Local Flood Analysis

Villages of Stamford and Hobart, Hamlet of South Kortright
Town of Stamford, New York
October 2020

Prepared for:
Delaware County Soil and
Water Conservation District
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EXECUTIVE SUMMARY

The Delaware County Soil and Water Conservation District has retained Milone & MacBroom, Inc. to complete a Local Flood Analysis in the villages of Stamford and Hobart and the hamlet of South Kortright. A Local Flood Analysis is an engineering feasibility analysis that seeks to develop a range of hazard mitigation alternatives. Its primary purpose is to identify flood hazards and mitigation options for the community to implement. In the long term, these mitigation options are designed to reduce flooding and facilitate recovery from flood events. The flood analysis focuses on the West Branch of the Delaware River and several of its tributaries in the village and hamlet project areas.

The Catskill Mountains are subject to large storm events that are often unevenly distributed across watersheds. As a result, local flash floods can occur in one basin while an adjacent basin receives little rainfall. In addition to local flash floods, larger storm events can cause widespread flooding. Major floods have occurred periodically over the last century, with at least 11 major floods occurring since 1933. Floods can take place any time of the year but are commonly divided into those occurring in winter and spring and those occurring in summer and fall. Floods that take place in summer and fall are typically due to extreme rainfall events caused by hurricanes and tropical storms. Floods in winter and spring are associated with rain on snow events and spring snowmelt.

A public meeting was convened at the Stamford Village Hall at the beginning of the Local Flood Analysis process. Attendees were provided with an overview of the project, the Local Flood Analysis process, and hydraulic modeling techniques. Large-format maps were provided, and attendees were asked to point out locations of flooding and flood damages during past flood events, including Tropical Storm Irene. Information was collected on flood damages and potential flood mitigation alternatives. This information was used throughout the Local Flood Analysis process to verify flood damages, pinpoint problem areas, and develop flood mitigation alternatives.

Public remarks indicated that the village and hamlet areas have not witnessed an extreme flood event, such as a 100-year flood, along the West Branch Delaware River in recent memory. These areas emerged from the especially devastating floods of 2006 and 2011 relatively unscathed. The United States Geological Survey (USGS) operates a stream flow gauge in Hobart to monitor discharge on the West Branch of the Delaware River. Analysis of peak stream flow data collected at this station confirms that these communities have experienced several moderate and severe storms and flood events over the past two decades although an event capable of causing widespread catastrophic damage has not been recorded. In the available period of record (2000 to current), annual peak flows recorded at the gauge have marginally exceeded the estimated 10-year peak discharge while the 2011 flood surpassed the estimated 50-year storm.

Hydraulic assessment was used to evaluate historical and predicted water surface elevations, to identify flood-prone areas, and to help develop mitigation strategies to minimize future flood damages and protect water quality. Specific locations were identified within the project area as being prone to flooding. Alternatives were developed and assessed at each area where flooding is known to have caused damage to infrastructure and properties.

Seven bridges and four culverts were evaluated with hydraulic models. In the village of Stamford project area, three bridges spanning the West Branch of the Delaware River were evaluated for hydraulic adequacy. These were the structures carrying Roosevelt Avenue, Railroad Avenue, and the Catskill Scenic

Rail Trail. In addition, the culverts along Graham Drive and Buntline Drive on the West Branch Delaware River Tributary 1 were included in this study.

In the village of Hobart, the bridge carrying Cornell Avenue over the West Branch Delaware River and the Catskill Scenic Rail Trail and Hobart River Road bridges over Town Brook were assessed for hydraulic adequacy. Additionally, the Maple Avenue culvert on Grant Brook, a tributary to Town Brook, was evaluated in this study. For the hamlet of South Kortright, the historic Bovina Center-South Kortright Road bridge over the West Branch Delaware River main stem was evaluated. Bridges and culverts that were found to be undersized and acting as hydraulic constrictions were identified.

Hydraulic modeling suggested that the bridges specified above are adequately sized and do not significantly contribute to flooding under normal circumstances. However, all culverts evaluated in this study were found to be severely undersized and inadequate to convey flood flows. These may contribute to backwater flooding or exacerbate damage to adjacent infrastructure and property. Adequately sized recommended replacement structures are summarized in TABLE ES-1. Recommendations are prioritized based on factors, including the severity of flooding caused by the structure and its existing structural condition. When these culverts are scheduled for replacement, it is recommended that a full hydraulic assessment be conducted to ensure that the new structures meet applicable New York State Department of Transportation hydraulic design standards and New York State Department of Environmental Conservation stream crossing guidelines.

TABLE ES-1
Recommendations for Local Flood Analysis Undersized Culverts

Priority	Location	Existing		Recommended		Notes
		Inlet Description	Inlet Capacity	Description	Capacity	
1	South Street	9-foot-span and 4-foot-rise concrete arch culvert in poor condition	10-year flood	20' x 5' concrete box w/wingwalls	100-year flood	Requires modifications of channel sections upstream and downstream of the crossing to accommodate new structure
2*	Buntline Drive	4-foot-diameter corrugated metal pipe in moderate condition	10-year flood	10' x 4' concrete box w/wingwalls	100-year flood	Proposed culvert inverts should be kept the same as existing to prevent drawdown of the Department of Environmental Conservation wetland.
3*	Graham Drive	2-foot- and 3.5-foot-diameter dual corrugated metal pipes in poor condition	<10-year flood	12' x 5' concrete box w/wingwalls	100-year flood	Alternative configurations should be investigated in order to reach a cost-effective solution.
4	Maple Avenue	5-foot-diameter smooth metal pipe in poor condition	10-year flood	10' x 7' concrete box w/wingwalls	100-year	Requires modifications of channel sections upstream and downstream of the crossing to accommodate new structure

*Priority is listed based on recommended project implementation sequence for the structures along the West Branch Delaware River Tributary 1.

Flooding of bridges, culverts, and roadways during storm events has been reported at several locations in Stamford. It is recommended that risks associated with the flooding of bridges and roadways be reduced by temporarily closing flood-prone roads during flooding events. This requires effective signage, road closure barriers, and consideration of alternative routes.

A report was received from a property owner along the West Branch of the Delaware River just upstream of Main Street who described their backyard as always soggy and reported riverine flooding to have worsened on their property in recent years. It is recommended that the town investigate and determine whether removing obstructions from the adjoining disturbed section of channel and regrading to more natural conditions could be undertaken to reduce the frequency of backyard flooding. If deemed unfavorable, other flood mitigation strategies might be applicable such as anchoring or elevating utilities and removing outbuildings from the flood-prone areas.

Critical facilities are public facilities that if destroyed or damaged would impair the health and/or safety of the community. In these communities, no such facilities were reported to have experienced flooding in the past. Nevertheless, several critical facilities are located partially or wholly within the regulatory flood zones and are susceptible to flooding in more severe events. It is advisable that critical facilities located within the Special Flood Hazard Area consider relocating outside the designated flood zone to reduce the likelihood of future flood disaster losses.

For homes and properties located within the Special Flood Hazard Area, it is recommended that the town work to relocate the most flood-vulnerable properties where there is owner interest and programmatic funding available through flood buyout, relocation, and structure elevation programs.

Some homes in the Special Flood Hazard Area are rarely flooded. Residents and businesses may benefit from minor individual property improvements. Providing landowners with information regarding individual property protection is recommended. In areas where properties are vulnerable to flooding, improvements of individual properties and structures may be appropriate. Potential measures for property protection include the following:

- Elevation of the structure
- Dry floodproofing of the structure to keep floodwaters from entering
- Wet floodproofing of the structure to allow floodwaters to pass through the lower area of the structure unimpeded
- Performing other home improvements, such as elevating utilities, to mitigate damage from flooding
- Encouraging property owners to purchase flood insurance under the National Flood Insurance Program (NFIP) and to make claims when damage occurs

The town of Stamford has adopted a Local Flood Damage Prevention Law as local law No. 1 in 2016. This is a requirement of the NFIP. It is recommended that town and village staff seek training regarding the content and implementation of the law. This will allow town officials to successfully disseminate information regarding the law to the public and to implement the law accurately.

It is recommended that sources of man-made pollution be reduced or eliminated through the relocation or securing of fuel oil and propane tanks as well as any other stored chemicals. It is recommended that the town gather and file flood-related lost revenue information as provided by businesses and that the town record and compile municipal, county, and state costs related to cleanup and recovery. During and after future floods, it is recommended that high water marks be recorded if it is safe to do so.

A number of potential funding sources are identified in Section 6.0 of this report. As the recommendations of this Local Flood Analysis are implemented, the Town of Stamford should work closely with potential funders to ensure that the best combinations of funds are secured for the recommended flood mitigation alternatives. It would be advantageous for the town to identify combinations of funding sources in order to reduce its own requirement to provide matching funds.

1.0 INTRODUCTION

1.1 Project Background

Milone & MacBroom, Inc. (MMI) has been retained to conduct a Local Flood Analysis (LFA) in the village of Stamford, the village of Hobart, and the hamlet of South Kortright. These communities are located within the town of Stamford, Delaware County, New York. The LFA has been undertaken with funding provided by the New York City Department of Environmental Protection (NYCDEP), administered through the Delaware County Soil and Water Conservation District (DCSWCD).

The Catskill Mountains are subject to large storm events that are often unevenly distributed across watersheds. As a result, local flash floods can occur in one basin while an adjacent basin receives little rainfall. In addition to local flash floods, larger storm events can cause widespread flooding.

The LFA is a program specific to the New York City water supply watersheds that was initiated following Tropical Storm Irene to help communities identify long-term, cost-effective projects to mitigate flood hazards.

Project recommendations generated through an approved LFA may be eligible for Flood Hazard Mitigation funding available through the Stream Management Implementation Program (SMIP) administered by DCSWCD, the Catskill Watershed Corporation's (CWC) Flood Hazard Mitigation Implementation Program (FHMIP), or the NYCDEP-funded Buyout Program. A more detailed list of potential funding sources is included in Section 6.0 of this LFA report.

1.2 Study Area

The villages of Stamford and Hobart and the hamlet of South Kortright are part of the town of Stamford located in the eastern part of Delaware County. The communities are connected by New York State (NYS) Route 10, a central thoroughfare that parallels the main stem of the West Branch Delaware River for approximately 66 miles, beginning at its headwaters to just downstream of the Cannonsville Reservoir.

The subject LFA focuses on riverine flooding mitigation and infrastructure improvements within the hamlet and villages although flooding hazards may exist elsewhere in the town. A total of 11 road crossings across four focus watercourses have been assessed. The following structures spanning the West Branch Delaware River were evaluated:

- Roosevelt Avenue (village of Stamford)
- State Route 23 (village of Stamford)
- South Street (village of Stamford)
- Catskill Scenic Rail Trail (village of Stamford)
- Cornell Avenue (village of Hobart)
- Bovina Center – South Kortright Road (hamlet of South Kortright)

In addition, the following structures spanning an Unnamed Tributary 1 of the West Branch Delaware River within the village of Stamford were considered in this study:

- Graham Drive
- Buntline Drive

Lastly, the following crossings along their respective watercourses were evaluated in the village of Hobart:

- Maple Avenue (Grant Brook)
- Catskill Scenic Rail Trail (Town Brook)
- County Route 18 (Town Brook)

As a supplemental task, MMI performed a dam breach analysis for the Rexmere Lakes dams in the village of Stamford. These include:

- Rexmere Dam (NYS ID 160-3493, NID ID NY00524)
- Churchill Dam (NYS ID 160-3505, NID ID NY12726)

The dams, which are owned by the village of Stamford, are located in series along a small tributary of the West Branch Delaware River. Rexmere Dam is immediately upstream of Churchill Dam, has a structural height of 27 feet, and impounds approximately 104 acre-feet of water. Churchill dam is slightly smaller with a height of 21 feet and a normal impoundment volume of 21 acre-feet. Both structures are classified as small, Hazard Class C (i.e., high hazard) dams. The goal of the dam breach analysis was to determine if the current hazard classification for the dams is appropriate or if the village should explore reclassification of the dams to better reflect the level of hazard posed to downstream areas. Over the years, several changes have occurred downstream of the dams, including the removal of a mobile home park, which could reduce the life safety hazard and the amount of property damage expected in a breach event.

The breach analysis assumed a cascading dam breach where failure of the upstream dam subsequently leads to the failure of the downstream dam. The assessment was performed according to procedures outlined in the NYS Department of Environmental Conservation (DEC) Draft Guidance Dam Hazard Classification, DOW 3.1.5, Section IV. The flood hazard potential for the areas downstream of the dams was assessed based on the resulting flooding extents, water surface elevations, and flow velocities from modeled dam breach scenarios.

Figures 1-1, 1-2, and 1-3 illustrate the extent of the LFA project areas and the respective structures of interest.

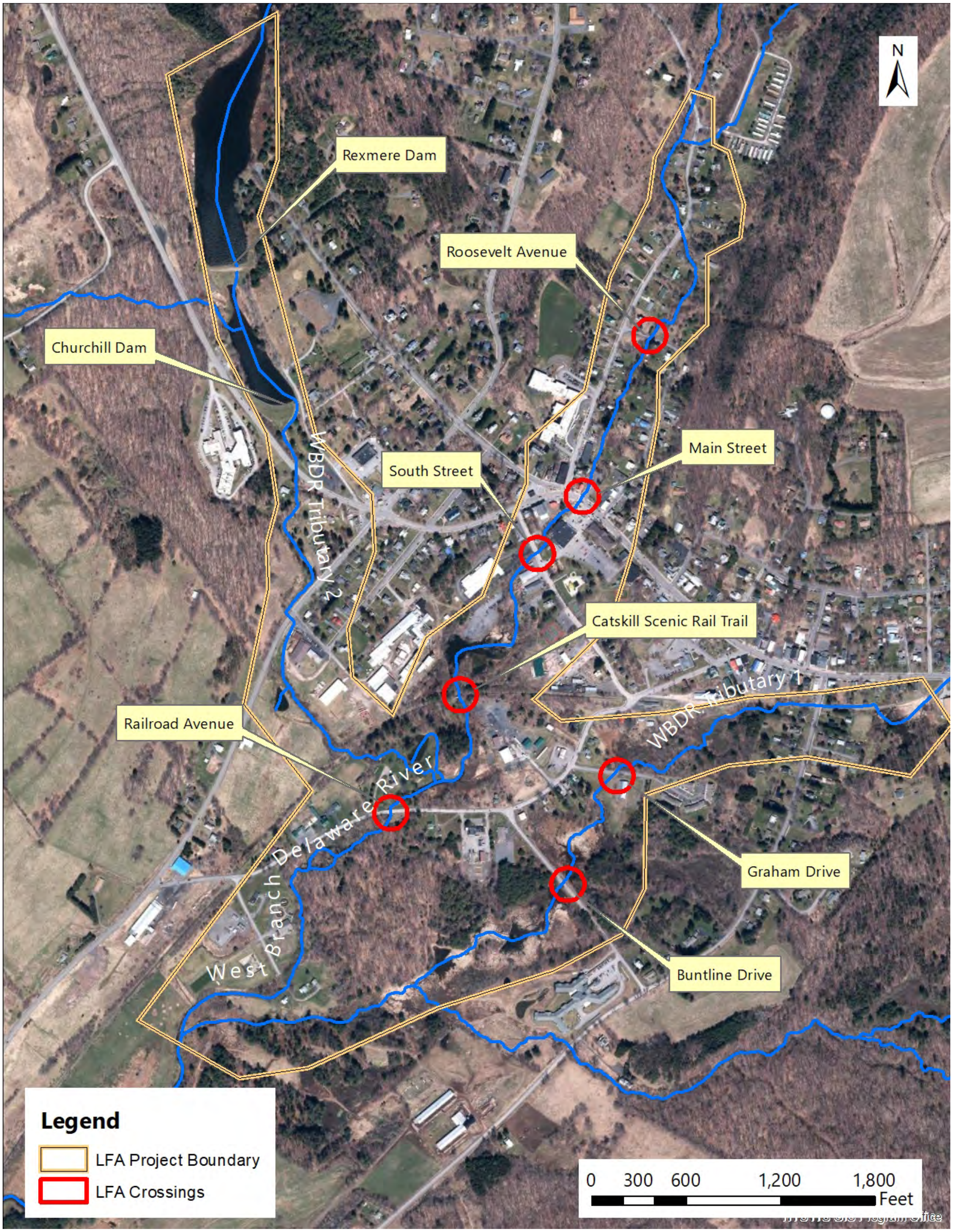

Figure 1-1: Village of Stamford LFA study area

Figure 1-2: Village of Hobart LFA study area

Figure 1-3: Hamlet of South Kortright LFA study area

1.3 Community Involvement

The LFA was undertaken in close consultation with the Stamford Flood Advisory Committee (FAC), which was assembled for this purpose. The FAC is comprised of individuals with technical and nontechnical backgrounds and is meant to represent various interests and stakeholders at town and county levels as well as the DCSWCD, CWC, and NYCDEP. The FAC met regularly over the course of the LFA process to review results and provide input on flood mitigation alternatives. Minutes from the FAC meetings are included in Appendix A. FAC members include representatives from the following organizations and backgrounds:

- Officials from the hamlet and villages
  - Elected officials and town and village board members
  - Highway Department representatives
- Residents of the hamlet and villages
- DCSWCD
- NYCDEP
- CWC
- MMI

The LFA process included one public meeting. This public meeting took place at the start of the LFA in order to inform the public about the LFA process and gather input about flood events and flood damages within the project area.

TABLE 1-1 summarizes FAC and public meetings that took place during the LFA process.

TABLE 1-1
LFA Meeting Schedule

Date	Type of Meeting	Topic
November 14, 2019	FAC (#1)	Introduction to and overview of LFA process; gathering of flood information from FAC members
January 14, 2020	Public (#1)	Introduction to and overview of LFA process; gathering of flood information from members of the public
February 20, 2020	FAC (#2)	Present initial findings and gather feedback from FAC members
May 7, 2020	Virtual FAC (#3)	Summary recap of previous meeting and presentation of additional findings, including the dam breach analysis component of the LFA and refined hydraulic modeling results
August 11, 2020	Virtual FAC (#4)	Presentation of recommendations and solicitation of additional feedback for final report

1.4 Nomenclature

In order to provide a common standard, the Federal Emergency Management Agency's (FEMA) NFIP has adopted a baseline probability called the base flood. The base flood has a 1 percent (one in 100) chance of occurring in any given year, and the base flood elevation (BFE) is the water surface elevation of floodwaters. In this report, the 1 percent annual chance flood is referred to as the 100-year flood event. Other common recurrence probabilities referred to in this report include the 2-year flood event (50 percent annual chance flood), the 10-year flood event (10 percent annual chance flood), the 25-year flood event (4 percent annual chance flood), the 50-year flood event (2 percent annual chance flood), and the 500-year flood event (0.2 percent annual chance flood). The Special Flood Hazard Area (SFHA) is the area inundated by flooding during the 100-year flood event.

It should be noted that over the time period of a standard 30-year property mortgage a property located within the SFHA will have a 26 percent chance of experiencing a 100-year flood event. Structures falling within the SFHA may be at an even greater risk of flooding if a house is low enough that it may be subject to flooding during the 25-year or 10-year flood events. In this case, during the period of a 30-year mortgage, the chance of being hit by a 25-year flood event is 71 percent, and the chance of being hit by a 10-year flood event is 96 percent, which is a near certainty.

The FEMA-designated floodway is defined as the stream channel and that portion of the adjacent floodplain that must remain open to permit passage of the base flood. Floodwaters are typically deepest and swiftest in the floodway, and anything in this area is in the greatest danger during a flood. The portion of the floodplain that is outside the floodway is referred to as the flood fringe and is generally (but not in all cases) associated with less rapidly flowing water. Figure 1-4 illustrates the SFHA, floodway, and flood fringe on a typical channel cross section.

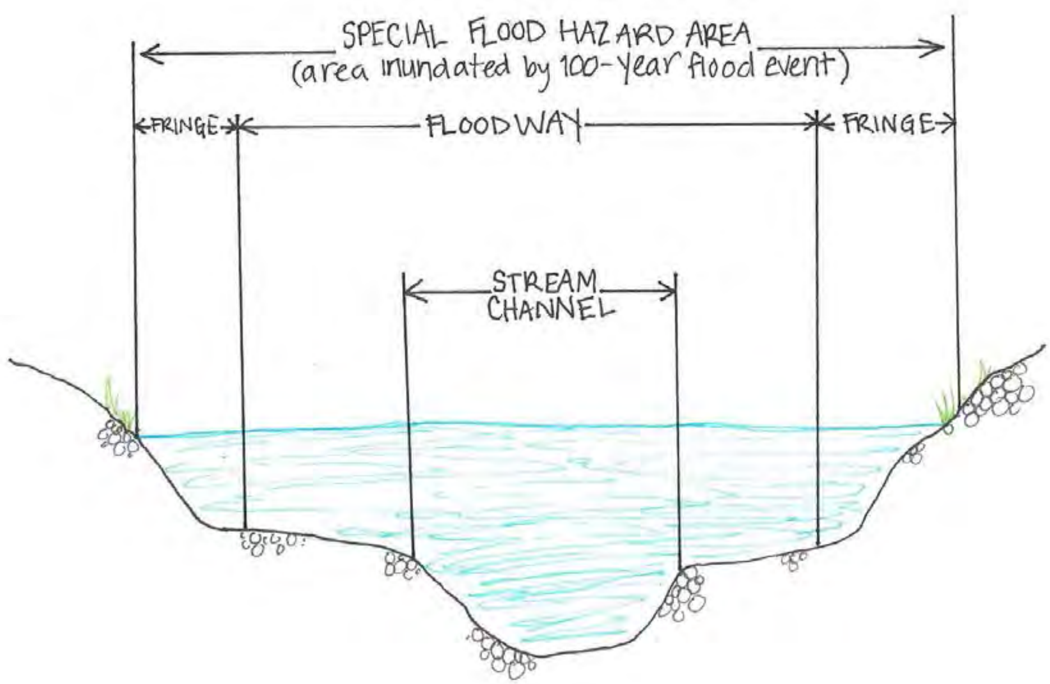

Figure 1-4: Special Flood Hazard Area, Floodway, and Flood Fringe

Throughout this report, the West Branch of the Delaware River is referred to as the WBDR. All references to right bank and left bank refer to "river right" and "river left," meaning the orientation assumes that the reader is standing in the river looking downstream.

In addition, the name of the tributary to Town Brook that runs under Maple Avenue in the village of Hobart may be a source of confusion. The watercourse does not appear to be identified in any historical USGS topographic quadrangles for Hobart, nor in any other historical maps of the area. However, this tributary was frequently called Grant Brook by the community and will therefore be referred to as such in this report.

Furthermore, the unnamed tributaries to the WBDR main stem that enter in the village of Stamford were not identified by recognized names within the community. Therefore, these tributaries will be referred to as WBDR T1 and WBDR T2, for Tributary 1 and Tributary 2, as listed in the revised FEMA Flood Insurance Study (FIS) report dated 2016. Lastly, the tributary that enters the WBDR in the hamlet of South Kortright will be referred to as Dry Creek, so-called by a road sign adjacent to the stream.

The New York State Department of Transportation (NYSDOT) classifies stream crossings as bridges or culverts based on their span length alone rather than their hydraulic design or construction. Any structure with a span greater than 20 feet is considered a bridge; spans shorter than 20 feet are considered culverts. For example, a 25-foot-span box culvert would be classified as a bridge, and a 15-foot-span bridge would be considered a culvert. NYSDOT enforces substantially different hydraulic design standards for bridges and culverts, which may have considerable implications for project cost.

2.0 WATERSHED INFORMATION

2.1 Initial Data Collection

FEMA FIS

FEMA has produced a FIS dated June 16, 2016, for Delaware County. The purpose of the FEMA FIS is to determine potential floodwater elevations and delineate existing floodplains in order to identify flood hazards and establish insurance rates. For the LFA study area, the FIS includes a detailed study of the WBDR, the unnamed tributaries in the village of Stamford, Town Brook and Grant Brook in the hamlet of Hobart, and Dry Creek in the hamlet of South Kortright. The hydrologic and hydraulic analyses for the WBDR were completed in October 2013 for the revision of the current effective FIS.

As part of its detailed studies in the Delaware County FIS, FEMA developed a series of hydraulic models for these watercourses using the Hydrologic Engineering Center – *River Analysis System* (HEC-RAS) computer software. These models are available for professional use and are a valuable component of the LFA. A key element of the HEC-RAS analysis is the determination of the area flooded during the 100-year frequency event, referred to as the SFHA. A detailed HEC-RAS model was created for the WBDR and the focus tributaries identified in this analysis.

DCSWCD Stream Corridor Management Plan

For the villages and hamlet study areas, a detailed description of the WBDR watershed is contained in the WBDR *Stream Corridor Management Plan* (SCMP) prepared by DCSWCD in cooperation with the NYCDEP. This report presents information on the climate, physiography, hydrology, stream characteristics, watershed geology, wetlands, historical and current land use, infrastructure, and flood history/response. A digital copy of this document is available at http://www.dcswcd.org/Watershed%20Plans.htm.

Delaware County Multijurisdictional All-Hazard Mitigation Plan

The benefits of hazard mitigation plans (HMPs) include but are not limited to the following:

- An increased understanding of hazards faced by communities
- A more sustainable and disaster-resistant community
- Financial savings through partnerships that support planning and mitigation efforts
- Focused use of limited resources on hazards that have the biggest impact on the community
- Reduced long-term impacts and damages to human health and structures and reduced repair cost (Tetra Tech, 2013)

Flood hazard mitigation planning is promoted by various state and federal programs. At the federal level, FEMA administers two programs that provide reduced flood insurance costs for communities meeting minimum requirements – the NFIP and the Community Rating System (CRS) (Tetra Tech, 2013). Flood hazard planning is a necessary step in acquiring eligibility to participate in these programs (URS, 2009).

In 2013, Delaware County completed a multijurisdictional natural HMP. By participating in the plan, jurisdictions within the county comply with the Federal Disaster Mitigation Act of 2000. Compliance with this act allows jurisdictions to apply for federal aid for technical assistance and postdisaster mitigation project funding.

Hazards were ranked based on probability of occurrence and impact on the community. Delaware County was assigned an occurrence ranking of 'frequent' or '3' for flooding, indicating a hazard event that is likely to occur within 25 years. The impact ranking is determined based on the impact on population, on property (general buildings and critical facilities), and on the economy. A ranking of high, medium, or low is assigned to each of these factors based on historical losses and subjective assessment and then used to calculate the overall ranking. Flooding in Delaware County was assigned a ranking of 'medium.' As a result, the overall hazard ranking for flooding in Delaware County is 'high.' The town of Stamford was assigned an overall ranking for flooding of '3' (frequent), indicating an event is likely to occur within 25 years.

Water Quality Reports

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

The subject LFA will focus on the following watercourses in the project area: WBDR, which flows into the Cannonsville Reservoir, and WBDR T1 and T2 and Town Brook and its tributary Grant Brook, which flow into the WBDR at Hobart. All streams were classified by the NYSDEC as follows:

- WBDR Class C(T)
- WBDR T1 Class C(T)
- WBDR T2 Class B(T)
- Town Brook Class C(T)
- Grant Brook Class C(T)

A Class C waterbody is considered suitable to support aquatic life and noncontact activities but not for water supply. A classification B stream is considered best usage for swimming and other contact recreation but not for drinking water. The additional standard of T indicates that the watercourse may support a trout population and that special requirements by NYSDEC apply to sustain these waters that support these valuable and sensitive fisheries resources.

According to the Delaware River Waterbody Inventory/Priority Waterbodies List (WI/PWL), which provides water quality assessment data for waterbodies in the Delaware River Basin, the segment of the WBDR main stem above Delhi to the headwaters is characterized as having no water quality impacts with no apparent sources of pollutants. Town Brook is also listed in the WI/PWL although the report indicates that a reassessment is needed to confidently conclude the water quality assessment data for this watercourse. This document can be found online at http://www.dec.ny.gov/chemical/36745.html.

None of the LFA focus watercourses are mentioned in NYS's 2016 Section 303(d) inventory lists, a list of impaired waters that do not support appropriate uses.

Local Flood Damage Prevention Codes

The town of Stamford adopted a local Flood Damage Prevention Law in March 2016. The law is authorized by the NYS Constitution and is consistent with the federal guidelines, which are requirements for participation in the NFIP. The Town Code Enforcement Officer is empowered as the Local Administrator and is responsible for administering, implementing, and enforcing the local Flood Damage Prevention Law.

A copy of the document can be obtained from the Town of Stamford upon request.

The stated purposes of this local law are as follows:

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

The stated objectives of the local law are as follows:

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

USGS Stream Gauging Network

The USGS operates two stream flow gauges within the town of Stamford. In the village of Hobart, a stream gauge is stationed along the WBDR and is known as the 'West Branch Delaware River at Hobart NY' gauge (Gauge #01421610). This station has been in operation since 2000. It is located on the left bank, approximately 300 feet upstream from the Maple Street bridge. Similarly, USGS operates a stream gauge on the WBDR tributary Town Brook that is known as the 'Town Brook Southeast of Hobart NY' gauge (Gauge #01421618). This gauge is located on the left bank approximately 10 feet downstream from the Maple Avenue culvert and has been collecting data since 1996.

These gauges record daily stream flow, including flood flows that are essential to understanding long-term runoff trends. Gauge data can be utilized to determine flood magnitudes and frequencies. Additionally, real-time data is available to monitor water levels and provide flood alerts. Stream flow data and water levels are available at https://waterdata.usgs.gov/ny/nwis/sw.

NYS Community Risk and Resiliency Act

The NYS Community Risk and Resiliency Act (CRRA) was adopted in 2014 for the purpose of ensuring that projects receiving state funding or requiring permits include consideration of the effects of climate risk and extreme weather events.

To meet its obligation to develop guidance for the implementation of CRRA, NYSDEC has proposed a new document, *State Flood Risk Management Guidance*, which is intended to inform state agencies as they develop program-specific guidance to require that applicants demonstrate consideration of sea level rise, storm surge, and flooding as permitted by program-authorizing statutes and operating regulations. The guidance incorporates possible future conditions, including the greater risks of coastal flooding presented by sea level rise and enhanced storm surge and of inland flooding expected to result from increasingly frequent extreme precipitation events.

NYSDEC is also proposing a new guidance document entitled *Guidance for Smart Growth Public Infrastructure Assessment*. This new document is intended to guide state agencies as they assess mitigation of sea level rise, storm surge, and flooding in the design of public infrastructure projects as required by CRRA.

In response to CRRA, the NYSDOT has provided updates to its guidelines and manuals relating to the design of bridges and culverts, including a revision to Chapter 8 of the *Highway Design Manual* and a revised *Bridge Manual*. For new and replacement bridges and culverts, current peak flows are to be increased to account for future projected peak flows, which range from 10 to 20 percent. Bridges are required to pass the 50-year flow with a minimum of 2 feet of freeboard and must pass the 100-year flow without causing a rise in water surface elevations. Culverts must pass the 50-year flow and meet allowable headwater limits.

