DELHI
LOCAL FLOOD ANALYSIS
FLOOD ENGINEERING ANALYSIS REPORT
TOWN AND VILLAGE OF DELHI
DELAWARE COUNTY, NEW YORK

Prepared for:

Delaware County Soil and Water Conservation District

In partnership with

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For the Town and Village of Delhi, NY

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1.0 Executive Summary

The Town and Village of Delhi (Delhi) 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. The Local Flood Analysis report will be used as a decision making tool to help inform the residents of the Village and Town of Delhi regarding future flood mitigation actions and programs. The audience for this analysis includes officials of Delhi, future consultants, future funding agencies, contractors for flood mitigation projects, and the residents of Delhi.

The expected outcome of Delhi's Local Flood Analysis is an understanding of flooding hazards within its population centers, economic areas and infrastructure (roads and bridges) critical for first responders. Flood hazards were identified by engaging community members during a public meeting and over the course of several meetings with Delhi's Flood Advisory Commission (FC). This understanding is captured in the Local Flood Analysis report (LFA) and the solutions presented in the LFA were driven by Delhi's FC decisions on recommendations developed using engineering and geomorphic technical analyses. These solutions were then vetted by the FC, the Town Board, Village 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 Delhi'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.). There were six (6) priority areas within Delhi that were studied in the LFA and within these six study areas, a total of one hundred and sixty three (163) flooding hazards were characterized and twenty-one (21) mitigation solutions were developed. Several water quality pollution sources were identified, mostly consisting of unanchored petroleum tanks and inundation of commercial garages.

In the West Branch Delaware River Study Area, there were 96 homes and businesses located within a flood-prone area. The roadway approach of Bridge Street, which is important to public safety first response when Kingston Street Bridge is closed, is inundated during moderate flood events. Several water quality pollution sources were mapped in flood-prone areas including twelve (12) unanchored petroleum tanks, nine (9) commercial or government automobile/truck garages and one gas station. Ten (10) mitigation solutions, whose goal was to reduce flood water elevations were developed collaboratively with the FC and the technical team. Three mitigation solutions were furthered into a benefit cost analysis (BCA). The BCAs for all three solutions demonstrated the benefits gained by these solutions were greater than their costs.

In the Meredith Street Study Area, five buildings were identified by the public and a subsequent engineering analysis to be at risk of water damage from an insufficient stormwater drainage system. The drainage system begins near Cuddeback Road and parallels Meredith Street (State Route 28) on the east before crossing under the street where it collects more surface runoff from the west. The system sweeps down to the south where it enters a New York State Department of Transportation (NYSDOT) stormwater conveyance system that passes underneath Main Street (State Route 10) and finally daylights near the West Branch Delaware River. The stormwater system was modeled using a computer software program (HydroCAD) which showed the system was surcharged (i.e. water leaving the underground system via drainage basins resulting in surface flow) beginning at a frequently occurring rain fall event (1.0-year return interval rain event). The resulting surcharged surface flow is responsible for water damage to private property. Two proposed stormwater infrastructure improvements were developed to contain the water up to a 10-year return interval rain event (a typical design standard for closed stormwater systems). The cost for these solutions far exceeded the damage to the private properties. Property protection solutions were also developed to protect these homes.

In the Steele Brook Study area, 26 homes and businesses are located within the adjacent flood-prone area which is separate from the West Branch Study Area. The flooding mechanism is due to the insufficient capacity of the Elm Street Bridge to convey flood waters during moderate flood events (beginning at the 10-year return interval flood). Seventeen (17) flooding hazards were also identified by community members with most of the hazards caused by an obstruction of a culvert/bridge by debris (rock or trees) that leads to inundation hazards. The notable debris obstruction is located at the Main Street (NYS Route 10) culvert where floodwaters jump out of bank to the west and flow towards the Delhi Senior Community building. Seven (7) mitigation solutions were identified and two had a BCA completed which showed the costs of the solutions exceeded the expected benefits. A Letter of Map Revision (LOMR) recommendation was also identified that could lead to notable reductions (50% or greater) in flood insurance premiums of the homes and businesses in the floodprone area.

In the Platner Brook Study Area, four (4) flooding hazards were identified by the public. During the June 2006 flood, floodwaters entered the FrieslandCampina Domo manufacturing plant and the Morningstar-Ultra Dairy causing hundreds of thousands of dollars in damages and weeks of lost wages. The floodwater source originated in Platner Brook where it jumped its' banks and washed out the adjacent farm field to the north before running down County Road 16 and into the buildings. Platner Brook was modeled using a computer software program (HEC-RAS) and the location where the water overtopped its banks identified. A mitigation solution that created more floodwater conveyance within the channel was developed and the computed benefit from this solution was three times the cost of the mitigation solution.

In the Elk Creek study area, two flooding hazards were identified by the public when the Elk Creek road culvert becomes obstructed with debris. A field assessment identified numerous debris sources caused by large eroding banks which confirmed that obstructions of the culvert occur frequently. A larger culvert was designed that could pass large flood flows (50-year return interval flood) even considering that a notable obstruction could still form upstream of the culvert crossing.

In the Little Delaware River Study Area, there was one flooding hazard identified by the public. Arbor Hill Road would become inundated beginning at a moderate flooding event. During the 25-year return interval storm, approximately 1,200' of the road would be inundated with a maximum depth of 1.0 feet of water over the roadway. Due to the relative small frequency of occurrence, and the presence of a proximal road that could detour this flooding area, a flood mitigation solution was not developed for this area.

After all the flood solutions were vetted by the FC and Town and Village Boards, an implementation strategy was developed for the Town and Village of Delhi for the highest priority mitigation strategies. Potential funding sources, implementation constraints and opportunities were also identified for these high priority mitigation solutions.

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 and Village of Delhi does have the ability to investigate and initiate flooding solutions. To that end, Delhi's Flood Commission (FC), the Village and Town Boards, along with the Delaware County Soil and Water Conservation District, authorized this Local Flood Analysis (LFA) as the first step towards reducing the damage and disruption of future floods.

The primary concerns that are driving this project are:

- Concern for the safety of Delhi's 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
- The protection of water quality and natural resources

During development of the LFA, the FC has worked toward finding solutions to reduce or remove flood hazards using the following key values to guide their decisions:

- Solutions should be cost-effective for Delhi to build and to maintain
- Solutions should be cost-effective for individuals and businesses directly involved
- Solutions should maintain, as much as possible, the sense of community and the "flavor" of businesses and residential areas
- Solutions were reviewed in public meetings and should be accepted by the community as realistic and desirable
- Solutions should protect natural resources, especially the streams and wildlife.

The six Study Areas for Delhi's LFA are located within the Town of Delhi's municipal boundary as seen in Figure 1. The southernmost Study Area (Platner Brook) starts near the Delhi-Hamden municipal boundary and extends 1.5 miles upstream along the West Branch Delaware River and also includes roughly 0.75 miles of the downstream end of Platner Brook. The Little Delaware River Study Area starts at the confluence with the West Branch and extends about 1.0 mile upstream along the Little Delaware River. The West Branch Delaware Study Area starts 0.75 miles downstream of the confluence with the Little Delaware and extends approximately 4.0 miles upstream along the West Branch. At this location, the Study Area is named the Elk Creek Study Area and continues upstream for about one mile. The Elk Creek Study Area was expanded during the LFA to include the tributary that flows under Elk Creek Road before flowing into Elk Creek. The Steele Brook Study Area starts at its confluence with the West Branch and extends 3.5 miles upstream. The Meredith Street Study area starts at the Main Street and Meredith Street intersection and runs uphill along Meredith Street for approximately 0.75 miles.

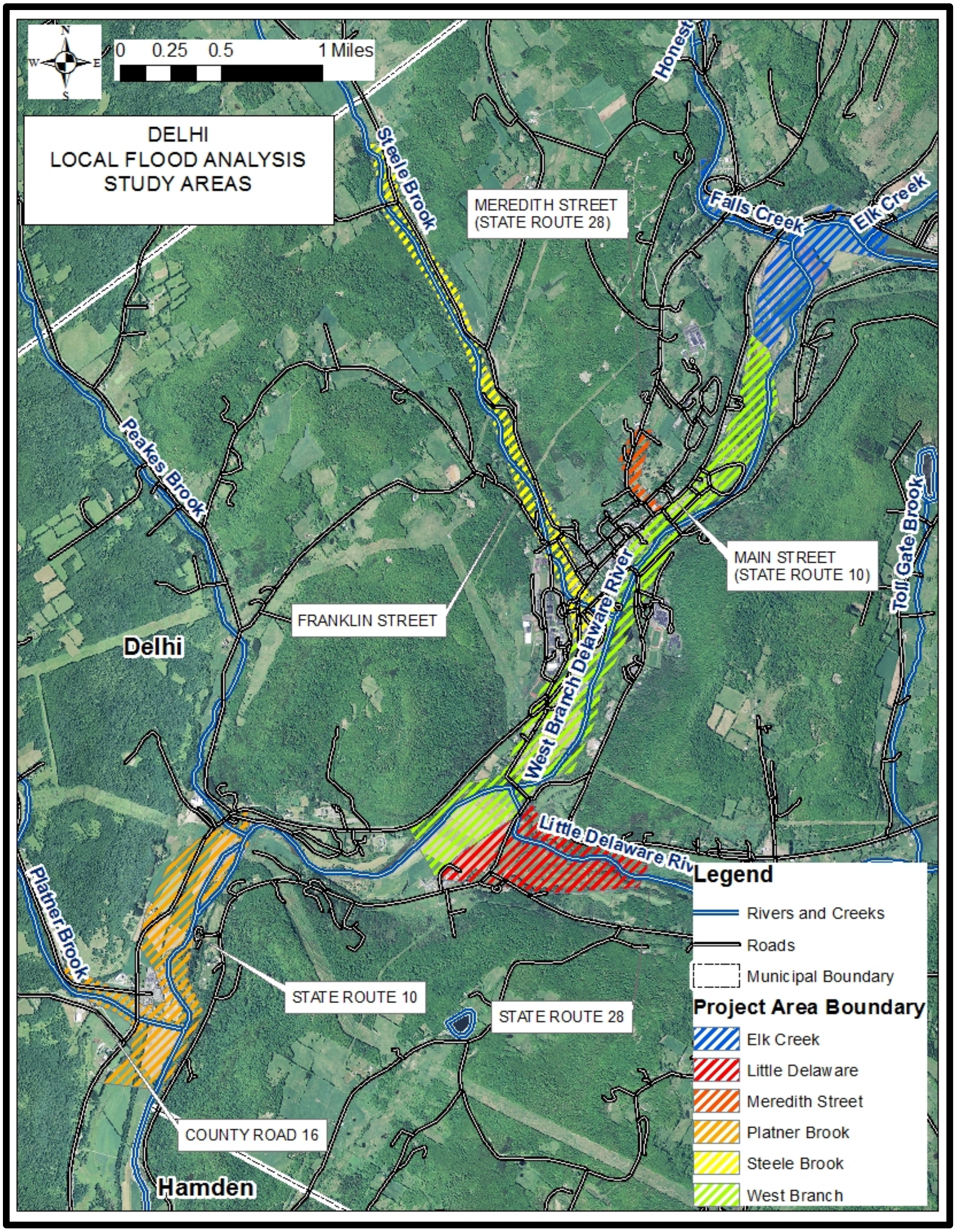


Figure 1 - Exhibit of the Six Study Areas in Delhi's LFA

All study areas are located within the New York City Department of Environmental Protection (DEP) Cannonsville Reservoir's watershed. Since DEP provides drinking water to New York City, the incoming water quality to the Cannonsville Reservoir is an important management strategy. Both study areas are located in an area within the West Branch Delaware River Stream Management Plan (SMP). The SMP is a managerial document that guides water quality preservation and enhancement. There are five long term goals of the SMP: Flooding and Erosion; Water Quality; Aquatic Ecology; and 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 Delhi 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 local, county, state and federal governments to characterize the causes of flooding in Delhi. 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 FC for approval. The FC is a group of individuals, appointed by the Delhi Town Board and Delhi Village Board with technical advisors from Delaware County Soil and Water Conservation District, the Catskill Watershed Corporation and the NYC Department of Environmental Protection. The FC's purpose is to vet and recommend flood mitigation solutions to the Village and Town of Delhi.

An initial public meeting was held to introduce the LFA process to community members and its expected outcome was explained. Forty-two flooding hazards and information about their suspected cause and frequency of occurrence was collected at this meeting and can be seen in Appendix A, Figure A-1. An initial FC meeting was held to collect additional flood hazard locations.

Next, a series of existing hydraulic modeling runs were completed to characterize the identified flood hazards and to document other flood hazards not identified during the initial set of meetings. 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 FC and a joint meeting of the Town of Delhi Board and Village of Delhi 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 FC 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 FC were then 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 Delhi's road map for flood resiliency.

3.1 Data Gap Analysis Summary and Purpose

Data was collected during the "windshield site visit" in October 2015 and from soliciting several data sources. Collected data can be seen in Appendix A, Figure A-2. 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 their streambed, 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 six Study Areas and placed on maps. The FC 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 FC 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 FC 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 FC 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 FC 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.

3.2.1 Rapid Geomorphic Assessment

If needed, a Terrace and Floodplain Terrain (TAFT) map was created for the assessment to understand the relationship between the rivers' (West Branch Delaware River, Steele 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 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 therefore avoiding hazards to existing buildings, roads, and bridges. Findings and results for each TAFT map assessment will be explained within each Study Area's chapter.

3.2.2 FC Meetings and Public Meeting Data Collection

The first public meeting was held on June 22, 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, 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 FC meeting. There were a total of 42 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 assets 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. Such areas occur from a combination of infiltration and surface runoff (sheet flow) where water may accumulate and cause flooding problems generally in concave basins.

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

3.2.3 Water Depth Maps

Hydraulic results were exported from the duplicated HEC-RAS models and converted into water surface elevations 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 represented the depth of water over the topography which was used to create the Water Depth Map. Isolated inundation areas were removed from the Water Depth Maps. 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. Water Depth Maps will be presented in each Study Area's Chapter.

3.2.4 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 cost of benefit achieved by a flood mitigation project by the cost it will take to implement the flood mitigation project. FEMA's Benefit to Cost Analysis software program (version 5.1) 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 (GE), height from GE 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.

4.0 Delhi LFA Watershed General Watershed Characteristics

4.1 Climate

The climate of the Delhi LFA Boundary is very similar to most of rest of New York and is classified as Humid Continental. Delaware County generally experiences seasonable weather patterns characteristic of the northeastern U.S. Average summer temperatures typically range from about 62°F to 67°F (Fahrenheit). Winter high temperatures are usually in the middle to upper 30's°F, with minimum temperatures of 20°F expected (The Weather Channel, 2017).

Precipitation is evenly distributed through the year with eastward moving cold fronts bringing the area's most frequent rain showers. Episodic tropical storms will typically track north from the warmer southern coastline and are responsible for larger rainfall depths. Differences in latitude and topography all have an effect on the climate across the watershed. Moisture rich air moving easterly runs into the Catskill Mountains, which act as a barrier. As the air moves up and over this mountain range, the air slows and cools forming raindrops leading to more rain falling over a shorter distance.

Climate change models predict the continued warming of winter temperatures (3.8° between 1970 and 2000) and summer temperatures (1.0° between 1970 and 2000). The amount of rainfall will become more sporadic leading to more frequent short (one to three month) seasonal droughts broken by large intense rainfall (The Union of Concerned Scientists, 2017). Average annual rainfall depth will increase by as much as 2.5" by the year 2060 (a 5% increase) (Northeast Regional Climate Center, 2017) with higher percentages of the annual rainfall falling during intense storms between short seasonal droughts.

4.2 Geology

The majority of bedrock in the Delhi LFA Boundary is sandstone and shale formed during the Devonian time period some 60 million years ago. Three notable geologic formations make up the UDR watershed; Unadilla Formation, the Slide Mountain Formation and the Lower Walton Foundation.

The surficial geology of the basin is representative of activity during the last ice age. "Surficial geology" is a term to describe the medium that sits on top of the geological bedrock and often is covered by soil. Surficial geology is important to the LFA because often this medium is responsible for sources of water quality pollution. Surficial geology is broken into three broad categories differentiated by the way the surficial geology was created: Glacially-created; Geological bedrock; or alluvial created (transported by flowing water).

The LFA watershed is located in the northern portion of the Appalachian Plateau consisting of a glaciated ridge and valley systems. During the last glacial ice age, the entire watershed was under a sheet of ice and in some areas the ice was over a mile thick. The ice sheet flowed south towards the Atlantic Ocean. The immense weight of this ice scraped the landscape clean of vegetation, broke off weak rock from mountain tops and ridges and began to shape the valley that contains the West Branch Delaware River.

Once the last ice age began to wane, the retreating glaciers left clay, sands and larger stones behind. Large deposits of this material (some hundreds of feet thick) are called moraines. Glacial deposits are also responsible for being the source of the sand and gravels that line Delhi's creeks and river valleys. As the glaciers receded, flowing water carried material out from underneath the glacier or cut through moraines carrying all this rock downhill, leading to the creation of our river valleys as we know them.

4.3 Anthropogenic Activities in the LFA Boundary

The Delhi LFA watershed has undergone notable changes over the last two centuries. First settled in late 18th century, the inhabitants of the Delhi LFA watershed practiced subsistence farming and used the waterways as transportation and drinking water sources. By the late 19th century, the regional economy had diversified with a focus on natural resource development and manufacturing. Businesses such as tanneries, mills, charcoal kilns and quarries sprung up throughout the watershed and their manufactured goods could be more easily transported to larger markets due to proximal railroads (Kudish, 1979). These activities changed the way the landscape looked and the relationship between the land and the water bodies within the watershed. By the late 19th century, roughly 80% to 90% of the original forest was gone (Kudish, 1979) leaving the steep hill slopes barren of mature vegetation that would capture and retain rainfall. With more rainfall hitting the ground and running off the hillsides, more water entered the small creeks draining these highlands surcharging the creek's stability. The creeks eroded in response, becoming deeper, narrower and muddier, resulting in the material that once lined the creeks' bottom and sides to be swept downstream into bigger creeks and eventually into the larger rivers in the Delhi LFA basin. 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.

By the mid-20th century, with the decrease in natural resource intensive businesses and an increase in land conservation practices such as reforestation, the dominant land use became forested area. With the conversion of most of the watershed back to forest, the depth of rainfall running off hillsides reverted back to a depth closer to what occurred pre the late 18th century, i.e. before large swaths of natural resources were disturbed. Despite the increase in forested area, the creeks and rivers that had deepened and narrowed did not return to their previous elevation and dimensions. They remained disconnected from the land they once flooded into.

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 deposit 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 sediments. This often results in higher water surface elevations during flooding events because there is now inadequate space within the river to move floodwaters

Recent anthropogenic activities influencing the creek are infrastructure encroachments into the active floodplain.

5.0 West Branch Study Area

5.1 Data Gap Analysis

5.1.1 Public Flooding Hazards and FC Flooding Hazards

Six (6) flooding hazards were identified by the public within the West Branch Study Area as seen in Appendix Figure A-5. The most common flooding hazard was overbank flooding caused by the West Branch. The characterization of flooding hazards (47 through 50) (i.e. frequency of flood damage, dollar damage, etc.) was explored and captured in the narrative in Section 5.3. Flooding hazard #19 was due to overbank flooding from a ditch impacting a lawn and town road and the FC did not feel this warranted further investigation. The two obstruction flooding hazards (#20 and #21) are caused by gravel bars located near the West Branch and Little Delaware River confluence. Since no buildings are located near these gravel bars the FC did not feel these obstructions caused a flooding hazard and further analysis of these flooding hazards was not completed.

Table 1: Public Flooding Hazards in West Branch Study Area

Overbank	50,49,48,47,19
Obstruction	20,21

5.1.2 Rapid Geomorphic Assessment

The West Branch Study Area contains both the Village of Delhi and Town of Delhi. Their largest commercial and population center, the Village of Delhi, was built along the West Branch Delaware River on its terraces and floodplains. Portions of the Village of Delhi were built on the alluvial fan created by Steele Brook at its junction with the West Branch. An alluvial fan is a fan or cone shaped deposit of sediment crossed and built up by a stream. To characterize the vertical relationship between The Village of Delhi and West Branch Delaware River (i.e. the Village's susceptibility to flooding), a Terrace and Floodplain Terrain Map (TAFT) was developed. A TAFT map compares the river's water surface elevation to the elevations of adjacent landforms. The closer the water surface elevation is to a landform elevation, the more flood-prone the landform is.

The average daily water surface elevation (ADWSE) profile for the Study Area was created from measuring the water surface elevation of the West Branch Delaware River when the 2009 LiDAR survey was completed. The TAFT map in Figure 2 shows two general areas between the West Branch and its floodplains within the Study Area. Beginning at the upstream extent of the Study Area to about 1,000 feet upstream of the Bridge Street Bridge, there is notable low lying floodplain (0.5'-3.5' and 3.5' to 6.5') along the right bank (the light blue color and lighter tans). This low-lying floodplain is constricted starting near the County DPW salt shed with the constriction persisting all the way downstream to the southern end of Depot Street near the State University of New York (SUNY) ball fields. In the area of the ball fields, a wide low lying floodplain exists on the left bank and then the floodplain transitions to the right floodplain downstream of the Price Chopper Plaza. Low lying floodplains are desirable because this allows floodwaters to spill over the top of the bank, reducing the stream's power to cause erosive damages. Between the upstream and downstream low lying floodplains, there are moderately connected floodplains (6.6'-9.5') along the right bank (looking downstream). The left bank appears to be a valley wall (>12.5' above ADWSE) and is not connected to the West Branch's floodwaters. The right bank floodplain is interrupted by high spots (9.6'-12.5' above ADWSE). Typically, these high spots are caused by anthropogenic activities and are referred to as "suspected fill areas". For example, the County DPW salt shed (Fill area "H") is a high spot (>12.5') between a moderately connected floodplain upstream and downstream. Another example of a suspected fill area is at location "C" which is the SUNY ballfields. These ballfields were built on an abandoned dump by filling over the refuse to create level playing fields.

These suspected fill sites cause a hydraulic condition called a constriction during a flood event by forcing a wide area of floodwaters to move through a narrower area. This often leads to water "backing up" which results in higher floodwater surface elevations. One common flood hazard mitigation approach is to model what would happen if these suspected fill sites (high spots) are removed.

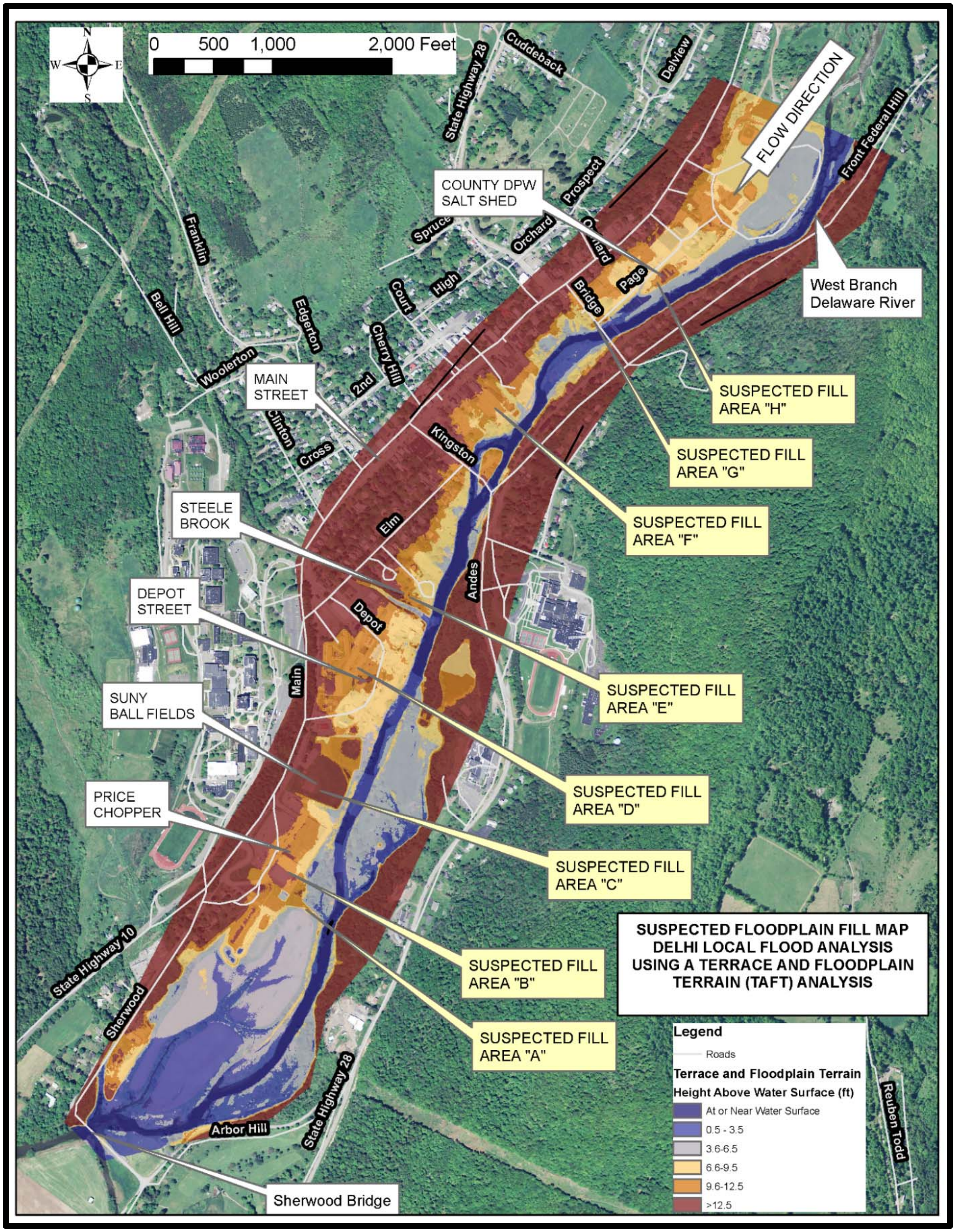


Figure 2: Terrace and Floodplain Terrain Map of West Branch Delaware Study Area

5.1.3 West Branch Delaware Stream Feature Inventory (SFI) Review

The West Branch Delaware Stream Management Plan (SCMP) was reviewed to identify and to understand the conditions that may cause potential flooding hazards or lead to water quality pollution sources. The West Branch Study Area is located entirely within Segment 3 of the SCMP and in management units (MU) 15 to 19 as seen in Appendix A, Figures A-3 and A-4. Management units are defined and delineated by similar geomorphic characteristics which guide specific management unit recommendations. The SCMP notes that in the 7.8 miles of the river (15.6 miles of streambank) within MUs 15 to 19, there were 3.5 miles of eroding streambanks which represent roughly 23% of the streambanks when the survey was completed (2006). These are water pollution sources but the debris (stone and logs) from these sources were not identified by the FC as causing flood inundation hazards. Therefore, no additional SFI information was collected in the West Branch Study Area

5.1.4 Hydraulic and Hydrologic Model Review: Hydrology

The peak discharges for the 10, 25, 50, 100 and 500 year return interval floods used in the West Branch Delaware River's preliminary FEMA HEC-RAS model were developed as part of the County's Flood Insurance Study (#36025CV001B, effective date 6/16/16). 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.

A log-Pearson III flood-frequency analysis was performed on data from the USGS gage in the Village of Delhi for the West Branch Delaware River (USGS gage number 01421900). The peak discharges were then transposed upstream and downstream using the ratio of the drainage areas raised to the 0.73 power. The location of the USGS stream gage (#01421900) is approximately 0.5 miles upstream of the Bridge Street Bridge crossing as seen in Figure 2. This gage replaces an older USGS stream gage that was located 0.9 miles downstream in 1996.

The 2 and 25-year storm intervals were then estimated through the interpolation of exceedance probability versus flow curves. The table below identifies the peak flows for the 2, 10, 25, 50, 100, and 500-year return intervals for the study reach in the HEC-RAS model obtained from FEMA.

Table 2: Flood Frequency versus Discharge Relationships-WB Delaware River

Storms/Floods		Peak Flow (cfs)	Used In Duplicate Model at Section 324676
Return Interval	Exceedance Probability	At USGS gage #01421900	located 0.8 miles upstream of USGS Gage
2-year	0.5	3,995	Discharge Not Used
10-year	0.1	6,399	6,399
25-year	0.04	8,647	8,828
50-year	0.02	8,828	Discharge Not Used
100-year	0.01	9,883	9,883
500-year	0.002	12,372	12,372

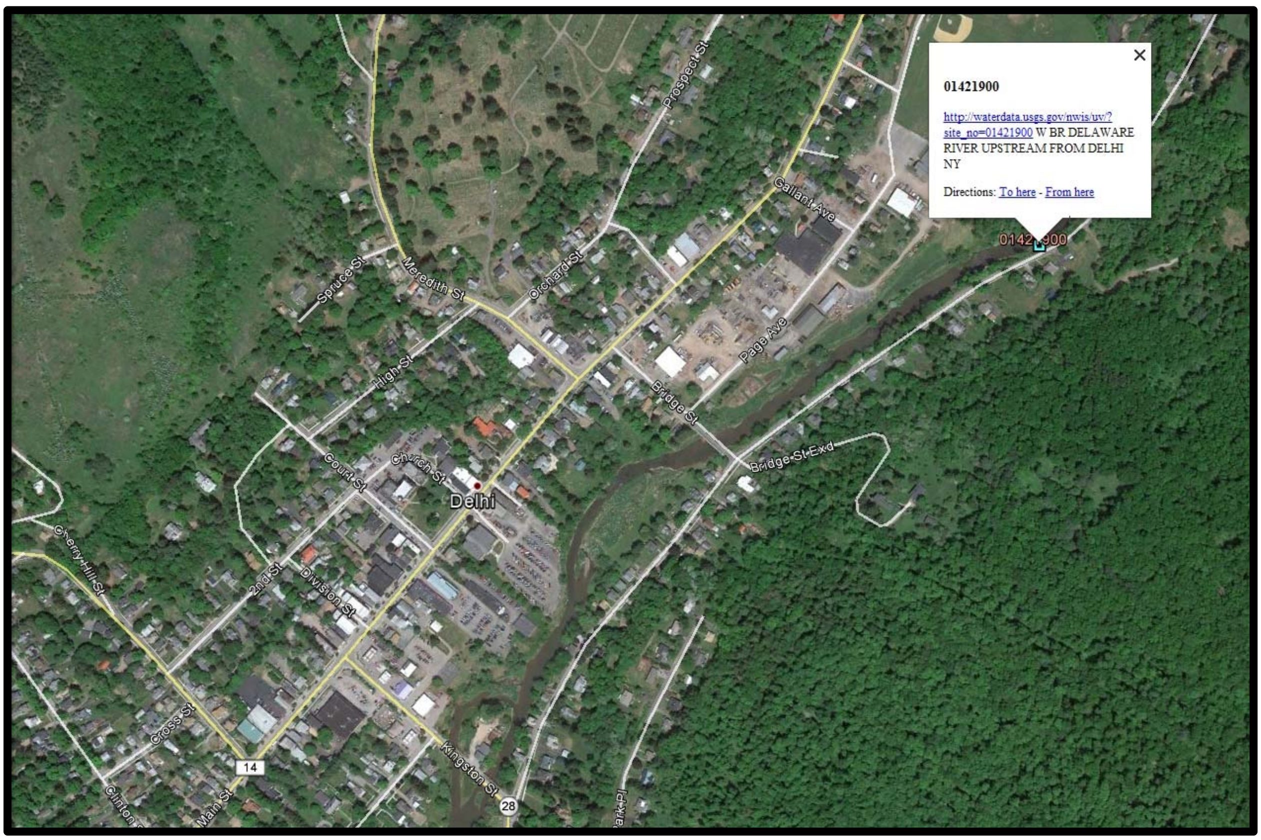


Figure 3: Location of USGS Stream Gage in Delhi

5.1.5 Flooding History

Four of the five highest recorded discharges along the West Branch Delaware River have occurred within the last twenty-one years as seen in Table 3. The highest discharge on record was measured in January 1996 (13,000 cubic feet per second) and was equivalent to a flood between the 200 year to 500 year return interval flood, a very large and infrequent event.

Table 3: Five Highest Recorded Discharges at the Delhi USGS Stream Gage

Date	Discharge (cfs)	Return Interval Flood
01/19/1996	13,000	Greater than a 500year
09/21/1938	8,940	Between a 50-year and 100-year
08/28/2011	8,860	50-year
06/28/2006	8,060	Between a 25year and 50year
11/09/1996	7,000	10-year-25-year

5.1.6 Hydraulic and Hydrologic Model Review: Hydraulics

The West Branch Study Area was mapped using detailed methods to support the effective Flood Insurance Study (FIS) (#36025CV001B, effective date 6/16/16). The area was mapped using the US Army Corps of Engineers hydraulic modeling software program (HEC-RAS). Floodplain elevations used to build the model were obtained in 2009 by LiDAR and stream topography (top of bank to top of bank) was collected in the spring 2012. The model used to map the area was acquired and run on WEC's computers and is referred to as the duplicate model. The duplicate model's results were compared to the FIS's results at locations through the Study Area to ensure replication. These results can be seen in Table 4. The duplicated model appears to replicate the base flood elevations (BFE) in the flood insurance study with most difference being less than 0.04'.

Table 4: Comparison of Base Flood Elevations in FIS to Duplicated Model Results (Elevations in NAVD 88)

Cross Section In Duplicated Model	Location	FIS (ft)	Duplicated Model (ft)
324038	~1.0 mile upstream of Bridge Street	1368.5	1368.53
318875	Bridge Street	1362.7	1362.64
317051	Kingston Street	1361.1	1361.21
315485	Confluence with Steele Brook	1357.3	1357.26
312884	Price Chopper shopping plaza	1349.0	1349.04
309139	700 ft downstream of Little Delaware River confluence	1343.4	1343.4

The first reviewed model 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. The energy grade line slope used for this normal depth was 0.0025 slope which is an acceptable approach for non-backwater flow conditions. The Cannonsville Dam lies between the most downstream cross section and the West Branch Study Area and causes a backwater flow condition as seen by the relative flat 100-year return interval water surface elevation in Figure 4. This dam is located 36.4 miles downstream from the West Branch Study Area and has no impact on the Study Area as seen by the water surface elevation profile that roughly parallels the ground profile between the dam and the Study Area.

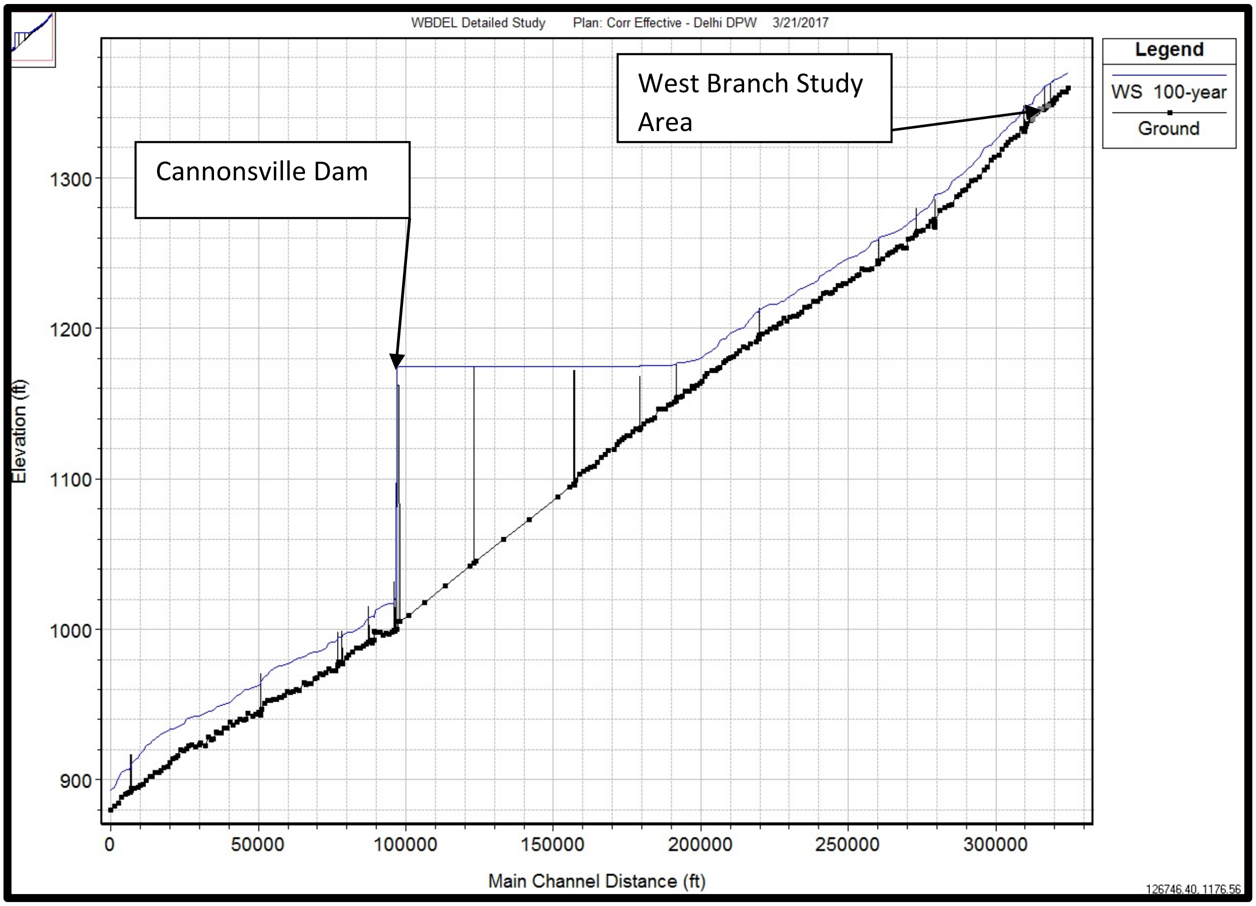


Figure 4: 100-Year Return Interval Profile of West Branch Delaware Duplicate Hydraulic Model

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). Five high water marks were surveyed after the June 28, 2006 flood and can be seen in Table 5 and Figure 5. Four of these marks were upstream of Bridge Street (WBDR-5 through WBDR-8) and one was located at the Price Chopper Plaza. The discharge recorded during this flood was the fourth highest recorded discharge on record (8,060 cfs) which means the 2006 flood was between a 25-year and 50-year flood return interval. In order to calibrate the hydraulic model to the observed high water marks, 2006 flows were estimated at all possible discharge change locations in the hydraulic model by transposition of the flows from locations where flow was measured (at USGS stream gages) to the rest of the studied reach. The estimated discharge in the West Branch Study Area's duplicate hydraulic model at cross section 324676 (the beginning of the model as seen in Table 4) used to calculate a water surface elevation that matched the high water mark elevation was 13,987 cfs. The estimated discharge was much higher than the measured discharge (8,060 in Table 3). This means that either the measured discharge was wrong or the calibration of the model in the West Branch Study Area did not accurately predict the measured high water marks. It was assumed that the duplicate model was the best tool to calculate water surface elevations so the duplicate model was used for the LFA.

Table 5: High Water Marks (Elevations in NAVD 88)

High Water Mark ID	Elevation (NAVD 88)	Latitude	Longitude
WBDR-4	1348.7	42°16'0.5"N	74°55'15.6"W
WBDR-5	1361.3	42°16'44.4"N	74°54'43.2"W
WBDR-6	1363.6	42°16'51.6"N	74°54'25.2"W
WBDR-7	1363.6	42°16'51.6"N	74°54'32.4"W
WBDR-8	1364.0	42°16'55.2"N	74°54'21.6"W

Figure 5: Location of High Water Marks in Delhi during June 2006 Flood

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. There was little ineffective area used to model the obstructions caused by the Kingston Street Bridge and the Bridge Street Bridge. A representative cross section of ineffective flow can be seen in Figure 6. The ineffective flow areas are the space landward of the green vertical lines. Bridge infrastructure block the flow of water which causes hydraulic ineffectiveness (contraction and expansion losses) that are typically modeled using ineffective flow areas. The FIS (effective date June 2016) did not mention any reasoning to why this wasn't used. It was assumed that the duplicate model was the best tool to calculate water surface elevations so the duplicate model was used for the LFA.

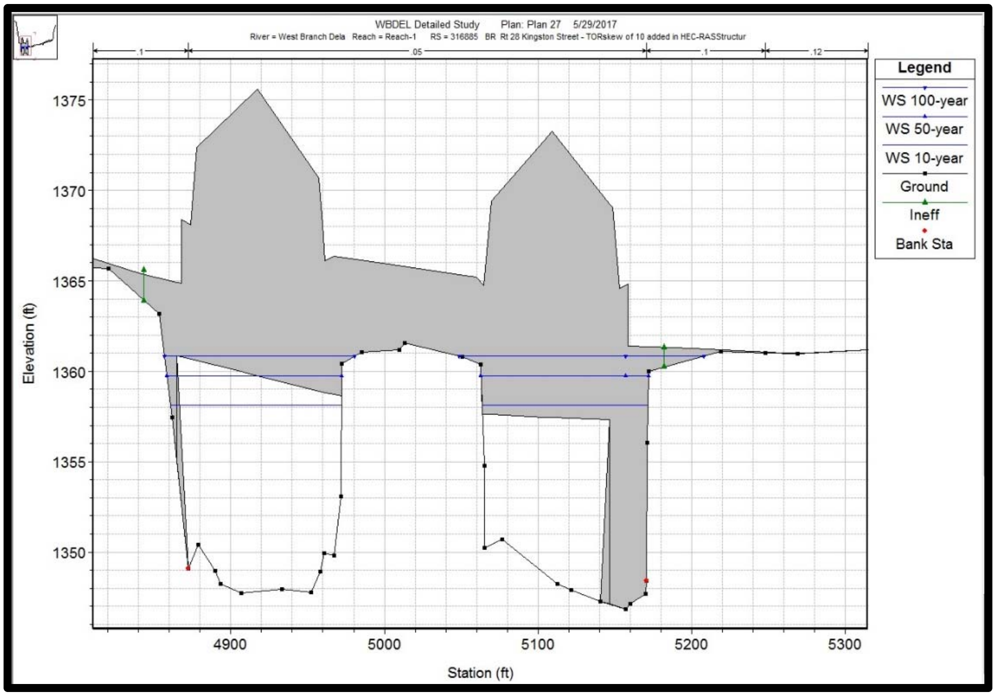


Figure 6: Representative Cross Section of Ineffective Flow in the West Branch Study Area

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 in 2012 and spliced into the 2009 LIDAR information to create the cross sections used in the duplicate hydraulic model. The FC did not note any change in the topography at any of the sections in the model. There has not been a notable flood event after the cross section survey data was collected that would cause a notable change in channel topography.

5.1.6 Water Quality Assessment Data Review

As described in section 5.1.2, a notable percentage of stream bank was actively eroding when the SCMP was developed in 2006. These eroding banks are sources of water quality pollution. During the windshield survey that was completed on April 5th 2016, several petroleum tanks in Delhi were observed. Unanchored tanks can pose a water quality problem if their contents leak and a public safety concern since tanks floating in water can strike something, leading to a rupture. Also observed were several commercial garages that service cars/trucks and fuel stations where larger volumes of chemicals could be stored.

5.1.7 Flood Damage Prevention Code

Delhi's Floodplain Damage Prevention Code was authorized on May 16th, 2016. It defines the statutory authority and purpose of floodplain management within the Village. The code is comprehensive and clearly defines what activities are allowed within a delineated FEMA floodplain and FEMA floodway and provides specific criteria for various types of development activity. The ordinance meets or exceeds the minimum federal standards for development within a delineated FEMA floodplain or Floodway as defined by the National Flood Insurance Program.

The code, in accordance with the NFIP criteria, allows filling of the 100-year (1% annual chance flood) floodplain fringe along streams that were studied by detailed methods and include a floodway. As written, encroachments such as fill in the floodplain fringe are allowed if the encroachments do not result in a rise in the 100-year (Base Flood Elevation) of more than 1.0 feet.

This essentially allows filling of the floodplain fringe to the limits of the Floodway. As such, the Village may want to consider adopting a more restrictive floodplain fringe encroachment code that lowers the threshold of Base Flood Elevation increase. This action could improve the Community Rating System score for the Village and Town.

5.1.8 Identified Data Gaps and Proposed Field Methodology

The review of existing data discussed in section 5.1 identified several gaps that cannot fully explain existing or potential flood hazards or allow for informed mitigation solutions to be developed. As such, the following questions and associated discussion/answers to data gaps issues (identified by LFA section) are as follows:

1. Is the duplicate FEMA hydraulic model sufficient to model flood mitigation activities? Refer to Section 5.2.1.
2. Which flood events cause the most damage to buildings? Refer to section 5.2.2
3. Are there any other water quality pollution sources that have not been identified in the SCMP? Refer to section 5.2.3.
4. What impact does the gravel bar at the confluence between Steele Brook and the West Branch Delaware River have on flooding conditions? Refer to section 5.2.4?

5.2 Data Gap Analysis Results

After a review of existing data, there were several questions (section 5.1.8) regarding the causes of or damage from flooding hazards that could not be sufficiently answered. There were also questions that could not be sufficiently answered to quantify the efficacy of flood mitigation strategies. This insufficiency, was referred to as a “Data Gap” and to fill the gap to answer each question, additional data was collected in the field. The methodology and results of data collected to fill the gap are described in subsections of section 5.2.

5.2.1 Corrected FEMA Hydraulic Model

Using the TAFT map as described in section 5.1.2 and from discussions in several FC meetings, three preliminary groups of flood mitigation activities were identified. The first group was natural resources, the second group was infrastructure (for example, replacing a bridge) and the final group was property protection (raising first floor elevations, flood proofing, etc.).

To understand the efficacy of the first group of flood mitigation activities, a hydraulic model is needed to calculate the drop in water surface elevations between the existing conditions and proposed conditions. The higher the drop means there is less water that would submerge buildings causing structural or utility damage. To correctly model this group of flood mitigation activities, additional stream cross sections may need to be added to the duplicate hydraulic model to accurately capture the change in geometric conditions that are common with this group of flood mitigation activities such as excavation. The second group also requires a hydraulic model to understand if changing the dimensions of a bridge crossing would reduce floodwater elevation. Additional cross sections may need to be required to calculate the change in geometric conditions at the stream crossing. The final third group of flood mitigation activities (property protection) does not need additional stream cross sections.

Per the TAFT map as described in section 5.1.2 and from discussions in several FC meetings, a total of seven flood mitigation strategies were identified as part of the natural resource flood mitigation group. To understand the efficacy of each strategy, additional cross sections were added to the duplicate flood mitigation model. For each cross section, geometry of the floodplains (stream bank top, landwards) was obtained from the 2009 LiDAR data. Geometry for the active channel (stream bank top to stream bank top) was obtained using the interpolation tool embedded in the HEC-RAS hydraulic modeling software platform. Manning’s “n” values were developed using values from the

FEMA flood insurance study (effective date 6/2016) and site observations. The cross section locations can be seen in Figure 7.

Table 6: Comparison of Base Flood Elevations in Duplicated Model to Corrected Model (Elevations in NAVD 88)

Cross Section In Duplicated Model	Location	Duplicated Model (ft)	Corrected Model (ft)
324038	~1.0 mile upstream of Bridge Street	1368.53	1368.54
318875	Bridge Street	1362.64	1362.80
317051	Kingston Street	1361.21	1361.22
315485	Confluence with Steele Brook	1357.26	1357.07
312884	Price Chopper shopping plaza	1349.04	1349.14
309139	700 ft downstream of Little Delaware River confluence	1343.4	1343.40

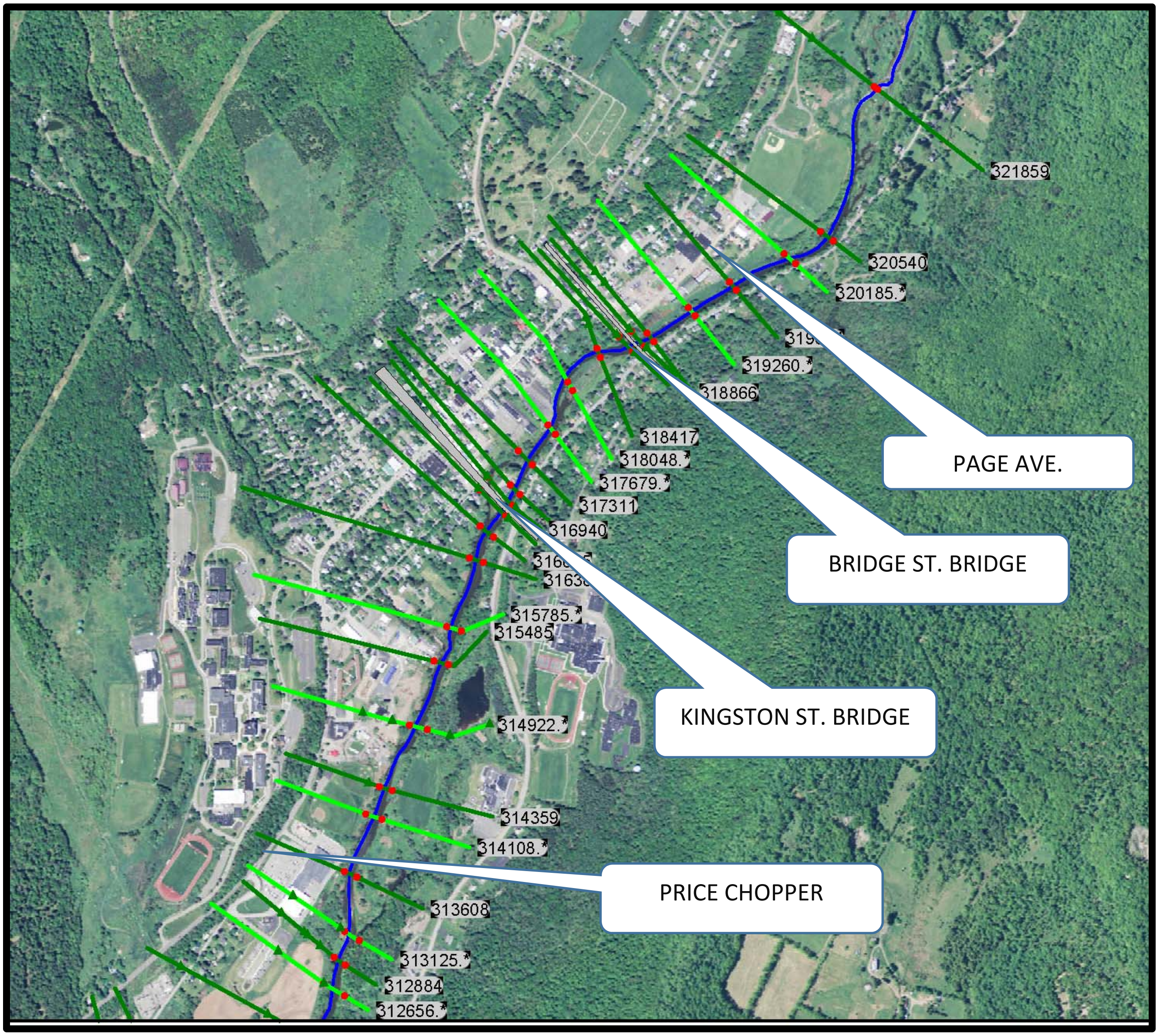


Figure 7: Added Cross Sections (In Lighter Green Color) to Correct the Duplicate Hydraulic Model

5.2.2 Water Depth Maps

Using the results of the corrected FEMA hydraulic modeling results, several exhibits were created that captured the depth of water at various flood events. These are useful exhibits that begin to characterize the location of where overbank flooding occurs from swollen rivers and how often it occurs. Water depths for the 10-year, 25-year, 50-year, 100-year and 500-year flood return interval floods are presented in Appendix A and notable observations are discussed below

<u>10-Year Return Interval Flood (Figure A-6):</u> Floodwaters are generally contained within the West Branch except near Page Avenue between FEMA sections 318665 and 320540 where shallow water (0.0'-2.0') can be observed on Page Avenue around 12 buildings. There is one critical facility (the County Department of Public Works) which begins to see floodwater around its storage facility.

25-Year Return Interval Flood (Figure A-7): Notable increase in flooding near Page Ave (water depths often exceeding 2.0'). Water inundation is observed between the Kingston Street Bridge and Bridge Street Bridge (FEMA sections 317311 and 318665) where there are several homes along the south bank shoreline and two buildings on the north bank (near the telephone building).

50-Year Return Interval Flood (Figure A-8): Flood depths are now exceeding 3.0' along Page Avenue with floodwater depths increasing between FEMA sections 317311 and 318665. With water depths exceeding 3.0', it is assumed the DPW facility is inaccessible. Several buildings (private homes) along Bridge Street have shallow water (0.0'-1.0') around them. This means that Bridge Street is under water and would be closed resulting in Kingston Street as the only proximal crossing over the West Branch. Water is observed over Depot Street between sections 314359 and 316635 where several commercial outbuildings are inundated.

100-Year Return Interval Flood (Figure A-9): Water depth around the DPW facility is between 4.1' and 6.0' which is a water depth that would cause considerable damage to the facility and the surrounding commercial buildings and private homes. The buildings parallel with Bridge Street are now surrounded by 3.0' of water as well as the buildings on the north and south shore between FEMA sections 317311 and 318665. The commercial property on the island at Kingston Bridge has 0.0' to 2.0' of water around it as well as the Price Chopper at section 313608.

500-Year Return Interval Flood (Figure A-10): In general, the 500-year water depths are notably higher than the 100-year water depths. The approaches to Kingston Street Bridge are under water (0.0'-2.0') which means this crossing would be closed as well as the Bridge Street Bridge, resulting in no stream crossing across the West Branch.

5.2.2 Building Flooding Damage Evaluation

Flooding typically damages buildings by submerging utilities (furnace, hot water heater, etc.) and/or submerging living space (dry wall, flooring, etc.). To quantify this flooding damage, a field team identified the ground elevation (GE) around buildings within the FEMA Special Flood Hazard Boundary (SFHA also referred to as the 100-year floodplain boundary). Buildings within this boundary are considered flood prone. Next, the field team measured the height from the GE to the first floor elevation using a standard foot and tenths tape measure. The foundation type was noted (slab, crawl space, finished basement, unfinished basement). It was assumed unfinished basements contained utilities and finished basements contained living spaces. Utilities were considered at the first floor elevations (or higher) for buildings with a crawl space and were considered at the first floor elevation for buildings built on a slab. Characteristics of each building can be seen in Appendix B, Figure B-1 through B-2.

Using the results from the hydraulic model discussed in section 5.2.1, during the 100-year flood event, dozens of buildings had flood water elevations over the buildings' first floor elevations or higher than the GE. The first floor elevation is defined as the first floor with living space. An unfinished basement was considered below the building's first floor elevation. It was also assumed if a building had an unfinished basement, the basement contained utilities and if floodwater elevation was higher that the GE, these utilities would be damaged.

All the buildings that met these criteria were contained within the Village of Delhi. General comments on the 100-year, 50-year and 10-year flooding event are listed below.

100-Year Flood (Refer to Figure 7)

The highest concentration of buildings with floodwater depths over first floor elevations are located between the Kingston Street Bridge and the upstream extent of the Village of Delhi. The buildings that have the most damage over first floor elevations are concentrated on the east streambank of the West Branch between the river and State Route 28. These buildings have finished basements that are vertically close to the river and therefore have 3.5' or more of water over them during the 100-year flood. The largest concentration of buildings with unfinished basements where the 100-year flood water elevation is higher than the GE is located between Kingston Street Bridge and Bridge Street Bridge. The second highest cluster of buildings with flood damage are located north by northeast of Bridge Street along Page Avenue.

<u>50-Year Flood (Refer to Appendix A Figure A-11)</u>

Most of the homes or businesses with water over their first floor elevations during the 50-year flood event occur between Bridge Street and Kingston Street on the south bank (between 1.0'-3.5') and on Page Avenue, notably the County DPW building.

<u>10-Year Flood (Refer to Appendix A Figure A-12)</u>

There are only seven homes with a first floor water depth greater than 0.5' within Delhi during this flood event.

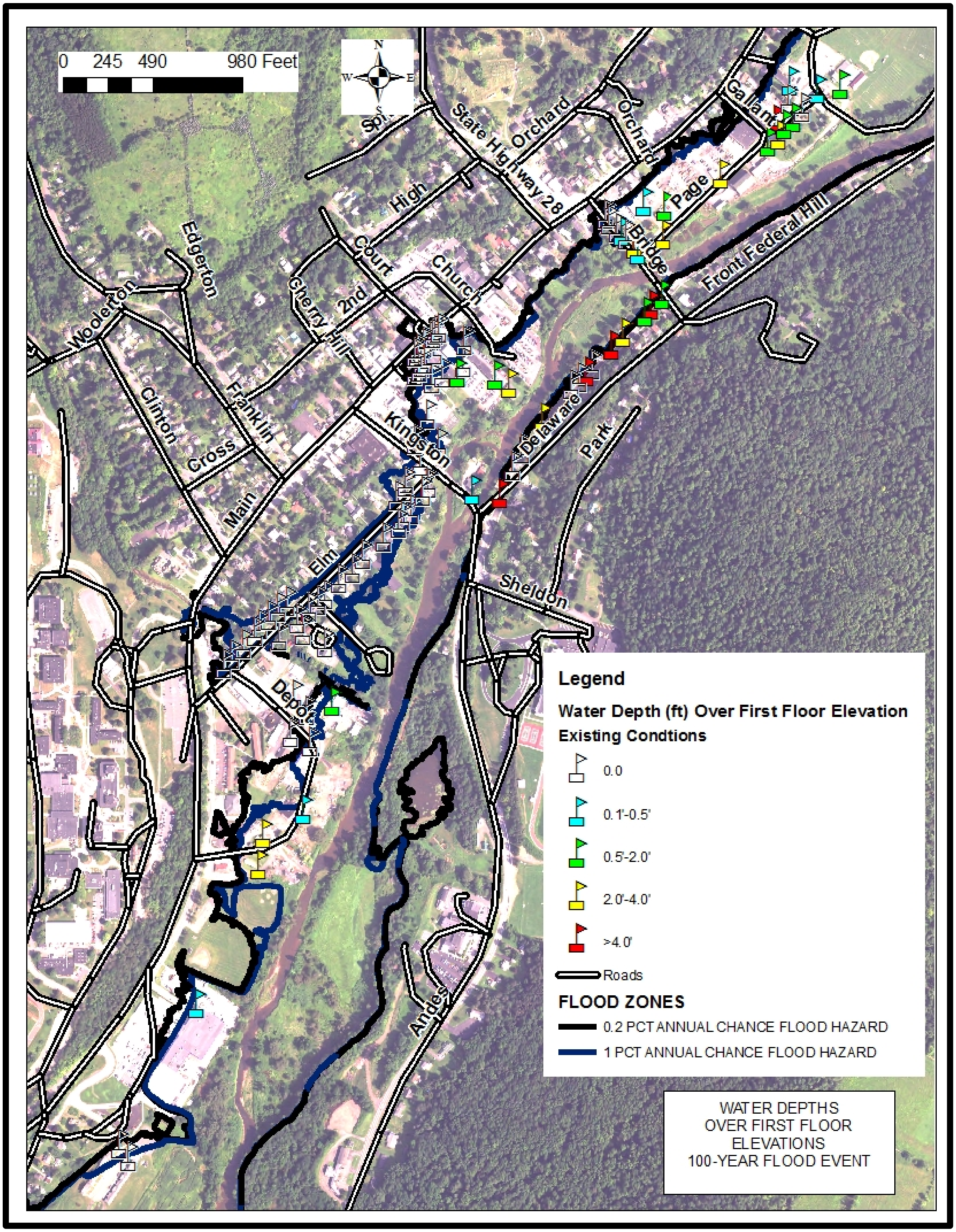


Figure 8: Water Depths over First Floor Elevations

5.2.3 Water Quality Pollution Sources.

Per the windshield survey completed in August 2015, several potential sources of water pollution were observed. A field visit was completed in April 2016 and a total of 16 petroleum tanks were mapped. The tanks include both anchored and unanchored tanks as can be seen in Figure 9. Commercial garages that service trucks or cars were also mapped as potential pollution sources since it was assumed these buildings contained a larger volume of harmful chemicals than the typical residential building. Gas stations were also mapped as potential water pollution sources. Their geospatial coordinates can be seen in Appendix A Figure A-13.

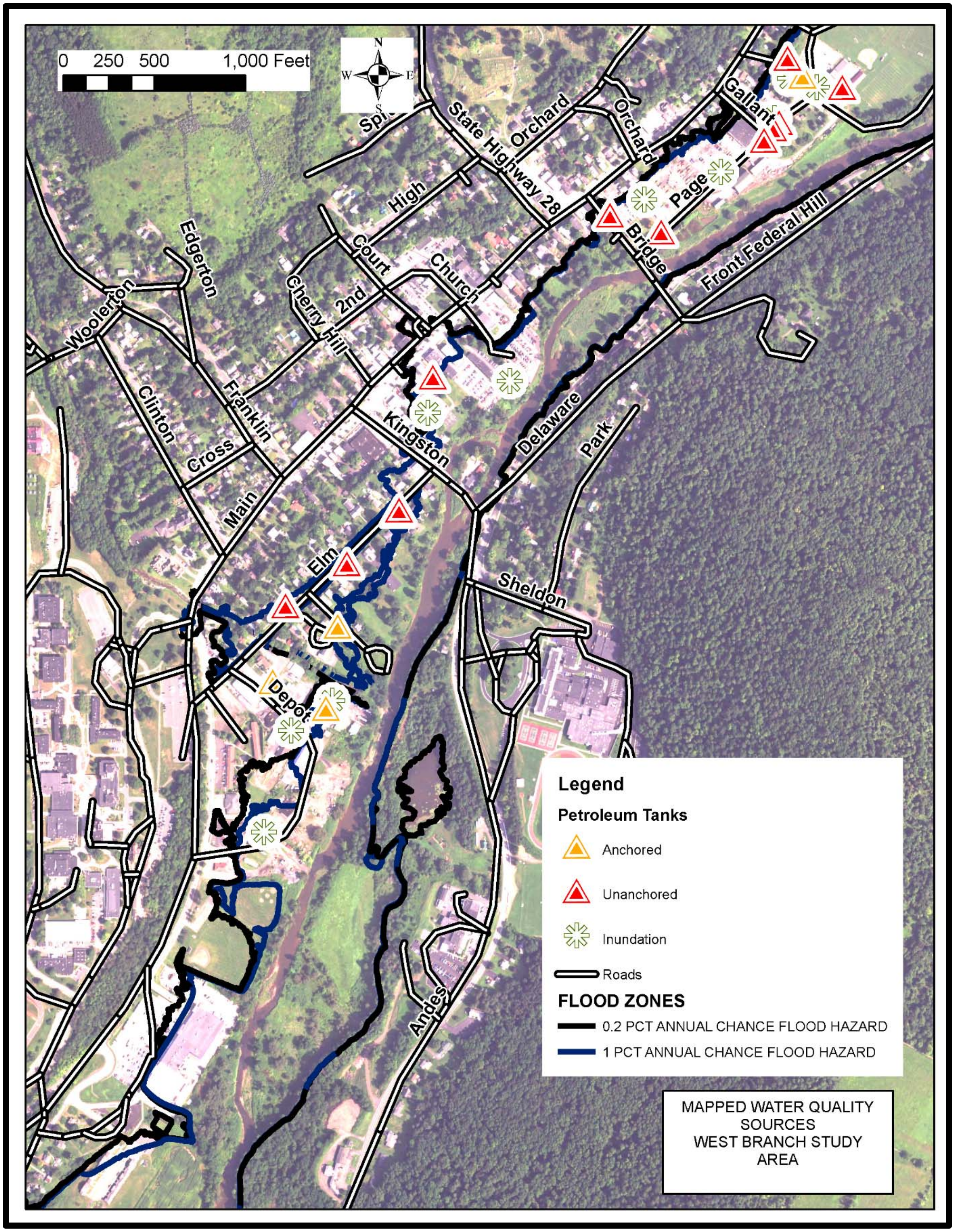


Figure 9: Mapped Water Quality Sources West Branch Study Area

5.2.4 Gravel Bar Obstruction

A gravel bar has formed at the confluence between the West Branch and Steele Brook. The gravel bar begins at the confluence and extends downstream for several hundred feet. There was a concern among the FC that this gravel bar obstructs flows during flooding events on the West Branch. An obstruction impedes the flow of water often resulting in the water being forced to go around the obstruction. When this occurs, a corresponding reduction of waterway area results in a rise of water surface elevations upstream of the constriction during flooding conditions. This gravel bar was not included in the duplicate effective model (i.e. the model that was used to create FEMA's flood maps for Delhi).

