Plug4 9/20/2016
BUSK BUSK
Legend
WS 100-yr - CorrWEC
WS 100-yr - Plug4
WS 50-yr - CorrWEC
WS 50-yr - Plug4
WS 25-yr - Plug4
WS 25-yr - CorrWEC
WS 10-yr - CorrWEC
WS 10-yr - Plug4
Ground
Elevation (ft)
640
630
620
610
600
1398.155
1479.531
1558.957
1681.564
1964.779
2507.393
1500
2000
2500
3000
Main Channel Distance (ft)



DryBrook Plan: MultipleProfile 4/2/2015
DRY_BROOK DRY_BROOK
Legend
WS 100yr
WS 50yr
WS 25yr
WS 10yr
Ground
Elevation (ft)
690
685
680
675
670
665
660
2000
2200
2400
2600
2800
Main Channel Distance (ft)


DryBrook Plan: Plan1 9/19/2016
DRY_BROOK DRY_BROOK
Legend
WS 100yr
WS 50yr
WS 25yr
WS 10yr
Ground
Elevation (ft)
690
685
680
675
670
665
660
2000
2200
2400
2600
2800
Main Channel Distance (ft)

TITLE	Opinion of Estimated Construction Cost for Burgher Road Crossing				
DESIGN LEVEL	Conceptual				
DATE	8/19/2016				
BY:	GDF				
CHECKED					
BID ITEM #	ITEM	Unit	Unit Cost	Quantity	Total
1	Mobilization, Demobilization and Restore Site to Pre-Construction Conditions	LS	$6,800	1	$6,800
2	Traffic Bypass Control (Burgher Road is reduced to one lane)	LS	$10,000	1	$10,000
3	Install Silt Fence	LF	$3	200	$600
4	Water Quality Protection (Assume Pump Around)	Day	$1,600	10	$16,000
5	Remove and Dispose of Existing Culvert Under Bergher Road	LS	$7,300	1	$7,300
6	Procure and Install 25' Long 18' Wide Three Sided Box Culvert for Burgher Road	LS	$21,000	1	$21,000
7	Procure and Install Stacked Rock Headwalls and Concrete Culvert footer	LS	$9,100	1	$9,100
8	Grade Road and Install 60' of Guardrail	LS	$3,300	1	$3,300
				Subtotal	$74,100
				Contigency (15%)	$11,200
	*Note Boundary Survey is assumed not to be required			Surveying*, Permiting, Engineering (12%)	$8,900
				Grand Total	$94,200

Total Benefits: **$38,753** Total Costs: **$99,720** BCR: **0.39**

Project Number: Disaster #: Program: HMGP Agency:

State: **New York** Point of Contact: Analyst:

Expected Annual Damages Before Mitigation	Expected Annual Damages After Mitigation	Expected Avoided Damages After Mitigation (Benefits)
Annual: $2,828	Annual: $20	Annual: $2,808
Present Value: $39,029	Present Value: $276	Present Value: $38,753

Mitigation Benefits: $38,753

Benefits Minus Costs: ($60,967)

Mitigation Costs: $99,720

Benefit-Cost Ratio: 0.39

Cost Estimate

Project Useful Life (years): 50

Mitigation Project Cost: $0

Annual Project Maintenance Cost: $400

Final Mitigation Project Cost: $99,720

Cost Basis Year:

Construction Start Year:

Construction End Year:

Construction Type:

Detailed Scope of Work: Yes

Detailed Estimate for Entire Project: No

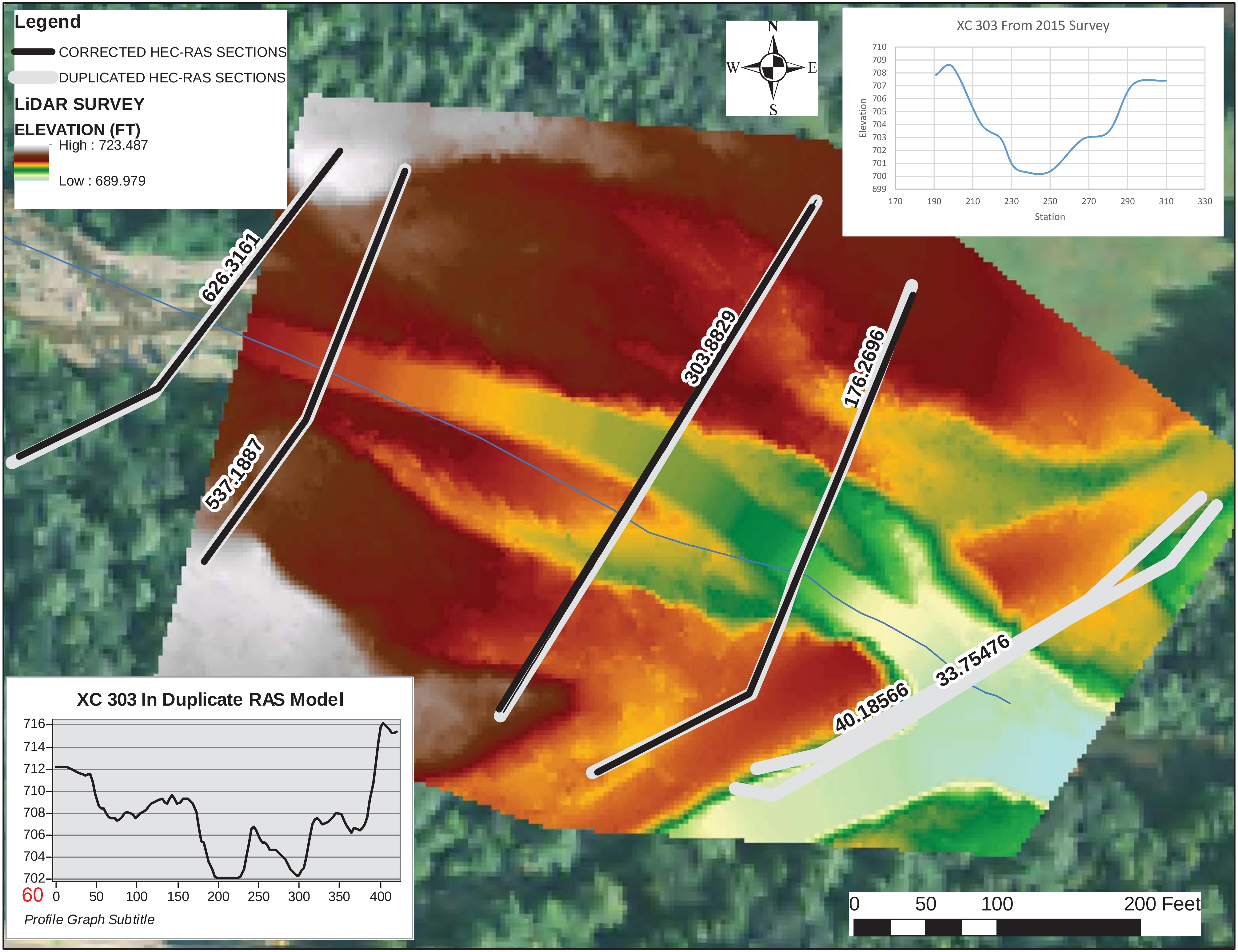