NYSDEC Stream Crossing Guidelines and Standards

The NYSDEC has developed stream crossing guidelines and standards aimed at protecting and restoring stream continuity. They provide minimum criteria to avoid fragmentation of streams. The objective is to maintain natural conditions that do not restrict the movement of fish and wildlife through the stream system.

These are summarized below and are available in more detail at https://www.dec.ny.gov/permits/49060.html and https://www.dec.ny.gov/permits/49066.html.

- Provide a minimum opening width of 1.25 times the bankfull width of the waterway in the vicinity of the culvert.
- Use open-bottom culverts or closed-bottom culverts that have the bottom slabs placed below the streambed elevation, which allows for installation of natural streambed material through the length of the culvert.
- Match the channel slope through the culvert to the natural channel slope upstream and downstream of the culvert.
- The culvert should not be skewed relative to the direction of flow of the stream.
- Install new or replacement structures so that no inlet or outlet drop would restrict aquatic organism passage.

Field Assessment

During the LFA process, MMI staff conducted several field visits to the project area, including during fall 2019 and in the winter and spring seasons of 2020. During these visits, various data were collected on several culverts, bridges, and the streams they cross; channel morphology, configuration, and floodplain characteristics; and high-water marks and other evidence of past flooding extents. Culvert and bridge geometries of the structures under WBDR, Town Brook, and Grant Brook were measured to compare to the openings of the structures in the HEC-RAS model. Additional stream channel cross sections were surveyed along the WBDR and added to the hydraulic model where appropriate. The overbanks for these cross sections were supplemented with a 2-meter resolution Light Detection and Ranging (LiDAR)-derived Digital Elevation Model (DEM) available from the New York State Geographic Information System (NYS GIS) Clearinghouse.

2.2 Watershed Characteristics and Land Use

The WBDR has a 48.5-square-mile watershed measured just downstream of the municipal line for the hamlet of South Kortright. The basin is predominantly comprised of forested land, which covers approximately 62 percent of total land use, namely in the upland watershed areas. Located along the watercourse and in the adjacent hillsides, agriculture land use makes up approximately 32 percent of the overall land area. The villages and hamlet parcels along the WBDR main stem represent much of the total developed area and, along with other impervious surfaces such as roads, account for 6 percent of the total land use within the basin. Average river slope is gradual at 35.7 feet per mile, or approximately 0.68 percent, from the outlet of Utsayantha Lake to the downstream end of the LFA project area.

Surficial geology in the project watershed is dominated by glacial drift; till and kame surround the valleys of the WBDR and its tributaries. Alluvial substrate, including proglacial outwash sand and gravel as well as recent deposits of fine sand and gravel, underlies the floodplains of subject watercourses. Shallow or exposed bedrock is encountered at higher elevations and along ridge tops. Underlying bedrock geology is sedimentary in origin and consists primarily of the Middle-Upper Devonian Oneonta Formation of the Genesee Group, which is made up of mudstones, shales, sandstones, and conglomerates. The southeastern portion of the watershed is mapped as part of the Upper Devonian Lower Walton Formation of the Sonyea Group, which occupies the ridgetops of the drainage divide between the WBDR and the East Branch of the Delaware River. This younger formation is similarly composed of clastic sedimentary rock, including sandstones, conglomerates, and shales.

Soils are assigned a hydrologic soil group (HSG) identifier, which is a measure of the infiltration capacity of the soil. These are ranked A through D. An HSG A soil is often very sandy, with a high infiltration capacity and a low tendency for runoff except in the most intense rainfall events; a D-ranked soil often has a high silt or clay content or is very shallow to bedrock and does not absorb much stormwater, which instead is prone to run off even in small storms. A classification of B/D indicates that when dry the soil exhibits the properties of a B soil, but when saturated, it has the qualities of a D soil. Over 80 percent of the mapped soils in the WBDR watershed are classified as HSG C or D, indicating a low capacity for infiltration and high tendency for runoff (Figure 2-1). This contributes to flash flooding in the watershed as rainfall runoff moves swiftly into streams rather than gradually seeping through the soils. This is mitigated to some degree by the large areas of forest in the watershed, which tend to encourage infiltration and reduce runoff.

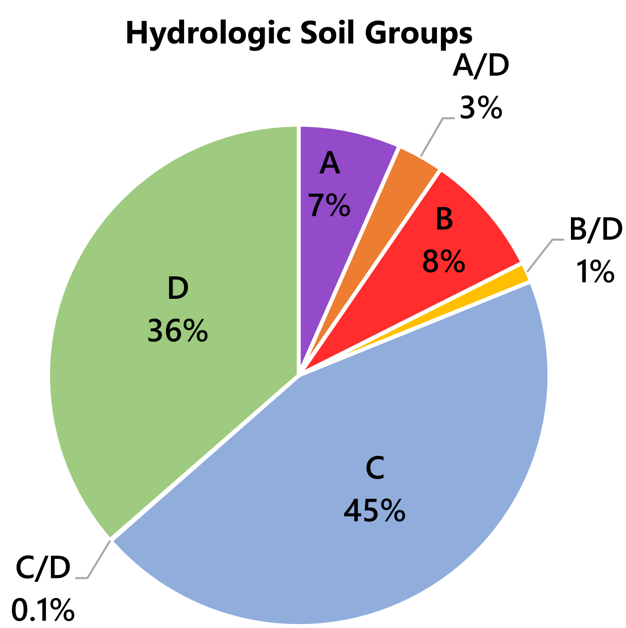

Figure 2-1: Distribution of Hydrologic Soil Groups in LFA WBDR Watershed

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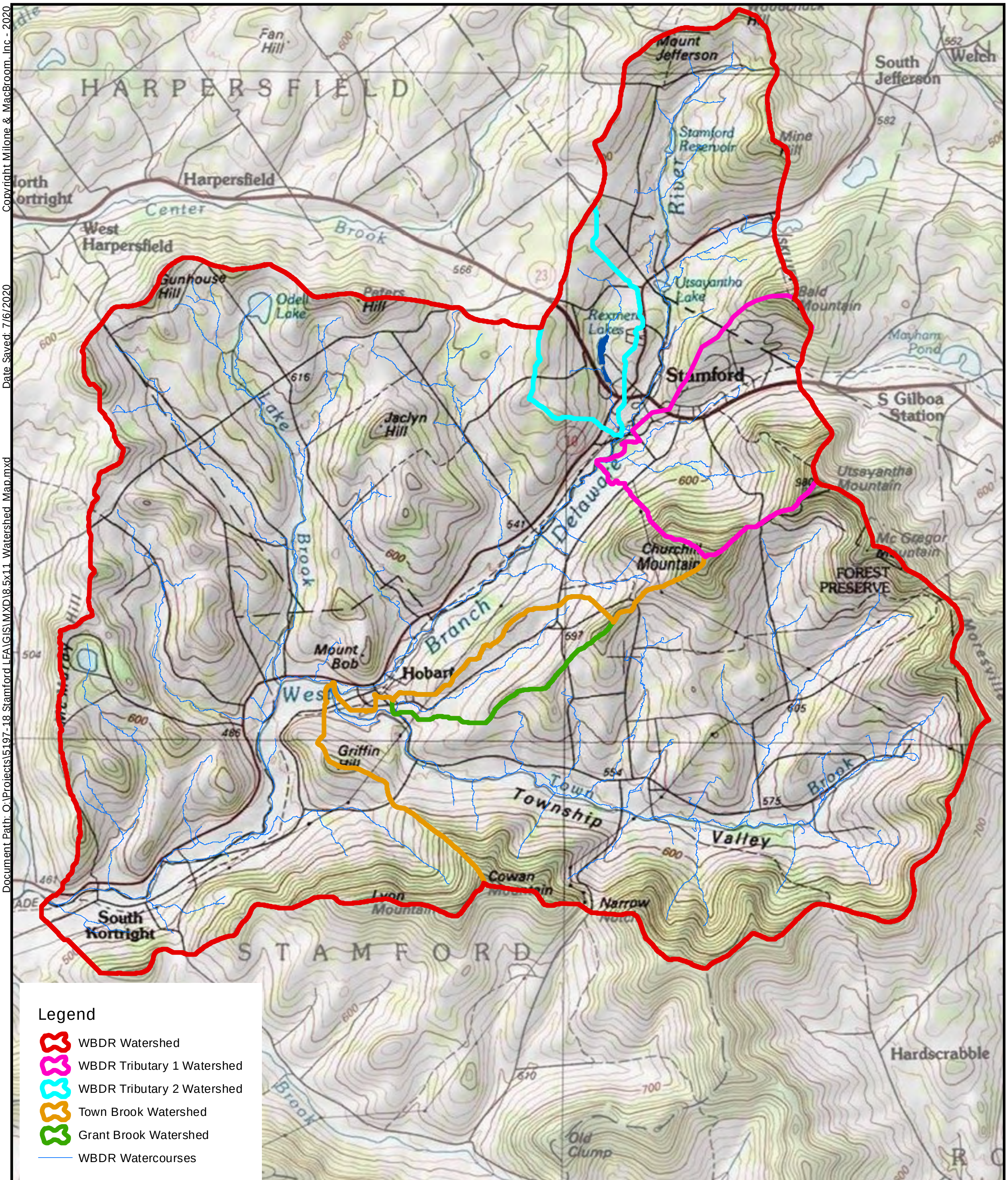

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WEST BRANCH DELAWARE RIVER WATERSHED

STAMFORD
LOCAL FLOOD ANALYSIS
STAMFORD, NY
DELAWARE COUNTY

0 3,000 6,000
Feet

SCALE 1 " = 6,500 '
DATE 9/3/2020
PROJ. NO. 5197-18

FIG. 2-2A

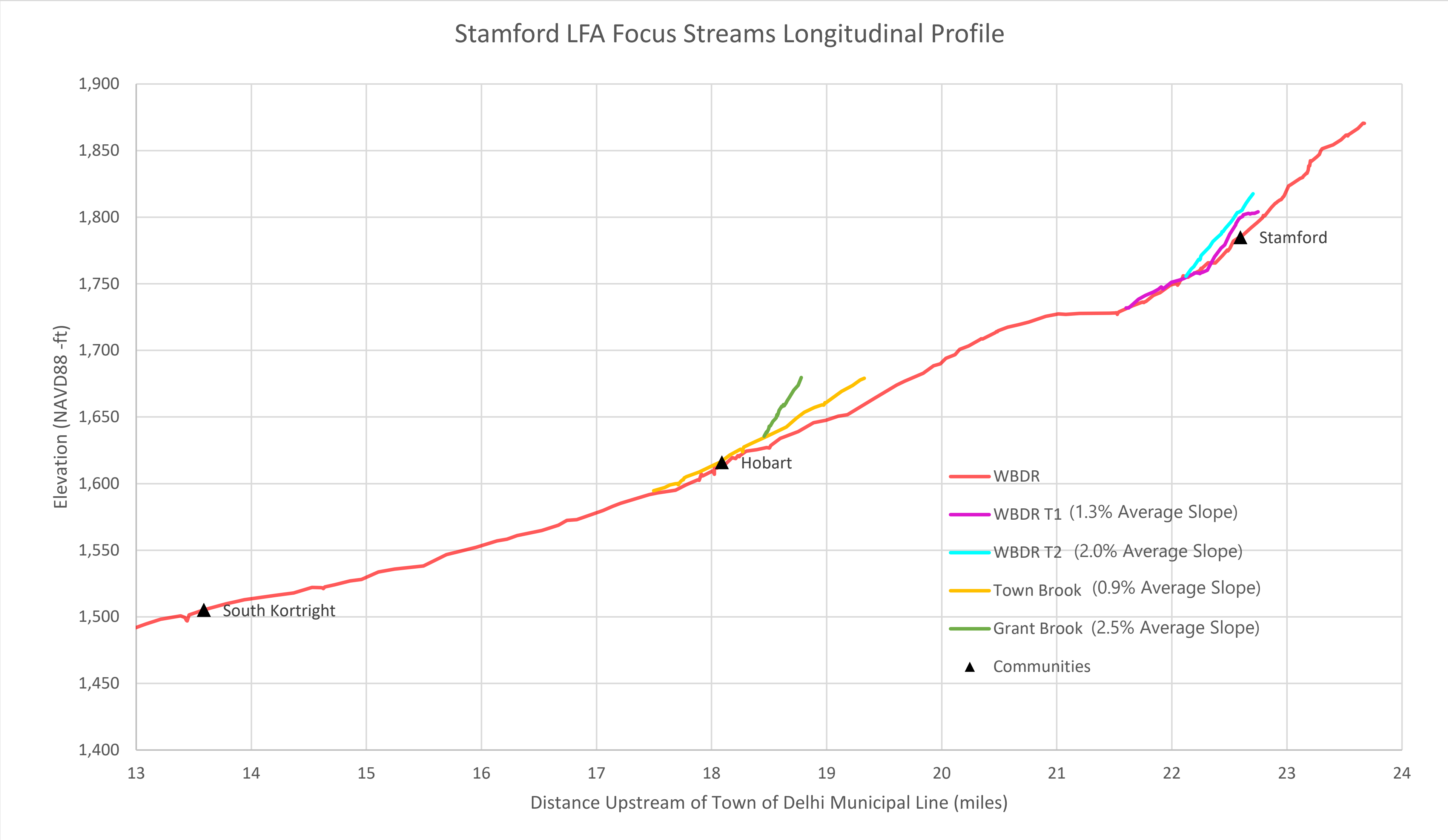

Figure 2-2B: Focus Watercourses and the LFA Communities in Longitudinal Profile Form; Colors Match with Watersheds Displayed in Figure 2-2A

In addition to the WBDR main stem, the following focus tributaries are included in this flood study:

- Tributary 1 to WBDR
- Tributary 2 to WBDR
- Town Brook
- Grant Brook – Tributary to Town Brook

Tributary 1 and Tributary 2 enter the WBDR in the village of Stamford. Tributary 2 flows southward and enters the WBDR at about 500 feet northwest of the intersection of Railroad Avenue and Buntline Drive. Measured at the confluence, Tributary 2 has a watershed area of 1.3 square miles and a mean channel slope of 2.0 percent. Along the watercourse, there are two small impoundments in series, which are referred to jointly as the Rexmere Lakes. The dams that form these lakes are both registered in the NYS Inventory of Dams and have a dam hazard classification of "C," or "High Hazard," due to the potential for loss of life and threat to homes, businesses, and infrastructure downstream if a dam failure were to occur.

Tributary 1 flows westward through the eastern half of the village of Stamford and joins with the WBDR approximately 2,500 feet downstream from where Tributary 2 outlets. Tributary 1 has a contributing watershed of 2.9 square miles and an average basin slope of 1.3 percent. Historical USGS mapping and aerial imagery indicate that the tributary experienced substantial alignment modifications at its confluence with the WBDR sometime in the mid 1900s (Figure 2-3). Public remarks revealed that the watercourse had been redirected to its current alignment to build a carwash on top of the former pond. The channel gained about 2,800 linear feet of length, consequently resulting in an unstable reach of channel with a flatter slope than that of the upper WBDR main stem. The unnamed stream is spanned by five structures; only the culverts on Graham Drive and Buntline Drive were assessed for hydraulic adequacy in this study.

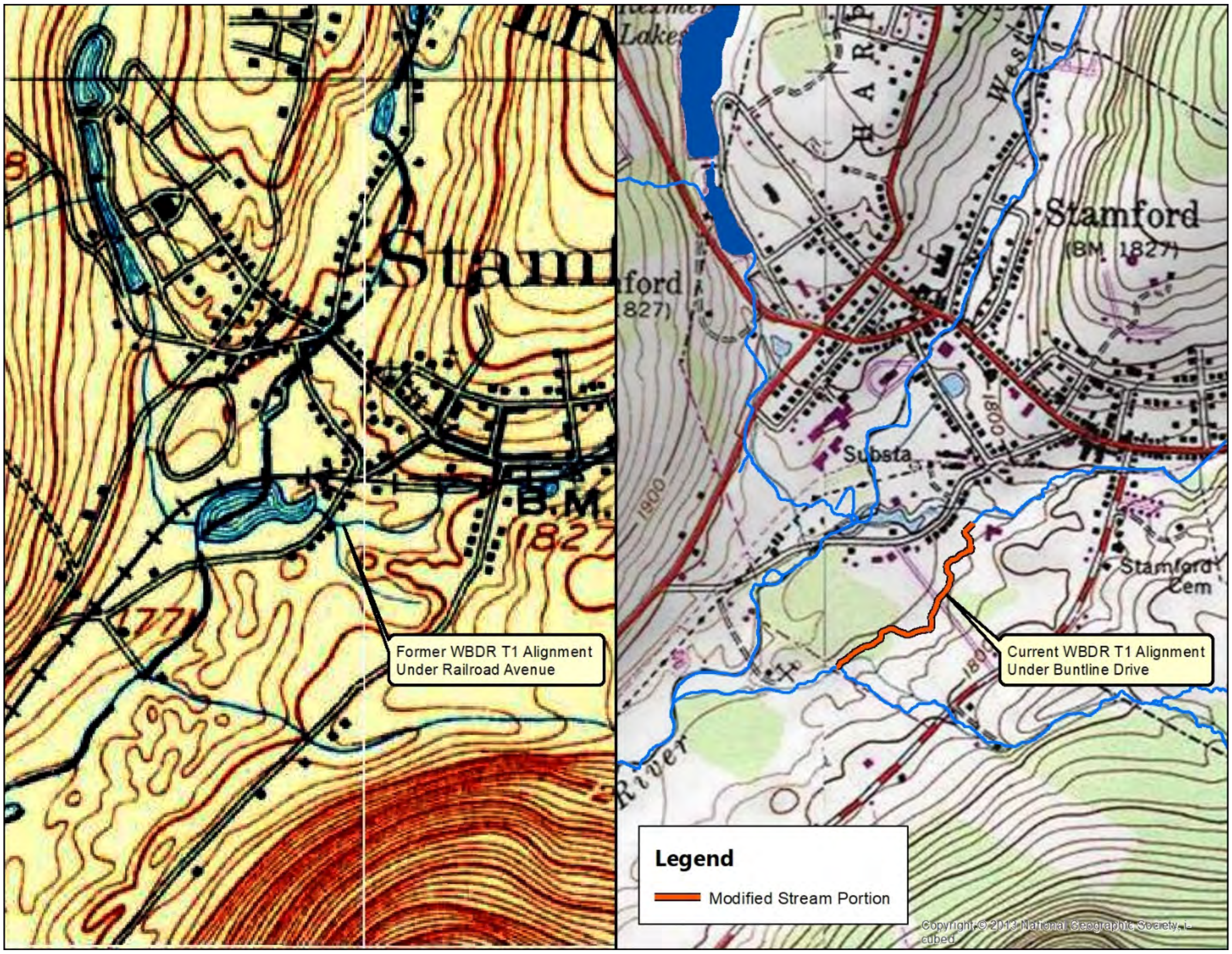

Figure 2-3: 1904 USGS Topographic Map (left) versus 2013 USA Topographic Map (right) illustrating the former and existing path of WBDR T1

Town Brook flows approximately 7.3 miles from its headwaters on the western flank of the Moresville Range, down through Township Valley, to its confluence with the WBDR immediately downstream of the village of Hobart municipal line. Town Brook has a drainage area of 16.0 square miles, and the FEMA-detailed study reach has a mean stream slope of 0.9 percent. The two downstreammost bridges, carrying the Catskill Scenic Rail Trail and County Route 18, were evaluated in this study.

Grant Brook is a tributary to Town Brook with a 1.0-square-mile watershed and an average stream slope of 2.5 percent for the section of channel that extends approximately 1,730 feet upstream from the confluence with Town Brook. Assessment of the crossing under Maple Avenue was included in this report.

2.3 Critical Infrastructure and Anchor Businesses

An important component of the LFA information-gathering stage is the identification of critical facilities and anchor businesses. Critical facilities are defined as follows: public facilities such as a firehouse, school, town hall, drinking water supply treatment or distribution facility, or wastewater treatment plant or collection facility, which if destroyed or damaged would impair the health and/or safety of the community.

The known critical facilities in the Stamford LFA project areas are listed in Table 2-1.

TABLE 2-1
Critical Municipal Facilities in the Project Areas

Facility	Address	Located in SFHA?
Stamford Village Clerk	84 Main Street, Stamford	No
Stamford Central School	1 River Street, Stamford	Partially
Stamford Fire Department	111 Main Street, Stamford	Partially
Stamford Waste Water Treatment Plant	57 Axtell Road, Stamford	Partially
Hobart Volunteer Fire Department	80 Cornell Avenue, Hobart	No
United States Postal Service	698 Main Street, Hobart	Partially
Hobart Village Clerk	80 Cornell Avenue, Hobart	No
South Kortright Central School	58200 NY-10, South Kortright	No
South Kortright Volunteer Fire Department	10668 County Route 18	No

Anchor businesses are defined as follows: private gas stations, grocery stores, lumber yards, hardware stores, and medical doctor's office or pharmacy, which if destroyed or damaged would impair the health and/or safety of the community.

The known anchor businesses in the town of Stamford LFA project areas are listed in Table 2-2.

TABLE 2-2
Anchor Businesses in the Project Areas

Facility	Address	Located in SFHA?
Tops Grocery Store	127 Main Street, Stamford	Partially
Connelly Robert J OD – Doctors Office	22 Harper Street, Stamford	No
Stamford Farmers Cooperative	6 South Street, Stamford	Yes

2.4 Hydrology

Hydrologic studies are conducted to understand historical and potential future river flow rates. Stream flow rates are a critical input for hydraulic models such as HEC-RAS. Stream flow is typically determined from USGS stream gauging stations or from regression equations based on variables such as precipitation and watershed area.

USGS operates and maintains over 10,000 stream flow gauges throughout the country that record daily stream flow, including flood flows. These data are essential to understanding long-term trends. Gauge data can be utilized to determine flood magnitudes and frequencies. USGS stream flow data can be accessed on the National Water Information System (NWIS) online mapper (https://maps.waterdata.usgs.gov/mapper/index.html).

For the 2016 revision of the FIS, a detailed hydrologic study was conducted for the 23-mile stretch of the upper WBDR extending from the village of Delhi, New York, upstream to the Delaware County boundary line. United States Army Corps of Engineers (USACE) hydrologic modeling software Hydrologic Engineering Center – *Hydrologic Modeling System* (HEC-HMS), a program that is designed to simulate the precipitation-runoff process of dendritic drainage basins, was utilized to calculate peak discharges for this stretch of the WBDR main stem. Peak flow values were calibrated using the stream flow data collected at the USGS gauge stations located in the villages of Delhi and Hobart. Considering that the development of a hydrologic model is a robust method for deriving peak discharges, the flows listed in the effective FIS report will be used in this LFA study. This is summarized in Table 2-3. For more details about the hydrologic comparison and validation process and corrections to the flow data files, see Appendix B.

TABLE 2-3
Peak Discharges for West Branch Delaware River in Villages of Stamford and Hobart and the Hamlet of South Kortright

Location	Basin Areas (mi²)	Peak Discharges (cubic feet per second)				
		Flood Return Interval				
		10-Year	25-Year	50-Year	100-Year	500-Year
End of Detailed Study at downstream of Utsanyantha Lake	3.85	147	290	318	708	962
Approximately 150 feet upstream of confluence with WBDR Tributary 3	4.06	152	296	326	742	1,023
Approximately 100 feet upstream of Roosevelt Avenue	4.37	157	305	335	789	1,119
Approximately 1,200 feet upstream of Railroad Avenue	4.56	161	310	341	795	1,161
Approximately 180 feet upstream of Confluence with WBDR Tributary 2	4.63	162	313	343	808	1,172
Approximately 410 feet upstream of Axtell Road	5.99	204	388	424	932	1,412
Just upstream of confluence with WBDR Tributary 1	6.07	206	391	429	939	1,410

Similarly, HEC-HMS modeling software was used to calculate peak flows for the tributaries to the WBDR, including Town Brook and Grant Brook in the village of Hobart as well as the Unnamed Tributaries in the village of Stamford. A summary of discharges for these focus watercourses is listed in Tables 2-4, 2-5, 2-6, and 2-7, respectively. These peak discharges were used for hydraulic analyses of these tributaries.

TABLE 2-4
Peak Discharges for Town Brook in the Village of Hobart (from FEMA FIS)

Location	Basin Areas (mi^2)	Peak Discharges (cubic feet per second)				
		Flood Return Interval				
		10-Year	25-Year	50-Year	100-Year	500-Year
Approximately 9,300 feet downstream of Narrow Notch Road	14.07	2,029	3,173	3,410	5,933	7,978
USGS Gauge 01421618 Town Brook just upstream of Clove Road	14.28	2,037	3,184	3,422	5,977	8,040
Just upstream of confluence with Town Brook Tributary 1	14.63	2,028	3,179	3,416	5,965	8,049
Approximately 1,850 feet upstream of County Route 18	15.69	2,067	3,253	3,517	6,145	8,339
Just upstream of County Route 18	15.99	2,077	3,256	3,547	6,179	8,342
Just upstream of confluence with WBDR	16.02	2,079	3,253	3,553	6,182	8,343

TABLE 2-5
Peak Discharges for Grant Brook in the Village of Hobart (from FEMA FIS)

Location	Basin Areas (mi^2)	Peak Discharges (cubic feet per second)				
		Flood Return Interval				
		10-Year	25-Year	50-Year	100-Year	500-Year
Just upstream of confluence with Town Brook	0.97	154	319	346	767	964

TABLE 2-6
Peak Discharges for Unnamed Tributary 1 to WBDR in the Village of Stamford (from FEMA FIS)

Location	Basin Areas (mi^2)	Peak Discharges (cubic feet per second)				
		Flood Return Interval				
		10-Year	25-Year	50-Year	100-Year	500-Year
Approximately 450 feet downstream of Beaver Street	1.35	85	175	194	433	576
Upstream of South Delaware Street	1.41	86	175	194	435	583
Upstream of confluence with unnamed tributary	2.76	100	186	205	430	863
Upstream of confluence with West Branch Delaware Study Reach 2	2.95	103	196	215	453	911

TABLE 2-7
Peak Discharges for Unnamed Tributary 2 to WBDR in the Village of Stamford (from FEMA FIS)

Location	Basin Areas (mi^2)	Peak Discharges (cubic feet per second) Flood Return Interval				
		10-Year	25-Year	50-Year	100-Year	500-Year
Downstream of Rexmere Lake	0.97	36	71	77	167	210
Upstream of confluence with Harpersfield Tributary 2	1.15	72	133	143	302	367
Just upstream of confluence with WBDR main stem	1.27	93	170	183	381	463

For the dam breach component of the LFA, a detailed hydrologic model was developed to calculate runoff flows for specific rainfall events and to perform the dam breach simulations. The model was developed using both *HydroCAD* Stormwater Modeling software and HEC-HMS. The Rexmere Lakes' 1.21-square-mile watershed was modeled as three subwatershed basins in which all runoff calculations were performed using the Soil Conservation Service (SCS) Curve Number (CN) methodology. The watershed is primarily forested, with some agricultural land use and a golf course. Runoff flows from the subbasins were routed through the two impoundments using the dynamic storage-indication routing method. The resulting discharge hydrographs produced by the model were used as input to hydraulic model, which simulates the flooding downstream of the dams.

Three different flooding scenarios were evaluated using the hydrologic model: a "Sunny-Day" dam breach scenario, a "Rainy-Day" dam breach scenario, and a "Rainy-Day" scenario without a dam breach. For the sunny-day breach scenario, the dam breach is assumed to occur spontaneously under normal flow conditions without the influence of a storm event. Under these conditions, breaches of earthen dams usually occur as piping failures where seepage through the dam leads to destabilization of the fill material, internal erosion, and the eventual failure of the structure. HEC-HMS was used to model the sunny-day breach scenario because the software has the capacity to model piping failures. Rainy-day dam breaches occur during storm events and are usually modeled as overtopping failures where flood flows exceed the capacity of a dam's spillways, overtop the dam, and cause erosion of the downstream face of the structure, eventually leading to complete structural failure. The rainy-day breach scenario was modeled using *HydroCAD*. Dam breach parameters, including the type, dimensions, and timing of a breach, were calculated for each scenario using empirical formulas that relate the parameters to various dimensions of a dam and its impoundment.

The spillway design flood (SDF) is modeled as the associated storm event for the rainy-day breach scenario because NYS DEC regulations require dams to have the capacity to pass the SDF with a specific amount of freeboard (Guidelines for Design of Dams, 1989). For a Hazard Class C dam, the SDF is equal to 50 percent of the Probable Maximum Flood (PMF) for a watershed. The PMF is defined as the flood that would result from "the most severe combination of critical meteorological and hydrologic conditions that is reasonably possible" for an area of interest (FEMA 64, 2013). For the Rexmere Lakes' watershed, the PMF was calculated from the 6-hour duration, probable maximum precipitation (PMP) of 24.97 inches, which was published by the

National Oceanic and Atmospheric Administration (NOAA) and USACE in *Hydrometeorological Report No. 51* (1978). The third scenario, which simulates the rainy-day storm event without a dam breach, was modeled for comparison purposes. When performing a dam breach analysis, the flooding resulting from the rainy-day breach is compared to that which results from the rainy-day, no-breach scenario in order to evaluate the incremental increase in flooding related to the dam breach. Under certain conditions, the flooding caused by a breach may be insignificant compared to the flooding caused by the rainy-day storm event or vice versa. The rainy-day scenario without a breach was modeled using *HydroCAD*. Table 2-8 presents the peak discharges calculated for the three flooding scenarios.

TABLE 2-8
Peak Discharges for the Dam Breach Analysis Flooding Scenarios

Flood Scenario	Peak Discharge (cubic feet per second)
Sunny-Day Dam Breach	4,620
Rainy-Day Dam Breach	12,800
Rainy-Day, No-Breach	2,850

2.5 Hydraulics

Hydraulic analysis of the WBDR, WBDR T1, WBDR T2, Town Brook, and Grant Brook was conducted using the HEC-RAS hydraulic modeling program. The HEC-RAS software was developed by the USACE Hydrologic Engineering Center (HEC) and is the industry standard for riverine flood analysis. The model is used to compute water surface profiles for one-dimensional, steady-state, or time-varied flow. The system can accommodate a full network of channels, a dendritic system, or a single river reach. HEC-RAS is capable of modeling water surface profiles under subcritical, supercritical, and mixed-flow conditions.

Water surface profiles are computed from one cross section to the next by solving the one-dimensional energy equation with an iterative procedure called the standard step method. Energy losses are evaluated by friction (Manning's Equation) and the contraction/expansion of flow through the channel. The momentum equation is used in situations where the water surface profile is rapidly varied such as hydraulic jumps, mixed-flow regime calculations, hydraulics of dams and bridges, and evaluating profiles at a river confluence.

In order to carry out hydraulic modeling of baseline conditions and alternatives, MMI obtained the effective FEMA HEC-RAS model for all focus watercourses from DCSWCD. This HEC-RAS model provided the starting point for the current analysis. Duplicate effective models were created for all rivers. The output of the duplicate effective models was compared to the models provided by DCSWCD and found to be identical. Additionally, the water surface elevations of the HEC-RAS models were compared to those published in Table 10 of the Revised FEMA FIS and the online Flood Insurance Rate Maps (FIRMs) and verified for similitude.