To determine if this gravel bar was an obstruction, a topographic survey was completed in October 2016 using total station methods that measured the active channel geometry (stream bank top to stream bank top). The active channel geometry was merged with floodplain geometry (stream bank top, landward) that was mapped in the 2009 LiDAR efforts to form one new cross section (315588) as seen in Figure 10. Manning's "n" values were obtained from the FEMA FIS (effective date June 2016) and from observations. These cross sections were used to correct the duplicate hydraulic model by adding more recent data to the model and to better capture the gravel bar's dimensions. The gravel bar's height was approximately 1' to 1.5' higher in the most recent survey data than the topographic data in the duplicate model as seen in Appendix A, Figure A-14, which compares the river profile of both data sets.

The 2-year, 10-year, 25-year, 50-year, 100-year and 500-year discharges were run in the corrected model. An assumption was made that the gravel bar did not erode during a flood event meaning that the size of the gravel bar obstruction did not change during a flood event. This is a conservative assumption (worst case scenario) because the size and elevation of the gravel bar may deform during a flood event. To determine if this gravel bar was an obstruction, the topography at the gravel bar was lowered to match interpolated channel topography between the adjacent upstream cross section and adjacent downstream cross section. This created the "proposed condition" model. The same discharges were run in the proposed model and the results for two flooding events are summarized in Table 7. If the corrected model's water surface elevations were higher than the proposed model condition than the gravel bar causes an increase in flood water elevations. It appears the gravel bar causes a 0.4' rise during the 100-year flood.

Table 7: Comparison of Base Flood Elevations in Duplicated Model to Corrected Model (Elevations in NAVD 88)

Section	10-year Flood Event		100-year Flood Event	
	Corrected Model	Proposed Model	Corrected Model	Proposed Model
316635	1358.60	1357.78	1360.60	1359.95
316385	1358.39	1357.48	1360.36	1359.64
315588	1354.96	1355.55	1357.03	1357.45
315485	1355.33	1355.33	1357.26	1357.26

Figure 10: Added Cross Sections in Model

5.3 Flood Mitigation Plan Summary

Seven (7) mitigation plans were vetted by the FC to improve flood resiliency in Delhi. Each plan was evaluated using the US Army Corps of Engineers HEC-RAS hydraulic modeling software package (HEC-RAS). The corrected RAS model was used for the baseline (existing conditions). For each plan, a conceptual design was developed which included changes in channel or floodplain topography. These changes were inputted into the corrected HEC-RAS model creating the proposed conditions model. Each plan had its own proposed conditions model and the HEC-RAS program was run for each plan. The results were compared to the existing conditions results. To quantify the changes caused by each plan's conceptual design, water surface conditions were compared for each proposed condition to the existing condition water surface elevation. It was assumed the greater reduction in water surface elevation, the higher the benefit was to Delhi.

To measure the change in water surface elevations, five locations were selected in the West Branch Study Area. The locations were chosen due to their proximity of flood damage infrastructure (as seen in Figure 11). The governing assumption for preliminary vetting of each plan's efficacy was the greater reduction in water surface elevation during flood events, the less flood damage would occur at these buildings. Mitigation plan implementation opportunities and constraints were developed to inform if the mitigation plan was feasible using FC input. If the water surface elevation reduction was modest and a plan's implementation constraints outweighed the plan's opportunities, then the plan was not furthered for a Benefit to Cost Analysis (BCA).

Of the seven preliminary solutions, three were advanced to calculate a benefit to cost analysis (BCA) using FEMA's BCA software (Version 5.1). Table 8 lists all seven plans that were vetted during FC meetings. To simplify mitigation plan nomenclature, the Plan IDs as discussed in FC meetings were changed to a chronological numbering system.

For the plans that had BCA analysis completed, several additional prioritization metrics were used to rank the mitigation plan. Using the BCA as the sole prioritization plan does not adequately capture the importance of a flood mitigation plan. For example, FEMA's BCA does not assign a benefit to water pollution sources mitigated, nor does FEMA's BCA document the importance of future economic growth to the community. Therefore, additional prioritization metrics to qualify flood mitigation plans were used and explained in Table 9.

5.3.1 Water Quality Pollution Source Mitigation

Water quality protection was used as one of the additional prioritization metrics. There were two groups of water quality pollution sources that were defined using floodwater elevations and certain building elevations. The first water quality pollution group was residential buildings with a finished basement. It was assumed that household chemicals, paints and other materials could be stored in the finished basement. Also included in the first group of water quality pollution sources were the following type of buildings: A garage that repaired vehicles, buildings used for light manufacturing, service stations, pharmacy and auto supply retail stores. It was assumed these buildings contained chemicals and other materials that would contribute to undesirable water quality conditions. If the floodwater elevation exceeded the first floor elevation of any of these buildings, then the building was considered a water quality pollution source.

The second group of water quality pollution sources were buildings with unfinished basements. It was assumed household chemicals, paints and other materials could be stored in the unfinished basement. If floodwater elevation exceeded the ground elevation next to the building, it was assumed floodwaters would also be entering the unfinished basement causing a water quality pollution source. If a proposed flood mitigation plan reduced floodwater elevations beneath the first floor elevation for the first group of buildings or the height of adjacent grade for the second group of buildings, the water quality pollution source was considered mitigated.

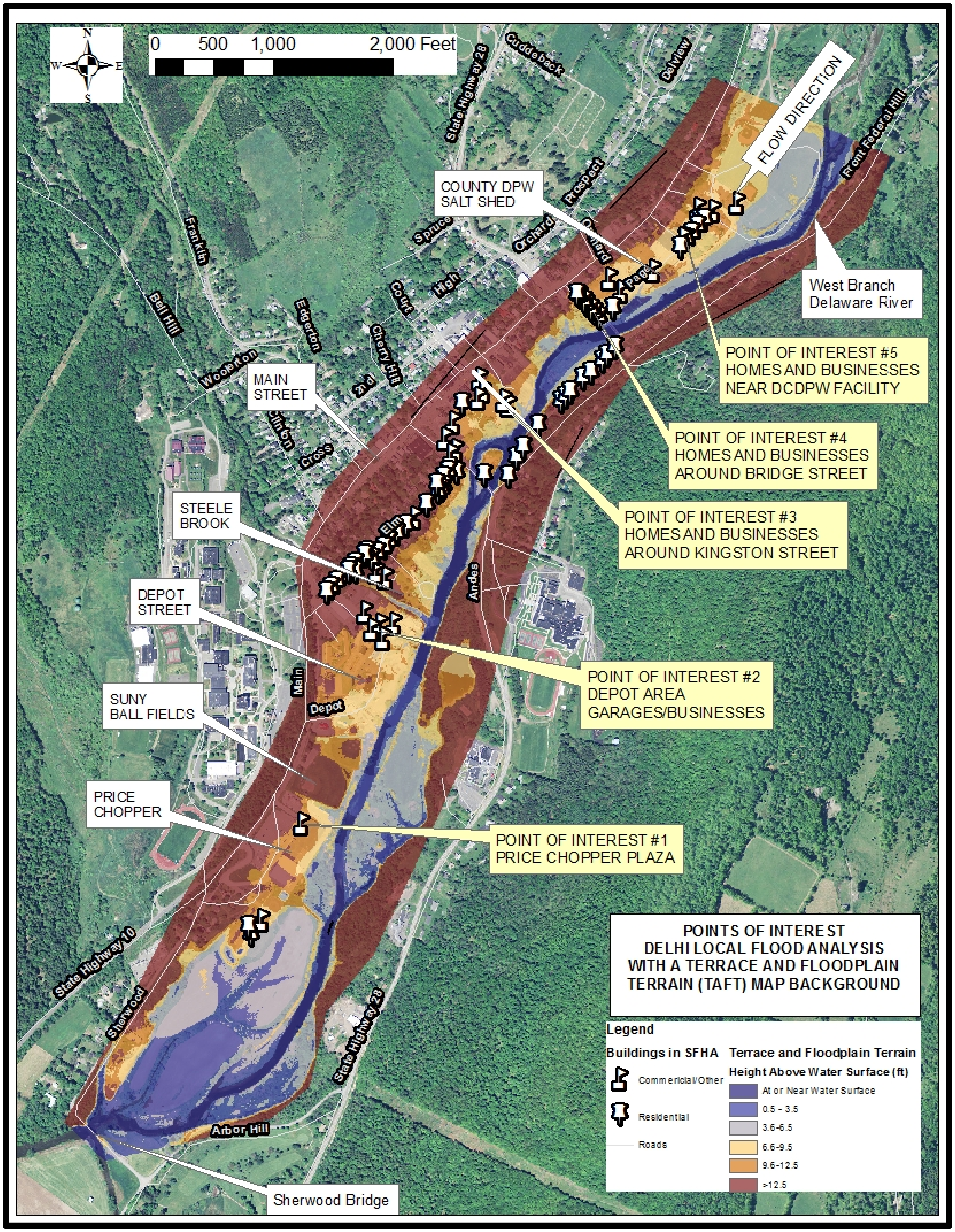


Figure 11: Points of Interest with TAFT Map

Table 8: List of Preliminary Mitigation Solutions

LFA Mitigation Plan #	FC Meetings Plan ID	Mitigation Plan Description	Hydraulic Analysis Performed?	Benefit Cost Analysis Performed?
1	WB3A (8/24/16)	Remove berm near Price Chopper	Yes	Yes
2	WB3B (8/24/16)	Lower floodplain upstream of County DPW salt shed and remove salt shed	Yes	No
3	WB3D (8/24/16)	Lower floodplain for the entire County DPW facility	Yes	No
4	WB3F (8/24/16)	Lower floodplain to 2-year flood level, between Kingston and Bridge Streets, average width 100'. Reshape island at Kingston Street bridge	Yes	No
5	WB3C (2/9/17)	LFA Mitigation Plan #1 and remove SUNY ball Fields	Yes	No
6	WB3J (2/9/17)	LFA Mitigation Plan #1 and lower floodplain to 2-year flood level at Depot Street. Remove two outbuildings.	Yes	Yes
7	WB3L (2/9/17)	LFA Mitigation Plan #9 and lower floodplain to 2-year flood level between Kingston Street bridge and Bridge street bridge.	Yes	Yes

Table 9: 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

5.3.2 Flood Mitigation Plan #1: Remove Berm near Price Chopper Plaza

Summary: This plan would feature the removal of a relic earthen berm located near the Price Chopper Plaza on State Route 10 as seen in Figure 13. Per discussions with the FC, this berm was originally built to protect an industrial facility which has been completely removed. This earthen berm causes a notable constriction in the floodplain from 400' upstream of the berm to 100' at the berm. As shown in Figure 13 the 100 year water surface elevation does not overtop this feature, so this large flood event is forced through the constriction caused by the berm. This constriction causes floodwaters to back up as seen in Figure 12, with a notable increase in the water surface profile upstream of the berm. The berm would be excavated to an elevation that matched the upstream and downstream floodplain elevation. Excavated material would be hauled off site. This flood mitigation project is considered a flood damage prevention action because it will reclaim floodplain and lower flood water elevations.

Hydraulic Results: The water surface elevation during the 100-year return interval flood drops notably when the berm is removed as observed in Figure 12. The berm is located at cross section 312884 as seen in Appendix A Figure A-16. The water surface drops three feet immediately upstream of the cross section and a water surface reduction is observed 2,300 feet upstream near the confluence of Steele Brook and the West Branch. The reduction in 100-year flood water surface elevations extends upstream for such a significant distance due to the relatively flat gradient of the West Branch (channel slope is 0.002) between the berm and Steele Brook.

Table 10: Comparison of Existing and Plan #1 Water Depths in Feet

	25 Year Flood			100 Year Flood		
Point of Analysis	Existing	Plan #1	Difference	Existing	Plan #1	Difference
POI #1	1351.45	1350.71	-0.74	1354.59	1352.83	-1.76
POI #2	1355.89	1355.89	0	1357.07	1356.83	-0.24
POI #3	1360.28	1360.28	0	1361.42	1361.42	0
POI #4	1361.64	1361.64	0	1362.59	1362.59	0
POI #5	1363.26	1363.26	0	1364.09	1364.09	0

Table 11: Number of Buildings Protected by Plan #1

Return Interval Flood	Number of Inundated Buildings		Number of Fully Protected Buildings
	Existing	Plan #1	
10-Year	12	10	2
50-Year	26	26	No Change
100-Year	36	34	2

Benefit to Cost Ratio: The cost of Plan #1 is estimated to be $159,600 (including engineering costs, permitting costs, etc.) and this details of the estimate can be seen in Appendix A Figure A-43. Using the FEMA's BCA version 5.1 short form, the preliminary benefit to cost ratio was 2.43 (Table 12).

Table 12: Plan #1 BCR Results

Number of Structures / Work Item	Benefits	Costs
2 (damages eliminated)	$387,424	
Construction, materials		$125,500
- Engineering/Design/Survey (12%)		$15,060
- Contingency (15%)		$19,000
TOTALS	**$387,424**	**$159,560**
Benefit to Cost Ratio (BCR)	**2.43**	

Implementation Challenges and Opportunities: The proposed flood mitigation plan will need to acquire a permanent easement for two privately held parcels (171.18-5-2.11 and 171.18-5-2.12). Roughly a half an acre would need to have a permanent easement to allow construction to be completed and to prevent any future fill being placed in this area.

Funding Sources: This project qualifies for funding under the Delaware County's Soil and Water Conservation District (DCSWCD) Stream Management Program. DCSWCD will be the lead for funding opportunities in partnership with other agencies. The preliminary BCR score of 2.43 exceeds the typical minimal threshold of 1.0 for submission of a grant for FEMA hazard mitigation sources.

Water Quality Protection: The reduction of water surface elevation at the 100-year flood (2.9') removes one building from inundation eliminating this water quality pollution source.

Table 13: Water Quality Protection Benefits Plan #1

Buildings That Could Create a Water Quality Pollution Source Removed From Inundation		
10-Year	50-Year	100-Year
0	0	1

Prioritization:

Table 14: Prioritization Score for Plan #1

Priority Metric name	Score	Numerical Value
Benefit to Cost Ratio	High	5
Water Quality Protection	Low	1
Community Cohesion Preservation	High	5
Ease of Obtaining Permits for Proposed Solution	High	5
Economic Impact	High	5
Ease to Acquire Funding	High	5
Ease to Acquire Easements	Moderate	3
Level of Town Effort To Implement Plan	Moderate	3
Total Score		32

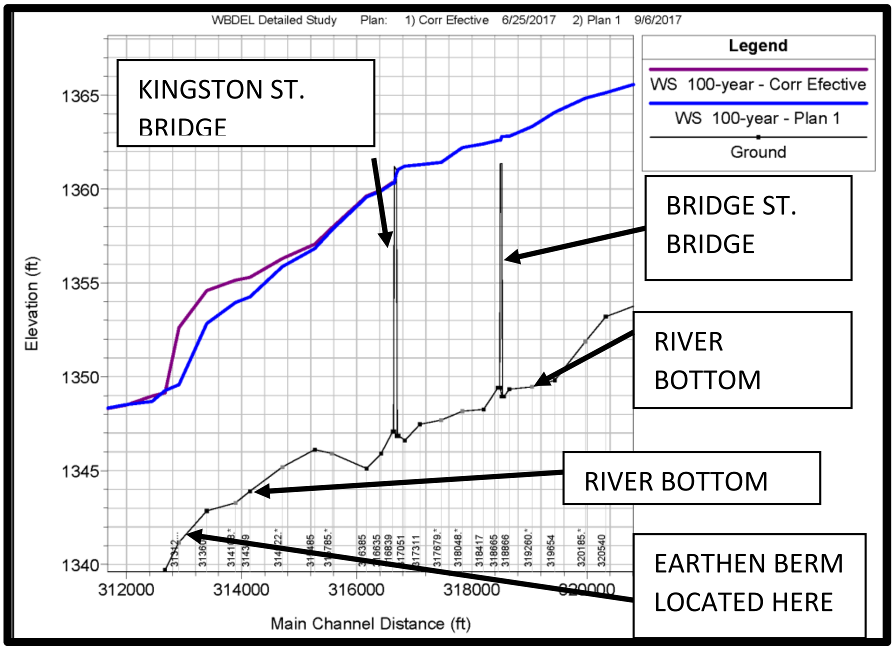


Figure 12: Water Surface Profile: Existing Conditions and Proposed Conditions

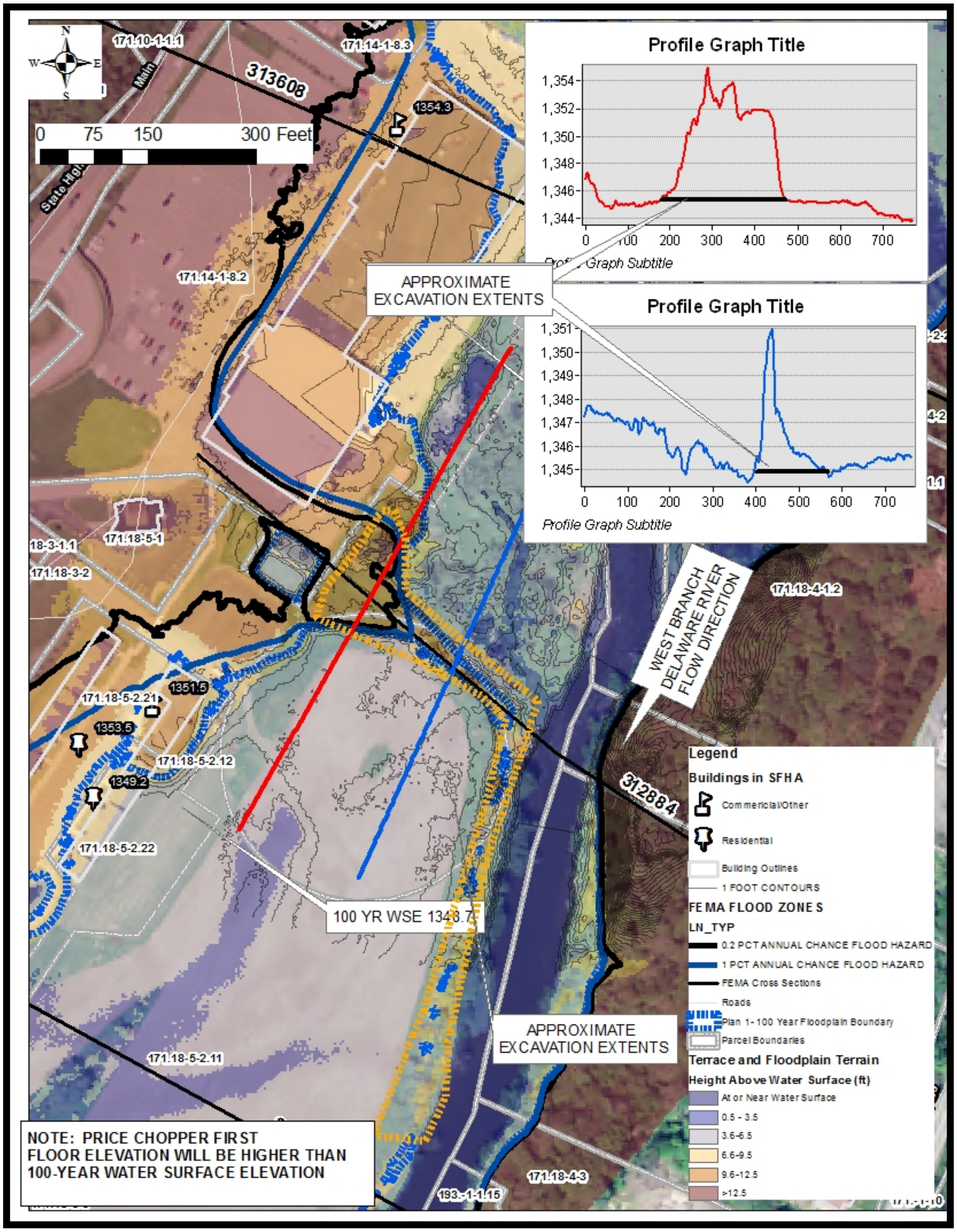


Figure 13: Conceptual Layout of Plan 1

5.3.3 Flood Mitigation Plan #2: Lower floodplain upstream of County DPW salt shed and remove salt shed

Summary: Per Figure 11 on Page 37, there are several buildings north of Bridge Street that have floodwater higher than their first floor elevation or highest adjacent ground (for buildings that have unfinished basements where mechanics could be stored). This is the highest concentration of flood prone buildings in the West Branch Study Area with buildings experiencing flood damage at moderately intense flooding (Appendix A, Figure A-12, the 10-year return interval flood). This area also includes the County's Department of Public Works (DPW) building which is a critical facility. To understand if floodwater elevations would decrease by increasing the floodplain area available to pass floodwaters, a floodplain bench was added into the corrected hydraulic model creating the proposed condition model. The proposed limits of the floodplain bench are shown in plan view in Figure 15 and in section view in Figure 14. The existing ground in Figure 14 is in brown with the proposed ground in black. The average width of the bench is 100' with an average depth of 3'. This bench removes the area of fill at the DPW salt shed as seen in Figure 15. The area of fill is observed by the dark brown color which forms an island around the lighter brown colors (elevations that are lower to the river).

To accommodate the wider floodplain (the floodplain bench) the Bridge Street Bridge crossing was widened which would require the removal of two residential homes. If left unchanged, the sudden constriction of floodwater width from the proposed floodplain bench into the narrower bridge crossing would offset any gain the floodplain bench would have provided.

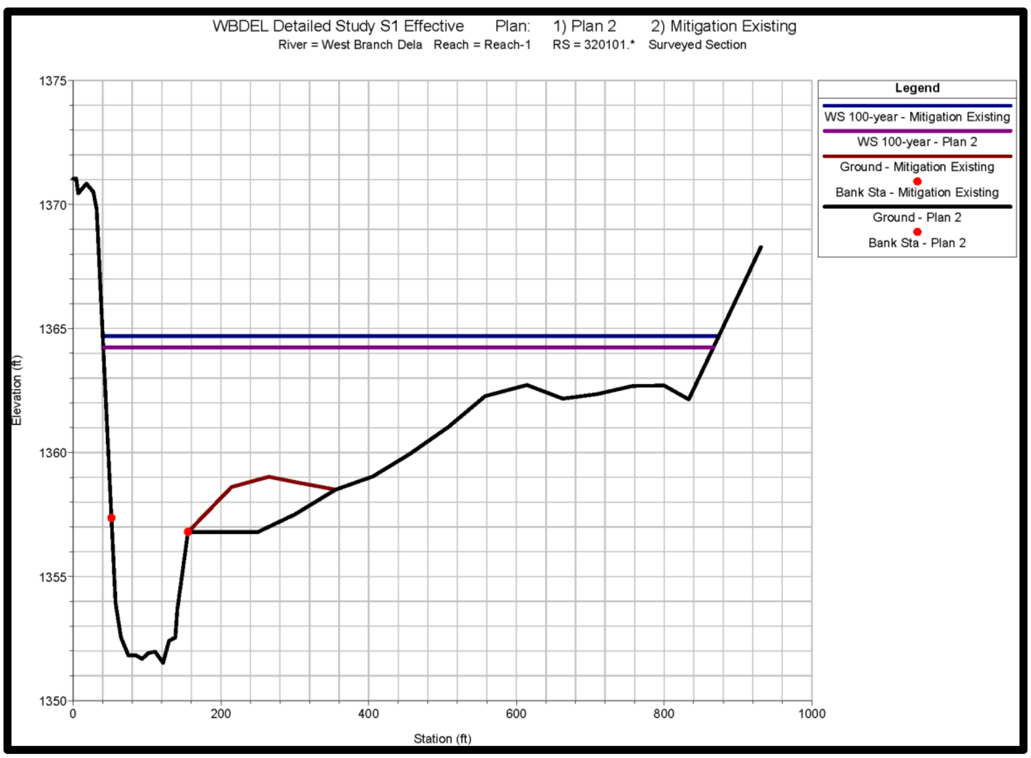


Figure 14: Typical Section View of Plan #2

Hydraulic Results: The proposed changes showed modest gains in floodwater reduction at the 25-year and 100-year flood events with a reduction of 0.4' at both flood stages as seen in Table 15. This benefit would be experienced by the homes and businesses near Point of Interest #5 (POI#5) and not downstream. Table 16 shows one building was completely removed from flood inundation during the 100-year flood. This means the buildings around POI#5 would still experience flooding damage despite the increase in allowable floodwater area. The flooding damage would be less than existing conditions but a large increase in flood damage reduction is not achieved because water levels would still be higher than most of the buildings' first floor elevations. The cost of Flood Mitigation Plan #2 was considered to be high given the modification to Bridge Street Bridge, the relocation of the DPW salt shed and amount of excavation and stabilization that would be needed to construction the floodplain bench. Due to the high construction cost and the low reduction of flood damage, the FC decided Plan #2 should not be furthered for a BCA.

Table 15: Comparison of Existing and Plan #2 Water Depths in Feet

	25-Year Flood			100-Year Flood		
Point of Analysis	Existing	Plan #1	Difference	Existing	Plan #1	Difference
POI #1	1351.45	1351.45	0	1354.59	1354.59	0
POI #2	1355.89	1355.89	0	1357.07	1357.07	0
POI #3	1360.28	1360.28	0	1361.42	1361.42	0
POI #4	1361.64	1361.62	-0.02	1362.59	1362.59	0
POI #5	1363.25	1362.81	-0.44	1364.07	1363.65	-0.42

Table 16: Number of Buildings Protected by Plan #2

Return Interval	Number of Inundated Buildings In West Branch Study Area		Number of Fully Protection Buildings
	Existing	Plan #2	
10-Year	12	12	No Change
50-Year	26	26	No Change
100-Year	36	35	1

Benefit to Cost Ratio: Not Applicable; mitigation solution not furthered.

Implementation Challenges and Opportunities: Not Applicable; mitigation solution not furthered.

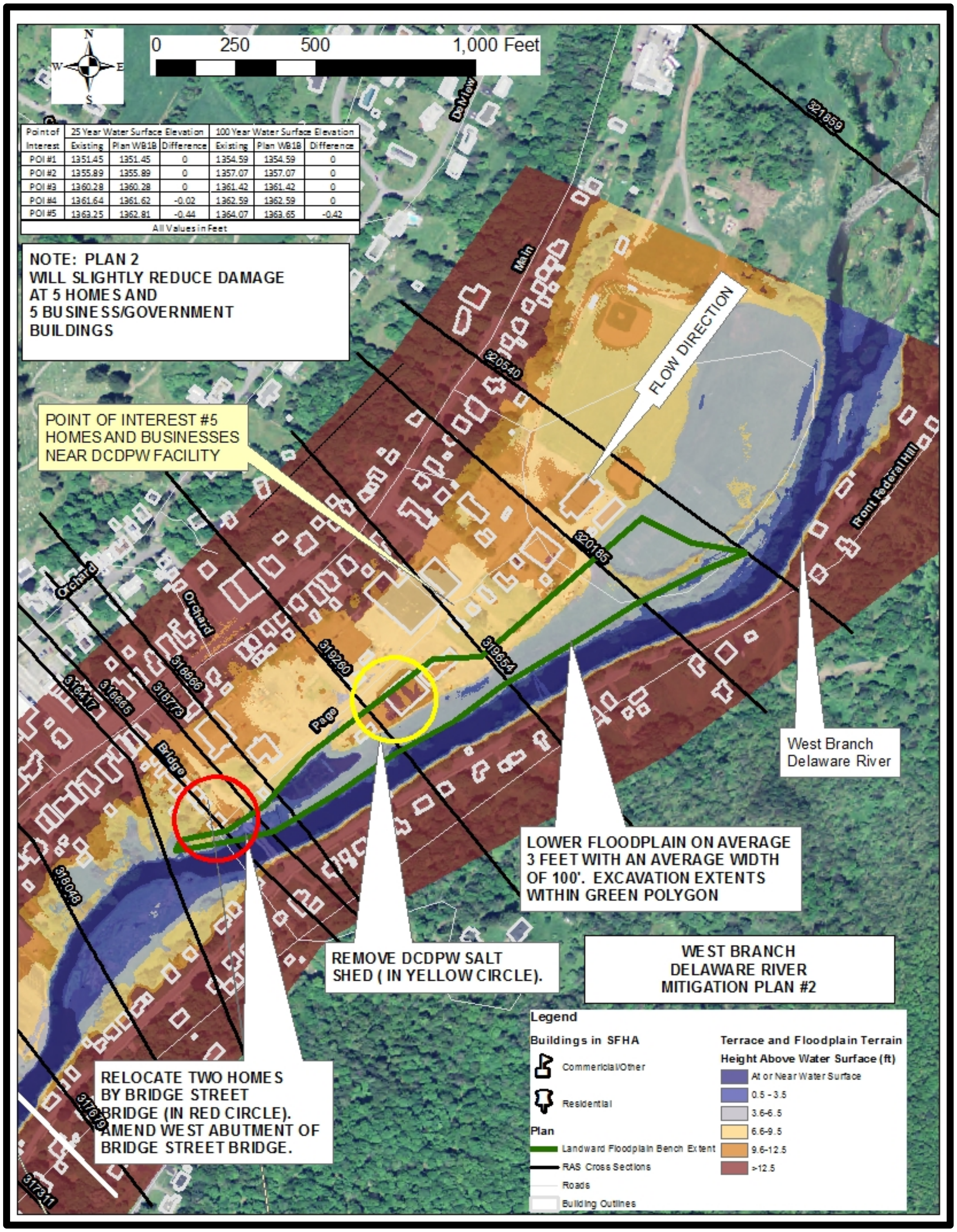
Funding Sources: Not applicable; mitigation solution not furthered.

Water Quality Protection: The reduction of water surface elevations only removed one building completely from inundation as seen in Table 16. This building was not defined as a water quality pollution source so no water quality pollution benefits were gained as seen in Table 17.

Table 17: Water Quality Protection Benefits Plan #2

Buildings That Could Create a Water Quality Pollution Source Removed From Inundation		
10-Year	50-Year	100-Year
0	0	0

Prioritization: Not applicable; no mitigation solution developed.



Point of Interest	25 Year Water Surface Elevation			100 Year Water Surface Elevation		
	Existing	Plan WB1B	Difference	Existing	Plan WB1B	Difference
POI #1	1351.45	1351.45	0	1354.59	1354.59	0
POI #2	1355.89	1355.89	0	1357.07	1357.07	0
POI #3	1360.28	1360.28	0	1361.42	1361.42	0
POI #4	1361.64	1361.62	-0.02	1362.59	1362.59	0
POI #5	1363.25	1362.81	-0.44	1364.07	1363.65	-0.42
All Values in Feet						

Figure 15: Conceptual Layout of Plan #2

5.3.4 Flood Mitigation Plan #3: Lower floodplain for the entire County DPW facility

Summary: Due to the limited results of Plan #2 which showed that a relatively large flood prevention project (the excavation of a floodplain bench) did not provide adequate protection to the DPW facility (a critical facility), Flood Mitigation Plan #3 was proposed. This plan assumed the DPW facility (buildings, parking, etc.) would be relocated out of the flood-prone area. A larger floodplain bench would be excavated in the footprint of this facility to understand if maximizing the volume available to convey floodwater would lower floodwater elevations for the adjacent property owners. The average width of the floodplain bench was 400' and the average excavation depth is 3.0' as seen in Figure 16. The existing topography is shown by the brown line while the proposed topography is shown in the black line. The buildings are removed (the black rectangle) as seen in Figure 16. The proposed concept can be seen in plan view in Figure 17. The green hatch is the ineffective flow area (the area in the model not available to convey flood flow).

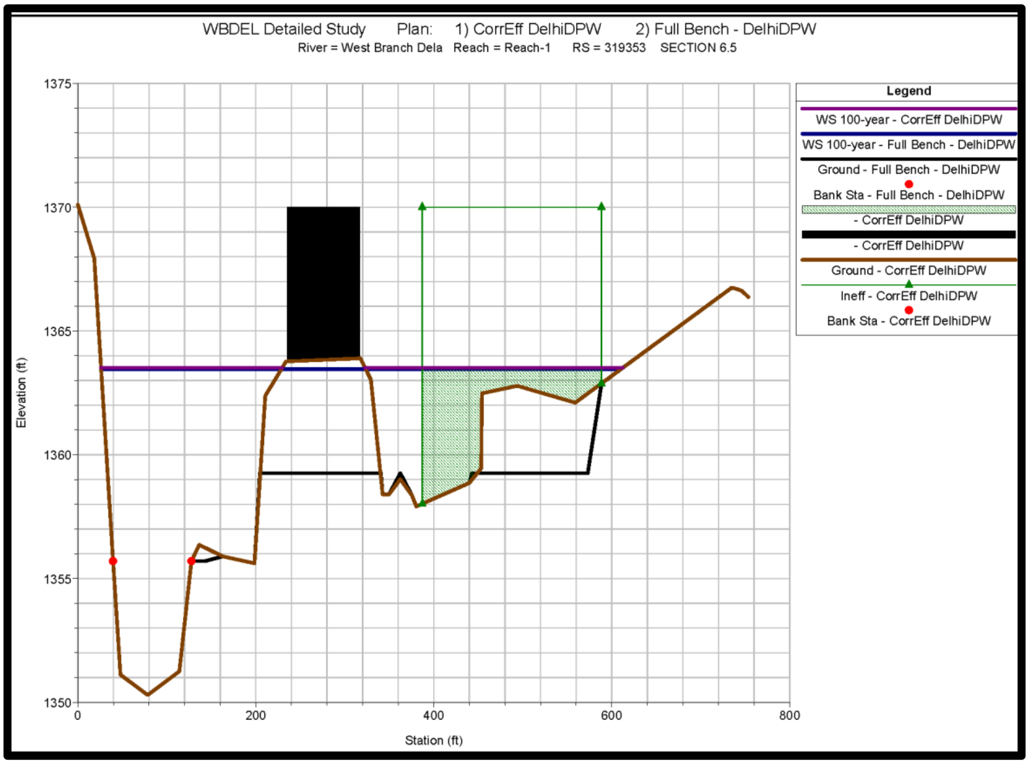


Figure 16: Typical Section View of Plan #3

Hydraulic Results: The proposed changes showed modest gains in floodwater reduction at the 25-year and 100-year flood events with a reduction of 0.45' during the 25-year flood and 0.56' reduction at the 100-year flood as seen in Table 18. This benefit would be experienced by the homes and businesses near Point of Interest #5 (POI#5) and not downstream. Table 19 shows one building was completely removed from flood inundation during the 100-year flood. This means the most buildings around POI#5 would still experience flooding damage. The flooding damage would be less than existing conditions but a large increase in flood damage reduction is not achieved because water levels would still be higher than most of the buildings' first floor elevations. The cost of Flood Mitigation Plan #3 was considered to be high given the relocation of the entire DPW facility and large amount of excavation and stabilization that would be needed to construction the floodplain bench. Due to the high construction cost and the low reduction of flood damage, the FC decided Plan #3 should not be furthered for a BCA.

Table 18: Comparison of Existing and Plan #3 Water Depths in Feet

	25-Year Flood			100-Year Flood		
Point of Analysis	Existing	Plan #1	Difference	Existing	Plan #1	Difference
POI #1	1351.45	1351.45	0	1354.59	1354.59	0
POI #2	1357.08	1357.08	0	1357.95	1357.95	0
POI #3	1360.28	1360.28	0	1361.42	1361.42	0
POI #4	1361.64	1361.64	0	1362.59	1362.59	0
POI #5	1363.4	1362.95	-0.45	1364.31	1363.75	-0.56

Table 19: Number of Buildings Protected by Plan #3

Return Interval	Number of Inundated Buildings In West Branch Study Area		Number of Fully Protection Buildings
	Existing	Plan #3	
10-Year	12	12	No Change
50-Year	26	26	No Change
100-Year	36	35	1

Benefit to Cost Ratio: Not Applicable; mitigation solution not furthered.

Implementation Challenges and Opportunities: Not Applicable; mitigation solution not furthered.

Funding Sources: Not applicable; mitigation solution not furthered.

Water Quality Protection: The reduction of water surface elevations only removed one building completely from inundation as seen in Table 20. This building was not defined as a water quality pollution source so no water quality pollution benefits were gained as seen in Table 20.

Table 20: Water Quality Protection Benefits Plan #3

Buildings That Could Create a Water Quality Pollution Source Removed From Inundation		
10-Year	50-Year	100-Year
0	0	0

Prioritization: Not applicable; mitigation solution not furthered.

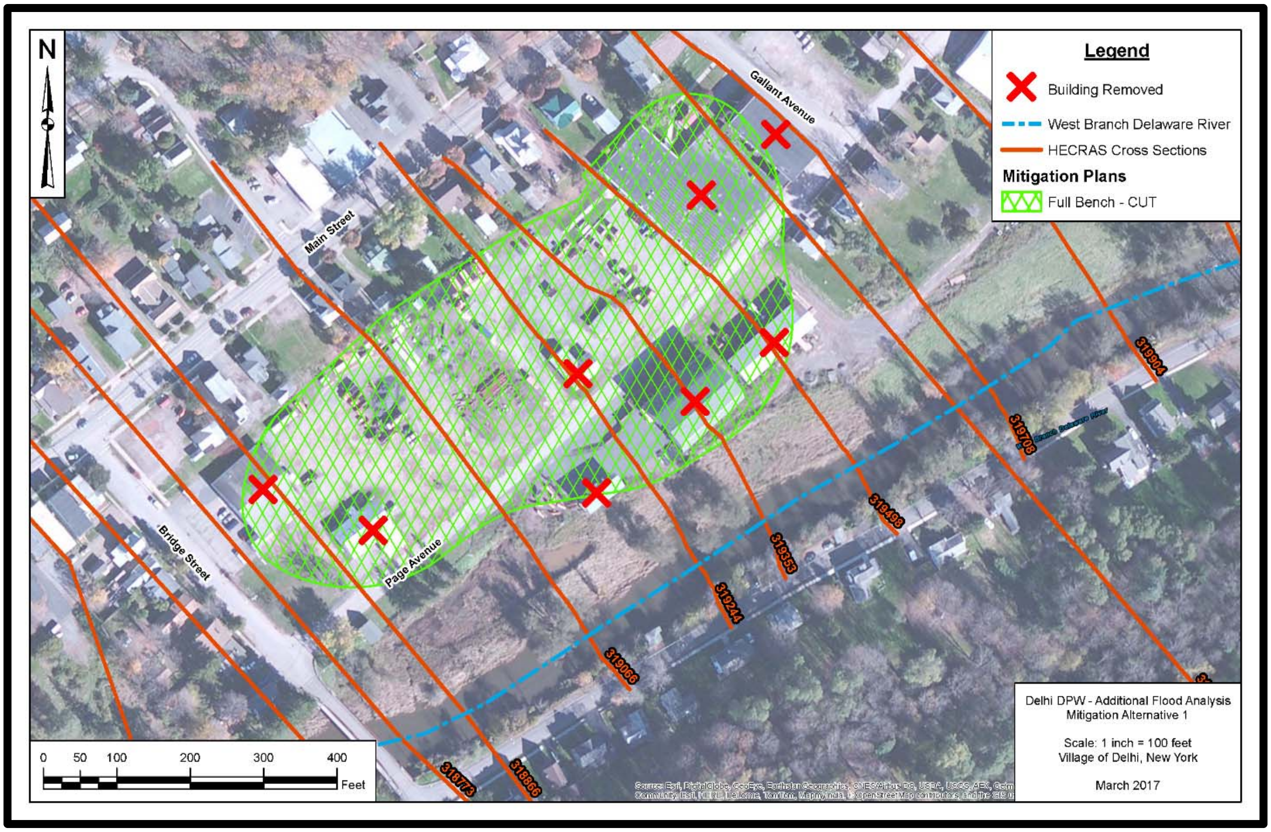


Figure 17: Conceptual Layout of Plan #3

5.3.5 Flood Mitigation Plan #4: Lower floodplain to 2-year flood level, between Kingston and Bridge Streets, average width 100'. Reshape island at Kingston Street Bridge.

Summary: The most flood prone buildings are located between Kingston Street Bridge and Bridge Street Bridge as seen in Figure 8 on Page 30. These buildings are mostly located on the east bank of the West Branch, with fewer located on the west bank. Inundation of the first floor elevations or the ground elevation (for buildings with unfinished basements) begins at relatively frequent flooding events (25-year return interval flood). A flood prevention project (floodplain bench) was developed proximal to these buildings to increase the volume available to convey floodwaters leading to a decrease in floodwater elevations.

An exhibit of the conceptual layout of this plan can be seen in Figure 19. The TAFT map in Figure 11 on page 36 shows there are low lying floodplain areas (blue coloring) interrupted by higher terraces (higher terraces in darker brown coloring, lower terraces in lighter brown coloring). This means that the low lying floodplain could have been filled in by human activity to form these higher terraces, an activity which commonly results in higher floodwater elevations. The proposed concept would remove these high terraces to a consistent elevation with the low lying floodplain, creating the floodplain bench which is delineated with the green line in Figure 19. A typical section of the floodplain bench is shown in Figure 18. Figure 19 also shows an island at Kingston Street Bridge which consists of higher terraces on which a commercial property is located. The island forms an obstruction from the transition of the floodplain bench through the bridge. This obstruction would reduce the benefit gained from floodplain bench so as part of mitigation plan #4, the commercial property would be removed, the island's elevation would be lowered and the floodplain bench would be carried through cross sections 317051 and 316940 as seen in Figure 19. A typical section of this can be seen in Appendix A, Figure A-15.

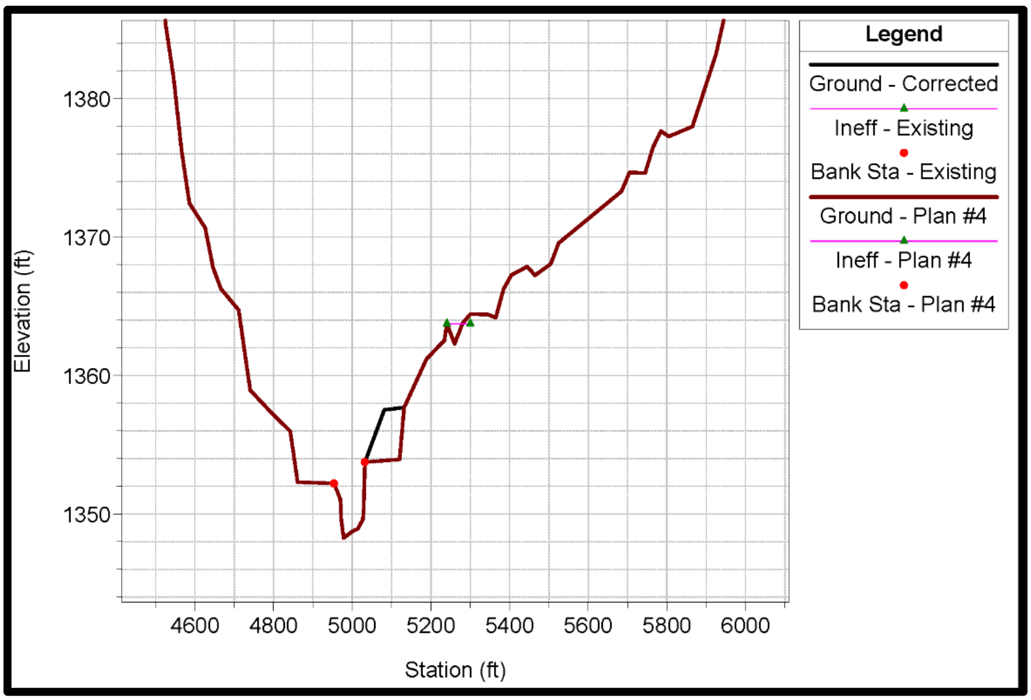


Figure 18: Typical Section View of Plan #4

Hydraulic Results: The proposed changes showed modest gains in floodwater reduction at the 25-year and 100-year flood events with a reduction of 0.14' during the 25-year flood and 0.47' reduction at the 100-year flood as seen in Table 21 at Point of Interest #3 (POI #3) which is where the proposed mitigation plan activities would be constructed. A reduction in water surface elevations would also be experienced by the homes and businesses upstream near POI#4 and POI#5. The further upstream from the proposed activities in Mitigation Plan #4, the lower the reduction. Table 22 shows five buildings were completely removed from flood inundation during the 100-year flood. This means 31 buildings between POI#3 and POI#5 would still experience flooding damage despite the decrease in floodwater elevation. The cost of Flood Mitigation Plan #4 was considered to be high given the relocation of the commercial property and the large amount of excavation and stabilization that would be needed to construct the floodplain bench and island manipulation. Due to the high construction cost and the low reduction of flood damage, the FC decided Plan #4 should not be furthered for a BCA.

Table 21: Comparison of Existing and Plan #4 Water Depths in Feet

	25-Year Flood			100-Year Flood		
Point of Analysis	Existing	Plan #4	Difference	Existing	Plan #4	Difference
POI #1	1351.55	1351.55	0	1354.64	1354.64	0
POI #2	1355.32	1355.32	0	1357.26	1357.26	0
POI #3	1360.16	1360.02	-0.14	1361.44	1360.97	-0.47
POI #4	1361.96	1361.7	-0.26	1362.89	1362.49	-0.4
POI #5	1362.93	1362.76	-0.17	1363.83	1363.56	-0.27

Table 22: Number of Buildings Protected by Plan #4

Return Interval	Number of Inundated Buildings In West Branch Study Area		Number of Fully Protection Buildings
	Existing	Plan #4	
10-Year	12	10	2
50-Year	26	22	4
100-Year	36	31	5

Benefit to Cost Ratio: Not Applicable; mitigation solution not furthered.

Implementation Challenges and Opportunities: Not Applicable; mitigation solution not furthered.

Funding Sources: Not applicable; mitigation solution not furthered.

Water Quality Protection: The reduction of water surface elevations only removed three buildings completely from inundation during the 100-year return flood interval as seen in Table 23.

Table 23: Water Quality Protection Benefits Plan #4

Buildings That Could Create a Water Quality Pollution Source Removed From Inundation		
10-Year	50-Year	100-Year
2	2	3

Prioritization: Not applicable; mitigation solution not furthered.

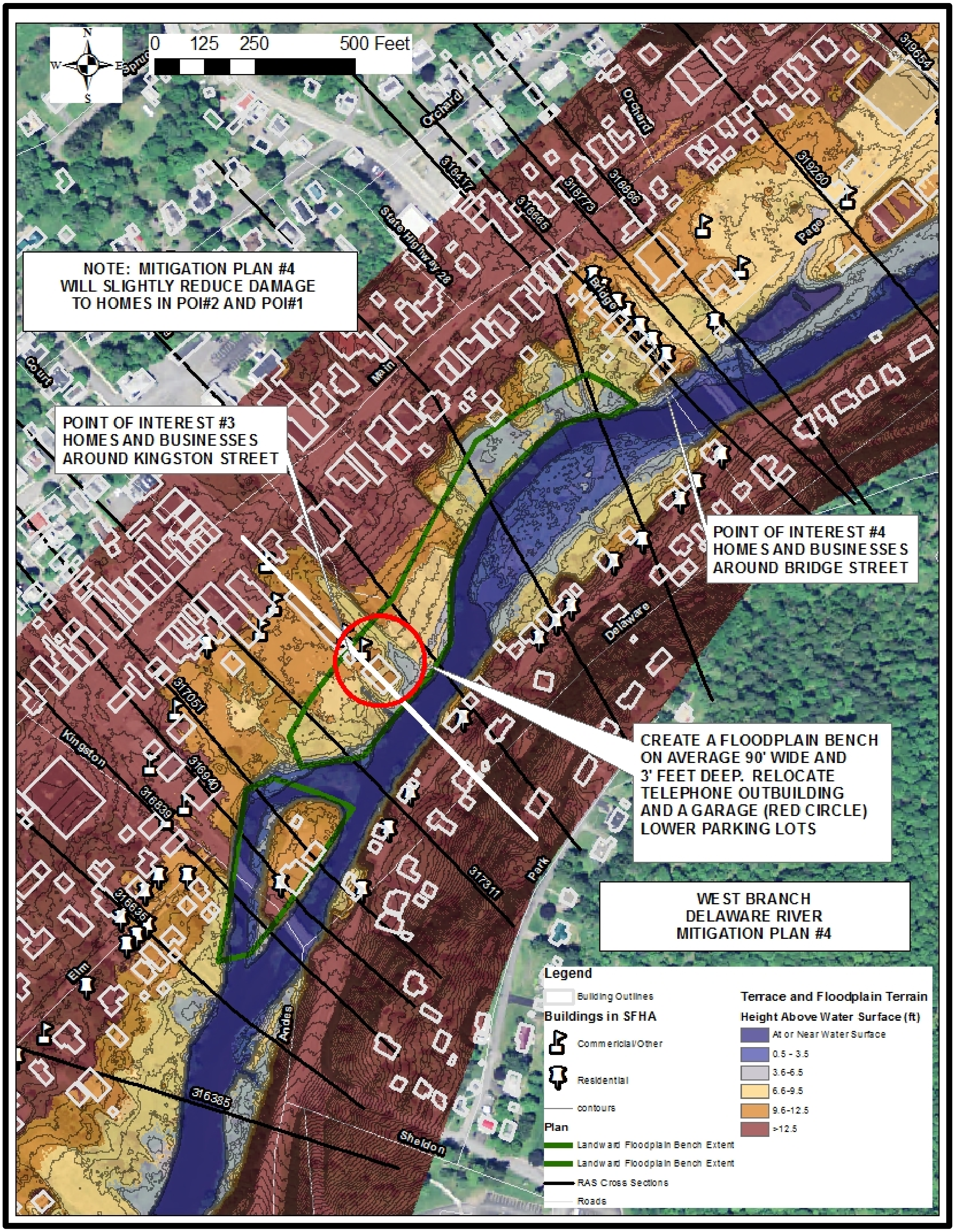


Figure 19: Conceptual Layout of Plan #4

5.3.6 Flood Mitigation Plan #5: LFA Mitigation Plan #1 and remove SUNY ball Fields.

Summary: As noted in section 5.3.2, table 10 on page 39, the reduction in water surface benefits from Mitigation Plan #1 did not translate upstream where by POI#2 (by Depot Street), the reduction in floodwater elevation at the 100-year return interval flood, was less than 0.05'. Figure 11 on page 36 shows the Terrace and Floodplain Terrain Map (TAFT). Between POI#1 and POI#2, there is a high terrace where the SUNY athletic fields were constructed. The high terrace (with dark brown coloring) is notably higher than the lower terraces and floodplain (lighter brown coloring and blue coloring respectively). The fields were possibly built over a former site of a dump which was filled in and capped several decades ago forming the high terrace. The Flood Commission was uncertain if a dump site existed at the site, therefore the boundaries of the former site and depth of fill are unclear. A review of the 1963 and 1972 aerial photos of the site document activity at the ball field 10 years to 20 years before the construction of the ball fields. These photos (Appendix A, Figure 45) show ground clearing, earth mounds and manmade objects. For this Plan, it was assumed a dump exists because it is the worst case scenario (conservative) in regards to construction costs. It is assumed a dump would contain hazardous materials therefore requiring special handling and disposal which would be more expensive than normal earthwork. To understand if this high terrace forms an obstruction which is reducing the water surface benefits gained by Mitigation Plan #1, the removal of the high terrace was modeled.

Figure 21 shows a close up of the proposed flood mitigation activity. The high terrace would be lowered to match the interpolated elevation between the upstream and downstream lower floodplain (represented by the black line in the two profiles in Figure 20). Figure 20 shows a typical section through the high terrace. The existing ground and proposed ground are represented by the brown and black lines respectively.

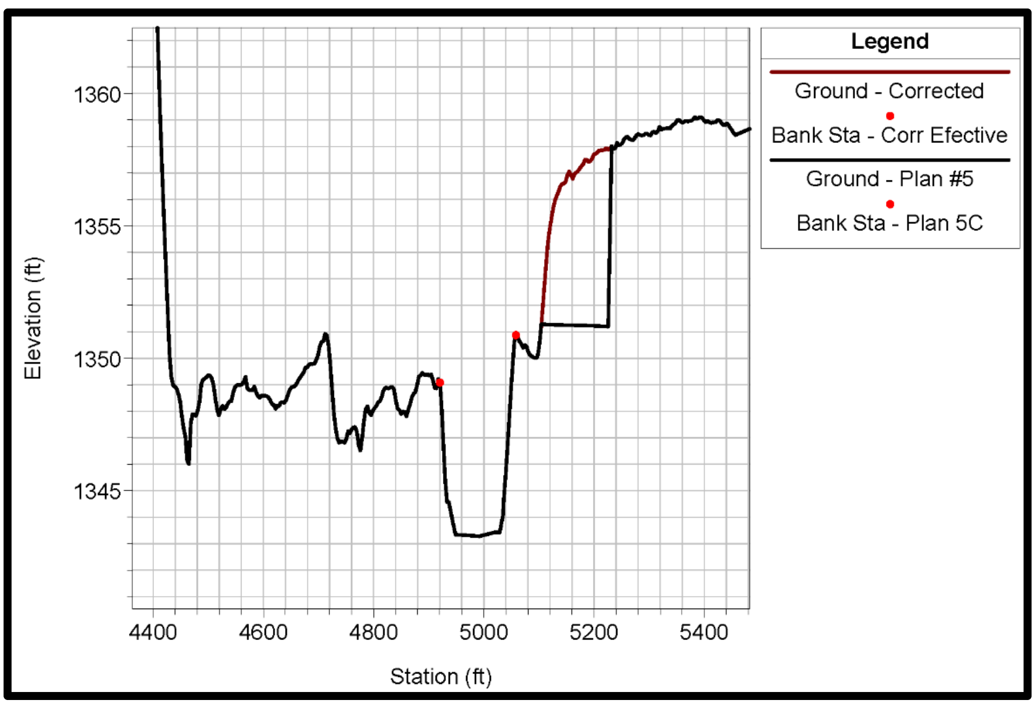


Figure 20: Typical Section View of Plan #5

Hydraulic Results: The proposed changes showed large gains in floodwater reduction at the 25-year and 100-year flood events with a reduction of 0.64' during the 25-year flood and 1.07' reduction at the 100-year flood as seen in Table 24 at Point of Interest #2 (POI #2) near Depot Avenue. A reduction in water surface elevations would also be experienced by the homes and businesses upstream at the remaining points of interest, with the largest reduction of 1.2' water surface elevation at POI#3. Table 25 shows four buildings were completely removed from flood inundation during the 100-year flood. This means 32 buildings between POI#1 and POI#5 would still experience flooding damage despite the decrease in floodwater elevation. The cost of Flood Mitigation Plan #5 was assumed to be high given the relocation of the SUNY ball fields. Since the ball fields were built on an abandoned dump it was assumed that the excavation needed to build the floodplain bench would need to remove material from the abandoned dump. It was expected this material would be contaminated and require special treatment for removal, hauling and disposing. Due to the assumed high construction cost and the moderate reduction of flood damage, the FC decided Plan #5 should not be furthered for a BCA.

Table 24: Comparison of Existing and Plan #5 Water Depths in Feet

	25-Year Flood			100-Year Flood		
Point of Analysis	Existing	Plan #5	Difference	Existing	Plan #5	Difference
POI #1	1351.45	1350.01	-1.44	1354.59	1351.86	-2.73
POI #2	1355.89	1355.25	-0.64	1357.07	1356	-1.07
POI #3	1360.28	1359.44	-0.84	1361.42	1360.18	-1.24
POI #4	1361.64	1361.21	-0.43	1362.59	1361.94	-0.65
POI #5	1363.25	1363.13	-0.12	1364.07	1363.8	-0.27

Table 25: Number of Buildings Protected by Plan #5

Return Interval	Number of Inundated Buildings In West Branch Study Area		Number of Fully Protection Buildings
	Existing	Plan #5	
10-Year	12	12	0
50-Year	26	22	4
100-Year	36	32	4

Benefit to Cost Ratio: Not Applicable; mitigation solution not furthered.

Implementation Challenges and Opportunities: Not Applicable; mitigation solution not furthered.

Funding Sources: Not applicable; mitigation solution not furthered.

Water Quality Protection: The reduction of water surface elevations removed five water quality pollution sources completely from inundation during the 100-year return flood interval as seen in Table 26. Three buildings would be completely removed from inundation during the 50-year return interval flood.

Table 26: Water Quality Protection Benefits Plan #5

Buildings That Could Create a Water Quality Pollution Source Removed From Inundation		
10-Year	50-Year	100-Year
0	3	5

Prioritization: Not applicable; mitigation solution not furthered.

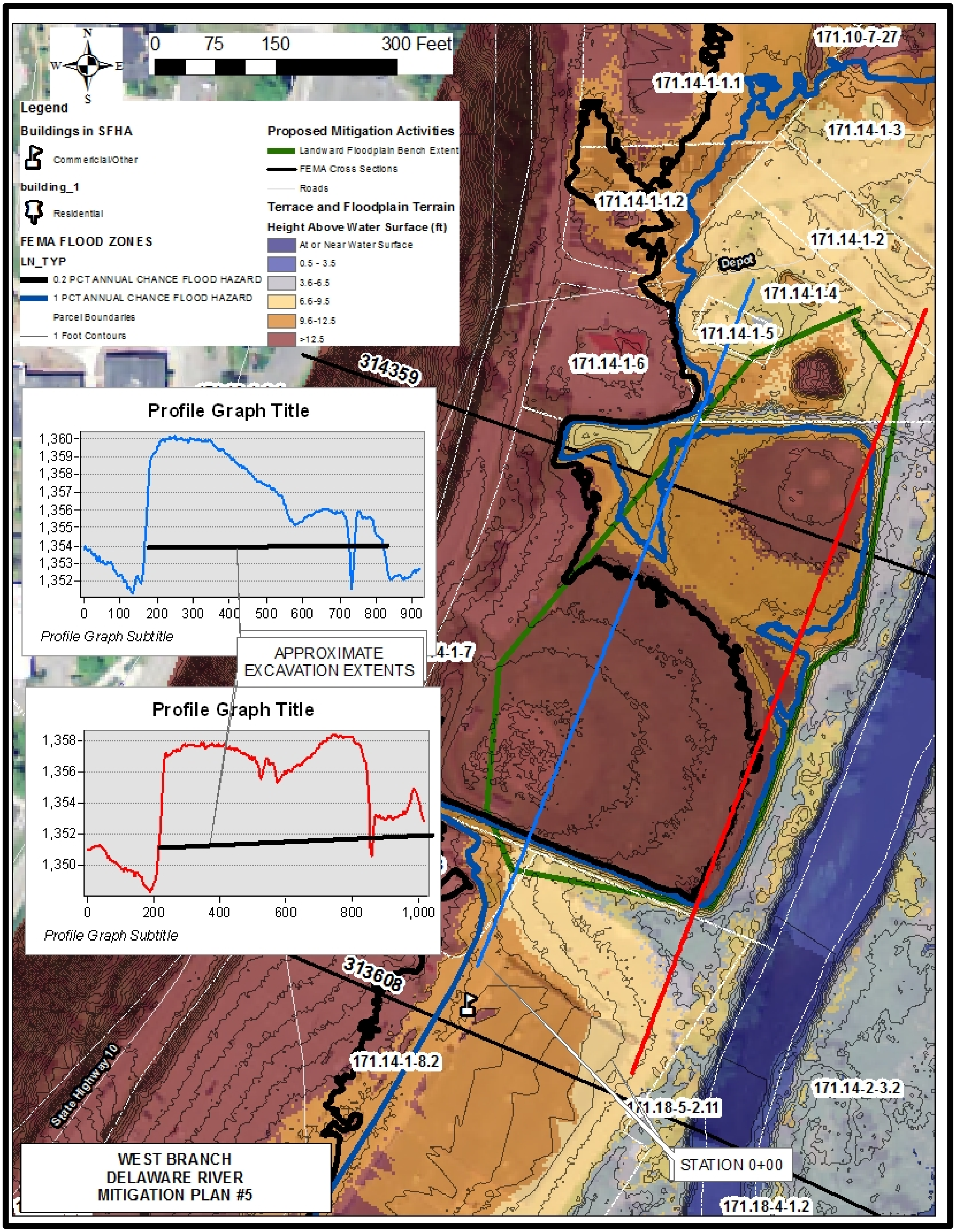


Figure 21: Conceptual Layout of Plan #5

5.3.7 Flood Mitigation Plan #6: LFA Mitigation Plan #1 and lower floodplain to 2-year flood level at Depot Street. Remove two outbuildings.

Summary: Results from Flood Mitigation Plan #5 showed if the volume available to convey floodwaters increases upstream of Flood Mitigation Plan #1, large reductions in floodwater elevations can be achieved further upstream. The assumed construction cost for Plan #5 and the unknowns of excavating into an abandoned dump deterred furthering Plan #5 into a Benefit Cost Analysis. Flood Mitigation Plan #6 looks at increasing the volume available to convey floodwaters in a location near Depot Avenue (Point of Interest #2).

The proposed flood protection project would excavate a floodplain bench into the western floodplain of the West Branch as seen in Figure 23. The excavation would start 300' upstream of the SUNY ball fields and extend 1,000' upstream, including lowering the area around the confluence between Steele Brook and the West Branch. Per Figure 23, there is a high terrace (the dark brown coloring) on the north shore of Steele Brook which was more than likely caused by human activity when gravels and cobbles were removed from the Brook. The average width of the bench is 100' with an average depth of 2.0'. Figure 22 shows a typical section through the floodplain bench.