Years of Maintenance: 50

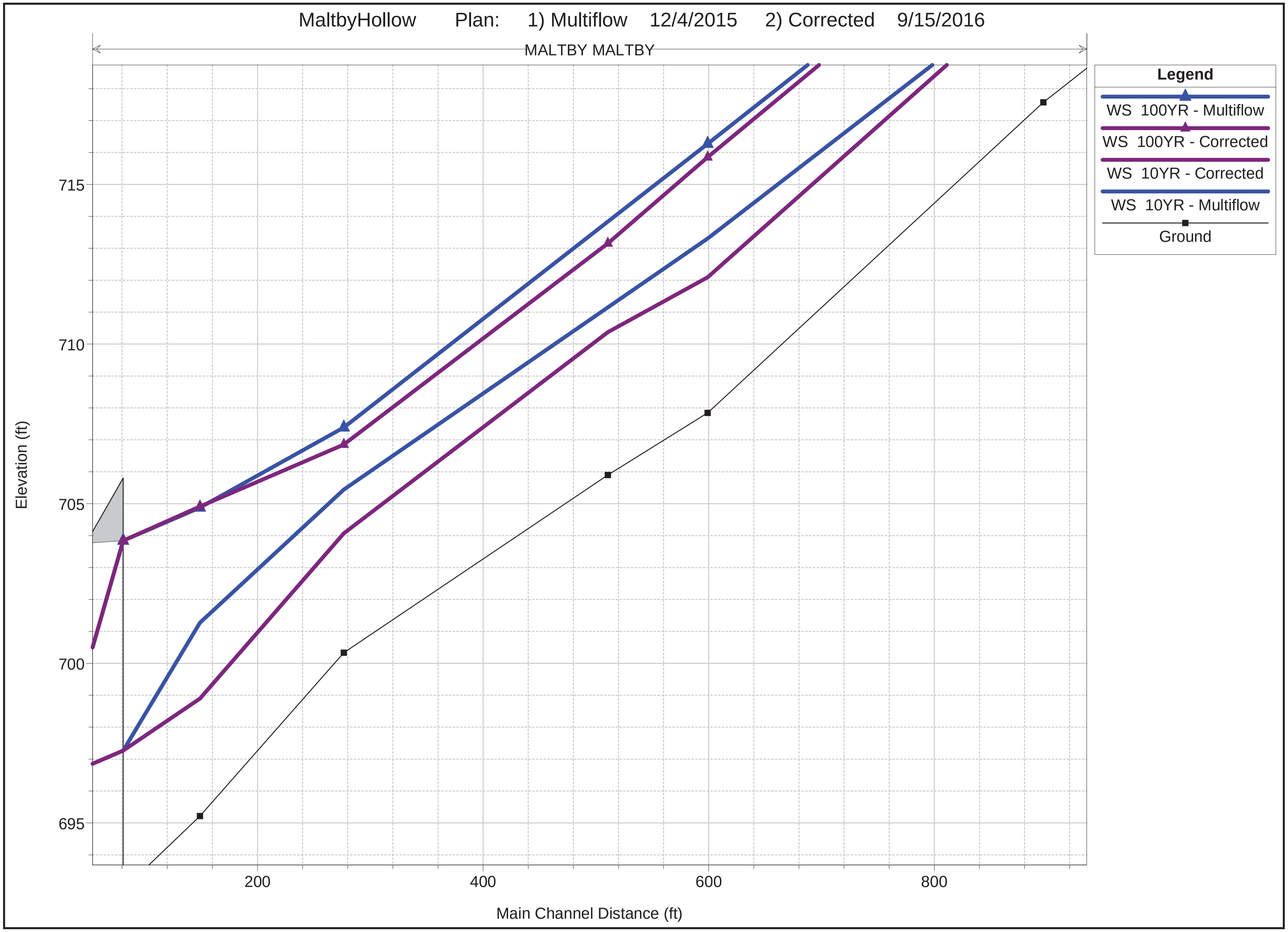
Present Worth of Annual Maintenance Costs: $5,520