For the dam breach analysis, a two-dimensional, unsteady-state hydraulic model was developed using HEC-RAS to simulate the flooding downstream of the two dams along WBDR T2 and the

WBDR. The model extends approximately 0.6 miles downstream along WBDR T2 and 0.5 miles down the WBDR. Unlike the one-dimensional model described previously, the two-dimensional model simulates the flow of water through a gridded mesh of cells rather than linearly between cross sections. The water surface elevation in each cell and the flow between adjacent cells are calculated iteratively for each time step of a flood hydrograph. Flow is computed based on the St. Venant shallow water (two-dimensional) approximations of the Navier-Stokes equations for fluid flow in three dimensions as numerically discretized by HEC. Two-dimensional modeling can be advantageous for flood simulations, especially when modeling complex, nonlinear flow paths, because it allows water surface elevations to vary spatially and allows for a more detailed assessment of flooding. Additionally, unsteady-state models allow for simulation of an entire flood hydrograph rather than a single peak discharge. The flooding extents, water surface elevations, and flow velocities produced by the hydraulic model were evaluated to determine the potential consequences of the various dam breach scenarios.

3.0 EXISTING FLOOD HAZARDS

3.1 Flood History

The Catskill Mountains are subject to large storm events that are often unevenly distributed across watersheds. As a result, local flash floods can occur in one basin while an adjacent basin receives little rainfall. In addition to local flash floods, larger storm events can cause widespread flooding. An examination of stream flow gauges indicates that floods can take place any time of the year but are commonly divided into those occurring in winter and spring and those occurring in summer and fall. Floods that take place in summer and fall are typically due to extreme rainfall events caused by hurricanes and tropical storms. Floods in winter and spring are associated with rain on snow events and spring snowmelt (FEMA, 2015).

On August 28, 2011, Tropical Storm Irene caused extensive flooding and devastation in eastern New York. Flooding throughout the entire Catskill region was widespread, and FEMA estimated that statewide damages were approximately $102 million. Following the flood, $15.2 million in state and federal aid was allocated to 377 municipalities in the state (GCSWCD, 2007). In the town of Stamford, as shown in Figure 3-1, Tropical Storm Irene was the flood of record captured at the WBDR gauge at Hobart, cresting at 995 cubic feet per second (cfs). Hydrologic comparison indicates that peak flow at the gauge for the 2011 storm was marginally higher than the FEMA-estimated peak discharge for a 50-year storm. During public meetings, there were no clear indications that the 2011 storm had caused severe flooding damages within these communities, and no major damage to infrastructure was documented. However, many developed areas along the WBDR floodplain did experience significant inundation flooding during the 2011 storm as illustrated in Figure 3-2.

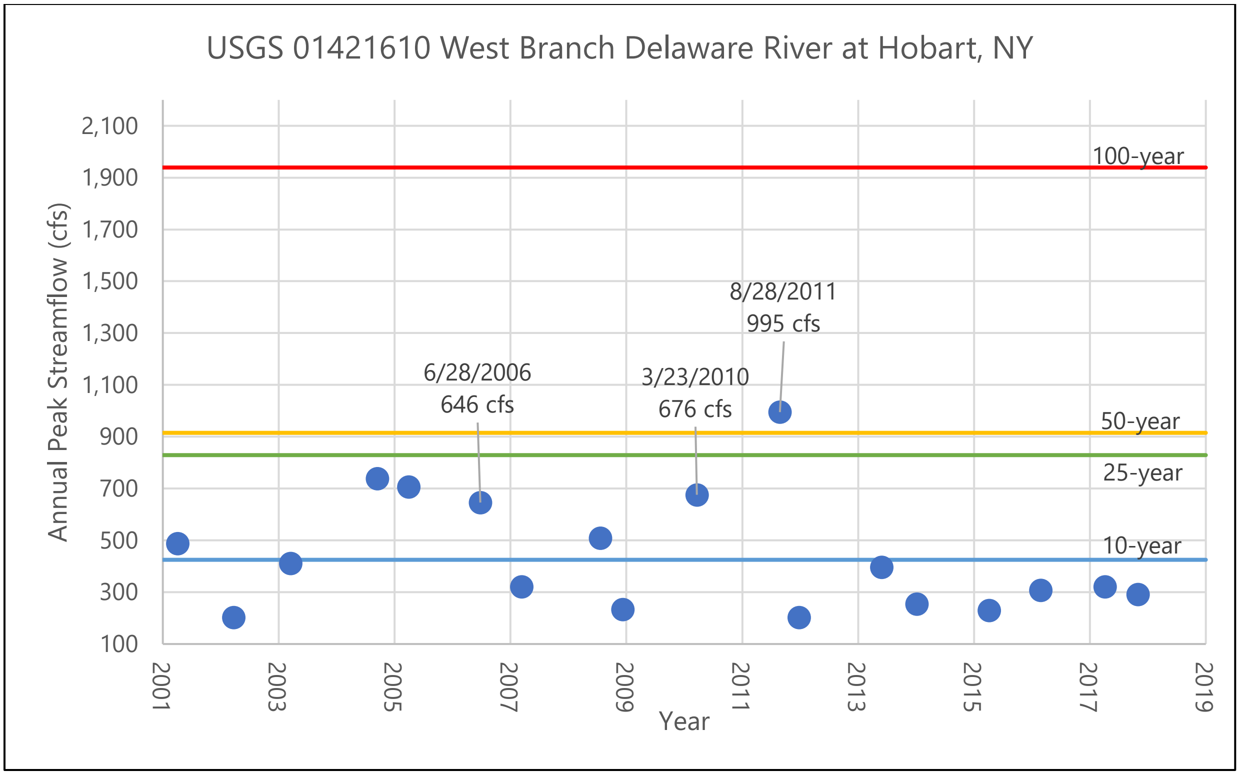

Figure 3-1: Annual peak discharge at USGS Stream Gauge #01421610 at Hobart, New York, compared to FEMA-calculated peak discharges near the gauge site

Figure 3-2: Flooding behind 12½ Roosevelt Avenue during Tropical Storm Irene 2011

In comparison, peak flows collected at the USGS stream gauging station along the WBDR in Delhi, New York, with 61 years of record, show the 1996 winter storm as the largest event. This flood reached 13,000 cfs while the 2011 storm peaked at 8,860 cfs, or just over the estimated 25-year peak discharge (Figure 3-4). The 1996 flood was a rain-on-snow event where unseasonably warm weather produced significant melting of the snowpack combined with heavy rain, resulting in widespread flooding (USGS, 1998). Temperatures reached as high as 60°F while at least 3 inches of rain fell on over 5 inches in liquid equivalent of snowpack (Delaware County Multi Jurisdiction Hazard Plan, Tetra Tech, 2013). The January 1996 event resulted in more than $120 million in individual and public disaster assistance throughout NYS. In Delaware County, flash flooding resulted in over $9M in reported damages and in six fatalities, all of which occurred in vehicles. The headwaters of the WBDR, including the LFA project areas, did not appear to experience damages in proportion to other parts of the Catskills during this flood. Public remarks suggest that there were minimal cases of flooding coming from the WBDR or its tributaries during the 1996 storm.

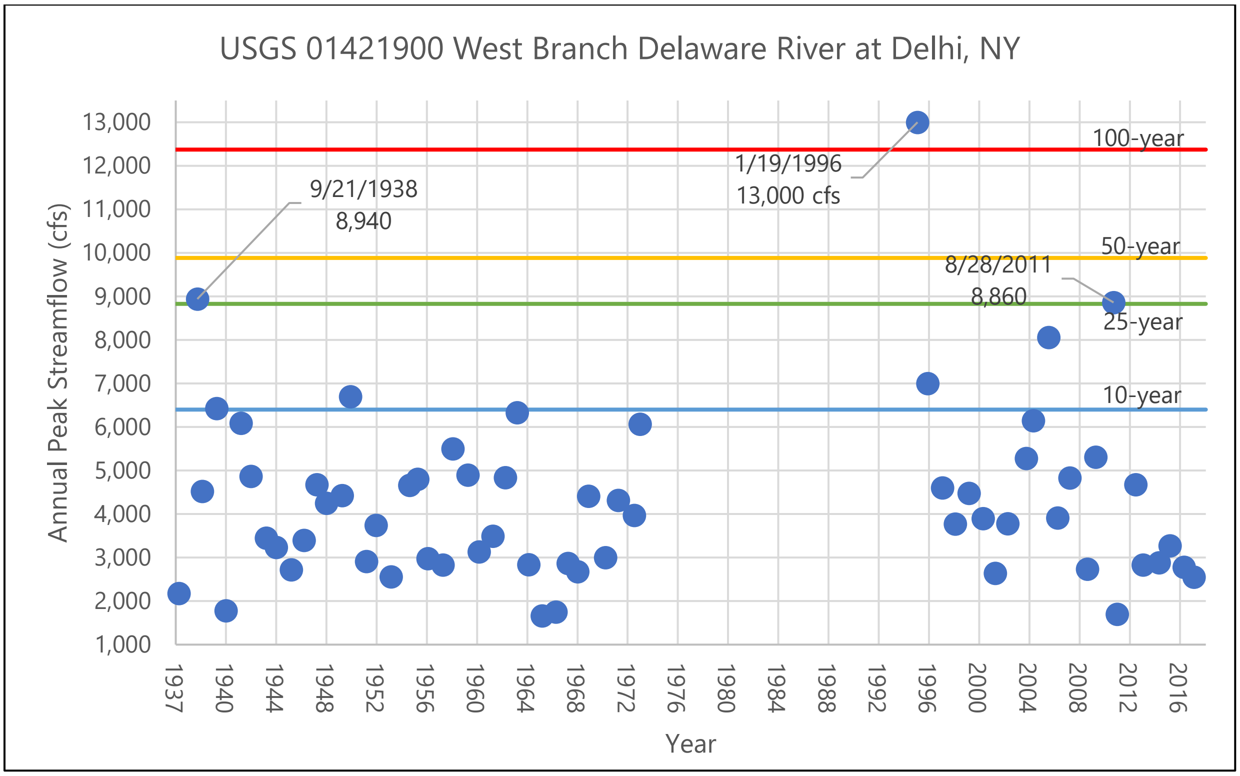

Figure 3-4: Annual peak discharge at USGS Stream Gauge #01421900 at Delhi, New York, compared to FEMA-calculated peak discharges near the gauge site

In addition to the events described above, the unforeseen system that passed over the region on July 4, 1999, was mentioned as disastrous by the public. The towns of Roxbury and Stamford declared states of emergency; a rain spotter in Roxbury reported over 3.8 inches of rain falling in 2 hours. This storm and the resulting flooding were fairly localized and primarily affected Oneida, eastern Otsego, and eastern Delaware Counties. Over $4.5M in total damages were reported in NYS; $1.5M in damage to property and $500k in damage to crops were reported in Delaware County. The USGS stream gauge stationed along Town Brook in the village of Hobart has a period of record dating back to 1996 and measured a peak discharge of 4,400 cfs during the 1999 storm (Figure 3-4). On Town Brook, this event surpassed the expected peak discharge for a 50-year event and is shown to have peaked at a substantially greater flow than the 1996 storm. Public accounts indicate that the town of Stamford operated the outlet works at Rexmere Lake as a precautionary measure due to fear that the reservoirs would overtop and cause the earthen embankments to fail.

According to NOAA's National Climatic Data Center's storm event database, a total of 57 flood and flash flood events have been reported in Delaware County since 1996, resulting in a combined 15 fatalities and over $366M in reported damages. Actual losses are likely considerably greater due to underreporting, lost revenues, and other intangibles.

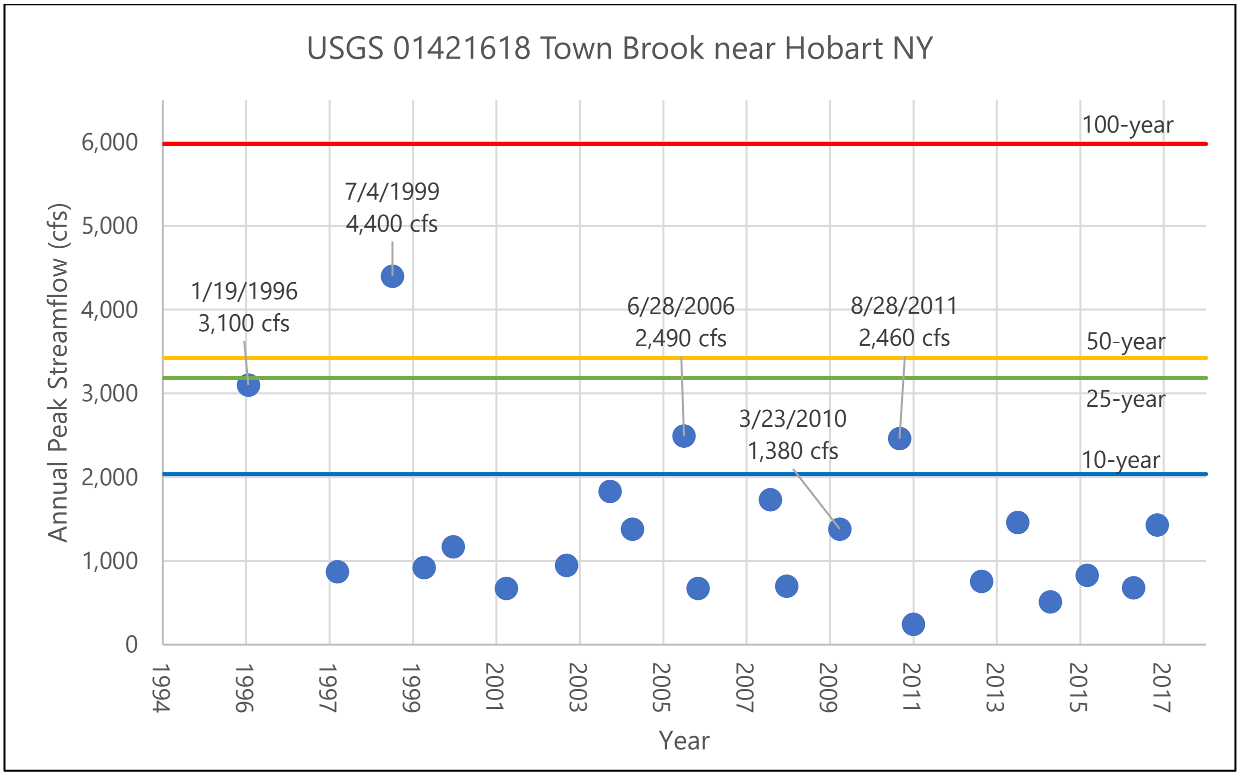

Figure 3-4: Annual peak discharge at USGS Stream Gauge #01421618 on Town Brook in Hobart, New York, compared to FEMA-calculated peak discharges near the gauge site

3.2 FEMA Mapping

FEMA FIRM panels are available for the Stamford study area and depict the SFHA, which is the area inundated by flooding during the statistical 100-year flood event. The maps also depict the 500-year floodplain and the FEMA-designated floodway along WBDR, which is the stream channel and that portion of the adjacent floodplain that must remain open to permit passage of the base flood. Floodwaters are typically deepest and swiftest in the floodway, and anything in this area is in the greatest danger during a flood (FEMA, 2008).

Many of the tributaries to the WBDR in the study area have been mapped to identify their regulatory flood zones including WBDR T1 and WBDR T2 in the village of Stamford and Town Brook and its tributary Grant Brook in the village of Hobart.

FEMA FIRMs that are relevant to the village of Stamford project area include 36025C0190E and 36025C0170E, both effective as of June 16, 2016. These maps address the following areas:

- 36025C0170E: This FIRM covers the WBDR from the Delaware County line upstream to near where the WBDR crosses Railroad Avenue. This panel also includes flood mapping for the majority of the WBDR T1 from the start of the detailed study at the Catskill Scenic Rail Trail crossing to approximately 800 feet upstream of the confluence with the WBDR main stem. Mapping of approximately 450 feet of the WBDR T2 reach upstream from its WBDR confluence is included.
- 36025C0190E: This FIRM covers the WBDR in the vicinity of Railroad Avenue upstream to about 800 feet upstream of the Cornell Avenue bridge in the village of Hobart. This panel also includes detailed mapping for the majority of detailed study reach for WBDR T2, with approximately 450 feet of reach mapped within the adjacent FIRM panel 36025C0170E.

FEMA FIRM 36025C0385E covers the majority of the village of Hobart project area and has an effective date of June 16, 2016. This map addresses the following areas:

- 36025C0385E: This FIRM covers the WBDR from 800 feet upstream of the Maple Avenue bridge to where Lake Brook enters under Route 10. This FIRM also captures detailed mapping of Town Brook and its Grant Brook tributary in their entirety.

FEMA FIRM 36025C0380E, effective June 16, 2016, covers the full mapping extent for the hamlet of South Kortright project area. The map addresses the following area:

- 36025C0380E: This FIRM covers the WBDR from downstream of the Lake Brook confluence to the vicinity of where Rose Brook comes in. Detailed mapping for the WBDR T10 is also included in this FIRM.

The FIRMs are accessible to the public on the FEMA Flood Map Service Center website (https://msc.fema.gov/portal).

4.0 FINDINGS AND RECOMMENDATIONS

Multiple flood mitigation approaches to reduce water surface elevations, including bridge and culvert replacements and floodplain bench alternatives, were evaluated in the project areas. These are listed below and described in more detail in the sections that follow. Alternatives target minimal alterations of roadways and alignments unless necessary. Complete hydraulic assessments are recommended prior to any upgrades to ensure that replacement structures meet NYSDOT standards and NYSDEC guidelines for new culverts in terms of hydraulic opening, permissible headwater depths, and aquatic organism passage. Meeting these criteria frequently requires a substantial capital investment, so upgrades must be prioritized to maintain a robust transportation network and efficiently improve flood resiliency. Unscheduled upgrades, such as replacement of a failed culvert following a flood, are often ad hoc, intended to quickly reopen roads in the aftermath of a storm. In these cases, the replacement structure is frequently the same size or just slightly larger than the one that failed, and the crossing is likely to be damaged again in future floods. Flood resiliency may be improved if undersized culverts have been identified and replacement structures adequately sized, even if only approximately, before damage occurs. Regular culvert inspections and an up-to-date asset inventory may help to prioritize culverts for scheduled replacement and prepare for appropriate repairs in case of flooding damage.

In addition to the flood mitigation approaches listed above, which seek to reduce or eliminate flood damages by reducing water surface elevations, flood protection measures for individual properties were explored. These scenarios were evaluated case by case and seek to reduce flood-related damages by either relocating, floodproofing, or elevating homes and businesses located in flood-prone areas.

Based on hydrologic and hydraulic modeling results, a flood hazard assessment was conducted for areas downstream of the Rexmere dams that are expected to be affected by a range of dam breach scenarios. This assessment was undertaken to determine if the current hazard classification for the dams is appropriate or if seeking reclassification may be warranted. Recommendations are provided for improvements and modifications that would bring these dams up to modern dam safety standards per NYSDEC regulations.

4.1 Bridge and Culvert Enhancement Assessment

Roosevelt Avenue – WBDR – Village of Stamford, New York

Roosevelt Avenue is a 1,500-foot-long thoroughfare that connects with River Street and Main Street in the northwestern part of the village. The structure that spans the WBDR at this site is a CON/SPAN concrete bridge that measures 20 feet wide and approximately 5 feet high (Figure 4-1). The NYS Highway Bridge Database for Delaware County lists the crossing as being county owned, built in the year 2012, and structurally in good condition. There were no reports from the public of the Roosevelt Avenue bridge or roadway overtopping during past storm events.

An existing conditions hydraulic simulation of the crossing shows this bridge passing the 10-, 25-, and 50-year peak discharges. During the 100-year storm, the model suggests that the bridge is flanked to its right, and the adjacent roadway is anticipated to be covered with roughly 3.5 inches of water. Removing the bridge from the hydraulic model is shown to have significant reductions in water surface elevations for the 100-year storm event only, resulting in a 2.0-foot reduction at the crossing. This reduction diminishes moving upstream approximately 370 feet and is fully contained within the stream channel. This is illustrated in Figure 4-2.

Figure 4-1: Roosevelt Avenue over WBDR (looking downstream at culvert inlet)

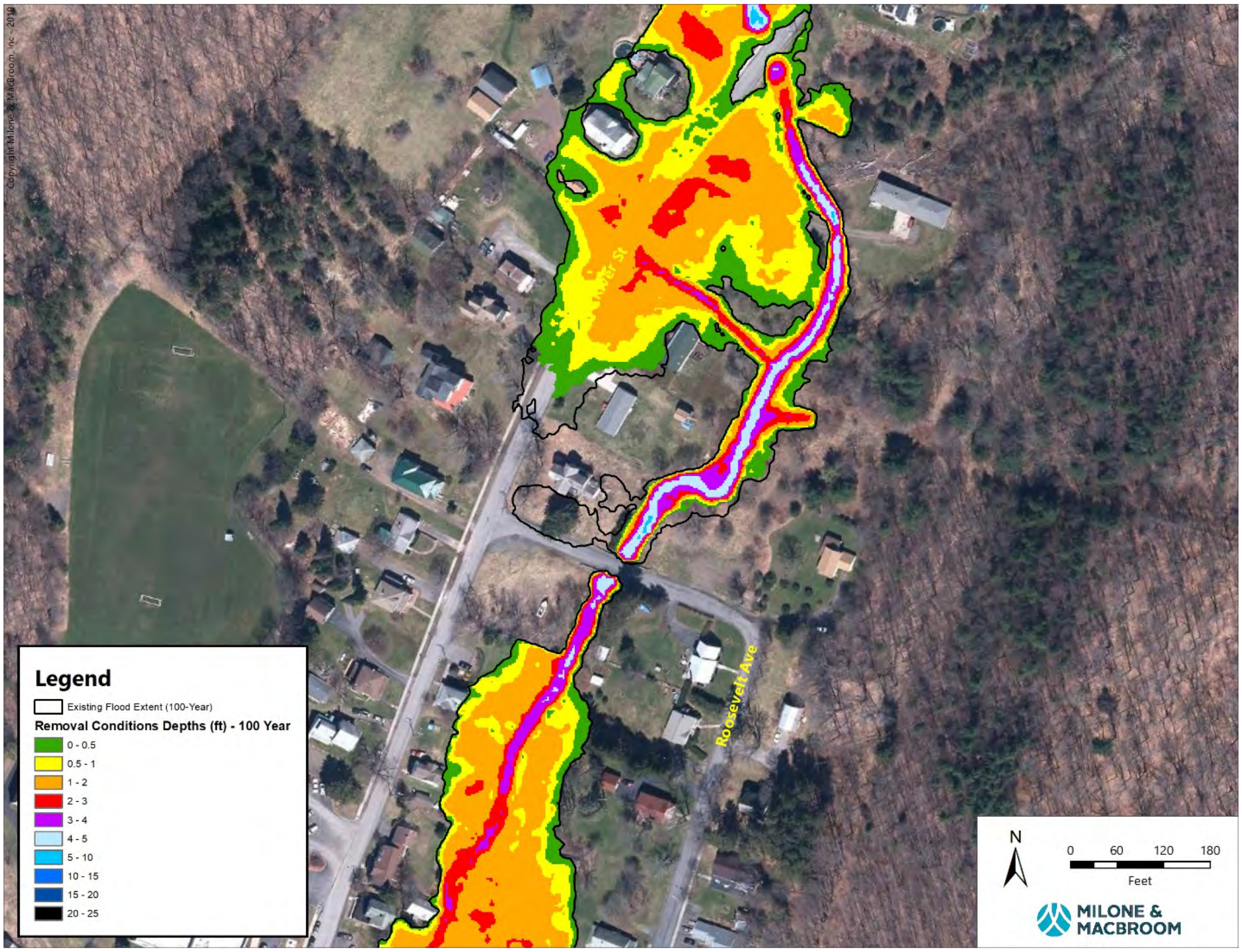

Figure 4-2: Roosevelt Avenue bridge removal depth grids and existing flood extent (100-year)

Considering that the Roosevelt Avenue culvert was recently constructed and that it does not contribute to flooding of upstream properties, no further recommendations aside from regularly scheduled maintenance and inspection are proposed for this structure.

NYS Route 23 (Main Street) – WBDR – Village of Stamford, New York

Route 23 is an east-west state highway that traverses the Catskill Mountains and serves as a central thoroughfare for many rural communities in the area. In Stamford, Route 23 runs through the center of the village and functions as the village's Main Street with businesses and residences located on either side of the road. The structure that carries Main Street over the WBDR is a four-sided concrete box culvert that measures approximately 18 feet wide by 4 feet high (Figure 4-3).

Hydraulic modeling indicates that the current structure can sufficiently convey the 10-, 25-, and 50-year discharges but is expected to overtop during the 100-year peak flow. Existing conditions depth grid mapping of the adjoining area revealed that the backyards of homes located to the east and west of the WBDR main stem are inundated as frequently as the 10-year peak discharge (Figure 4-4).

Removing the culvert in the hydraulic model resulted in reductions in water surface elevations of approximately 0.3 feet for the 10-, 25-, and 50-year discharges. During the 100-year storm event, the 'no crossing' analysis showed water surface elevation reductions of approximately 0.5 feet, which extend upstream for about 500 feet before fully diminishing. This modest drop in flood depth for the 100-year storm did not result in significant reductions in the lateral extent of inundation for the surrounding area.

Figure 4-3: Main Street culvert over WBDR (looking downstream at culvert inlet)

Figure 4-4: Main Street bridge removal depth grid and existing flood extent (100-year)

Interpretation of the results discussed above suggests that the existing structure is not the sole contributor to the flooding that was mentioned at this reach of the upper WBDR. In fact, a combination of factors, including the conveyance capacity of the active channel and development along the well-connected floodplain, exacerbates flooding problems in this area.

Multiple replacement culvert sizes and configurations were evaluated. It was determined that a concrete box culvert with a 22-foot horizontal span and a 6-foot height would pass the 100-year storm discharge. This configuration would require that the channel immediately upstream and downstream of the culvert be reconstructed to enhance conveyance. Channel work would entail widening and deepening sections of stream to achieve a larger active channel for approximately 220 feet upstream and 175 feet downstream of the crossing. Additionally, the creation of a floodplain bench along the existing parking lot would be necessary to provide additional flood depth alleviation without overwidening the channel. A more detailed hydraulic assessment is recommended in order to appropriately size a multistage compound channel that includes a properly sized low-flow channel, a main bankfull channel, and floodplain.

South Street – WBDR – Village of Stamford, New York

The existing structure carrying South Street over the WBDR is a concrete arch culvert with a 9.1-foot maximum horizontal span and an approximately 4.2-foot vertical opening. It appears to have been cast in place. The culvert inlet consists of a concrete headwall, covered with several inches of earthen fill, and poorly aligned stacked stone wingwalls that extend upstream along the banks of the main channel (Figure 4-5). Anecdotal accounts suggested that this culvert is prone to overtopping during severe storm events; one resident emphasized that this was the case during the flood of 1996.

Figure 4-5: South Street culvert inlet (looking downstream at upstream headwall)

Figure 4-6: South Street culvert outlet (looking upstream through culvert)

From a visual standpoint, the structure looks to be in very poor physical condition, exhibiting several sites of spalling concrete both inside the culvert barrel and on the exterior headwalls (Figure 4-6). In December 2019, the Stamford Village Mayor announced that South Street would no longer be a through street due to the formation of a sinkhole directly above the structure near the culvert outlet. Upon closer examination, it appeared that the fieldstone aggregate and cement that had been used to form the culvert were deteriorating.

Hydraulic modeling indicates that the current structure has the capacity to convey only the 10-year peak discharge and overtops at all greater flows. A 'no crossing' simulation demonstrated that the culvert under South Street gravely obstructs stream flow conveyance and contributes to major energy losses. For the 25-, 50-, and 100-year discharges, removal of the existing structure would result in water surface elevation reductions of roughly 2.5 feet at the culvert extending upstream for roughly 250 feet before diminishing. As illustrated in Figures 4-7 and 4-8, the resulting reductions in flood depths would prevent floodwaters from breaking over the stream banks during the 25-year and 50-year storms, eliminating the inundation of the left adjacent roadway.