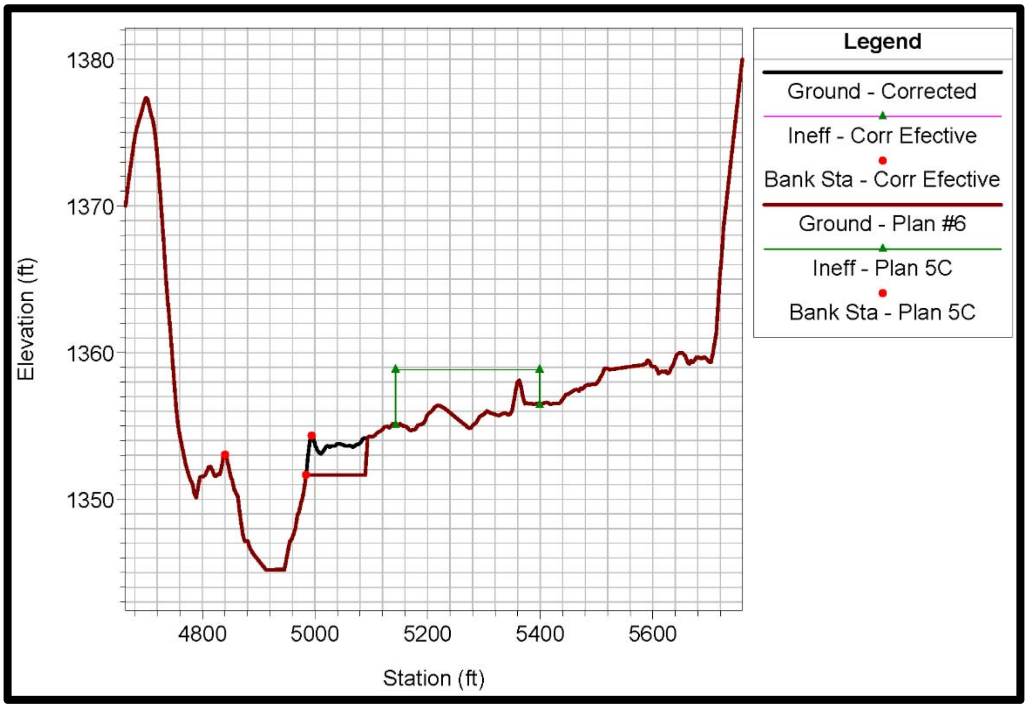


Figure 22: Typical Section View of Plan #5

Hydraulic Results: The proposed changes showed notable gains in floodwater reduction at the 25-year and 100-year flood events with a reduction of 0.4' during the 25-year flood and 0.68' reduction at the 100-year flood as seen in Table 27 upstream of the proposed floodplain bench (POI #3 through POI#5). A water surface profile comparison of the 100-year flood under existing conditions and under proposed conditions can be seen in Appendix A, Figure A-16. Table 28 shows nine (9) buildings were completely removed from flood inundation during the 100-year flood and six (6) were removed from the 50-year flood. This means 27 buildings between POI#1 and POI#5 would still experience flooding damage during the 100-year flood despite the decrease in floodwater elevation. The notable reduction in water surface elevations, the assumed low implementation cost for Plan #6 led the FC recommending that a benefit to cost ratio be completed.

Table 27: Comparison of Existing and Plan #6 Water Depths in Feet

	25-Year Flood			100-Year Flood		
Point of Analysis	Existing	Plan #6	Difference	Existing	Plan #6	Difference
POI #1	1351.45	1350.71	-0.74	1354.59	1352.83	-1.76
POI #2	1355.89	1355.64	-0.25	1357.07	1356.72	-0.35
POI #3	1360.28	1359.88	-0.4	1361.42	1360.74	-0.68
POI #4	1361.64	1361.42	-0.22	1362.59	1362.2	-0.39
POI #5	1363.26	1363.16	-0.1	1364.09	1363.92	-0.17

Table 28: Number of Buildings Protected by Plan #6

Return Interval	Number of Inundated Buildings In West Branch Study Area		Number of Fully Protection Buildings
	Existing	Plan #6	
10-Year	12	12	No Change
50-Year	26	20	6
100-Year	36	27	9

Benefit to Cost Ratio: The proposed construction cost of Mitigation Plan #6 is $527,500. The total cost for Plan #6 must include the cost for Mitigation Plan #1 since Mitigation Plan #6 assumes Mitigation Plan #1 is in place before its implementation. This plus the engineering and contingency costs for Mitigation Plan #6's proposed construction cost is $829,400. The proposed construction cost can be seen in Appendix A, Figure A-17. The cost also includes the relocation of two buildings and the needed permanent parcel easements as seen in Figure 23. The BCA summary is shown in Table 29 and the benefit to cost ratio is 7.88. A BCR for each building can be seen in Appendix B, B-4.

Table 29: Plan #6 BCR Results

Number of Structures / Work Item	Benefits	Costs
9 (damages eliminated)	$6,535,109	
Construction, materials		$686,900
- Engineering/Design/Survey (12% of $527,500)		$79,200
- Contingency (15% of $527,500)		$63,300
TOTALS	**$6,535,109**	**$829,400**
Benefit to Cost Ratio (BCR)	**7.88**	

Implementation Challenges and Opportunities: Most of the proposed flood protection project would disturb undeveloped land spanning seven parcels. This means very few buildings would need to be relocated (two outbuildings) to successfully build the project. The analysis shows that 36 buildings were within FEMA's special flood hazard area (SFHA) with the 100-year water surface elevation higher than their first floor elevation. The analysis also showed that 61 buildings were within FEMA's special flood hazard area with the 100-year water surface elevation lower than the first floor elevation. The latter buildings may still experience flooding damage during the 100-year flooding event or larger events (for example, if they have mechanics in the unfinished basement which is lower than the 100-year). However these home owners may be still be eligible for lower flood insurance premiums, saving the community money.

A permanent easement will be needed on seven parcels as seen in Figure 23 to build the proposed mitigation solution. There needs to be a willing landowner to sell this easement.

Funding Sources: This project qualifies for funding under the Delaware County Soil and Water Conservation District (DCSWCD) Stream Management Program. DCSWCD will be the lead for funding opportunities in partnership with other agencies. The preliminary BCR score of 7.73 exceeds the typical minimal threshold of 1.0 for submission of a grant for FEMA hazard mitigation sources.

Water Quality Protection: The reduction of water surface elevations removed six (6) water quality pollution sources completely from inundation during the 100-year return flood interval as seen in Table 30. Four buildings would be completely removed from inundation during the 50-year return interval flood.

Table 30: Water Quality Protection Benefits Plan #6

Buildings That Could Create a Water Quality Pollution Source Removed From Inundation		
10-Year	50-Year	100-Year
0	4	6

Prioritization:

Table 31: Prioritization Score for Plan #6

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	High	5
Ease to Acquire Easements	Moderate	3
Level of Town Effort To Implement Plan	Moderate	3
Prioritization Score Total		30

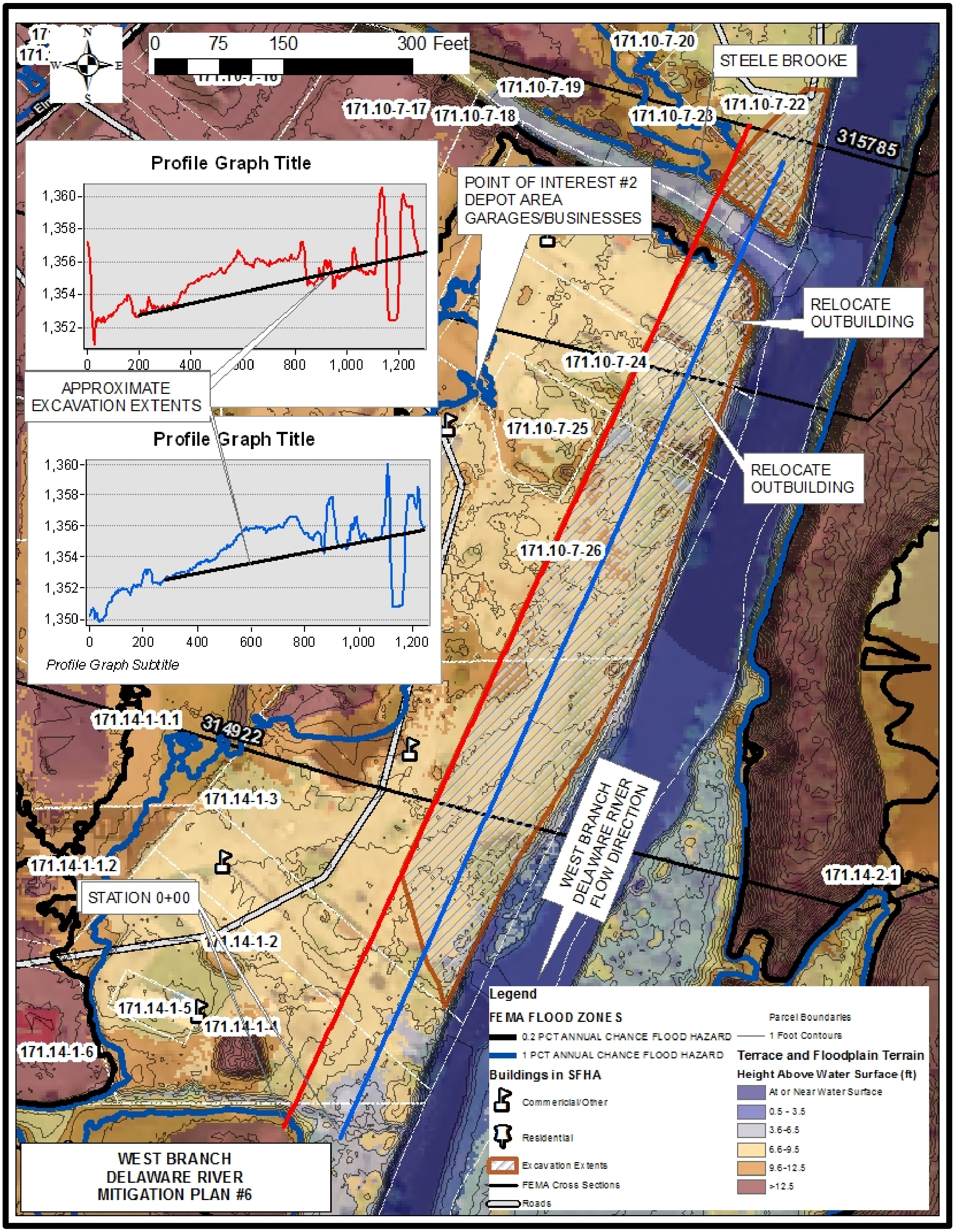


Figure 23: Conceptual Layout of Plan #6

5.3.8 Flood Mitigation Plan #7: LFA Mitigation Plan #6 and lower floodplain to 2-year flood level between Kingston Street Bridge and Bridge Street Bridge.

Summary: Flood Mitigation Plan #6 showed notable reductions in water surface elevations and removed several buildings from inundation (Table 28 on Page 58). The reduction of floodwater elevations however, was not large at POI#4 and POI#5, approximately an average of 0.16' for the 25-year flood and 0.28' for the 100-year flood (Table 27 on Page 58). Flood Mitigation Plan #7 looks to extend the floodwater reduction to POIs #4 and #5 since there are clusters of buildings that suffer frequent flooding damage (as seen in Figure 8 on Page 30) and Appendix A, Figure A-11 and A-12. A flood prevention project (floodplain bench) was proposed for Plan #7 between Kingston Street Bridge and Bridge Street Bridge and is similar to Flood Mitigation Plan #4 except the island upstream of the Kingston Street Bridge would remain unchanged. The bench would be 850 feet long and would be on average 80 feet wide and have an average excavation depth of two feet as seen in the plan view in Figure 25 and in section view in Figure 24.

The proposed flood prevention project would require the Delhi Telephone outbuilding to be relocated. This outbuilding is used for storage of vehicles and equipment as seen in Figure 25. Approximately 20% of the county owned parking (171.6-10-9, 171.6-10-6) and 25% of the bank parking lot (171.6-10-5) would need to be lowered or removed. The flat section of the floodplain bench is set at an elevation that would be inundated with floodwaters starting at the 2-year return interval flood. The portion of the floodplain bench where the lowered parking lot is proposed would be more frequently inundated than under existing conditions when these sections of the parking lots are inundated with flood water starting at the 10-year flood. Flood Mitigation Plan #7 would also disturb the Riverwalk, built along the west shoreline of the river. The Riverwalk would need to be removed and rebuilt at the new elevation of the floodplain bench.

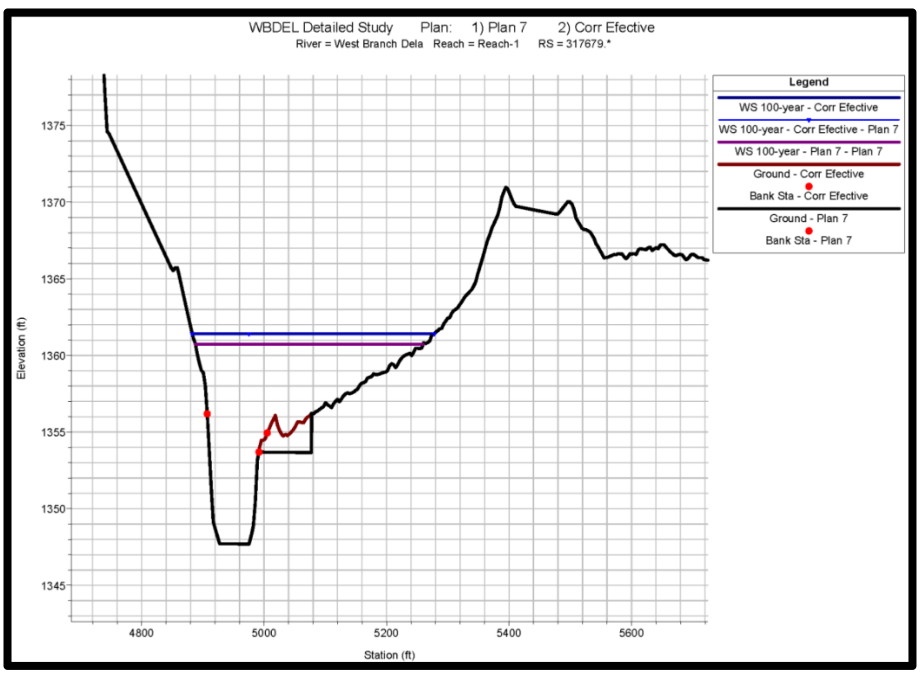


Figure 24: Typical Section of Plan #7

Hydraulic Results: The proposed changes showed notable gains in floodwater reduction at the 25-year and 100-year flood events with a reduction of 0.55' during the 25-year flood and 0.7' reduction at the 100-year flood as seen in Table 32 upstream of the proposed floodplain bench (POI #4). There is a larger reduction in the 100-year water surface elevation at POI#5 in Plan #7 than was calculated in Plan #6 but this difference was slight, 0.3' versus 0.17' respectively. A water surface profile comparison of the 100-year flood under existing conditions and under proposed conditions can be seen in Appendix A, Figure A-18. Table 33 shows ten (10) buildings were completely removed from flood inundation during the 100-year flood and six (6) were removed from the 50-year flood. This means 26 buildings between POI#1 and POI#5 would still experience flooding damage during the 100-year flood despite the decrease in floodwater elevation. The notable reduction in water surface elevations, the assumed low implementation cost for Plan #7 led the FC to recommend a benefit that a BCR be completed.

Table 32: Comparison of Existing and Plan #7 Water Depths in Feet

	25-Year Flood			100-Year Flood		
Point of Analysis	Existing	Plan #7	Difference	Existing	Plan #7	Difference
POI #1	1351.45	1350.71	-0.74	1354.59	1352.83	-1.76
POI #2	1355.89	1355.64	-0.25	1357.07	1356.72	-0.35
POI #3	1360.28	1359.86	-0.42	1361.42	1360.73	-0.69
POI #4	1361.64	1361.09	-0.55	1362.59	1361.89	-0.7
POI #5	1363.26	1363.13	-0.13	1364.09	1363.79	-0.3

Table 33: Number of Buildings Protected by Plan #7

Return Interval	Number of Inundated Buildings In West Branch Study Area		Number of Fully Protection Buildings
	Existing	Plan #7	
10-Year	12	11	No Change
50-Year	26	20	6
100-Year	36	26	10

Benefit to Cost Ratio: The proposed construction cost of Mitigation Plan #7 would include the cost for Mitigation Plan #6 (which includes the cost for Flood Mitigation Plan #1) since Mitigation Plan #7 assumes these plans are in place before its implementation. The hydraulic modeling and benefit cost analysis also assumes Mitigation Plan #1 and #6 has been implemented. The proposed construction cost of Plan #7 is $515,000 and when added to the cost of Mitigation Plan #6 is $1.5 million which can be seen in Appendix A, Figure A-19. The cost includes: the relocation of the Delhi Telephone storage building (which is used for storing vehicles and equipment), lowering the three parking lots and acquiring the needed permanent parcel easements for the remaining eleven parcels as seen in Figure 25. The BCA summary is seen in Table 34 and the benefit to cost ratio is 4.35. A BCR for each building can be seen in Appendix B, B-5. Plan #7 does not reduce water surface elevations notably more than Plan #6, therefore the benefit gained from Plan #7 is about equal to the benefit gained in Plan #6 (Table 29 on page 61). Since Plan #7 costs considerably more than Plan #6 and will require moving community infrastructure such as the Riverwalk, Plan #7 is not recommended. It was assumed that the benefit gained from further flood protection projects upstream of Plan #7 would not result in notably lower reductions in flood water elevations therefore, other floodplain manipulations upstream of Plan #7 were not investigated.

Table 34: Plan #7 BCR Results

Number of Structures / Work Item	Benefits	Costs
10 (damages eliminated)	$6,525,905	
Construction, materials		$1,329,800
- Engineering/Design/Survey (12% of $500,300)		$60,000
- Contingency (15% of $500,300)		$75,000
TOTALS	**$6,533,740**	**$1,464,800**
Benefit to Cost Ratio (BCR)	**4.45**	

Implementation Challenges and Opportunities: The proposed flood prevention activity would disturb mostly undeveloped land (seven of the eleven parcels). Since the land along the floodplain bench would be lowered and put under a non-developable easement, there may be an opportunity to expand the Riverwalk for the entire length of the bench. The analysis shows that 36 buildings were within FEMA's special flood hazard area (SFHA) with the 100-year water surface elevation higher than their first floor elevation. The analysis also showed that 61 buildings were within FEMA's special flood hazard area with the 100-year water surface elevation lower than the first floor elevation. The latter building type will still experience flooding damage during the 100-year flooding event or larger events (for example, if they have mechanics in the unfinished basement which is lower than the 100-year). However, these home owners may be eligible for lower flood insurance premiums, saving the community money.

A permanent easement is needed on eleven parcels as seen in Figure 25 to build the proposed mitigation solution. There needs to be willing landowners to sell these easements. The proposed changes in the parking lots should require community notification that the lowered parking lots would flood more frequently.

Funding Sources: This project qualifies for funding under the Delaware County's Soil and Water Conservation District (DCSWCD) Stream Management Program. DCSWCD will be the lead for funding opportunities in partnership with other agencies. The preliminary BCR score of 4.35 exceeds the typical minimal threshold of 1.0 for submission of a grant for FEMA hazard mitigation sources.

Water Quality Protection: The reduction of water surface elevations removed six (6) water quality pollution sources completely from inundation during the 100-year return flood interval as seen in Table 35. Four buildings would be completely removed from inundation during the 50-year return interval flood. There is no difference in the number of water quality pollution sources mitigated from Plan #7 and Plan #6.

Table 35: Water Quality Protection Benefits Plan #6

Buildings That Could Create a Water Quality Pollution Source Removed From Inundation		
10-Year	50-Year	100-Year
0	4	6

Prioritization:

Table 36: Prioritization Score for Plan #7

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	High	5
Ease to Acquire Easements	Low	1
Level of Town Effort To Implement Plan	Moderate	3
Prioritization Score Total		26

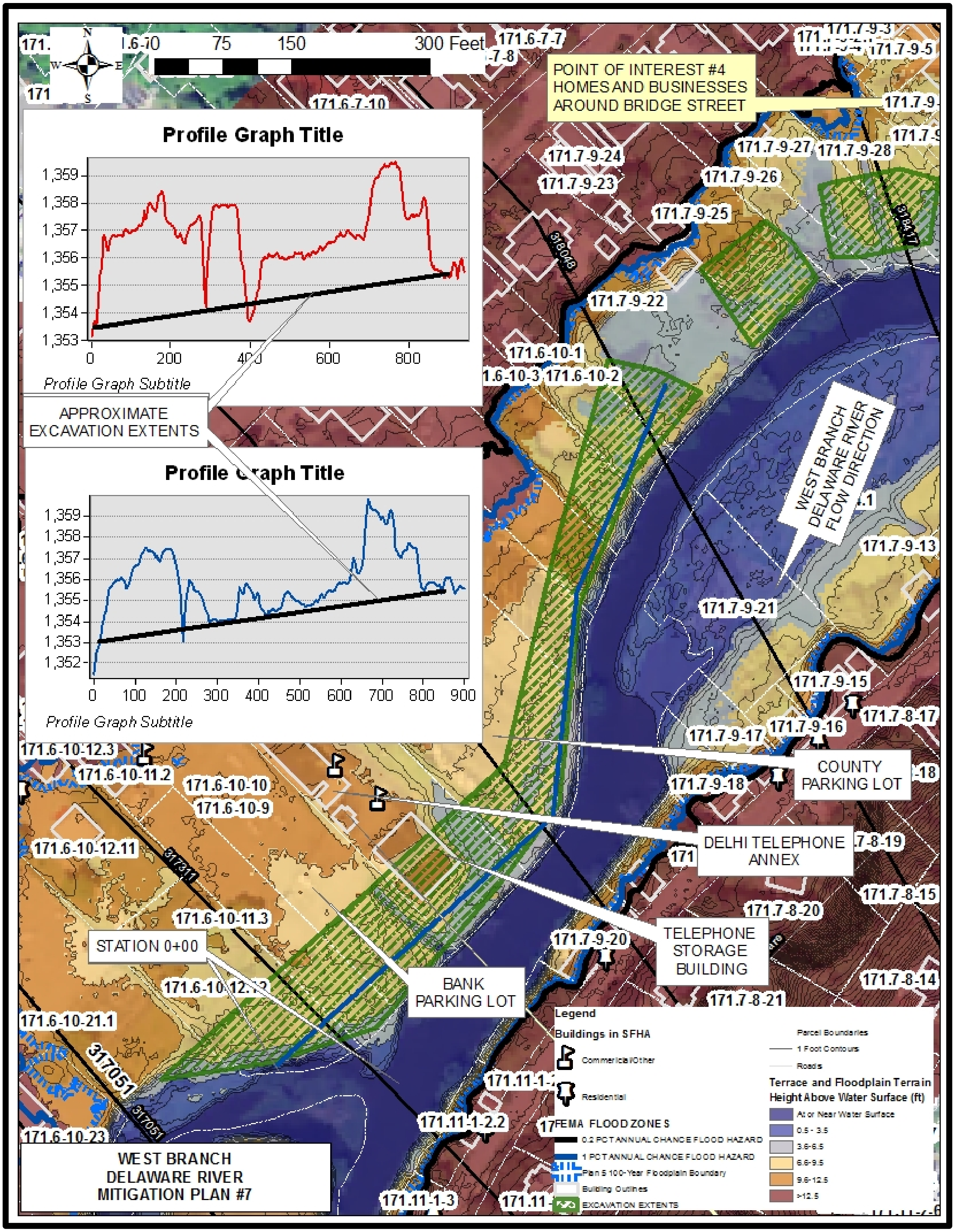


Figure 25: Conceptual Layout of Plan #7

5.3.9 Plan #8 Planning and Relocation

Summary: Delhi 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. The County DPW facility located on Page Ave and the Delhi Telephone Outbuilding located on Main Street are the critical facilities prone to flood damage.

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 pharmacy and the supermarket located in the Price Chopper plaza are the two anchor businesses that would qualify since their building is inundated by water (less than a foot of water depth) starting at the 100-year return interval flood.

The third type of buildings eligible as flood hazard mitigation projects are individual properties that have experienced or may experience significant damage from flooding. This analysis shows that twelve buildings located in the West Branch Study 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 at least twice within the last 20 years (1996, 2005, 2006,). Per NYCFFBO rules, an inundation damaged property is eligible for the NYCFFBO if it 1) 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's value. If a property meets any of these criteria then the property could be eligible for buyout or buyout with relocation.

Delhi has the option to support flood buyout with or without relocation. 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 Delhi. It is recommended that Delhi pursue funding under the CWC Sustainable Communities Planning Program to identify and plan for the development of relocation properties.

There are 61 buildings in FEMA's special flood hazard area (SFHA) whose first floor elevations are estimated to be higher than the 100-year water surface elevation (often referred to as the Base Flood Elevation or BFE) on the West Branch. Some of these building owners may be eligible for reduced flood insurance premiums if they certify their lowest floor elevation and lowest adjacent grades are higher than the BFE. Buildings with basements may not be eligible for flood insurance reductions unless the basement is filled and utilities are raised above the BFE. An elevation certification and a letter of map amendment to FEMA is often sufficient to achieve reduction in flood insurance rates. Potential eligible buildings for flood insurance reductions can be seen in Appendix B, Figure B-3.

Implementation Challenges and Opportunities: There may be community resistance to change Delhi'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: Not applicable; mitigation solution not furthered.

5.3.10 Plan #9--Structural Interventions (Property Protection)

Summary: There are 47 buildings in the flood prone area of Delhi 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). Appendix Figures B-1 and B-2 show 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 is much more complex and financially unfeasible.

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. The basement of this structure could be wet flood proofed 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 37.

The buildings have been proposed to be elevated to 2.0' above the 100 year water surface elevation (known as the BFE). A preliminary BCR of 0.06 was calculated. The highest BCR observed for a building was 0.65 (Building #73) as seen in Appendix B, Table B-3.

Implementation Challenges and Opportunities: When buildings are lifted, utilities and ingress/egress also need to be changed to match the higher first floor elevation.

Funding Sources: The Catskill Watershed Corporation's (CWC) FHMIP also has funding available, up to 75% of the total cost, to assist with elevating qualified buildings. FEMA also provides funding for elevating structures through their National Flood Insurance Program (NFIP) and Hazard Mitigation Grant Program (HMGP).

Water Quality Protection: Raising buildings will improve water quality by removing some of the water pollution sources from floodwaters (47 buildings) but some buildings and activities cannot be elevated (buildings built on slabs, 32 buildings), therefore some water pollution sources will exist as long as those building remain.

Table 37: Cost of Property Protection (Structural Intervention)

Work Item	Cost/Square Foot
Cost of Elevating Structure	$15
Cost of Building New Foundation	$20
Engineering/Permitting	$5

Table 38: Plan 9 BCR Results

Number of Structures / Work Item	Benefits	Costs
47 (damages avoided)	$420,512	
Implementation		$6,699,480
Benefit to Cost Ratio (BCR)	0.062	

Prioritization:

Table 39: Prioritization Score for Plan 9

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

6.0 Steele Brook Study Area

6.1 Data Gap Analysis

6.1.1 Public Flooding Hazards and FC Flooding Hazards

Fifteen (15) flooding hazards were identified by the public within the Steele Brook Study Area as seen in Figure 26. The most common flooding hazard was erosion (7) which is a flood hazard that leads to the damage of infrastructure near a stream bank when the stream bank material is removed by fast moving water. This process is commonly referred to as erosion and will result in the stream bank to over steepen to a unstable geotechnical slope which causes more material to be removed from the stream bank. Erosion leads to the streambank moving landward and is considered an erosion hazard when this movement damages or threatens to damage close by infrastructure (i.e. homes, roads, etc.). The second most common flood hazard was obstruction hazards (4). Obstruction hazards are caused by debris (logs or stones) being deposited in locations that reduce the capacity of infrastructure (bridge or culvert) or of a waterway (ditch or stream) to contain floodwaters. Feedback from the initial public meeting and FC meetings described the debris obstruction at the Main Street Bridge as causing the most amount of flood damage.

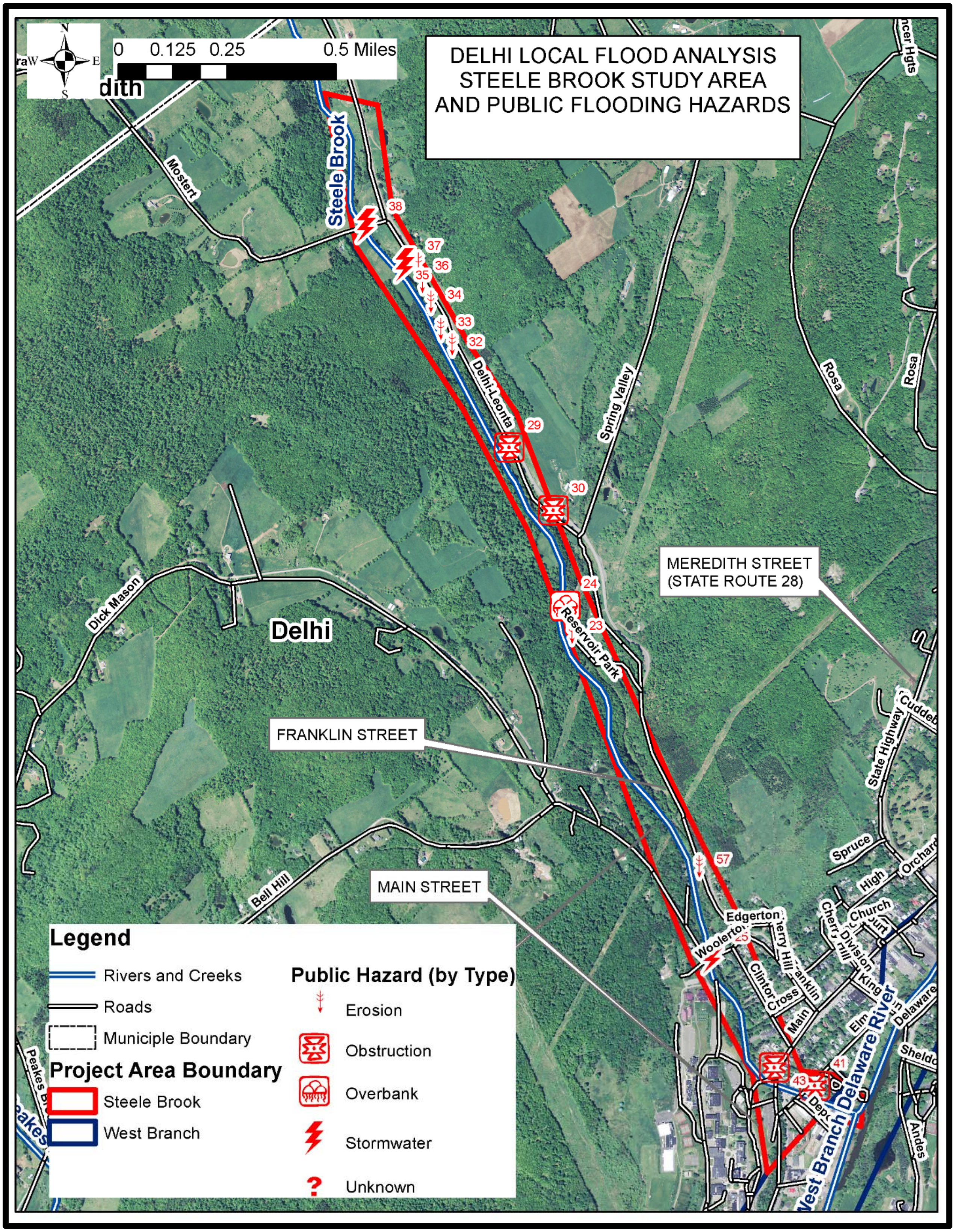


Figure 26: Steele Brook Boundary with Publicly Submitted Hazards

To understand the source of the debris leading to the obstruction hazards, a rapid geomorphic assessment was completed to map which eroding banks generated the most amount of debris and to understand why debris may be accumulating near Main Street Bridge.

6.1.2 Rapid Geomorphic Assessment

The Steele Brook Study Area begins at its confluence and extends approximately 2.5 miles upstream near the Meredith/Delhi municipal boundary. At the confluence with the West Branch, the drainage area is 6.8 square miles. A contour map of the Study Area was produced using data collected in the 2009 LiDAR mapping efforts. Three distinct valley types are characterized by contour spacing as seen in Figure 27. At the upstream of extent of the Study Area (Map 1), the contours adjacent to Steele Brook have more space between them than the contours adjacent to Steele Brook in Map 2. Wider contours show there is more horizontal distance between each contour (5' foot contours in Figure 27) which often means Steele Brook has relatively more floodplain to flood into than in Map 2 where the contours are closer. Steele Brook, in Map 2, appears to run through a steep gorge which is often characterized by narrower floodplains and faster moving water. Map 3 shows a different relationship between Steele Brook and the surrounding terrain as Steele Brook approaches Main Street. The space between contours increases and the shape of the contours resembles a fan as they spread out from narrow to wider. This is a common characteristic of an alluvial fan.

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. This would explain why debris (stone and logs) settle near Main Street, causing debris obstructions.

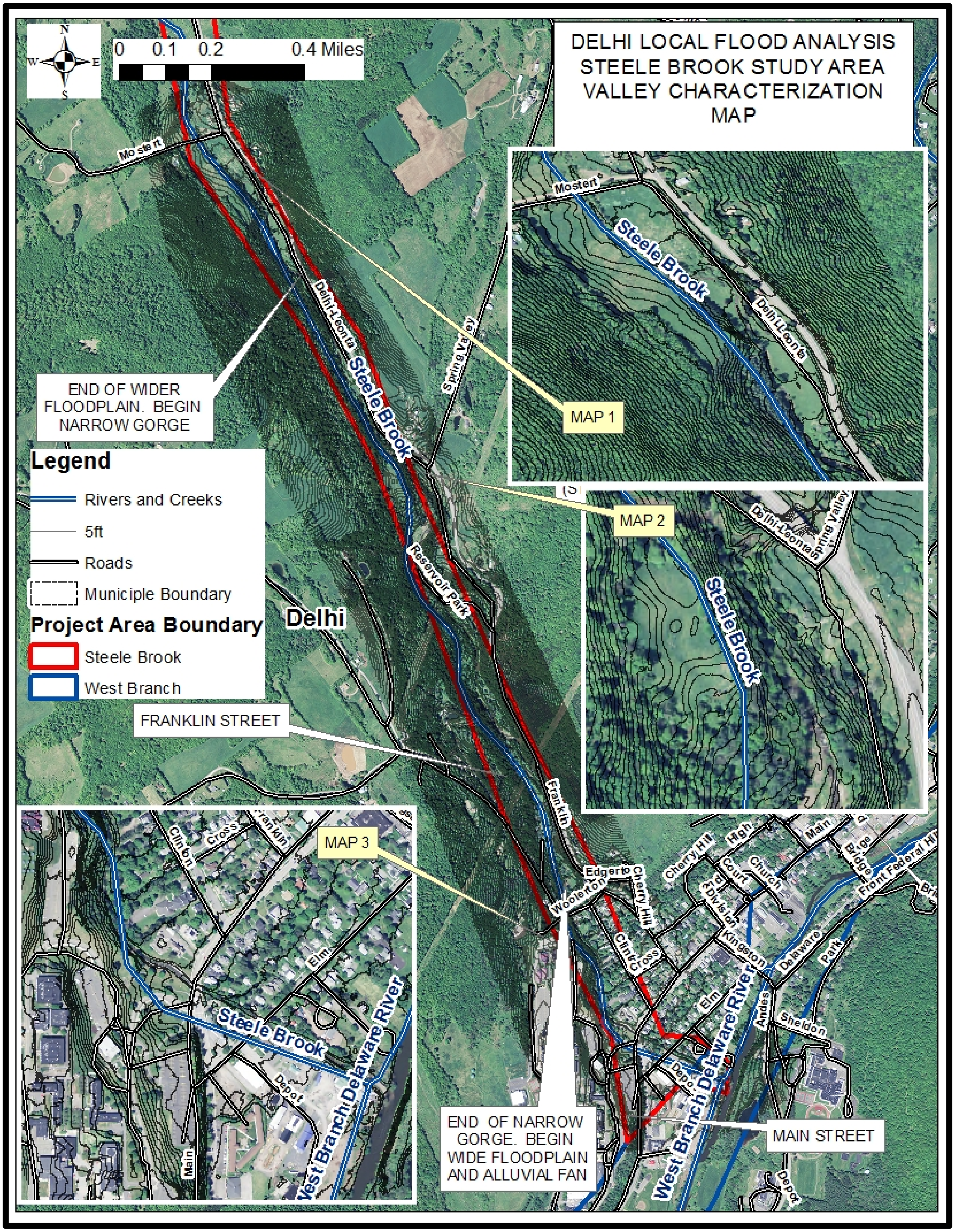


Figure 27: Valley Characterization Map of Steele Brook Study Area

6.1.3 Steele Brook Stream Feature Inventory (SFI) Review
No SFI data has been collected for Steele Brook

6.1.4 Hydraulic and Hydrologic Model Review: Hydrology
Steele Brook was studied by detailed methods and included in the Flood Insurance Study (FIS) for Delaware County. The study was completed on June 16th, 2016 (FIS effective date) by SUN Engineers, under a subcontract with Risk Assessment, Mapping, and Planning Partners (RAMPP) and the Federal Emergency Management Agency (FEMA). As this study provides the basis for floodplain management for Delaware County, information from the study was used to establish existing starting water surface elevations and discharges for the various flooding events.

Peak flows in the FIS were calculated using USGS StreamStats, a web service Implementation of USGS Report SIR-2006-5112. The FIS discharges for the 10, 25, 50,100 and 500-year recurrence can be seen in Table 40.

Table 40: Flood Frequency versus Discharge Relationships

Storms/Floods		Peak Flow (cfs) At Confluence With West Branch
Return Interval	Exceedance Probability	Using USGS 2006 SIR
2-year*	0.5	568
10-year	0.1	717
25-year	0.04	909
50-year	0.02	1,060
100-year	0.01	1,222
500-year	0.002	1,600
*The 2-year flood is not part of the FIS but was calculated following the same methodology.		

6.1.5 Flooding History
The most notable recent flooding event occurred in Steele Brook in 2006. Comments gathered from the initial public meeting and flood commission meetings described the debris jam that formed at Main Street and caused floodwaters to jump out of the stream channel and flow across Main Street to the west. This resulted in floodwaters flowing through a retirement community building as seen in Appendix A Figure A-20 (the blue flow arrow). Overbank flooding also occurred at the Elm Street Bridge (the green flow arrow). Another flooding event occurred in 1973 when water sheet flowed across Elm Street.

Figure 28: Photo of Flooding Aftermath. Looking West at Main Street Bridge

6.1.6 Hydraulic and Hydrologic Model Review: Hydraulics

The Steele Brook Study Area was mapped using detailed methods to support the effective Flood Insurance Study (FIS) (#36025CV001B, effective date 6/16/16). The area was mapped using the US Army Corps of Engineers hydraulic modeling software program (HEC-RAS). Floodplain elevations used to build the model were obtained in 2009 by LiDAR and stream topography (top of bank to top of bank) was collected in the spring 2012. The model used to map the area was acquired and run on WEC's computers and is referred to as the duplicate model. The duplicate model's results were compared to the FIS's results at locations through the Study Area to ensure replication. These results can be seen in Table 41. The duplicated model closely matches the base flood elevations (BFE) in the flood insurance study with largest difference being less than 0.05'.

Table 41: Base Flood Elevation Comparison in FIS and Duplicated Model

Cross Section In Duplicated Model (Section in FI)	Location	FIS (ft)	Duplicated Model (ft)
535 (A)	~300' Downstream of Elm Street Bridge	1360.3	1360.26
943 (B)	~50' Upstream of Elm Street Bridge	1369.2	1369.25
1447 (D)	~150' Upstream of Main Street Bridge	1377.2	1377.2
2919 (F)	Confluence with Steele Brook	1408.0	1408.03

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. The energy grade line slope used for this normal depth was 0.016 which is an acceptable approach for non-backwater flow conditions.

The second assumption checked was the calibration of the model. This model was not calibrated so no review of calibration was completed.

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. Notable portions (over 60%) of the cross sections between Main Street and the confluence (beginning at section 943) were made ineffective as seen in Figure 29. The cross sections in the duplicate model did not contain the 100 year floodwaters as seen in Figure 29. To improve the modeling accuracy (and as a conservative assumption for a higher water surface elevation), large areas of the cross sections were made ineffective flow areas which resulted in higher water surface elevations along Steele Brook's centerline.

The supportive FIS documentation (FEMA 2014) identified that a "Split flow analysis" was performed along the Elm Street Bridge (Bridge 898) as all the water surface profiles 25-Yr, 50-Yr, 100-Yr. 500-YR overtop at the Elm Street Bridge. This results in sheet flow flooding along the left overbank of Steele Brook that is directed towards Kingston Street, where it eventually meets the effective West Branch Delaware River floodplain. As a result of the Spilt Flow analysis, the area along the left overbank of Steele Brook towards Kingston Street was mapped as Zone AO. In addition, since there is a risk that the sheet flow will spill over behind the houses downstream of Elm Street, an area was mapped as Zone X." This modeling and mapping approach is reasonable given the limitations of the one dimensional model used in the FIS but does not reflect how water moved over the land during the 2006 flooding event as discussed in section 6.1.4 and as seen in Appendix Figure A-20.

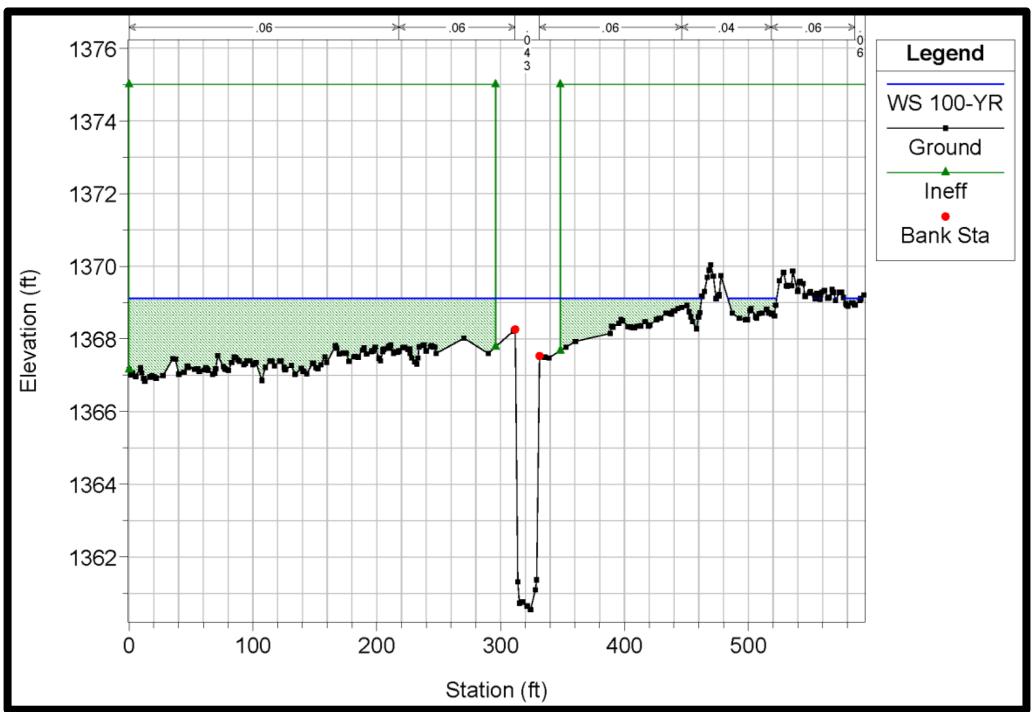


Figure 29: Representative Cross Section of Ineffective Flow in the Steele Brook Study Area

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 in 2012 and spliced into the 2009 LIDAR information to create the cross sections used in the duplicate hydraulic model. The FC did not note any change in the topography at any of the sections in the model. There has not been notable flood events after the cross section survey data was collected that would cause a notable change in channel topography.

6.1.7 Water Quality Assessment Data Review

There was no data available describing potential water quality pollution sources in the Steele Brook Study Area.

6.1.8 Floodplain Development Ordinance and Related Town Planning Documents.

Please refer to section 5.1.8

6.1.9 Identified Data Gaps and Proposed Field Methodology

The review of existing data discuses in section 6.1 identified several gaps that cannot fully explain existing or potential flood hazards or allow for informed mitigation solutions to be developed. As such, the following questions and associated discussion/answers to data gaps issues are as follows:

1. Is the duplicate FEMA hydraulic model sufficient to model flood mitigation activities and calculate the 100-year flood elevation (BFE)? Refer to Section 6.1.5.
2. Where are the sources of debris in the Steele Brook Study Area and are there potential mitigation solutions within the watershed?

6.2 Data Gap Analysis Results

After a review of existing data, there were several questions (section 6.1) regarding the causes of damage from flooding hazards that could not be sufficiently answered. There were also questions that could not be sufficiently answered to quantify the efficacy of flood mitigation strategies. This insufficiency was referred to as a “Data Gap” and to fill the gap to answer each question, additional data was collected in the field. The methodology and results of data collected to fill the gap are described in subsections of section 6.2.

6.2.1 Corrected FEMA Hydraulic Model

From discussions in several FC meetings, two preliminary groups of flood mitigation activities were identified. The first group was natural resources (trapping the debris before Main Street), the second group was infrastructure improvements (for example, replacing a bridge).

To understand the efficacy of the first group of flood mitigation activities, a hydraulic model is needed to calculate the decrease in water surface elevations between the existing conditions and proposed conditions. The higher the drop means there is less water that would submerge buildings causing structural or utility damage. To correctly model this group of flood mitigation activities, additional sections may need to be added to the duplicated hydraulic model to accurately capture the change in geometric conditions that are common with this group of flood mitigation activities such as excavation. A review was completed of the location and frequency of cross sections in the duplicate model and it was determined that the duplicate model did not need to be corrected. For naming consistency of the other study areas, the model that was used to calculate water surface elevations under existing conditions was referred to as the corrective model.

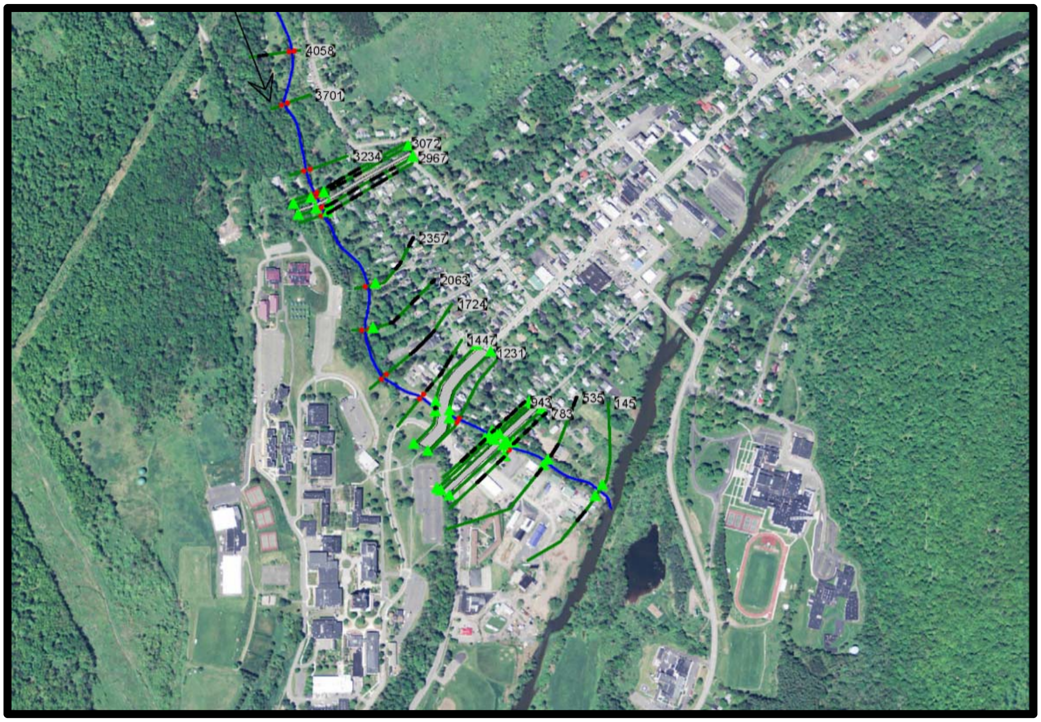


Figure 30: Cross Section Locations in Corrected Model

6.2.2 Obstructed Conditions

Per Figure 28 on page 78 and from feedback from the FC and public meetings, the Main Street stream crossings along Steele Brook is prone to blockage from logs and large woody debris. The FC believes that the woody debris could obstruct roughly 50% of the bridge before equipment is dispatched to the crossing to remove debris. The debris blockage was modeled in the corrected model using the "obstruction" tool embedded in the HEC-RAS software. The opening area beneath the bridge was measured and then 50% of this area was blocked out. A typical section of the bridge obstruction can be seen in Figure 31. The obstruction causes the 10-year flood waters to overtop the bridge whereas the 100-year flood could pass under the bridge under unobstructed conditions as seen in Appendix A, Figure A-23. The floodwater depth over the bridge ranges from 4.0 to 5.5 feet for the 10-year flood to the 100-year flood. It's reasonable to expect there would be minor damage to the bridge if this occurred.

The water surface elevation of the obstructed 100-year flow returns to the same elevation of the 100-year flow elevation under clear water conditions (i.e. no obstruction) by the next downstream cross section (as seen in Appendix A, Figure A-23). This contradicts anecdotal evidence that some river water flowed across Main Street into several buildings on the west side of the river. This is one of the limitations of one dimensional hydraulic modeling since water surface elevations are interpolated between cross sections longitudinally and do not consider how water may flow laterally across a broad feature such as the topography between Main Street and Elm Street.

Figure 31: Cross Section View of Obstructed Main Street Bridge

6.2.3 Water Depth Maps

Using the results of the corrected FEMA hydraulic modeling results, several exhibits were created that captured the depth of water at various flood events. These are useful exhibits that begin to characterize the location of where overbank flooding occurs from swollen rivers and how often it occurs. For example, during the 10-year flood event (Appendix A, Figure A-27) Elm Street is dry. Compare this location to Figure 32 where Elm Street is inundated during the 25-year flood. These figures suggest the homes along Elm Street are flood prone at a relatively moderately size flooding event. Water depths for the 10-year, 50-year, 100-year and 500-year flood return interval flood are presented in Appendix A Figures A-24 through A-27. Notable observations are discussed below

<u>10-Year Return Interval Flood (Appendix A, Figure A-24):</u> Floodwaters are generally contained within Steele Brook.

<u>25-Year Return Interval Flood (Appendix A, Figure A-31):</u> Floodwaters are generally contained within Steele Brook until Elm Street where they leave the channel and flow northeast along Elm Street towards Kingston Street.

<u>50-Year Return Interval Flood (Appendix A, Figure A-25):</u> Floodwaters are generally contained within Steele Brook until Elm Street where overbank flooding was calculated along the south bank. Water depths along the north bank along Elm Street deepen.

<u>100-Year Return Interval Flood (Appendix A, Figure A-26):</u> Floodwaters are generally contained within Steele Brook until Main Street where overbank flooding begin to occur. Elm street flooding depths deepen along the south bank. Water depths along the north bank along Elm Street deepen.

<u>500-Year Return Interval Flood (Appendix A, Figure A-27):</u> Floodwaters are generally contained within Steele Brook until Main Street where overbank flooding begins to occur. Elm Street flooding depths deepen more along the south bank. Water depths along the north bank along Elm Street deepen more than the 100-year flood.

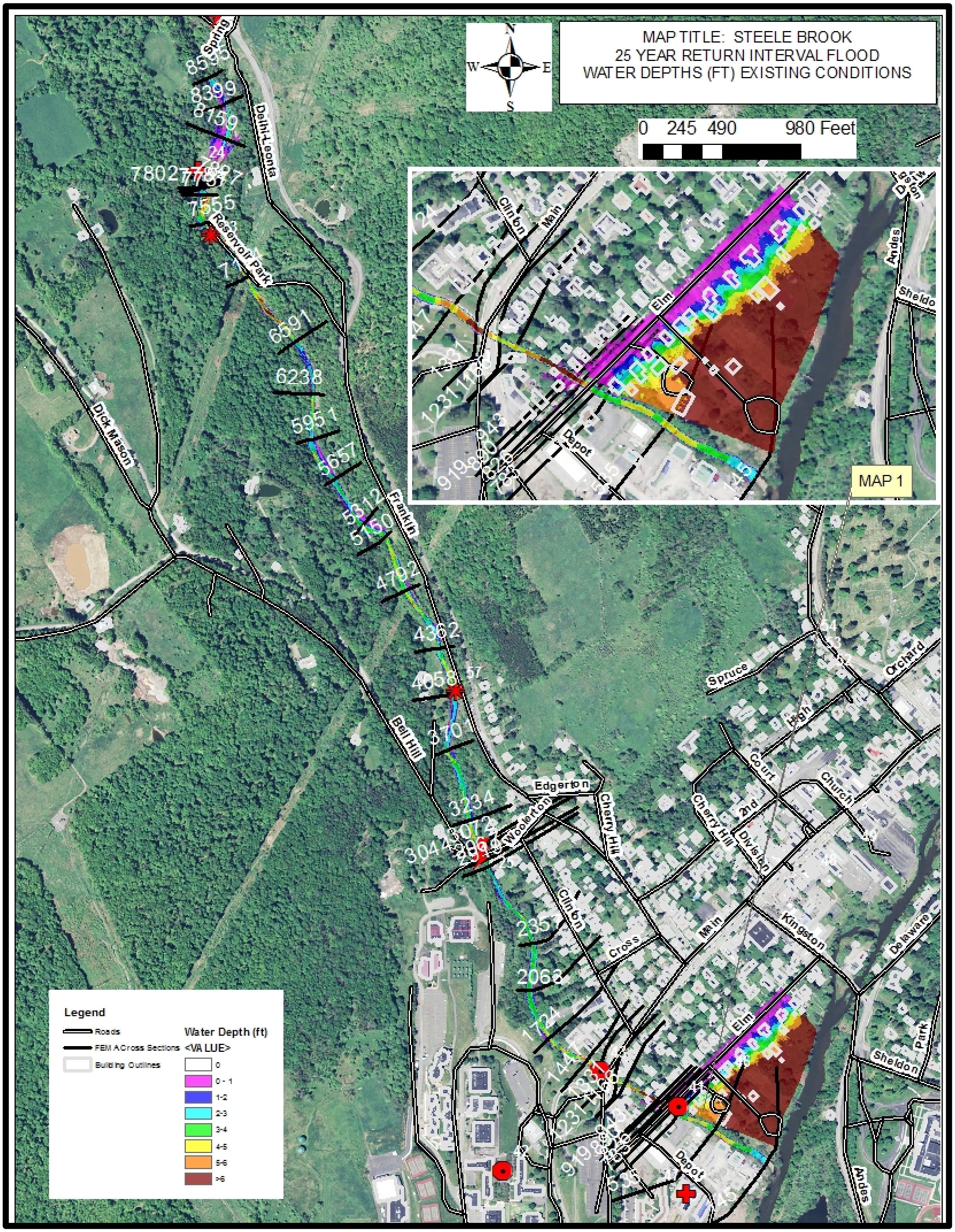


Figure 32: Water Depth Map for 25-Year Flood Steele Brook

6.2.4 Rapid Geomorphic Assessment: Debris Source Mapping

A one day field assessment was completed of the Steele Brook Study Area to map the sources of debris that can be transported to Main Street and Elm Street and assign a Debris Index Score. The RGA was completing following a modified Environmental Protection Agency's (EPA) Bank Assessment for Nonpoint Source Consequences of Sediment (BANCS) guidelines. Eroding stream banks were mapped and for each, a Hazard Score was defined. The Hazard Score was defined as the water's potential to erode material following the methodology for determining Near Bank Stress (NBS) and the banks potential to fail following the Bank Erosion Hazard Index (BEHI). Using the NBS and BEHI guidelines, a categorical score was given for each category: extreme, very high, high, moderate and low. A numerical score was then assigned to each categorical score: 5,4,3,2,1 respectively. NBS and BEHI numerical scores were added together to produce a Debris Index Score where 10 was the highest potential for the bank to erode and undermine adjacent trees that would fall into the stream. Eroding banks that did not have a tree (defined as at least 10 feet tall and 0.5 feet diameter at breast height, were considered non-debris sources.

The results as seen in Figure 33 show a large concentration of flood debris sources between the two abandoned dams along Steele Brook. The upstream dam, used to be the municipal drinking water supply and its unknown what the second dam's purpose was. Often when dams are installed, the water body will often adjust, typically by washing away gravels and other stone sizes upstream which results in the river bed being lowered. This lowering, increases the heights of the streambank causing the streambank heights to fail because they can no longer support their new heights. Streambank failures often have near vertical streambank angles, little to no vegetation and exposed soil.

The percentage of stream banks that are actively eroding is 22% which is often considered a "fair" indicator of streambank stability. Thirteen percent of the streambank length in Steele Brook was found to be an extreme flooding debris source as seen in Table 42.

Table 42: Length of Flood Debris Sources

Name	Length (ft)	Percentage of Total Stream Banks
Total Stream Bank	25,854	100%
Total Stream Banks That Are Eroding	5,730	22%
Extreme Flooding Debris Source Eroding Banks	790	3%
Very High Flooding Debris Source Eroding Banks	3,410	13%
High Flooding Debris Source Eroding Banks	1,530	6%
Moderate Flooding Debris Source Eroding Banks	0	0%
Low Flooding Debris Source Eroding Banks	0	0%
Non Flooding Debris Source Eroding Banks	2,581	10%

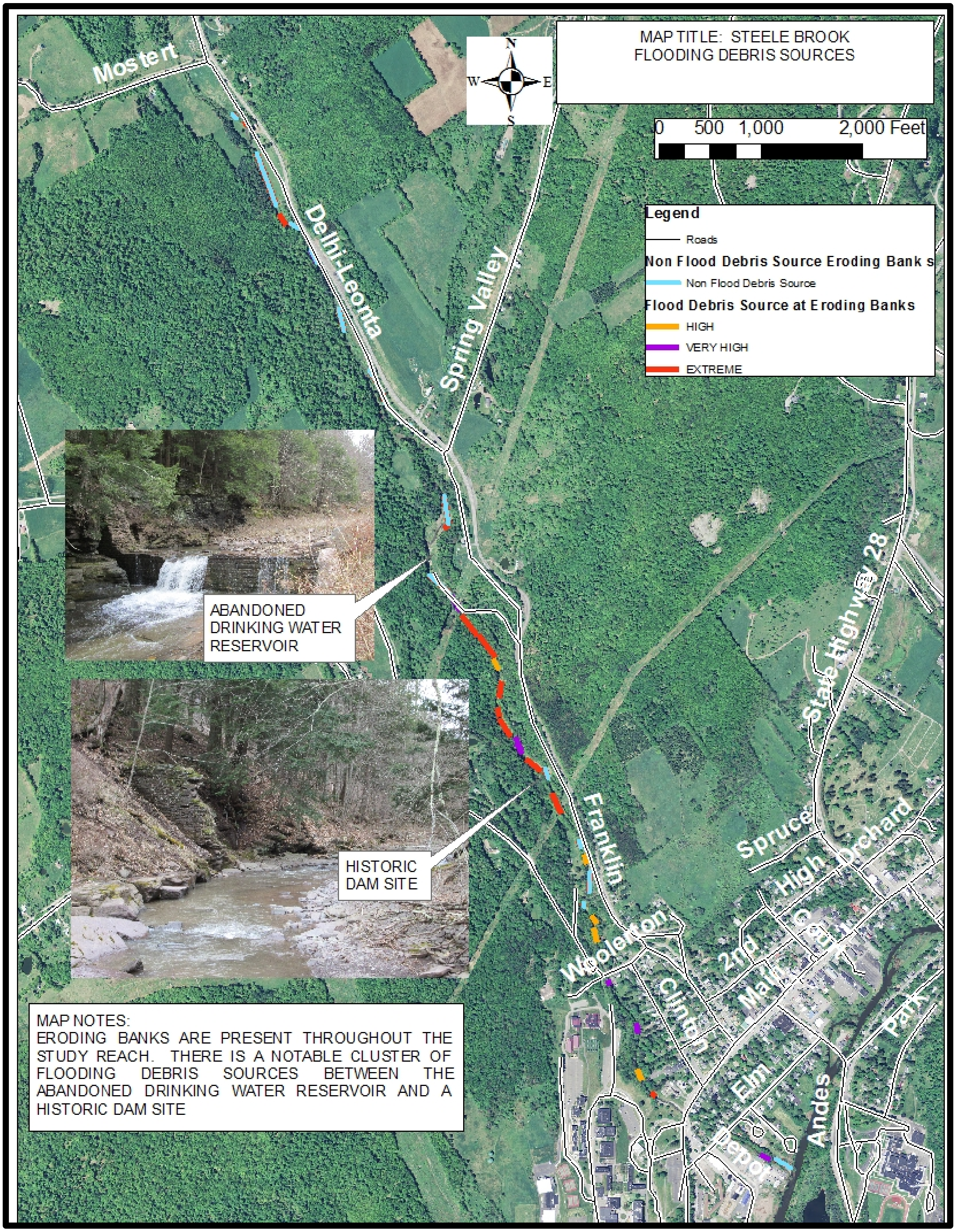


Figure 33: Debris Source Map for Flood Steele Brook

6.3 Flood Mitigation Plan Summary

Three (3) mitigation plan were vetted by the FC to improve flood resiliency along Steele Brook. Each plan was evaluated using the US Army Corps of Engineers HEC-RAS hydraulic modeling software package (HEC-RAS). The corrected HECRAS model was used for the baseline (existing conditions). For each plan, a conceptual design was developed which included changes in channel or floodplain topography. These changes were input into the corrected HEC-RAS model creating the proposed conditions model. Each plan had its own proposed conditions model and the HEC-RAS program was run for each plan. The results were then compared to the existing conditions results. To quantify the changes caused by each plan's conceptual design, water surface conditions were compared for each proposed condition to the existing condition water surface elevation. It was assumed the greater reduction in water surface elevation, the higher the benefit was to Delhi.

Please refer to section 5.3.1 for a description of the Benefit to Cost Analysis approach.

6.3.1 Flood Mitigation Plan #10: Increase Size of Elm Street Bridge and Steele Brooke between Elm Street and Main Street.

Summary: As seen in Figure 32 on page 84, floodwaters escape Steele Brook starting at the 25-year return interval flood. The floodwaters then sheet flow to the north towards Kingston Street along Elm Street. Flood Mitigation Plan 10 would increase the volume available for floodwater conveyance starting downstream of the Main Street Bridge and continuing through the Elm Street crossing. This would include a proposed floodplain bench with an average width of 13' that would increase the channel top width from 17 feet to 30 feet. To avoid relocating a house, a sheet pile wall would be installed that would narrow the proposed channel 3' before it expanded again. A typical section view of the proposed channel can be seen in Figure 34.