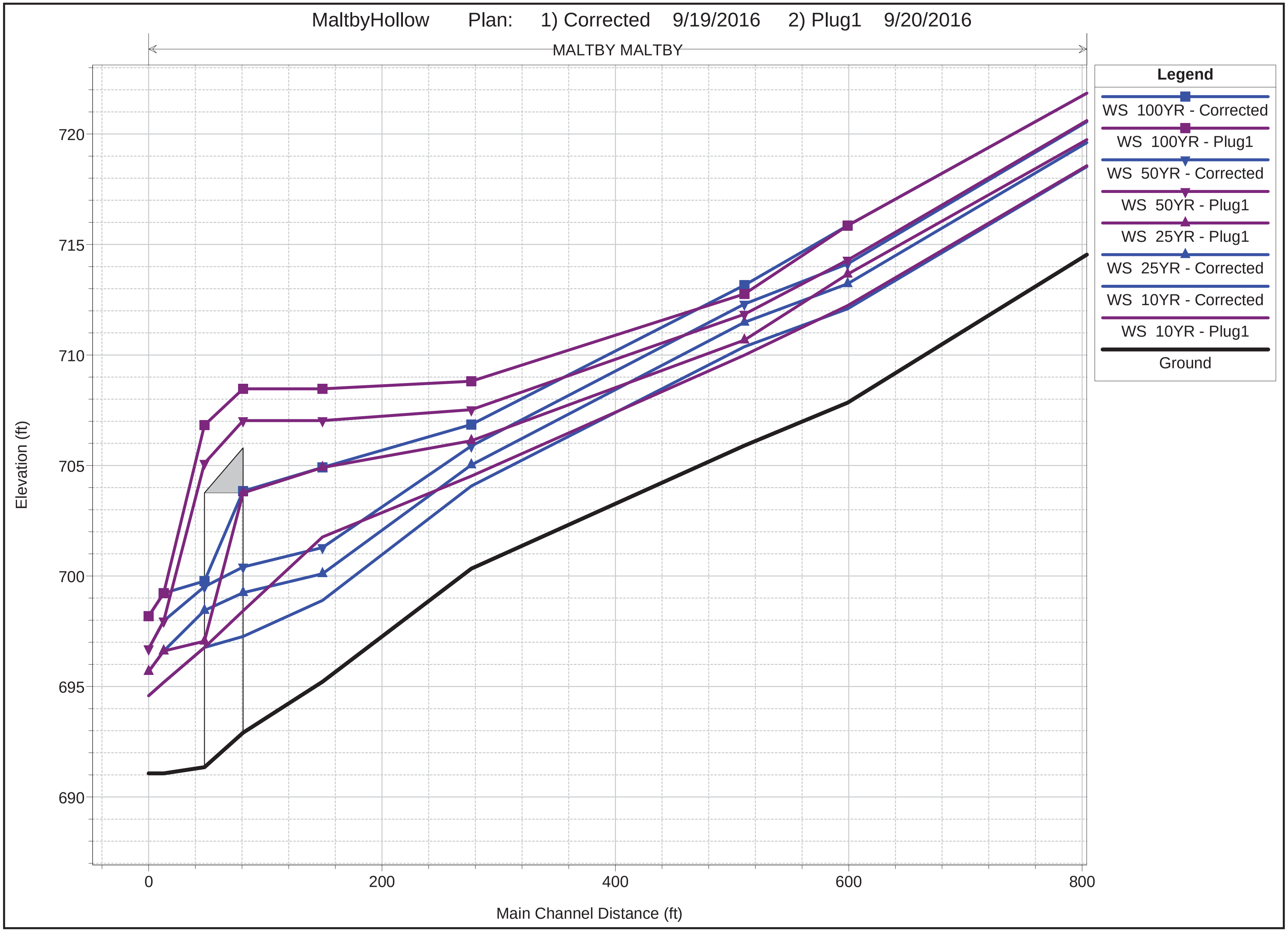
Estimate Reflects Current Prices: No

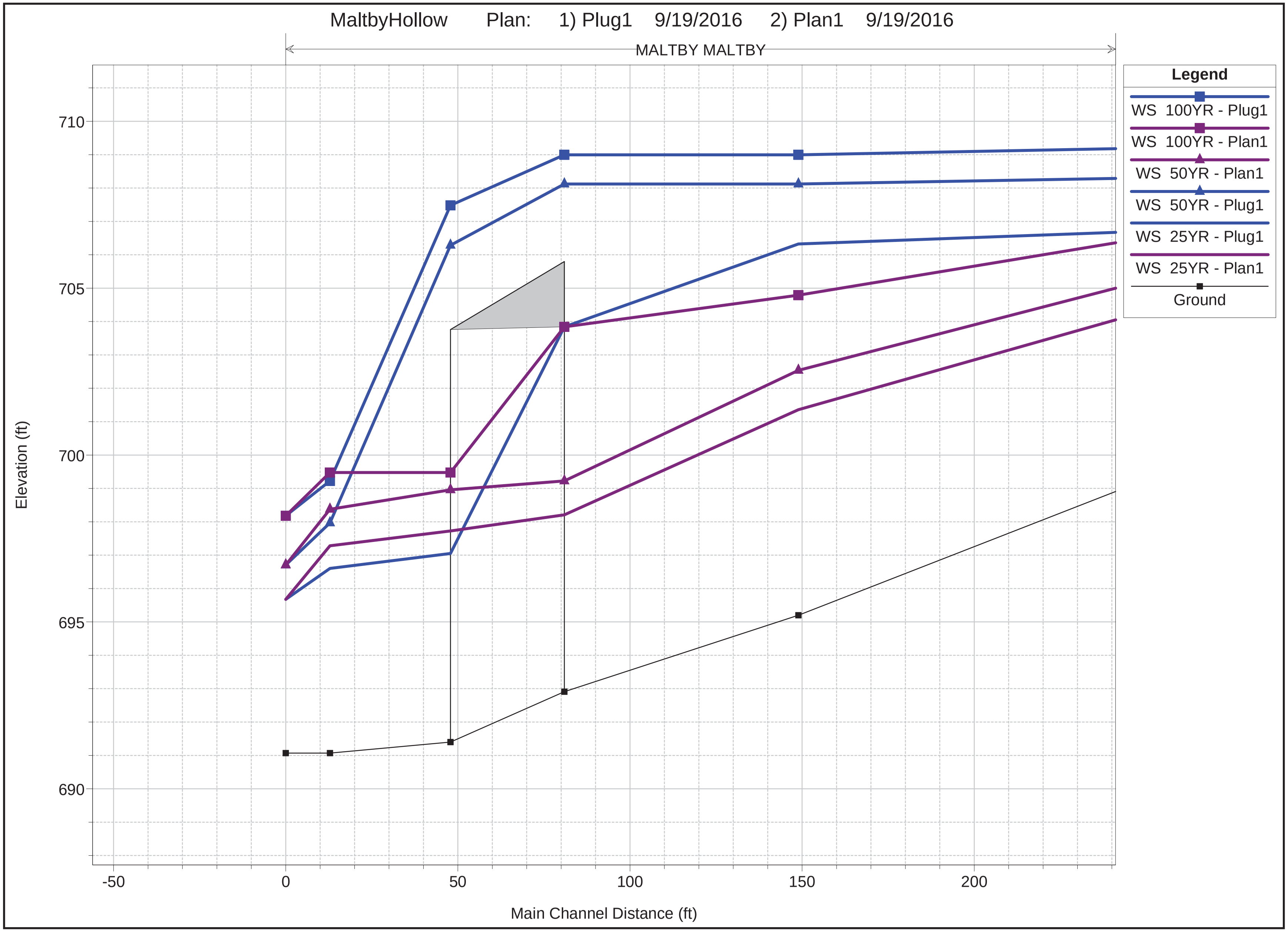
Project Escalation:

Phase and Item	Pub	Hist	Contr	Qty	Unit	Unit Cost	Task Cost
PRE-CONSTRUCTION COSTS							
Lump Sum							$8,900
CONSTRUCTION COSTS							
Lump Sum							$85,300
ANNUAL PROJECT MAINTENANCE COSTS							
Lump Sum							$400
CONSTRUCTION MARKUPS							


Legend
CORRECTED HEC-RAS SECTIONS
DUPLICATED HEC-RAS SECTIONS
LiDAR SURVEY
ELEVATION (FT)
High : 723.487
Low : 689.979
N
W
E
S
XC 303 From 2015 Survey
Elevation
Station
626.3161
537.1887
303.8829
176.2696
33.75476
40.18566
XC 303 In Duplicate RAS Model
60
Profile Graph Subtitle
0 50 100 200 Feet


MaltbyHollow Plan: 1) Multiflow 12/4/2015 2) Corrected 9/15/2016
MALTBY MALTBY
Legend
WS 100YR - Multiflow
WS 100YR - Corrected
WS 10YR - Corrected
WS 10YR - Multiflow
Ground
Elevation (ft)
715
710
705
700
695
200
400
600
800
Main Channel Distance (ft)