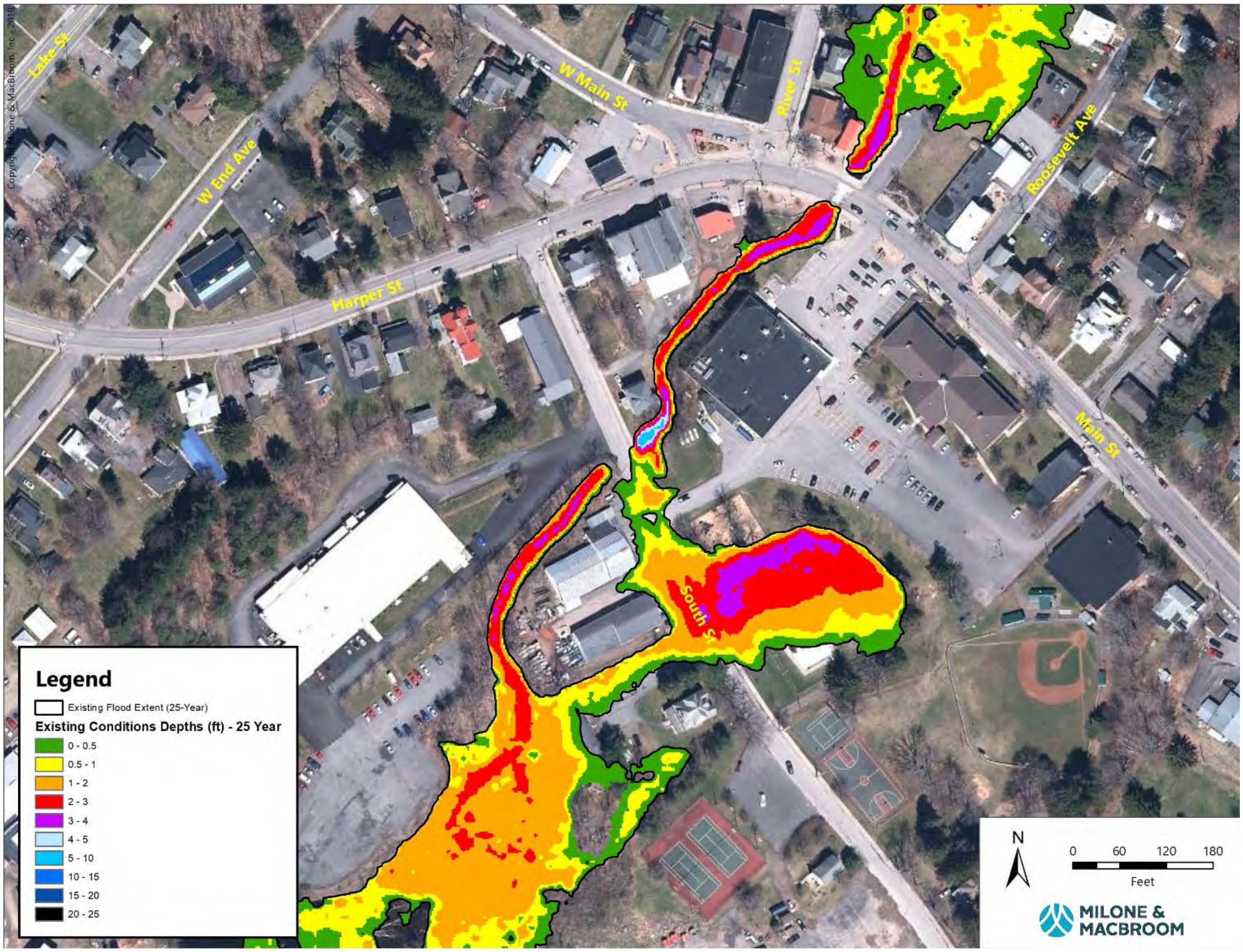

Figure 4-7: Existing conditions depth grid mapping of South Street culvert (25-year)

Figure 4-8: Depth grid mapping of South Street culvert removal (25-year)

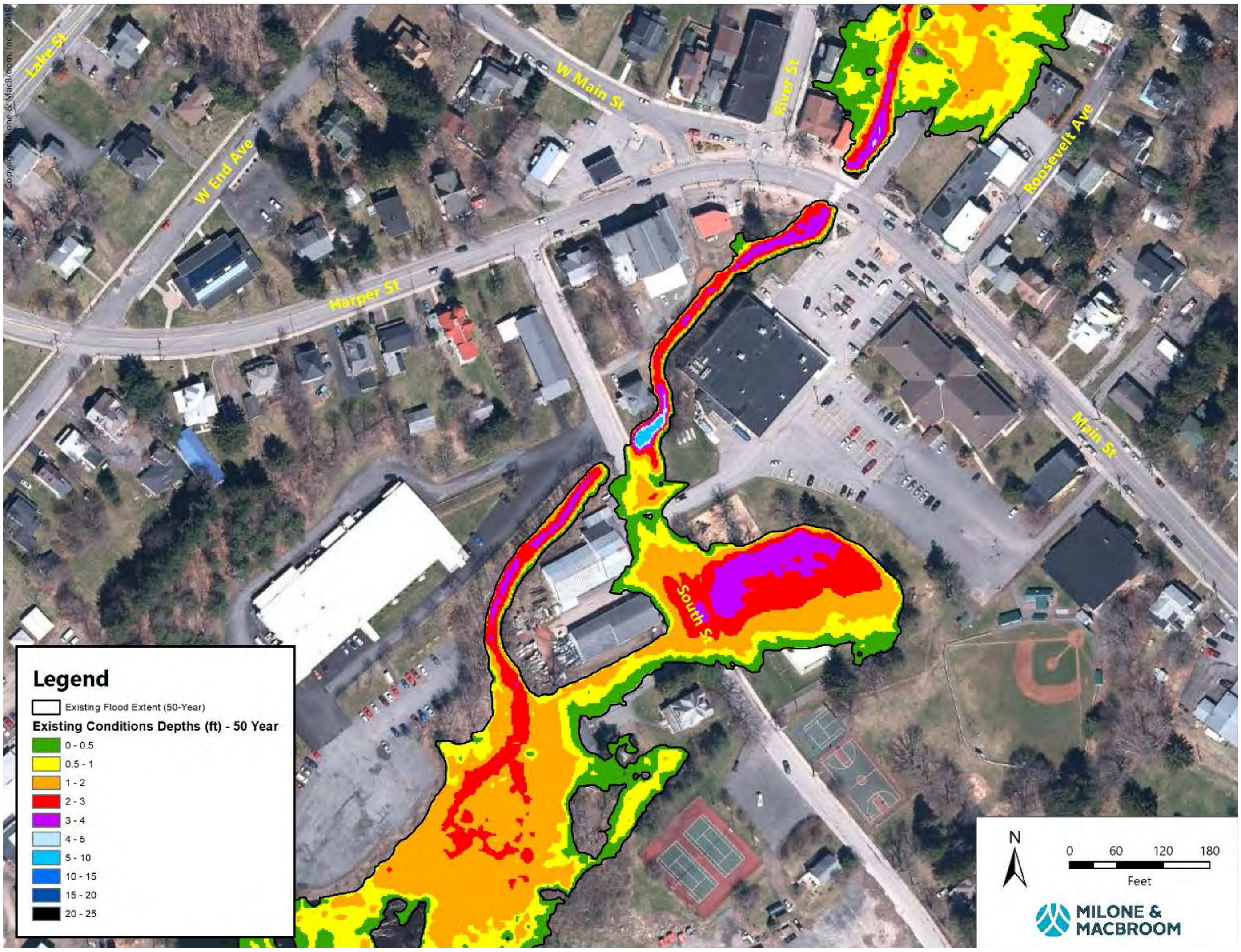

Figure 4-9: Existing conditions depth grid mapping of South Street culvert (50-year)

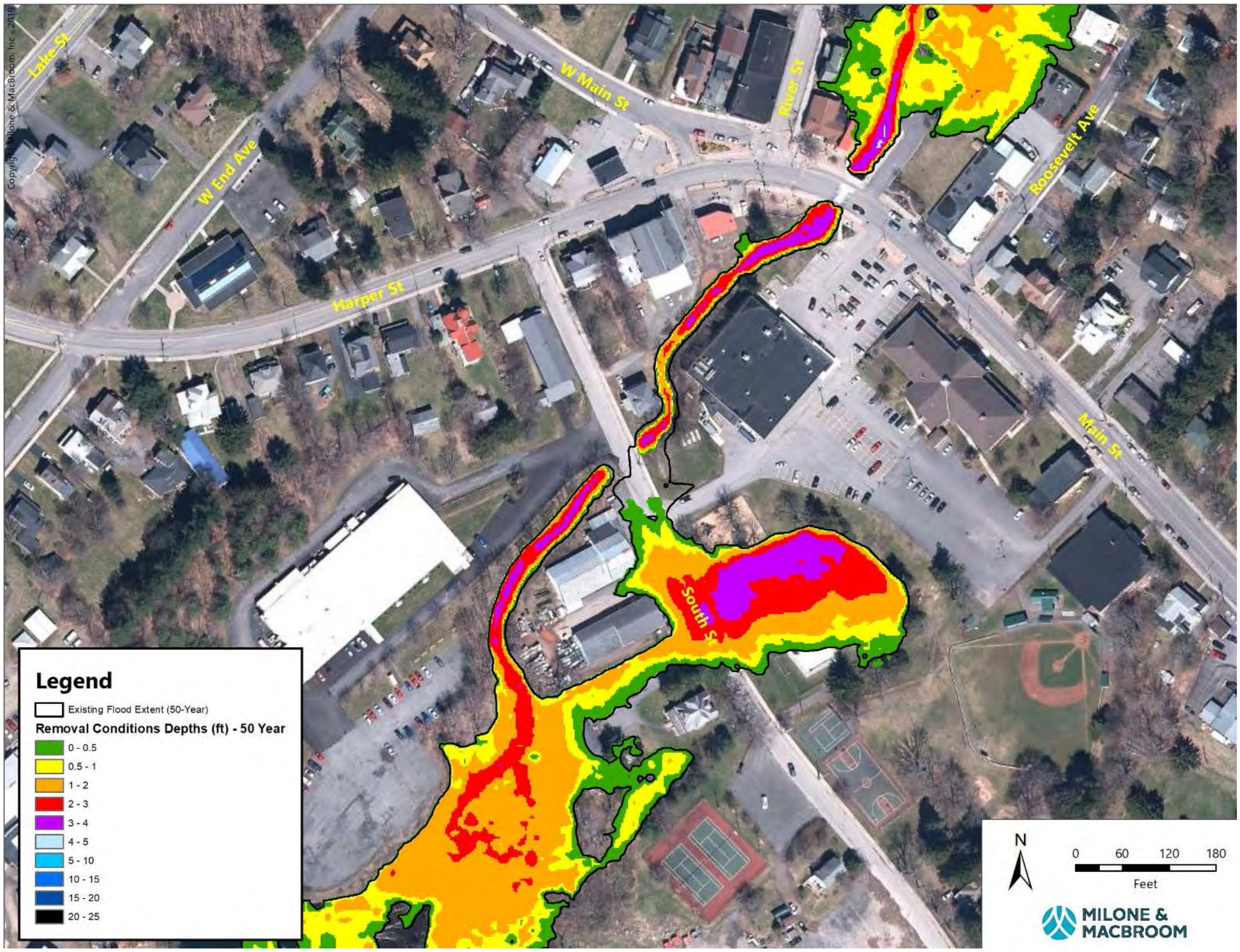

Figure 4-10: Depth grid mapping of South Street culvert removal (50-year)

Similarly, for the 100-year storm event, removal of the South Street culvert from the hydraulic model suggests that significant reductions in floodwater surface elevations are possible upstream of the structure. Depth grid mapping for the no-crossing scenario indicates that the house located immediately upstream of the culvert on the right overbank would no longer be inundated during the 100-year storm (Figures 4-11 and 4-12).

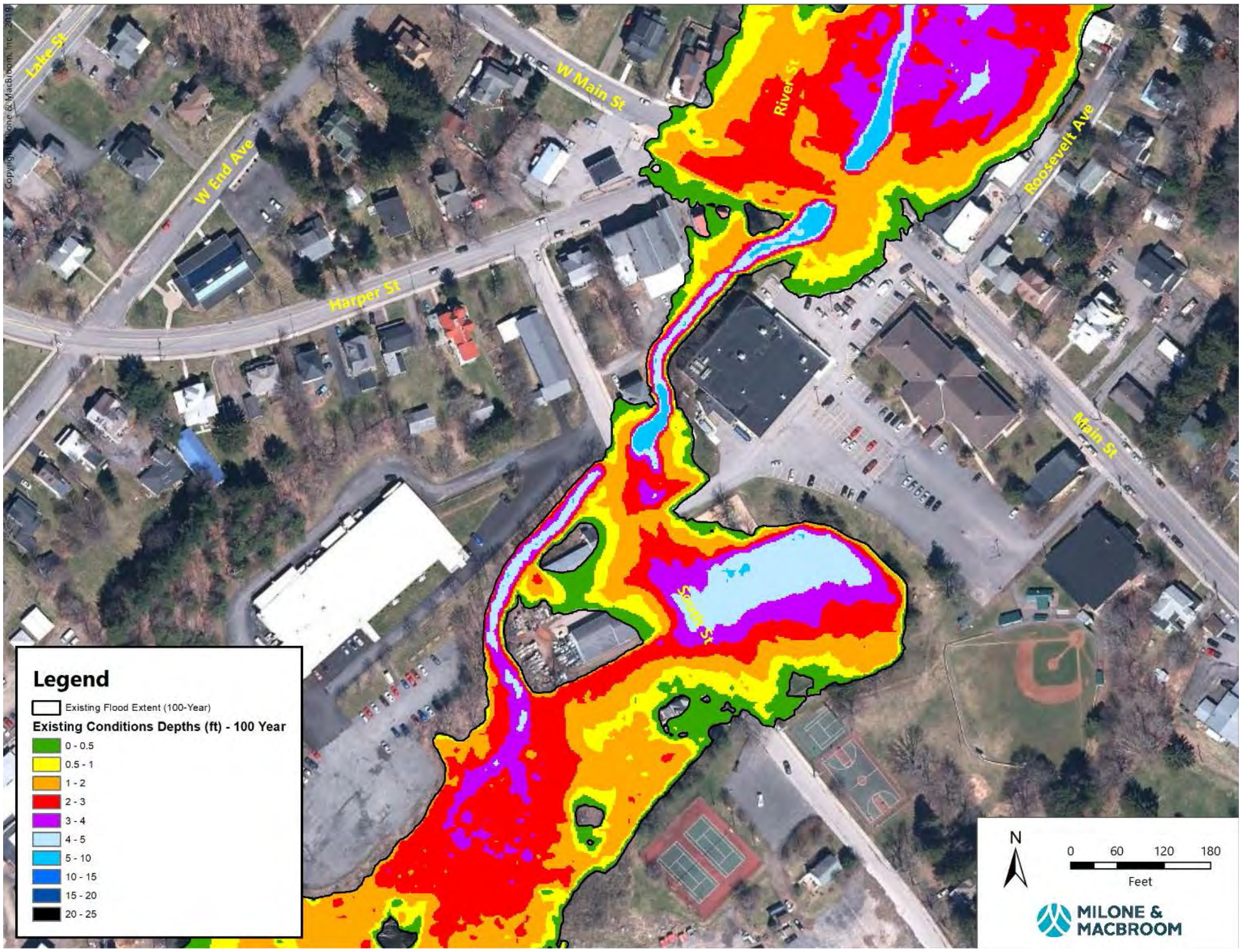

Figure 4-11: Existing conditions depth grid mapping of South Street culvert (100-year)

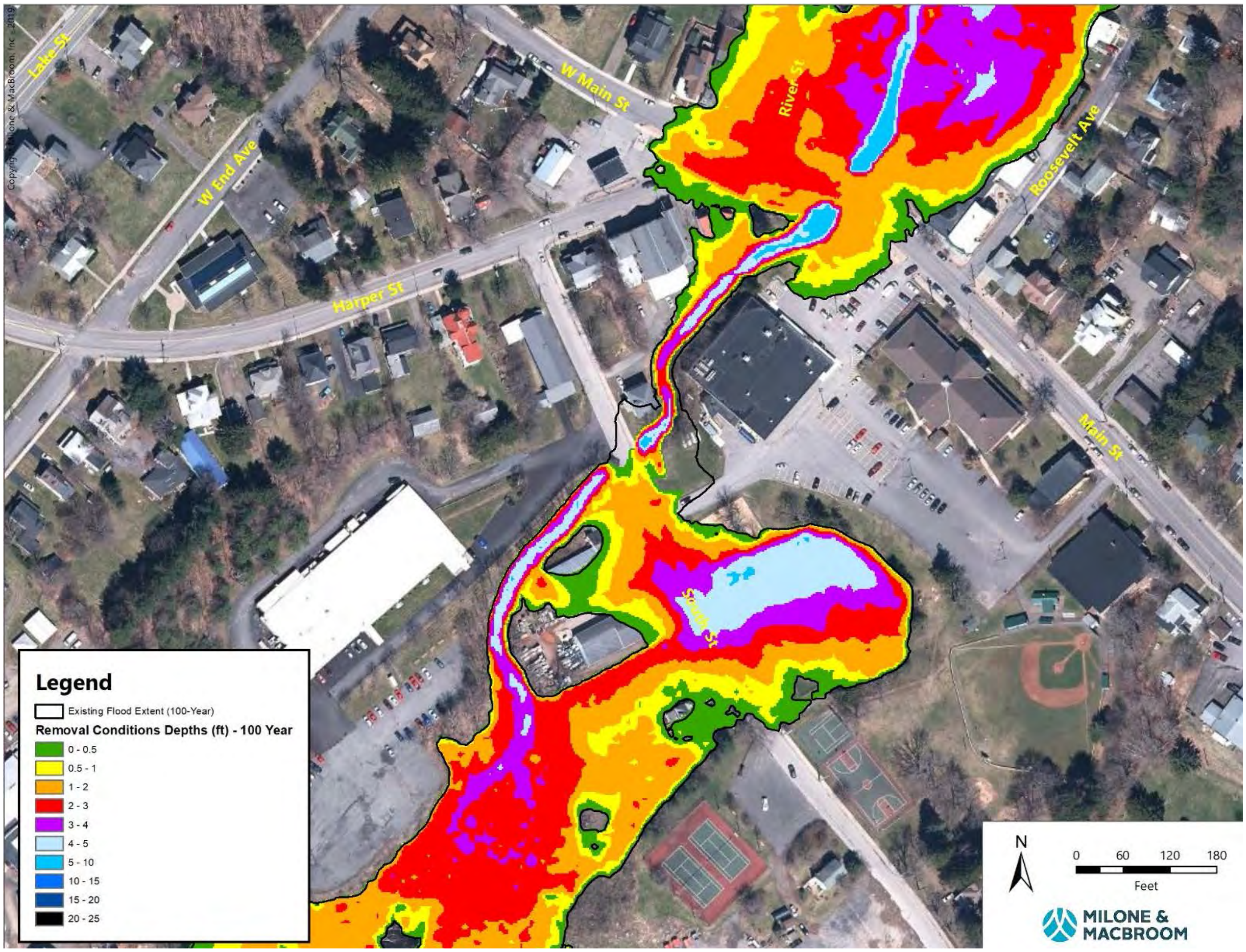

Figure 4-12: Depth grid mapping of South Street culvert removal (100-year)

One proposed conditions simulation investigated the effects of a 20-foot-span by 5-foot-rise box culvert able to convey the 100-year peak discharge. This configuration assumed that the subsequent sections of channel upstream and downstream of the culvert would be adjusted to help enhance conveyance. The project would also include realignment of the channel or culvert to ensure that there is no longer a degree of skew between the culvert opening and the direction of flow, which currently reduces the hydraulic opening capacity of the structure. It is recommended that a detailed hydraulic assessment be conducted in order to properly size a multistage compound channel that includes a properly sized low-flow channel, a main bankfull channel, and floodplain.

Alternatively, it was determined that a 12-foot-span by 5-foot-rise box culvert would be able to pass the 50-year peak discharge. This configuration has less capacity but would not require significant modifications of the adjacent sections of stream. This culvert would satisfy NY DOT culvert design guidelines for permissible headwater depth to culvert height ratio of less than one. Per DOT guidelines, peak flow values were increased by 20 percent to account for projected future peak flows at the replacement structure. Hydraulic modeling indicated that this structure would also be adequately sized to convey the future 50-year discharge. Estimated implementation costs are discussed in Section 5.0.

Catskill Scenic Rail Trail – WBDR – Village of Stamford, New York

The Catskill Scenic Rail Trail (CSRT) runs approximately 26 miles from Grand Gorge, New York, to Bloomville, New York. Formerly the Ulster and Delaware Railroad right-of-way, the rail line is now an established trail for year-round recreational purposes. The steel beam rail trail bridge over the WBDR main stem has a 30-foot span and approximately 7 feet of vertical clearance. The hydraulic model shows the existing structure as passing all the modeled peak flows and indicates that the structure is not acting as a severe hydraulic constriction at this location. The lack of development immediately upstream of the bridge makes this crossing less of a priority; therefore, no further recommendations aside from regularly scheduled inspections and maintenance are proposed in this report.

Figure 4-13: Upstream rail trail bridge face (looking downstream)

Railroad Avenue – WBDR – Village of Stamford, New York

The structure that spans the WBDR along Railroad Avenue is a CON/SPAN arch bridge that measures 20 feet wide by about 5 feet high. Like the Roosevelt Avenue bridge, this crossing is also county owned, was installed in the year 2012, and is listed as being in good structural standing as of its last inspection in September 2018. Residents did not report any past flooding issues at this crossing.

Figure 4-14: Railroad Avenue outlet (looking downstream)

The baseline conditions model shows this bridge passing the 10-, 25-, and 50-year peak flows. The predicted water surface elevation for the 100-year discharge is shown to be just barely overtopping the adjacent roadway to the right. During such an event, the bridge and road embankment backwater flows for approximately 175 feet upstream; however, there are no flood-prone properties situated within the resulting inundation extent (Figure 4-15). Given the relatively new bridge crossing and the fact that there is no development upstream that is impacted by the backwaters, there are no further recommendations for the Rail Avenue bridge aside from regularly scheduled inspection and maintenance. In addition, if the roadway were to overtop during a flood event, it is recommended that the village temporarily close the thoroughfare and implement effective signage for alternative routes. A 2.0-mile detour is available to residents situated on Railroad Avenue if the roadway were to be closed during a major storm. Recommendations are summarized in Section 6.0.

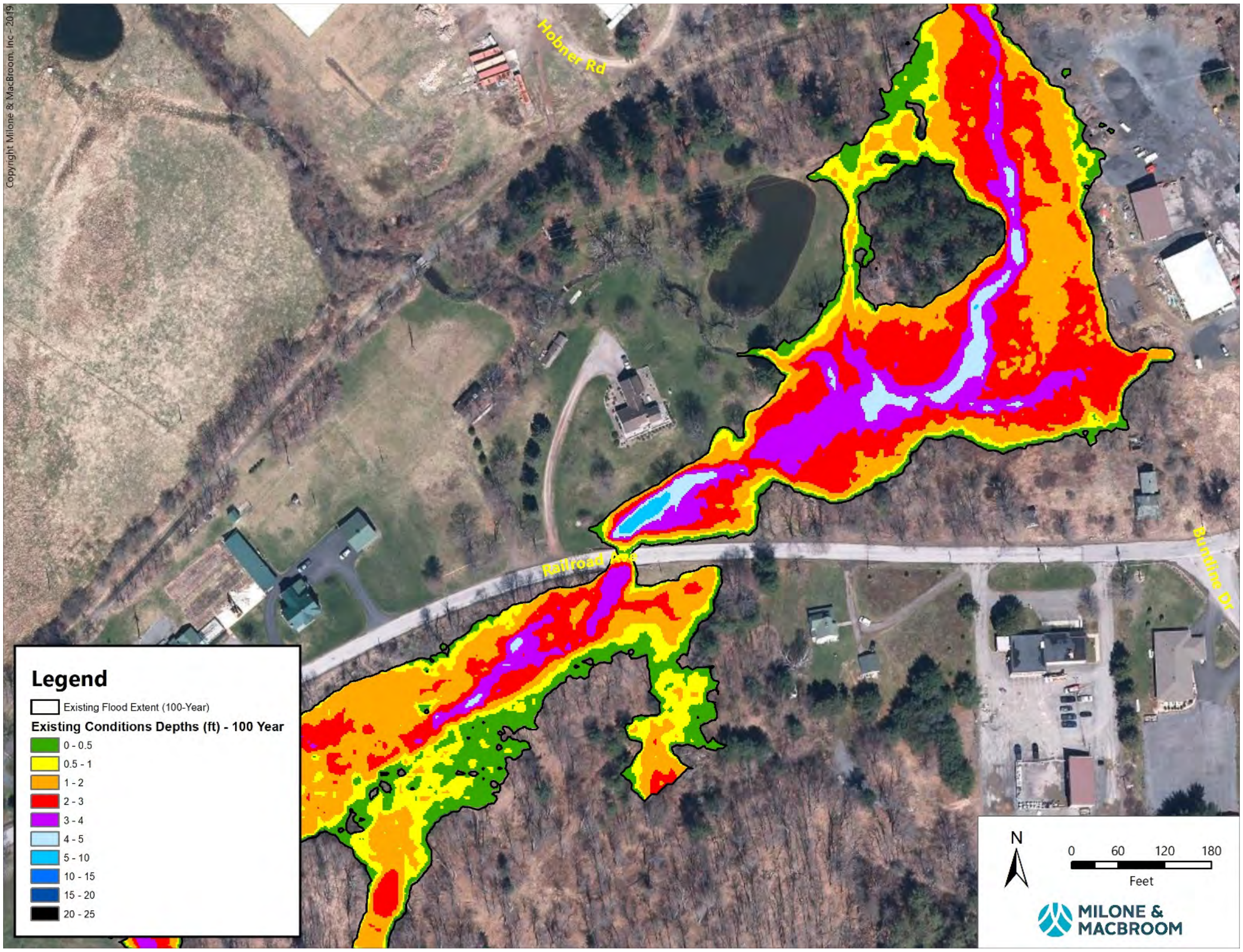

Figure 4-15: Railroad Avenue existing 100-year flood extent and depths

Graham Drive – WBDR T1 – Village of Stamford, New York

WBDR T1 is carried under Graham Drive in two metal corrugated pipes that measure 2 feet and 3.5 feet in diameter (Figure 4-16). The existing structure inlets are covered with a few inches of fill material, abutted with poorly aligned stacked stone wingwalls, and run underground for approximately 214 feet. Graham Drive is a dead-end road that serves as the only means of access to an apartment complex situated due east of the crossing. There are no detours available in the event of a flood. Discussions at FAC meetings indicate that the roadway floods at this location from time to time.

Figure 4-16: Graham Drive culvert outlets (looking upstream)

The model showed the existing culvert overtopping during the 10-year discharge and all greater modeled peak flows. Flood depths on the roadway range from 0.3 feet to 3.0 feet for the 10-year and 100-year discharges, respectively. The model also outlined that the hydraulics at this structure are heavily influenced by the backwaters produced downstream by the culvert under Buntline Drive. This indicates that action at Buntline Drive is preferred first before considering mitigation alternatives at Graham Drive. The following analysis at Graham Drive assumes that the necessary flood reduction measures have been implemented at Buntline Drive.

Replacing the culverts with an 8-foot-span by 4-foot-rise box culvert with flared wingwalls would convey the 100-year peak discharge. This simulation investigated replacing the entire 214 linear feet of pipe with a single box culvert while all else was held constant such as the culvert invert elevations and channel alignment. It is recommended that the village explore additional configurations and conduct a detailed hydraulic and hydrologic analysis for the replacement structure. Considering the anticipated frequent flooding of the roadway and that it could cut off emergency access to residents of the complex on the other end, high priority should be given to this crossing. Additionally, as discussed in the subsequent section, it is recommended that any actions at Graham Drive be taken only after flood relief measures are implemented at Buntline Drive first or in a way that accounts for proposed future improvements if other constraints preclude the preferred order of replacements. A summary of recommendations and the preferential sequence of design execution is discussed in Section 6.0 of this report.

Buntline Drive – WBDR T1 – Village of Stamford, New York

The existing culvert under Buntline Drive carrying Unnamed Tributary 1 to the WBDR is a 4-foot-diameter, 69-foot-long corrugated metal pipe projecting from fill (Figure 4-17). Historical aerial photography indicates that the road was introduced sometime after the 1960s to serve as a direct thoroughfare between Railroad Avenue and South Delaware Street in the southeast portion of the village. The roadway runs perpendicularly to the direction of flow of the WBDR T1, across a registered DEC wetland, where the existing culvert functions as the only means of river connectivity through the earthen embankment. Public narrative suggests that this culvert is susceptible to debris jams and requires frequent upkeep.

Figure 4-17: Buntline Drive culvert carrying WBDR T1 (looking downstream at projecting culvert outlet)

The FEMA effective hydraulic model indicated that the existing culvert can only contain the 10-year discharge, with all greater flows overtopping the roadway to the right. The embankment and the inadequately sized culvert significantly backwater flows for approximately 900 feet upstream, which influences the hydraulics at Graham Avenue by creating a tailwater condition. Properties situated upstream along the right overbank are predicted to experience flooding in their backyards as frequently as the 25-year peak discharge. Flooding extents become worse as the flows increase and eventually lead to these homes and the adjoining portion of Railroad Avenue being inundated during the 100-year storm. In this event, flow divergence over a topographically low spot on Railroad Avenue is anticipated to occur where water splits from the tributary and flows toward the WBDR main stem. This flow path resembles the former alignment of WBDR T1 before it was directed southward and placed under Buntline Drive.

The full removal of Buntline Drive is highly unlikely and unfavorable to the community; therefore, analysis of a 'no crossing' condition was not considered for this structure. Rather, an assessment of alternative structures was evaluated at this location for the purpose of improving conveyance and mitigating upstream flooding of nearby homes. It was determined that installing two corrugated metal relief culverts would greatly reduce water surface elevations upstream of the structure by over 3 feet for the 100-year discharge. Implementation of these relief structures would likely be accomplished by boring through the embankment to install the extra pipes to avoid disturbing the roadway and buried utilities. The inverts of the new structures can be set just slightly above the existing to prevent complete drawdown of the upstream wetland.

Replacing the existing structure with a 10-foot-span by 4-foot-rise box culvert was also investigated. The proposed hydraulic simulation showed that this scenario would lead to additional flood depth reductions of 1.5 feet compared to the previous scenario, or 5.0 feet when compared to the existing conditions model for the 100-year peak flow. The proposed box culvert would greatly reduce inundation extents upstream of Buntline Drive as illustrated in Figure 4-18.

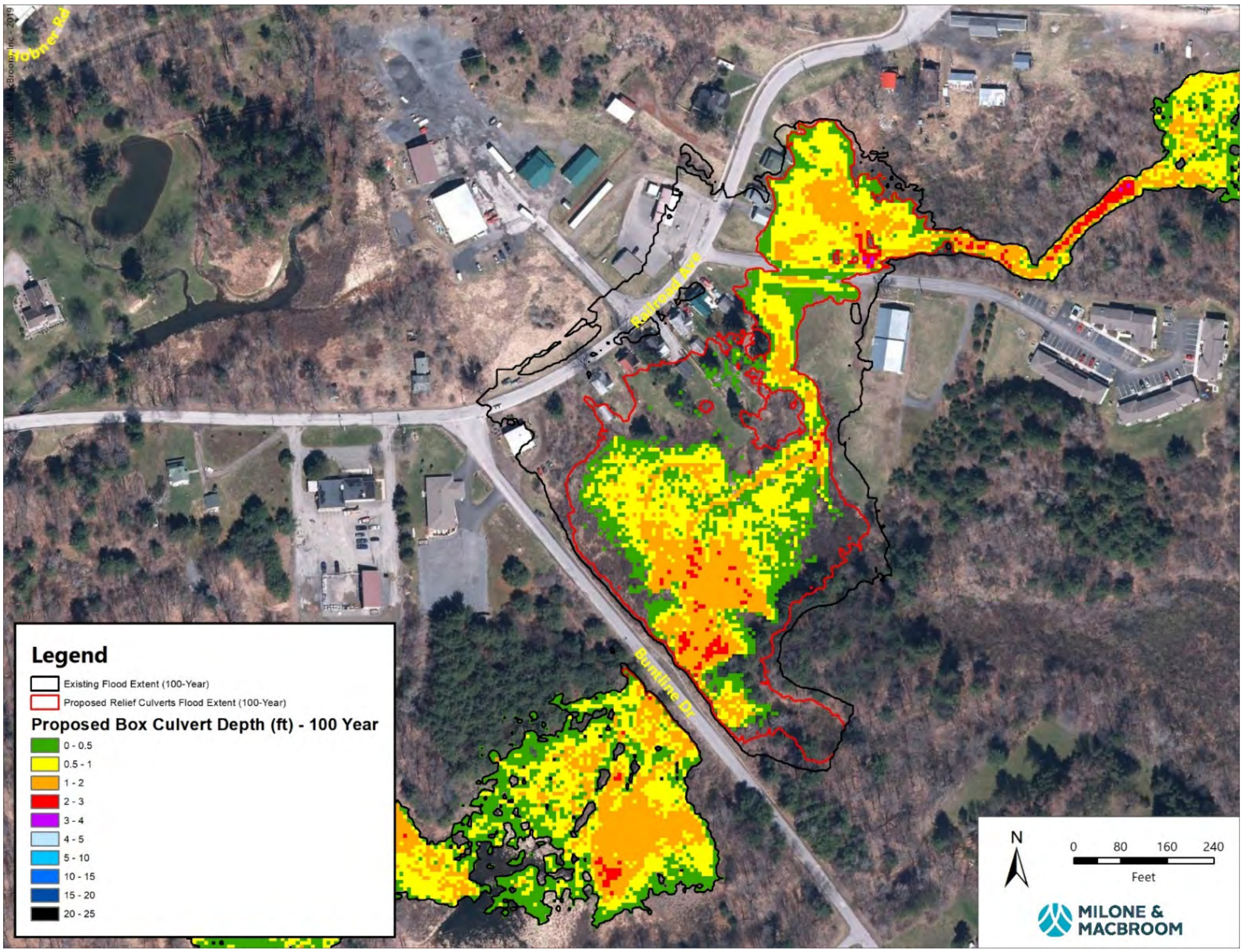

Figure 4-18: Depth grid mapping for modeled box culvert under Buntline Drive with proposed twin relief culverts and existing conditions flood extents superimposed (100-year discharge)

Considering the widespread flooding resulting from the hydraulic inadequacy of the culvert under Buntline Drive and that it greatly impacts the situation at Graham Drive, high priority should be given to executing a long-term solution that will diminish headwater depths during severe storm events. A full hydraulic and hydrologic study is recommended for the approach that the village wishes to pursue and should ideally be sequenced from downstream to upstream, beginning at Buntline Drive and moving upstream to Graham Drive.