The proposed Elm Street crossing would combine the pedestrian bridge and the vehicle bridge at Elm Street to accommodate the wider channel. The clear span of the bridge would increase from 17' to 30'. A conceptual sketch of the bridge crossing is seen in Figure 34

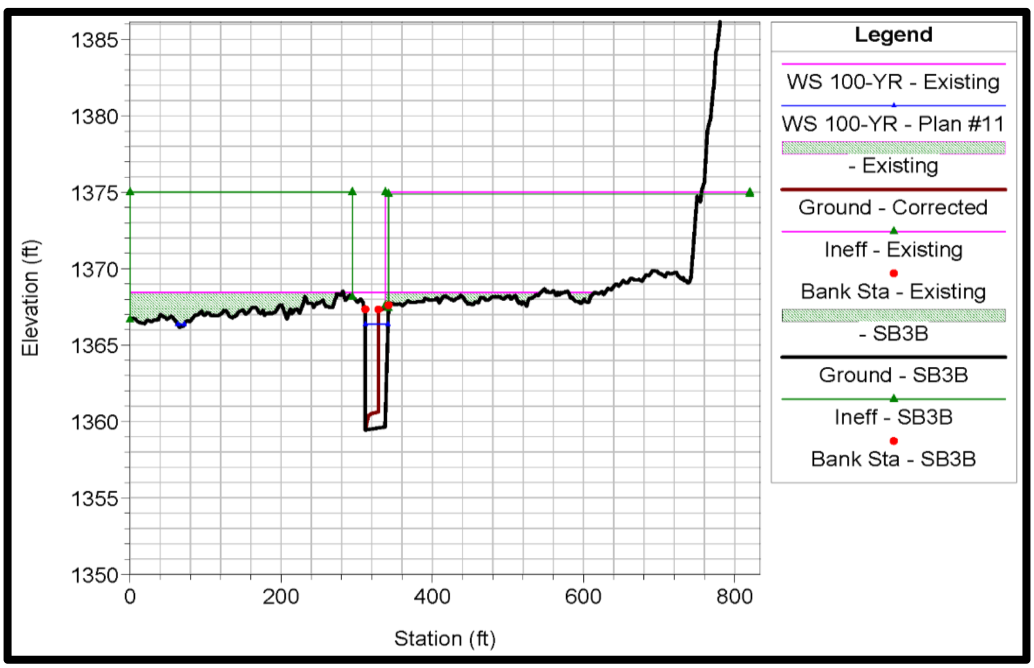


Figure 34: Cross Sectional View of Plan #10

The proposed structure consists of a prestressed adjacent deck units carried by permanent steel sheeting with a concrete cap acting as a bridge seat. The proposed precast superstructure will provide a smooth bottom that will help prevent snagging debris and will provide shallow construction depth across the entire width of the bridge. Construction will be faster.

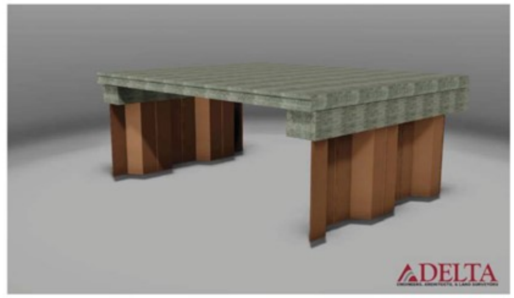


Figure 35: Conceptual Sketch of Proposed Elm Street Crossing in Plan #11

Hydraulic Results: To compare the proposed water surface elevations and the existing water surface elevations, four locations were selected, one upstream of Main Street and three between the Main Street crossing and Elm Street crossing. The proposed mitigation efforts reduced the 25-year and 100-year water surface elevations over 2' and the 100-year is now contained within the channel in all areas that used to overflow into the surrounding neighborhood. This can be seen in the typical section in Figure 34 on page 90 by comparing the pink line (existing condition's 100-year flood water surface elevation) with the blue line (proposed conditions) 100-year flood water surface elevation.

This plan would remove 27 homes and businesses from the Special Flood Hazard Area because the 100-year water surface boundary is contained within Steele Brook. This activity could also reduce their flood insurance premiums if FEMA was petitioned to either rezone the area or on a building by building basis. As seen in Table 44, seven homes would be completed protected by the proposed activities (i.e. the 100-year water surface elevation is lower than the building's first floor elevation) during the 100-year flood and 5 would be fully protected during the 50-year flood.

Table 43: Comparison of Existing and Plan #10 Water Depths in Feet

	25-Year Flood			100-Year Flood		
Cross Section	Existing	Plan #11	Difference	Existing	Plan #11	Difference
1331	1375.69	1373.28	-2.41	1377.19	1374.13	-3.06
1166	1370.20	1366.92	-3.28	1367.92	1371.05	-3.13
943	1368.35	1365.67	-2.68	1366.61	1369.25	-2.64
890	1367.65	1365.42	-2.23	1366.37	1368.44	-2.07

Table 44: Number of Buildings Protected by Plan #10

Return Interval	Number of Inundated Buildings In Steele Brook Study Area		Number of Fully Protection Buildings
	Existing	Plan #7	
10-Year	0	0	No Change
50-Year	5	0	5
100-Year	7	0	7

Benefit to Cost Ratio: The proposed construction cost is $866,500 and can be seen in Table 45 and in Appendix A Figure A-28. It includes increasing the channel width to 30', the stabilization methods required for the proposed streambank and disturbed stream bed and replacing the Elm Street Bridge.

Table 45: Plan #10 BCR Results

Number of Structures / Work Item	Benefits	Costs
7 (damages eliminated)	$286,124	
Construction, materials		$866,600
- Engineering/Design/Survey (12% of $866,600)		$130,000
- Contingency (15% of $866,600)		$103,980
TOTALS	$286,124	$1,100,480
Benefit to Cost Ratio (BCR)	0.26	

Implementation Challenges and Opportunities: The proposed flood prevention activity would disturb three parcels and would require a permanent easement on each parcel and a willing landowner would be needed.

Funding Sources: This project qualifies for funding under the Delaware County's Soil and Water Conservation District (DCSWCD) Stream Management Program. DCSWCD will be the lead for funding opportunities in partnership with other agencies.

Water Quality Protection: The reduction of water surface elevations removed 13 water quality pollution sources completely from inundation during the 100-year return flood interval as seen in Table 46. Ten buildings would be completely removed from inundation during the 50-year return interval flood.

Table 46: Water Quality Protection Benefits Plan #10

Buildings That Could Create a Water Quality Pollution Source Removed From Inundation		
10-Year	50-Year	100-Year
0	10	13

Prioritization:

Table 47: Prioritization Score for Plan #10

Priority Metric name	Score	Numerical Value
Benefit to Cost Ratio	Low	1
Water Quality Protection	High	5
Community Cohesion Preservation	High	5
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	Moderate	3
Prioritization Score Total		28

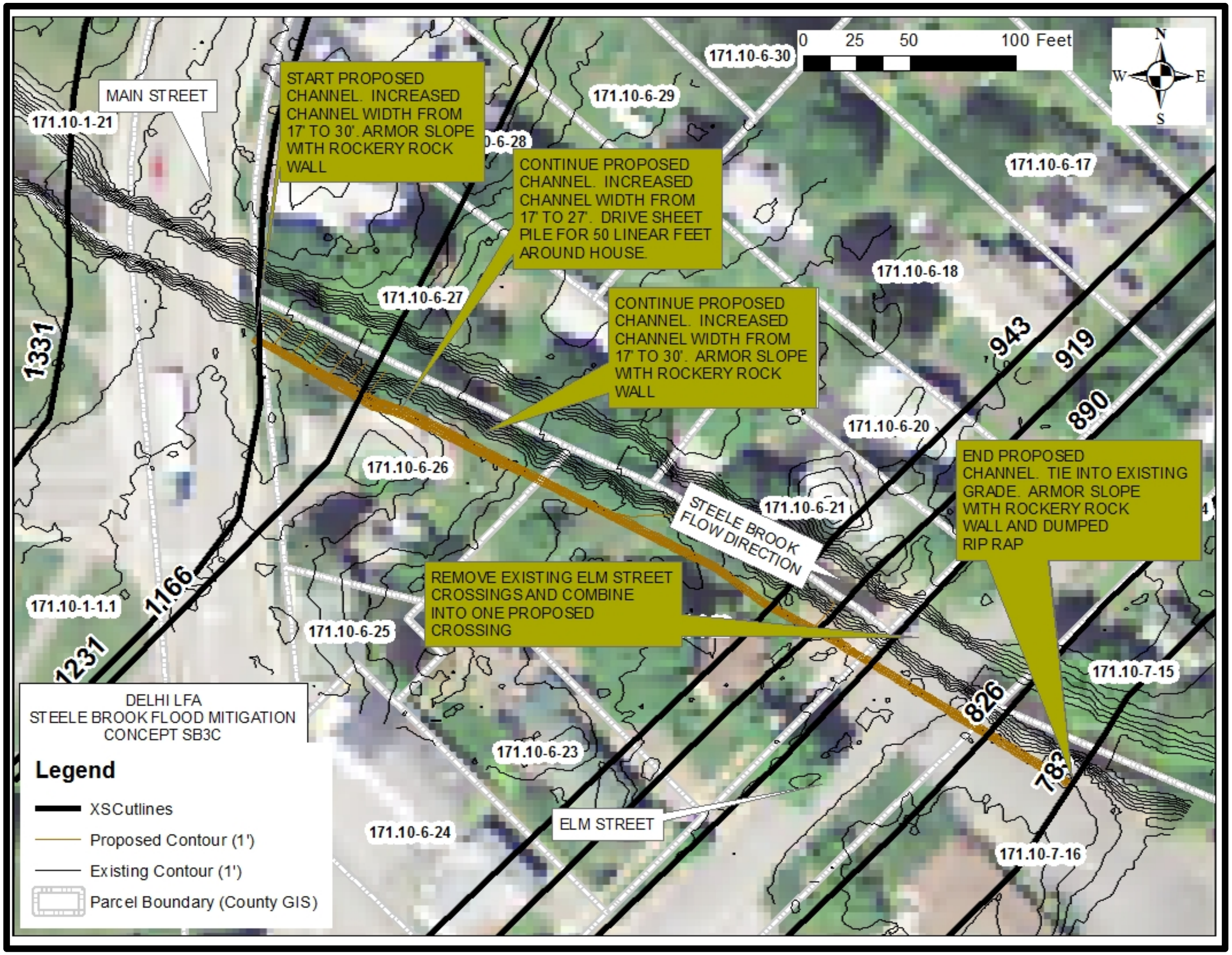


Figure 36: Conceptual Layout of Plan #10

6.3.2 Flood Mitigation Plan #11: Increase Size of Main Street Bridge to Accommodate Debris

Summary: As discussed in Section 6.2.2 on page 77, the Main Street Bridge is prone to plugging with debris and causing all floods exceeding a 10-year flood elevation to overtop the bridge. This causes water to run downhill and enter the retirement community and surrounding buildings as seen in Appendix A, Figure A-21. This also shuts down Main Street, (State Highway #10) for several hours. To accommodate the anticipated blockage, the proposed structural improvement project will increase the clear span of Main Street Bridge from 17 feet to 30 feet. Flood Mitigation Plan #11 assumes Plan #10 is in place downstream because the channel width downstream needs to match the new clear span of the bridge or it would negate ~~the~~ the hydraulic benefits gained by a wider bridge. The obstructed proposed clear span can be seen in Figure 37 and a conceptual sketch of the proposed crossing is shown in Figure 38.

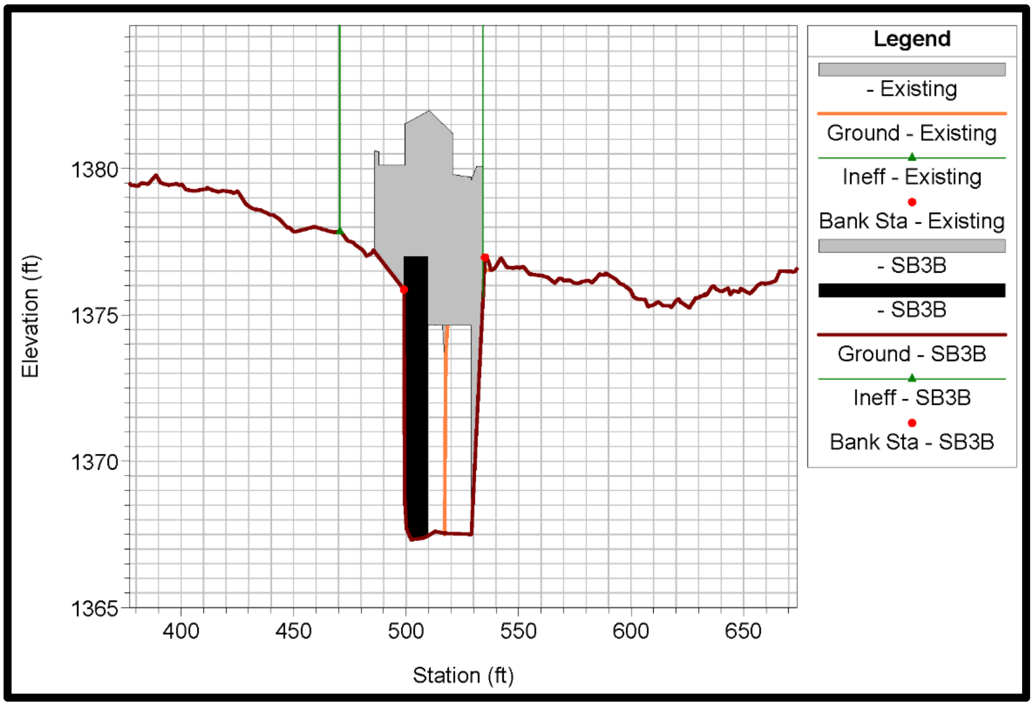


Figure 37: Typical Section of Plan #11

The proposed structure consists of a three sided precast concrete frame runs under Main Street, the clear span is 30 feet and the clear height is 6 feet, the total width is 55 feet carries two sidewalks, the top slab thickness is 18" and the maximum fill height is 12", the three sided structure is carried by a cast-in-place footings founded on H-piles. The proposed precast concrete frame will provide a smooth bottom that will help prevent snagging debris and will provide shallow construction depth across the entire width of the bridge. Construction will be faster because the structure walls and top slab are integrally cast and erected.

Figure 38: Typical Section of Proposed Main Street Crossing

Hydraulic Results: The water surface profile in Appendix A, Figure A-29 shows all flood flows go under the bridge. The water surface elevation reductiond upstream and downstream of the bridge are listed in Table 48. Table A-29, Appendix A, shows a 2.5 to 4.5 foot reduction of water surface elevations for the 25-year and the 100-year return interval floods. Per Appendix A, Figure A-23, the obstructed water surface elevation goes back into the channel immediately downstream of the bridge despite anecdotal evidence describing sheet flow into proximal buildings west of Steele Brook. Since there is uncertainty of water depths around buildings during obstructed conditions, it is assumed that the number of buildings being protected by Plan #11 is the same as Plan #10.

Table 48: Comparison of Obstructed and Plan #11 Water Surface Elevations in Feet

	25-Year Flood			100-Year Flood		
Point of Analysis	Obstructed Conditions	Plan #11	Difference	Obstructed Conditions	Plan #11	Difference
1447	1380.51	1376.17	-4.34	1381.65	1377.17	-4.48
1166	1370.20	1366.92	-3.28	1371.05	1367.92	-3.13
943	1368.35	1365.67	-2.68	1369.25	1366.61	-2.64

Table 49: Number of Buildings Protected by Plan #11

Return Interval	Number of Inundated Buildings In West Branch Study Area		Number of Fully Protected Buildings
	Existing	Plan #11	
10-Year	0	0	No Change
50-Year	5	0	5
100-Year	7	0	7

Benefit to Cost Ratio: The cost of the Mitigation Plan #11 ($1,022,000) was added to the implementation cost of Plan #10 ($1,100,480) and the total cost of Plan #11 was $2,398,420.

Table 50: Plan #11 BCR Results

Number of Structures / Work Item	Benefits	Costs
7 (damages eliminated)	$286,124	
Construction, materials		$2,122,480
- Engineering/Design/Survey (12% of $1,022,000)		$165,072
- Contingency (15% of $1,022,000)		$132,060
TOTALS	$286,124	$2,419,640
Benefit to Cost Ratio (BCR)	0.12	

The proposed flood prevention activity would disturb three parcels and would require a permanent easement on each parcel and a willing landowner would be needed.

Funding Sources: This project qualifies for funding under Delaware County's Soil and Water Conservation District (DCSWCD) Stream Management Program. DCSWCD will be the lead for funding opportunities in partnership with other agencies. The Main Street (NYS Route 10) bridge and roadway is owned and maintained by the NYSDOT and improvement funding could be sought through the NYSDOT. The CWC FHMIP and the NYCDEP Stream Management Program will fund a flood damage prevention activity.

Water Quality Protection: The reduction of water surface elevations removed 13 water quality pollution sources completely from inundation during the 100-year return flood interval as seen in Table 51. Ten buildings would be completely removed from inundation during the 50-year return interval flood.

Table 51: Water Quality Protection Benefits Plan #11

Buildings That Could Create a Water Quality Pollution Source Removed From Inundation		
10-Year	50-Year	100-Year
0	10	13

Prioritization:

Table 52: Prioritization Score for Plan #11

Priority Metric name	Score	Numerical Value
Benefit to Cost Ratio	Low	1
Water Quality Protection	High	5
Community Cohesion Preservation	High	5
Ease of Obtaining Permits for Proposed Solution	Low	1
Economic Impact	High	5
Ease to Acquire Funding	Moderate	3
Ease to Acquire Easements	Moderate	3
Level of Town Effort To Implement Plan	Moderate	3
Prioritization Score Total		26

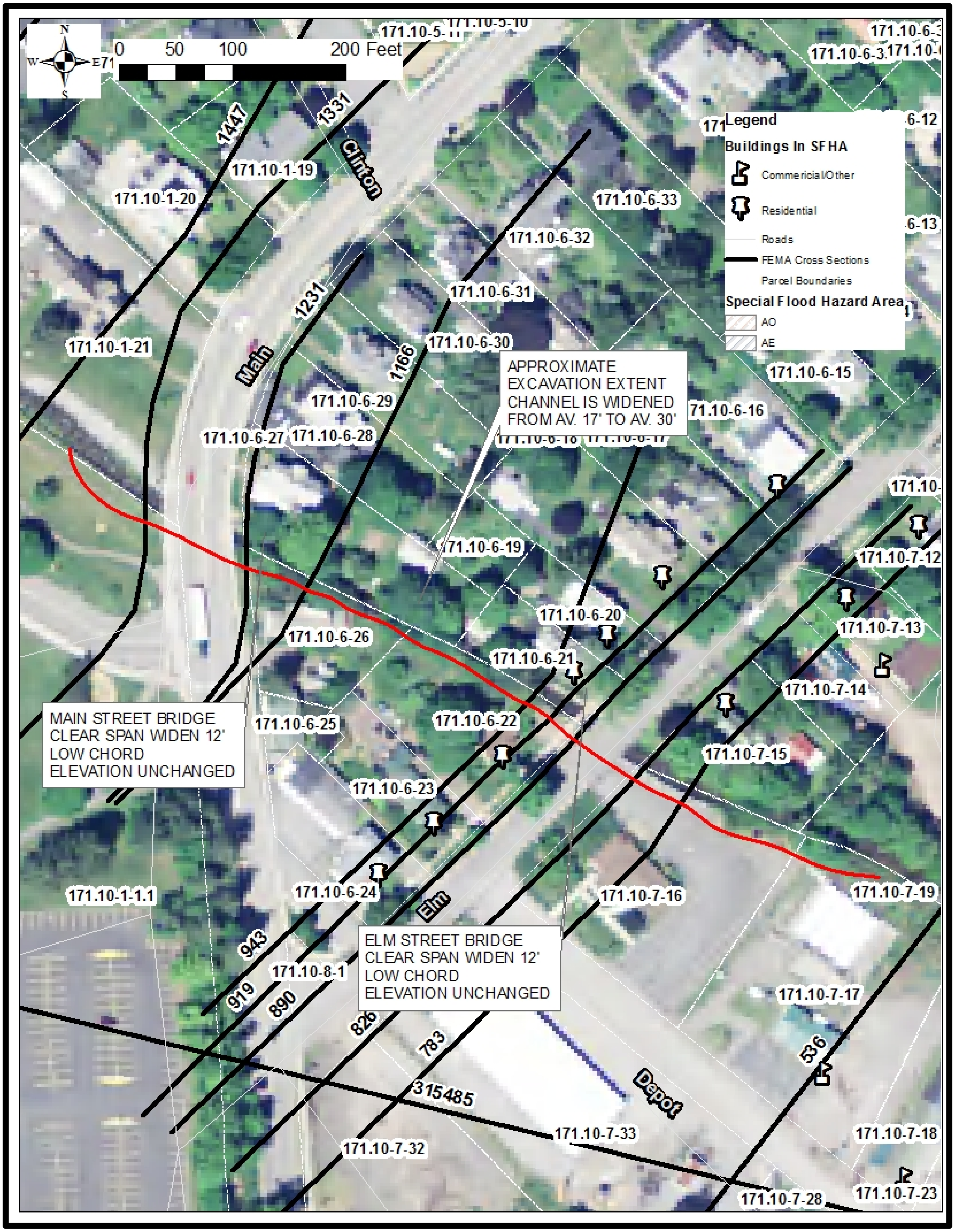


Figure 39: Conceptual Layout of Plan #11

6.3.3 Flood Mitigation Plan #12: Reducing Debris Load Upstream

Summary: Per Table 42, 22% of the total stream bank length (22,000 total feet) was actively eroding and roughly 13% of that stream bank was found to be an extreme source of flood debris (logs) that would eventually make its way down to the Main Street Bridge. Stream restoration using natural channel design is a design process to restore the stream's processes to match the stream's power to move logs, water and sediment within its geometric dimensions. There are several approaches to mitigating debris sources so it's best to assume a uniform cost per linear foot of eroding bank. Often this cost to implement a natural channel design is a function of the access to the construction site from the nearest public road. If construction access is relatively easy, the cost of construction is estimated at $125/linear foot of eroding stream bank. If construction access is difficult, then the cost would be closer to $225/linear foot. Shutting down all or most of the debris sources is a multiyear process and it would be important to help mitigate the transport of trees downstream by intercepting them upstream from the Main Street Bridge. The FC was consulted about the optimal location of a debris catcher and it felt the catcher should not be along the flats upstream of Main Street but located near the downstream abandoned dam which is seen in Figure 40.

Figure 40: Photo Looking Downstream At Abandoned Dam

Hydraulic Results: Not Completed, No Hydraulic Modeling was completed.

Benefit to Cost Ratio: Assuming that most if not all the debris sources are mitigated, then the likelihood of debris jams forming at Main Street goes down. However, floodwaters still leave Steele Brook under clear water conditions (i.e. no obstructions) at Elm Street so Mitigation Plan #11 would need to be implemented to gain notable benefits. The cost of Mitigation Plan #12 however just includes the range of costs for debris source control and debris management at the downstream dam. The length of debris source control is the summation of the Extreme, Very High and High debris source lengths. The opinion of estimated construction cost can be seen in Appendix A, Figure A-31. Operation and maintenance costs for the debris source management are not included in the proposed construction costs. These costs are a function of the accumulation rate of debris which varies from year to year. A conservative planning estimate for annual removal costs is 3% of the construction cost (about $7,000)

Table 53: Plan #12 Proposed Construction Costs

Number of Structures / Work Item	Easy Construction Access	Difficult Construction Access
Debris Source Control (5,730 feet)	$716,250	$1,289,250
Debris Source Management	$238,300	$238,300
TOTALS	**$954,550**	**$1,527,550**

Implementation Challenges and Opportunities: The proposed flood prevention activity would need a variety of easements since the work is proposed on many different parcels of land. All the proposed work would also need permitting from NYSDEC and the US Army Corps of Engineers.

Funding Sources: This project qualifies for funding under Delaware County's Soil and Water Conservation District (DCSWCD) Stream Management Program. DCSWCD will be the lead for funding opportunities in partnership with other agencies.

Water Quality Protection: Not Completed; No Hydraulic Modeling was completed

Prioritization: Not Completed; No Hydraulic Modeling was completed

6.3.4 Flood Mitigation Plan #13: Additional Hydraulic Analysis to Support a Letter of Map Revision (LOMR)

Summary: As discussed in Section 6.16, the hydraulic model that was used to create the floodplain maps assumed floodwater would leave Steele Brook near Elm Street and flow directly downhill along Elm Street. This is shown graphically in Figure 41 that shows a cross section across Elm Street (the area to the left of the green hatch). The area of the green hatch is the land that slopes downhill from Elm Street to the West Branch. The green hatched area that was used in the hydraulic modeling assumed that no water would actively flow through this area. Per public feedback and FC comments, some of the flow does turn towards the southeast as seen in Figure 41. Delhi could support additional hydraulic analysis to show the portion of floodwaters that flow towards the West Branch. This analysis may show that some homes and businesses do not belong in the FEMA floodplain and thereby may be eligible for flood insurance premium reduction. Currently there are 8 homes located in SFHA Zone AO and 2 homes and 3 businesses located in SFHA Zone AE.

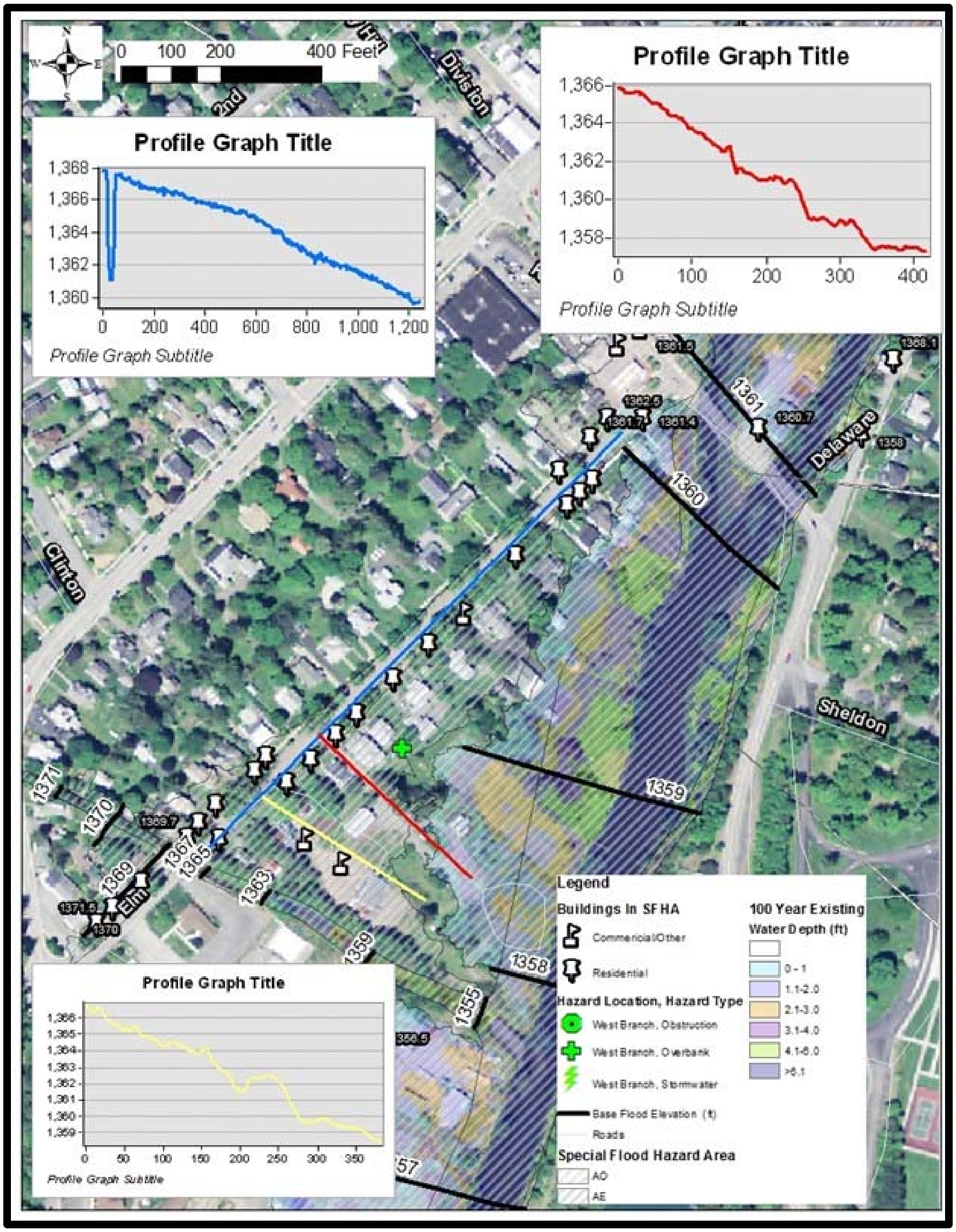


Figure 41: Exhibit Showing Possible Flow Paths for Floodwater Leaving Steele Brook

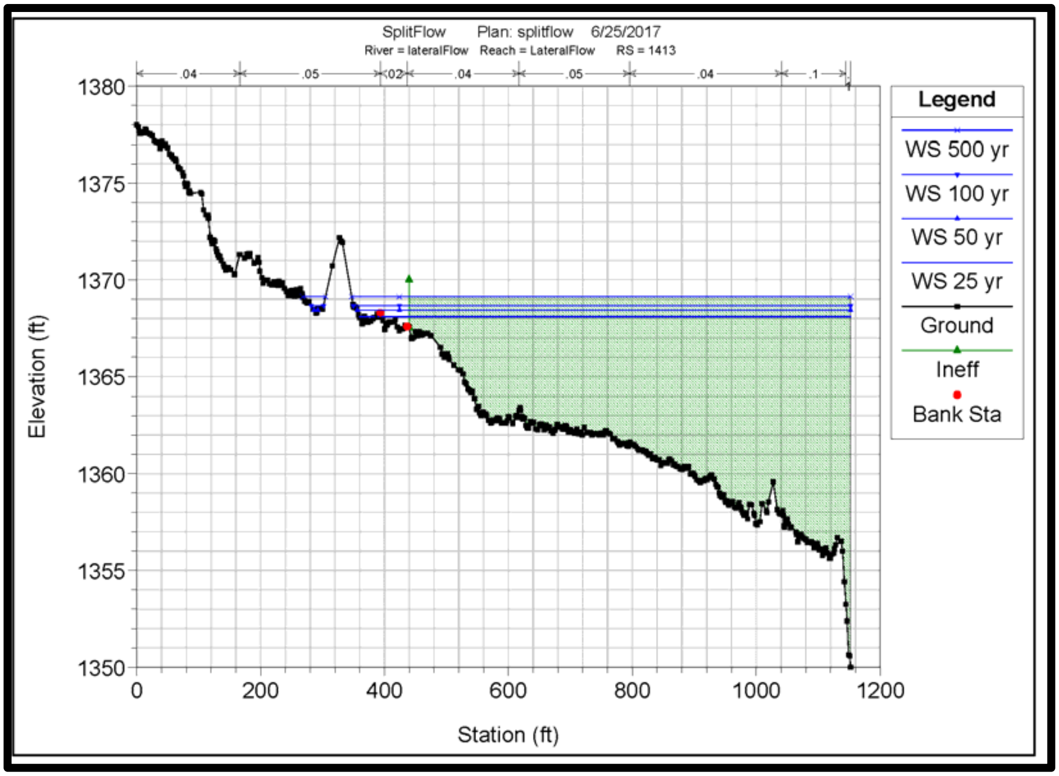


Figure 42: Exhibit Showing How Floodwater was modeled to Flow down Elm Street

Hydraulic Results: Not Applicable; no Hydraulic Modeling Completed

Benefit to Cost Ratio: Not Applicable; no Mitigation Solution Completed

Implementation Challenges and Opportunities: Not Applicable; no Mitigation Solution Completed

Funding Sources: Not Applicable; no Mitigation Solution Completed

Water Quality Protection: Not Applicable; no Mitigation Solution Completed

Prioritization: Not Applicable; no Mitigation Solution Completed

6.3.4 Flood Mitigation Plan #17: Woolerton Bridge Street Protection

Summary: The Flood Commission requested the crossing over Steele Brook be analyzed to understand if an inundation hazard and/or erosion hazard exists at this crossing. Per communications with the FC, debris obstruction has not been an issue. For example, when the Main Street Bridge flooded because of debris in 2006, no debris was removed from Woolerton Bridge. Therefore, an inundation hazard exists if the water surface elevation of the 100-year return interval flood overtops the bridge. An erosion hazard exists if the bridge causes erosion of downstream streambanks which are a source of flood debris. Erosion of downstream streambanks would occur if the bridge causes a notable increase of floodwater velocity. Often this is a result of the crossing constricting the floodwater width as the water approaches the bridge and needs to squeeze through. Of note, the concrete wall upstream of the bridge's wing wall failed in the fall of 2015. Per a Delaware County Department of Public Works letter (dated 11/10/15), this wall was not part of the bridge's substructure, nor is its failure deemed significant to the protection of the bridge. The cause of the failure was more than likely attributed to geotechnical causes, not hydraulic caused (erosion)

Hydraulic Results: The corrected hydraulic model for Steele Brook was run for 2-year, 10-year, 25-year, 50-year, 100-year and 500-year return interval floods. Cross section locations can be seen in plan view in Appendix A, Figure 47. The water surface profile can be seen in Appendix A, Figure 48 and in section view in Appendix A, Figure 49. No calculated water surface elevation reaches the low chord elevation of the bridge and there is 5.0' of freeboard (height between the water surface elevation and the low chord elevation) which is sufficient to pass debris. A flood inundation hazard does not exist at this crossing.

The table in Appendix A, Figure 50 shows water velocities slow from 9.71 ft/sec (River Station 3234) to 6.5 ft/sec (River Station 3044) just upstream of the bridge and then speed up immediately downstream of the bridge (13.21 ft/sec at River Station 2967). Downstream velocities approximately match upstream velocities roughly 500' downstream (near River Station 2919). Looking at the flood debris source map on Figure 33 on Page 81, there is one eroding bank (56 feet in length), with a high ranking as a flood debris source. This is located fifty feet downstream of the bridge. This erosion may be attributed to the increased velocities by the bridge. Comparing the eroding bank length to the other eroding bank lengths upstream of the Main Street Bridge, this flood debris source is one of the least contributing sources of flood debris to the Main Street Bridge. The next flood debris source is located 560 feet downstream in length which is outside the influence of the Woolerton Bridge's constriction.

Benefit to Cost Ratio: The Woolerton Bridge crossing does not have an inundation hazard. This crossing does create erosive conditions downstream of the bridge resulting in the erosion of one streambank, however, the most cost effective way to mitigate this flood debris source is to armor or reshape the bank. For these reasons, no mitigation solution was completed.

Implementation Challenges and Opportunities: Not Applicable; no Mitigation Solution Completed

Funding Sources: Not Applicable; no Mitigation Solution Completed

Water Quality Protection: Not Applicable; no Mitigation Solution Completed

Prioritization: Not Applicable; no Mitigation Solution Completed

7.0 Meredith Street Study Area

7.1 Data Gap Analysis

7.1.1 Public Flooding Hazards and FC Flooding Hazards

Five flooding hazards were identified from the initial public meeting and the first several FC meetings. The overall flooding hazard in Meredith Street is due to stormwater surcharging the existing underground system (pipes, covered channels, etc.), leading to surface water flow that erodes driveways and damages homes. Four of the five hazards are clustered between Spruce Street and High Street. This is where most of the building or land damage occurs when stormwater leaves the underground system. The other stormwater flood hazard is located at Cuddeback Avenue which is part of the drainage system that drains to the other four hazards. Community members have observed that the culvert under Cuddeback Avenue overtops during rain events once every several years, overtopping the road with a few inches of water.

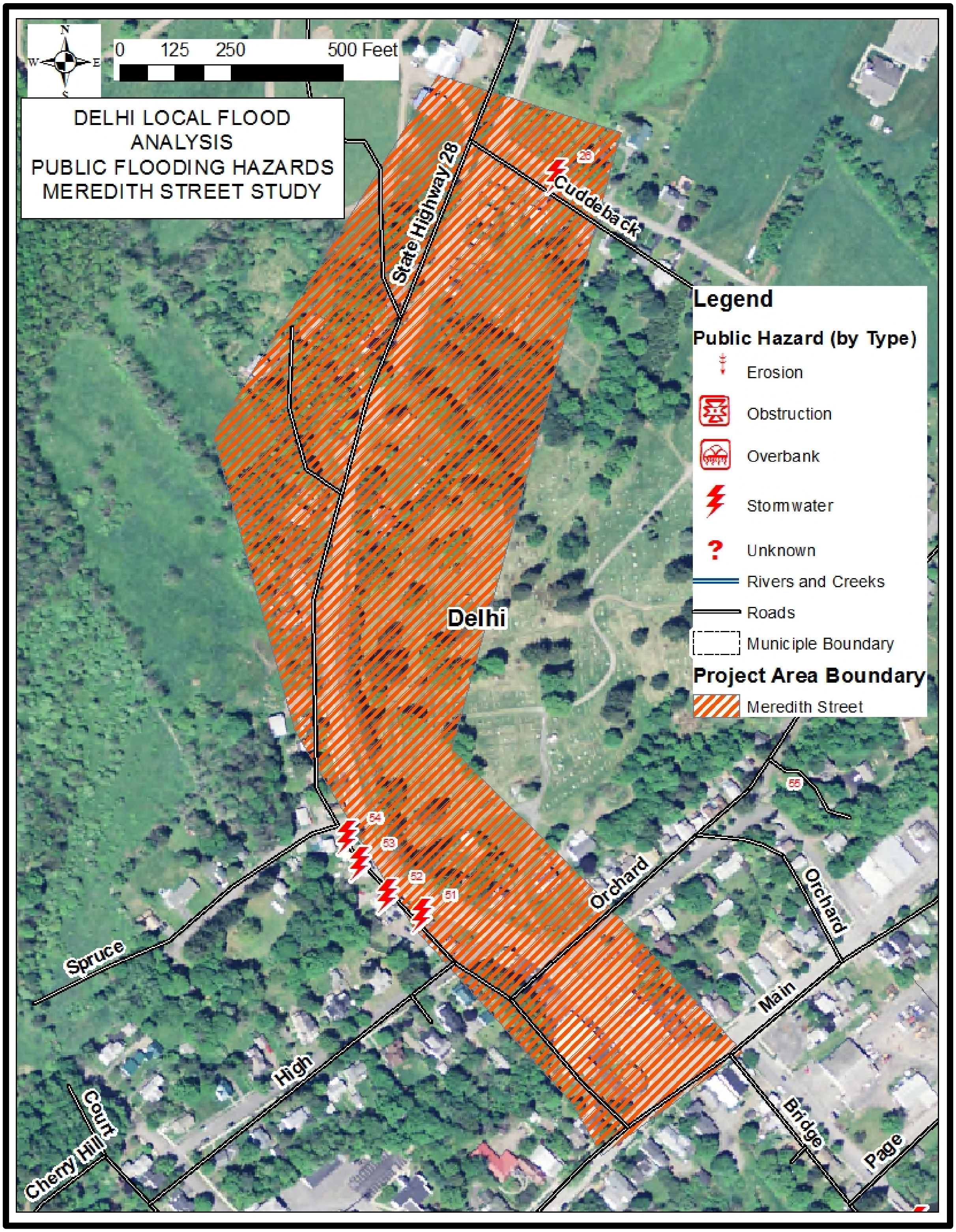


Figure 43: Public Flooding Hazards in Meredith Study Area

7.1.2 Rapid Geomorphic Assessment:
Not applicable; not completed

7.1.3 Meredith Street Stream Feature Inventory (SFI) Review
No SFI data was available for Meredith Street Study Area; not completed

7.1.4 Hydraulic and Hydrologic Model Review: Hydrology
No existing hydrology to review; not completed

7.1.5 Flooding History:
Per feedback from the initial public meeting and several FC meetings, the stormwater flooding hazard occurs several times a year with as little as 0.5" of rainfall over the area draining down to Meredith Street.

7.1.6 Hydraulic and Hydrologic Model Review: Hydraulics
No existing hydraulics to review; not completed

7.1.7 Water Quality Assessment Data Review
No existing hydrology to review; not completed

7.1.8 Floodplain Development Ordinance and Related Town Planning Documents
Please refer to section 5.1.7 for applicable stormwater ordinances.

7.1.9 Identified Data Gaps and Proposed Field Methodology
1. No existing hydrology or hydraulic data was available to review so a hydrologic model (rainfall runoff model) is needed to understand the relationship between rainfall depth and the peak discharges flowing into the Meredith Street drainage system.

2. First floor elevations and highest adjacent grade elevations were needed to characterize the water depth and damage relationship

7.2 Data Gap Analysis Results

7.2.1 Hydrologic Conditions
To characterize the rainfall depth, runoff discharge relationship, the existing stormwater drainage system along Meredith Street was mapped using a Trimble 7X handheld GPS unit. GPS points at each easily observable catch basin were located to determine entry points for runoff discharge into the system.

The major drainage areas contributing runoff to the system were then delineated using 2009 LiDAR data and these areas can be seen in Appendix A, Figure A-31. The largest contributing area to the stormwater system is the 213 acre area above Cuddeback Avenue. An additional 75 acres drain to the catch basins between Cuddeback Avenue and the final curve that sweeps Meredith Street to the south. A third, smaller drainage area (60 acres) drains to the stormwater system near High Street.

Soil classifications (hydrologic soil groups) for each watershed were mapped and measured from the National Resource Conservation Service Delaware County soil map. Land use classifications were mapped and measured from the NLCD 2011 data set. This information can be seen in Appendix A, Figure A-32 through A-34.

The Time of Concentration was calculated following SCS travel velocity methods and can be seen for each watershed in Table 54.

Table 54: Times of Concentration

Watershed	Cuddeback	Meredith	High Street
1st Tc	26.6 (sheet)	38.9 (sheet)	23.7 (sheet)
2nd Tc	34.9 (shallow)	5.8 (shallow	17.5 (Shallow)
3rd Tc	13.9 (Trap)	4.1 (shallow)	4.5 (Shallow)
4th Tc		2.2 (trap)	
Total	75.4	51	45.7

Inflow hydrographs were developed using proprietary hydrologic software HydroCAD using the NRCS TR-20 methodology which is imbedded within the software package. Peak runoff values are shown in Table 55.

Table 55: Peak Runoff Discharges

		Discharge (cfs)		
Rainfall Event	Rainfall Depth	Cuddeback	Meredith	High Street
1-Year	2.18”	13.39	4.92	9.10
5-Year	3.18”	54.04	22.55	29
10-Year	3.71”	82.73	35.03	45.51
50-Year	5.33”	189.34	81.35	85.25
100-Year	6.24”	257.88	111.02	112.34

7.2.2 Existing Hydraulic Conditions

The drainage system was mapped using the handheld GPS and conveyance system changes (i.e. from pipe to covered channel, open channel flow to culvert, etc.), catch basin elevations, and pipe/channel inverts were mapped using GPS points, 2009 LiDAR data and tape measure.

Five points of interest (POI) were identified as locations where the highest areas of stormwater surcharging and stormwater depths occur. These depths were compared with the first floor elevations of the homes that experience water damage. POI #3 is just uphill of the four public hazards along Meredith Street as seen in Figure 43. There are a couple of other homes in POI#4 that also see some water damage. Figure 43 shows a detailed map of the existing drainage system and the corresponding largest storm the existing system can pass before water comes out (surcharges) of the stormwater system and sheet flows downhill. Table 56 summarizes the existing system’s capacity. The system is surcharged beginning at POI#3 during the 1-year, 24-hour rainfall event. This is a common rainfall event that corroborates the comments made by the public and FC members about the frequency the system overtops (several times a year). This analysis assumes unobstructed conditions so if the system is even partially blocked, stormwater may escape and flow over the surface more frequently than the results show.

Table 56: Largest Rainfall Runoff Event That Can Be Passed Under Existing Conditions.

Point of Interest	Description Of POI	Largest Rainfall Runoff Event That Can Be Passed
#1	Delview Terrace	5-year, 24-hour storm
#2	Cuddeback Avenue	5-year, 24-hour storm
#3	Cluster of Four Flood Hazards	1-year, 24-hour storm
#4	High Street	2-year, 24-hour storm

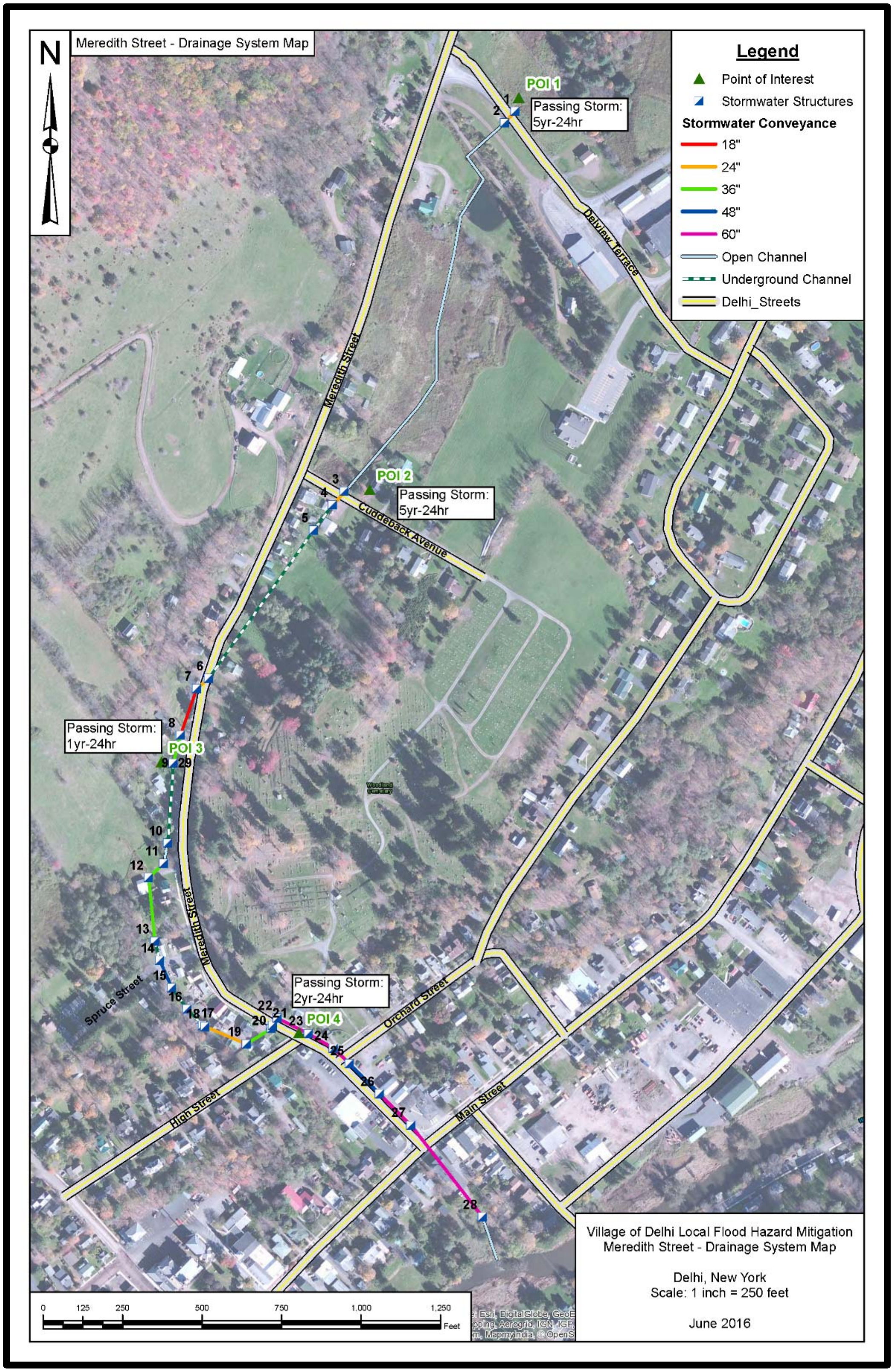


Figure 44: Exhibit of Existing Conditions

7.2.2 Water Depth Maps

HEC-RAS modeling not used for this assessment, not completed.

7.2.3 Water Quality Pollution Sources

One building at POI#3 was built on a slab (Building #1) and the other had an unfinished basement. The three buildings at POI#4 had unfinished basements so if the water surface exceeded the surrounding adjacent grade elevation (GE) for the latter three buildings or the first floor elevation for the former building, a water quality pollution source would occur.

7.3 Flood Mitigation Plans

7.3.1 Flood Mitigation Plan #14: Install New Stormwater Conveyance Down Meredith Street.

Summary: To minimize impacts to landowners and reduce the number of easements required to complete the proposed concept, a new stormwater alignment was proposed to run down the NYSDOT Route 10 highway right of way along Meredith Street. The proposed concept can be seen in Figure 45.

Hydraulic Results: Two Buildings at POI3 and three buildings at POI4 were assessed to determine their flood proneness and can be seen in Appendix A, Figure A-44. This is summarized in Table 57. The 1-year to the 25-year rain fall events were modeled. Larger rainfall events than the 25-year surcharged the stormwater system creating a water depth that exceeded the assumptions used to complete the reach routing calculations.

Table 57: Water Surface Elevation Comparison at POI#3.

	Building 1			Building 2		
Storm	WSEL (ft)	FFE (ft)	GE (ft)	WSEL (ft)	FFE (ft)	GE (ft)
1-yr	1438.00	1438.00	1438	1434.00	1435.00	1434
2-yr	1438.13	1438.00	1438	1434.13	1435.00	1434
5-yr	1438.29	1438.00	1438	1434.29	1435.00	1434
10-yr	1438.42	1438.00	1438	1434.71	1435.00	1434
25-yr	1438.94	1438.00	1438	1434.94	1435.00	1434

Table 58: Water Surface Elevation Comparison at POI#4.

Storm	WSEL	Building #3		Building #4		Building #5	
		FFE	GE	FFE	GE	FFE	GE
	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)
1-yr	1390.00	1392.50	1391	1394.50	1393	1397.00	1395
2-yr	1390.00	1392.50	1391	1394.50	1393	1397.00	1395
5-yr	1390.18	1392.50	1391	1394.50	1393	1397.00	1395
10-yr	1390.30	1392.50	1391	1394.50	1393	1397.00	1395
25-yr	1390.55	1392.50	1391	1394.50	1393	1397.00	1395

Benefit to Cost Ratio:

The cost of Mitigation Plan #14 can be seen in Appendix A, Figure A-36.

Table 59: Plan #14 BCR Results

Number of Structures / Work Item	Benefits	Costs
2 (damages eliminated up to 25-year flood)	$12,690	
Construction, materials		$859,700
- Engineering/Design/Survey (16% of $859,700)		$157,000
- Contingency (20% of $859,700)		$117,500
TOTALS	$12,690	$1,134,200
Benefit to Cost Ratio (BCR)	0.01	

Since the Benefit to Cost Ratio is very low which suggests the project would not be implemented if the BCR alone was a determining factor, the building owners should look at acquiring flood insurance. These policies would be in a Zone X which offers the lowest insurance premiums.

Implementation Challenges and Opportunities: The proposed flood prevention activity would need to obtain five parcels between Cuddeback Avenue and Meredith Street in order to upgrade to the new 24" HDPE pipe. A permanent easement would be needed to acquire the land north of Cuddeback Avenue to build the storage facility. The area where the proposed storage facility will be located may impact wetlands.

Funding Sources: The CWC FHMIP and the NYCDEP Stream Management Program may fund a flood damage prevention and natural resource preservation project. The proposed work includes a detention pond at Cuddeback Avenue which is a stormwater facility and would not meet the dam threshold.

Water Quality Protection: The proposed activities will remove Building #1 and Building #2 as potential water pollution sources since the water surface elevation during flooding will not exceed the elevations of the adjacent grade or first floor elevation.

Table 60: Water Quality Protection Benefits Plan #14

Buildings That Could Create a Water Quality Pollution Source Removed From Inundation		
1-Year	10-Year	25-Year
2	2	2

Prioritization:

Table 61: Prioritization Score for Plan #14

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

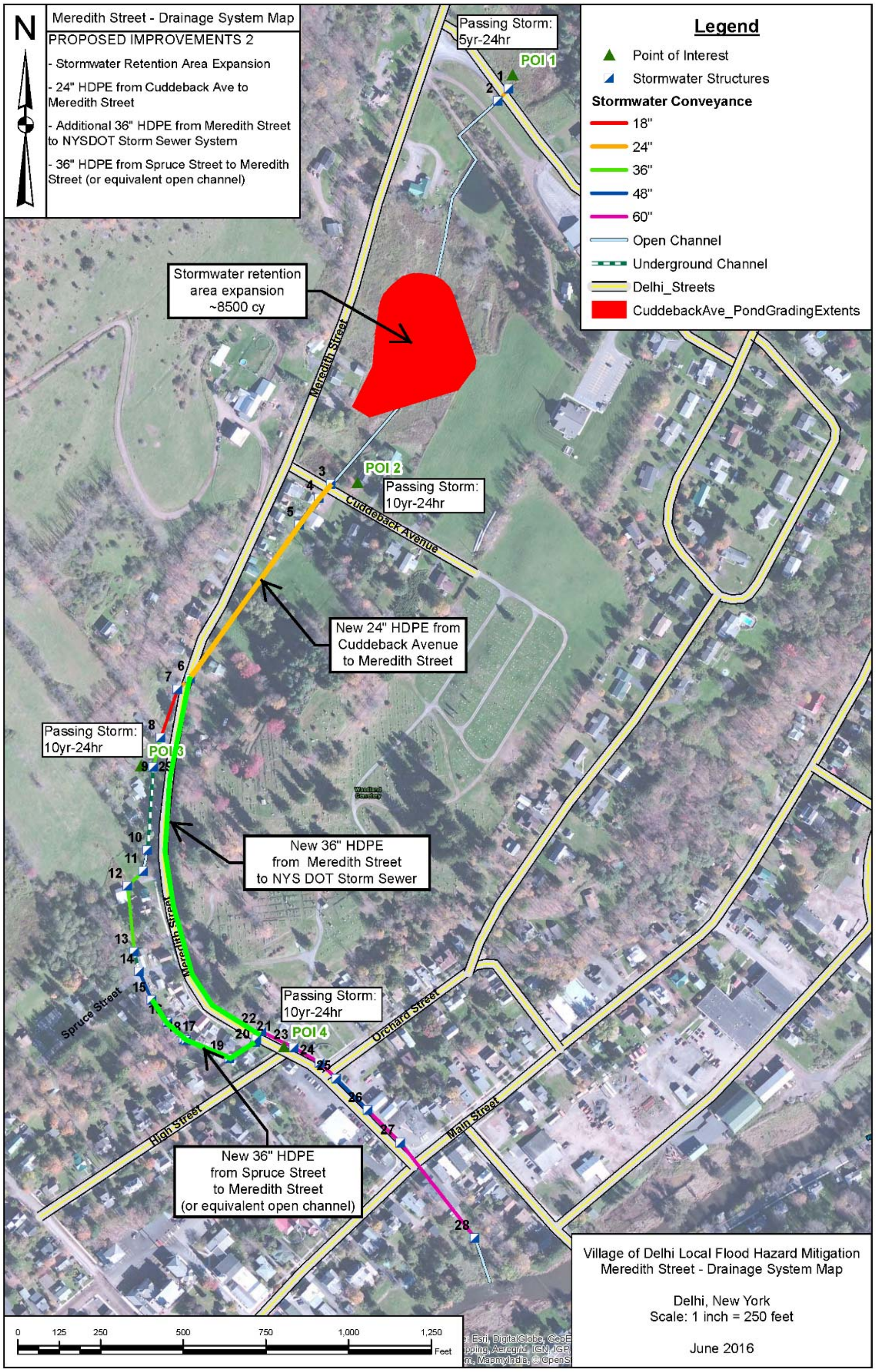


Figure 45: Conceptual Plan for Mitigation Plan #14

7.3.3 Plan #15--Structural Interventions (Property Protection)

Summary: There are 5 buildings in the Meredith Street Study Area that can be structurally altered to raise the first floor elevation and/or relocate mechanics (furnace, water heater, etc.) out of basements. These buildings can be structurally elevated because they have crawl spaces underneath them.

Results: Implementation of this plan would lead to lifting the buildings to allow floodwaters to pass underneath them using flood vents.

Benefit to Cost Ratio: The opinion of probable construction cost to raise these structures is summarized in Table 37.

The buildings have been proposed to be elevated 3.0' above the 25-year water surface elevation. This will allow for ample freeboard (vertical clearance) because of the unknown water depths during floods larger than the 25-year flood event as described in section 7.3.1 on page 103. A preliminary BCR of 0.05 was calculated

Implementation Challenges and Opportunities: When buildings are lifted, utilities and ingress/egress also need to be changed to match the higher first floor elevation.

Funding Sources: The Catskill Watershed Corporation's (CWC) FHMIP 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 (5 buildings).

Table 62: Cost of Property Protection (Structural Intervention)

Work Item	Cost/Square Foot
Cost of Elevating Structure	$15
Cost of Building New Foundation	$20
Engineering/Permitting	$5

Table 63: Plan #15 BCR Results

Number of Structures / Work Item	Benefits	Costs
5 (damages avoided)	$12,690	
Implementation		$264,080
Benefit to Cost Ratio (BCR)	0.05	

Prioritization:

Table 64: Prioritization Score for Plan #15

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

8.0 Elk Creek Area

8.1 Data Gap Analysis

8.1.1 Public Flooding Hazards and FC Flooding Hazards

There were no identified flooding hazards within the Elk Creek Study Area boundary. Two stormwater flooding hazards (#1 and #2) were identified on a tributary to Elk Creek. The cause of the flooding hazards was due to a roadway culvert along the tributary plugging with large cobbles. This obstruction resulted in floodwater overtopping Elk Creek Road and sheet flowing into the adjacent properties causing water damage to the homes.

Figure 46: Elk Creek Study Area and Public Hazards

8.1.2 Rapid Geomorphic Assessment
It was assumed that controlling flood debris at its source or managing it upstream was not feasible for this flood hazard. Geomorphic data was not collected.

8.1.3 Elk Creek Stream Feature Inventory (SFI) Review
No SFI data was available for Elk Creek for review; not completed

8.1.4 Hydraulic and Hydrologic Model Review: Hydrology
No hydrology data was available for Elk Creek for review; not completed

8.1.5 Flooding History
During the 2006 flood, floodwaters overtopped the culvert and inundated the two homes with approximately 0.5' of water.

8.1.6 Hydraulic and Hydrologic Model Review: Hydraulics
No existing hydraulic data to review; not completed.

8.1.7 Water Quality Assessment Data Review
Two homes are located near the Elk Creek Tributary crossing. Each home has a non-finished basement where household chemicals, paints, etc. could be stored. If floodwaters exceed the elevations of adjacent grades then it is assumed water is flowing into and out of the basement and a water quality pollution source exists.

8.1.8 Identified Data Gaps and Proposed Field Methodology
1. What flood elevations overtop Elk Creek road under clear water conditions (i.e. no obstructions) and which flood elevations overtop Elk Creek road under obstructed conditions.

2. How frequently do the potential water pollution sources occur?

8.2 Data Gap Analysis Results
A topographic survey was completed in March 2016 to develop a hydraulic model that would be used to understand the existing flooding conditions and to inform the dimensions of a structural protection project to alleviate the flooding hazard. Topographic survey data was collected using a total station. Cross sections were obtained beginning 100' upstream through the Elk Creek crossing, ending several hundred feet downstream as seen in Figure 47.

Figure 47: Elk Creek Cross Section Map

8.2.1 Hydraulic Model / Hydrology

The unnamed tributary to Elk Creek is an ungauged stream and is not included as a separate flooding source in the Flood Insurance Study (FIS) for Delaware County (Effective Date: June 16th, 2016). As such, no flood frequency and discharge relationships have been computed for this tributary. The inflow hydrology, for the purposes of the LFA, was computed at the Elk Creek Road crossing of the tributary, which is approximately 1,000 feet above the confluence of the tributary with the main stem of Elk Creek.

Peak flows were developed using the Soil Conservation Service (SCS) Unit hydrograph method imbedded in the HydroCAD version 10.00-19 software. "CN" values were estimated from review of land use, aerial photography and Delaware County Soil Mapping. Predominant soil types consist of Hydrologic Group C and D soils intermixed with smaller amounts of types A and B soils for the inflow area upstream of the point of analysis. Land cover primarily consists of heavily wooded areas and pasture.

The total drainage area reaching the point of analysis is approximately 424 acres or 0.66 square miles (see drainage area map – Appendix A, Figure A-37). Lag time's (Tlag) for the inflow hydrographs were computed utilizing travel time methodology from NRCS TR-55 procedures, with Tlag = 0.6 X Tc (time of concentration).

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

Table 65 depicts the peak flows used in the modeling and analysis of the study reach of the unnamed tributary to Elk Creek.

Table 65: Flood Frequency versus Discharge Relationships

Storms/Floods		24hr Rainfall Totals	Peak Flow
Return Interval	Exceedance Probability	(inches)	(cfs)
2-year	0.5	2.58	70.89
10-year	0.1	3.70	188.49
50-year	0.02	5.30	403.07
100-year	0.01	6.20	537.10
500-year	0.002	8.95	984.06

Hydraulics

Using the March 2016 survey data, a hydraulic model was developed using the US Army Corp's software modeling package (HEC-RAS). Manning's roughness values were developed from published values and engineering judgment.

A debris jam was inserted into the model using the obstruction function of the HEC-RAS software. The area of the obstruction was roughly half the size of the culvert opening and can be seen in section view in Figure 48. The model was run for the five discharges listed in Table 62 and the water surface elevations at the Elk Creek Road Culvert can be seen in Figure 47 and in profile view in Appendix A, Figure A-37.

The water surface elevation at the 100-year return interval flood overtops Elk Creek Road but the smaller floods all pass through the culvert. The tall stream bank heights keep the floodwaters contained within the stream corridor. With a 50% blockage, the existing crossing can pass the design standard flood for a county road (25-year). Per section 8.1.5, the two homes were inundated by 0.5' of water. Both homes' first floor elevations are 0.5' above the highest adjacent ground so the culvert under Elk Creek Road must have plugged completely with debris to cause water surface elevations to be so high to cause these water depths.

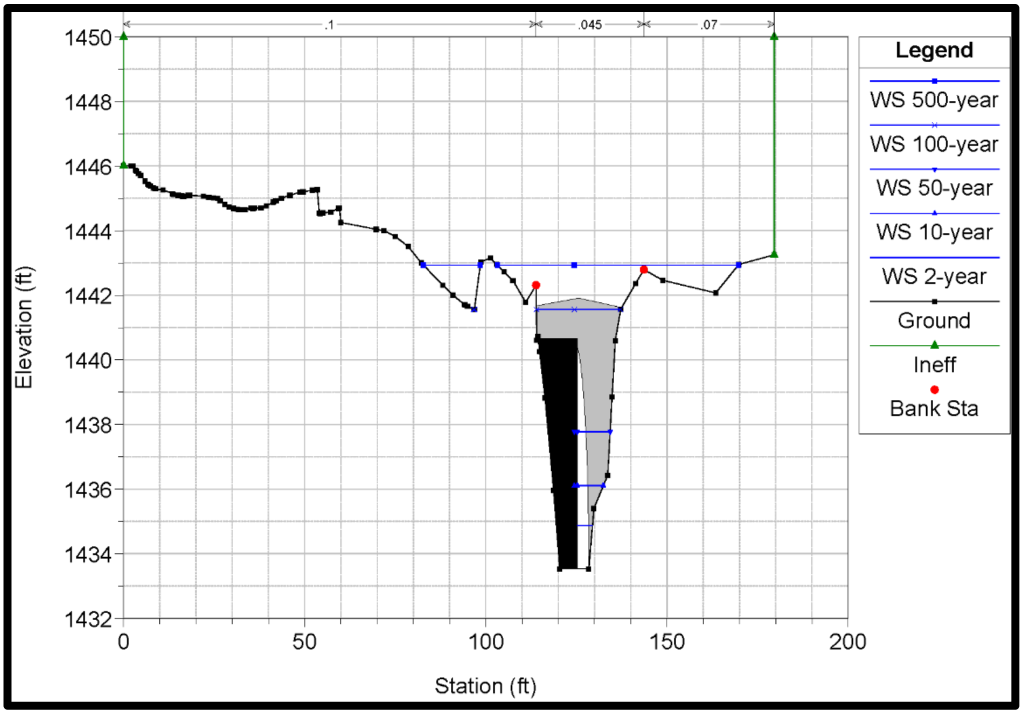


Figure 48: Obstructed Cross Section

8.2.2 Water Depth Maps

Flooding hazards were caused from the undersized or blocked culvert under Elk Creek Road so water depth maps were not needed to characterize the flooding hazard and there for not created.