MaltbyHollow Plan: 1) Corrected 9/19/2016 2) Plug1 9/20/2016
MALTBY MALTBY
Legend
WS 100YR - Corrected
WS 100YR - Plug1
WS 50YR - Corrected
WS 50YR - Plug1
WS 25YR - Plug1
WS 25YR - Corrected
WS 10YR - Corrected
WS 10YR - Plug1
Ground
Elevation (ft)
720
715
710
705
700
695
690
0
200
400
600
800
Main Channel Distance (ft)


MaltbyHollow Plan: 1) Plug1 9/19/2016 2) Plan1 9/19/2016
MALTBY MALTBY
Legend
WS 100YR - Plug1
WS 100YR - Plan1
WS 50YR - Plan1
WS 50YR - Plug1
WS 25YR - Plug1
WS 25YR - Plan1
Ground
Elevation (ft)
710
705
700
695
690
-50
0
50
100
150
200
Main Channel Distance (ft)

TITLE	Opinion of Estimated Construction Cost for Watson Hollow Road Crossing Over Maltby Hollow Creek				
DESIGN LEVEL	Conceptual				
DATE	9/15/2016				
BY:	GDF				
CHECKED					
BID ITEM #	ITEM	Unit	Unit Cost	Quantity	Total
1	Mobilization, Demobilization and Restore Site to Pre-Construction Conditions	LS	$102,300	1	$102,300
2	Traffic Bypass Control (One Cross Over, Two Tempoary Traffic Signals)	LS	$68,000	1	$68,000
3	Demolition of Existing Bridge	LS	$54,000	1	$54,000
4	Water Quality Protection (Assume Culvert and Channel Bypass)	LS	$12,000	1	$12,000
5	Earthwork (Excavation and Haul)	CY	$55	900	$49,500
6	Two Span Concrete Bridge	LS	$546,200	1	$546,200
7	Pier Installation	LS	$139,000	1	$139,000
8	Abutment Replacement	LS	$65,522	1	$65,522
9	Bridge Railing	LS	$15,000	1	$15,000
10	Scour Countermeasures	LF	$150	300	$45,000
11	Approach Paving and Gaurdrails	LF	$280	100	$28,000
				Subtotal	$1,124,600
				Contigency (15%)	$168,700
	*Note Boundary Survey is assumed not to be required			Surveying*, Permiting, Engineering (12%)	$135,000
				Grand Total	$1,428,300

Total Benefits: **$1,602,929** Total Costs: **$1,438,651** BCR: **1.11**

Project Number: Disaster #: Program: HMGP Agency:

State: **New York** Point of Contact: Analyst:

Expected Annual Damages Before Mitigation		Expected Annual Damages After Mitigation		Expected Avoided Damages After Mitigation (Benefits)	
Annual:	$116,415	Annual:	$267	Annual:	$116,148
Present Value:	$1,606,614	Present Value:	$3,685	Present Value:	$1,602,929

Mitigation Benefits: $1,602,929

Benefits Minus Costs: $164,278

Mitigation Costs: $1,438,651

Benefit-Cost Ratio: 1.11

Cost Estimate

Project Useful Life (years): 50

Mitigation Project Cost: $0

Annual Project Maintenance Cost: $750

Final Mitigation Project Cost: $1,438,651

Cost Basis Year:

Construction Start Year:

Construction End Year:

Construction Type:

Detailed Scope of Work: Yes

Detailed Estimate for Entire Project: No

Years of Maintenance: 50

Present Worth of Annual Maintenance Costs: $10,351

Estimate Reflects Current Prices: No

Project Escalation:

Phase and Item	Pub	Hist	Contr	Qty	Unit	Unit Cost	Task Cost
PRE-CONSTRUCTION COSTS							
Lump Sum							$135,000
CONSTRUCTION COSTS							
Lump Sum							$1,293,300
ANNUAL PROJECT MAINTENANCE COSTS							
Lump Sum							$750
CONSTRUCTION MARKUPS							