Cornell Avenue – WBDR – Village of Hobart, New York

The Cornell Avenue steel girder bridge over the WBDR measures 31 feet long and has an approximately 10-foot-high opening. The bridge's abutments have been armored with sheet piling. Built in 1980, the conduit has served village of Hobart residents as one of the two ways for getting across the WBDR at this location. According to the 2020 NY State Highway Bridge Data for Delaware County, the Cornell Avenue bridge was last inspected in spring 2019 and is listed as being in overall good condition. There are no reports of prior flooding at this bridge crossing.

Figure 4-19: Cornell Avenue bridge upstream opening (looking downstream)

The hydraulic model shows the existing structure passing all of the modeled peak discharges up to the 100-year storm with 3.0 feet of freeboard. Under the 'no crossing' scenario, water surface elevation reductions of about 1 foot on average were shown in the hydraulic model for the 50-year and 100-year discharges, extending 2,000 feet upstream before fully diminishing. However, upstream of the bridge, there is almost no development on the floodplain, and the decreases in flood depths do not benefit anyone in the upstream locality. The overall structural soundness of the bridge in conjunction with the lack of flooding upstream makes this crossing a low priority. When the bridge is due for replacement, it is recommended that a detailed hydraulic and hydrologic study be performed to properly size the new structure. Recommendations are summarized in Section 6.0 of this report.

Maple Avenue – Grant Brook – Village of Hobart, New York

Maple Avenue is a central roadway that branches off Route 30 at the center of the village, traversing over the WBDR and Grant Brook moving southeast and eventually becoming Township Road as it exits the village boundary line. The existing culvert under Maple Avenue carrying Grant Brook is a 5-foot-diameter smooth metal pipe (Figure 4-20) abutted with a stacked stone headwall and wingwalls. In the event of a severe flood that would lead to closure of Maple Avenue, a 4.0-mile detour is available to residents located on either end of the crossing.

There were no reports from the public of flooding at this location although the hydraulic model shows this crossing as being severely undersized, only capable of conveying the 10-year peak discharge and overtopping at all greater flows. The model also indicates that the two upstream homes nearest to the stream could see flooding as frequently as the 25-year storm. Two additional homes are shown to flood during the 100-year storm, making a total of four residences upstream of the culvert that are mapped within the 100-year floodplain.

Figure 4-20: Maple Avenue culvert inlet (looking downstream at upstream headwall)

Figure 4-21: Maple Avenue culvert outlet (looking upstream at downstream headwall)

Removal of the culvert from the hydraulic model reduced flood depths upstream of the crossing by approximately 6.0 feet. Reductions in flooding extend for over 400 linear feet upstream before fully diminishing. The results from this simulation run removed residential buildings to the east and west of the stream from the inundation zones for the 25-, 50-, and 100-year storms. Depth grid mapping of the 100-year storm event under existing conditions and with the culvert removal are shown in Figures 4-22 and 4-23, respectively.

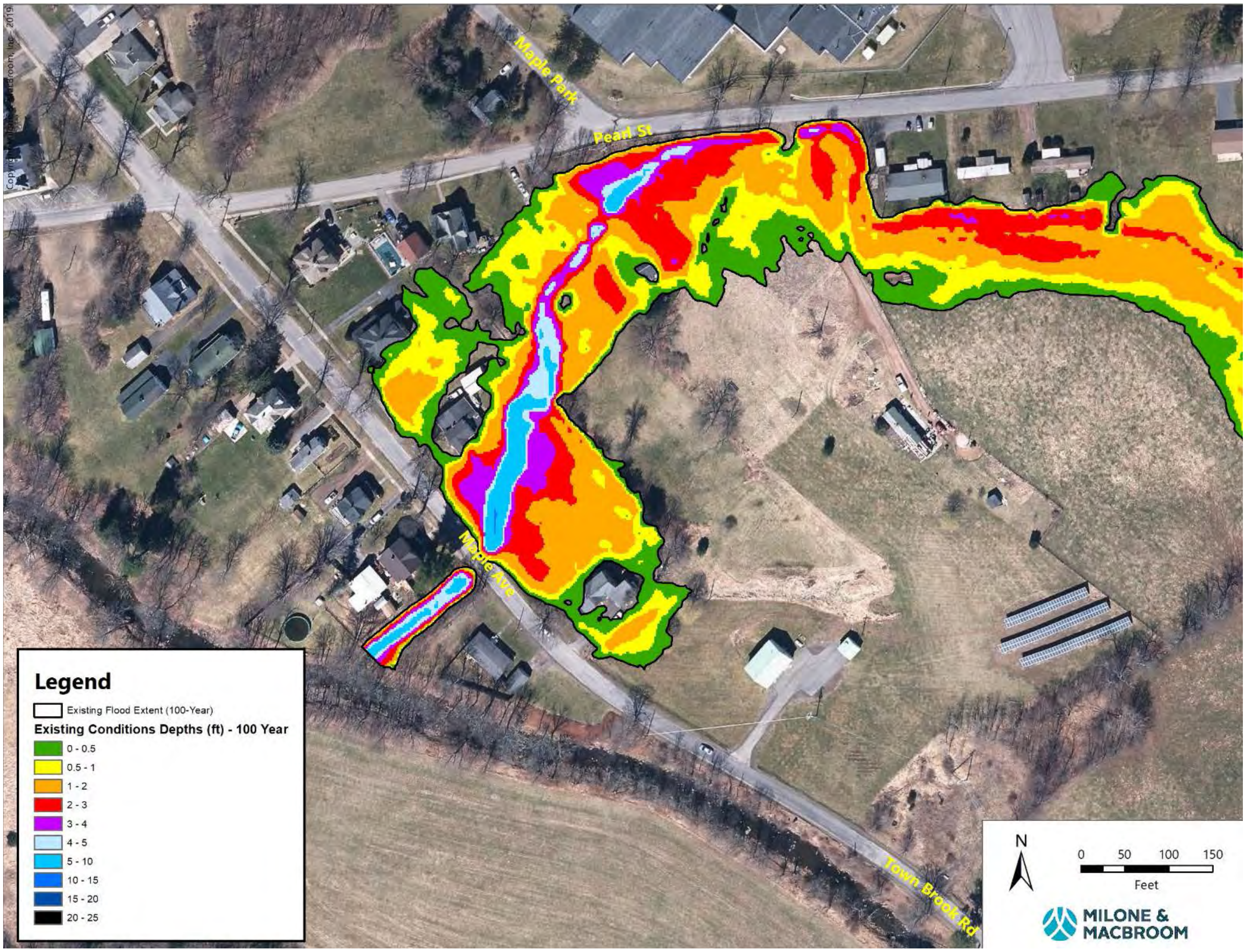

Figure 4-22: Maple Avenue culvert existing conditions depth grid mapping (100-year flood)

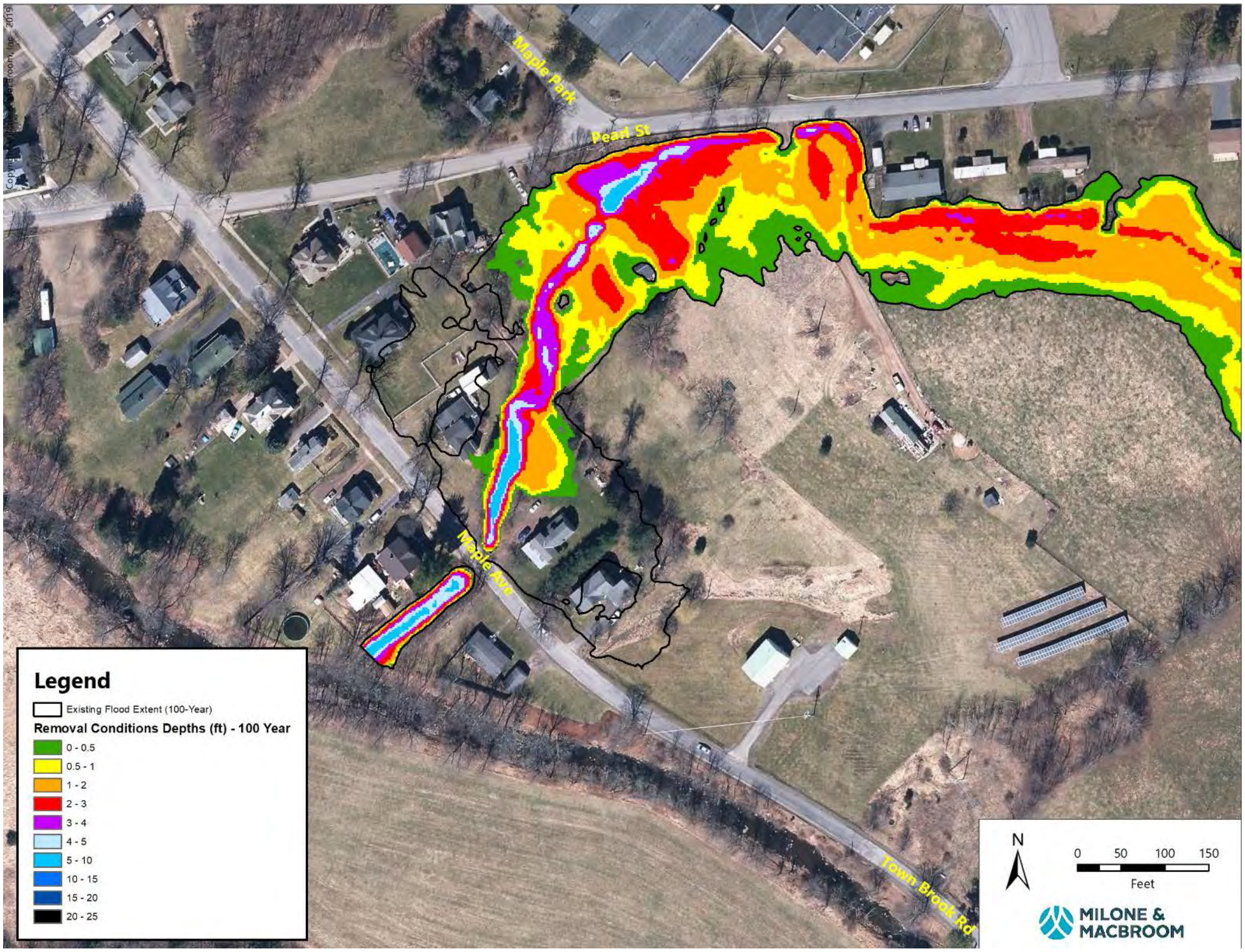

Figure 4-23: Maple Avenue culvert removal analysis depth grid mapping (100-year flood)

Multiple hydraulic simulations for replacement structures were investigated in order to avoid overtopping of the roadway during events of higher magnitude than the 10-year discharge. The following replacement simulations were determined to significantly mitigate flooding at this location:

1. A 7-foot-diameter metal corrugated pipe to pass the 50-year discharge with an allowable headwater depth to culvert height ratio in accordance with NYSDOT standards
2. A 10-foot-span, 7-foot-high box culvert to convey the 100-year storm in accordance with Delaware County stream crossing replacement protocol

Either scenario would be equally as effective at containing floodwaters within the channel during the 25-year and 50-year events. The proposed 7-foot culvert would help reduce but would not eliminate water from overtopping the roadway and backwaters from affecting the nearby homes during the 100-year storm. The 10-foot by 7-foot concrete box culvert would contain the 100-year flood in the channel and is expected to remove the four homes from the 100-year mapped floodplain. A rigorous hydrologic and hydraulic analysis for a replacement culvert is recommended.

Catskill Scenic Rail Trail – Town Brook – Village of Hobart, New York

The steel girder bridge on the CSRT crosses Town Brook about 13 feet above the channel bed and measures approximately 67 feet in total width, with a center pier separating two spans. During the information-gathering process of the LFA, there was no mention of flooding issues or concerns at this crossing. In addition, as shown in Figure 4-24, there are no flood-prone structures situated within the expected FEMA SFHAs.

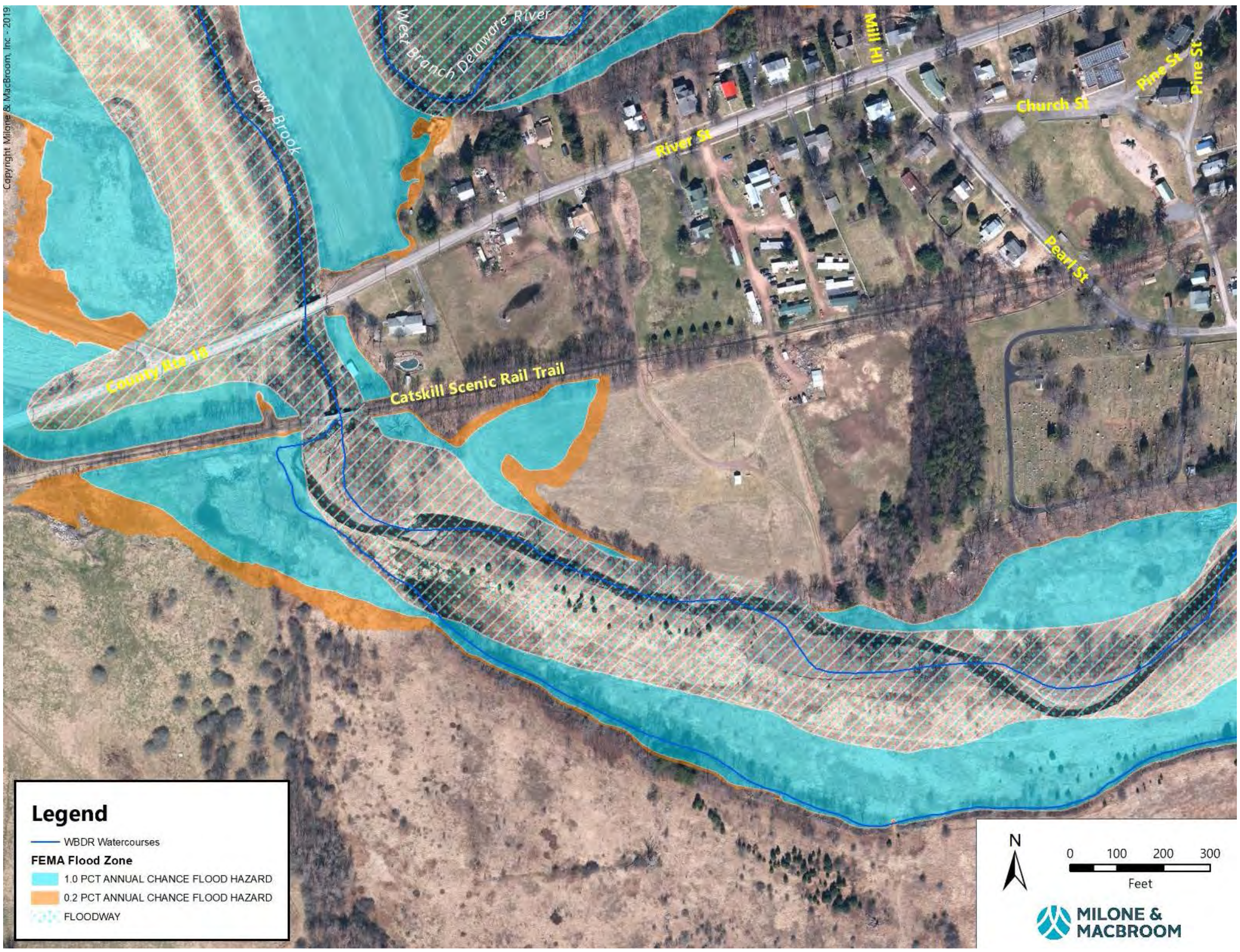

Figure 4-24: FEMA-designated SFHA upstream of the CSRT bridge

The effective FEMA hydraulic model shows the bridge passing all modeled peak discharges with ample freeboard. A hydraulic run without the bridge and bridge pier in the model displayed drops in water surface elevation of 2.5 feet immediately upstream of the structure for the 50-year and 100-year peak flows, which carried upstream for about 1,200 feet. These reductions in water surface elevations resulted in minor changes to the overall extent of flooding upstream of the crossing due to the broad valley bottom that is fully inundated as early as the 10-year discharge. This crossing is given low priority because of the lack of development upstream and because it is solely used for recreational purposes. Aside from routine maintenance and inspection of the bridge structure, there are no further recommendations.

Hobart River Street (County Route 18) – Town Brook – Village of Hobart, New York

Hobart River Street, also known as County Route 18, is located 225 feet downstream of the Catskill Rail Trail bridge discussed above. Built in 1961, the steel multibeam bridge crossing has a 50-foot span with an estimated 8.0-foot vertical clearance. The 2019 NYSDOT bridge inspection report gave the structure an overall rating of '5' or "...good conditions and [does] not need major repairs."

Figure 4-25: Downstream bridge face

The existing structure can fully convey the 10-, 25-, and 50-year discharges with adequate freeboard. For the 100-year discharge, the bridge low chord is drowned, and flows are pressurized. This condition may lead to or exacerbate existing abutment scour hazards. The latest bridge inspection report (2019) gave the structure a scour critical rating of 4, meaning the foundation is considered stable under current conditions but that action is required. Floodwaters are also shown to flank the structure to its left at this flow, covering the adjacent roadway with 0.5 to 2.3 feet of water (Figure 4-26). Waters appear to be constricted by the bridge abutments, which causes a rise in upstream water surface elevation, eventually to the point that they break over the left bank. Floodwaters spill over a low spot along a dirt road where they travel north across River Street and onto nearby farm fields. Removal of the structure lowers the water surface elevations by upwards of 2.0 feet upstream, but this does not prevent water from escaping the channel and flooding River Street with 0.5 to 1.3 feet of water.

Besides flooding of the road during large storm events, the River Street bridge does not contribute to flooding of any nearby properties. Immediate action at this crossing is not a priority for the town; rather, it is recommended that regular inspection and maintenance be continued. Proper road signage and blockage should be implemented during major storm events where floodwaters could possibly inundate the roadway.

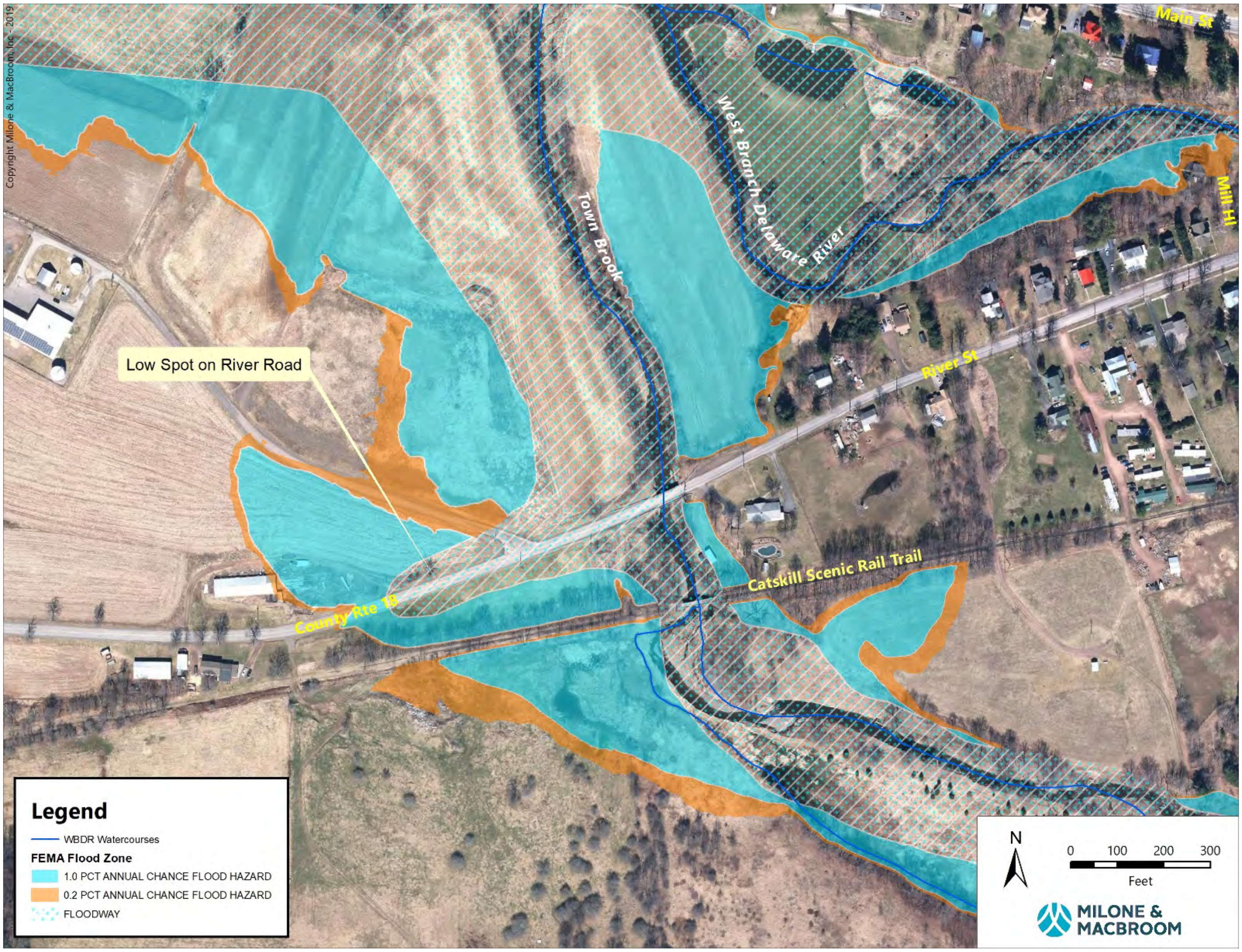

Figure 4-26: Aerial view of River Street with FEMA flood zones overlaid showing inundation of the roadway

Bovina Center-South Kortright Road – WBDR – Hamlet of South Kortright, New York

Built sometime in the early 1900s, the County Route 18 structure traversing the WBDR is a mortared twin-arch deck bridge; each arch measures approximately 40 feet wide and roughly 14 feet high (Figure-4-27). The structure is listed as an undetermined historic landmark by the NYS Historic Trust Office of Parks and Recreation with unique site number 02517.000003. The bridge is oriented north to south and serves as a direct connection between NYS Route 10 and Delhi-South Kortright Road. Without this structure, residents located on opposite sides of the WBDR would need to take an 8-mile detour to get across the river. The 2019 NYSDOT bridge inspection report gave the structure an overall rating of '5' or "...good conditions and [does] not need major repairs." There were no reports of flooding from the public at this crossing.

Figure 4-27: County Route 18 downstream bridge face

According to the hydraulic model, this bridge passes the 10-, 25-, 50-, and 100-year modeled peak discharges with a considerable amount of freeboard. The structure does not appear to be a major constriction to flows. Even though it does back up water during the 50- and 100-year storms, the roadway does not appear to get overtopped, nor does it lead to flooding upstream. Removal of the structure from the model only has considerable reductions in water surface elevations during the 50- and 100-year storms, resulting in drops of 0.85 feet and 2.5 feet, respectively. These reductions propagate upstream for approximately 2,500 linear feet before fully vanishing. However, there are minimal changes to the overall inundation extents (Figures 4-28 and 4-29).

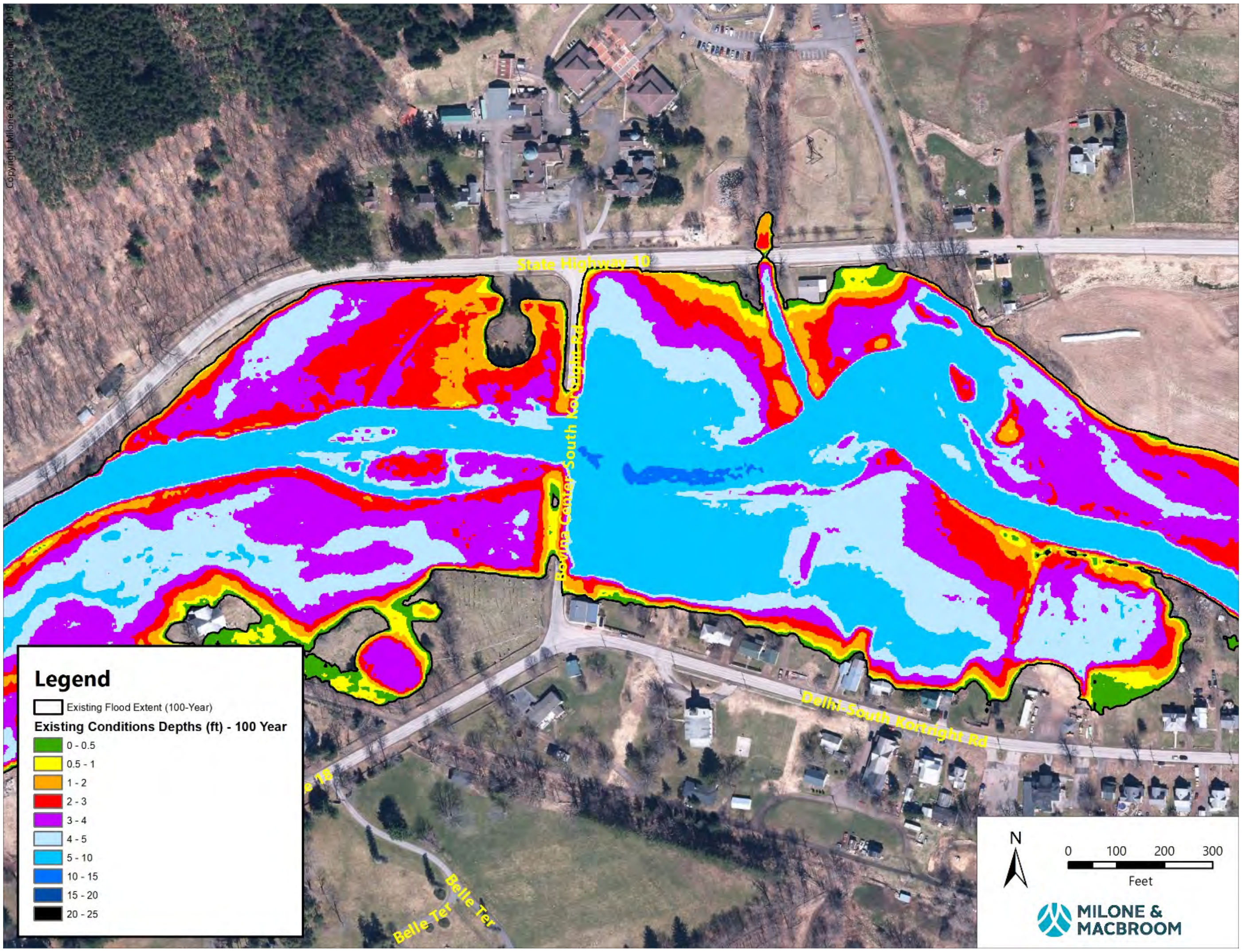

Figure 4-28: Existing conditions depth grid mapping of County Route 18 (100-year discharge)

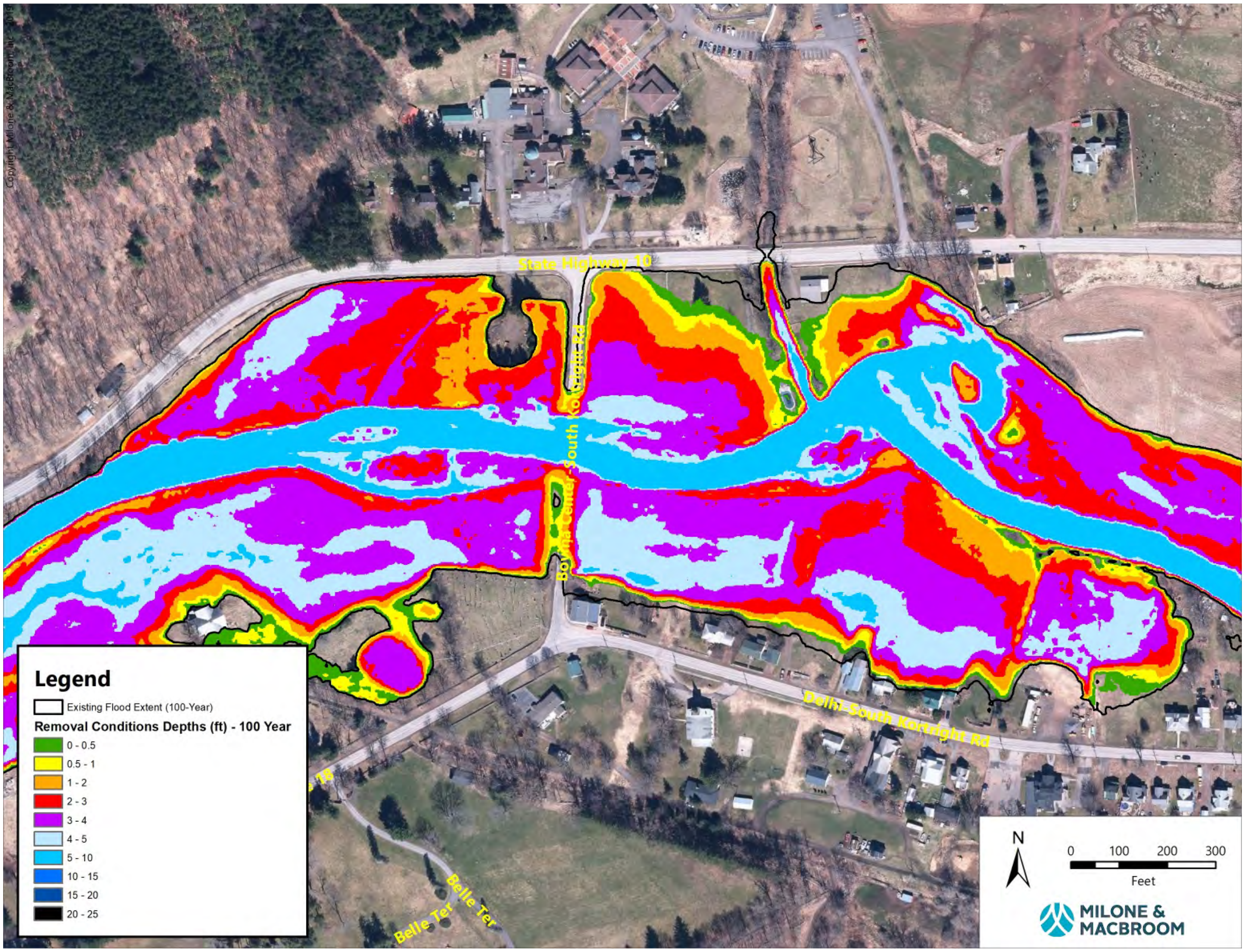

Figure 4-29: Resulting depth grid for County Route 18 removal (100-year discharge)

Currently, parts of a few homes upstream of the County Route 18 bridge on the left overbank along Delhi-South Kortright Road are shown to be partially within the estimated 100-year floodplain. Although this might be the case in aerial view, the model cross sections show these structures to be situated well above the predicted BFE. If property owners at this location are currently paying for flood insurance, it might be in their best interest to seek out a feasibility study to determine if they are eligible for an elevation certificate, which can result in lower flood insurance premiums. Recommendations for property owners mapped within the FEMA SFHA are discussed in greater detail in Section 4.5.