8.2.3 Building Flooding Damage Evaluation

Building #1 is located at section 0943 as seen in Figure 47 and building #2 is located at section 0809 (hidden in Figure 46). Per section 8.2.1, the culvert must have plugged completely in order to create the water surface elevations that led to the inundation of the two homes. The water surface profile under fully obstructed conditions showed the water surface elevations are contained within the creek at section 0943 and 0809 as seen in Appendix Figure A-38. This is a limitation of one dimensional hydraulic modeling which cannot use lateral flow vectors in calculating water depth. Therefore it was assumed that the two buildings were inundated during the 100-year flood and the water depths at the two cross sections were 0.5' higher than the buildings' first floor elevation as seen in Table 66.

Table 66: Elevations for Water Surface, First Floor and Highest Adjacent Ground

	100-year Flood Elevation (ft)	FFE (ft)	GE (ft)
Building 1	1433.5	1433.0	1432.5
Building 2	1431.5	1431.0	1430.5

8.2.4 Water Quality Pollution Sources

It was assumed the only return interval flood that water elevations were higher than the highest adjacent ground occurred during the 100-year flood under fully obstructed conditions. During this hydraulic condition, two buildings were classified as water quality pollution sources.

8.3 Flood Mitigation Plan Summary

Per section 8.2.1, the flooding hazard only occurred during fully obstructed conditions at the culvert and at a very large and infrequent flooding event, the 100-year flood. The proposed mitigation solution increased the size of the culvert in order to pass the 100-year flood.

8.3.1 Flood Mitigation Plan #16: Increase Size of Elk Creek Road Culvert

Summary: The arch culvert's dimensions were increased to 12' wide with a 7' height span. The culvert alignment, headwall and wing wall dimensions and locations were assumed to be roughly the same. The same size obstruction that was modeled under fully obstructed conditions was placed in the proposed condition model and can be seen in Figure 49.

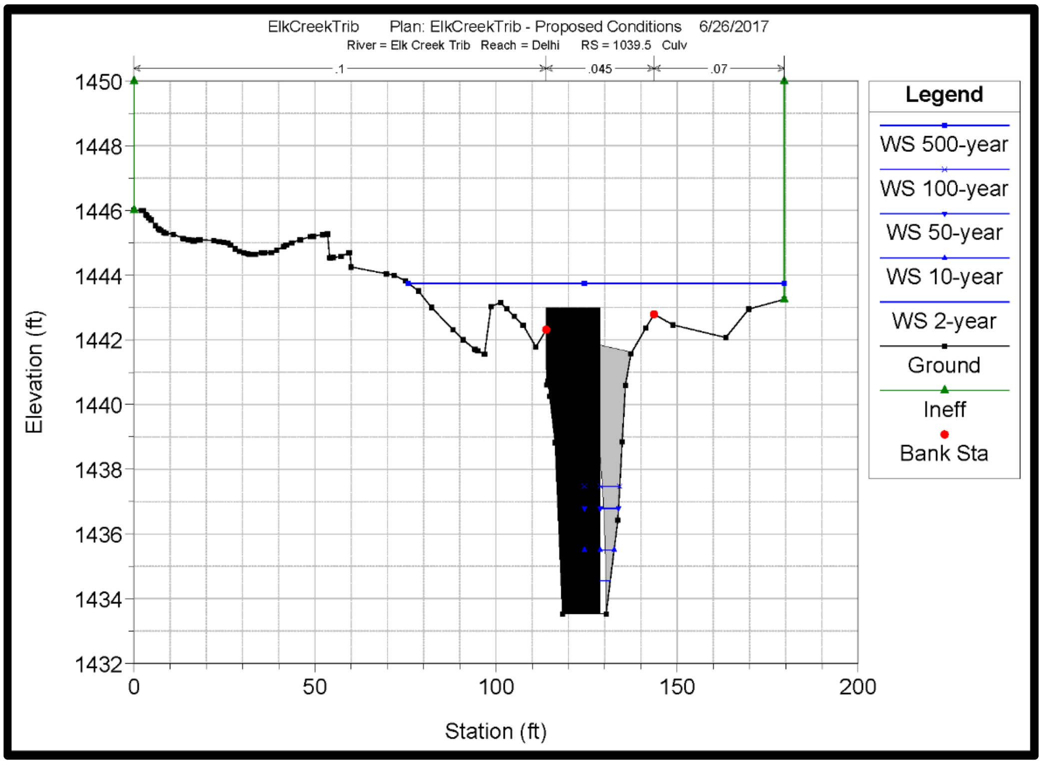


Figure 49: Obstructed Cross Section under Proposed Conditions

Hydraulic Results: The 100-year water surface elevation is passed through the proposed culvert under the obstructed condition and can be seen in section view in Figure 48 and in profile view in Appendix A, Figure A-39. Two buildings would be protected during the 100-year flood.

Table 67: Number of Buildings Protected by Plan #16

Return Interval	Number of Inundated Buildings In West Branch Study Area		Number of Fully Protection Buildings
	Existing	Plan #15	
10-Year	0	0	No Change
50-Year	0	0	No Change
100-Year	2	0	2

Benefit to Cost Ratio: The opinion of probable construction cost for Elk Creek Crossing was estimated to be $110,000 for construction. Contingency and engineering costs increase the project cost to $150,000 (as seen in Appendix A, Figure 46). There was only two events (the 100-year and 500-year) flood events that caused damage to the two buildings. To use FEMA's Damage Frequency analysis, a minimum of three flooding events need to cause flooding damage. Therefore a benefit to cost analysis was not completed.

Implementation Challenges and Opportunities: The proposed structural project could be installed while maintaining one lane of traffic on Elk Creek Road.

Funding Sources: This project qualifies for funding under Delaware County's Soil and Water Conservation District (DCSWCD) Stream Management Program. DCSWCD will be the lead for funding opportunities in partnership with other agencies.

Water Quality Protection: Two water quality pollution sources could be mitigated in Plan #16.

Table 68: Water Quality Protection Benefits Plan #16

Buildings That Could Create a Water Quality Pollution Source Removed From Inundation		
10-Year	50-Year	100-Year
0	0	2

Prioritization:

Table 69: Prioritization Score for Plan #16

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

9.0 Platner Brook Study Area

9.1 Data Gap Analysis

9.1.1 Public Flooding Hazards and FC Flooding Hazards

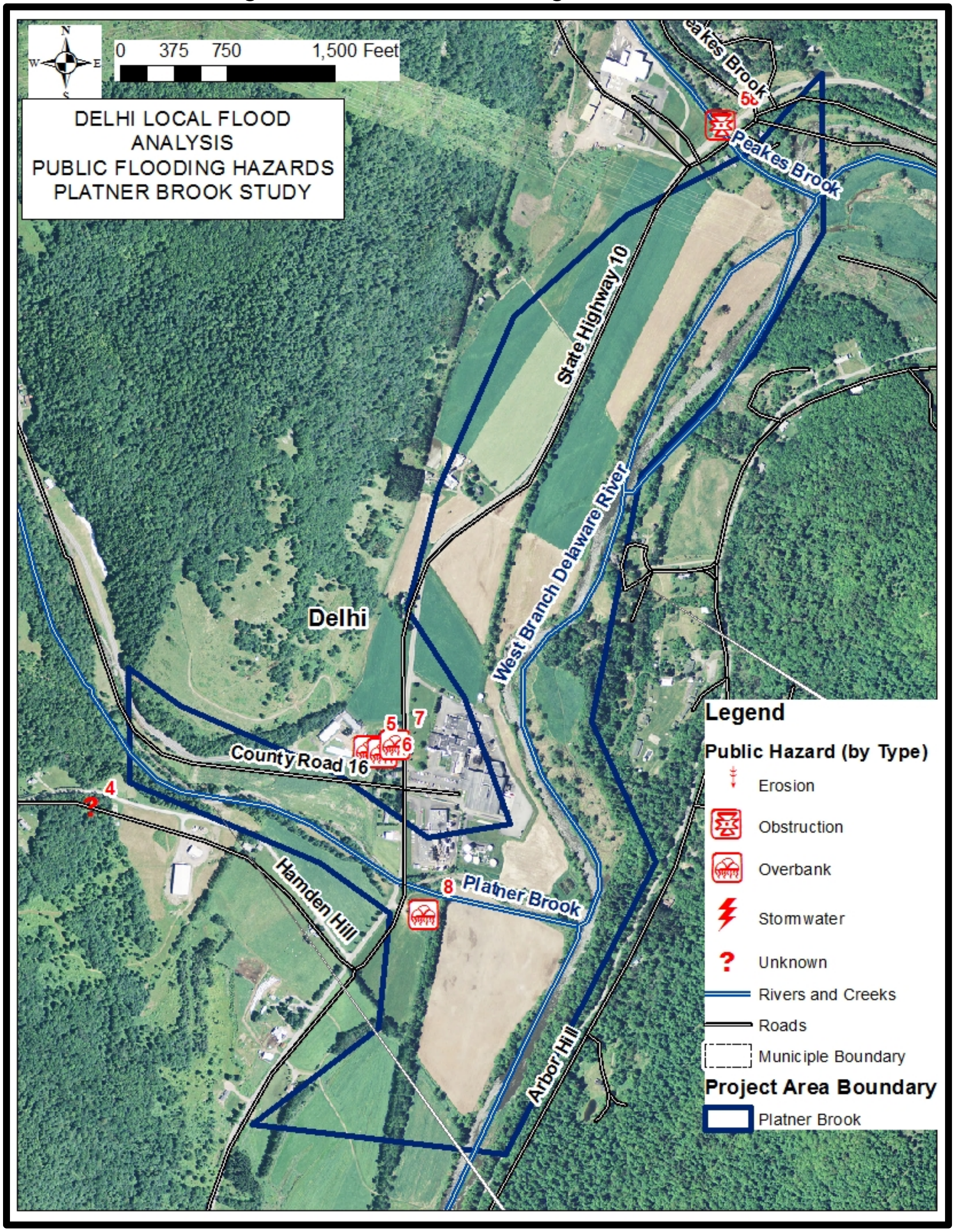


Figure 50: Public Flooding Hazards in Platner Brook

9.1.2 Rapid Geomorphic Assessment

It was assumed that flood debris or floodplain encroachment were not the causes of this flooding hazard, therefore, Geomorphic data was not collected.

9.1.3 Platner Brook Stream Feature Inventory (SFI) Review

No SFI data was available for Platner Brook for review; not completed

9.1.4 Hydraulic and Hydrologic Model Review: Hydrology

No hydrology data was available for Platner Brook for review; not completed

9.1.5 Flooding History

During the 2006 flood, floodwaters jumped out of the Brook about 700' upstream from the cluster of flood hazards seen along County Road 16 in Figure 50. The water then flowed down County Road 16 and into the manufacturing plants on the east side of State Route #10 resulting in approximately a foot of water in the buildings.

9.1.6 Hydraulic and Hydrologic Model Review: Hydraulics

No existing hydraulic data to review; not completed.

9.1.7 Water Quality Assessment Data Review

The two manufacturing facilities are assumed to hold large stores of potential chemicals and other materials that would pose a water quality pollution source if water flowed through the buildings. The buildings are set on slabs so if floodwater elevations exceed their first floor elevation then a water quality pollution source exists.

9.1.8 Identified Data Gaps and Proposed Field Methodology

1. What flood elevations overtop Platner Brook under clear water conditions (i.e. no obstructions)?

2. How frequent do the potential water pollution sources occur.

9.2 Data Gap Analysis Results

9.2.1 Corrected FEMA Hydraulic Model

Hydrology

The effective Flood Insurance Study (FIS) for Delaware County (Effective Date: June 16th, 2016) does not provide summary tables of drainage areas and discharges for streams studied by approximate methods, which includes Platner Brook. The FIS identifies the methodology used for estimating peak discharges on streams studied by approximate methods as the Regional Regression equation methods in accordance with the USGS Scientific Investigations Report 2006-5112 "Magnitude and Frequency of Floods in New York".

Platner Brook is an ungauged stream and is not included as a separate flooding source in the Flood Insurance Study (FIS) for Delaware County (Effective June 16th, 2016), but was studied using approximate methods. As such, no flood frequency and discharge relationships have been computed for this creek. The inflow hydrology, for the purposes of the LFA, was computed at the New York State Highway Route 10 crossing of the stream, which is approximately 1,400 feet above the confluence of the stream with the West Branch of the Delaware River.

Peak flows for this study reach were developed using the USGS StreamStats program, which utilizes the most up-to-date regression methodology (the same as identified in the FIS) to calculate the peak flows for specific return interval storms. Table 70 identifies the peak flows for the 2, 10, 25, 50, 100, and 500-year return intervals for the study reach in the HEC-RAS model.

The total drainage area reaching the point of analysis is approximately 8,906 acres or 13.92 square miles (Appendix A, Figure A-40)

Table 70: Discharges for Platner Brook

Storms/Floods		Peak Flow (cfs)
Return Interval	Exceedance Probability	
2-year	0.5	701
10-year	0.1	1,360
50-year	0.02	1,740
100-year	0.01	2,030
500-year	0.002	2,340

Hydraulics

A topographic survey was completed in March 2016 to develop a hydraulic model that would be used to understand the existing flooding conditions and to inform the dimensions of a structural protection project to alleviate the flooding hazard. Topographic survey data was collected using a total station. Cross sections were obtained beginning at the private bridge located approximately 3,000' upstream from the State Route 10 crossing and ending several hundred feet downstream as seen in Figure 51. The State Route #10 bridge was replaced by NYSDOT during the summer of 2017 and their proposed bridge crossing dimensions were obtained and included in the corrected model.

Figure 51: Cross Section Locations in Platner Brook

9.2.2 Water Depth Maps

Using the results of the corrected FEMA hydraulic modeling results, several exhibits were created that captured the depth of water at various flood events. These are useful exhibits that begin to characterize the location of where overbank flooding occurs from swollen rivers and how often it occurs.

<u>25-Year Return Interval Flood (Appendix A, Figure A-41):</u> Floodwaters are generally contained within Platner Brook.

<u>100-Year Return Interval Flood (Appendix A, Figure A-51):</u> Floodwaters are generally contained within Platner Brook. Water surface elevations appear to remain within the active channel and not spread over land towards County Road 16. There is approximately 1.0’ to 2.0’ of freeboard between the highest water surface elevation and the lowest land elevation between the floodwaters and County Road 16.

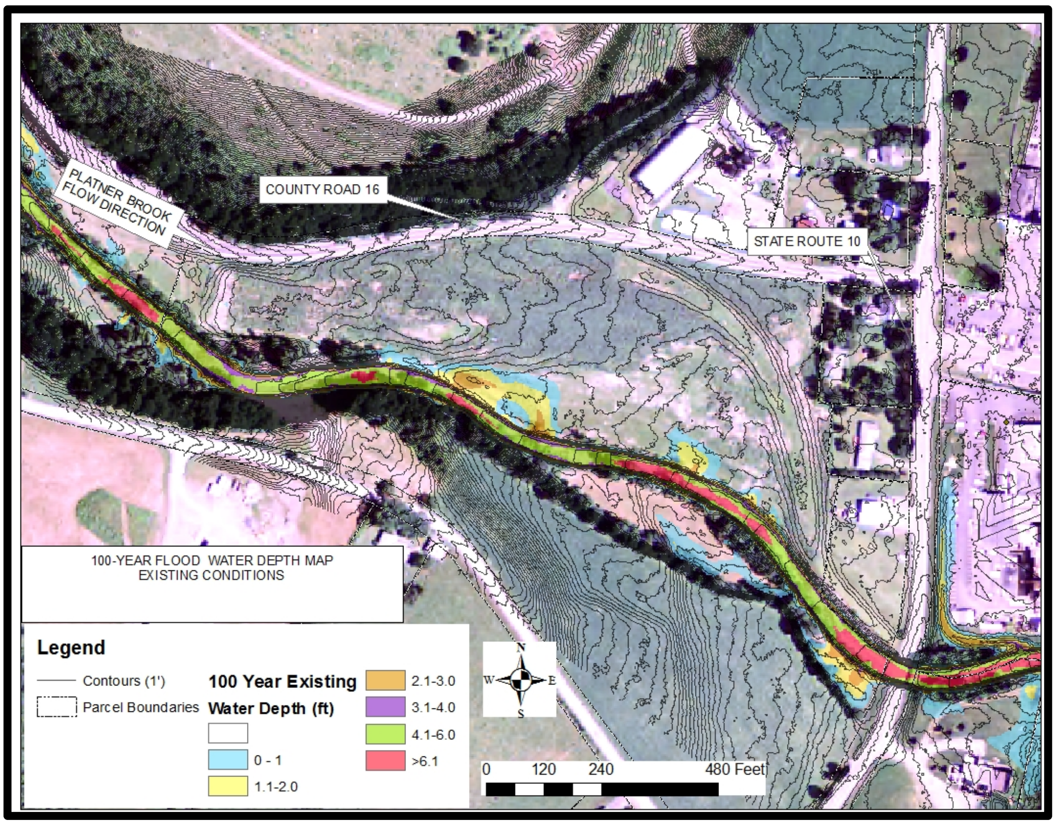


Figure 52: 100 Year Water Depth Map under Existing Conditions

9.2.2 Building Flooding Damage Evaluation

No surface water was calculated to flow through any buildings

9.2.3 Water Quality Pollution Sources

No surface water was calculated to flow through any buildings

9.3.0 Flood Mitigation Plan Summary

No flood hazards were identified during modeling so no flood mitigation plans were developed. It appears Platner Brook may have down cut (vertically eroded) and now the 100-year flood elevation is completely contained with the active channel. There were no signs of logs debris jams that may have plugged the channel leading to water surface elevations being higher which could flow across the land towards County Road 16.

10.0 Summary and Recommendations

10.1 Summary

There are six study areas that were reviewed as part of Delhi's LFA. The West Branch Study Area and Steele Brook Study Area had both overbank flooding hazards and debris flooding hazards. Meredith Street Study Area and Elk Creek Study Area had stormwater flood hazards. Platner Brook and Little Delaware River did not have any apparent flooding hazards.

West Branch

In the West Branch Study Area, this analysis showed that thirty six buildings are prone to flooding at moderately occurring flooding events (25-return interval flood). Various mitigation scenarios were evaluated to protect these buildings.

The analysis conducted for this LFA assessed all options suggested by the consultants, the community and the Flood Commission. Some alternatives, such as those to improve the conveyance of flood flows (Plan 2, 3 and 4) did not provide significant flood elevations reductions and are not prioritized in this plan. Others alternatives (Plan 1, 10 and 14) 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.

The community must decide if:

1) They want to do nothing and leave these buildings exposed to future flooding suppressing the property values (and increased flood insurance premiums) which may lead to a loss of residents and businesses.
2) Protect their community in place by installing the necessary flood prevention measures
3) Begin relocating residences, businesses, and critical facilities out of the flood hazard area
4) Elevate and/or flood proof structures where appropriate.

Each of these options has their advantages and disadvantages.

1. Do nothing:
   If Delhi takes no action then individual property owners are left to their own resources to recover after future flood events. Flood insurance premiums are rising as the Federal government reduces subsidies on the NFIP. Current property owners may not be able to afford flood insurance. The sale of floodplain properties 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. Build Flood Protective Measures and Natural Resource Preservation Projects :
   There were several suggested plans that involved reconnecting floodplains or removing suspected fill sites. These activities would reduce floodwater elevations and remove some homes from the FEMA mapped floodplain entirely. Annual maintenance costs would be an on-going responsibility of the Village and Town. The time required to design, acquire property and permits and construct the flood prevention projects may be an issue for some property owners seeking relief. Where relocation of buildings is required to complete Flood Protective Measures and Natural Resource Preservation Projects, the Town and Village should seek out grant sources (as listed in Table 71, #8) to fund community growth studies

to relocate these structures to areas that will preserve community character as much as possible and provide informed community growth.

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 to, 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 flood proofing are not feasible, buyout may be the primary option.

4. Elevations and Flood proofing:

   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 a structure 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. Flood proofing, either to prevent water from entering a structure (dry flood proofing) or allowing waters to flow through lower parts of the structure such as a crawlspace (wet flood proofing), 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. Flood proofing 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. Delhi 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.

10.2 Recommendations

Recommendations for All 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 71 on page 127), these projects often take long periods of time and can be very costly. In these study areas, where many structures are at risk of flooding, elevations, and/or wet/dry flood proofing 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. Delhi should implement the most cost effective and easily achievable flood prevention projects as seen in Table 71.
2. 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 Delhi. In particular, the County DPW facility is subject to flooding and should be a high priority for mitigation. Owners of these properties are encouraged to seek input from the Town on possible mitigation actions. Figure 57 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."

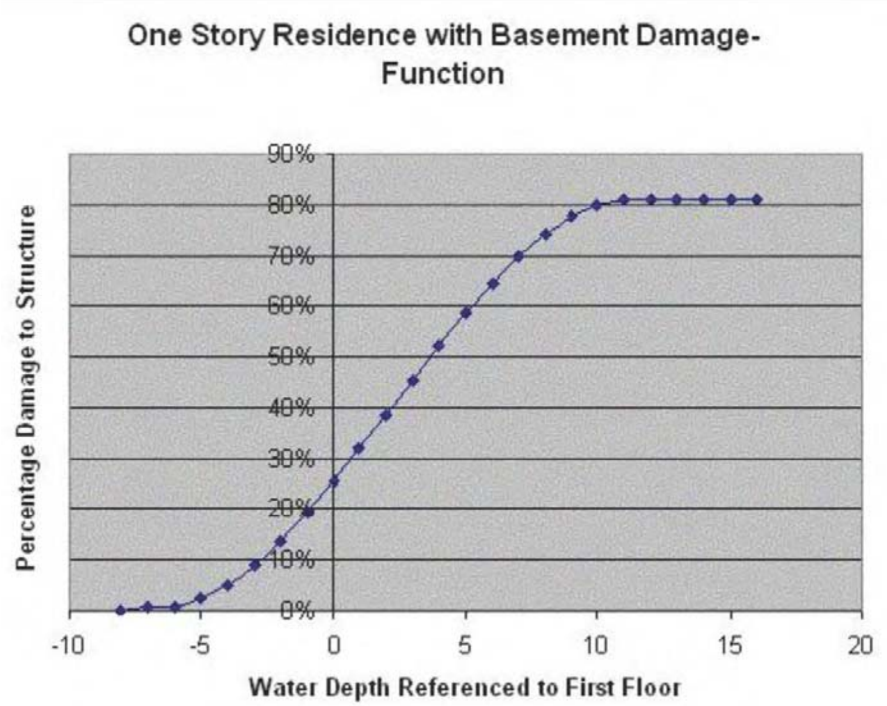


Figure 57: Estimate of Percent Damage to a Structure Based Upon Depth of Inundation

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 Delhi 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" Flood proofing (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. Flood proofing 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 flood proofing 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 flood proofing 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" Flood proofing (Allows Floodwaters to Pass Through) - Wet flood proofing 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 flood proofing 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 flood proofing only in in limited situations. As with dry flood proofing techniques, developing a wet flood proofing 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 should take advantage of the tank anchoring / relocation program through the Catskill Watershed Corporation.

5. Delhi 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 71 summarizes the prioritization of the proposed mitigation solutions which have been reviewed by the FC.

The FC then will select which mitigation strategies and standalone recommendation to present to the Town Board that should be pursued to improve the Town's flood resiliency.

Table 71: Prioritization Results for Delhi's Local Flood Analysis

Plan ID	Plan Name	Prioritization Score	BCR
1	Remove Berm near Price Chopper	32	2.43
2	Lower floodplain upstream of County DPW salt shed and remove salt shed	Not Calculated	Not Calculated
3	Lower floodplain for the entire County DPW facility	Not Calculated	Not Calculated
4	Lower floodplain to 2-year flood level, between Kingston and Bridge Streets, average width 100'. Reshape island at Kingston Street bridge.	Not Calculated	Not Calculated
5	LFA Mitigation Plan #1 and remove SUNY ball Fields.	Not Calculated	Not Calculated
6	LFA Mitigation Plan #1 and lower floodplain to 2-year flood level at Depot Street. Remove two outbuildings.	30	7.88
7	LFA Mitigation Plan #6 and lower floodplain to 2-year flood level between Kingston Street bridge and Bridge street bridge.	26	4.40
8	Planning and Relocation	Not Calculated	Not Calculated
9	Structural Interventions (Property Protection)	22	0.53
10	Increase Size of Elm Street Bridge and Steele Brook between Elm Street and Main Street.	28	0.26
11	Increase Size of Main Street Bridge To Accommodate Debris	26	0.13
12	Reducing Debris Load Upstream	Not Calculated	Not Calculated
13	Additional Hydraulic Analysis to Support a Letter of Map Revision (LOMR)	Not Calculated	Not Calculated
14	Install New Stormwater Conveyance Down Meredith Street	20	0.01
15	Property Protection for Five Buildings at Meredith Street	22	0.05
16	Increase Size of Elk Creek Road Culvert	20	N/A

CATSKILL WATERSHED CORPORATION

FLOOD HAZARD MITIGATION IMPLEMENTATION PROGRAM

SUMMARY OF ELIGIBLE PROJECTS

In Communities that have completed an LFA

1. Relocation assistance for residence or business as recommended by an LFA
2. Alterations to public infrastructure as recommended by LFA
3. Property protection measures recommended by LFA
4. Elimination of potential sources of pollution as recommended by LFA
5. Stream related construction work recommended by LFA
6. Relocation assistance for anchor business currently in LFA study area
7. Relocation assistance for critical community facility currently in LFA study area

Throughout Entire Watershed (Not Restricted to LFA Communities)

1. Stream Debris Removal after serious storm event
2. Tank Anchoring (Oil and Propane)
3. Relocation assistance to residential or business property owners participating in City Flood Buyout Program

See CWC Flood Hazard Mitigation Implementation Program Rules

for details on each category

http://cwconline.org/fhmi-program-overview/

FLOOD HAZARD MITIGATION IMPLEMENTATION PROGRAM
SUMMARY OF PROGRAM RULES
PROJECT FUNDING COST SHARES AND CAPS

IN COMMUNITIES THAT HAVE COMPLETED AN LFA

RELOCATION ASSISTANCE

Business (Anchor Business or LFA Recommendation) Relocation Assistance

Cost Category	*Cost Share*	*Cap*
Feasibility Study, including SEQRA	Not Required	$15,000
Soft Costs	Not Required	$10,000
Land	Not Required	No Cap
Wastewater	25%	$50,000

Critical Community Facility Relocation Assistance

Cost Category	*Cost Share*	*Cap*
Feasibility Study, including SEQRA	Not Required	$10,000
Land	Not Required	No Cap
Wastewater	25%	$50,000

Residential Relocation Assistance

Cost Category	*Cost Share*	*Cap*
Planning (for redevelopment community)	25%	$20,000
Wastewater (per single family home)	Not Required	$10,000 at CWC Septic Program Schedule of Values
Wastewater (per redevelopment community)	25%	$250,000
Moving of Residence to location outside of 500 year floodplain	Not Required	$10,000

ALTERATION OF PUBLIC INFRASTRUCTURE

Cost Category	*Cost Share*	*Cap*
Feasibility Study	Not Required	$20,000
Design Costs	Not Required	10% of Construction Costs
Construction Costs	Not Required	No cap

IN COMMUNITIES THAT HAVE COMPLETED AN LFA

PROPERTY PROTECTION MEASURES (per property)

Cost Category	*Cost Share*	*Cap*
Feasibility Study	Not Required	$5,000
Design Costs	Not Required	10% of Construction Costs
Construction Costs	25%	No Cap

COMMUNITY-WIDE ELIMINATION OF POTENTIAL SOURCES OF POLLUTION

Cost Category	*Cost Share*	*Cap*
Design Costs	25%	No Cap
Project Implementation Costs	25%	$15,000

STREAM CONSTRUCTION

Cost Category	*Cost Share*	*Cap*
Design Costs	Not Required	10% of Construction Costs
Construction Costs	Not Required	No Cap

Caps and cost shares for the above can by waived by CWC Board on an individual project based upon extraordinary community or water quality benefit.

THROUGHOUT WEST OF HUDSON WATERSHED
(NOT RESTRICTED TO LFA COMMUNITIES)

RELOCATION ASSISTANCE FOR CERTAIN PROPERTIES PARTICIPATING IN CITY FLOOD BUY-OUT PROGRAM

Business Relocation Assistance

Cost Category	*Cost Share*	*Cap*
Feasibility Study, including SEQRA	Not Required	$15,000
Soft Costs	Not Required	$10,000
Land	Not Required	No Cap
Wastewater	25%	$50,000

Residential Relocation Assistance

Cost Category	*Cost Share*	*Cap*
Planning (for redevelopment community)	25%	$20,000
Wastewater (per single family home)	Not Required	$10,000 at CWC Septic Program Schedule of Values
Wastewater (per redevelopment community)	25%	$250,000
Moving of Residence to location outside of 500 year floodplain	Not Required	$10,000

TANK-ANCHORING
OIL UP TO 330 GALLONS, PROPANE UP TO 420 GALLONS

Cost Category	*Cost Share*	*Cap*
Project Implementation Costs	None	$5,000 per property*

*All costs per CWC FHMIP Schedule of Values

STREAM DEBRIS REMOVAL AFTER A SERIOUS STORM EVENT

Cost Category	*Cost Share*	*Cap*
Eligible Costs will include Tipping Fees	Not Required	$10,000*. All costs per CWC Schedule of Values

*Unless waived by CWC Board on project by project basis

(CWC Board will identify locations eligible for Stream Debris Removal grants after a serious storm event)

11.0 Delhi Local Flood Mitigation Implementation Plan

To increase the Village of Delhi and Town of Delhi's flood resiliency, an implementation strategy for the flood hazard mitigation recommendations as described in sections 5.0 through 10.0 are outlined in Table 72. This implementation strategy has been informed by scientific and engineering evaluation, vetting by several meetings with the Flood Commission and by incorporating feedback from the public, Village Board 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 through 9.0 and are presented in Table 71.

Delhi's Flood Commission (FC) has prioritized the standalone recommendations and flood mitigation plans. The FC recommends to Delhi's Village Board and Delhi's Town Board that the implementation of each flood resiliency strategy be followed in order as presented in the Plan (Table 72). 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 72: Local Flood Mitigation Implementation Plan

Flood Resiliency Strategy	Strategy Name	Note
1	Flood Mitigation Plan #1: Remove Berm Near Price Chopper	This had the highest prioritization score and is needed to be completed in order for any of the other mitigation plans in the West Branch Study Area to achieve their discussed benefits (chapter 5.3.1)
2	Anchor Unanchored Fuel Tanks	As shown in Figure 9 on page 32, there are approximately a dozen fuel tanks that could become mobile during a flood. The CWC has a program for landowners to anchor these thanks. GIS coordinates for these tanks have been acquired.
3	Encourage Flood Insurance	Per Figure #11 on page 36, there are approximately 93 buildings within a flood prone area. Home owners should be encouraged to purchase flood insurance to protect themselves from the financial costs of future floods.
4	Flood Mitigation Plan #13: Additional Hydraulic Analysis to Support a Letter of Map Revision	There are approximately a dozen homes in the Special Flood Hazard Area. This may be a function of the limitation of the hydraulic modeling approach that delineated the SFHA. A two dimensional hydraulic model may show that these homes may not be in a SFHA which might result in a decrease in the annual insurance premiums. (Section 6.3.4)

Table 72 Continued: Local Flood Mitigation Implementation Plan

Flood Resiliency Strategy	Strategy Name	Note
5	Flood Mitigation #14: Install New Stormwater Conveyance Down Meredith Street	Several homes are at risk of flooding several times a year from an undersized stormwater system. When this system surcharges, water damages homes, driveways and sends debris to the intersection of Main Street and Meredith Street. This solution had a low BCR score despite the community identified this as the biggest flooding hazard priority. (Section 7.3.1)
6	Flood Mitigation Plan #12: Reducing Flood Debris Load Upstream	Flood debris causes obstructions at the Main Street bridge that exacerbates flooding conditions in several homes and buildings. The permanent solution is to stop the flood debris at their sources as shown in Figure 33 on page 81. A solution that bridges the gap till a permanent solution can be reached is capturing debris higher up in the watershed. (Section 6.3.3)
7	Flood Mitigation Plan #6: LFA Mitigation Plan #1 and lower floodplain at Depot Street	This project had the second highest prioritization score, and the highest benefit to cost ratio. This will resolve several potential water quality pollution sources and remove several homes from the Special Flood Hazard Area, potentially reduction annual flood insurance premiums. (Section 5.3.7).
8	Flood Mitigation Plan #10: Increase Size of Elm Street Bridge and Steele Brook between Elm Street and Main Street.	This had the third highest prioritization score from this analysis. The BCA score was low given the cost of this implementation solution. If Flood Resiliency Strategy #4 does not remove the homes from the SFHA, then this would be the mitigation strategy to remove these homes and businesses from the SFHA and protect them from flood damage. (Section 6.3.1)

12.0 References

FEMA. 2016. Flood Insurance Study Delaware County, NY.

FEMA. 2014. Hydraulic Analysis Technical Support Data Notebook. Task Order HSFE02-11-J-0001 for (West Branch Delaware. River Watershed) Delaware County, New York. FEMA Contract No. HSFEHQ-09-D-0369.

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

13.0 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

FC: Flood commission

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

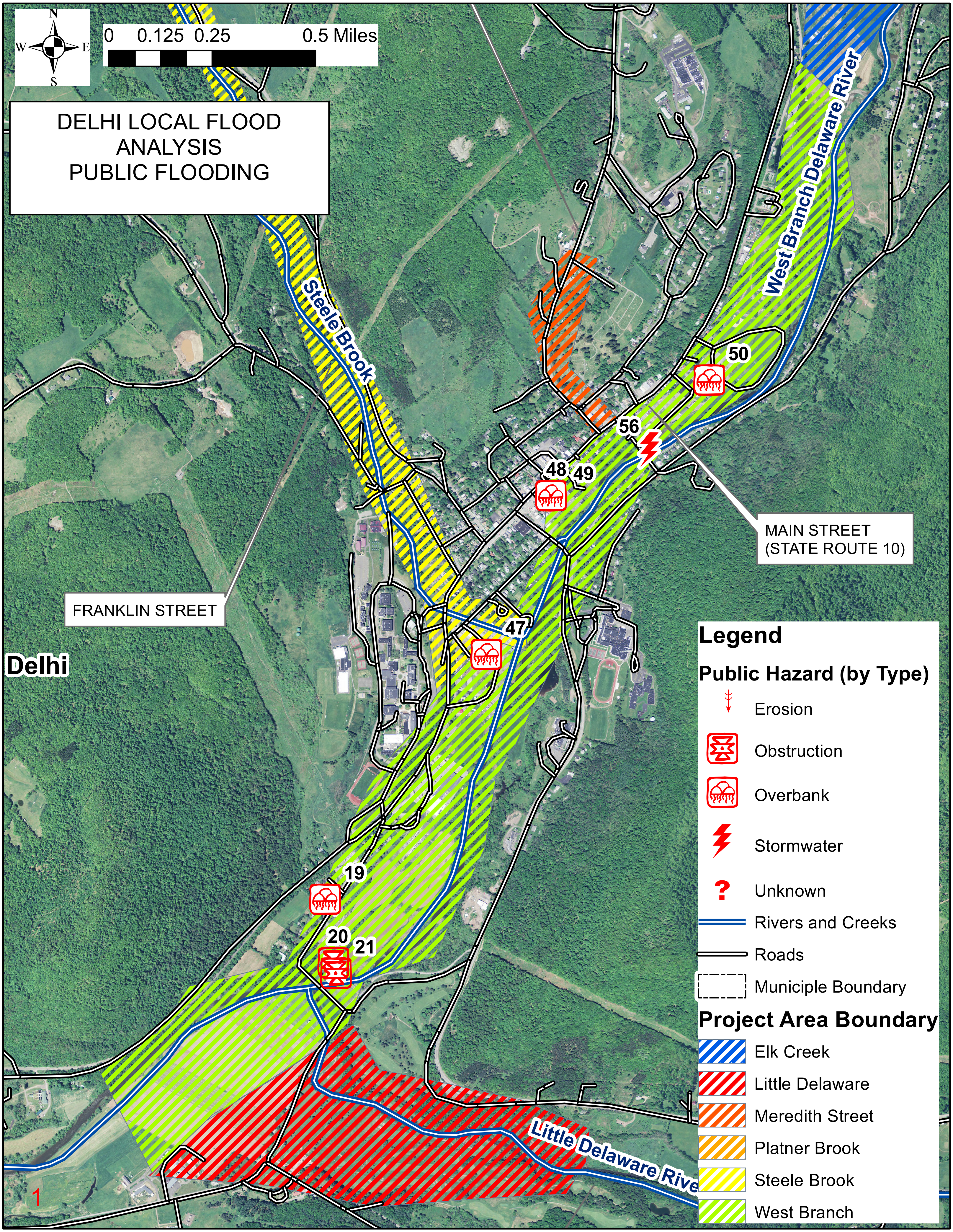
SMP: Stream Management Plan

SMIP: Stream Management Implementation Program

TAFT: Terrace and Floodplain Terrain

USGS: United States Geological Survey

APPENDIX A



N
S
E
W
0 0.125 0.25 0.5 Miles
DELHI LOCAL FLOOD ANALYSIS PUBLIC FLOODING
Steele Brook
West Branch Delaware River
Little Delaware River
MAIN STREET (STATE ROUTE 10)
FRANKLIN STREET
Delhi
50
56
48
49
47
19
20
21
Legend
Public Hazard (by Type)
Erosion
Obstruction
Overbank
Stormwater
Unknown
Rivers and Creeks
Roads
Municiple Boundary
Project Area Boundary
Elk Creek
Little Delaware
Meredith Street
Platner Brook
Steele Brook
West Branch
1

Inventory of Data

Federal Emergency Management Agency (FEMA)

FEMA Flood Insurance Study For Delaware County Number 36025CV01B

Task Order HSFE02-11-J-0001for (West Branch Delaware River Watershed) Delaware County, New York

FEMA Preliminary Effective Hydraulic Model for West Branch Delaware River

FEMA Preliminary Effective Hydraulic Model for Steele Brook

FEMA Flood Insurance Map Number 36025C0343D

FEMA Flood Insurance Map Number 36025C0342D

FEMA Flood Insurance Map Number 36025C0343E

FEMA Preliminary Effective Hydraulic Model GIS Shapefiles (cross section locations, etc.)

Delaware 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

2007 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

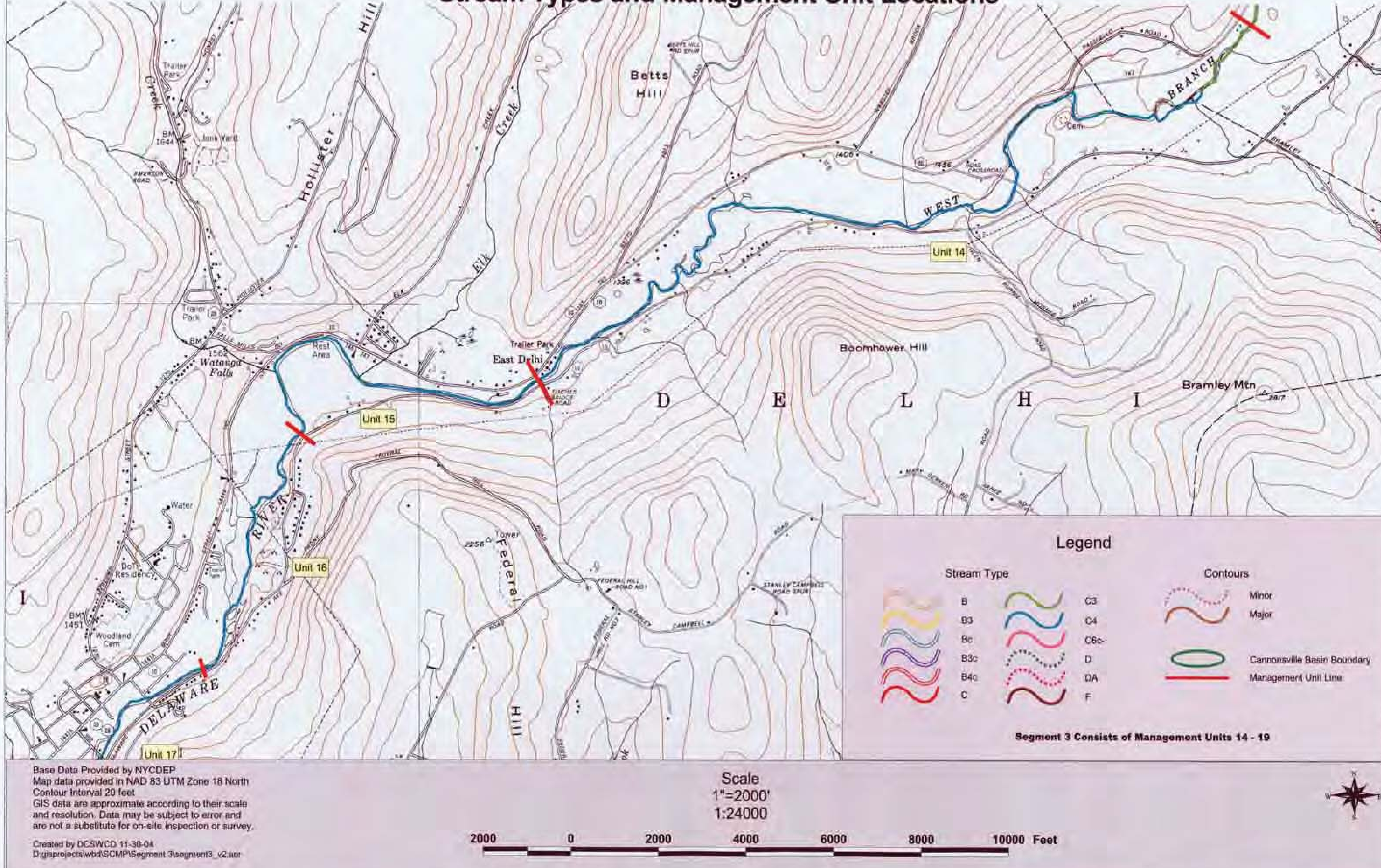
New York State Department of Transportation

Proposed State Route 10 Bridge Dimensions

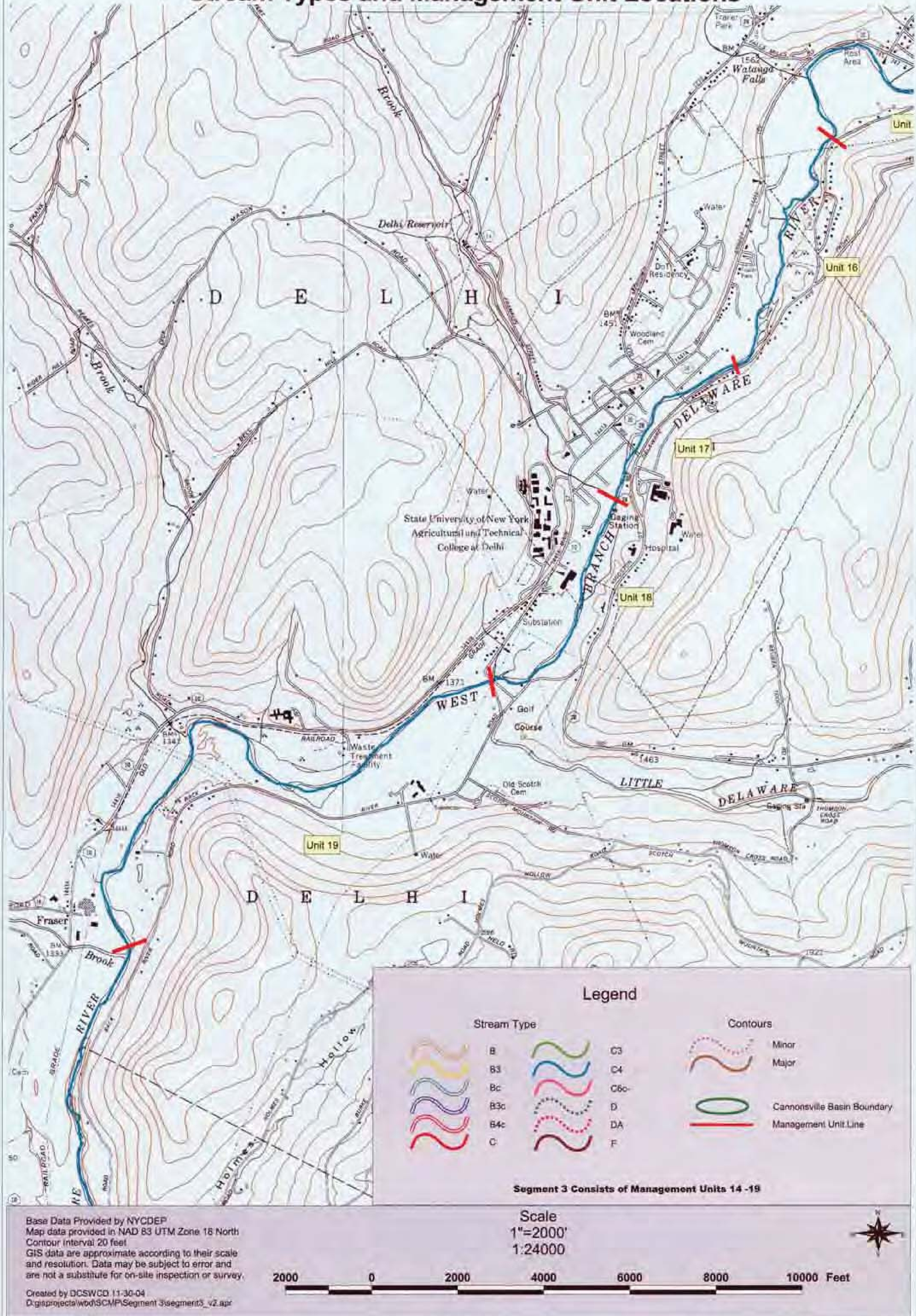
Delaware County Soil and Water

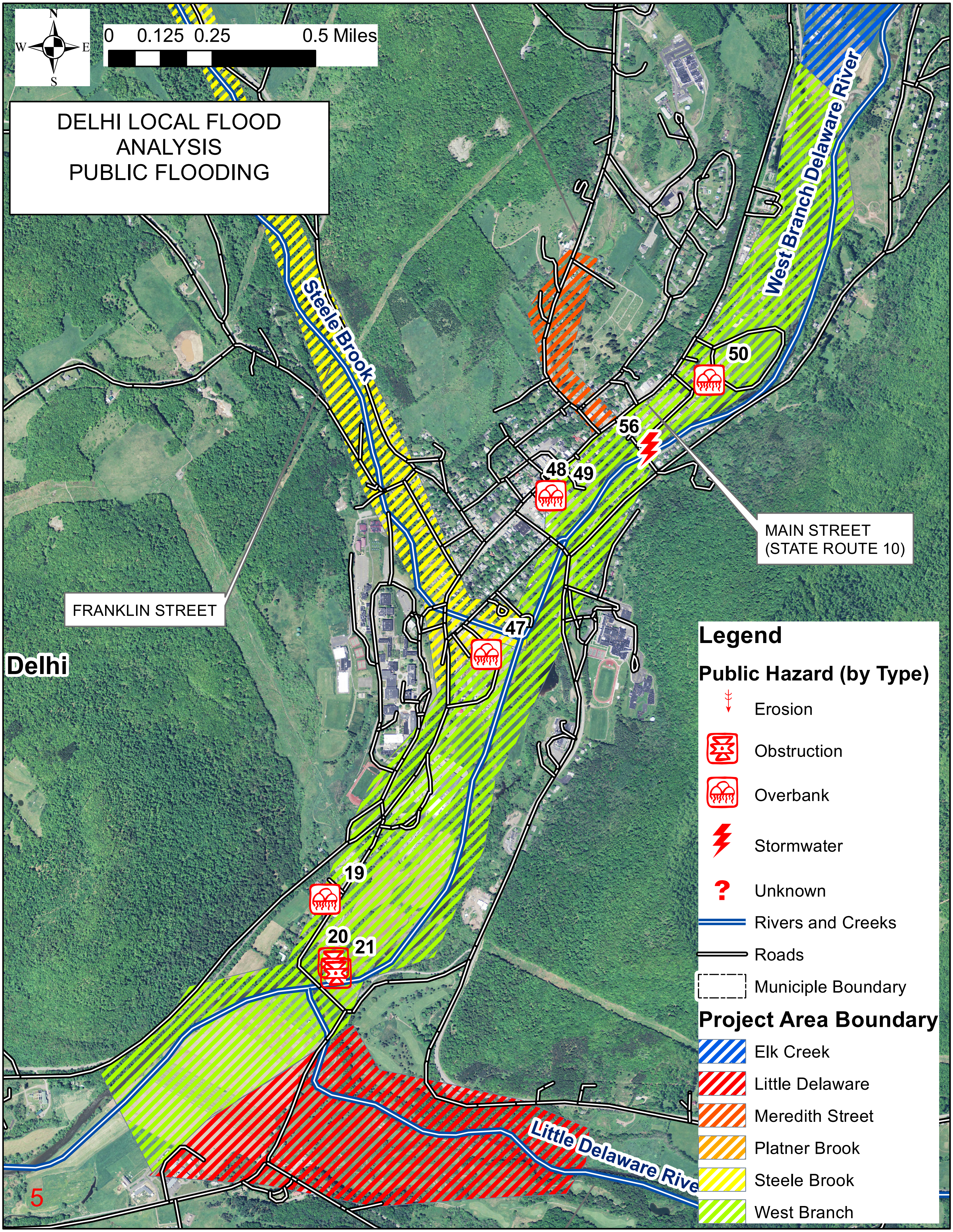
West Branch Delaware Stream Management Plan 2006

Segment 3 - Map 1
Stream Types and Management Unit Locations

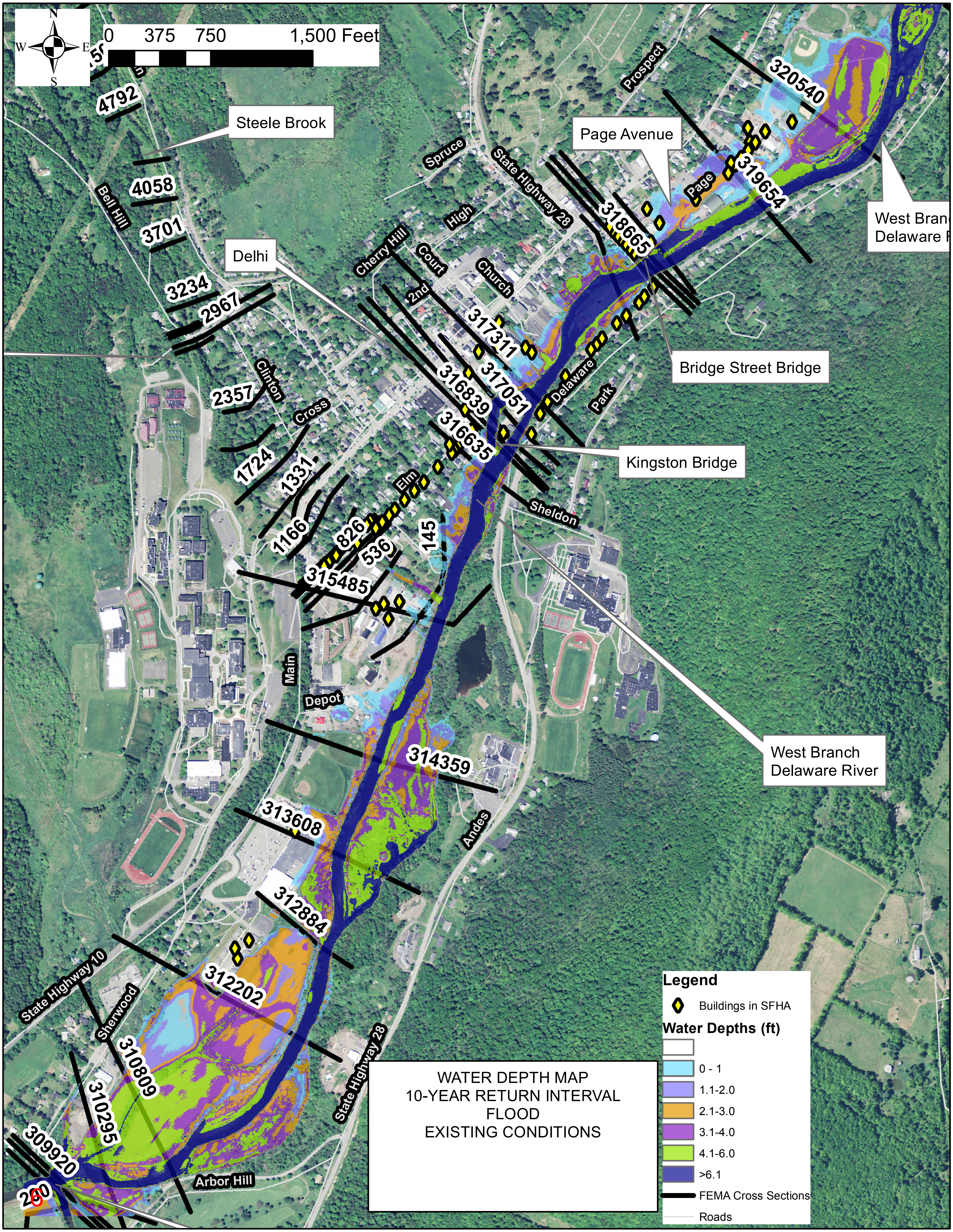


Segment 3 - Map 2
Stream Types and Management Unit Locations





0 0.125 0.25 0.5 Miles
DELHI LOCAL FLOOD ANALYSIS PUBLIC FLOODING
Steele Brook
West Branch Delaware River
Little Delaware River
MAIN STREET (STATE ROUTE 10)
FRANKLIN STREET
Delhi
50
56
48
49
47
19
20
21
Legend
Public Hazard (by Type)
Erosion
Obstruction
Overbank
Stormwater
Unknown
Rivers and Creeks
Roads
Municiple Boundary
Project Area Boundary
Elk Creek
Little Delaware
Meredith Street
Platner Brook
Steele Brook
West Branch



N
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E
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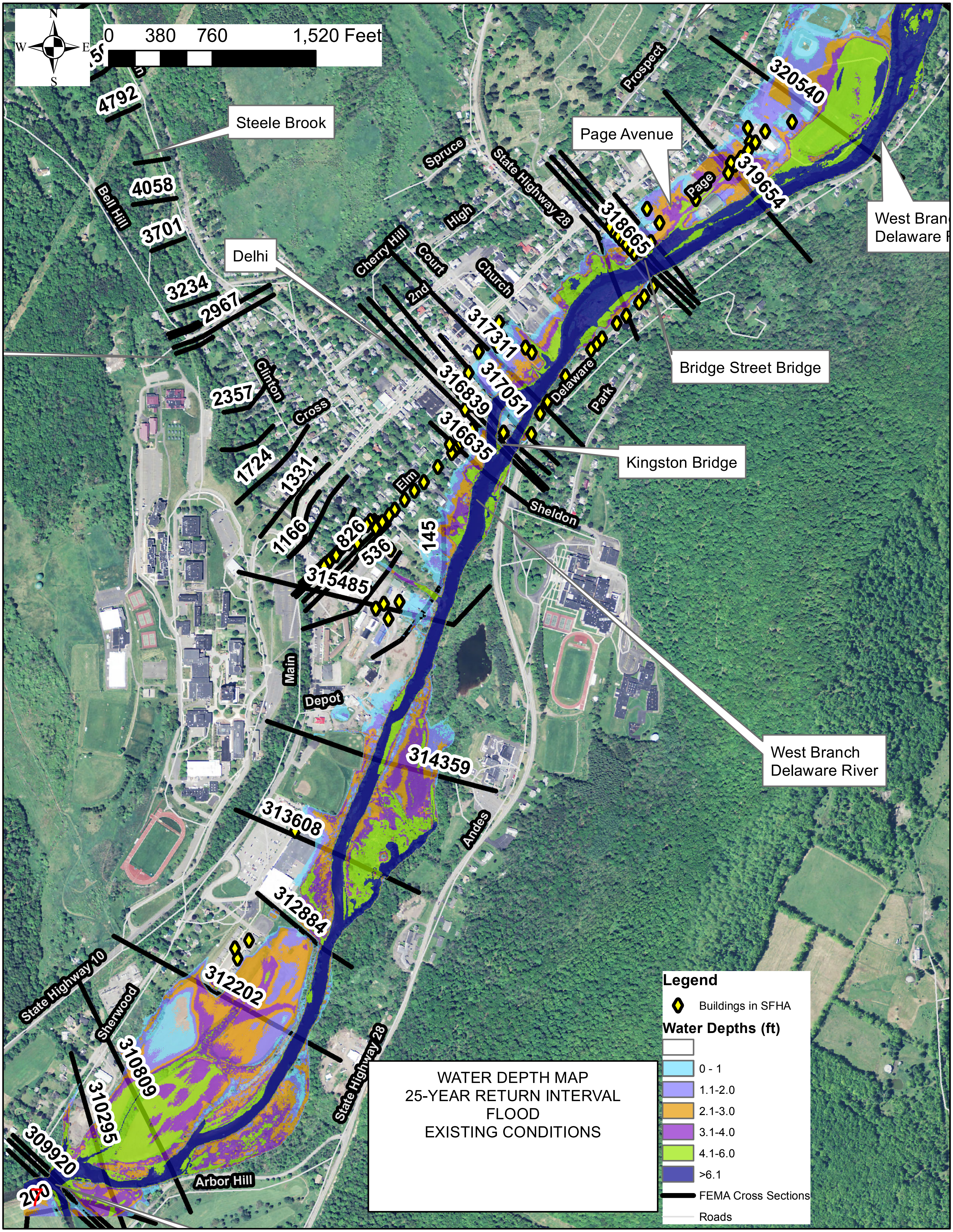
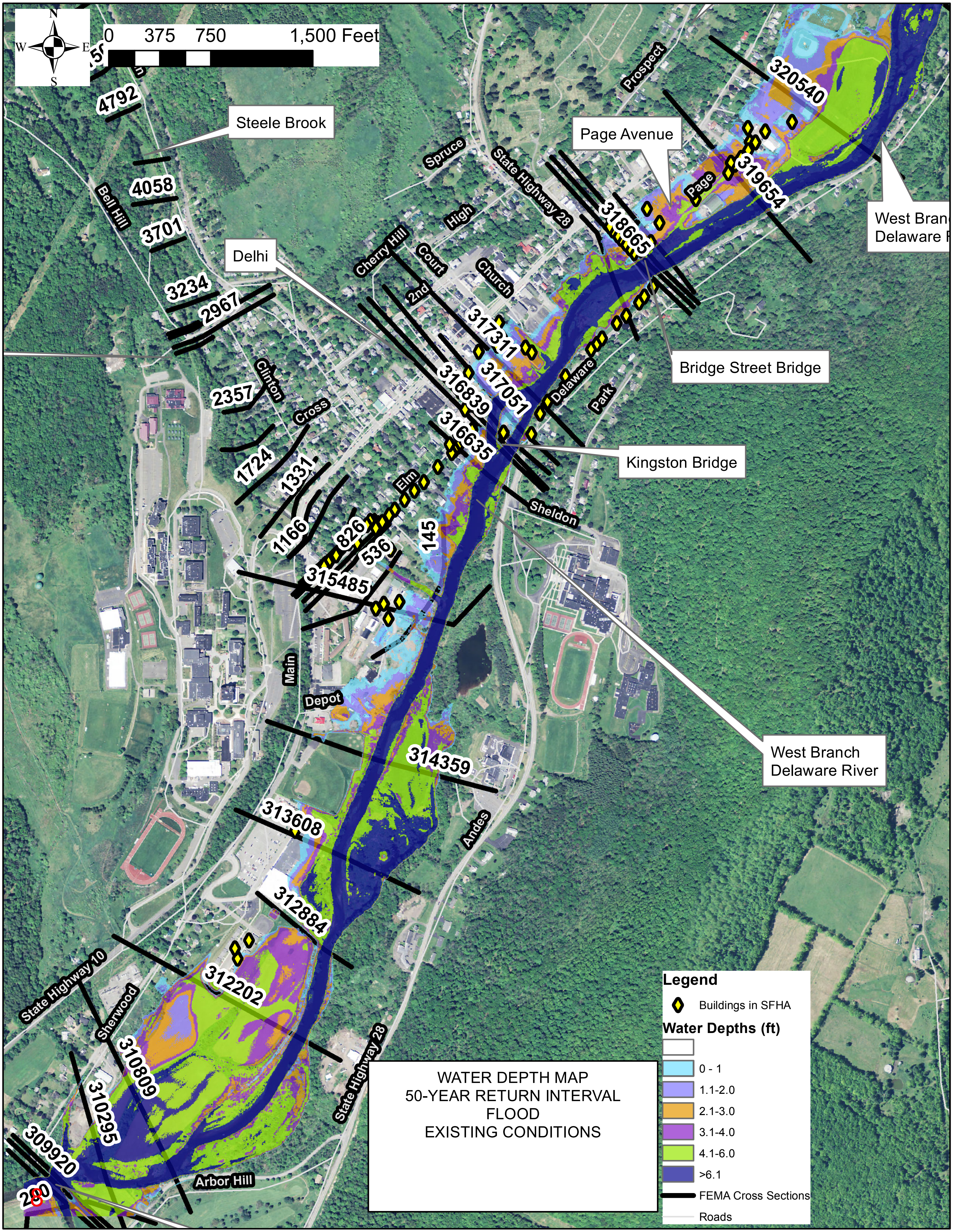
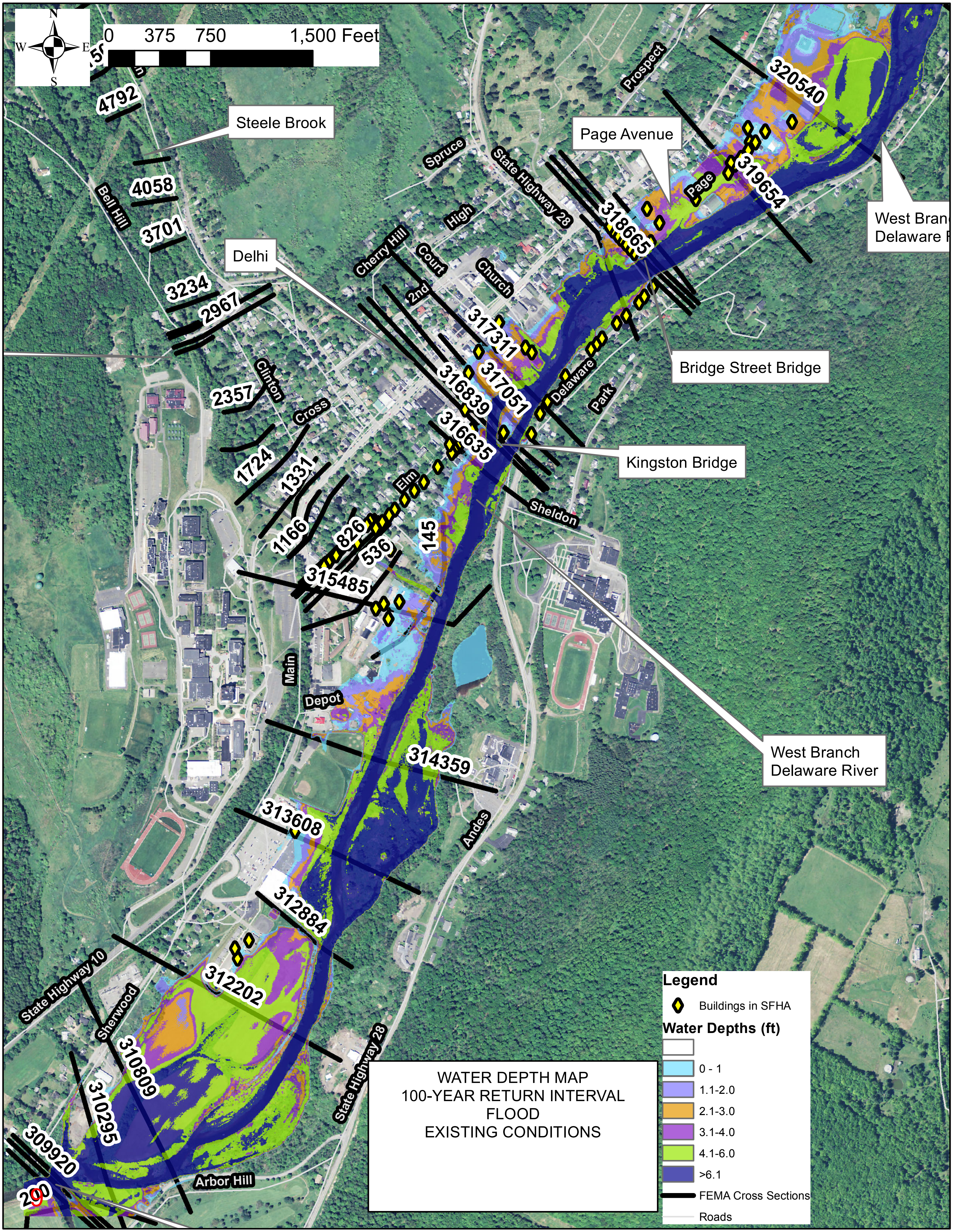
0 375 750 1,500 Feet
Steele Brook
Delhi
Page Avenue
West Branch Delaware River
Bridge Street Bridge
Kingston Bridge
West Branch Delaware River
Prospect
Spruce
State Highway 28
High
Cherry Hill
Court
Church
2nd
Delaware
Park
Page
Bell Hill
Clinton
Cross
Elm
Sheldon
Main
Depot
Andes
State Highway 10
Sherwood
Arbor Hill
4792
4058
3701
3234
2967
2357
1724
1331
1166
826
536
145
315485
316635
316839
317051
317311
318665
319654
320540
314359
313608
312884
312202
310809
310295
309920
Legend
Buildings in SFHA
Water Depths (ft)
0 - 1
1.1-2.0
2.1-3.0
3.1-4.0
4.1-6.0
>6.1
FEMA Cross Sections
Roads
WATER DEPTH MAP
10-YEAR RETURN INTERVAL
FLOOD
EXISTING CONDITIONS