4.2 Rexmere Lakes Dam Breach Analysis

The area downstream of the Rexmere Lakes dams contains several neighborhoods and businesses that could be impacted if the dams were to fail. While the number of homes has decreased over the years due to the removal of a mobile home park, there are still numerous homes and several businesses within the potential path of breaching flows. Inundation maps were developed from the results of the hydraulic model to evaluate potential hazards and assess the consequences of a breach. The depth of flooding, flow velocities, and number of affected properties were considered when quantifying downstream hazards.

As outlined in Section 2.4, three breach scenarios were modeled: a sunny-day breach, which assumes that the dams fail during normal conditions, independently of a storm event; a rainy-day breach, which assumes that the dams fail when the pond reaches its maximum elevation in the SDF; and a rainy-day no-breach scenario, which is used as a baseline of expected downstream inundation extents during the SDF for comparison.

During the sunny-day dam breach scenario (see Figure 4-30), the flood wave overtops several streets, including Harper Street, Hobart Road, Grant Place, Railroad Avenue, and the rail trail. A total of 33 homes, which are primarily located along Hobart Road and West End Avenue, are within the inundation extent of the flood. Of these homes, four experience flooding of greater than 1 foot above the lowest occupied floor. Four businesses, including Robert J. Connelly Optometry, Vasta's Bistro and Pizzeria, Hillhaven Farms, and Catskill Craftsmen, and the village's wastewater treatment plant also experience flooding under the sunny-day breach scenario. Residents of the home at the end of Axtell Road could become isolated due to potential flood damages to the crossing over the WBDR. The flood wave becomes attenuated as it travels downstream, so that the difference in water surface elevation between breach and no-breach scenarios is less than 2 feet once the flood wave passes the wastewater treatment plant.

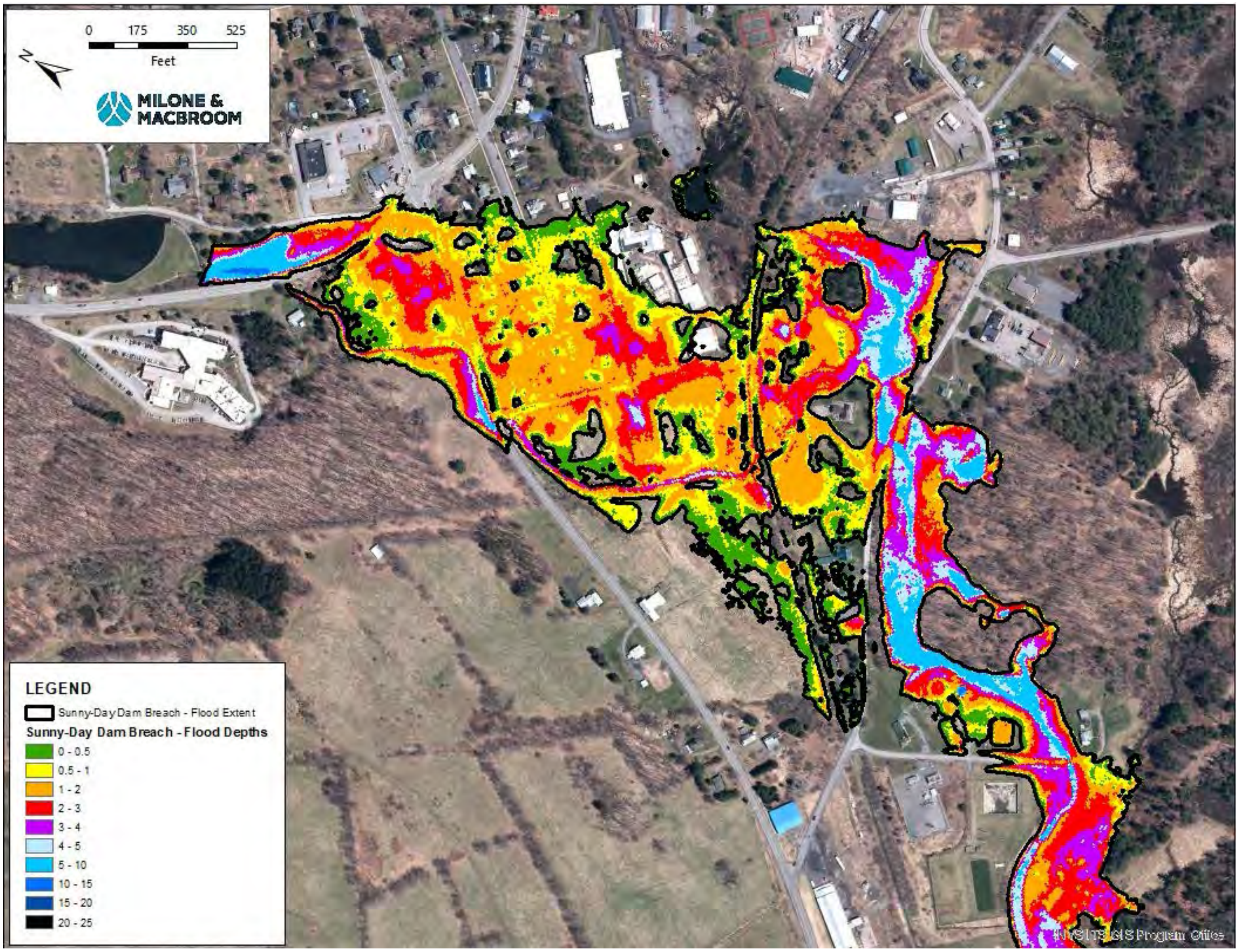

Figure 4-30: Depth grid map of sunny-day dam breach scenario for the Rexmere Lakes dams

Similar results were produced by the simulation of the rainy-day scenario without a dam breach (see Figure 4-31). Flooding occurs at 33 homes and four businesses with the most extensive flooding occurring in the neighborhoods along Hobart Road and West End Avenue. As with the sunny-day breach scenario, four homes are impacted by flooding depths greater than 1 foot above the lowest occupied floor. When the rainy-day scenario includes failure of the Rexmere Lakes dams, the inundation extent and flood depths increase significantly (see Figure 4-32). In addition to flooding the roads and neighborhoods described for the previous scenario, flooding depths increase throughout the neighborhoods along Hobart Road and West End Avenue. Floodwaters also cross over Railroad Avenue between Graham Drive and Buntline Drive, flowing into the wetlands along WBDR T1. The rainy-day dam breach scenario produced more severe flooding at the village's wastewater treatment plant. However, the same number of homes and businesses are flooded during the rainy-day breach scenario as with the two previous scenarios. The number of homes with flood depths greater than 1 foot increases from four to seven.

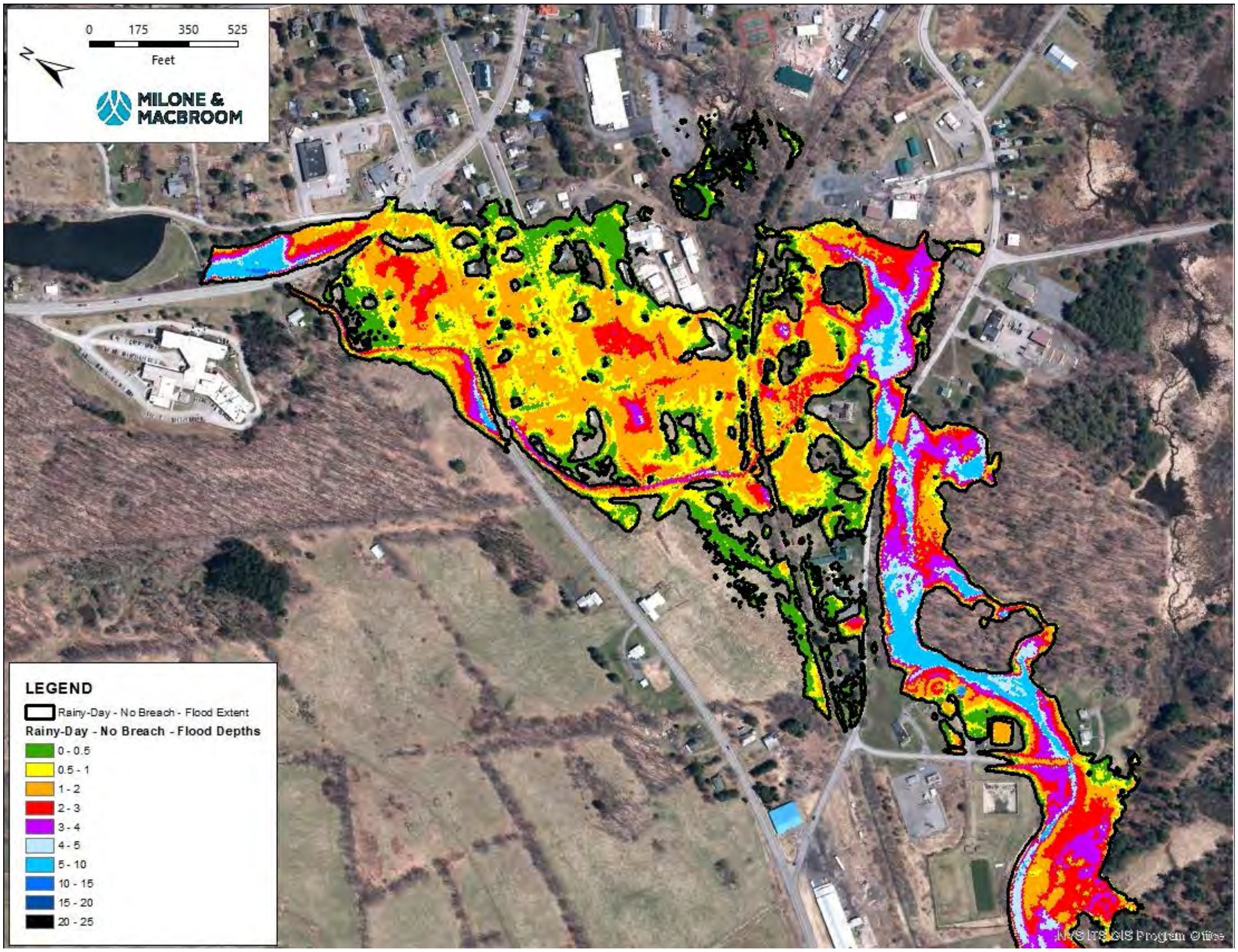

Figure 4-31: Depth grid map of rainy-day, no-breach scenario for the Rexmere Lakes dams

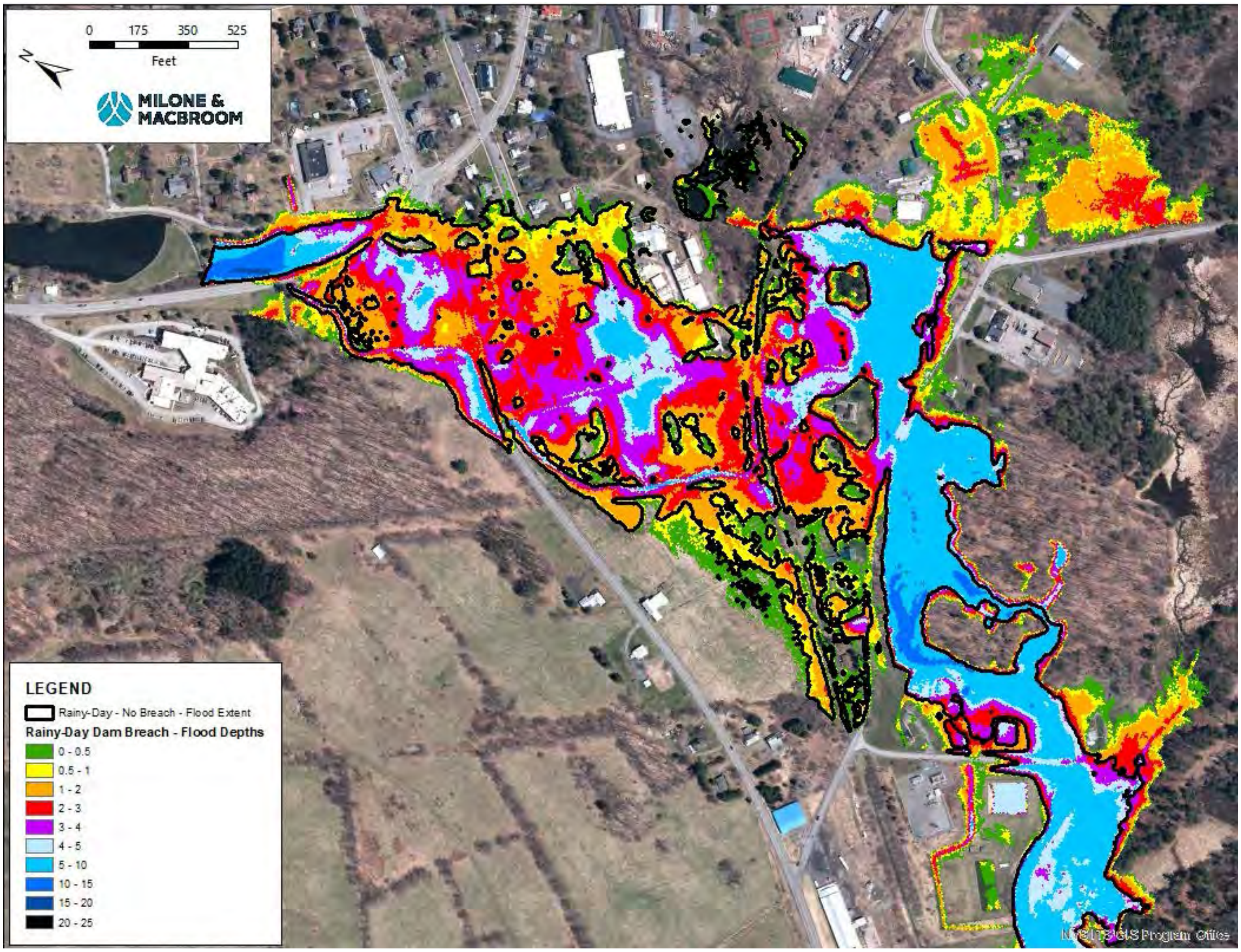

Figure 4-32: Depth grid map showing difference between rainy-day dam breach scenario and rainy-day, no-breach scenario for the Rexmere Lakes dams

The difference in peak flooding depths between the three scenarios can be visualized using the water surface profiles presented in Figure 4-33. The profile lines follow the preferential flow path of the flood wave, as opposed to the stream centerline, as it travels downstream from Churchill Lake dam to the model boundary along the WBDR near the Axtell Road crossing. Immediately downstream of the dams, the rainy-day scenario without a dam breach produces the lowest peak flood depths while the rainy-day dam breach scenario produces the highest depth, with a peak water surface that is over 4 feet higher than the no-breach scenario. Once the flood waters overtop Harper Street, the difference in flooding depths between each scenario decreases because the flood waters spread out in the Stamford neighborhoods along Hobart Road and West End Avenue. Downstream of the Catskill rail trail, the flood wave enters the WBDR, constricting the flow width and increasing the difference in water surface elevation between the rainy-day dam breach and no-breach scenarios. Along the WBDR, the flooding depths for the sunny-day dam breach and rain-day, no-breach scenarios are approximately equal.

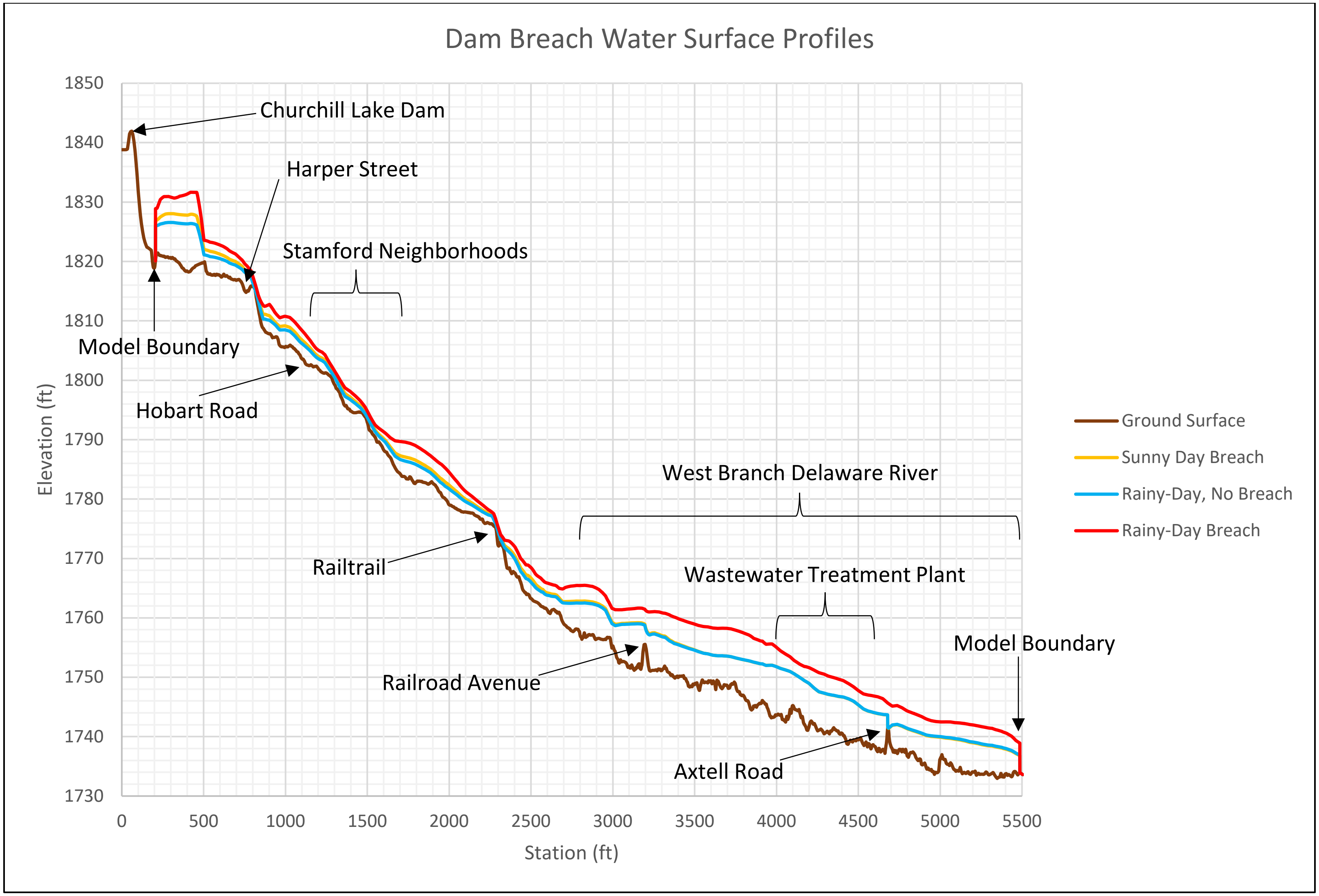

Figure 4-33: Profile showing maximum water surface elevations downstream of the Rexmere dams for each dam breach scenario

Downstream flooding hazards due to high-flow velocities were also assessed for the dam breach analysis. The modeling results for the three scenarios show high-flow velocities in excess of 10 feet per second immediately downstream of the dam and along several roads, including Harper Street, Hobart Road, Grant Place, and Railroad Avenue. These conditions could be hazardous for any pedestrians caught out on these roads during a dam breach. The areas of high velocities can also be extremely dangerous for people in their homes depending on the depth of flooding. *Technical Memorandum No. 11* (1988), a publication of the U.S. Bureau of Reclamation, provides guidelines for classifying downstream dam breach hazards according to the relationship between flood depth and flow velocity. The guidelines describe three danger zones, which are defined based on the likelihood that potentially fatal conditions may result. If flooding depths and velocities at a specific home are relatively low, the home is considered in the low-danger zone because it is unlikely that lives are in jeopardy. When flooding depths and velocities are high, there is a much higher likelihood that conditions could lead to a fatality, and the home is classified as being in the high-danger zone. The third zone is referred to as the judgement zone because one must consider other factors when determining whether there is the potential for fatalities. For example, it is less likely that a flood will cause loss of life if the home being flooded has two floors and the living quarters are on the second floor. However, residents of a one-story home may have more difficulty escaping the floodwaters.

According to the model results, 32 homes are in the low-danger zone, and one home is in the judgement zone for the sunny-day dam breach scenario. For the rainy-day, no-breach scenario, all of the 33 homes are in the low-danger zone. The number of homes in the judgement zone increases to four under the rainy-day dam breach scenario. There are no homes in the high-danger zone for any of the flooding scenarios. Table 4-1 summarizes the results of the flood danger analysis for the homes that could be impacted by a dam breach. The danger analysis was also performed for the four businesses that are within the flood extents. For all three scenarios, one business remains in the high-danger zone due to flooding depths greater than 5 feet and flow velocities greater than 5 feet per second. A second business is added to the high-danger zone during the rainy-day dam breach scenario. Under these conditions, there is a high risk for loss of life, especially during the sunny-day breach scenario where flooding would be unexpected.

TABLE 4-1
Flood Danger Analysis for Homes

Guideline	Number of Homes Impacted by Flooding		
	Sunny-Day Dam Breach Scenario	Rainy-Day, No-Breach Scenario	Rainy-Day Dam Breach Scenario
≤ 1 foot above Lowest Occupied Floor	29	29	26
> 1 foot above Lowest Occupied Floor	4	4	7
Low-Danger Zone	32	33	29
Judgement Zone	1	0	4
High-Danger Zone	0	0	0

Due to the potential for loss of life and serious damage to homes and businesses from failure of the Rexmere Lakes dams, MMI recommends that both dams remain classified as Hazard Class C. The NYSDEC guidelines specify that if "serious damage" is likely to occur to any homes (i.e., if any homes experience flooding greater than the low-hazard zone defined in *Technical Memorandum No. 11*), the dam should be classified as a high-hazard structure because loss of life is likely. Based on the results of the dam breach analysis, one home would have greater flooding than the low-danger zone for the sunny-day breach scenario. The number of homes with greater flooding than the low-danger zone increases to four under the rainy-day breach scenario. The potential for life-threatening conditions is also higher due to the severity of flooding at some businesses. The office building for Robert J. Connelly Optometry is located approximately 300 feet downstream of Churchill dam. During a sunny-day dam breach, people in the office may not have enough time to escape the flooding due to the proximity to the dam.

The village of Stamford has several options for improving or modifying the Rexmere Lakes dams in order to meet NYSDEC regulatory requirements. For small, Hazard Class C dams, the state requires that the service spillway have the capacity to pass the 25-year storm event and have a total capacity to pass 50 percent of the PMF, all with at least 1 foot of freeboard below the crest of the dam. Currently, neither of the dams meets the spillway capacity or freeboard requirements for its hazard classification. Rexmere dam has a primary outlet and an emergency spillway, giving it a service spillway capacity of about 120 cfs, which is less than the expected 10-year storm event, and a total capacity of 1,850 cfs, which is less than 50 percent of the PMF. Churchill dam has only one spillway and therefore has a service spillway and total capacity of 240 cfs, which is less than the 25-year storm event. In order to meet the requirements, a variety of modifications would need to be made to the dams and their outlets, including enlarging both of the dams' primary outlets, increasing the span of Rexmere dam's emergency spillway, constructing a new emergency spillway for Churchill dam, and potentially raising the top elevation of the dam. These modifications would represent a significant investment and would require more rigorous hydrologic and hydraulic analyses as well as geotechnical and structural assessments and the necessary permitting.

Another option for the village would be to remove the dams and restore the stream to a natural condition. Past experience with dam removals has shown that removal can be a more cost-effective option than repair, especially since there are several potential funding sources available for dam removals. The stream channel could then be restored, and the existing reservoirs could be converted into recreational areas. Dam removal would also eliminate the hazard posed by the two dams to the downstream community. A third option would be to remove one of the dams and make improvements to the other. This would prevent the occurrence of a cascading dam failure, which could significantly reduce the risk to the downstream community and would allow the village to maintain one of the impoundments. The remaining dam could also potentially be reclassified to a lower hazard classification, thereby reducing the spillway capacity requirements for the structure and lowering the cost to upgrade. For Hazard Class B, a dam must have a minimum service spillway capacity for the 25-year storm event and a total spillway capacity for 150 percent of the 100-year storm event. With some improvements to the primary outlet, Rexmere dam could meet these requirements. Additional hydrologic and hydraulic analysis would be required to determine how to proceed with any of the three options described above.

Public remarks suggested that there is an Emergency Action Plan (EAP) prepared for the Churchill dam for use in the event of a developing dam failure or uncontrolled release of stored water. However, during MMI's investigations, it was unclear whether the town or village of Stamford had developed an EAP for the Rexmere dam. It is recommended that the village or town ensure that the necessary Dam Safety Regulations are being met, including the development, maintenance, and adherence to an EAP. As discussed in Section 6.0 of this report, compliance with these regulations may open the opportunity for available funds to rehabilitate the Class C high-hazard dams.

4.3 Individual Solutions for Flood-Prone Homes and Businesses

During the public data-gathering process, specific areas within the villages and hamlet project areas were identified as being prone to flooding during severe rain events. Several alternatives were developed and assessed at areas where flooding is known to have caused extensive damage to homes and properties. Alternatives were assessed with hydraulic modeling to determine their effectiveness. The narrative below describes the alternatives and the results of modeling analysis.

Properties Along Roosevelt Avenue – WBDR – Village of Stamford, New York

Anecdotal accounts indicated that the backyards of properties on Roosevelt Avenue are frequently saturated with water, making them wet and inconvenient for the owners almost all year round. Hydraulic modeling at this location shows flood depths within 0.5 to 1.0 feet during the 10-year storm event (Figure 4-34), the depth and extent of flooding becoming more drastic and widespread for all greater peak discharges. According to the flood record at the USGS stream gauge in Hobart, there have been several storm events over the recent years that have exceeded the estimated 10-year peak discharge, including the 2006, 2008, 2010, and 2011 floods. The 2011 storm peaked just above the 50-year storm, and Figure 4-35 illustrates the flooding extents witnessed during this event.

Figure 4-34: Existing 10-year depth grid mapping behind homes on Roosevelt Avenue

Figure 4-35: Flooding behind 12½ Roosevelt Avenue during Tropical Storm Irene 2011

In February 2020, MMI conducted a site walk of the WBDR section between Roosevelt Avenue and Main Street to examine and identify potential causes for the chronically saturated backyards. Field observations revealed that the sections of channel have a well-connected floodplain at the locations shown to be inundated in the image above. In some spots, the overbank was at a lower grade than the water in the active channel, which could mean that groundwater table outflow is the source of excess moisture at these backyards. Other observations included the presence of obstructions along the river that might impede flow conveyance during lower magnitude, less frequent storm events (Figures 4-36 and 4-37). It is worth noting that this area has been heavily modified to have direct access to the stream edge, and currently, there are several spots on the floodplain that lack a healthy riparian buffer zone. A riparian buffer is a vegetated strip of land that covers the stream bank and extends outward. This area provides stream channel stability and water quality benefits by controlling erosion of the banks and filtering out pollutants that would otherwise enter the stream.

Figure 4-36: Structures potentially obstructing flows on the WBDR and lack of well-established riparian buffer zone

Figure 4-37: Abutment remains restricting low flows on the WBDR

The recent low-magnitude, high-frequency floods in combination with the channel characteristics at this area explain the prevalence of water on these well-connected floodplains that residents have claimed for backyards. Determining a viable long-term solution that will fully eliminate flooding at the backyards is difficult given the limited space for any flood mitigation project. It is recommended that the village investigate the following options:

- Removal of abandoned structures in the immediate stream reach to improve flow conveyance
- Work with stakeholders to investigate the possibility of restoring the disturbed section of stream and establishing a buffer setback to discourage landowners from being near the water edge. This work would include obtaining a representative cross section at a less disturbed section of channel upstream (Figure 4-38) and reconstructing the channel behind these yards to reduce the frequency of flooding during low-magnitude events. It should be noted that during larger storm events such as the 25-, 50-, and 100-year storms, flooding on the floodplain is inevitable.
- Village and stakeholder collaboration to create a robust vegetation buffer zone along the banks of the stream to prevent further erosion and improve effective water absorption

Figure 4-38: Photographs of the channel form illustrating the drastic change in channel top width as the stream approaches the area where regular flooding is being reported

In addition, property owners should look for ways to minimize flood-related damages by repositioning personal belongings out of the floodplain. Wherever relocation is not feasible, residents should consider actions such as anchoring or elevating utilities to be more resilient to riverine flooding.

Properties Along NYS-10 – WBDR – Village of Hobart, New York

Several homes and businesses along the southeastern side of NYS-10 in the village of Hobart are mapped within the FEMA flood zones (Figure 4-39), which mandates post-FIRM property owners (i.e., those with homes constructed after the development of FIRMs) with a federally backed mortgage to purchase flood insurance. However, property owners expressed skepticism about needing to pay for flood insurance since they have never experienced flooding before. Private and public building owners were curious about their lowest floor elevation (LFE) in relation to the FEMA BFE that is used to establish the insurance rate. FEMA defines the LFE as the lowest floor of the lowest enclosed area, including basements. The BFE is important for the insured because a building with its lowest floor below the BFE stands a greater chance of being flooded, and that means higher premiums. Figure 4-40 shows an example of how flood insurance premium rates are influenced by a home's LFE in relation to the BFE.