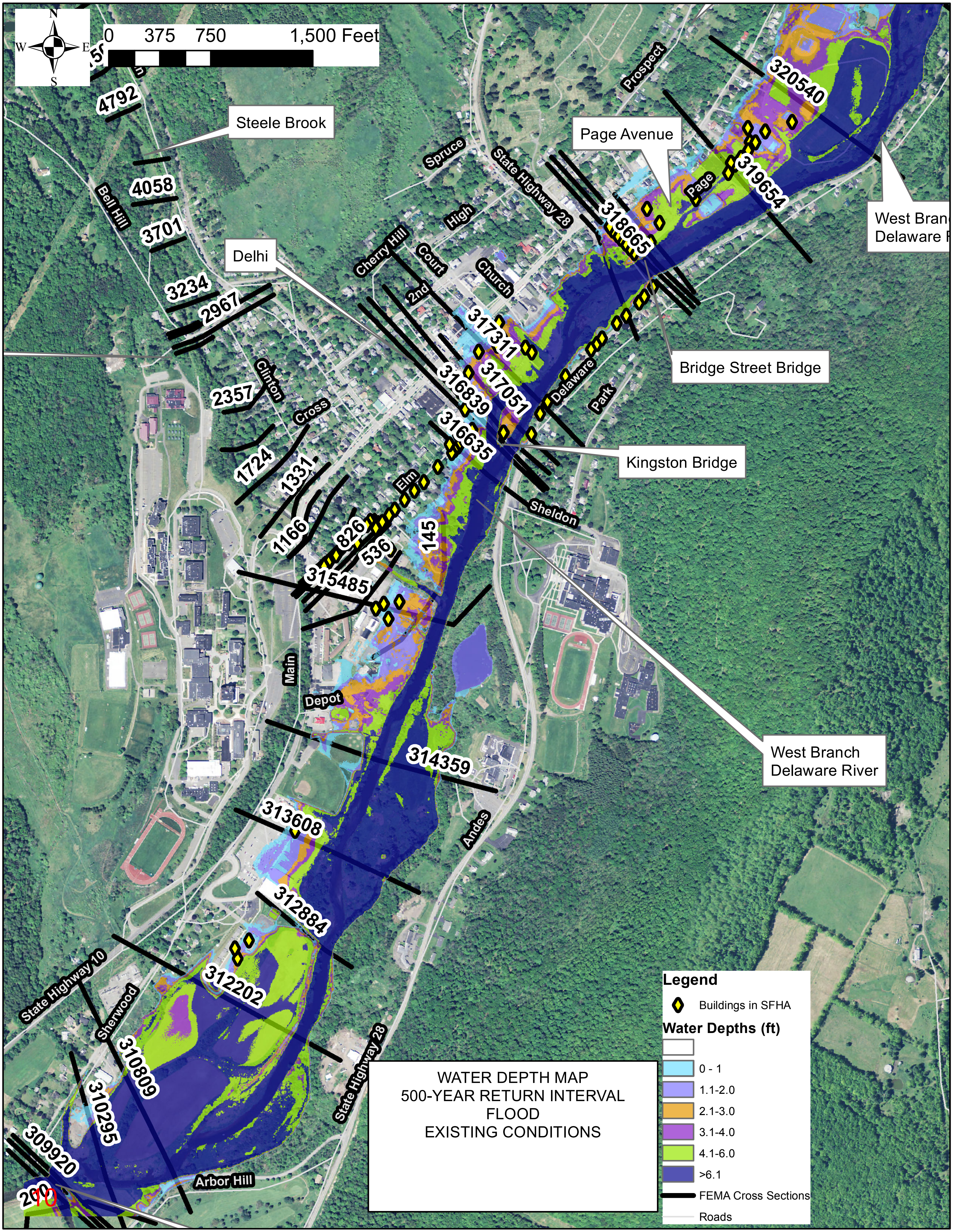

N
S
E
W
0 380 760 1,520 Feet
Steele Brook
Delhi
Page Avenue
West Bran
Delaware F
Bridge Street Bridge
Kingston Bridge
West Branch
Delaware River
Prospect
Spruce
State Highway 28
High
Cherry Hill
Court
Church
2nd
Page
Delaware
Park
Sheldon
Elm
Clinton
Cross
Bell Hill
Main
Depot
Andes
State Highway 10
Sherwood
Arbor Hill
4792
4058
3701
3234
2967
2357
1724
1331
1166
826
536
145
315485
316635
316839
317051
317311
318665
319654
320540
314359
313608
312884
312202
310809
310295
309920
200
Legend
Buildings in SFHA
Water Depths (ft)
0 - 1
1.1-2.0
2.1-3.0
3.1-4.0
4.1-6.0
>6.1
FEMA Cross Sections
Roads
WATER DEPTH MAP
25-YEAR RETURN INTERVAL
FLOOD
EXISTING CONDITIONS

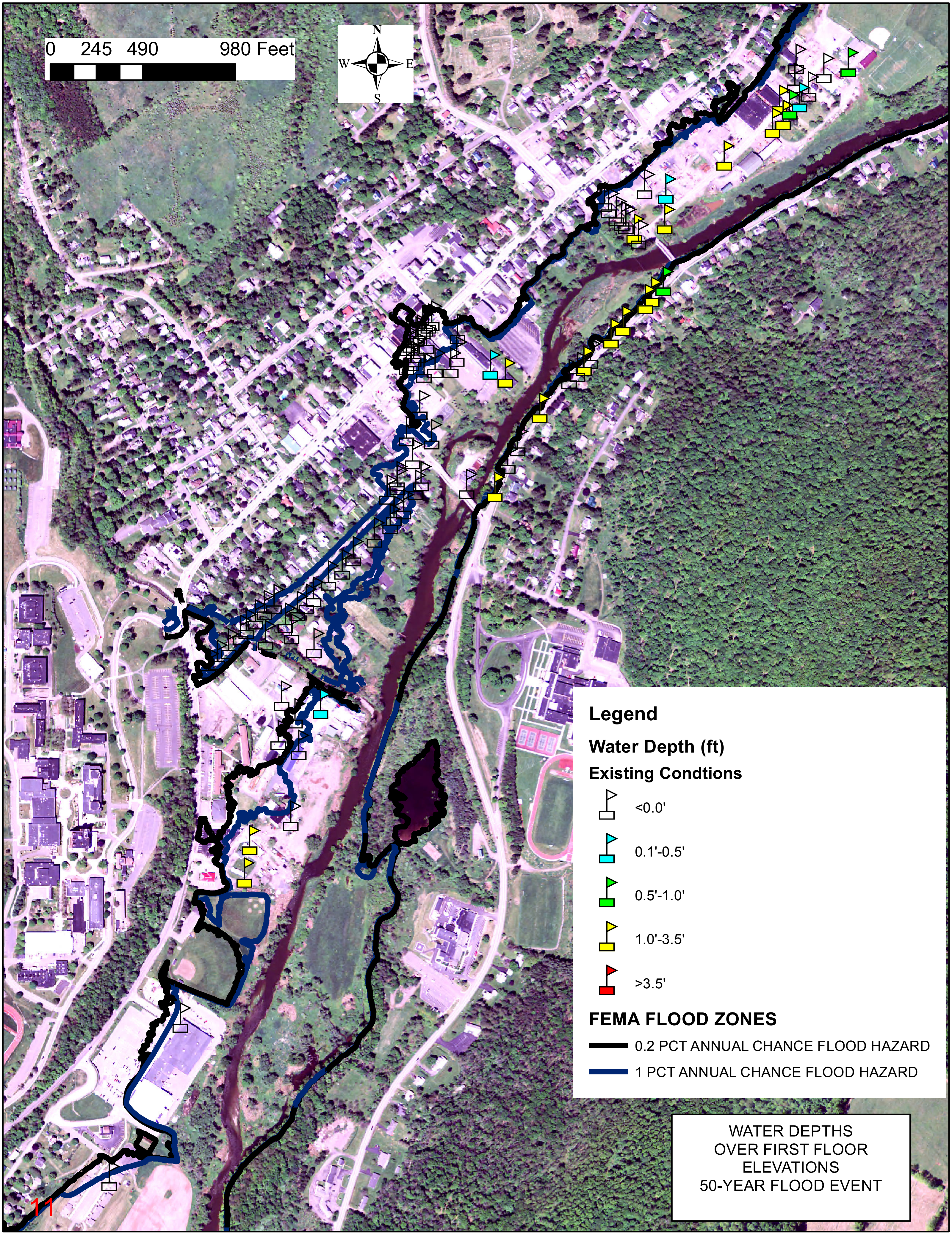


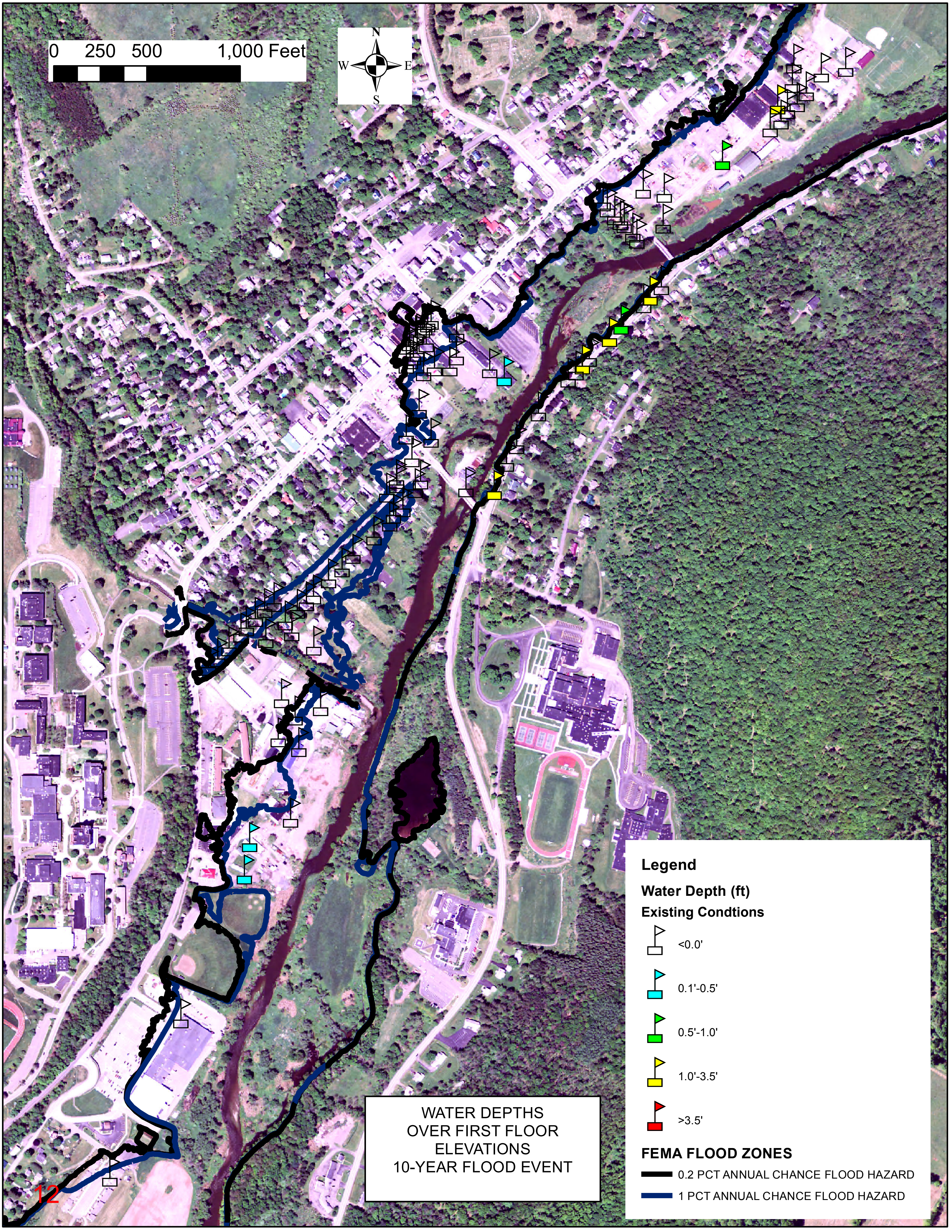
N
S
E
W
0 375 750 1,500 Feet
Steele Brook
Delhi
Page Avenue
West Branch Delaware River
Bridge Street Bridge
Kingston Bridge
West Branch Delaware River
Legend
Buildings in SFHA
Water Depths (ft)
0 - 1
1.1-2.0
2.1-3.0
3.1-4.0
4.1-6.0
>6.1
FEMA Cross Sections
Roads
WATER DEPTH MAP
50-YEAR RETURN INTERVAL
FLOOD
EXISTING CONDITIONS
4792
4058
3701
3234
2967
2357
1724
1331
1166
826
536
145
315485
316635
316839
317051
317311
318665
319654
320540
314359
313608
312884
312202
310809
310295
309920
Bell Hill
Clinton
Cross
Elm
Main
Depot
Cherry Hill
2nd
Court
Church
High
Spruce
State Highway 28
Prospect
Page
Delaware
Park
Sheldon
Andes
State Highway 10
Sherwood
Arbor Hill



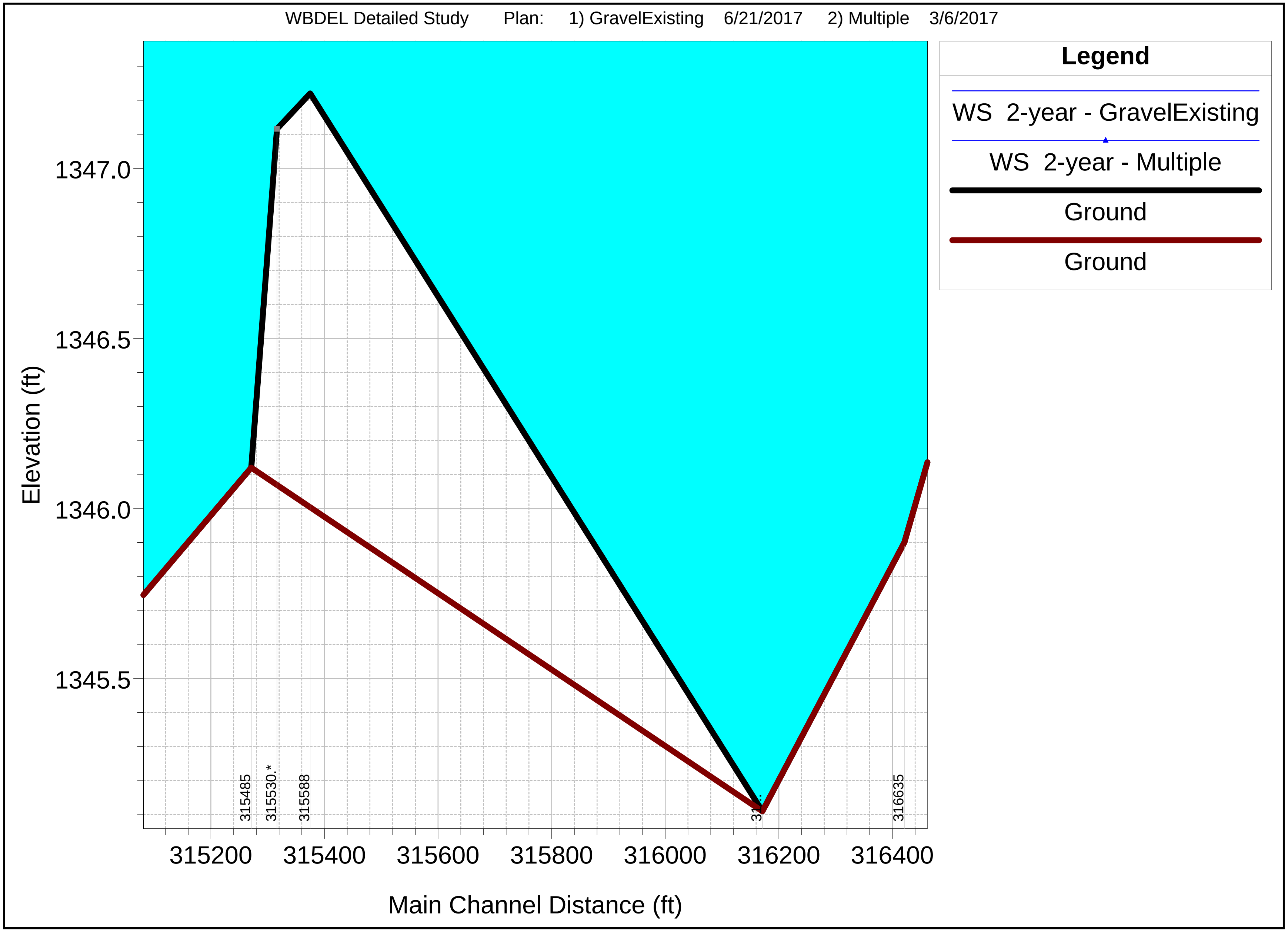
N
S
E
W
0
375
750
1,500 Feet
Steele Brook
Delhi
Page Avenue
Bridge Street Bridge
Kingston Bridge
West Branch Delaware River
4792
4058
3701
3234
2967
2357
1724
1331
1166
826
536
145
315485
316635
316839
317051
317311
318665
319654
320540
314359
313608
312884
312202
310809
310295
309920
200
Bell Hill
Spruce
State Highway 28
Prospect
Page
High
Cherry Hill
Court
Church
2nd
Clinton
Cross
Delaware
Park
Elm
Sheldon
Main
Depot
Andes
State Highway 10
Sherwood
Arbor Hill
Legend
Buildings in SFHA
Water Depths (ft)
0 - 1
1.1-2.0
2.1-3.0
3.1-4.0
4.1-6.0
>6.1
FEMA Cross Sections
Roads
WATER DEPTH MAP
100-YEAR RETURN INTERVAL
FLOOD
EXISTING CONDITIONS

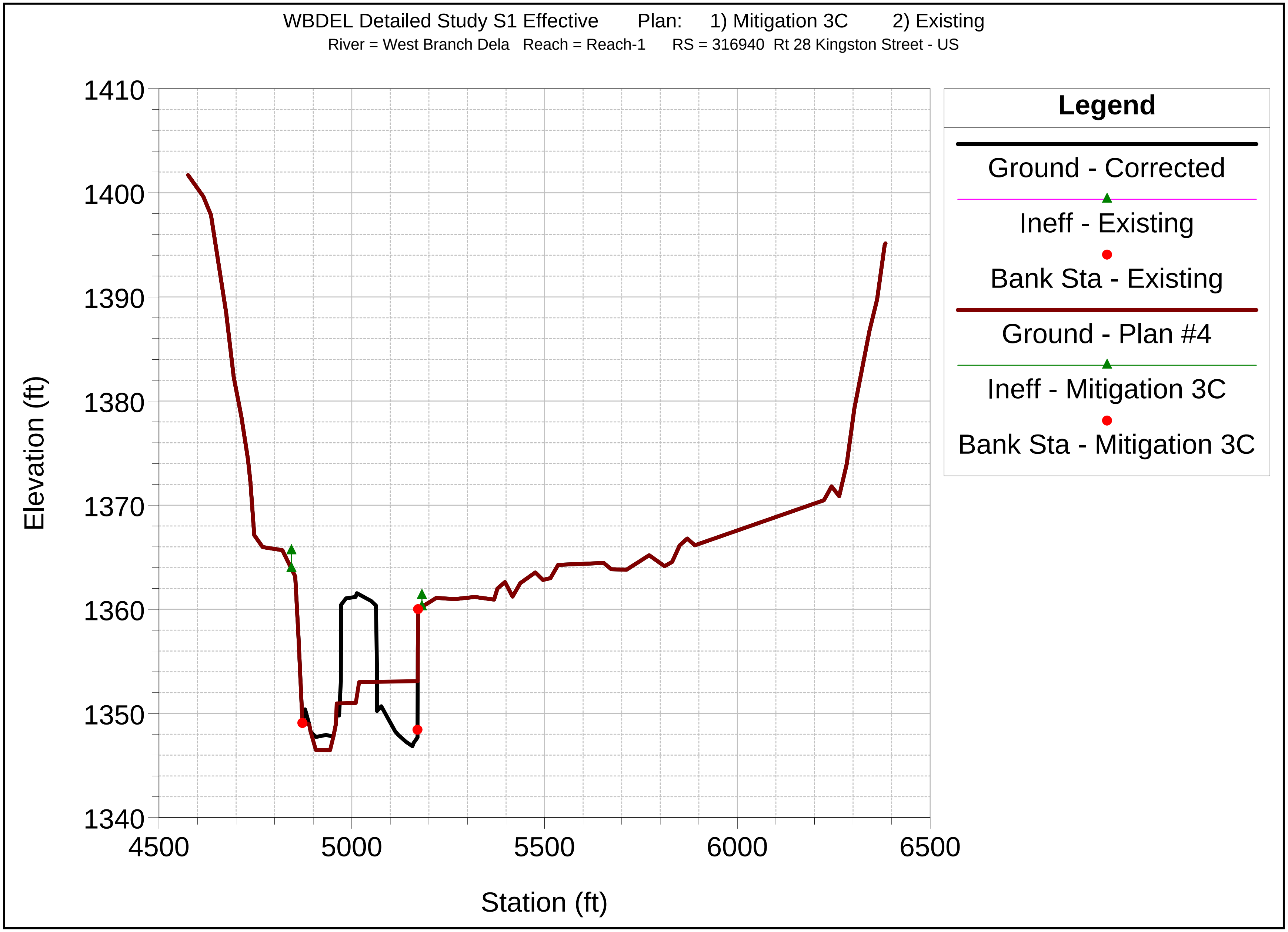

N
S
W
E
0
375
750
1,500 Feet
Steele Brook
Delhi
Page Avenue
Bridge Street Bridge
Kingston Bridge
West Branch Delaware River
Prospect
Spruce
State Highway 28
High
Cherry Hill
Court
Church
2nd
Page
Delaware
Park
Sheldon
Clinton
Cross
Elm
Main
Depot
Andes
Bell Hill
State Highway 10
Sherwood
Arbor Hill
4792
4058
3701
3234
2967
2357
1724
1331
1166
826
536
145
320540
319654
318665
317311
317051
316839
316635
315485
314359
313608
312884
312202
310809
310295
309920
WATER DEPTH MAP
500-YEAR RETURN INTERVAL
FLOOD
EXISTING CONDITIONS
Legend
Buildings in SFHA
Water Depths (ft)
0 - 1
1.1-2.0
2.1-3.0
3.1-4.0
4.1-6.0
>6.1
FEMA Cross Sections
Roads


0 245 490 980 Feet
N
W E
S
Legend
Water Depth (ft)
Existing Condtions
<0.0'
0.1'-0.5'
0.5'-1.0'
1.0'-3.5'
>3.5'
FEMA FLOOD ZONES
0.2 PCT ANNUAL CHANCE FLOOD HAZARD
1 PCT ANNUAL CHANCE FLOOD HAZARD
WATER DEPTHS
OVER FIRST FLOOR
ELEVATIONS
50-YEAR FLOOD EVENT

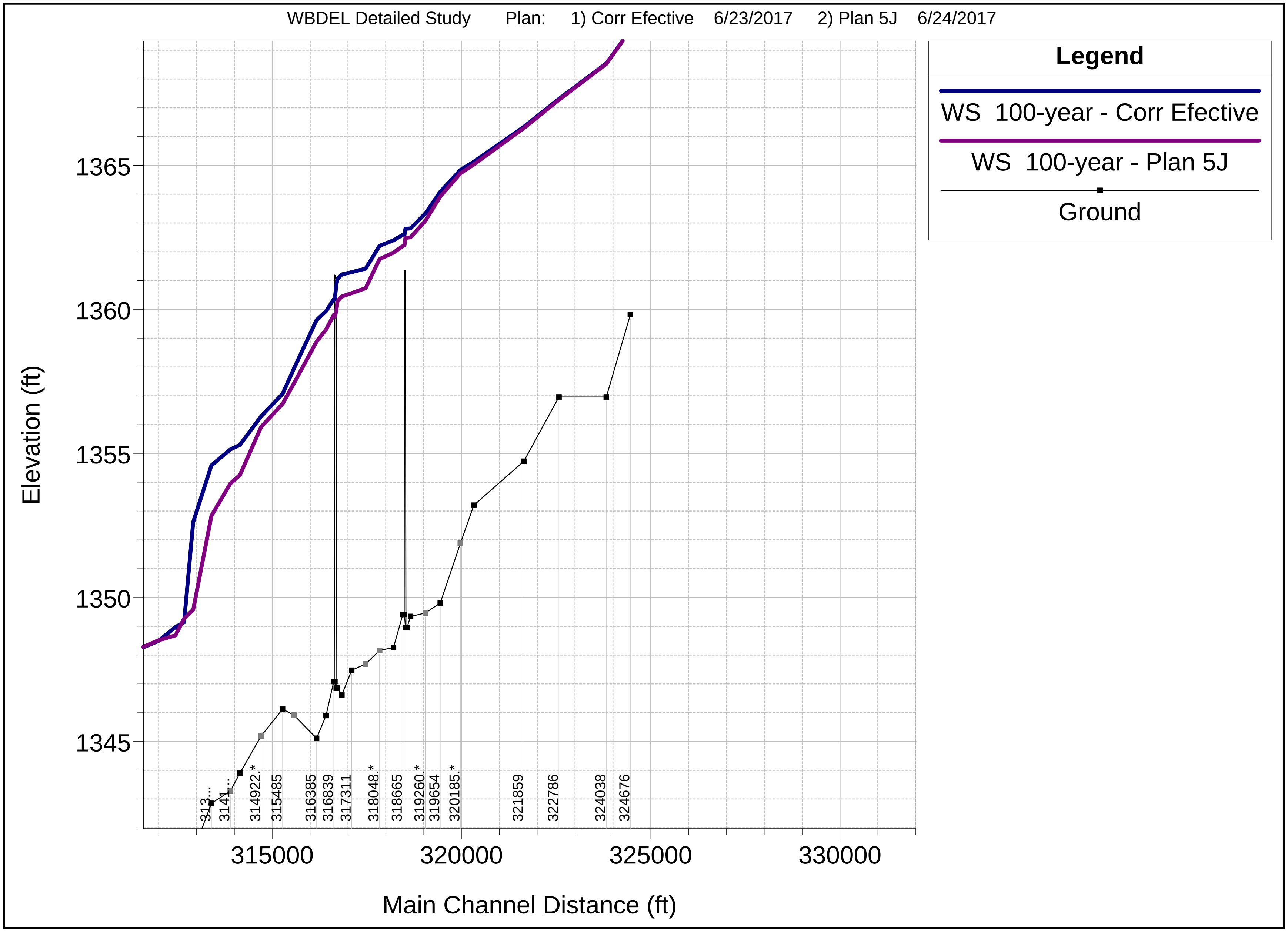

0 250 500 1,000 Feet
N
W
E
S
Legend
Water Depth (ft)
Existing Condtions
<0.0'
0.1'-0.5'
0.5'-1.0'
1.0'-3.5'
>3.5'
FEMA FLOOD ZONES
0.2 PCT ANNUAL CHANCE FLOOD HAZARD
1 PCT ANNUAL CHANCE FLOOD HAZARD
WATER DEPTHS
OVER FIRST FLOOR
ELEVATIONS
10-YEAR FLOOD EVENT
12

Title:	Water Quality Pollution Sources			
Date:	6/20/2017			
ID	Comment	Anchor	POINT_X	POINT_Y
1	Propane Tank	NO	381544.9	1256249
2	Gas Tank	YES	381325.4	1256310
3	Propane Tank	NO	381240.9	1256410
4	Propane Tank	NO	381194.6	1256053
5	Propane Tank	NO	381161.6	1256019
6	Propane Tank	NO	381109.8	1255956
7	Propane Tank	NO	380540.5	1255448
8	Propane Tank	NO	380256	1255542
9	Propane Tank	NO	379274.7	1254644
10	Propane Tank	NO	379076.1	1253897
11	Propane Tank	NO	379086.8	1253908
12	Propane Tank	NO	378797	1253612
13	Diesel Tank	YES	378746.3	1253265
14	Propane Tank	NO	378456.6	1253379
15	Gas Tank	YES	378385.2	1252959
16	Gas Tank	YES	378680.8	1252811
17	Auto Repair	N/A	379244.7	1254447
18	Highway Garage	N/A	381167.1	1256078
19	Highway Garage	N/A	381253.8	1256297
20	Pole Barn	N/A	381401.7	1256248
21	Highway Garage	N/A	378336	1252125
22	Other Storage	N/A	378488.2	1252687
23	Garage	N/A	378715.2	1252854
24	Highway Garage	N/A	380445.4	1255628
25	Highway Bldg	N/A	380870.4	1255780
26	Garage	N/A	379700.1	1254622
State Plane NY East (ft)				


WBDEL Detailed Study Plan: 1) GravelExisting 6/21/2017 2) Multiple 3/6/2017
Legend
WS 2-year - GravelExisting
WS 2-year - Multiple
Ground
Ground
Elevation (ft)
1347.0
1346.5
1346.0
1345.5
315485
315530.*
315588
316635
315200
315400
315600
315800
316000
316200
316400
Main Channel Distance (ft)

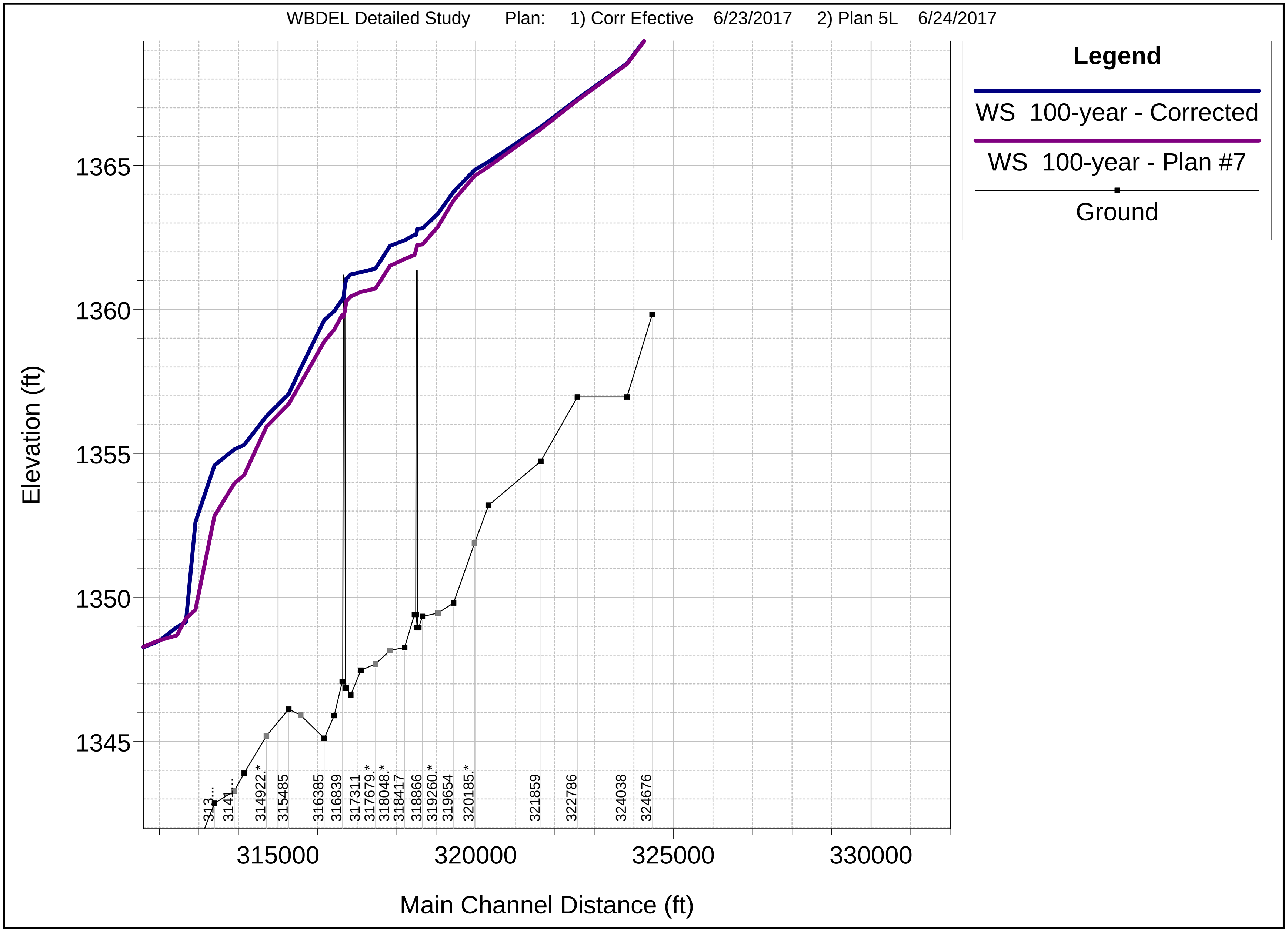


WBDEL Detailed Study S1 Effective Plan: 1) Mitigation 3C 2) Existing
River = West Branch Dela Reach = Reach-1 RS = 316940 Rt 28 Kingston Street - US
Legend
Ground - Corrected
Ineff - Existing
Bank Sta - Existing
Ground - Plan #4
Ineff - Mitigation 3C
Bank Sta - Mitigation 3C
Elevation (ft)
Station (ft)
1340
1350
1360
1370
1380
1390
1400
1410
4500
5000
5500
6000
6500



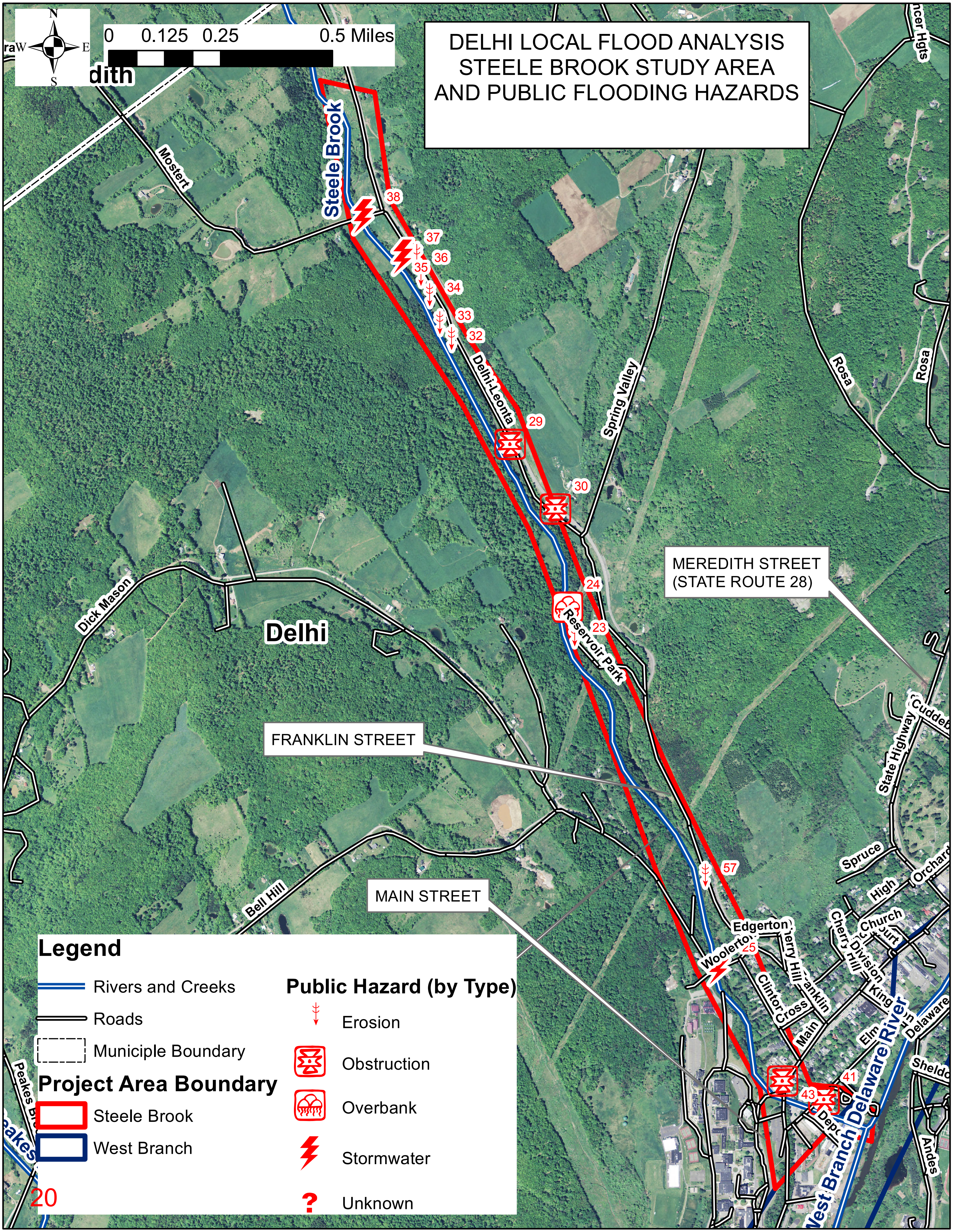
WBDEL Detailed Study Plan: 1) Corr Efective 6/23/2017 2) Plan 5J 6/24/2017
Legend
WS 100-year - Corr Efective
WS 100-year - Plan 5J
Ground
Elevation (ft)
1345
1350
1355
1360
1365
Main Channel Distance (ft)
315000
320000
325000
330000
313...
3141...
314922.*
315485
316385
316839
317311
318048.*
318665
319260.*
319654
320185.*
321859
322786
324038
324676

TITLE	Opinion of Estimated Construction Cost for Delhi LFA Plan #6				
DESIGN LEVEL	Conceptual Design				
DATE	6/22/2017				
BY:	GDF				
CHECKED					
BID ITEM #	ITEM	Unit	Unit Cost	Quantity	Total
1	Mobilization, Demobilization and Restore Site to Pre-Construction Conditions	LS	$61,266	1	$62,000
2	Clear Area	Acre	$2,250	4.6	$11,000
3	Excavation Bench (Average Depth, width and length:1.8',100', 1,000)	CY	$15	6,442	$97,000
4	Haul Excavated Material Off Site	CY	$35	6,442	$226,000
5	Seed and Mulch Site	Acre	$3,250	5	$15,000
6	Procure and Install Silt Fence	LF	$3	1,250	$4,000
7	Procure and Install Biodegradable Erosion Control Fabric	SY	$7.5	1,667	$12,500
8	Aquire Parcel for Two Garages	LS	$35,000	1	$35,000
9	Demolition and Relocate Two Garages (171.10-7-24,171.10-7-23)	LS	$65,000	1	$65,000
10	Mitigation Plan #1 Concept Cost	EA	$159,385	1	$159,385
				Sub Total	$686,900
	items have been rounded up			Contigency (15%) (Items 1-8)	$79,200
				Engineering, Surveying and Design (12%) (Items 1-8)	$63,300
				Grand Total	$829,400



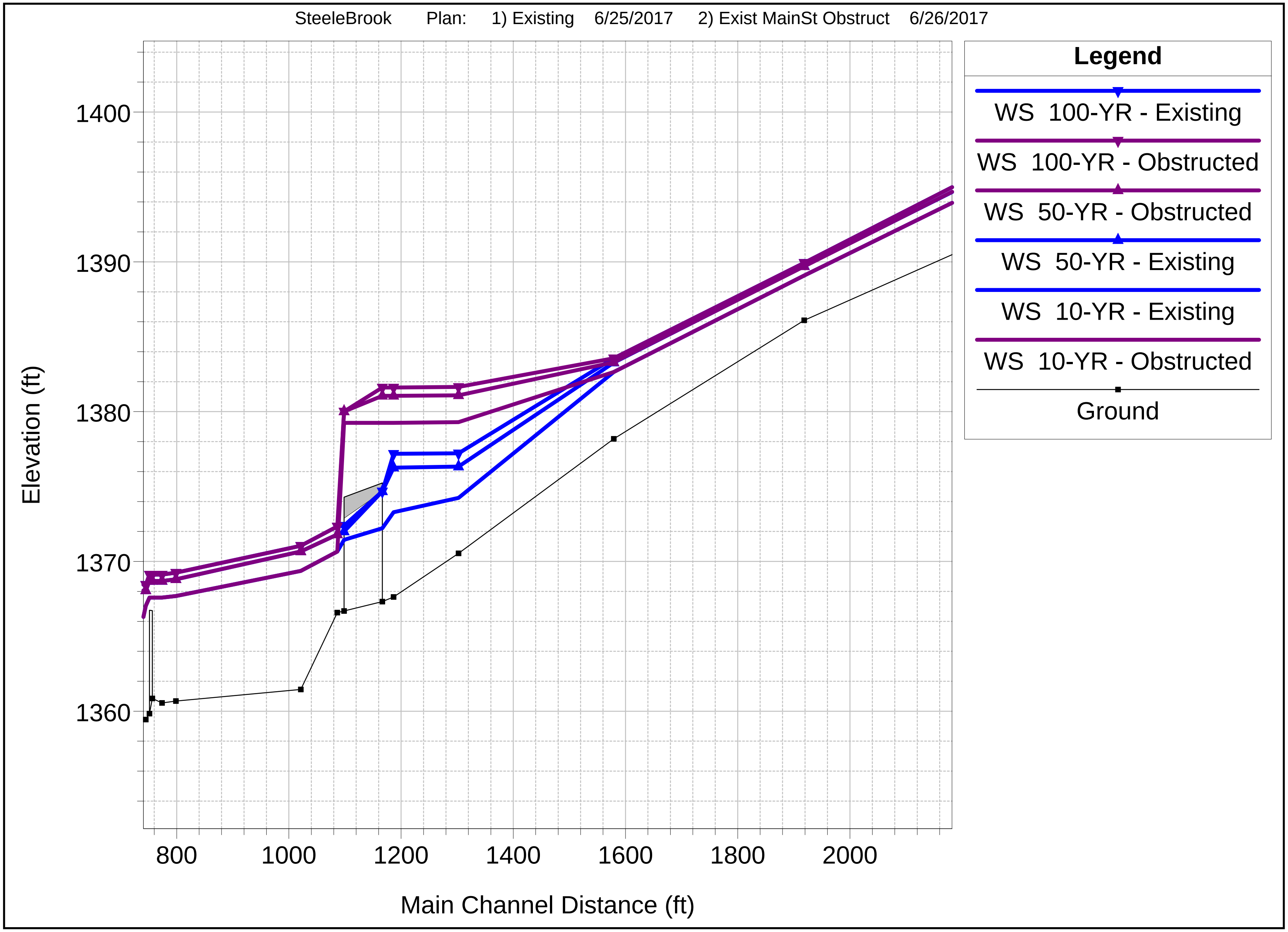
WBDEL Detailed Study Plan: 1) Corr Efective 6/23/2017 2) Plan 5L 6/24/2017
Legend
WS 100-year - Corrected
WS 100-year - Plan #7
Ground
Elevation (ft)
1365
1360
1355
1350
1345
Main Channel Distance (ft)
315000
320000
325000
330000
313...
3141...
314922.*
315485
316385
316839
317311
317679.*
318048.*
318417
318866
319260.*
319654
320185.*
321859
322786
324038
324676

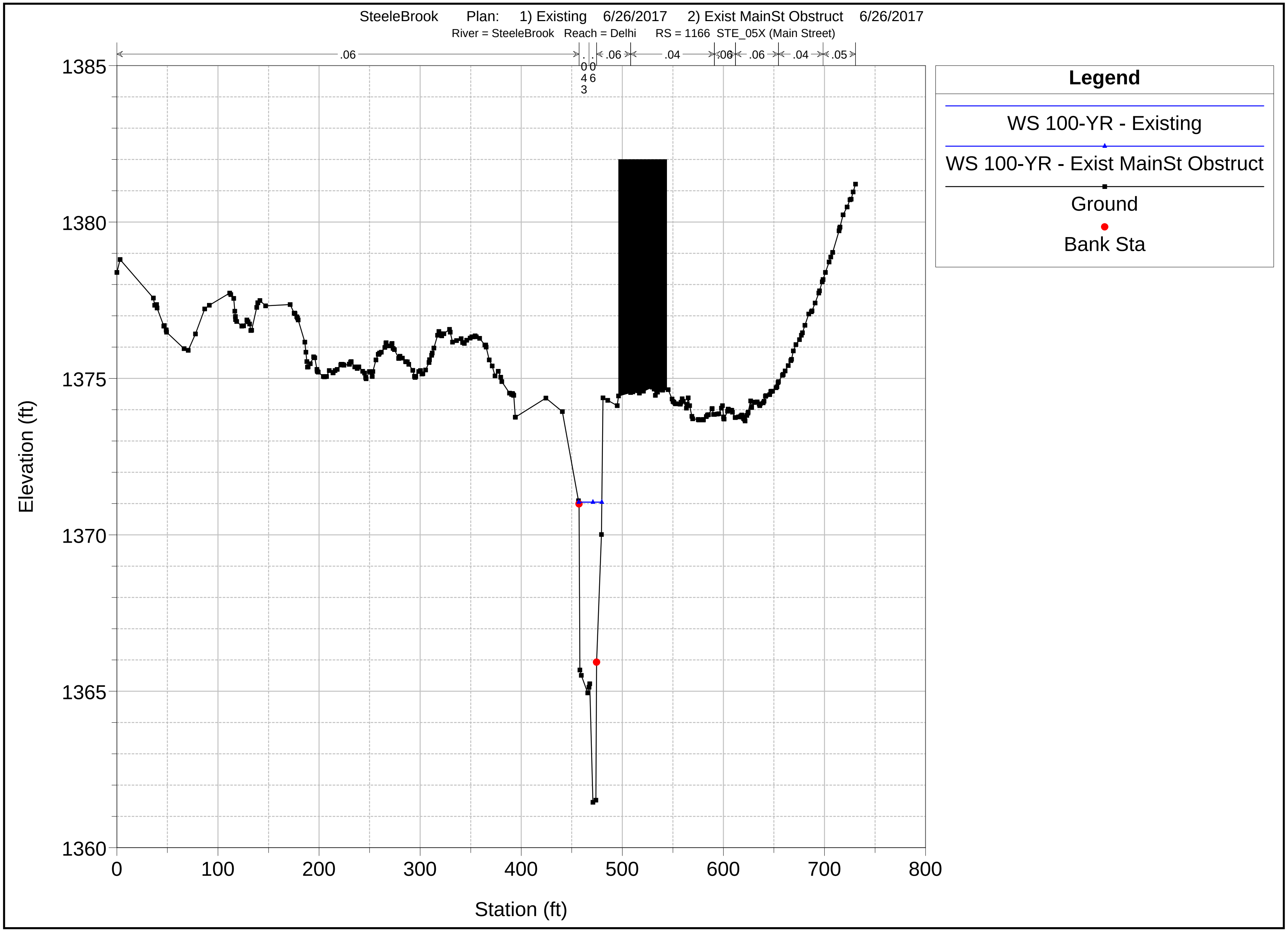
TITLE	Opinion of Estimated Construction Cost for Delhi LFA Plan #7				
DESIGN LEVEL	Conceptual Design				
DATE	11/10/2017				
BY:	GDF				
CHECKED					
BID ITEM #	ITEM	Unit	Unit Cost	Quantity	Total
1	Mobilization, Demobilization and Restore Site to Pre-Construction Conditions	LS	$45,315	1	$46,000
2	Clear Area	Acre	$2,250	1.7	$3,895
3	Earthwork for Bench (Average Depth, width and length:1.9',80', 900)	CY	$15	5,100	$76,500
4	Haul Excavated Material Off Site	CY	$35	5,100	$178,500
5	Seed and Mulch Site	Acre	$3,250	2	$5,626
6	Procure and Install Silt Fence	LF	$3	1,100	$3,300
7	Procure and Install Biodegradable Erosion Control Fabric	SY	$7.5	1,467	$11,000
8	Aquire Easement for Parking Lots (171.6-10-9,171.6-10-6,171.6-10-5)	LS	$9,350	1	$10,000
9	Demolition and Rebuild Parking	Acre	$55,000	0.3	$19,000
10	Aquire Easements And Demolition Telephone Building (171.6-10-9)	LS	$15,250	1	$15,250
11	Relocate Telephone Out building (171.6-10-9) and Purchase New Parcel For Building	LS	$95,000	1	$95,000
12	Aquire Easements on Other Non-Developed Parcels (11 Parcels)	Acre	$26,000	1.4	$36,293
11	Mitigation Plan #6 Cost	EA	$829,400	1	$829,400
				Sub Total	$1,329,800
	items have been rounded up			Contigency (15%) (Items 1-12)	$76,000
				Engineering, Surveying and Design (12%) (Items 1-12)	$60,044
				Grand Total	$1,465,844


DELHI LOCAL FLOOD ANALYSIS
STEELE BROOK STUDY AREA
AND PUBLIC FLOODING HAZARDS
N
E
S
0
0.125
0.25
0.5 Miles
Steele Brook
Mostert
Delhi-Leonta
Spring Valley
Rosa
Rosa
Dick Mason
Delhi
Reservoir Park
MEREDITH STREET
(STATE ROUTE 28)
FRANKLIN STREET
MAIN STREET
Bell Hill
State Highway
Spruce
High
Orchard
Church
Edgerton
Woolerton
Clinton Cross
Main
Cherry Hill
Division
King
Elm
Delaware
West Branch Delaware River
Andes
38
37
36
35
34
33
32
29
30
24
23
57
25
41
43
Legend
Rivers and Creeks
Roads
Municiple Boundary
Project Area Boundary
Steele Brook
West Branch
Public Hazard (by Type)
Erosion
Obstruction
Overbank
Stormwater
Unknown

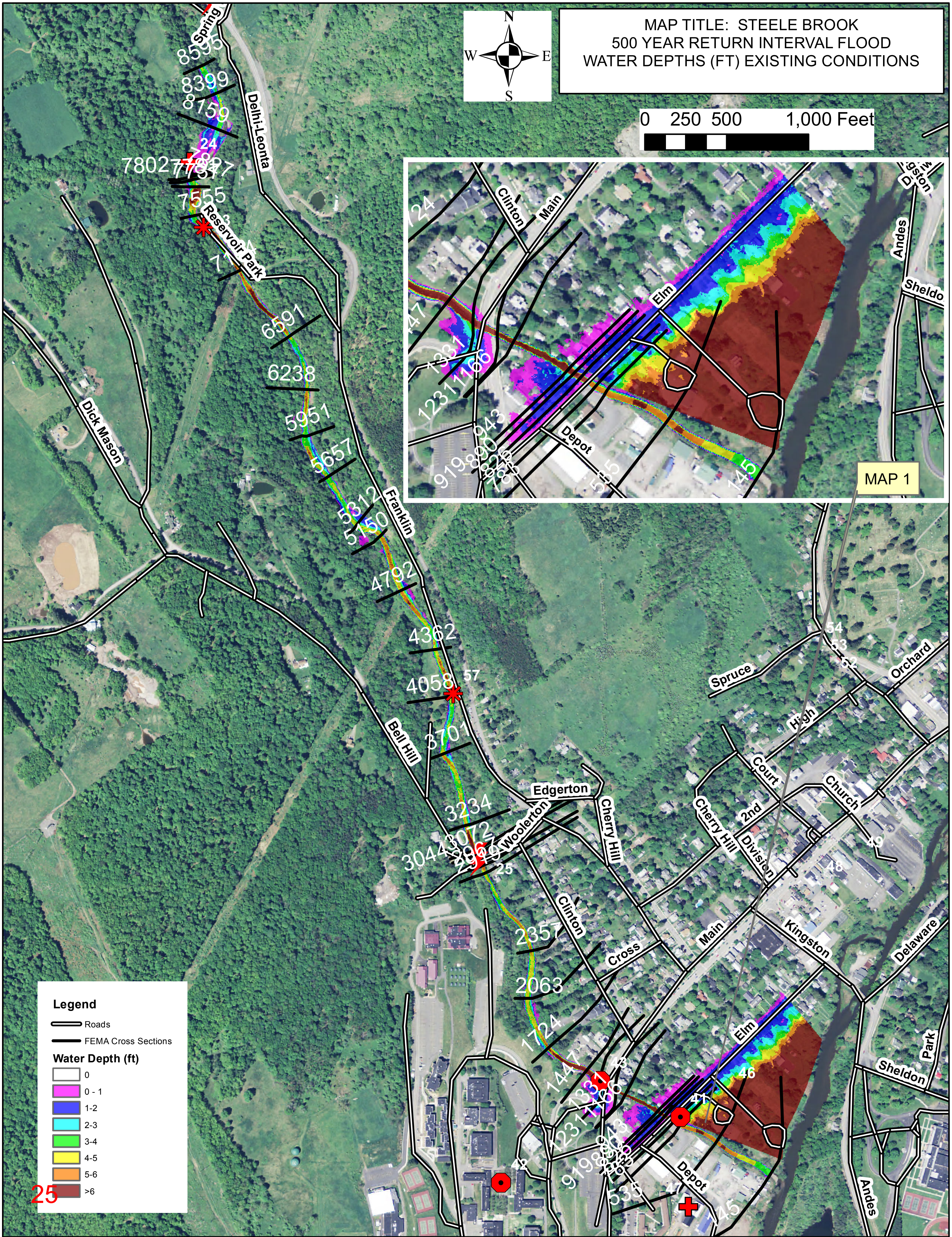

FLOODING HISTORY
STEELE BROOK STUDY AREA
2006 FLOODING EVENT
0 62.5 125 250 Feet
N
S
E
W
MAIN STREET BRIDGE
ELM STREET BRIDGE
TOWN HALL
RETIREMENT COMMUNITY
Steele Brook
West Branch Delaware River
Delhi
Elm
Main
41
Legend
Rivers and Creeks
5 Foot Contours
Roads
Municiple Boundary
Public Hazard (by Type)
Erosion
Obstruction
Overbank
Stormwater
Unknown

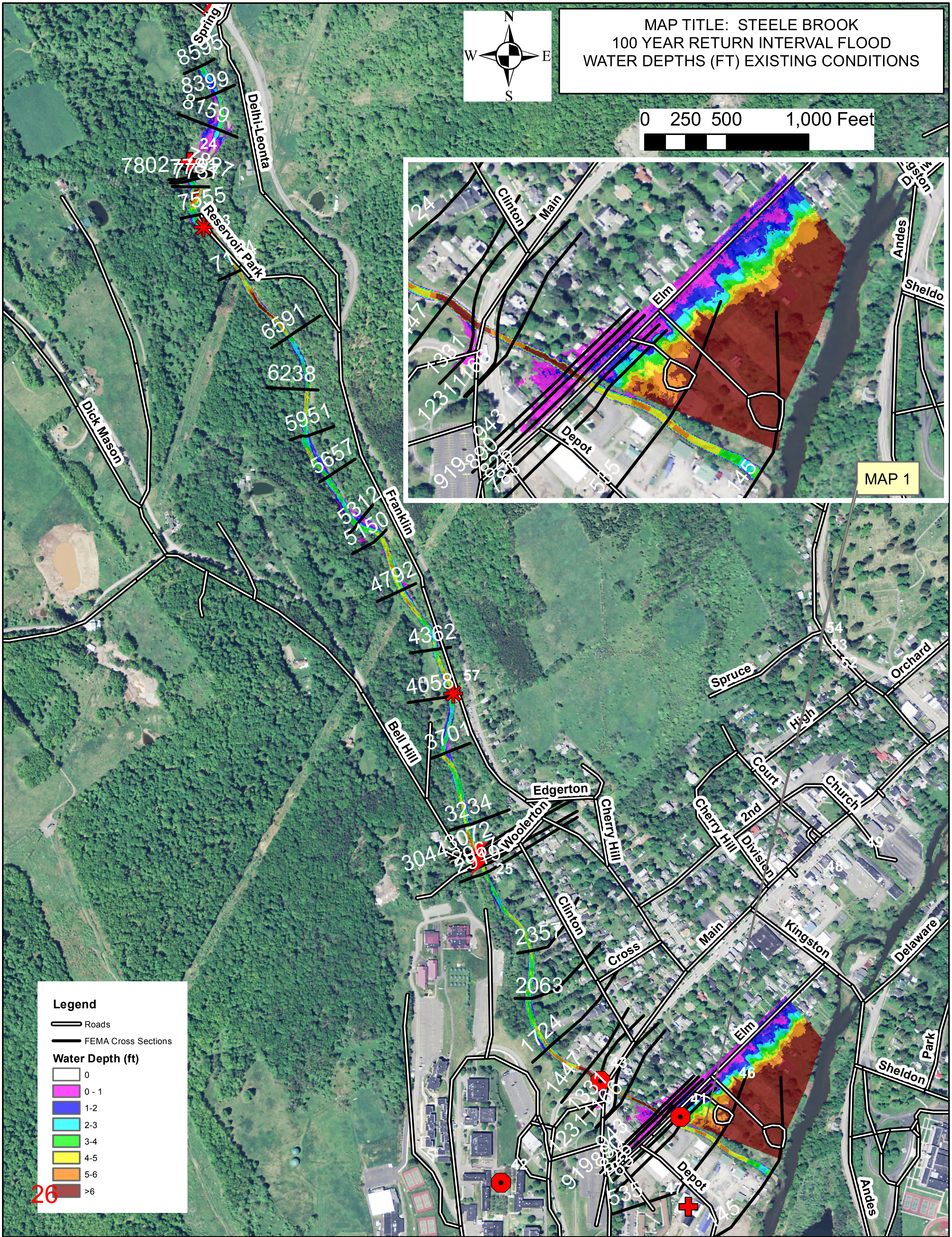

943
898
826
783
535
145

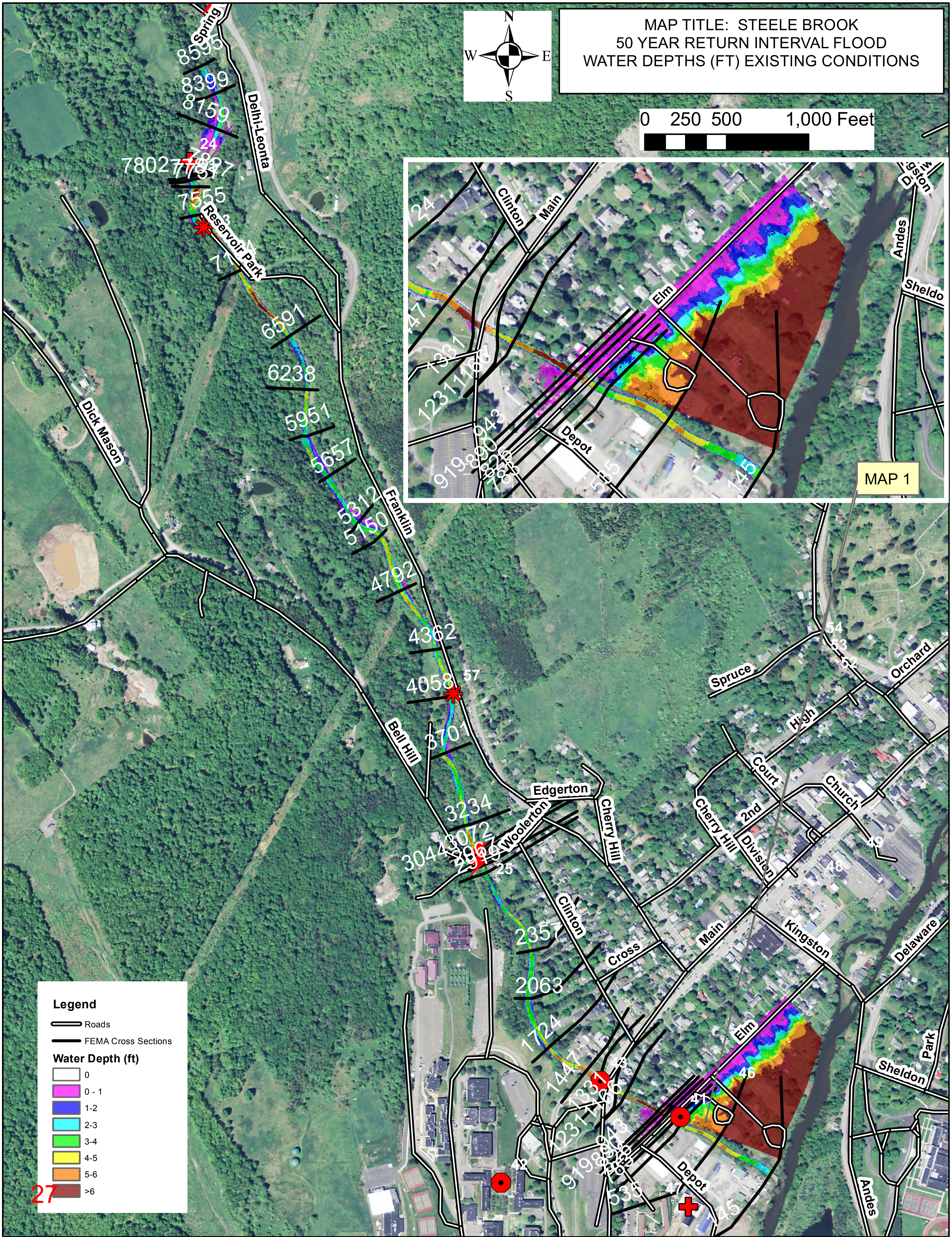

SteeleBrook Plan: 1) Existing 6/25/2017 2) Exist MainSt Obstruct 6/26/2017
Legend
WS 100-YR - Existing
WS 100-YR - Obstructed
WS 50-YR - Obstructed
WS 50-YR - Existing
WS 10-YR - Existing
WS 10-YR - Obstructed
Ground
Elevation (ft)
1400
1390
1380
1370
1360
800
1000
1200
1400
1600
1800
2000
Main Channel Distance (ft)



SteeleBrook Plan: 1) Existing 6/26/2017 2) Exist MainSt Obstruct 6/26/2017
River = SteeleBrook Reach = Delhi RS = 1166 STE_05X (Main Street)
.06
.06
.04
.06
.06
.04
.05
Legend
WS 100-YR - Existing
WS 100-YR - Exist MainSt Obstruct
Ground
Bank Sta
Elevation (ft)
Station (ft)
1385
1380
1375
1370
1365
1360
0
100
200
300
400
500
600
700
800


MAP TITLE: STEELE BROOK
500 YEAR RETURN INTERVAL FLOOD
WATER DEPTHS (FT) EXISTING CONDITIONS
N
S
E
W
0 250 500 1,000 Feet
MAP 1
Legend
Roads
FEMA Cross Sections
Water Depth (ft)
0
0 - 1
1-2
2-3
3-4
4-5
5-6
>6
Spring
Delhi-Leonta
Reservoir Park
Dick Mason
Franklin
Bell Hill
Edgerton
Woolerton
Cherry Hill
Clinton
Cross
Main
Elm
Depot
Spruce
High
Orchard
Court
2nd
Church
Division
Kingston
Delaware
Park
Sheldon
Andes
8595
8399
8159
7555
6591
6238
5951
5657
5312
5150
4792
4362
4058
3701
3234
2357
2063
1724
1447
1331
145
535


MAP TITLE: STEELE BROOK
100 YEAR RETURN INTERVAL FLOOD
WATER DEPTHS (FT) EXISTING CONDITIONS
N
S
E
W
0 250 500 1,000 Feet
MAP 1
Legend
Roads
FEMA Cross Sections
Water Depth (ft)
0
0 - 1
1-2
2-3
3-4
4-5
5-6
>6
Spring
Delhi-Leonta
Reservoir Park
Dick Mason
Franklin
Bell Hill
Edgerton
Woolerton
Cherry Hill
Clinton
Cross
Main
Elm
Depot
Spruce
High
Court
Church
Orchard
2nd
Division
Kingston
Delaware
Sheldon
Park
Andes
8595
8399
8159
7555
6591
6238
5951
5657
5312
5150
4792
4362
4058
3701
3234
2357
2063
1724
1447
535
145


MAP TITLE: STEELE BROOK
50 YEAR RETURN INTERVAL FLOOD
WATER DEPTHS (FT) EXISTING CONDITIONS
N
W
E
S
0 250 500 1,000 Feet
MAP 1
Legend
Roads
FEMA Cross Sections
Water Depth (ft)
0
0 - 1
1-2
2-3
3-4
4-5
5-6
>6
Spring
Delhi-Leonta
Reservoir Park
Dick Mason
Franklin
Bell Hill
Edgerton
Wooleton
Cherry Hill
Clinton
Cross
Main
Elm
Depot
Spruce
High
Orchard
Court
Church
2nd
Division
Kingston
Delaware
Sheldon
Park
Andes
8595
8399
8159
7555
6591
6238
5951
5657
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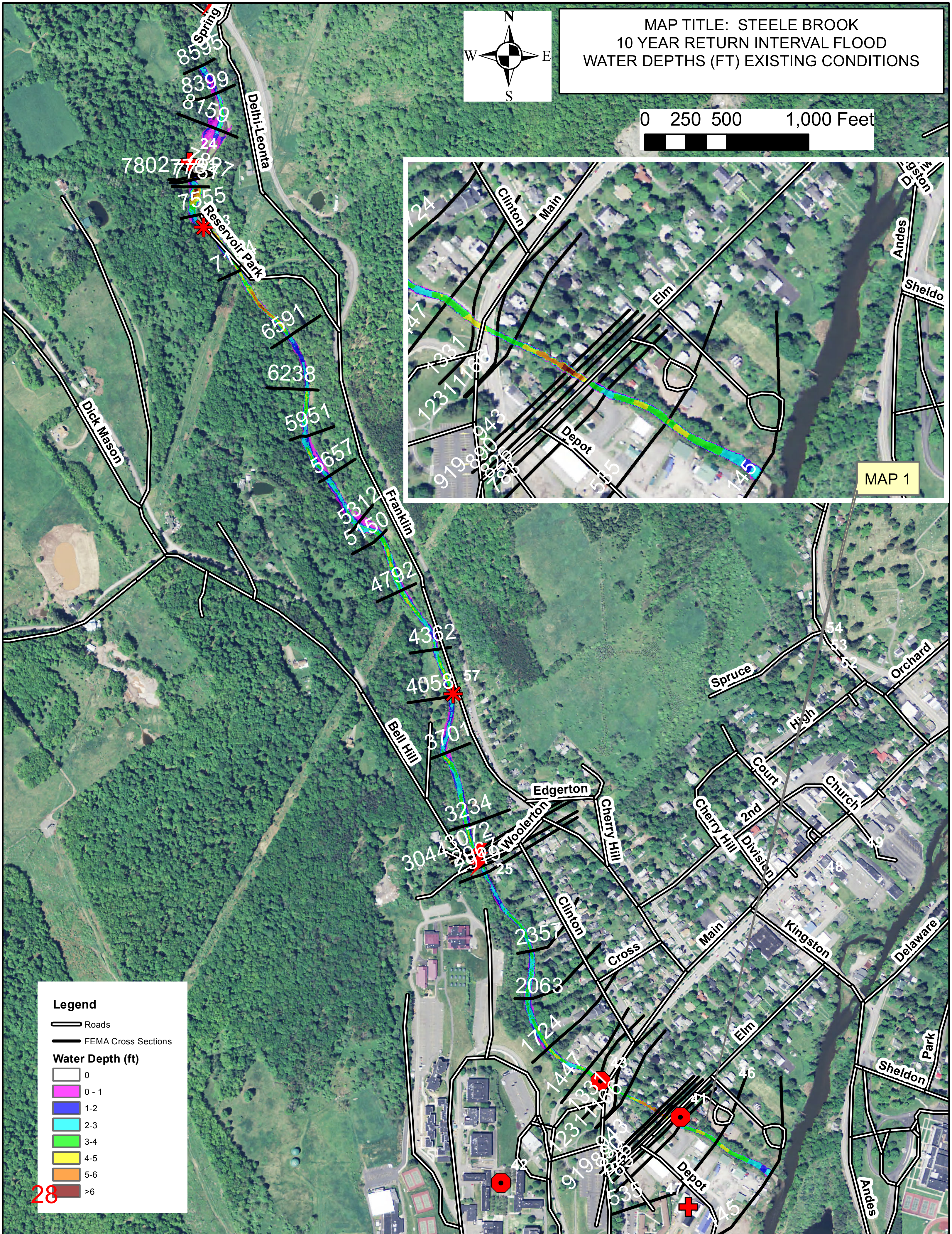
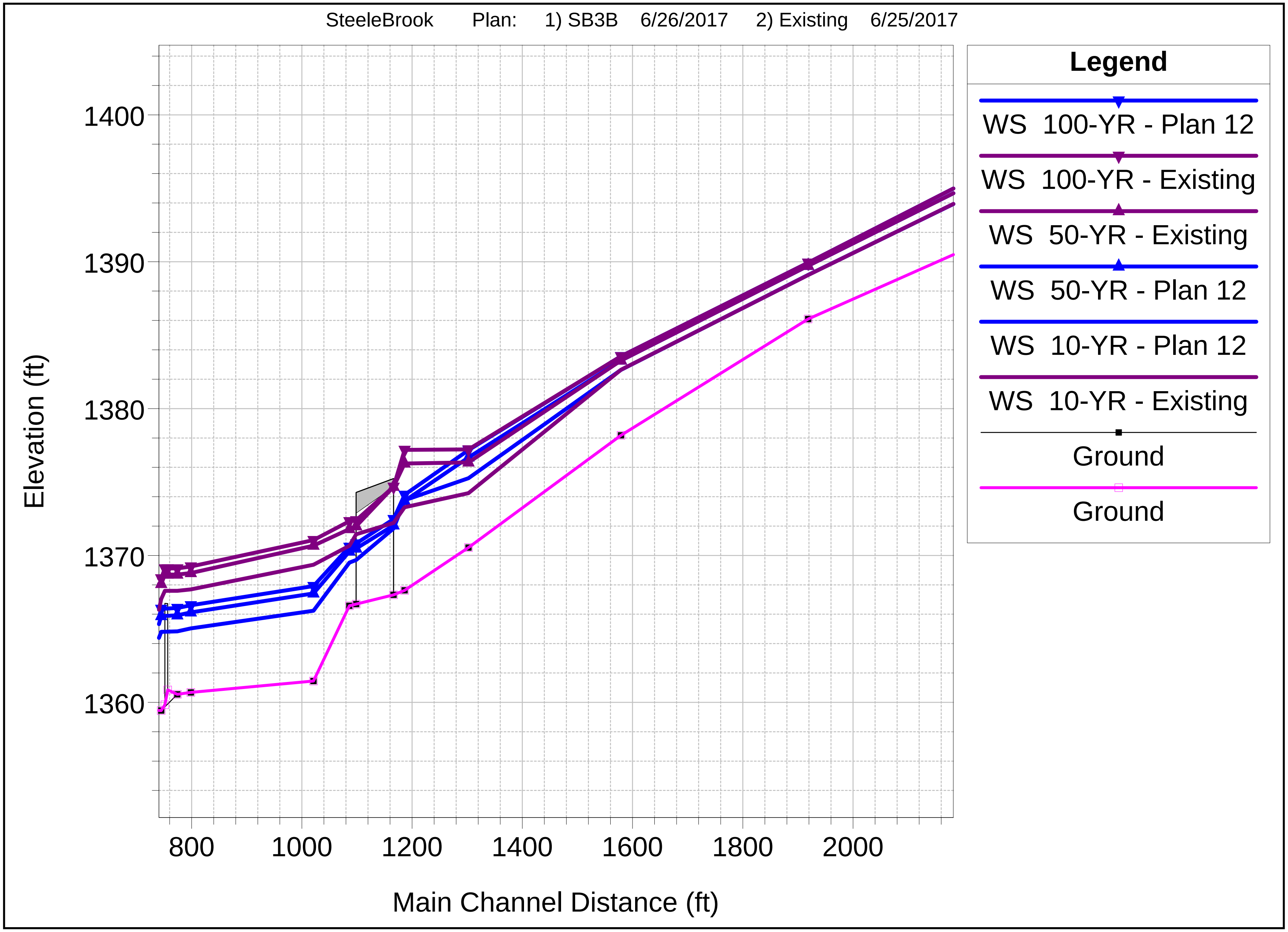
3234
2357
2063
1724
1441
1331
1231
535
145

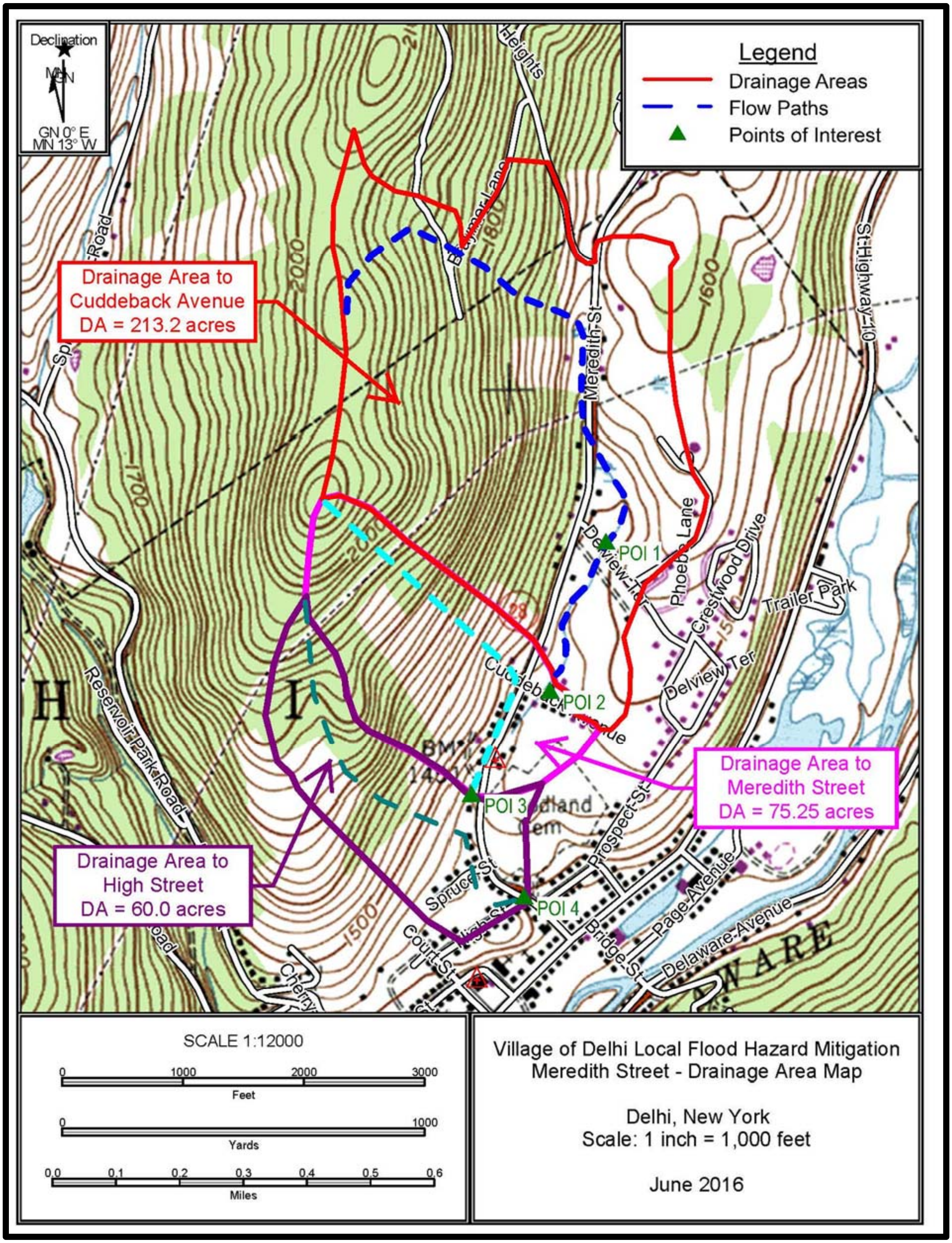

MAP TITLE: STEELE BROOK
10 YEAR RETURN INTERVAL FLOOD
WATER DEPTHS (FT) EXISTING CONDITIONS
N
S
E
W
0 250 500 1,000 Feet
MAP 1
Legend
Roads
FEMA Cross Sections
Water Depth (ft)
0
0 - 1
1-2
2-3
3-4
4-5
5-6
>6
Spring
Delhi-Leonta
Reservoir Park
Dick Mason
Franklin
Bell Hill
Edgerton
Woolerton
Cherry Hill
Clinton
Cross
Main
Elm
Depot
Spruce
High
Court
2nd
Division
Church
Orchard
Kingston
Delaware
Park
Sheldon
Andes
8595
8399
8159
7555
6591
6238
5951
5657
4792
4362
4058
3701
3234
2357
2063
1724

TITLE	Opinion of Estimated Construction Cost for Delhi LFA Plan #10				
DESIGN LEVEL	Conceptual Design				
DATE	1/30/2017				
BY:	GDF				
CHECKED					
BID ITEM #	ITEM	Unit	Unit Cost	Quantity	Total
1	Mobilization, Demobilization and Restore Site to Pre-Construction Conditions	LS	$78,618	1	$79,000
2	Excavation Bench (Average Depth, width and length:6.0',13', 450)	CY	$15	1,450	$22,000
3	Haul Excavated Material Off Site	CY	$35	1,450	$51,000
4	Seed and Mulch Site	Acre	$3,250	0.2	$1,000
5	Procure and Install Low Head Coffer Dam (Water Quality Control)	LF	$8	450	$4,000
6	Procure and Install 10' Average High Rockery Rock Wall	Tons	$85	1,500	$127,500
7	Procure and Install Sheet Pile At House (171.10-6-26)	SF	$30	1,000	$30,000
8	Procure and Install Step Pool Grade Control	EA	$1,200	10	$12,000
9	Remove Existing and Procure and Install Elm Street Crossing	LS	$540,000	1	$540,000
				Sub Total	$866,500
	items have been rounded up			Contigency (15%) (Items 1-9)	$130,000
				Engineering, Surveying and Design (12%) (Items 1-9)	$103,980
				Grand Total	$1,100,480



SteeleBrook Plan: 1) SB3B 6/26/2017 2) Existing 6/25/2017
Elevation (ft)
1400
1390
1380
1370
1360
800
1000
1200
1400
1600
1800
2000
Main Channel Distance (ft)
Legend
WS 100-YR - Plan 12
WS 100-YR - Existing
WS 50-YR - Existing
WS 50-YR - Plan 12
WS 10-YR - Plan 12
WS 10-YR - Existing
Ground
Ground

TITLE	Opinion of Estimated Construction Cost for Delhi LFA Plan #12-Debris Management Only				
DESIGN LEVEL	Conceptual Design				
DATE	3/1/2017				
BY:	GDF				
CHECKED					
BID ITEM #	ITEM	Unit	Unit Cost	Quantity	Total
1	Mobilization, Demobilization and Restore Site to Pre-Construction Conditions	LS	$16,682	1	$17,000
2	Clear Area	Acre	$2,250	0.96	$3,000
3	Earthwork (Waste Material on Site)	CY	$20	3,500	$70,000
4	Procure and Install Heavy Stone Fill for Armored Riffle	Tons	$75	31	$3,000
5	Procure and Install Heavy Stone Fill for Vanes	Tons	$75	62.7	$5,000
6	Procure and Install Rockery Rock For Cross Vanes	Tons	$115	150	$18,000
7	Procure and Install Medium Stone Fill For Debris Strainers	Tons	$55	160	$8,800
8	Procure and Install 15'Long, 1.0' Diameter Logs For Debris Strainers	EA	$150	80	$12,000
9	Water Quality Control (Utilize Existing Stream Channel Until Proposed Channel is Complete)	LS	$6,500	1	$7,000
10	Seed and Mulch Site	LS	$2,650	0.96	$2,555
11	Stabalize Access to Site (For Construction and Future Debris Removal)	LF	$15	2,700	$40,500
				Sub Total	$186,900
	items have been rounded up			Contigency (15%) (Items 1-11)	$29,000
				Engineering, Surveying and Design (12%) (Items 1-11)	$22,423
				Grand Total	$238,323


Legend
Drainage Areas
Flow Paths
Points of Interest
Declination
GN 0° E
MN 13° W
Drainage Area to Cuddeback Avenue
DA = 213.2 acres
Drainage Area to Meredith Street
DA = 75.25 acres
Drainage Area to High Street
DA = 60.0 acres
POI 1
POI 2
POI 3
POI 4
Meredith St
Delview Ter
Phoebe Lane
Crestwood Drive
Trailer Park
Prospect St
Bridge St
Page Avenue
Delaware Avenue
Spruce St
Court St
Reservoir Park Road
St Highway 10
Heights
SCALE 1:12000
Feet
Yards
Miles
Village of Delhi Local Flood Hazard Mitigation
Meredith Street - Drainage Area Map
Delhi, New York
Scale: 1 inch = 1,000 feet
June 2016

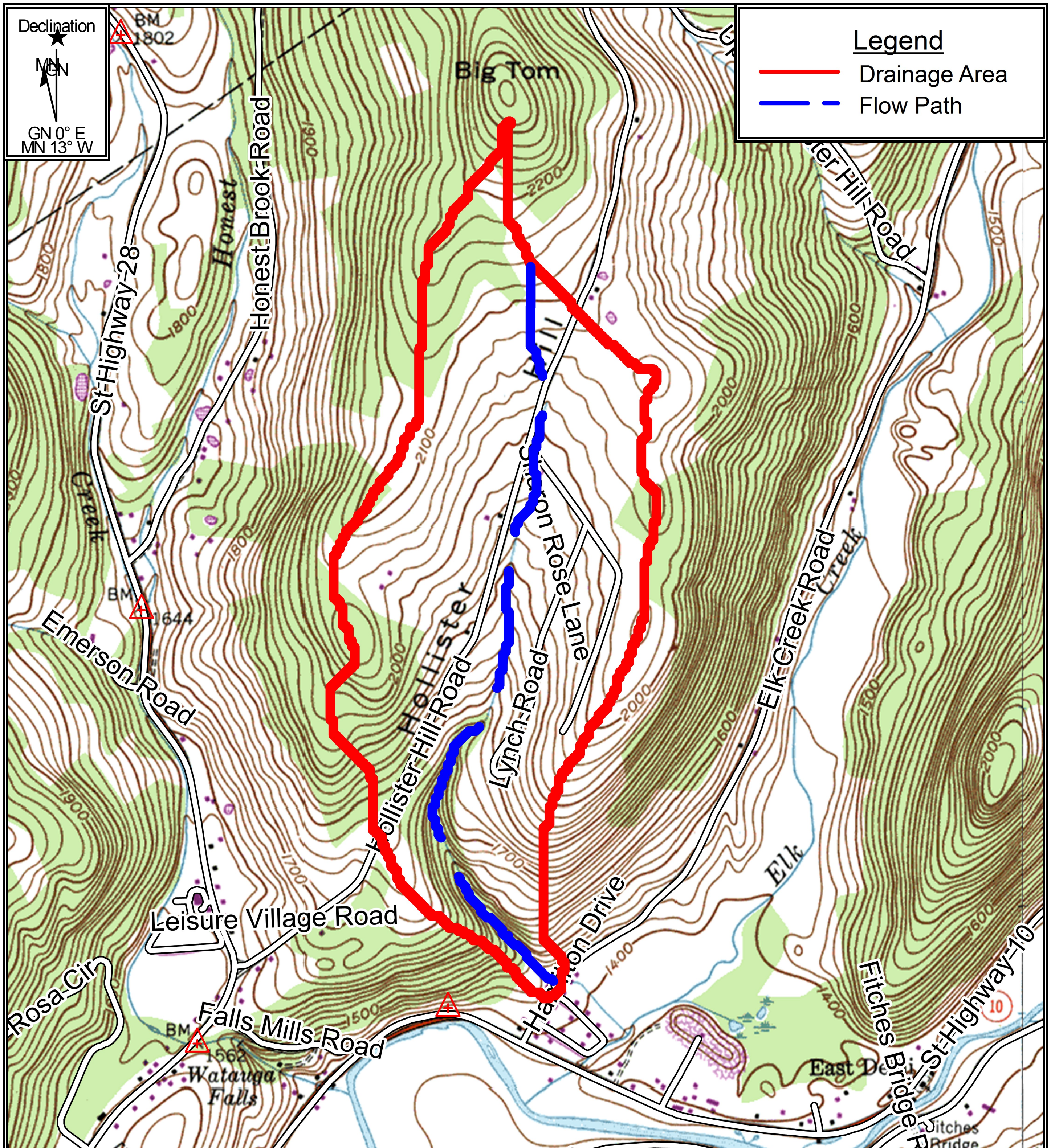
Hydrologic Soil Group — Summary by Map Unit — Delaware County, New York (NY025)				
Map unit symbol	**Map unit name**	**Rating**	**Acres in AOI**	**Percent of AOI**
HcC	Halcott, Mongaup, and Vly soils, 2 to 15 percent slopes, very rocky	C	19.4	10.2%
HcF	Halcott, Mongaup, and Vly soils, 35 to 70 percent slopes, very rocky	C	15.2	8.0%
LaD	Lackawanna flaggy silt loam, 15 to 25 percent slopes	C/D	30.0	15.7%
LaE	Lackawanna flaggy silt loam, 25 to 40 percent slopes	C/D	8.9	4.7%
MaB	Maplecrest gravelly silt loam, 3 to 8 percent slopes	B	2.5	1.3%
MaC	Maplecrest gravelly silt loam, 8 to 15 percent slopes	B	62.0	32.5%
MaD	Maplecrest gravelly silt loam, 15 to 25 percent slopes	B	0.5	0.3%
MrB	Morris flaggy silt loam, 3 to 8 percent slopes	D	10.9	5.7%
OpE	Oquaga channery silt loam, 25 to 35 percent slopes	C	40.6	21.3%
VlD	Vly channery silt loam, 15 to 25 percent slopes	C	0.6	0.3%
Totals for Area of Interest			**190.6**	**100.0%**

NRCS Web Soil Survey HSG Ratings		
Rating	**Acres in AOI**	**Percent of AOI**
HSG	Acres	%
A	0.00	0.00%
B	65.00	34.10%
C	75.80	39.77%
D	49.80	26.13%
Other	0.00	0.00%
Totals	**190.60**	**100.00%**

Adjusted Values for Area Calculations		
Rating	**Acres in AOI**	**Percent of AOI**
HSG	Acres	%
A	0.00	0.00%
B	65.00	34.10%
C	75.80	39.77%
D	49.80	26.13%
Totals	**190.60**	**100.00%**

StreamStats Basin Characteristics				Total
Forest	Urban Land	Storage	Grass	
70.90%	3.18%	0.00%	25.92%	
0.00	0.00	0.00	0.00	0.00
46.09	2.07	0.00	16.85	65.00
53.74	2.41	0.00	19.65	75.80
35.31	1.58	0.00	12.91	49.80
135.14	**6.06**	**0.00**	**49.40**	**190.60**

TITLE	Opinion of Estimated Construction Cost for Delhi LFA Meridith Study Area Plan #14				
DESIGN LEVEL	Conceptual Design				
DATE	1/31/2017				
BY:	GDF				
CHECKED					
BID ITEM #	ITEM	Unit	Unit Cost	Quantity	Total
1	Mobilization and Demobilization	LS	$76,500	1	$76,500
2	Excavate Stormwater Retention Area	CY	$12	8,500	$102,000
3	Haul Excavated Material Off Site	CY	$35	8,500	$297,500
4	Grade Open Channel	LF	$50	200	$10,000
5	Procure and Install 24" ADS N-12 Pipe	LF	$44	730	$33,000
6	Install and Remove Traffic Bypass at Cudeback Avenue (1 lane bypass)	LS	$17,000	1	$17,000
7	Procure and Install NYSDOT Std Drainage Unit (Point 7)	EA	$4,600	2	$9,000
8	4' Dia. Manhole w/ top slab, frame and cover (Point 6)	EA	$3,200	1	$3,200
9	Traffic Control at State Route 28 (Reduce to One Lane Traffic on Southbound Lane)	Day	$500	90	$45,000
10	Procure and Install 36" ADS N-12 Pipe	LF	$60	1,250	$75,000
11	8' Dia. Manhole w/ top slab, frame and cover (Point 21)	EA	$9,020	5	$46,000
12	4' Dia. Manhole w/ top slab, frame and cover (Point 17,19,20)	EA	$3,190	3	$10,000
13	Demo Red Barn and Relocate	LS	$45,000	1	$45,000
14	Headwall and Inlet Structure (Point 16)	EA	$8,000	1	$8,000
15	Procure and Install 36" ADS N-12 Pipe	LF	$121	500	$60,500
16	Sediment and Erosion Control	LS	$5,000	1	$5,000
17	Temporary and Permanent Easements (8 Parcels)	LS	$17,000	1	$17,000
				Sub Total	$859,700
	items have been rounded up			Contigency (20%) (Items 1-17)	$157,000
				Engineering, Surveying and Design (16%) (Items 1-17)	$117,500
				Grand Total	$1,134,200



SCALE 1:18000

0 1000 2000 3000 4000 5000 6000
Feet

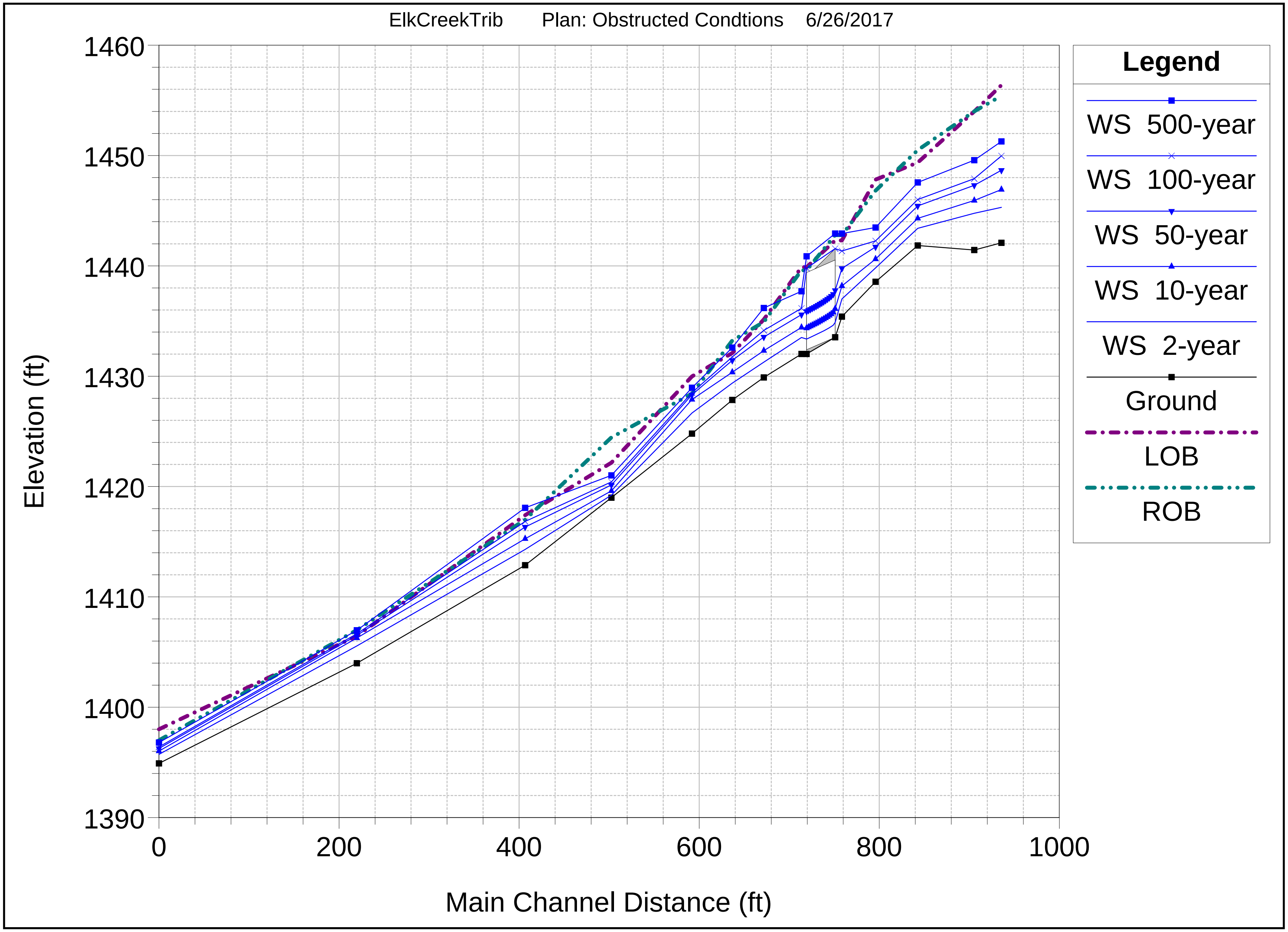
0 1000 2000
Yards

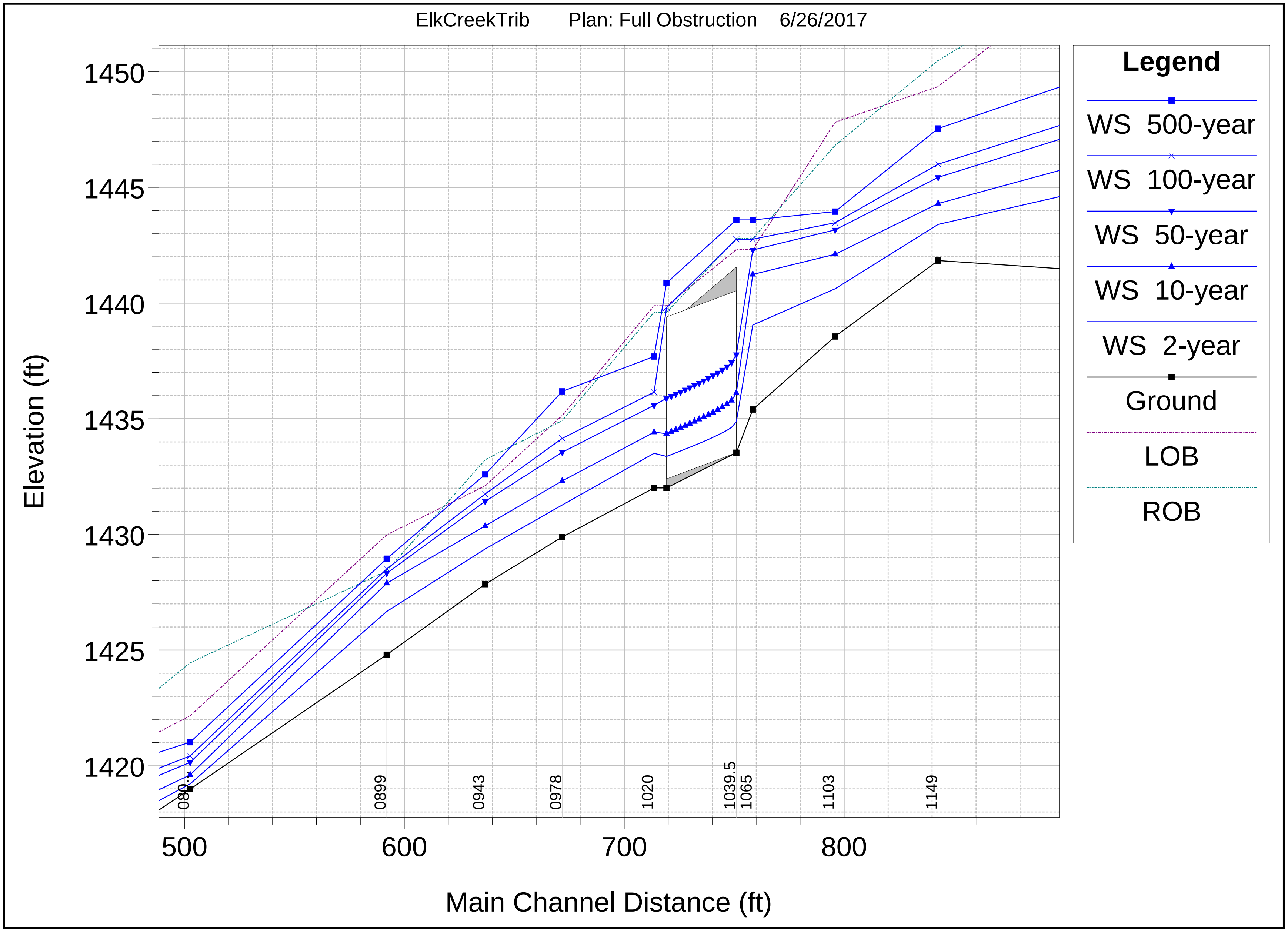
0 1
Mile

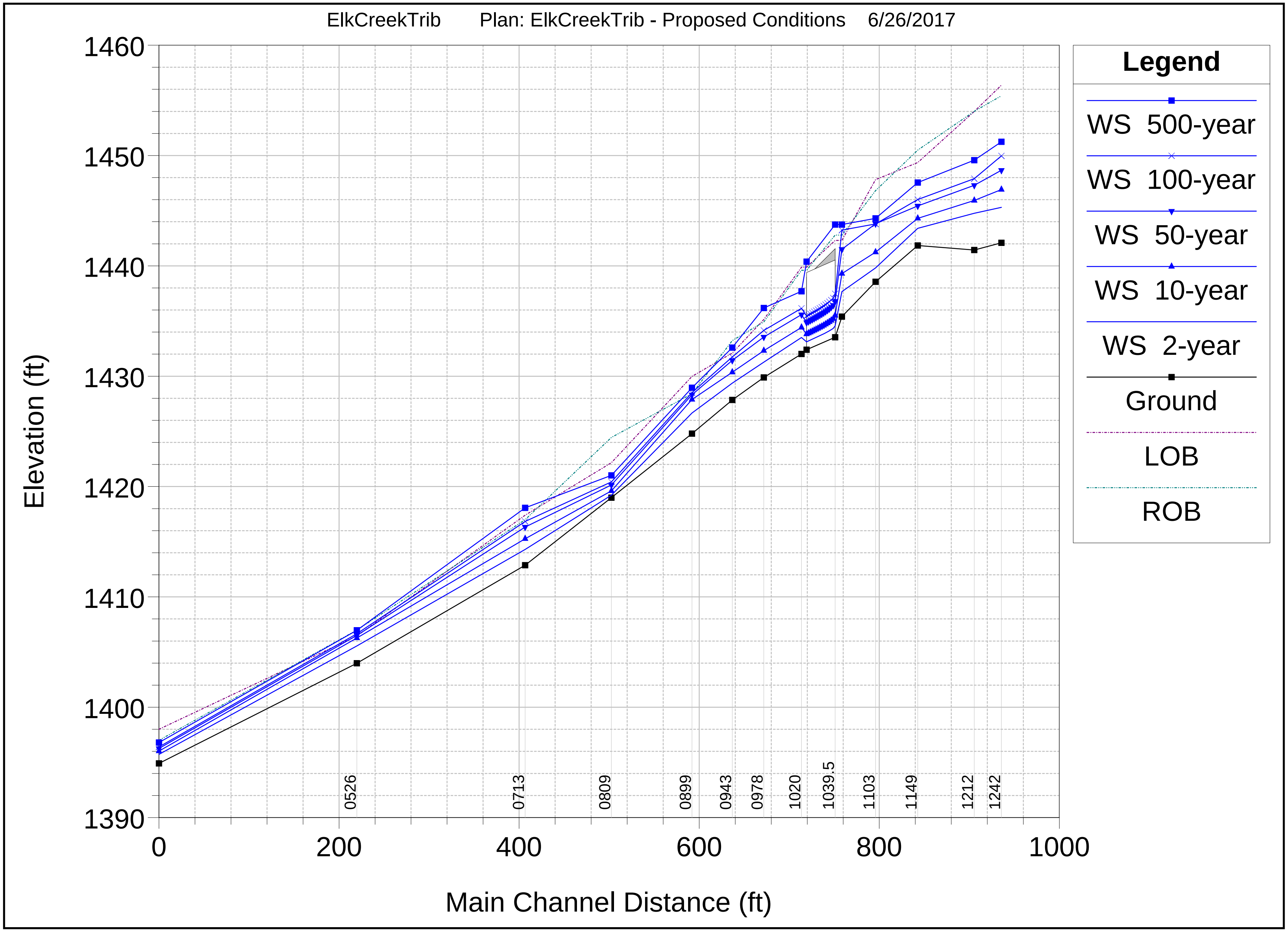
Elk Creek Tributary
Drainage Area Map

Scale: 1 inch = 1,500 feet
Delhi, New York

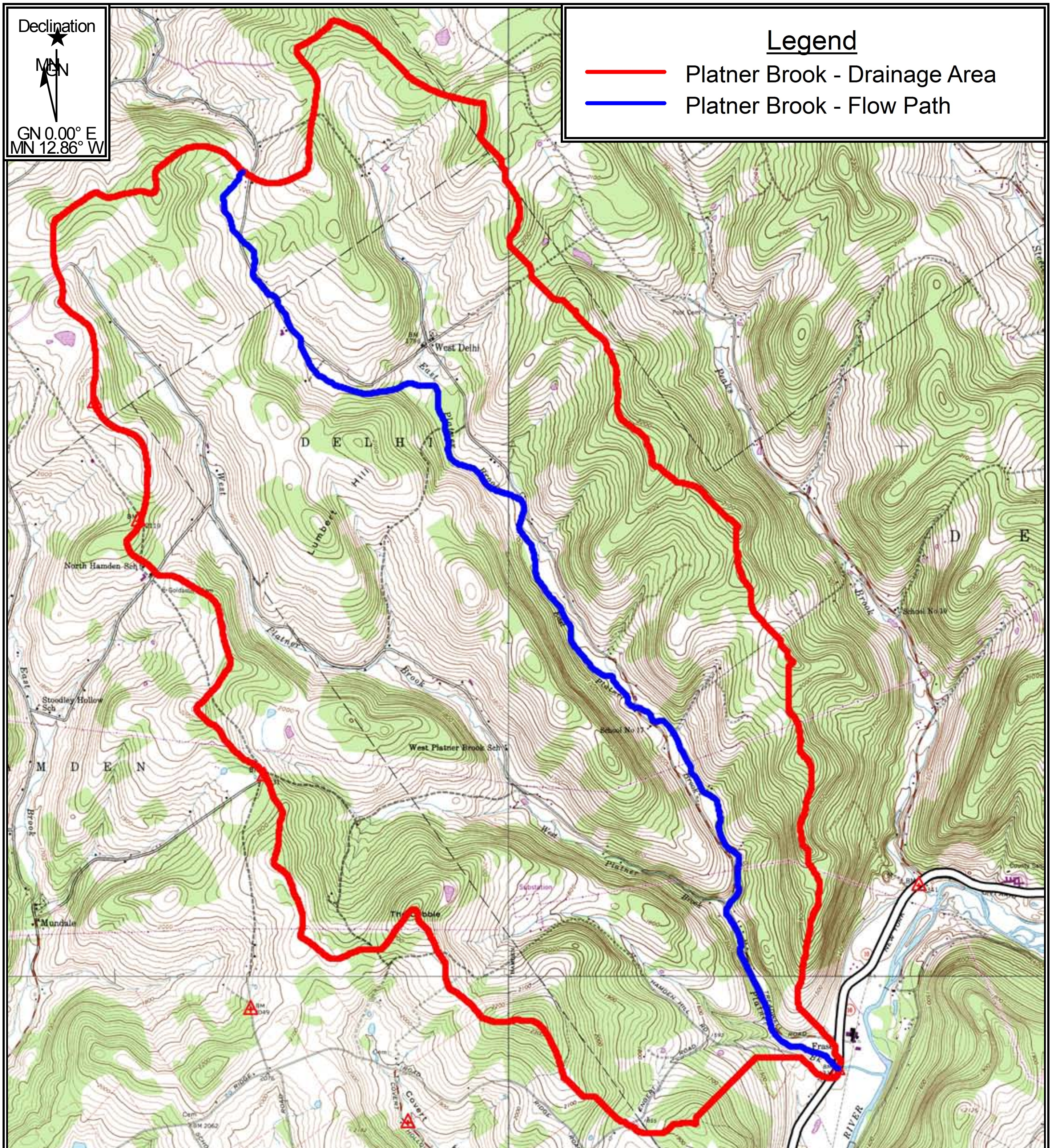
June 2016


ElkCreekTrib Plan: Obstructed Condtions 6/26/2017
Elevation (ft)
1460
1450
1440
1430
1420
1410
1400
1390
0
200
400
600
800
1000
Main Channel Distance (ft)
Legend
WS 500-year
WS 100-year
WS 50-year
WS 10-year
WS 2-year
Ground
LOB
ROB


ElkCreekTrib Plan: Full Obstruction 6/26/2017
Elevation (ft)
1450
1445
1440
1435
1430
1425
1420
Main Channel Distance (ft)
500
600
700
800
080...
0899
0943
0978
1020
1039.5
1065
1103
1149
Legend
WS 500-year
WS 100-year
WS 50-year
WS 10-year
WS 2-year
Ground
LOB
ROB



ElkCreekTrib Plan: ElkCreekTrib - Proposed Conditions 6/26/2017
Elevation (ft)
Main Channel Distance (ft)
1460
1450
1440
1430
1420
1410
1400
1390
0
200
400
600
800
1000
0526
0713
0809
0899
0943
0978
1020
1039.5
1103
1149
1212
1242
Legend
WS 500-year
WS 100-year
WS 50-year
WS 10-year
WS 2-year
Ground
LOB
ROB



SCALE 1:48000

0 10000
Feet

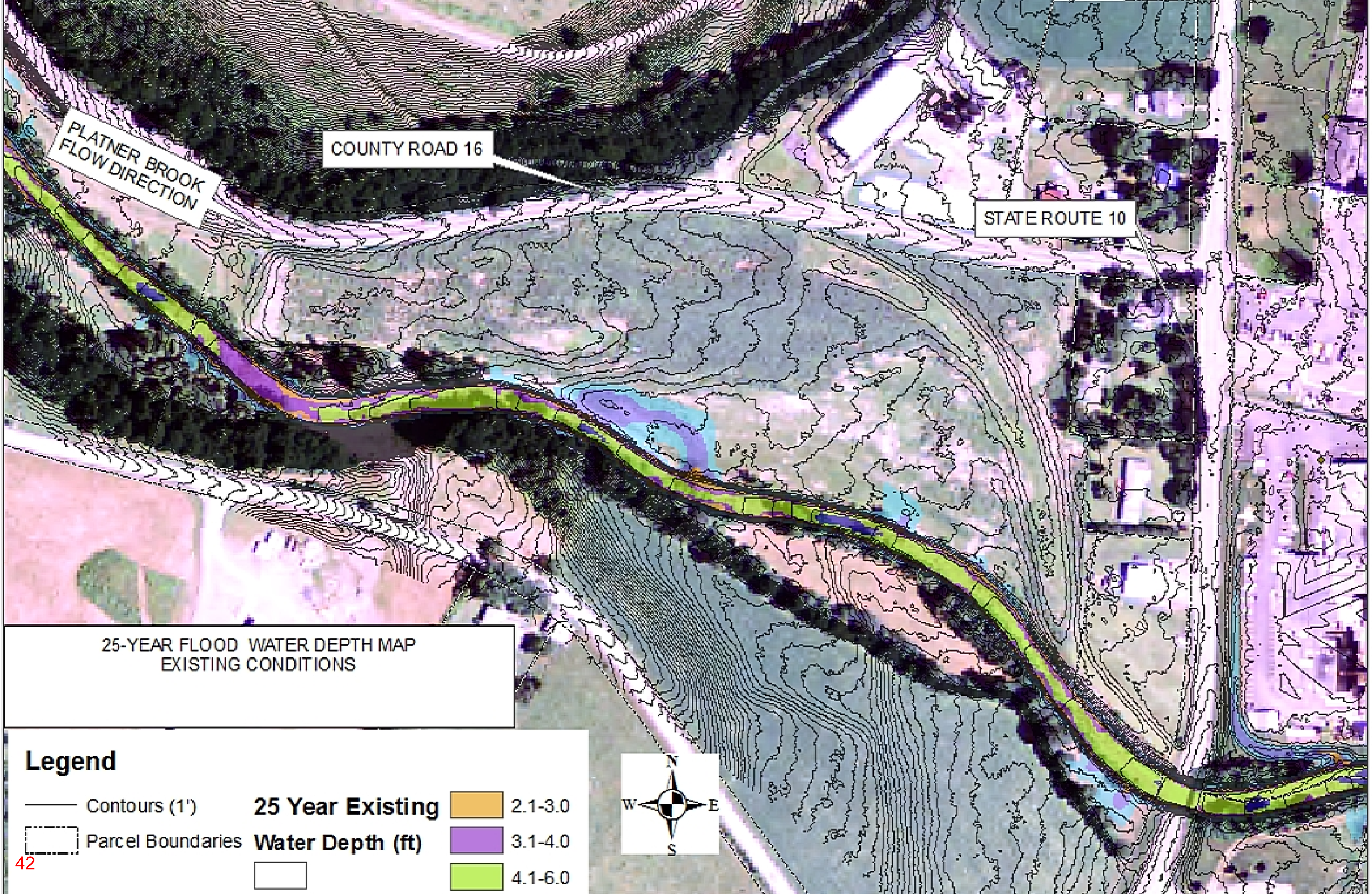
0 1000 2000 3000 4000
Yards

0 1 2
Miles

Village of Delhi Local Flood Hazard Mitigation
Platner Brook - Drainage Area Map

Delhi, New York
Scale: 1 inch = 4,000 feet

October 2015


PLATNER BROOK
FLOW DIRECTION
COUNTY ROAD 16
STATE ROUTE 10
25-YEAR FLOOD WATER DEPTH MAP
EXISTING CONDITIONS
Legend
Contours (1')
Parcel Boundaries
25 Year Existing
Water Depth (ft)
2.1-3.0
3.1-4.0
4.1-6.0
N
W
E
S

TITLE	Opinion of Estimated Construction Cost for Delhi LFA Plan #1
DESIGN LEVEL	Conceptual Design
DATE	6/5/2017
BY:	GDF
CHECKED	

BID ITEM #	ITEM	Unit	Unit Cost	Quantity	Total
1	Mobilization, Demobilization and Restore Site to Pre-Construction Conditions	LS	$11,251	1	$12,000
2	Excavate Berm (Berm Average Dimensions: 40' Wide, 5' High, 250' Long)	CY	$20	1,850	$37,000
3	Haul Excavated Material Off Site	CY	$35	1,850	$65,000
4	Seed and Mulch Site	Acre	$3,250	1	$2,000
5	Procure and Install Silt Fence	LF	$3	190	$1,000
6	Procure and Install Biodegradable Erosion Control Fabric	SY	$7.5	200	$1,500
7	Permanent Easement	Acre	$12,500	1	$7,000
				Sub Total	$125,500
	items have been rounded up			Contigency (15%) (Items 1-6)	$19,000
				Engineering, Surveying and Design (12%) (Items 1-6)	$15,060
				Grand Total	$159,560

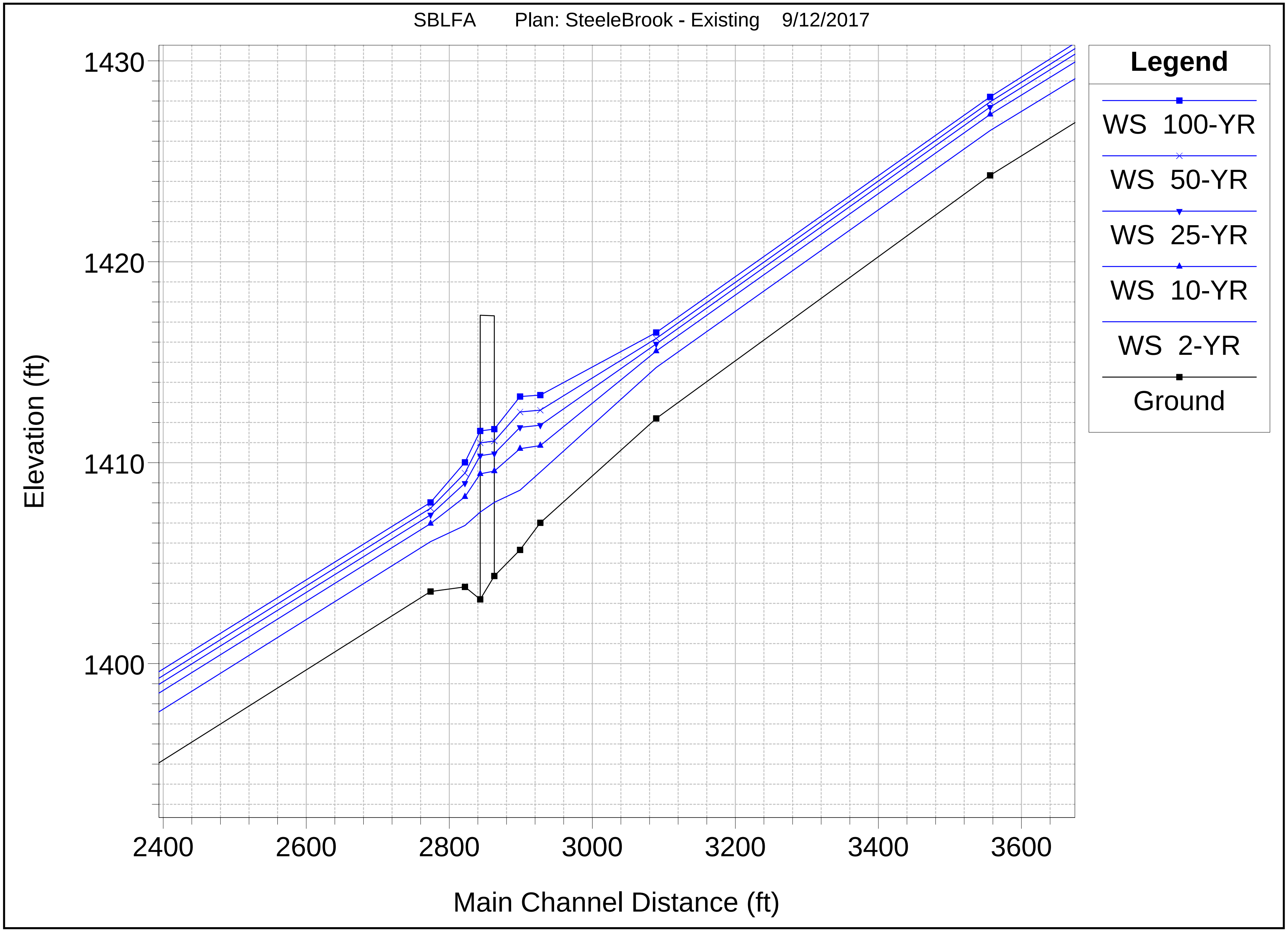

BUILDING #1
BUILDING #2
BUILDING #5
BUILDING #4
BUILDING #3
28
Meredith St
Spruce St
High St
Orchard St
Prospect St
Main St
376 ft
© 2017 Google
Google earth


1963 HISTORIC AERIAL PHOTO OF EXISTING SUNY BALL FIELD

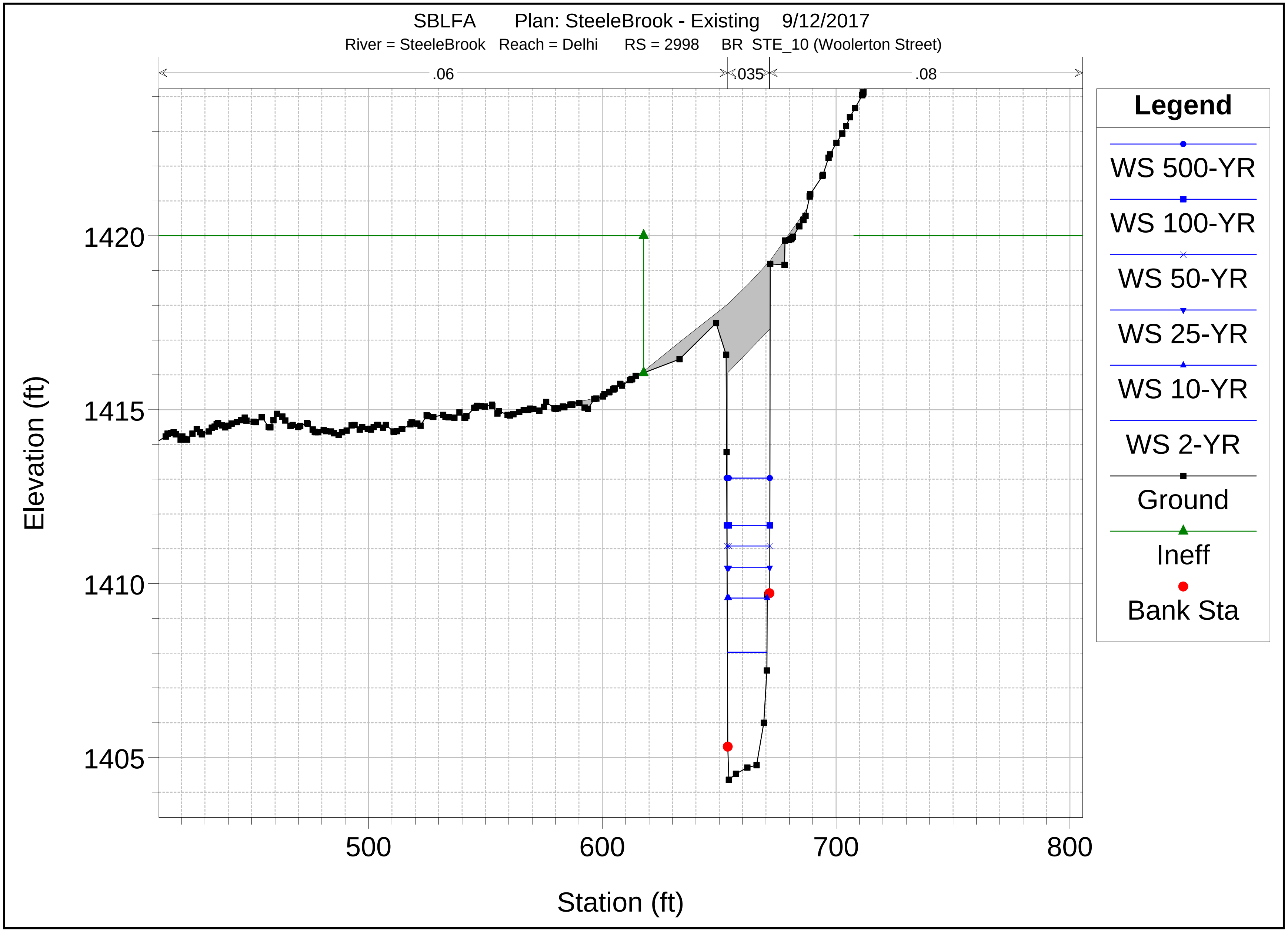

1972 HISTORIC AERIAL PHOTO OF EXISTING SUNY BALL FIELD

TITLE	Opinion of Estimated Construction Cost for Delhi LFA Plan #7				
DESIGN LEVEL	Concept				
DATE	6/24/2017				
BY:	GDF				
CHECKED					
BID ITEM #	ITEM	Unit	Unit Cost	Quantity	Total
1	Mobilization and Demobilization (10% of Construction Cost)	LS	$8,600	1	$8,600
2	Traffic Control Warning Signs (Assume Complete Road Closure)	LS	$2,500	1	$2,500
3	Water Control Plan (Assume coffer dam, water remains in existing channel, shift water as needed)	EA	$5,500	1	$5,500
4	Procure and Install Three Sided Pre-Cast Culvert (20' Clear Span, 50' Length, 6' High)	EA	$35,000	1	$35,000
5	Procure and Install 2 ton Rockery Wall Stone (Four 10' Long, 7' Tall Wingwalls)	Tons	$125	60	$7,500
6	Procure and Install Engineered Backfill Behind Rockery Wall	CY	$45	100	$4,500
7	Procure and Install Footer Subbase (Compact)	CY	$35	70	$2,500
8	Procure and Install Box Culvert Footer	LS	$6,500	1	$6,500
9	Procure and Install 1.0 Ton to 2.0 Ton Size Stones (12 ton per Grade Control, 2 features)	Tons	$85	24	$2,100
10	Procure and Install Medium Stone Fill (25 ton per Grade Control, 2 feature)	Tons	$55	50	$2,800
11	Earthwork for Box Culvert Installation (50' Long, 30' Wide, 8' deep trench)	CY	$12	450	$5,400
12	Haul Earthwork Off Site	CY	$25	200	$5,000
13	Procure and Install Biodegradable Erosion Control Blanket (200 feet)	SY	$8	190	$1,600
14	Procure and Install Course Stone Fill (Scour protection)	Tons	$35	40	$1,400
15	Procure and Install Geotextile Fabric (180 feet)	SY	$7	140	$1,000
16	Procure and Install Seed and Mulch	Acre	$4,500	0.40	$1,800
17	Dispose of Existing Culvert	LS	$3,500	1	$3,500
18	Procure and Install Corrugated Beam Guide Railing	LF	$112	80	$9,000
19	Road Rehabilitation (Gravel subbase, Stone finish)	LS	$1	5,400	$5,400
				Construction Total	$111,600
				Contigency (15%)	$16,740
				Engineering and Permitting (20%)	$22,320
				Project Total	$150,660


4058
3701
3072
2998
3234
2967
2919
2357
2063
1724
1447



SBLFA Plan: SteeleBrook - Existing 9/12/2017
Legend
WS 100-YR
WS 50-YR
WS 25-YR
WS 10-YR
WS 2-YR
Ground
Elevation (ft)
1430
1420
1410
1400
2400
2600
2800
3000
3200
3400
3600
Main Channel Distance (ft)


SBLFA Plan: SteeleBrook - Existing 9/12/2017
River = SteeleBrook Reach = Delhi RS = 2998 BR STE_10 (Woolerton Street)
.06
.035
.08
Elevation (ft)
1420
1415
1410
1405
500
600
700
800
Station (ft)
Legend
WS 500-YR
WS 100-YR
WS 50-YR
WS 25-YR
WS 10-YR
WS 2-YR
Ground
Ineff
Bank Sta

Title:	100-Year Flood Water Velocities	
	At and Near Woolerton Bridge	
Date: 9/12/17		
By: GDF		
Reach	River Sta	Vel Chnl
		(ft/s)
Delhi	3701	9.26
Delhi	3234	9.71
Delhi	3072	7.12
Delhi	3044	6.5
Delhi	2998	WOOLERTON BRIDGE
Delhi	2967	13.21
Delhi	2919	10.65
Delhi	2357	10.12
Delhi	2063	9.06
Delhi	1724	9.69
Delhi	1447	6.87