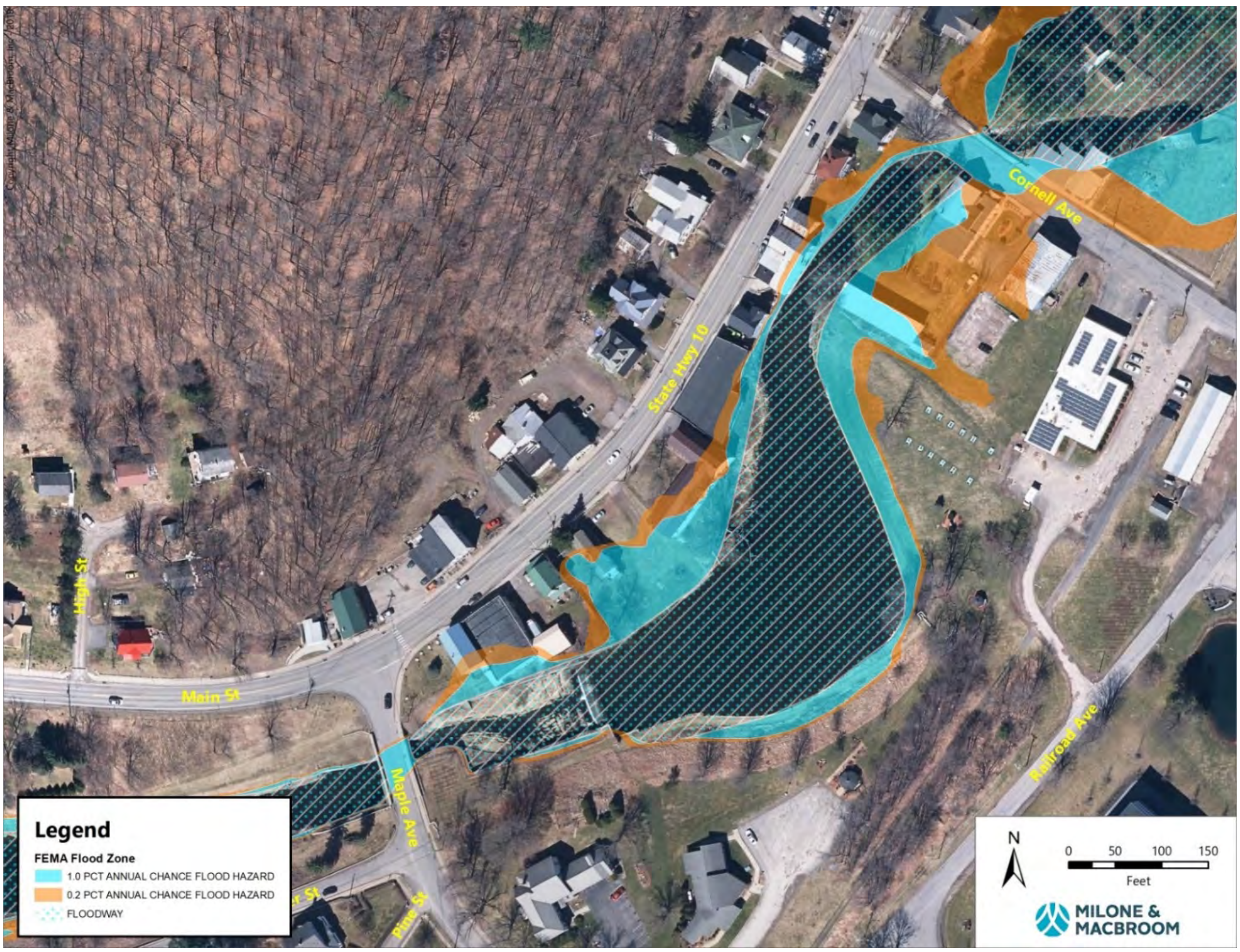

Figure 4-39: FEMA-mapped SFHAs of the WBDR behind properties along NYS-10

Figure 4-40: FEMA graphic illustrating flood insurance premium rates relating to the difference between the BFE and LFE

MMI evaluated two buildings in this reach and considered the LFE to be at grade with the front entrance of each building that faces NYS Route 10. These LFEs were estimated using LiDAR-derived elevation models and compared to the BFEs from the WBDR hydraulic model. The comparison revealed that the assumed LFEs were significantly higher than the calculated BFE. In addition, MMI assumed that the buildings had a basement, which is defined by FEMA as "any area of the building, including any sunken room or sunken portion of a room, having its floor below ground level (subgrade) on all sides." Buildings with a basement have different insurance ratings than a building without a basement. Assuming a 6-foot-tall basement at each building, the base flood longitudinal profile of the WBDR was plotted against the possible LFEs of the two buildings (Figure 4-41).

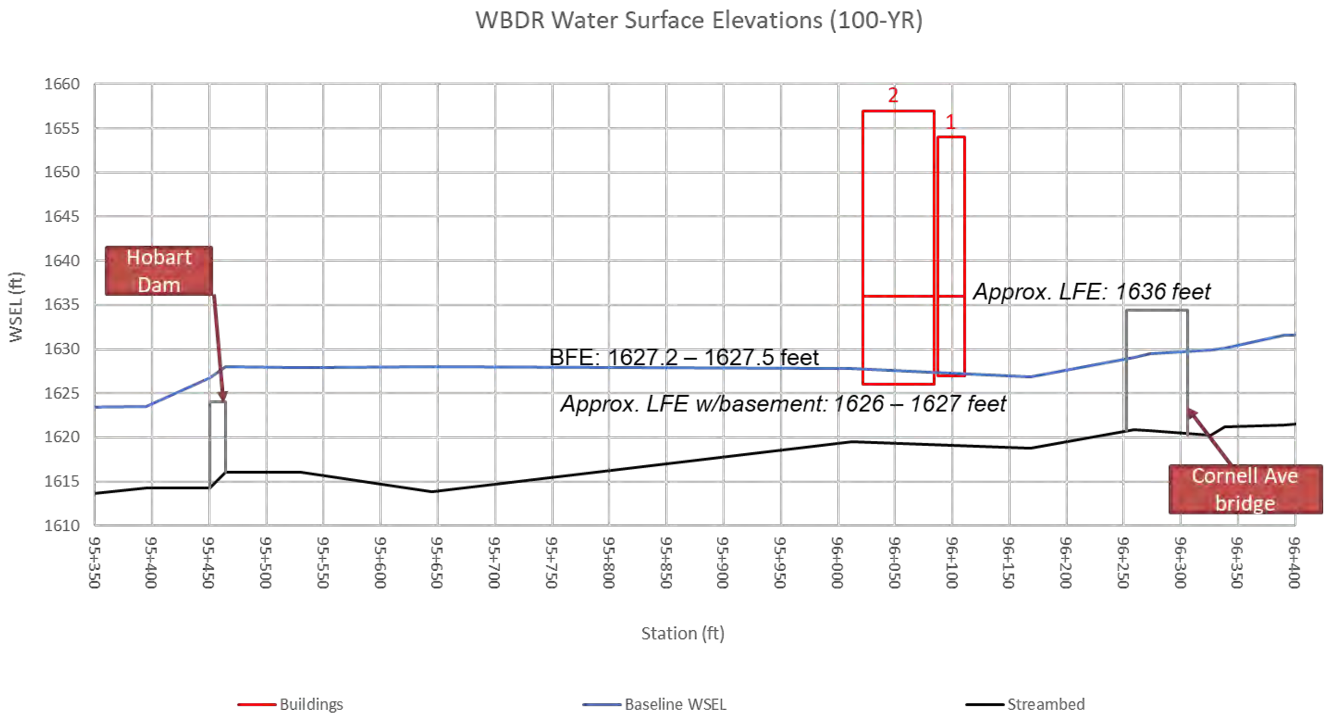

Figure 4-41: WBDR longitudinal profile with base flood elevation and potential lowest floor elevations for buildings on NYS Route 10

The resulting profile suggests that landowners along Route 10 have options available to them if they are interested in refinancing their flood insurance premium rates contingent upon their true LFE. Solutions would be on a case-by-case basis and can include obtaining Elevation Certificates (EC) or the removal of a basement so that the lowest floor elevation is that of the NYS Route 10 roadway elevation. It is recommended that private and public building owners interested in this idea pursue individual feasibility studies to investigate the options available to them. Additional recommendations for flood-prone homes and businesses are discussed in Section 4.5 of this report.

4.4 Obsolete Dam Remnants – WBDR – Village of Hobart

While conducting field investigations, the remnants of a former dam were discovered approximately 230 feet upstream of the Cornell Avenue bridge. The dam measures approximately 5 feet high and 30 feet across. The dam impounds waters on the WBDR and is a popular site for beaver activity as demonstrated in the sequence of photos taken of the dam in Figure 4-42. There were no reports from the public that the dam or the beaver dam causes flooding upstream. However, the structure is a barrier to aquatic organism passage, and therefore, the village should consider its removal to improve stream connectivity.

Figure 4-42: Photos of dam remnants taken at three separate occasions. Middle image shows beaver dam built across the top of the dam.

Additionally, a low-head dam was noted on the WBDR approximately 190 feet upstream of the Railroad Avenue bridge. The structure measures 0.4 feet high by 28 feet wide and forms a 0.4-acre pond upstream, which was where the WBDR T1 and the WBDR T2 join with the WBDR main stem. It is recommended that this structure be evaluated for removal although it was reported that the dam protects a sanitary sewer pipe that runs under the WBDR just upstream. Figure 4-43 shows a picture of the small concrete dam.

Figure 4-43: Low-head dam on the WBDR (looking upstream)

4.5 Supplementary Recommendations for Flood-Prone Homes and Buildings

Within the project areas, several homes are mapped within, near, or bordering the SFHA. Other properties may not be included in these delineated floodplains but incur substantial flood damages from unmapped tributaries. Although there were few reports of flooding at the village and hamlet areas, it is recommended that property owners who have experienced flooding damage in the past seek appropriate flood mitigation strategies whether through buyouts, relocation, or individual floodproofing measures. A comprehensive description of potential sources of funding for flood mitigation and damage reduction projects is included in Section 6.0 of this report. Residents may consult the current effective FEMA FIRM to determine the location of their home relative to the SFHA, which is the area inundated by flooding during the 100-year flood event.

The effective FIRM products for the town of Stamford at the time of this report are available here: https://msc.fema.gov/portal/availabilitySearch?addcommunity=360213&communityName=STAMFORD,%20VILLAGE%20OF#searchresultsanchor.

Residents may also search for their home address directly by visiting https://msc.fema.gov/portal/home.

- It is recommended that the town and village work to floodproof or relocate the most flood-vulnerable properties where there is owner interest and programmatic funding available through flood buyout and relocation programs. The two flow charts below provide decision-making guidance for nonresidential (Figure 4-44) and residential (Figure 4-45) properties.

- It is recommended that the town identify priority areas and structures that are prone to most frequent and deepest flooding. These areas should be considered the highest priority for individual flood protection measures.

Some of the homes in the SFHA are rarely flooded. Residents and businesses may benefit from minor individual property improvements. Providing landowners with information regarding individual property protection is recommended.

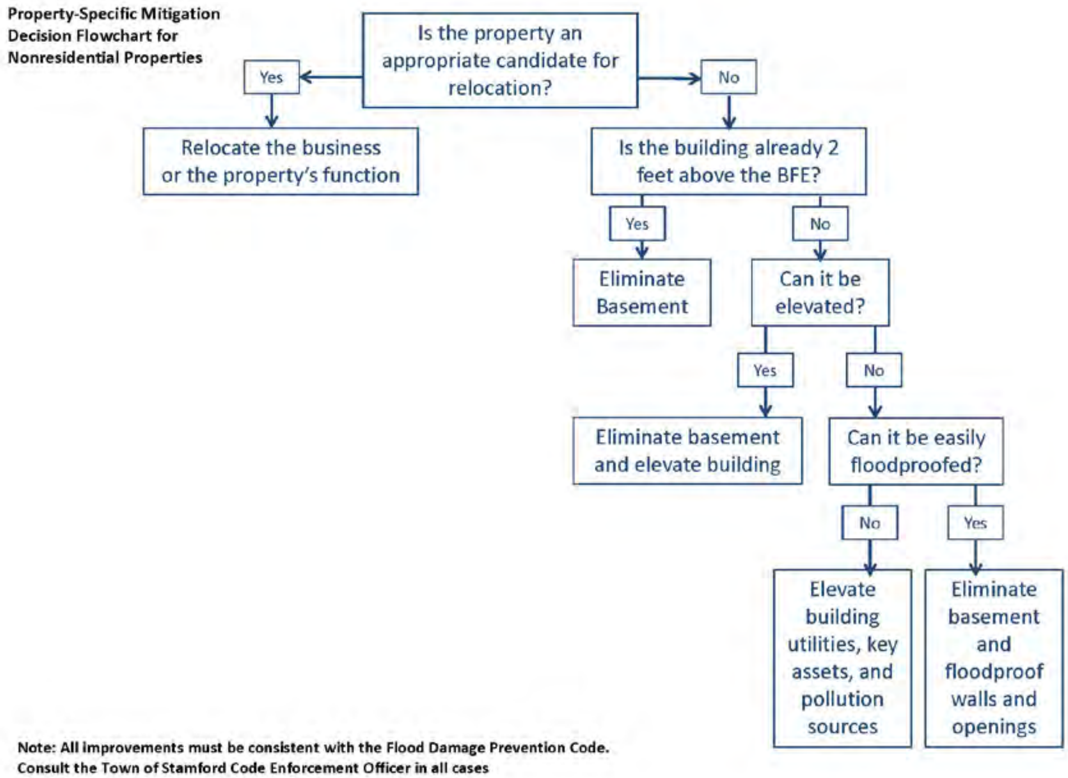

Figure 4-44: Property-specific mitigation for nonresidential properties

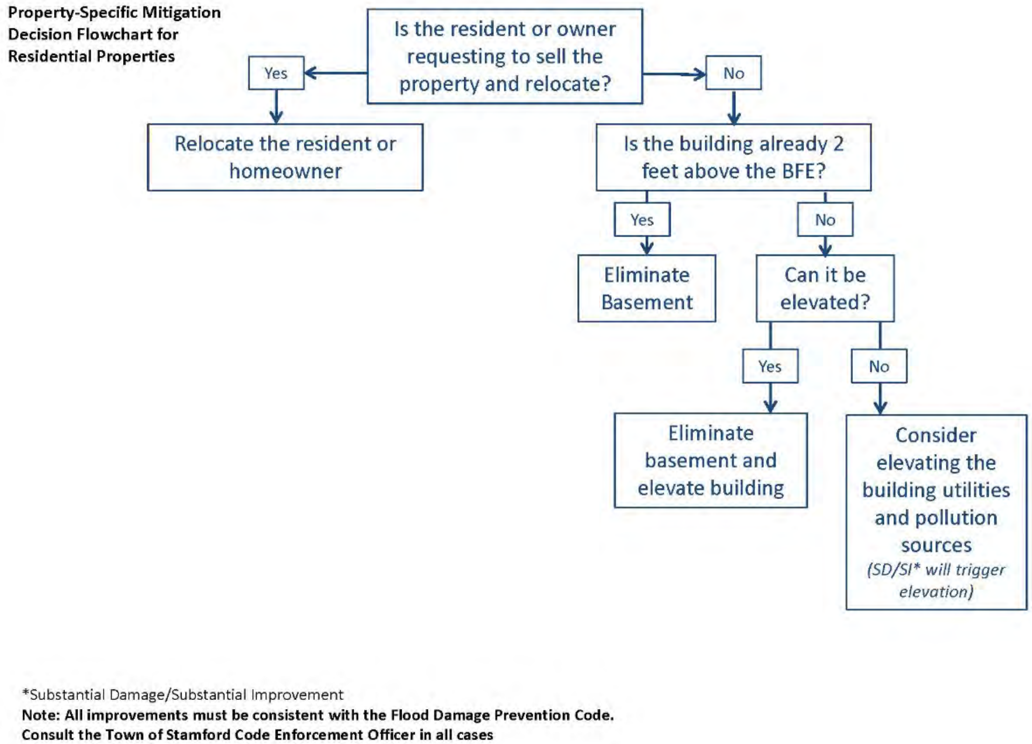

Figure 4-45: Property-specific mitigation for residential properties

In areas that are vulnerable to flooding, improvements of individual properties and structures may be appropriate. All practices to protect property within a floodplain must comply with local flood law and obtain the approval of the town floodplain administrator or code enforcement officer. Potential measures for property protection include the following:

<u>Elevation of the structure</u> – Home elevation entails the removal of the building structure from the basement and elevating it on piers to a height such that the first floor is located 2 feet or more above the level of the 100-year flood event. The basement area is abandoned and filled to be no higher than the existing grade. All utilities and appliances located within the basement must be relocated to the first-floor level or installed from basement joists or similar mechanism at an elevation no less than 2 feet above the BFE.

<u>Dry floodproofing of the structure to keep floodwaters from entering</u> – Dry floodproofing refers to the act of making areas below the flood level watertight. Walls may be coated with compound or plastic sheathing. Openings such as windows and vents would be either permanently closed or covered with removable shields. Flood protection should extend only 2 to 3 feet above the top of the concrete foundation because building walls and floors cannot withstand the pressure of deeper water.

Wet floodproofing of the structure to allow floodwaters to pass through the lower area of the structure unimpeded – Wet floodproofing refers to intentionally letting floodwater into a building to equalize interior and exterior water pressures. Furniture and electrical appliances should be moved away or elevated above the 100-year flood elevation. Wet floodproofing should only be considered as a last resort.

Performing other home improvements to mitigate damage from flooding – The following measures can be undertaken to protect home utilities and belongings:

- Relocate valuable belongings above the 100-year flood elevation to reduce the amount of damage caused during a flood event.
- Relocate or elevate water heaters, heating systems, washers, and dryers to a higher floor or to at least 12 inches above the BFE.
- Anchor fuel tanks to the wall or floor with noncorrosive metal strapping and lag bolts.
- Install a backflow valve to prevent sewer or septic 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 high-water mark.

Encouraging property owners to purchase flood insurance under the NFIP and to make claims when damage occurs – While having flood insurance will not prevent flood damage, it will help a family or business put things back in order following a flood event. Property owners should be encouraged to submit claims under the NFIP whenever flooding damage occurs, which will increase the eligibility of the property for projects under the various mitigation grant programs.

Construction of property improvements such as barriers, floodwalls, and earthen berms – Such structural projects can be used to prevent shallow flooding. There may be properties within the town where implementation of such measures will serve to protect structures. Such barriers must not be permitted unless designed by a qualified engineer and shown to comply with NFIP and local floodplain laws. These improvements are not eligible for funding under CWC or Stream Management Plan – Flood Hazard Mitigation (SMP-FHM) grant programs.

4.6 General Recommendations

Flooding of and damage to bridges, culverts, and roadways during flood events have been reported at numerous locations in the villages and hamlet project areas. Most flood-related fatalities occur in vehicles, often when drivers attempt to cross flooded roadways. Of the 15 flood-related fatalities reported in Delaware County since 1996, 11 of them occurred in vehicles. It is impossible to tell if a flooded roadway is safe just by looking at it. It is recommended that risks associated with the flooding of bridges and roadways be reduced by temporarily closing flood-prone roads during high-flow events. This requires effective signage, road closure barriers, and consideration of alternative routes. Because it is impossible to prepare for every contingency and closing roads and establishing detours in a flash flood event is not always possible, it is critical that residents be advised of the extreme dangers of attempting to cross flooded roadways and reminded not to do so when flooding occurs or is forecasted. Informed and prepared residents are the foundation of life safety preservation in floods.

In the event of future flooding, it is highly recommended that the town of Stamford collect and maintain clear, detailed records of all damages and associated repair costs, including materials and labor. These should be distinguished by site so that problem areas can be identified and addressed and not lost amongst the overall total. Where possible, once waters recede and it is safe to do so, high water marks and other evidence of flooding extents should be photographed and carefully documented and their elevations measured from a permanent reference. These data may be extremely valuable when seeking funding for flood mitigation assistance.

Public welfare depends on awareness and proper enforcement of the town's local Flood Prevention Law. It is recommended that town government staff seek training regarding the content and implementation of this law, especially the Town Code Enforcement Officer. As the Local Administrator, this individual is responsible for administering, implementing, and enforcing the local Flood Damage Prevention Code. This will allow town officials to successfully disseminate important information regarding the law to the public and to implement the law accurately to meet its stated purposes (Section 2.1).

It is recommended that the Town of Stamford maintain its status in the NFIP and regularly participate in a Community Assistance Visit (CAV). The CAV is a major component of the NFIP's Community Assistance Program (CAP). The CAV is a visit to a community by a FEMA staff member or staff of NYSDEC on behalf of FEMA that serves the dual purpose of providing technical assistance to the community and assuring that the community is adequately enforcing its floodplain management regulations. Generally, a CAV consists of a tour of the floodplain, an inspection of community permit files, and meetings with elected officials. If any administrative problems or potential violations are identified during a CAV, the community will be notified and given the opportunity to correct those administrative procedures and remedy the violations to the maximum extent possible within established deadlines. FEMA or NYSDEC will work with the community to help it bring its program into compliance with NFIP requirements. In extreme cases where the community does not take action to bring itself into compliance, FEMA may initiate an enforcement action against the community. For Stamford to be eligible for funding under the CWC FHMIP or the Stream Management Program LFA, the town needs to participate in a CAV. According to NYSDEC, as of January 20, 2020, Stamford has never completed a CAV.

Riparian Buffers

The Natural Resources Conservation Service (NRCS) (2016) defines a riparian buffer as, "a corridor of trees and/or shrubs planted adjacent to a river, stream, wetland or water body." The definition continues to note that the width of the buffer and the distance of the buffer from the waterbody are essential characteristics determining the functioning of the buffer.

The benefits provided by riparian buffers to their adjacent waterbodies have been well documented. These benefits can include those to the physical stability of the stream as well as those to habitat and water quality.

The physical benefit of a riparian buffer to a stream has been shown to include increased stability, reduced stream bank erosion, and reduced channel migration. Scientific studies have found that intertwining roots within a stream bank can increase stream bank strength, increase resistance to erosion caused by high flows, and provide greater channel stability (Sweeney and Newbold, 2014). One study found that following major floods bank erosion was 30 times more prevalent along stream bends without forests than those with forests (Beeson and Doyle, 1996). Other studies have also shown that forested stream reaches exhibit slower channel migration and thus provide more stability than deforested channels (Hession et al., 2003; Allmendinger et al., 2005). The NRCS (2016) notes that stabilized stream banks also help maintain the geometry of the stream, including characteristics such as the meander length and profile.

The dimensions of the riparian buffer have been shown to play an important role in the functioning of the buffer. Burckhardt and Todd (1998) found that streamside forests with widths of around 10 meters (approximately 33 feet) provide some protection from channel migration. Similarly, Zaimes et al. (2006) found bank erosion was lowered significantly by the presence of a streamside forest approximately 33 feet wide along reaches within an agricultural landscape. Sweeney and Newbold (2014) found that the influence of vegetation appears to be greatest when the roots extend to the toe of banks (Thorne, 1990; Anderson et al., 2004). Otherwise, the stream bank is susceptible to erosion from the stream as it flows. According to the NRCS Practice Standard for Riparian Forest Buffers, the minimum width should be at least 35 feet from the top of the bank.

In terms of the vegetation making up the riparian buffer, the NRCS recommends utilizing native species, if available, that are:

- Adapted to the soil and climate of the planting site
- Water-loving or water-tolerant species and tolerant of extended periods of flooding (depending on the width of the planting and distance from the stream banks)
- Moderate to aggressive root and crown spread to occupy the site quickly and provide adequate litter fall
- Resistant to pests and herbicides (if adjacent to farmland)

The benefits of riparian buffers to habitat include providing food and cover for wildlife and shade that helps to lower water temperatures. Buffers can also increase habitat diversity in several ways. The addition of large woody debris to a stream provides habitat to a range of species, and a reduction in sedimentation helps prevent silt from covering large rocks or stones and from filling pools in the streambed, both of which serve as habitat. In terms of improvements to water quality, buffers have been shown to protect water resources from pollutants in surface runoff such as sediment and nutrients. Vegetated riparian buffers serve to slow water velocity, thus allowing sediment to settle out of the runoff water. The nitrogen and phosphorus attached to the sediment settle out of the surface runoff as well. To a lesser extent, dissolved nitrogen and phosphorus and other pollutants can be sequestered, degraded, and processed within the riparian buffer.

5.0 EVALUATION OF PROJECT COSTS

5.1 Introduction

A benefit-cost analysis (BCA) is used to validate the cost effectiveness of a proposed hazard mitigation project. A BCA is a method by which the future benefits of a project are estimated and compared to its cost. The end result is a benefit-cost ratio (BCR), which is derived from a project's total net benefits divided by its total project cost. The BCR is a numerical expression of the cost effectiveness of a project. A project is considered to be cost effective by FEMA when the BCR is 1.0 or greater, indicating that the benefits of the project are sufficient to justify the costs. FEMA's *BCA Calculator* software (Version 6.0) was used.

It is worth noting that the BCA tool does not consider water quality benefits and does not consider aquatic organism passage benefits that would be gained from improving stream connectivity.

5.2 South Street Culvert BCA

A BCR was calculated for the proposed South Street culvert replacement that would minimize overtopping of the roadway and flooding of the Stamford Farmers Cooperative. Replacing the existing structure with the 20-foot-wide, 5-foot-high culvert, which conveys the 100-year storm, resulted in benefits amounting to $2,567 and $134,276 for minimizing road damages and reducing flooding at the Farmers Cooperative, respectively.

Factors and assumptions for the BCA include the following:

- Benefits for the individual properties were determined as 'Floodplain and Stream Restoration.'
- Specifics about the roadway average daily traffic and closure periods due to flood were estimated.
- Default depth-damage curves were used in the program.
- Water surface elevations were determined from the HEC-RAS model for the WBDR.
- The Stamford Farmers Cooperative building was assumed to be for 'AGR1: Agricultural' use and a default 'Warehouse, Refrid' building type.
- Lowest floor elevation data was determined from LiDAR-derived DEMs and field observations.

The cost for replacing the existing culvert with a new culvert with the capacity to pass the 100-year storm discharge (20-foot span, 5-foot rise) would likely be in the range of $325,000 to $575,000. The cost of a new culvert with the capacity to pass the 50-year storm discharge (12-foot span, 5-foot rise) would likely be in the range of $285,000 to $400,000. These cost opinions assume that the replacement structure would consist of a four-sided concrete box culvert with the same approximate length as the existing culvert. It is important to note that the final project cost may vary and is contingent upon factors not included here such as the presence of underground utilities, geotechnical considerations, design and permitting costs, and property easement agreements.

Depending on the combination of funds for the replacement of the culvert, there is the possibility for the project to have a BCR greater than 1.0 and justify its replacement. It is recommended that the village further investigate the viability of the project by reassessing the benefits that are associated by resolving the assumptions that were made in this initial calculation.

5.3 Maple Avenue Culvert BCA

A BCR was calculated for the proposed Maple Avenue culvert replacement that would result in reduced flooding at homes situated upstream of the structure (Figure 5-1). The resulting benefits varied depending on whether the homes had a basement as indicated in Table 5-1. Depending on the combination of funds for the replacement of the culvert, there is the possibility for the project to have a BCR greater than 1.0 and justify its replacement. It is recommended that the village further investigate the viability of the project by reassessing the benefits that are associated by resolving the assumptions that were made in this initial calculation.

Factors and assumptions for the BCA include the following:

- Benefits for the individual properties were determined as 'Floodplain and Stream Restoration.'
- Specifics about the roadway average daily traffic and closure periods due to flood were estimated.
- Default depth-damage curves were used in the program.
- Water surface elevations were determined from the HEC-RAS model for Grant Brook.
- Lowest floor elevation data for each home were determined from LiDAR-derived DEMs that were adjusted with measurements taken in the field.

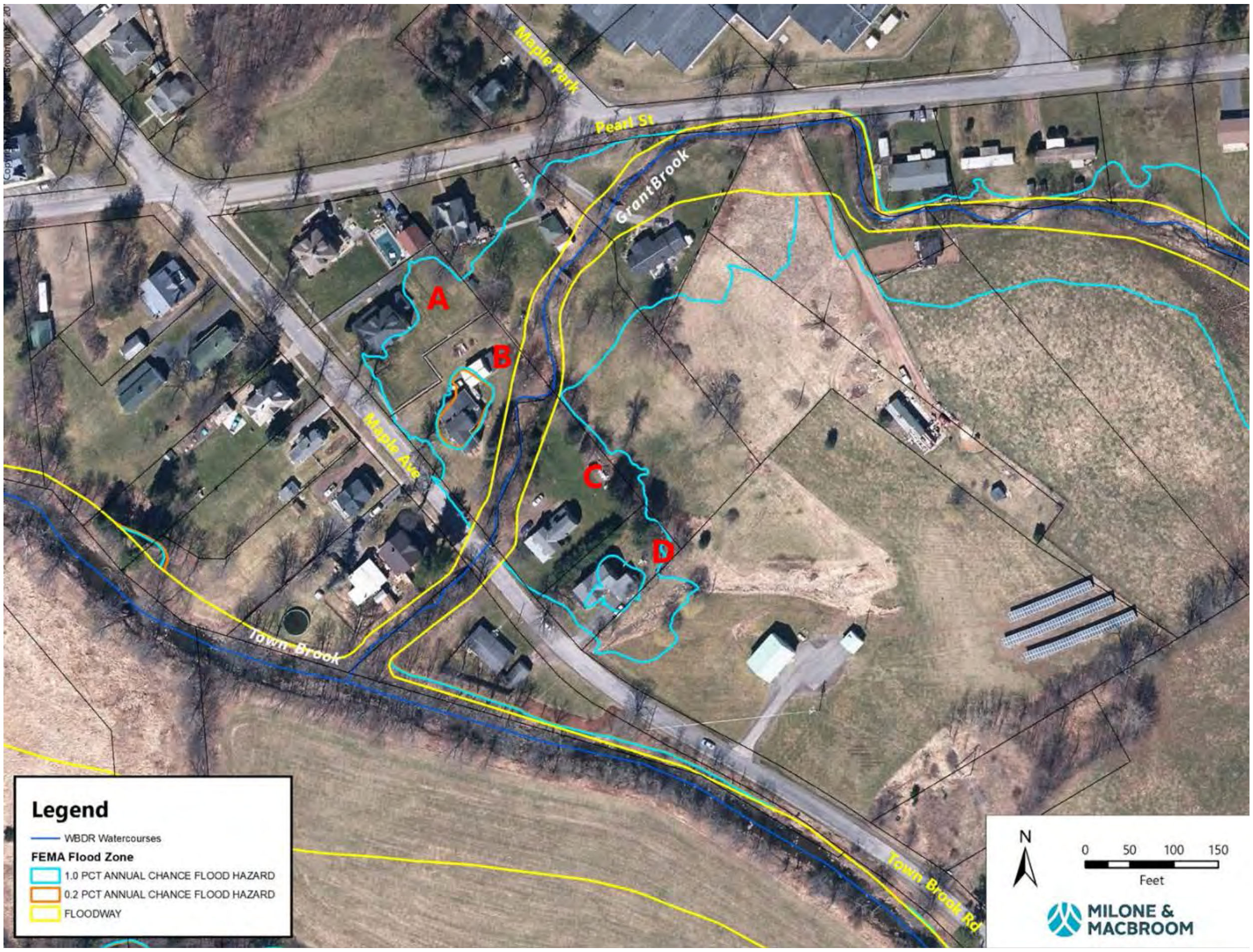

Figure 5-1: Properties mapped within the FEMA 100-year floodplain evaluated in culvert replacement benefit analysis

TABLE 5-1
Estimated Benefits Derived from FEMA Benefit-Cost Analysis Tool

Structure	Benefits	
	Unfinished Basement	Full Basement
A	$0	$4,106
B	$0	$7,818
C	$179,500	$254,547
D	$0	$7,083
CULVERT	$3,616	$3,616
TOTAL	**$183,116**	**$277,170**

5.4 Other Stream Crossings BCA

It is difficult to perform an accurate BCA on a bridge or culvert crossing replacement in isolation without information regarding multiple historical damages. Sufficient data are not available for many of these crossings in order to derive an accurate BCR. Critical contingencies such as the potential unavailability of detours are not considered in the BCR calculations, nor is a structure's importance considered as part of a detour route in the event of another crossing's failure. Likewise, the consequences of loss of access for emergency responders are not accounted for either. These are vital considerations that should be considered outside of the BCA when prioritizing allocation of funds for culvert or bridge replacements.