APPENDIX B

Structure Name	Total size of building (sf)	Value of building (BRV) ($/sf)	Demolition Damage Threshold	First Floor Elevation	Address	Streambed Elevation (ft)	Is the building residentail?	What is the building type?	What is the foundation type?	Does a basement exist?	What is the structure's primary use?	Depth Damage Function Type	Depth Damage Function	Ground Surface 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
0	1768.00	$84.82	50.00%	1362.5	171.10-6-4	1347.06	No	One Story	Slab	No	Grocery	Library	Grocery	1363	1358.13	1359.78	1360.44	1361.74
1	2716.00	$23.12	50.00%	1362.1	171.10-7-1	1347.04	Yes	Two or More Stories	Pier	No		Library	FEMA FIA, 2-Story, No Basement	1361	1358.05	1359.67	1360.29	1361.57
2	4494.00	$28.84	50.00%	1361.5	171.6-10-23	1346.66	No	One Story	Slab	No	Service Station	Library	Service Station (Default)	1362	1358.35	1360.16	1361.11	1362.43
3	4200.00	$14.54	50.00%	1361.7	171.10-6-6	1346.51	Yes	Two or More Stories	Pile	No		Library	FEMA FIA, 2-Story, No Basement	1361	1357.88	1359.49	1360.09	1361.34
4	6716.00	$11.04	50.00%	1364	171.10-6-7	1346.06	Yes	Two or More Stories	Pile	No		Library	FEMA FIA, 2-Story, No Basement	1363	1357.76	1359.36	1359.96	1361.19
5	3884.00	$15.78	50.00%	1362.5	171.10-6-5	1346.62	Yes	Two or More Stories	Pile	No		Library	FEMA FIA, 2-Story, No Basement	1361	1357.90	1359.52	1360.12	1361.38
6	2972.00	$22.71	50.00%	1361.4	171.10-7-3	1346.04	Yes	Two or More Stories	Pile	No		Library	FEMA FIA, 2-Story, No Basement	1360	1357.76	1359.36	1359.96	1361.18
7	6465.00	$11.85	50.00%	1362.5	171.10-7-4	1345.76	Yes	Two or More Stories	Pile	No		Library	FEMA FIA, 2-Story, No Basement	1361	1357.68	1359.27	1359.88	1361.09
8	3422.00	$20.72	50.00%	1362	171.10-7-5	1345.59	Yes	Two or More Stories	Pile	No		Library	FEMA FIA, 2-Story, No Basement	1361	1357.62	1359.22	1359.82	1361.03
9	5460.00	$18.90	50.00%	1363.8	171.10-7-6	1345.30	Yes	Two or More Stories	Pile	No		Library	FEMA FIA, 2-Story, No Basement	1362	1357.56	1359.15	1359.75	1360.96
10	2977.00	$56.84	50.00%	1365.6	171.10-7-7	1345.13	No	Two or More Stories	Pile	No	Office One-Story	Library	Office One-Story (Default)	1363	1357.47	1359.06	1359.66	1360.87
11	2854.00	$23.83	50.00%	1366.9	171.10-7-10	1345.31	Yes	Two or More Stories	Pile	No		Library	FEMA FIA, 2-Story, No Basement	1365	1356.96	1358.45	1359.03	1360.16
12	7776.00	$13.77	50.00%	1366.6	171.10-7-9	1345.17	Yes	Two or More Stories	Pile	No		Library	FEMA FIA, 2-Story, No Basement	1365	1357.18	1358.73	1359.31	1360.48
13	3424.00	$26.29	50.00%	1366.4	171.10-7-8	1345.12	Yes	Two or More Stories	Pile	No		Library	FEMA FIA, 2-Story, No Basement	1364	1357.35	1358.93	1359.53	1360.72
14	7161.00	$13.64	50.00%	1366.6	171.10-7-11	1345.39	Yes	Two or More Stories	Pile	No		Library	FEMA FIA, 2-Story, No Basement	1365	1356.85	1358.33	1358.90	1360.01
15	4032.00	$13.12	50.00%	1369	171.10-7-12	1345.49	Yes	Two or More Stories	Pile	No		Library	FEMA FIA, 2-Story, No Basement	1367	1356.74	1358.19	1358.76	1359.86
16	6656.00	$14.71	50.00%	1368.5	171.10-6-16	1345.51	Yes	Two or More Stories	Pile	No		Library	FEMA FIA, 2-Story, No Basement	1368	1356.73	1358.19	1358.75	1359.85
17	1781.00	$27.18	50.00%	1364.9	171.10-7-13	1345.69	No	One Story	Pile	No	Industrial Light	Library	Industrial Light (Default)	1364	1356.46	1357.86	1358.41	1359.47
18	3687.00	$16.03	50.00%	1369.5	171.10-6-20	1345.77	Yes	Two or More Stories	Pile	No		Library	FEMA FIA, 2-Story, No Basement	1368	1356.36	1357.74	1358.29	1359.33
19	5112.00	$12.72	50.00%	1368.2	171.10-7-15	1345.81	Yes	Two or More Stories	Pile	No		Library	FEMA FIA, 2-Story, No Basement	1367	1356.31	1357.68	1358.22	1359.25
20	4466.00	$12.04	50.00%	1369	171.10-6-17	1345.58	Yes	Two or More Stories	Pile	No		Library	FEMA FIA, 2-Story, No Basement	1368	1356.64	1358.07	1358.63	1359.71
21	4662.00	$12.57	50.00%	1369.5	171.10-6-18	1345.68	Yes	Two or More Stories	Pile	No		Library	FEMA FIA, 2-Story, No Basement	1368	1356.50	1357.91	1358.46	1359.53
22	1994.00	$29.69	50.00%	1369.4	171.10-6-22	1345.92	Yes	Two or More Stories	Pile	No		Library	FEMA FIA, 2-Story, No Basement	1368	1356.09	1357.42	1357.94	1358.95
23	3964.00	$15.18	50.00%	1370	171.10-6-23	1345.98	Yes	Two or More Stories	Pile	No		Library	FEMA FIA, 2-Story, No Basement	1369	1355.89	1357.21	1357.75	1358.76
24	3278.00	$31.85	50.00%	1371.5	171.10-6-24	1346.04	Yes	Two or More Stories	Pile	No		Library	FEMA FIA, 2-Story, No Basement	1370	1355.74	1357.05	1357.59	1358.60
25	2483.00	$9.00	50.00%	1362	171.6-10-19	1346.63	No	One Story	Slab	No	Service Station	Library	Service Station (Default)	1361	1358.38	1360.23	1361.20	1362.53
26	8532.00	$13.91	50.00%	1362.8	171.6-10-16	1347.24	Yes	Two or More Stories	Pile	No		Library	FEMA FIA, 2-Story, No Basement	1362	1358.47	1360.31	1361.27	1362.61
27	4266.00	$27.82	50.00%	1362	171.6-10-16	1347.04	No	Two or More Stories	Slab	No	Retail-Electronics	Library	Retail-Electronics (Default)	1362	1358.45	1360.29	1361.26	1362.59
28	2220.00	$55.77	50.00%	1361.8	171.6-10-12.11	1347.47	No	Two or More Stories	Pier	No	Office One-Story	Library	Office One-Story (Default)	1361	1358.51	1360.34	1361.29	1362.63
29	896.00	$28.57	50.00%	1362.5	171.6-10-12.3	1347.32	No	Two or More Stories	Pile	No	Retail-Clothing	Library	Retail-Clothing (Default)	1362	1358.48	1360.32	1361.28	1362.61
30	4132.00	$41.99	50.00%	1361.8	171.6-10-11.1	1347.60	No	Two or More Stories	Slab	No	Non-Fast Food	Library	Non-Fast Food (Default)	1362	1358.54	1360.36	1361.31	1362.64
31	6215.00	$115.85	50.00%	1362.7	171.6-10-10	1347.59	No	Two or More Stories	Pile	No	Office One-Story	Library	Office One-Story (Default)	1361	1358.57	1360.39	1361.33	1362.66
32	6593.00	$45.57	50.00%	1360.2	171.6-10-9	1347.54	No	One Story	Pile	No	Office One-Story	Library	Office One-Story (Default)	1358	1358.64	1360.43	1361.37	1362.69
33	2653.00	$70.83	50.00%	1364	171.6-10-8	1347.64	No	Two or More Stories	Pile	No	Office One-Story	Library	Office One-Story (Default)	1364	1358.62	1360.42	1361.36	1362.68
34	3630.00	$9.34	50.00%	1363.4	171.7-9-3	1349.38	Yes	Two or More Stories	Pile	No		Library	FEMA FIA, 2-Story, No Basement	1361	1360.15	1361.85	1362.63	1363.93
35	2572.00	$11.47	50.00%	1362.9	171.7-9-4	1349.39	Yes	Two or More Stories	Pile	No		Library	FEMA FIA, 2-Story, No Basement	1361	1360.13	1361.84	1362.62	1363.92
36	2242.00	$21.90	50.00%	1362.8	171.7-9-5	1349.36	Yes	Two or More Stories	Pile	No		Library	FEMA FIA, 2-Story, No Basement	1361	1360.14	1361.84	1362.62	1363.93
37	3480.00	$12.69	50.00%	1362.3	171.7-9-6	1349.35	Yes	Two or More Stories	Pile	No		Library	FEMA FIA, 2-Story, No Basement	1361	1360.14	1361.85	1362.63	1363.93
38	2906.00	$10.17	50.00%	1362.7	171.7-9-7	1349.32	Yes	Two or More Stories	Pile	No		Library	FEMA FIA, 2-Story, No Basement	1361	1360.16	1361.87	1362.64	1363.94
39	2808.00	$21.72	50.00%	1360.5	171.7-9-8	1349.29	Yes	Two or More Stories	Pile	No		Library	FEMA FIA, 2-Story, No Basement	1360	1360.16	1361.87	1362.64	1363.94
40	4365.00	$10.58	50.00%	1361	171.7-9-10	1349.41	Yes	Two or More Stories	Pier	Yes		Library	FEMA FIA, 2-Story, With Basement	1361	1360.05	1361.76	1362.56	1363.87
41	3324.00	$9.60	50.00%	1358.5	171.7-9-11	1349.06	Yes	Two or More Stories	Pier	Yes		Library	FEMA FIA, 2-Story, With Basement	1359	1359.99	1361.71	1362.51	1363.83
42	4020.00	$15.52	50.00%	1360.5	171.7-9-12	1348.78	Yes	Two or More Stories	Pier	Yes		Library	FEMA FIA, 2-Story, With Basement	1361	1359.95	1361.68	1362.49	1363.80
43	3066.00	$19.55	50.00%	1359	171.7-9-13	1348.20	Yes	Two or More Stories	Pier	Yes		Library	FEMA FIA, 2-Story, With Basement	1359	1359.80	1361.55	1362.38	1363.70
44	4125.00	$11.27	50.00%	1358	171.7-9-14.1	1348.14	Yes	Two or More Stories	Pier	Yes		Library	FEMA FIA, 2-Story, With Basement	1358	1359.73	1361.49	1362.32	1363.64
45	4119.00	$16.23	50.00%	1363	171.7-9-15	1348.17	Yes	Two or More Stories	Pier	Yes		Library	FEMA FIA, 2-Story, With Basement	1363	1359.62	1361.39	1362.22	1363.54

Structure Name	Total size of building (sf)	Value of building (BRV) ($/sf)	Demolition Damage Threshold	First Floor Elevation	Address	Streambed Elevation (ft)	Is the building residentail?	What is the building type?	What is the foundation type?	Does a basement exist?	What is the structure's primary use?	Depth Damage Function Type	Depth Damage Function	Ground Surface 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
46	4068.00	$9.76	50.00%	1358	171.7-9-16	1348.13	Yes	Two or More Stories	Pier	Yes		Library	FEMA FIA, 2-Story, With Basement	1358	1359.50	1361.27	1362.12	1363.44
47	2880.00	$15.87	50.00%	1368.5	171.7-9-17	1348.05	Yes	Two or More Stories	Pier	No		Library	FEMA FIA, 2-Story, No Basement	1367	1359.36	1361.13	1361.99	1363.31
48	1680.00	$27.56	50.00%	1368.2	171.7-9-18	1347.95	Yes	Two or More Stories	Pier	No		Library	FEMA FIA, 2-Story, No Basement	1366	1359.20	1360.97	1361.84	1363.16
49	2776.00	$16.65	50.00%	1359	171.7-9-20	1347.64	Yes	Two or More Stories	Pile	No		Library	FEMA FIA, 2-Story, No Basement	1359	1358.67	1360.45	1361.39	1362.71
50	1610.00	$11.99	50.00%	1367	171.11-1-2.2	1347.52	Yes	Two or More Stories	Slab	No		Library	FEMA FIA, 2-Story, No Basement	1367	1358.52	1360.35	1361.30	1362.64
51	1782.00	$23.21	50.00%	1368.1	171.11-1-3	1347.16	Yes	Two or More Stories	Slab	No		Library	FEMA FIA, 2-Story, No Basement	1368	1358.47	1360.31	1361.27	1362.60
52	4716.00	$10.28	50.00%	1357	171.11-1-4	1346.62	Yes	Two or More Stories	Pile	Yes		Library	FEMA FIA, 2-Story, With Basement	1357	1358.39	1360.24	1361.21	1362.55
53	7644.00	$9.75	50.00%	1360.7	171.11-1-1	1346.81	Yes	Two or More Stories	Slab	No		Library	FEMA FIA, 2-Story, No Basement	1360	1358.33	1360.12	1361.07	1362.38
54	2274.00	$55.95	50.00%	1361.8	171.6-9-10	1347.60	No	Two or More Stories	Slab	No	Non-Fast Food	Library	Non-Fast Food (Default)	1362	1358.54	1360.36	1361.31	1362.64
55	799.00	$79.35	50.00%	1361.8	171.6-9-9	1347.65	No	Two or More Stories	Slab	No	Office One-Story	Library	Office One-Story (Default)	1362	1358.56	1360.38	1361.32	1362.65
56	4680.00	$27.24	50.00%	1361.8	171.6-9-11	1347.58	No	Two or More Stories	Slab	No	Retail-Furniture	Library	Retail-Furniture (Default)	1362	1358.53	1360.36	1361.31	1362.64
57	4680.00	$27.24	50.00%	1361.8	171.6-9-11	1347.46	No	Two or More Stories	Slab	No	Non-Fast Food	Library	Non-Fast Food (Default)	1362	1358.51	1360.34	1361.29	1362.63
58	31755.00	$78.73	50.00%	1360.2	171.7-4-2	1350.10	No	Two or More Stories	Slab	No	Service Station	Library	Service Station (Default)	1360	1361.88	1363.54	1364.23	1365.48
59	2828.00	$14.07	50.00%	1362.1	171.7-6-7	1349.78	Yes	Two or More Stories	Pile	No		Library	FEMA FIA, 2-Story, No Basement	1361	1361.66	1363.35	1364.05	1365.31
60	2715.00	$7.00	50.00%	1361.9	171.7-6-8	1349.95	Yes	Two or More Stories	Pile	No		Library	FEMA FIA, 2-Story, No Basement	1360	1361.80	1363.48	1364.17	1365.42
61	3399.00	$59.14	50.00%	1364.2	171.7-5-1	1351.27	No	One Story	Slab	No	Service Station	Library	Service Station (Default)	1364	1362.32	1363.93	1364.59	1365.82
62	2168.00	$15.31	50.00%	1364.8	171.7-5-2	1350.78	Yes	Two or More Stories	Pile	No		Library	FEMA FIA, 2-Story, No Basement	1364	1362.14	1363.77	1364.44	1365.69
63	8660.00	$14.69	50.00%	1364.3	171.7-6-12	1351.63	No	One Story	Slab	No	Service Station	Library	Service Station (Default)	1364	1362.50	1364.08	1364.73	1365.96
64	2709.00	$14.87	50.00%	1366	171.7-6-11	1350.87	Yes	Two or More Stories	Pile	No		Library	FEMA FIA, 2-Story, No Basement	1365	1362.19	1363.82	1364.48	1365.72
65	5493.00	$6.37	50.00%	1363.5	171.7-6-10	1350.47	Yes	Two or More Stories	Pile	No		Library	FEMA FIA, 2-Story, No Basement	1362	1362.05	1363.69	1364.37	1365.61
66	3993.00	$11.05	50.00%	1362.9	171.7-6-9	1350.19	Yes	Two or More Stories	Pile	No		Library	FEMA FIA, 2-Story, No Basement	1361	1361.93	1363.59	1364.27	1365.52
67	9329.00	$30.28	50.00%	1363.7	171.7-6-1	1352.17	No	Two or More Stories	Slab	No	Non-Fast Food	Library	Non-Fast Food (Default)	1363	1362.75	1364.29	1364.92	1366.14
68	95200.00	$37.27	50.00%	1354.3	171.14-1-8.2	1342.99	No	One Story	Slab	No	Medical Office	Library	Medical Office (Default)	1354	1351.97	1353.90	1354.70	1355.61
69	1691.00	$3.43	50.00%	1353	171.14-1-5	1344.48	No	One Story	Slab	No	Office One-Story	Library	Office One-Story (Default)	1353	1353.39	1355.01	1355.71	1356.72
70	5191.00	$34.15	50.00%	1353.6	171.14-1-4	1344.93	No	One Story	Slab	No	Service Station	Library	Service Station (Default)	1354	1353.84	1355.37	1356.03	1357.07
71	4851.00	$27.71	50.00%	1359	171.10-7-28	1346.06	No	One Story	Slab	No	Service Station	Library	Service Station (Default)	1359	1355.05	1356.37	1356.93	1357.96
72	8283.00	$17.14	50.00%	1357.5	171.10-7-27	1346.02	No	One Story	Slab	No	Office One-Story	Library	Office One-Story (Default)	1357	1355.00	1356.32	1356.89	1357.93
73	7134.00	$8.41	50.00%	1356	171.14-1-3	1345.29	No	One Story	Pile	No	Non-Fast Food	Library	Non-Fast Food (Default)	1355	1354.30	1355.74	1356.37	1357.42
74	4151.00	$28.85	50.00%	1361	171.10-7-18	1346.13	No	One Story	Pile	No	Retail-Clothing	Library	Retail-Clothing (Default)	1359	1355.34	1356.63	1357.18	1358.20
75	2056.00	$62.30	50.00%	1361.4	171.10-7-17	1346.10	No	One Story	Slab	No	Service Station	Library	Service Station (Default)	1361	1355.55	1356.85	1357.39	1358.41
76	3842.00	$12.94	50.00%	1356.5	171.10-7-23	1346.08	No	One Story	Slab	No	Service Station	Library	Service Station (Default)	1357	1355.58	1356.89	1357.43	1358.44
77	4082.00	$17.40	50.00%	1362.3	171.10-7-19	1345.75	No	Two or More Stories	Slab	No	Office One-Story	Library	Office One-Story (Default)	1362	1356.37	1357.75	1358.29	1359.34
78	11309.00	$0.00	50.00%	1553.5	171.18-5-2.21	1338.44	No	Two or More Stories	Slab	No	Office One-Story	Library	Office One-Story (Default)	1553	1347.54	1348.59	1348.96	1350.72
79	24826.00	$0.00	50.00%	1351.5	171.18-5-2.21	1338.37	Yes	Two or More Stories	Pile	No		Library	FEMA FIA, 2-Story, No Basement	1350	1347.49	1348.55	1348.93	1350.67
80	8815.00	$34.49	50.00%	1362.5	171.7-4-3	1349.40	No	One Story	Slab	No	Service Station	Library	Service Station (Default)	1363	1360.44	1362.13	1362.84	1364.11
81	4813.00	$63.16	50.00%	1362	171.7-4-3	1349.53	No	One Story	Slab	No	Industrial Light	Library	Industrial Light (Default)	1362	1360.54	1362.23	1362.94	1364.21
82	1330.00	$7.44	50.00%	1360.7	171.7-6-4	1349.24	Yes	Two or More Stories	Slab	No		Library	FEMA FIA, 2-Story, No Basement	1359	1360.40	1362.10	1362.81	1364.08
83	2197.00	$1,137.92	50.00%	1360.5	171.7-4-2	1349.46	No	One Story	Slab	No	Service Station	Library	Service Station (Default)	1361	1361.06	1362.74	1363.44	1364.71
84	2152.00	$23.14	50.00%	1361.4	171.10-7-2	1346.80	Yes	Two or More Stories	Pile	No		Library	FEMA FIA, 2-Story, No Basement	1360	1357.95	1359.57	1360.18	1361.44
85	3297.00	$14.68	50.00%	1367.5	171.10-7-13	1345.62	Yes	Two or More Stories	Pile	No		Library	FEMA FIA, 2-Story, No Basement	1367	1356.57	1357.99	1358.54	1359.62
86	2262.00	$23.47	50.00%	1362.8	171.6-10-14	1347.21	Yes	Two or More Stories	Pile	No		Library	FEMA FIA, 2-Story, No Basement	1362	1358.47	1360.31	1361.27	1362.61
87	1197.00	$50.38	50.00%	1362	171.6-10-12.2	1347.43	No	Two or More Stories	Slab	No	Non-Fast Food	Library	Non-Fast Food (Default)	1362	1358.50	1360.33	1361.29	1362.62
88	4163.00	$27.38	50.00%	1360.7	171.6-10-11.2	1347.56	No	One Story	Slab	No	Office One-Story	Library	Office One-Story (Default)	1360	1358.54	1360.36	1361.31	1362.64
89	845.00	$35.38	50.00%	1362.3	171.6-9-7	1347.69	No	Two or More Stories	Pile	No	Office One-Story	Library	Office One-Story (Default)	1362	1358.58	1360.39	1361.34	1362.67
90	845.00	$35.38	50.00%	1362.3	171.6-9-7	1347.67	No	Two or More Stories	Pile	No	Office One-Story	Library	Office One-Story (Default)	1362	1358.57	1360.38	1361.33	1362.66
91	1223.00	$42.52	50.00%	1362.3	171.6-9-6	1347.70	No	Two or More Stories	Pile	No	Office One-Story	Library	Office One-Story (Default)	1362	1358.60	1360.40	1361.34	1362.67
92	2267.00	$32.77	50.00%	1362.1	171.6-9-12	1347.38	No	Two or More Stories	Pile	No	Office One-Story	Library	Office One-Story (Default)	1362	1358.49	1360.33	1361.28	1362.62
93	3422.00	$13.85	50.00%	1362.3	171.7-9-9	1349.31	Yes	Two or More Stories	Pile	No		Library	FEMA FIA, 2-Story, No Basement	1362	1360.15	1361.85	1362.63	1363.93
94	4390.00	$68.43	50.00%	1358.2	171.6-10-9	1347.59	No	One Story	Slab	No	Service Station	Library	Service Station (Default)	1358	1358.65	1360.44	1361.38	1362.70
95	2262.00	$30.95	50.00%	1363.7	171.6-10-21.1	1346.94	No	One Story	Pile	No	Grocery	Library	Grocery (Default)	1363	1358.23	1359.95	1360.75	1362.05
96	2913.00	$18.23	50.00%	1369.7	171.10-6-21	1345.81	Yes	Two or More Stories	Pile	No		Library	FEMA FIA, 2-Story, No Basement	1368	1356.27	1357.64	1358.18	1359.21

Structure Name	What is the foundation type?	Total size of building (sf)	First Floor Elevation	Address	Does a basement exist?	Return Interval 10 Elevation Before Mitigation	Return Interval 50 Elevation Before Mitigation	Return Interval 100 Elevation Before Mitigation	Return Interval 500 Elevation Before Mitigation	Annual Flood Costs	Total Flood Costs Over Design Life (68 Years)	Lifting House ($15/SF)	Building New Foundation ($20/SF)	Engineering/Permitting ($5/SF)	Total Cost	BCR
73	Pile	7134.00	1356	171.14-1-3	No	1354.30	1355.74	1356.37	1357.42	$2,747	$186,796	$107,010	$142,680	$35,670	$285,360	0.65
32	Pile	6593.00	1360.2	171.6-10-9	No	1358.64	1360.43	1361.37	1362.69	$868	$59,024	$98,895	$131,860	$32,965	$263,720	0.22
6	Pile	2972.00	1361.4	171.10-7-3	No	1357.76	1359.36	1359.96	1361.18	$193	$13,124	$44,580	$59,440	$14,860	$118,880	0.11
41	Pier	3324.00	1358.5	171.7-9-11	Yes	1359.99	1361.71	1362.51	1363.83	$215	$14,620	$49,860	$66,480	$16,620	$132,960	0.11
43	Pier	3066.00	1359	171.7-9-13	Yes	1359.80	1361.55	1362.38	1363.70	$166	$11,288	$45,990	$61,320	$15,330	$122,640	0.09
33	Pile	2653.00	1364	171.6-10-8	No	1358.62	1360.42	1361.36	1362.68	$130	$8,840	$39,795	$53,060	$13,265	$106,120	0.08
1	Pier	2716.00	1362.1	171.10-7-1	No	1358.05	1359.67	1360.29	1361.57	$123	$8,364	$40,740	$54,320	$13,580	$108,640	0.08
8	Pile	3422.00	1362	171.10-7-5	No	1357.62	1359.22	1359.82	1361.03	$131	$8,908	$51,330	$68,440	$17,110	$136,880	0.07
28	Pier	2220.00	1361.8	171.6-10-12.11	No	1358.51	1360.34	1361.29	1362.63	$81	$5,508	$33,300	$44,400	$11,100	$88,800	0.06
3	Pile	4200.00	1361.7	171.10-6-6	No	1357.88	1359.49	1360.09	1361.34	$144	$9,792	$63,000	$84,000	$21,000	$168,000	0.06
86	Pile	2262.00	1362.8	171.6-10-14	No	1358.47	1360.31	1361.27	1362.61	$76	$5,168	$33,930	$45,240	$11,310	$90,480	0.06
95	Pile	2262.00	1363.7	171.6-10-21.1	No	1358.23	1359.95	1360.75	1362.05	$64	$4,352	$33,930	$45,240	$11,310	$90,480	0.05
44	Pier	4125.00	1358	171.7-9-14.1	Yes	1359.73	1361.49	1362.32	1363.64	$116	$7,888	$61,875	$82,500	$20,625	$165,000	0.05
49	Pile	2776.00	1359	171.7-9-20	No	1358.67	1360.45	1361.39	1362.71	$78	$5,304	$41,640	$55,520	$13,880	$111,040	0.05
40	Pier	4365.00	1361	171.7-9-10	Yes	1360.05	1361.76	1362.56	1363.87	$122	$8,296	$65,475	$87,300	$21,825	$174,600	0.05
26	Pile	8532.00	1362.8	171.6-10-16	No	1358.47	1360.31	1361.27	1362.61	$166	$11,288	$127,980	$170,640	$42,660	$341,280	0.03
66	Pile	3993.00	1362.9	171.7-6-9	No	1361.93	1363.59	1364.27	1365.52	$75	$5,100	$59,895	$79,860	$19,965	$159,720	0.03
5	Pile	3884.00	1362.5	171.10-6-5	No	1357.90	1359.52	1360.12	1361.38	$69	$4,692	$58,260	$77,680	$19,420	$155,360	0.03
74	Pile	4151.00	1361	171.10-7-18	No	1355.34	1356.63	1357.18	1358.20	$73	$4,964	$62,265	$83,020	$20,755	$166,040	0.03
59	Pile	2828.00	1362.1	171.7-6-7	No	1361.66	1363.35	1364.05	1365.31	$48	$3,264	$42,420	$56,560	$14,140	$113,120	0.03
52	Pile	4716.00	1357	171.11-1-4	Yes	1358.39	1360.24	1361.21	1362.55	$67	$4,556	$70,740	$94,320	$23,580	$188,640	0.02
39	Pile	2808.00	1360.5	171.7-9-8	No	1360.16	1361.87	1362.64	1363.94	$39	$2,652	$42,120	$56,160	$14,040	$112,320	0.02
45	Pier	4119.00	1363	171.7-9-15	Yes	1359.62	1361.39	1362.22	1363.54	$50	$3,400	$61,785	$82,380	$20,595	$164,760	0.02
92	Pile	2267.00	1362.1	171.6-9-12	No	1358.49	1360.33	1361.28	1362.62	$26	$1,768	$34,005	$45,340	$11,335	$90,680	0.02
31	Pile	6215.00	1362.7	171.6-10-10	No	1358.57	1360.39	1361.33	1362.66	$62	$4,216	$93,225	$124,300	$31,075	$248,600	0.02
91	Pile	1223.00	1362.3	171.6-9-6	No	1358.60	1360.40	1361.34	1362.67	$11	$748	$18,345	$24,460	$6,115	$48,920	0.02
7	Pile	6465.00	1362.5	171.10-7-4	No	1357.68	1359.27	1359.88	1361.09	$58	$3,944	$96,975	$129,300	$32,325	$258,600	0.02
89	Pile	845.00	1362.3	171.6-9-7	No	1358.58	1360.39	1361.34	1362.67	$7	$476	$12,675	$16,900	$4,225	$33,800	0.01
90	Pile	845.00	1362.3	171.6-9-7	No	1358.57	1360.38	1361.33	1362.66	$6	$408	$12,675	$16,900	$4,225	$33,800	0.01
37	Pile	3480.00	1362.3	171.7-9-6	No	1360.14	1361.85	1362.63	1363.93	$22	$1,496	$52,200	$69,600	$17,400	$139,200	0.01
36	Pile	2242.00	1362.8	171.7-9-5	No	1360.14	1361.84	1362.62	1363.93	$13	$884	$33,630	$44,840	$11,210	$89,680	0.01
46	Pier	4068.00	1358	171.7-9-16	Yes	1359.50	1361.27	1362.12	1363.44	$23	$1,564	$61,020	$81,360	$20,340	$162,720	0.01
84	Pile	2152.00	1361.4	171.10-7-2	No	1357.95	1359.57	1360.18	1361.44	$9	$612	$32,280	$43,040	$10,760	$86,080	0.01
93	Pile	3422.00	1362.3	171.7-9-9	No	1360.15	1361.85	1362.63	1363.93	$14	$952	$51,330	$68,440	$17,110	$136,880	0.01
65	Pile	5493.00	1363.5	171.7-6-10	No	1362.05	1363.69	1364.37	1365.61	$20	$1,360	$82,395	$109,860	$27,465	$219,720	0.01
29	Pile	896.00	1362.5	171.6-10-12.3	No	1358.48	1360.32	1361.28	1362.61	$3	$204	$13,440	$17,920	$4,480	$35,840	0.01
64	Pile	2709.00	1366	171.7-6-11	No	1362.19	1363.82	1364.48	1365.72	$9	$612	$40,635	$54,180	$13,545	$108,360	0.01
9	Pile	5460.00	1363.8	171.10-7-6	No	1357.56	1359.15	1359.75	1360.96	$15	$1,020	$81,900	$109,200	$27,300	$218,400	0.00
35	Pile	2572.00	1362.9	171.7-9-4	No	1360.13	1361.84	1362.62	1363.92	$7	$476	$38,580	$51,440	$12,860	$102,880	0.00
38	Pile	2906.00	1362.7	171.7-9-7	No	1360.16	1361.87	1362.64	1363.94	$7	$476	$43,590	$58,120	$14,530	$116,240	0.00
60	Pile	2715.00	1361.9	171.7-6-8	No	1361.80	1363.48	1364.17	1365.42	$5	$340	$40,725	$54,300	$13,575	$108,600	0.00
4	Pile	6716.00	1364	171.10-6-7	No	1357.76	1359.36	1359.96	1361.19	$11	$748	$100,740	$134,320	$33,580	$268,640	0.00
34	Pile	3630.00	1363.4	171.7-9-3	No	1360.15	1361.85	1362.63	1363.93	$5	$340	$54,450	$72,600	$18,150	$145,200	0.00
10	Pile	2977.00	1365.6	171.10-7-7	No	1357.47	1359.06	1359.66	1360.87	$4	$272	$44,655	$59,540	$14,885	$119,080	0.00
62	Pile	2168.00	1364.8	171.7-5-2	No	1362.14	1363.77	1364.44	1365.69	$2	$136	$32,520	$43,360	$10,840	$86,720	0.00
42	Pier	4020.00	1360.5	171.7-9-12	Yes	1359.95	1361.68	1362.49	1363.80	$3	$204	$60,300	$80,400	$20,100	$160,800	0.00
47	Pier	2880.00	1368.5	171.7-9-17	No	1359.36	1361.13	1361.99	1363.31	$1	$68	$43,200	$57,600	$14,400	$115,200	0.00
Totals												$420,512			$6,699,480	0.062767857

Title:	Plan 6 Benefit Summary												
Date:	11/10/2017												
By:	GDF												
Building ID	**FFE**	**Flood Costs**	**Flood Benefit**	Building_1	POINT_X	POINT_Y	500 YR Existing	100 YR Existing	50 YR Existing	10 YR Existing	500 YR Plan 6	100 YR Plan 6	50 YR Plan 6	10 YR Plan 6
0	1362.5	845360	2549	grocery	379206.46	1254186.2	1361.74	1360.4399	1359.78	1358.13	1361.11	1359.87	1359.29	1357.78
1	1362.1	1	1014	prof	379251.81	1254068	1361.5699	1360.29	1359.67	1358.05	1360.92	1359.73	1359.16	1357.6801
2	1361.5	1	1317	retailauto	379307.6	1254291.8	1362.4301	1361.11	1360.16	1358.35	1361.88	1360.35	1359.67	1358.01
3	1361.7	1	1260	res	379124.42	1254048.1	1361.34	1360.09	1359.49	1357.88	1360.65	1359.49	1358.9399	1357.49
4	1364	1	61	res	379071.17	1253998.1	1361.1899	1359.96	1359.36	1357.76	1360.47	1359.33	1358.78	1357.35
5	1362.5	1	474	res	379122.46	1254069.5	1361.38	1360.12	1359.52	1357.9	1360.7	1359.53	1358.97	1357.52
6	1361.4	1	1711	res	379157.08	1253918.5	1361.1801	1359.96	1359.36	1357.76	1360.47	1359.3199	1358.78	1357.35
7	1362.5	1	414	res	379107.7	1253884.7	1361.09	1359.88	1359.27	1357.6801	1360.35	1359.21	1358.67	1357.25
8	1362	1	705	res	379087.12	1253841.9	1361.03	1359.8199	1359.22	1357.62	1360.28	1359.14	1358.6	1357.1801
9	1363.8	1	77	res	379002.86	1253768.1	1360.96	1359.75	1359.15	1357.5601	1360.1801	1359.05	1358.51	1357.1
10	1365.6	1	14	prof	378889.66	1253669.1	1360.87	1359.66	1359.0601	1357.47	1360.0601	1358.9301	1358.39	1356.99
11	1366.9	1	0	res	378678.24	1253451.1	1360.16	1359.03	1358.45	1356.96	1359.46	1358.37	1357.85	1356.51
12	1366.6	1	0	res	378757.75	1253537.6	1360.48	1359.3101	1358.73	1357.1801	1359.72	1358.61	1358.09	1356.72
13	1366.4	1	1	res	378830.14	1253597	1360.72	1359.53	1358.9301	1357.35	1359.92	1358.8	1358.26	1356.87
14	1366.6	1	0	res	378639.82	1253414.9	1360.01	1358.9	1358.33	1356.85	1359.34	1358.25	1357.74	1356.41
15	1369	1	0	res	378591.2	1253375.5	1359.86	1358.76	1358.1899	1356.74	1359.21	1358.13	1357.62	1356.3101
16	1368.5	1	0	res	378466.88	1253411.5	1359.85	1358.75	1358.1899	1356.73	1359.2	1358.13	1357.62	1356.3101
17	1364.9	1	0	lightman	378560.19	1253254.2	1359.47	1358.41	1357.86	1356.46	1358.89	1357.84	1357.34	1356.0601
18	1369.5	1	0	res	378317.65	1253280.1	1359.33	1358.29	1357.74	1356.36	1358.78	1357.73	1357.23	1355.97
19	1368.2	1	0	res	378422.14	1253218.6	1359.25	1358.22	1357.6801	1356.3101	1358.71	1357.67	1357.1801	1355.92
20	1369	1	0	res	378415.15	1253380.1	1359.71	1358.63	1358.0699	1356.64	1359.09	1358.02	1357.52	1356.22
21	1369.5	1	0	res	378366.34	1253331.3	1359.53	1358.46	1357.91	1356.5	1358.9399	1357.88	1357.38	1356.1
22	1369.4	1	0	res	378225.35	1253173.9	1358.95	1357.9399	1357.42	1356.09	1358.46	1357.4301	1356.95	1355.72
23	1370	1	0	res	378164.56	1253115.1	1358.76	1357.75	1357.21	1355.89	1358.3101	1357.27	1356.79	1355.5601
24	1371.5	1	0	res	378116.55	1253069	1358.6	1357.59	1357.05	1355.74	1358.1801	1357.14	1356.67	1355.4399
25	1362	1	275	garage	379244.75	1254447.2	1362.53	1361.2	1360.23	1358.38	1362	1360.4301	1359.74	1358.05
26	1362.8	1	2629	res	379268.47	1254647.3	1362.61	1361.27	1360.3101	1358.47	1362.09	1360.53	1359.84	1358.15
27	1362	1	639	Hardware	379174.81	1254688.5	1362.59	1361.26	1360.29	1358.45	1362.0699	1360.51	1359.8101	1358.13
28	1361.8	1	1775	prof	379326.9	1254674.6	1362.63	1361.29	1360.34	1358.51	1362.11	1360.5601	1359.87	1358.1899
29	1362.5	1	801	Hairdresser	379213.54	1254732.7	1362.61	1361.28	1360.3199	1358.48	1362.1	1360.54	1359.85	1358.16
30	1361.8	1	1887	restaurantnon	379282.65	1254802.4	1362.64	1361.3101	1360.36	1358.54	1362.13	1360.59	1359.9	1358.23
31	1362.7	1	24600	prof	379443.21	1254732.7	1362.66	1361.33	1360.39	1358.5699	1362.16	1360.62	1359.9301	1358.27
32	1360.2	1	39481	tele	379621.89	1254664.8	1362.6899	1361.37	1360.4301	1358.64	1362.1899	1360.67	1359.99	1358.35
33	1364	1	2067	prof	379445.89	1254855.6	1362.6801	1361.36	1360.42	1358.62	1362.1899	1360.66	1359.98	1358.33
34	1363.4	1	210	res	380231.24	1255558.7	1363.9301	1362.63	1361.85	1360.15	1363.64	1362.26	1361.63	1360.02
35	1362.9	1	420	res	380252.96	1255526.7	1363.92	1362.62	1361.84	1360.13	1363.63	1362.24	1361.61	1360
36	1362.8	1	817	res	380293.83	1255483	1363.9301	1362.62	1361.84	1360.14	1363.63	1362.25	1361.62	1360.01
37	1362.3	1	1393	res	380322.66	1255458.2	1363.9301	1362.63	1361.85	1360.14	1363.63	1362.25	1361.63	1360.01
38	1362.7	1	576	res	380344.24	1255441.6	1363.9399	1362.64	1361.87	1360.16	1363.64	1362.27	1361.65	1360.03
39	1360.5	1	12543	res	380389.67	1255391.1	1363.9399	1362.64	1361.87	1360.16	1363.65	1362.27	1361.65	1360.03
40	1361	1	21794	res	380543.34	1255110.3	1363.87	1362.5601	1361.76	1360.05	1363.5699	1362.16	1361.53	1359.91
41	1358.5	1	67685	res	380482.81	1255053.4	1363.83	1362.51	1361.71	1359.99	1363.52	1362.11	1361.47	1359.84
42	1360.5	1	39474	res	380448.59	1255013.4	1363.8	1362.49	1361.6801	1359.95	1363.49	1362.0699	1361.4399	1359.8
43	1359	1	86879	res	380328.02	1254898.7	1363.7	1362.38	1361.55	1359.8	1363.37	1361.9399	1361.3	1359.64
44	1358	1	105282	res	380265.43	1254832.1	1363.64	1362.3199	1361.49	1359.73	1363.3101	1361.88	1361.23	1359.5601
45	1363	1	3255	res	380156.25	1254723.9	1363.54	1362.22	1361.39	1359.62	1363.1899	1361.76	1361.11	1359.4399
46	1358	1	82308	res	380120.92	1254685.1	1363.4399	1362.12	1361.27	1359.5	1363.0699	1361.63	1360.98	1359.3101
47	1368.5	1	4	res	380086.03	1254652.5	1363.3101	1361.99	1361.13	1359.36	1362.9301	1361.47	1360.8199	1359.16
48	1368.2	1	5	res	380042.47	1254613.9	1363.16	1361.84	1360.97	1359.2	1362.75	1361.28	1360.62	1358.98
49	1359	1	9957	res	379885.13	1254432	1362.71	1361.39	1360.45	1358.67	1362.22	1360.6899	1360.02	1358.39
50	1367	1	7	res	379767.84	1254256.4	1362.64	1361.3	1360.35	1358.52	1362.13	1360.58	1359.89	1358.21
51	1368.1	1	4	res	379714.05	1254163.1	1362.6	1361.27	1360.3101	1358.47	1362.08	1360.52	1359.83	1358.15
52	1357	1	92364	res	379645.83	1254011.2	1362.55	1361.21	1360.24	1358.39	1362.02	1360.45	1359.75	1358.0601
53	1360.7	1	2127	res	379494.81	1254025.3	1362.38	1361.0699	1360.12	1358.33	1361.8199	1360.3	1359.63	1357.99
54	1361.8	1	1360	restaurantnon	379231.72	1254851.3	1362.64	1361.3101	1360.36	1358.54	1362.13	1360.59	1359.9	1358.23
55	1361.8	1	949	prof	379261.38	1254881.1	1362.65	1361.3199	1360.38	1358.5601	1362.15	1360.61	1359.92	1358.26
56	1361.8	1	1674	retailfurniture	379225.46	1254841.7	1362.64	1361.3101	1360.36	1358.53	1362.13	1360.58	1359.9	1358.22
57	1361.8	1	1379	restaurantnon	379193.57	1254808.8	1362.63	1361.29	1360.34	1358.51	1362.11	1360.5601	1359.87	1358.1899
58	1360.2	1	3810091	garage\office	381167.09	1256078.1	1365.48	1364.23	1363.54	1361.88	1365.34	1364.0699	1363.45	1361.8199
59	1362.1	1	7619	res	381127.12	1255955.8	1365.3101	1364.05	1363.35	1361.66	1365.15	1363.88	1363.25	1361.6
60	1361.9	1	5107	res	381185.04	1255997.7	1365.42	1364.17	1363.48	1361.8	1365.27	1364.01	1363.38	1361.74
61	1364.2	1	7983	garage	381253.8	1256297.1	1365.8199	1364.59	1363.9301	1362.3199	1365.7	1364.45	1363.85	1362.28
62	1364.8	1	442	res	381246.89	1256192.2	1365.6899	1364.4399	1363.77	1362.14	1365.55	1364.3	1363.6899	1362.1
63	1364.3	1	6976	county garage	381401.71	1256248.5	1365.96	1364.73	1364.08	1362.5	1365.84	1364.61	1364.01	1362.46
64	1366	1	317	res	381319.77	1256148	1365.72	1364.48	1363.8199	1362.1899	1365.59	1364.34	1363.73	1362.15
65	1363.5	1	2240	res	381271.18	1256090.9	1365.61	1364.37	1363.6899	1362.05	1365.47	1364.22	1363.6	1362
66	1362.9	1	4567	res	381219.31	1256053.3	1365.52	1364.27	1363.59	1361.9301	1365.38	1364.11	1363.49	1361.87
67	1363.7	1	59301	bar	381532.89	1256278.7	1366.14	1364.92	1364.29	1362.75	1366.03	1364.8101	1364.22	1362.72
68	1354.3	1	137710	pharmacy	377966.21	1251178.9	1355.61	1354.7	1353.9	1351.97	1354.1899	1353.0601	1352.55	1351.21
69	1353	1	10986	prof	378308.2	1251951.9	1356.72	1355.71	1355.01	1353.39	1356.04	1354.95	1354.45	1353.16
70	1353.6	1	94970	ServiceStation	378336.02	1252125.2	1357.0699	1356.03	1355.37	1353.84	1356.58	1355.49	1354.99	1353.71
71	1359	1	1203	garage	378488.16	1252687.2	1357.96	1356.9301	1356.37	1355.05	1357.64	1356.59	1356.11	1354.89
72	1357.5	1	2396	prof	378598.56	1252633.7	1357.9301	1356.89	1356.3199	1355	1357.6	1356.55	1356.0699	1354.84
73	1356	1	4404	restaurantnon	378555.18	1252256.3	1357.42	1356.37	1355.74	1354.3	1357.09	1356	1355.51	1354.24
74	1361	1	68	feedstore	378578.47	1252802.2	1358.2	1357.1801	1356.63	1355.34	1357.86	1356.8199	1356.34	1355.13
75	1361.4	1	47	carwash	378507.26	1252895.2	1358.41	1357.39	1356.85	1355.55	1358.03	1356.99	1356.51	1355.29
76	1356.5	1	6666	garage	378715.18	1252854	1358.4399	1357.4301	1356.89	1355.58	1358.0601	1357.02	1356.54	1355.3199
77	1362.3	1	53	prof	378679.99	1253178	1359.34	1358.29	1357.75	1356.37	1358.78	1357.73	1357.24	1355.97
78	1553.5	1	0	res	377536.88	1250402.9	1350.72	1348.96	1348.59	1347.54	1350.11	1348.6801	1348.21	1347
79	1351.5	1	0	prof	377586.19	1250332.4	1350.67	1348.9301	1348.55	1347.49	1350.1	1348.67	1348.2	1346.98
80	1362.5	1	11456	garage	380445.43	1255627.6	1364.11	1362.84	1362.13	1360.4399	1363.84	1362.54	1361.9399	1360.3199
81	1362	1	26433	lightman	380558.26	1255604	1364.21	1362.9399	1362.23	1360.54	1363.9399	1362.64	1362.04	1360.4301
82	1360.7	1	2335	res	380552.34	1255440.6	1364.08	1362.8101	1362.1	1360.4	1363.8	1362.5	1361.9	1360.29
83	1360.5	1	1509111	garage	380870.36	1255780	1364.71	1363.4399	1362.74	1361.0601	1364.5	1363.2	1362.59	1360.97
84	1361.4	1	1434	res	379222.7	1254021.8	1361.4399	1360.1801	1359.5699	1357.95	1360.77	1359.59	1359.04	1357.5699
85	1367.5	1	0	res	378527.43	1253311.9	1359.62	1358.54	1357.99	1356.5699	1359.01	1357.95	1357.45	1356.15
86	1362.8	1	1200	res	379197.95	1254712.2	1362.61	1361.27	1360.3101	1358.47	1362.09	1360.53	1359.83	1358.15
87	1362	1	379	restaurantnon	379234.49	1254752.7	1362.62	1361.29	1360.33	1358.5	1362.11	1360.5601	1359.87	1358.1899
88	1360.7	1	8236	prof	379409.16	1254674.6	1362.64	1361.3101	1360.36	1358.54	1362.13	1360.59	1359.9	1358.23
89	1362.3	1	624	prof	379290.05	1254910.4	1362.67	1361.34	1360.39	1358.58	1362.16	1360.63	1359.9399	1358.29
90	1362.3	1	641	prof	379274.03	1254893.9	1362.66	1361.33	1360.38	1358.5699	1362.15	1360.61	1359.9301	1358.27
91	1362.3	1	1028	prof	379309.11	1254924.7	1362.67	1361.34	1360.4	1358.6	1362.17	1360.64	1359.95	1358.3
92	1362.1	1	956	prof	379175.41	1254791	1362.62	1361.28	1360.33	1358.49	1362.1	1360.55	1359.86	1358.1801
93	1362.3	1	1500	res	380412.6	1255359.8	1363.9301	1362.63	1361.85	1360.15	1363.64	1362.26	1361.63	1360.02
94	1358.2	1	189860	garage	379700.14	1254621.8	1362.7	1361.38	1360.4399	1358.65	1362.2	1360.6801	1360	1358.37
95	1363.7	1	553	grocery	379175.03	1254309	1362.05	1360.75	1359.95	1358.23	1361.45	1360.08	1359.46	1357.88
96	1369.7	1	0	res	378288.25	1253247.5	1359.21	1358.1801	1357.64	1356.27	1358.6801	1357.63	1357.14	1355.89

Title: Plan 7 Benefit Summary

Date: 11/10/2017

By: GDF

Building ID	FFE	Flood Costs	Flood Benefit	Building_1	POINT_X	POINT_Y	500 YR Existing	100 YR Existing	50 YR Existing	10 YR Existing	500 YR Plan 7	100 YR Plan 7	50 YR Plan 7	10 YR Plan 7
0	1362.5	1465844	2549	grocery	379206.46	1254186.2	1361.74	1360.4399	1359.78	1358.13	1361.11	1359.87	1359.29	1357.78
1	1362.1	1	1014	prof	379251.81	1254068	1361.5699	1360.29	1359.67	1358.05	1360.92	1359.73	1359.16	1357.6801
2	1361.5	1	1317	retailauto	379307.6	1254291.8	1362.4301	1361.11	1360.16	1358.35	1361.88	1360.35	1359.67	1358.01
3	1361.7	1	1260	res	379124.42	1254048.1	1361.34	1360.09	1359.49	1357.88	1360.65	1359.49	1358.9399	1357.49
4	1364	1	61	res	379071.17	1253998.1	1361.1899	1359.96	1359.36	1357.76	1360.47	1359.33	1358.78	1357.35
5	1362.5	1	474	res	379122.46	1254069.5	1361.38	1360.12	1359.52	1357.9	1360.7	1359.53	1358.97	1357.52
6	1361.4	1	1711	res	379157.08	1253918.5	1361.1801	1359.96	1359.36	1357.76	1360.47	1359.3199	1358.78	1357.35
7	1362.5	1	414	res	379107.7	1253884.7	1361.09	1359.88	1359.27	1357.6801	1360.35	1359.21	1358.67	1357.25
8	1362	1	705	res	379087.12	1253841.9	1361.03	1359.8199	1359.22	1357.62	1360.28	1359.14	1358.6	1357.1801
9	1363.8	1	77	res	379002.86	1253768.1	1360.96	1359.75	1359.15	1357.5601	1360.1801	1359.05	1358.51	1357.1
10	1365.6	1	14	prof	378889.66	1253669.1	1360.87	1359.66	1359.0601	1357.47	1360.0601	1358.9301	1358.39	1356.99
11	1366.9	1	0	res	378678.24	1253451.1	1360.16	1359.03	1358.45	1356.96	1359.46	1358.37	1357.85	1356.51
12	1366.6	1	0	res	378757.75	1253537.6	1360.48	1359.3101	1358.73	1357.1801	1359.72	1358.61	1358.09	1356.72
13	1366.4	1	1	res	378830.14	1253597	1360.72	1359.53	1358.9301	1357.35	1359.92	1358.8	1358.26	1356.87
14	1366.6	1	0	res	378639.82	1253414.9	1360.01	1358.9	1358.33	1356.85	1359.34	1358.25	1357.74	1356.41
15	1369	1	0	res	378591.2	1253375.5	1359.86	1358.76	1358.1899	1356.74	1359.21	1358.13	1357.62	1356.3101
16	1368.5	1	0	res	378466.88	1253411.5	1359.85	1358.75	1358.1899	1356.73	1359.2	1358.13	1357.62	1356.3101
17	1364.9	1	0	lightman	378560.19	1253254.2	1359.47	1358.41	1357.86	1356.46	1358.89	1357.84	1357.34	1356.0601
18	1369.5	1	0	res	378317.65	1253280.1	1359.33	1358.29	1357.74	1356.36	1358.78	1357.73	1357.23	1355.97
19	1368.2	1	0	res	378422.14	1253218.6	1359.25	1358.22	1357.6801	1356.3101	1358.71	1357.67	1357.1801	1355.92
20	1369	1	0	res	378415.15	1253380.1	1359.71	1358.63	1358.0699	1356.64	1359.09	1358.02	1357.52	1356.22
21	1369.5	1	0	res	378366.34	1253331.3	1359.53	1358.46	1357.91	1356.5	1358.9399	1357.88	1357.38	1356.1
22	1369.4	1	0	res	378225.35	1253173.9	1358.95	1357.9399	1357.42	1356.09	1358.46	1357.4301	1356.95	1355.72
23	1370	1	0	res	378164.56	1253115.1	1358.76	1357.75	1357.21	1355.89	1358.3101	1357.27	1356.79	1355.5601
24	1371.5	1	0	res	378116.55	1253069	1358.6	1357.59	1357.05	1355.74	1358.1801	1357.14	1356.67	1355.4399
25	1362	1	275	garage	379244.75	1254447.2	1362.53	1361.2	1360.23	1358.38	1362	1360.4301	1359.74	1358.05
26	1362.8	1	2553	res	379268.47	1254647.3	1362.61	1361.27	1360.3101	1358.47	1362.12	1360.5601	1359.87	1358.1801
27	1362	1	639	Hardware	379174.81	1254688.5	1362.59	1361.26	1360.29	1358.45	1362.1	1360.53	1359.84	1358.15
28	1361.8	1	1775	prof	379326.9	1254674.6	1362.63	1361.29	1360.34	1358.51	1362.16	1360.61	1359.92	1358.23
29	1362.5	1	747	Hairdresser	379213.54	1254732.7	1362.61	1361.28	1360.3199	1358.48	1362.14	1360.58	1359.88	1358.1899
30	1361.8	1	1887	restaurantnon	379282.65	1254802.4	1362.64	1361.3101	1360.36	1358.54	1362.17	1360.63	1359.9399	1358.26
31	1362.7	1	23677	prof	379443.21	1254732.7	1362.66	1361.33	1360.39	1358.5699	1362.1899	1360.65	1359.96	1358.29
32	1360.2	1	39481	tele	379621.89	1254664.8	1362.6899	1361.37	1360.4301	1358.64	1362.21	1360.6801	1360	1358.34
33	1364	1	2015	prof	379445.89	1254855.6	1362.6801	1361.36	1360.42	1358.62	1362.21	1360.67	1359.99	1358.33
34	1363.4	1	300	res	380231.24	1255558.7	1363.9301	1362.63	1361.85	1360.15	1363.37	1361.96	1361.35	1359.72
35	1362.9	1	420	res	380252.96	1255526.7	1363.92	1362.62	1361.84	1360.13	1363.35	1361.9399	1361.3199	1359.7
36	1362.8	1	817	res	380293.83	1255483	1363.9301	1362.62	1361.84	1360.14	1363.36	1361.9399	1361.33	1359.71
37	1362.3	1	1393	res	380322.66	1255458.2	1363.9301	1362.63	1361.85	1360.14	1363.36	1361.95	1361.34	1359.71
38	1362.7	1	576	res	380344.24	1255441.6	1363.9399	1362.64	1361.87	1360.16	1363.38	1361.97	1361.37	1359.73
39	1360.5	1	12543	res	380389.67	1255391.1	1363.9399	1362.64	1361.87	1360.16	1363.38	1361.97	1361.37	1359.74
40	1361	1	21794	res	380543.34	1255110.3	1363.87	1362.5601	1361.76	1360.05	1363.3	1361.87	1361.22	1359.61
41	1358.5	1	67685	res	380482.81	1255053.4	1363.83	1362.51	1361.71	1359.99	1363.28	1361.83	1361.1899	1359.5601
42	1360.5	1	39474	res	380448.59	1255013.4	1363.8	1362.49	1361.6801	1359.95	1363.26	1361.8101	1361.16	1359.53
43	1359	1	86879	res	380328.02	1254898.7	1363.7	1362.38	1361.55	1359.8	1363.1801	1361.72	1361.0601	1359.4
44	1358	1	105282	res	380265.43	1254832.1	1363.64	1362.3199	1361.49	1359.73	1363.11	1361.65	1360.99	1359.33
45	1363	1	3354	res	380156.25	1254723.9	1363.54	1362.22	1361.39	1359.62	1363	1361.53	1360.87	1359.2
46	1358	1	82308	res	380120.92	1254685.1	1363.4399	1362.12	1361.27	1359.5	1362.9	1361.4301	1360.76	1359.1
47	1368.5	1	4	res	380086.03	1254652.5	1363.3101	1361.99	1361.13	1359.36	1362.79	1361.3	1360.64	1358.98
48	1368.2	1	5	res	380042.47	1254613.9	1363.16	1361.84	1360.97	1359.2	1362.65	1361.15	1360.48	1358.83
49	1359	1	9957	res	379885.13	1254432	1362.71	1361.39	1360.45	1358.67	1362.22	1360.7	1360.02	1358.37
50	1367	1	7	res	379767.84	1254256.4	1362.64	1361.3	1360.35	1358.52	1362.17	1360.62	1359.9301	1358.24
51	1368.1	1	4	res	379714.05	1254163.1	1362.6	1361.27	1360.3101	1358.47	1362.11	1360.55	1359.86	1358.17
52	1357	1	92364	res	379645.83	1254011.2	1362.55	1361.21	1360.24	1358.39	1362.02	1360.45	1359.75	1358.0601
53	1360.7	1	2127	res	379494.81	1254025.3	1362.38	1361.0699	1360.12	1358.33	1361.8199	1360.3	1359.63	1357.99
54	1361.8	1	1360	restaurantnon	379231.72	1254851.3	1362.64	1361.3101	1360.36	1358.54	1362.17	1360.63	1359.9399	1358.26
55	1361.8	1	949	prof	379261.38	1254881.1	1362.65	1361.3199	1360.38	1358.5601	1362.1801	1360.64	1359.95	1358.28
56	1361.8	1	1674	retailfurniture	379225.46	1254841.7	1362.64	1361.3101	1360.36	1358.53	1362.17	1360.62	1359.9301	1358.25
57	1361.8	1	1379	restaurantnon	379193.57	1254808.8	1362.63	1361.29	1360.34	1358.51	1362.16	1360.61	1359.92	1358.23
58	1360.2	1	3810091	garage\office	381167.09	1256078.1	1365.48	1364.23	1363.54	1361.88	1365.21	1363.95	1363.38	1361.71
59	1362.1	1	7619	res	381127.12	1255955.8	1365.3101	1364.05	1363.35	1361.66	1365.01	1363.74	1363.17	1361.47
60	1361.9	1	5107	res	381185.04	1255997.7	1365.42	1364.17	1363.48	1361.8	1365.14	1363.88	1363.3101	1361.63
61	1364.2	1	7983	garage	381253.8	1256297.1	1365.8199	1364.59	1363.9301	1362.3199	1365.59	1364.35	1363.79	1362.1899
62	1364.8	1	442	res	381246.89	1256192.2	1365.6899	1364.4399	1363.77	1362.14	1365.4301	1364.1899	1363.63	1362
63	1364.3	1	6976	county garage	381401.71	1256248.5	1365.96	1364.73	1364.08	1362.5	1365.74	1364.51	1363.96	1362.39
64	1366	1	455	res	381319.77	1256148	1365.72	1364.48	1363.8199	1362.1899	1365.48	1364.23	1363.67	1362.05
65	1363.5	1	2240	res	381271.18	1256090.9	1365.61	1364.37	1363.6899	1362.05	1365.35	1364.1	1363.54	1361.89
66	1362.9	1	4567	res	381219.31	1256053.3	1365.52	1364.27	1363.59	1361.9301	1365.25	1363.99	1363.4301	1361.76
67	1363.7	1	59301	bar	381532.89	1256278.7	1366.14	1364.92	1364.29	1362.75	1365.9301	1364.73	1364.1801	1362.66
68	1354.3	1	137710	pharmacy	377966.21	1251178.9	1355.61	1354.7	1353.9	1351.97	1354.1899	1353.0601	1352.55	1351.21
69	1353	1	10986	prof	378308.2	1251951.9	1356.72	1355.71	1355.01	1353.39	1356.04	1354.95	1354.45	1353.16
70	1353.6	1	94970	ServiceStation	378336.02	1252125.2	1357.0699	1356.03	1355.37	1353.84	1356.58	1355.49	1354.99	1353.71
71	1359	1	1203	garage	378488.16	1252687.2	1357.96	1356.9301	1356.37	1355.05	1357.64	1356.59	1356.11	1354.89
72	1357.5	1	2396	prof	378598.56	1252633.7	1357.9301	1356.89	1356.3199	1355	1357.6	1356.55	1356.0699	1354.84
73	1356	1	4404	restaurantnon	378555.18	1252256.3	1357.42	1356.37	1355.74	1354.3	1357.09	1356	1355.51	1354.24
74	1361	1	68	feedstore	378578.47	1252802.2	1358.2	1357.1801	1356.63	1355.34	1357.86	1356.8199	1356.34	1355.13
75	1361.4	1	47	carwash	378507.26	1252895.2	1358.41	1357.39	1356.85	1355.55	1358.03	1356.99	1356.51	1355.29
76	1356.5	1	6666	garage	378715.18	1252854	1358.4399	1357.4301	1356.89	1355.58	1358.0601	1357.02	1356.54	1355.3199
77	1362.3	1	53	prof	378679.99	1253178	1359.34	1358.29	1357.75	1356.37	1358.78	1357.73	1357.24	1355.97
78	1553.5	1	0	res	377536.88	1250402.9	1350.72	1348.96	1348.59	1347.54	1350.11	1348.6801	1348.21	1347
79	1351.5	1	0	prof	377586.19	1250332.4	1350.67	1348.9301	1348.55	1347.49	1350.1	1348.67	1348.2	1346.98
80	1362.5	1	11456	garage	380445.43	1255627.6	1364.11	1362.84	1362.13	1360.4399	1363.6	1362.29	1361.8	1360.0699
81	1362	1	26433	lightman	380558.26	1255604	1364.21	1362.9399	1362.23	1360.54	1363.72	1362.41	1361.91	1360.1899
82	1360.7	1	2335	res	380552.34	1255440.6	1364.08	1362.8101	1362.1	1360.4	1363.5601	1362.25	1361.77	1360.03
83	1360.5	1	1509111	garage	380870.36	1255780	1364.71	1363.4399	1362.74	1361.0601	1364.3199	1363.01	1362.49	1360.79
84	1361.4	1	1434	res	379222.7	1254021.8	1361.4399	1360.1801	1359.5699	1357.95	1360.77	1359.59	1359.04	1357.5699
85	1367.5	1	0	res	378527.43	1253311.9	1359.62	1358.54	1357.99	1356.5699	1359.01	1357.95	1357.45	1356.15
86	1362.8	1	1156	res	379197.95	1254712.2	1362.61	1361.27	1360.3101	1358.47	1362.12	1360.5601	1359.87	1358.17
87	1362	1	379	restaurantnon	379234.49	1254752.7	1362.62	1361.29	1360.33	1358.5	1362.16	1360.6	1359.91	1358.22
88	1360.7	1	8236	prof	379409.16	1254674.6	1362.64	1361.3101	1360.36	1358.54	1362.1801	1360.63	1359.9399	1358.26
89	1362.3	1	558	prof	379290.05	1254910.4	1362.67	1361.34	1360.39	1358.58	1362.1899	1360.65	1359.97	1358.3
90	1362.3	1	554	prof	379274.03	1254893.9	1362.66	1361.33	1360.38	1358.5699	1362.1899	1360.64	1359.96	1358.28
91	1362.3	1	925	prof	379309.11	1254924.7	1362.67	1361.34	1360.4	1358.6	1362.2	1360.66	1359.97	1358.3101
92	1362.1	1	665	prof	379175.41	1254791	1362.62	1361.28	1360.33	1358.49	1362.15	1360.59	1359.9	1358.21
93	1362.3	1	1500	res	380412.6	1255359.8	1363.9301	1362.63	1361.85	1360.15	1363.37	1361.96	1361.35	1359.72
94	1358.2	1	189860	garage	379700.14	1254621.8	1362.7	1361.38	1360.4399	1358.65	1362.22	1360.6899	1360.01	1358.35
95	1363.7	1	553	grocery	379175.03	1254309	1362.05	1360.75	1359.95	1358.23	1361.45	1360.08	1359.46	1357.88
96	1369.7	1	0	res	378288.25	1253247.5	1359.21	1358.1801	1357.64	1356.27	1358.6801	1357.63	1357.14	1355.89