The applicability of the FEMA BCA is limited in these instances because it does not adequately consider the costs of certain severe hazards that are faced by a small number of individuals. Economic losses due to the interruption of traffic are the primary considerations in the BCR for roads and bridges, not life safety.

Table 5-2 illustrates some of these culvert and roadway characteristics that are difficult to quantify but help to justify the need for replacement.

TABLE 5-2
Additional Culvert and Roadway Characteristics to Consider when Deciding Allocation of Replacement Funds

Structure	Area Normally Served?	Residents Stranded if Crossing Damages?	Are Detours Available?	Detour Includes Other At-Risk Structure(s)?	Critical Crossing for Emergency Response?	Replacement Priority?	Estimated Replacement Cost
VILLAGE OF STAMFORD							
Roosevelt Avenue	15 to 20 homes	No	Yes (0.5 mi.)	No	No	Low	Not recommended
NYS Route 23 (Main Street)	Entire village	No	Yes (multiple)	Yes	No	Moderate	$580,000
South Street	Homes and businesses	No	Yes (0.24 mi.)	No	No	High	$560,000
Catskill Rail Trail	Recreational trail	No	No	N/A	No	Low	Not recommended
Railroad Avenue	10 to 15 homes and businesses	No	Yes (1.6 mi.)	Yes	No	Low	Not recommended
Graham Drive	Apartment complex	Yes	No	N/A	Yes	High	$905,000
Buntline Drive	Entire village	No	Yes (1.2 mi.)	No	No	High	$370,000

Structure	Area Normally Served?	Residents Stranded if Crossing Damages?	Are Detours Available?	Detour Includes Other At-Risk Structure(s)?	Critical Crossing for Emergency Response?	Replacement Priority?	Estimated Replacement Cost
VILLAGE OF HOBART							
Cornell Avenue	Entire village	No	Yes (0.5 mi.)	No	Yes	Low	Not recommended
Maple Avenue	5 to 10 homes	No	Yes (4.0 mi.)	Yes	No	Moderate	$200,000
Catskill Rail Trail	Recreational trail	No	No	N/A	No	Low	Not recommended
Hobart River Road (County Route 18)	Entire village	No	Yes (8.1 mi.)	N/A	No	Low	Not recommended
HAMLET OF SOUTH KORTRIGHT							
Bovina Center-South Kortright Road	Entire hamlet	No	Yes (8.1 mi.)	Yes	Yes	Low	Not recommended

5.5 Other Homes and Properties

For repetitive loss homes in the SFHA where the town supports buyouts, FEMA has developed precalculated benefits for acquisition and elevation of buildings. The following is excerpted from a FEMA memorandum regarding Hazard Mitigation Assistance (HMA) precalculated benefits (FEMA, 2013):

> "FEMA's Risk Reduction Division analyzed over 11,000 structures acquired or elevated and found that the average benefits for each project type are $276,000 and $175,000 respectively. Therefore, FEMA has determined that the acquisition or elevation of a structure located in the 100-year floodplain as delineated on the Flood Insurance Rate Map (FIRM) or based on best available data, that costs less than or equal to the amount of benefits listed above is considered cost effective. For projects that contain multiple structures, the average cost of all structures in the project must meet the stated criterion. This methodology is available for all Hazard Mitigation Assistance (HMA) grant programs."

This dramatically simplifies the BCA process for homeowners in the SFHA floodplain if relocation or elevation costs are projected to be less than these average benefit values. Homeowners would require support for any acquisitions in the form of a resolution by the Town of Stamford that identifies the property as an inundation or erosion hazard.

6.0 FUNDING SOURCES

Funding for culvert replacements and other infrastructure upgrades is often scarce in a small community. In a 2017 survey of county, city, town, and village officials in NYS conducted by Aldag et al. of Cornell University, 80 percent of responders reported that infrastructure needs contribute to local fiscal stress, and 86 percent said that fiscal stress affects local infrastructure budgeting. The consequence is that local governments that are fiscally stressed are likely to have substantial needs for infrastructure investment but must defer addressing them (NYS Comptroller, 2017). Because of this, external funding is often necessary, and a concerted effort is required to secure these grants although small local governments may not have staff available to dedicate to these endeavors.

Several funding sources may be available for the implementation of recommendations made in this report (listed in Table 6-1). These and other potential funding sources are discussed in further detail below. Note that these may evolve over time as grants expire or are introduced.

TABLE 6-1
Potential Funding Sources for Flood Mitigation Alternatives

Recommendation	Potential Eligibility		
	Federal	State	Other
Replacement of assessed bridges and culverts with an appropriately sized structure		Bridge NY, NYSDOT	Delaware County, CWC, SMIP-FHM
Replacement and daylight of culvert carrying WBDR T1 under Graham Drive	FEMA	Bridge NY, NYSDOT	Delaware County, CWC, SMIP-FHM
Replacement of undersized culverts	FEMA	Bridge NY, NYSDOT	Delaware County, CWC, SMIP-FHM
Debris removal following floods	USACE, EWP		CWC
Floodplain enhancements	FEMA		SMIP-FHM
Removal of low-head dams or obsolete dams			SMIP-FHM
Rehabilitation of high hazard potential dams*	FEMA		
Install floodproofing at critical facilities and anchor businesses	FEMA		CWC
Floodproof or relocate the most flood-vulnerable properties where there is owner interest	FEMA		CWC; NYCFFBO
Anchor fuel tanks			CWC
Feasibility study to assess individual flood mitigation alternatives for properties, including qualifications for elevation certificates			CWC

*Application open to eligible states or territories

CWC = Catskill Watershed Corporation
EWP = Emergency Watershed Protection Program
FEMA = Federal Emergency Management Agency
FHM = Flood Hazard Mitigation
NYCFFBO = New York City Funded Flood Buyout Program
NYSDOT = New York State Department of Transportation
SMIP = Stream Management Implementation Program
USACE = United States Army Corps of Engineers

FEMA Rehabilitation of High Hazard Potential Dams (HHPD) Grant Program
The HHPD grant program was added to FEMA's National Dam Safety Program under the 2016 Water Infrastructure Improvements for the Nation Act. The program provides technical, planning, design, and construction assistance in the form of grants for the rehabilitation of eligible HHPDs. Any state or territory with an enacted dam safety program is eligible to apply for the HHPD grant. To be eligible for HHPD funding a dam must:

- Be located in a state/territory with a dam safety program
- Be classified as "high hazard potential" by the state/territory dam safety program
- Have an EAP approved state/territory dam safety program
- Fail to meet minimum state/territory dam safety standards and pose an unacceptable risk to the public (as determined by the state/territory)

Several states, such as New Hampshire, have applied to and been awarded HHPD funds to repair HHPDs across their states. Many states in the Northeast are expected to follow suit. It would be advantageous for the town of Stamford to be on the lookout for any opportunities that might arise from the State of New York to rehabilitate HHPDs in the future. In the meantime, the town can start preparing by ensuring that the Rexmere and Churchill dams fulfill the necessary requirements set forth by FEMA to be eligible to receive grant funds. More information on the HHPD grant guidelines can be obtained from the following website: https://www.fema.gov/emergency-managers/risk-management/dam-safety/grants#hhpd.

Stream Management Implementation Program Flood Hazard Mitigation Grants (SMIP-FHM)
FHM is a funding category in the SMIP for LFA communities and those participating in the NY Community Reconstruction Program. Municipalities may apply to implement one or more recommendations contained in their LFA and approved by the municipal board. All projects must have modeled off-site flood reduction benefits. Eligible projects include the following:

- Design/construction of floodplain restoration and reconnection
- Design/construction of naturally stable stream channel dimensions and sediment transport processes
- Design/construction of public infrastructure to reduce water velocity, flow path, and/or elevation
- Correction of hydraulic constrictions

Ineligible projects include construction of floodwalls, berms, or levees; stream dredging; routine annual maintenance; or replacement of privately owned bridges, culverts, or roads. Municipalities must apply to the SMP in their respective counties. Contact information for Delaware County, New York, is as follows:

Delaware County Soil and Water Conservation District
44 West Street, Suite 1
Walton, NY 13856
Phone: (607) 865-7161

New York City Funded Flood Buyout Program
The New York City Funded Flood Buyout Program (NYCFFBO) is a voluntary program intended to assist property owners who were not eligible for, or chose not to participate in, the FEMA flood buyout program. It is intended to operate between flood events, not as an immediate response to one. Categories of eligible properties include the following:

1. Properties identified in community LFAs
2. Anchor businesses, critical community facilities, and LFA-identified properties applying to the CWC for relocation assistance
3. Properties needed for a stream project
4. Erosion hazard properties
5. Inundation properties

Risk assessments and BCA are required for these purchases. Municipalities may choose to own and manage the properties after they are purchased and cleared of structures. Conservation easements must be given to NYSDEC, and there are limits to what may be placed on these parcels. Allowed structures are public restrooms served by public sewers or by septic systems whose leach field is located outside the 100-year floodplain or open-sided structures such as gazebos and pavilions.

The NYCFFBO is governed by the Water Supply Permit and the Property Evaluation and Selection Process document (Process document). Communities work through outreach and assessment leads appointed by the municipality to inform potential applicants about the program and evaluate the eligibility of properties based on the program criteria established in the Process document.

Local Flood Hazard Mitigation Implementation Program
The CWC funds LFA-recommended projects to prevent and mitigate flood damage in the West of Hudson watershed, specifically to remedy situations where an imminent and substantial danger to persons or properties exists or to improve community-scale flood resilience while providing a water quality benefit.

Municipalities and individual property owners may apply directly to the CWC. Municipalities may apply for grants for projects identified in an LFA or New York Rising planning process.

Eligible LFA-derived projects could include the following:

- Alterations of public infrastructure that are expected to reduce/minimize flood damage
- Private property protection measures such as elevation or floodproofing of a structure
- Elimination of sources of man-made pollution such as the relocation or securing of fuel oil/propane tanks
- Stream-related construction (Ineligible projects include construction of floodwalls, berms, or levees; stream dredging; or annual maintenance.)
- Relocation assistance for a residence or business recommended by an LFA to a location within the same town or village

Property owners may apply for the following assistance:

- Funds for relocation assistance of an anchor business. Anchor businesses must be located in a floodplain in a watershed hamlet where an LFA has been conducted, although their relocation does NOT have to be recommended in the LFA. These include gas stations, grocery stores, lumber yards and hardware stores, medical offices, or pharmacies, which if damaged or destroyed would immediately impair the health and/or safety of a community.
- Funds for relocation of critical community facilities, such as a firehouse, school, town hall, public drinking water treatment or distribution facility, or wastewater treatment plant or collection system, which if destroyed or damaged would impair the health and/or safety of a community. Facilities must have been substantially damaged by flooding. They do NOT have to be recommended by an LFA but MUST be located in an LFA community.
- Funds for assistance to relocate homes and/or businesses within the same town where the NYCFFBO covers purchase of former property (does NOT have to be in an LFA community)
- Stream debris removal after a serious flood event (does NOT have to be recommended in an LFA)

Sustainable Community Planning Program
This CWC program is for municipalities that have prepared LFAs. It is intended to fund revisions of local zoning codes or zoning maps or to upgrade comprehensive plans in order to identify areas within those municipalities that can serve as new locations for residences and/or businesses to be moved after purchase under the voluntary NYCFFBO. Grants of up to $20,000 are available through this program, part of the CWC's Local Technical Assistance Program. The CWC program rules can be accessed by clicking the 'Flood Hazard Mitigation Program Rules' link found here: http://cwconline.org/fhmi-program-overview

Emergency Watershed Protection Program (EWP)
Through the EWP program, the U.S. Department of Agriculture's NRCS can help communities address watershed impairments that pose imminent threats to lives and property. Most EWP work is for the protection of threatened infrastructure from continued stream erosion. NRCS may pay up to 75 percent of the construction costs of emergency measures. The remaining costs must come from local sources and can be made in cash or in-kind services. EWP projects must reduce threats to lives and property; be economically, environmentally, and socially defensible; be designed and implemented according to sound technical standards; and conserve natural resources.

FEMA Pre-Disaster Mitigation (PDM) Program

The PDM program was authorized by Part 203 of the Robert T. Stafford Disaster Assistance and Emergency Relief Act (Stafford Act), 42 U.S.C. 5133. The PDM program provides funds to states, territories, tribal governments, communities, and universities for hazard mitigation planning and implementation of mitigation projects prior to disasters, providing an opportunity to reduce the nation's disaster losses through PDM planning and the implementation of feasible, effective, and cost-efficient mitigation measures. Funding of pre-disaster plans and projects is meant to reduce overall risks to populations and facilities. The PDM program is subject to the availability of appropriation funding as well as any program-specific directive or restriction made with respect to such funds.
https://www.fema.gov/pre-disaster-mitigation-grant-program

FEMA Hazard Mitigation Grant Program (HMGP)

The HMGP is authorized under Section 404 of the Robert T. Stafford Disaster Relief and Emergency Assistance Act. The HMGP provides grants to states and local governments to implement long-term hazard mitigation measures after a major disaster declaration. The purpose of the HMGP is to reduce the loss of life and property due to natural disasters and to enable mitigation measures to be implemented during the immediate recovery from a disaster. A key purpose of the HMGP is to ensure that any opportunities to take critical mitigation measures to protect life and property from future disasters are not "lost" during the recovery and reconstruction process following a disaster.

The HMGP is one of the FEMA programs with the greatest potential fit to potential projects in this LFA. However, it is available only in the months subsequent to a federal disaster declaration in the State of New York. Because the state administers the HMGP directly, application cycles will need to be closely monitored after disasters are declared in New York.
https://www.fema.gov/hazard-mitigation-grant-program

FEMA Flood Mitigation Assistance (FMA) Program

The FMA program was created as part of the National Flood Insurance Reform Act (NFIRA) of 1994 (42 U.S.C. 4101) with the goal of reducing or eliminating claims under the NFIP. FEMA provides FMA funds to assist states and communities with implementing measures that reduce or eliminate the long-term risk of flood damage to buildings, homes, and other structures insurable under the NFIP. The long-term goal of FMA is to reduce or eliminate claims under the NFIP through mitigation activities.

The Biggert-Waters Flood Insurance Reform Act of 2012 eliminated the Repetitive Flood Claims (RFC) and Severe Repetitive Loss (SRL) programs and made the following significant changes to the FMA program:

- The definitions of repetitive loss and SRL properties have been modified.
- Cost-share requirements have changed to allow more federal funds for properties with RFC and SRL properties.
- There is no longer a limit on in-kind contributions for the nonfederal cost share.

One limitation of the FMA program is that it is used to provide mitigation for *structures* that are insured or located in SFHAs. Therefore, the individual property mitigation options described in this LFA are best suited for FMA funds. Like PDM, FMA programs are subject to the availability of appropriation funding as well as any program-specific directive or restriction made with respect to such funds.
http://www.fema.gov/flood-mitigation-assistance-grant-program

NYS Department of State
The Department of State may be able to fund some of the projects described in this report. In order to be eligible, a project should link water quality improvement to economic benefits.

NYS Department of Environmental Conservation – Municipal Waste Reduction and Recycling (MWRR) Program
The NYS DEC administers MWRR funding to local government entities for waste reduction and recycling projects. The overall goal of this funding program is to assist municipalities in expanding or improving local waste reduction and recycling programs and to increase participation in those programs.

The MWRR state assistance program can help fund the costs of the following:

- Capital Investment in Facilities and Equipment

Eligible projects are expected to enhance municipal capacity to collect, aggregate, sort, and process recyclable materials. Recycling equipment includes structures, machinery, or devices providing for the environmentally sound recovery of recyclables, including source separation equipment and recyclables recovery equipment.

U.S. Army Corps of Engineers (USACE)
The USACE provides 100 percent funding for floodplain management planning and technical assistance to states and local governments under several flood control acts and the Floodplain Management Services Program (FPMS). Specific programs used by the USACE for mitigation are listed below.

- Section 205 – Small Flood Damage Reduction Projects: This section of the 1948 Flood Control Act authorizes the USACE to study, design, and construct small flood control projects in partnership with nonfederal government agencies. Feasibility studies are 100 percent federally funded up to $100,000, with additional costs shared equally. Costs for preparation of plans and construction are funded 65 percent with a 35 percent nonfederal match. In certain cases, the nonfederal share for construction could be as high as 50 percent. The maximum federal expenditure for any project is $7 million.

- Section 14 – Emergency Stream Bank and Shoreline Protection: This section of the 1946 Flood Control Act authorizes the USACE to construct emergency shoreline and stream bank protection works to protect public facilities such as bridges, roads, public buildings, sewage treatment plants, water wells, and nonprofit public facilities such as churches, hospitals, and schools. Cost sharing is similar to Section 205 projects above. The maximum federal expenditure for any project is $1.5 million.

- Section 208 – Clearing and Snagging Projects: This section of the 1954 Flood Control Act authorizes the USACE to perform channel clearing and excavation with limited embankment construction to reduce nuisance flood damages caused by debris and minor shoaling of rivers. Cost sharing is similar to Section 205 projects above. The maximum federal expenditure for any project is $500,000.

- Section 206 – Floodplain Management Services: This section of the 1960 Flood Control Act, as amended, authorizes the USACE to provide a full range of technical services and planning guidance necessary to support effective floodplain management. General technical assistance efforts include determining the following: site-specific data on obstructions to flood flows, flood formation, and timing; flood depths, stages, or floodwater velocities; the extent, duration, and frequency of flooding; information on natural and cultural floodplain resources; and flood loss potentials before and after the use of floodplain management measures. Types of studies conducted under FPMS include floodplain delineation, dam failure, hurricane evacuation, flood warning, floodway, flood damage reduction, stormwater management, floodproofing, and inventories of flood-prone structures. When funding is available, this work is 100 percent federally funded.

In addition, the USACE provides emergency flood assistance (under Public Law 84-99) after local and state funding has been used. This assistance can be used for both flood response and postflood response. USACE assistance is limited to the preservation of life and improved property; direct assistance to individual homeowners or businesses is not permitted. In addition, the USACE can loan or issue supplies and equipment once local sources are exhausted during emergencies.

Other Potential Sources of Funding

New York State Grants
All New York State grants are now announced on the NYS Grants Gateway. The Grants Gateway is designed to allow grant applicants to browse all NYS agency anticipated and available grant opportunities, providing a one-stop location that streamlines the way grants are administered by the State of New York.
https://grantsmanagement.ny.gov/

Bridge NY Program
The Bridge NY program, administered by NYSDOT, is open to all municipal owners of bridges and culverts. Projects are awarded through a competitive process and support all phases of project development. Projects selected for funding are evaluated based on the resiliency of the structure, including such factors as hydraulic vulnerability and structural resiliency; the significance and

importance of the bridge including traffic volumes, detour considerations, number and types of businesses served and impacts on commerce; and the current bridge and culvert structural conditions.
https://www.dot.ny.gov/BRIDGENY.

Private Foundations
Private entities such as foundations are potential funding sources in many communities. The Town of Stamford and FAC members will need to identify the foundations that are potentially appropriate for some of the actions proposed in this report.

In addition to the funding sources listed above, other resources are available for technical assistance, planning, and information. While the following sources do not provide direct funding, they offer other services that may be useful for proposed flood mitigation projects.

Land Trust and Conservation Groups
These groups play an important role in the protection of watersheds, including forests, open space, aquatic ecosystems, and water resources.

As the recommendations of this LFA are implemented, the Town of Stamford will need to work closely with potential funders to ensure that the best combinations of funds are secured for the proposed alternatives and for the property-specific mitigation such as floodproofing, elevations, and relocations. It will be advantageous for the town to identify combinations of funding sources in order to reduce its own requirement to provide matching funds.

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APPENDIX A

Flood Advisory Committee Meeting Notes

MILONE & MACBROOM

MEETING NOTES

TO: Stamford Flood Advisory Committee
FROM: Milone & MacBroom, Inc.
RE: Stamford LFA FAC Kick-Off Meeting
DATE: November 19, 2019
MMI #: 5197-18

A kick-off meeting for the Stamford Local Flood Analysis (LFA) was held on the evening of November 14, 2019 at the Stamford Village Hall. In attendance were Mark Carabetta, Miguel Castellanos and Ethan Ely from Milone and MacBroom (MMI), as well as members of the Stamford Flood Advisory Commission (FAC). FAC members included representatives from the village of Stamford, the New York City Department of Environmental Protection (NYCDEP), the Delaware County Soil and Water Conservation District (DCSWCD), and local business owners and residents. A sign-in sheet, map, and presentation slides are appended.

The purpose of the meeting was to:

- Review the study areas
- Recap the LFA process and intended outcomes
- Collect information about flooding, flood damage and future town improvements
- Discuss next steps in the LFA process and set a date for the first public meeting

The meeting began with introductions and a presentation of the LFA process and intended outcomes. During the presentation, MMI discussed what is known about the flood history in the town of Stamford, steps involved in an LFA, and potential flood mitigation strategies. This LFA will include a dam breach analysis at Rexmere and Churchill dams in order to assess downstream flood risk. Flood mitigation strategies from other LFA studies in the Catskills were presented to provide examples of options that may be recommended in the town of Stamford.

Following the presentation, members of the committee discussed their experiences with flooding. MMI provided large scale maps so that flood advisory members could identify areas where flood damage occurred. MMI staff collected information and took detailed notes.

The meeting included a discussion of next steps and setting a date for the first public meeting, where more information on flooding will be gathered. Currently, the FAC has not selected a time and date for the first public meeting. DCSWCD and the FAC will also try to schedule a second kick-off meeting with representatives from the village of Hobart and hamlet of South Kortright as they were not able to attend the initial kick-off meeting.

Following is a summary of notes collected at the meeting:

<u>Town and Village of Stamford</u>

- Beavers were described to be a major issue at the Buntline Road culvert. Local efforts have been implemented to prevent beavers from clogging the structure with wood.
- The village of Stamford owns the two dams that make up the Rexmere Lakes along the Unnamed Tributary to the West Branch Delaware River (WBDR).

- Trailer park that was once downstream of Rexmere Lakes flooded during 1996 storm. During the 1999 flood on the 4th of July, the Rexmere Lake release valves were opened because of fear that the reservoirs would overtop and cause the earthen dam to fail.
- A comment was made about DWCSCD potentially funding Certified Floodplain Manager (CFM) training for town officials and business owners.
- USGS gauge along the WBDR at Hobart has a period of record only going back to 2001. It was mentioned that a USGS gauge at Delhi might have captured peak flow data for the 1999 flood event and it might be worthwhile looking into and possibly incorporating this data in the hydraulic model.

Comments Tied to Maps (see appended map):

1. Core Values, thrift store, experiences frequent flooding.
2. Stamford wastewater treatment plant, no record of previous flooding. Flood insurance was purchased for this facility back when FEMA Flood Insurance Rate Map (FIRM) showed the facility within the designated Zone A. After the 2016 revision of the Flood Insurance Study (FIS), which included a detailed study of the river reach, the property was remapped outside of the special flood hazard zone no longer requiring flood insurance. However, during past flooding, water has come in close proximity to the structure.
3. Culvert crossing downstream of the wastewater treatment plant.
4. Low spot along Railroad Ave, culvert prone to getting clogged with debris. Culvert has been overtopped in the past.
5. Location of doctor's office, town anchor business.
6. Vacant house, not because it was flooded.
7. Stamford Central School
8. Mechanic's shop that is owned by the Stamford school district.
9. The Pavilion at Robinson Terrace: Assisted Living, elderly housing.
10. Approximate extent of underground culvert near the headwaters of the Unnamed Tributary 1 to the WBDR (sketched on map).
11. No reports of these houses flooding.
12. Stamford highway garage.
13. Former wetland where Unnamed Tributary 1 would join the WBDR is now a carwash.
14. Stamford fire department
15. Water supply. Taylor reservoir is backup water supply.
16. A building used to sit directly on top of the WBDR at this location. The structure was demolished sometime in the early 1980. In the winter, ice scraping underneath the structure would be heard.
17. Water and sewer run directly over the culvert. Culvert has makeshift trash rack to keep beavers out of culvert. May need to analyze flooding when culvert is partially clogged with debris.
18. Graham Drive built for access to Deans Landing Apartments.

Schedule and Plan for Public Meeting

A public meeting will be convened for the purpose of gathering information on flooding in the study areas. Additionally, a second LFA kick-off meeting will be scheduled to meet with and gather information from the representatives from the village of Hobart and the hamlet of South Kortright. At this time, the schedule and the order of these meetings has yet to be determined. DCSWCD, with assistance from the Delaware County Planning Department, will provide the FAC with a list of addresses located within the

FEMA floodplain of the West Branch Delaware River and those in close proximity to the tributaries listed in the LFA scope.

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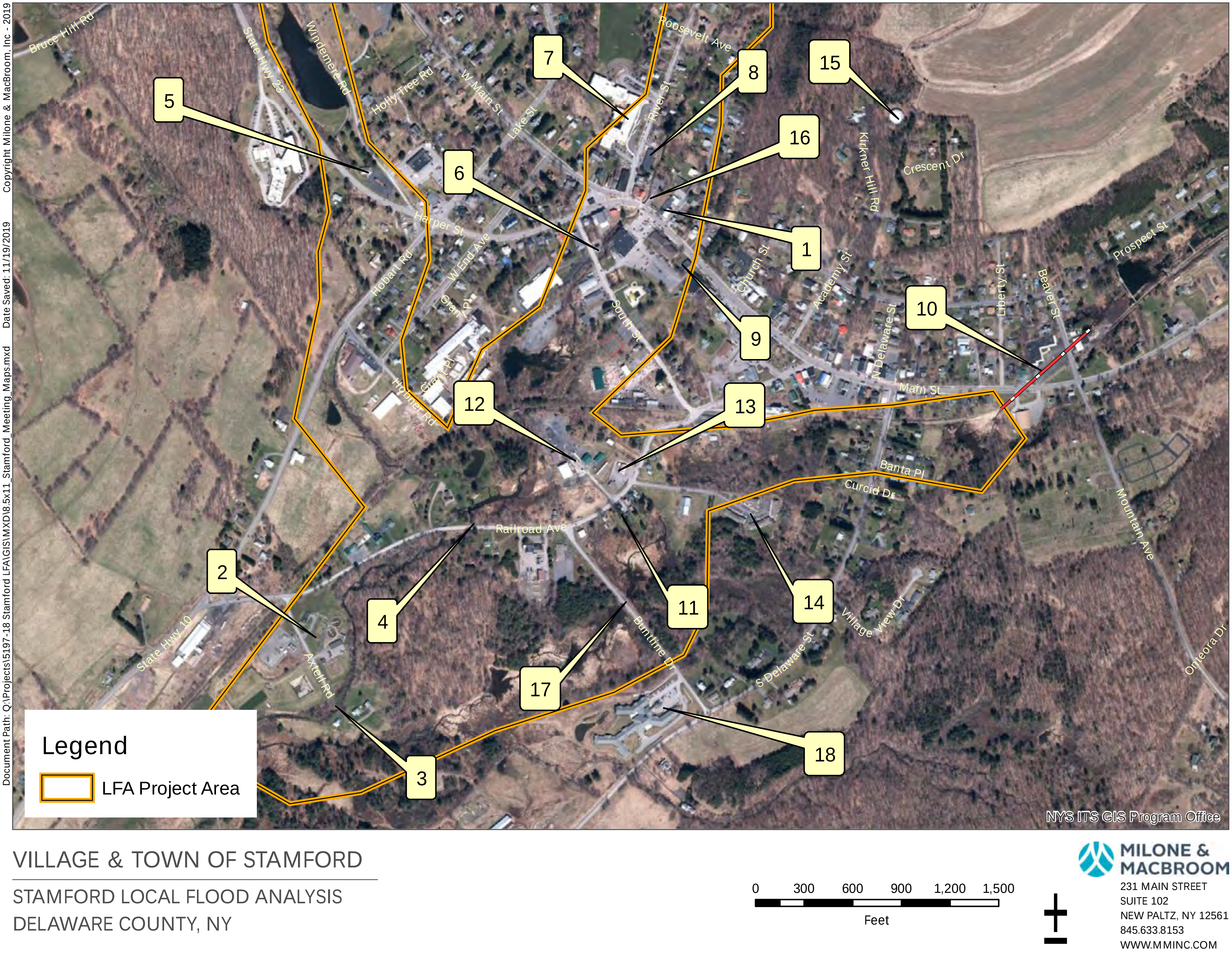


VILLAGE & TOWN OF STAMFORD

STAMFORD LOCAL FLOOD ANALYSIS
DELAWARE COUNTY, NY

MILONE & MACBROOM
231 MAIN STREET
SUITE 102
NEW PALTZ, NY 12561
845.633.8153
WWW.MMINC.COM

MEETING SIGN-IN SHEET

MILONE & MACBROOM		Meeting Date:	November 14 @ 6:30PM
Project:	Stamford LFA #5197-18	**Place/Room:**	Stamford Village Hall

Name	Company	Phone	E-Mail
Mark Carabetta	Milone & MacBroom	(845) 633-8153	mcarabetta@mminc.com
Ethan Ely	Milone & MacBroom	(845) 633-8153	eely@mminc.com
Miguel Castellanos	Milone & MacBroom	(845) 633-8153	mcastellanos@mminc.com
Jim Kopp	Village of Stamford	607-435-6918	Deputymayor@stamfordny.com
Ben Dates	DCSWCD	607-865-5223	ben-dates@dcswcd.org
John Bray	Village of STAMFORD	607 651 4031	John.bray@STAMFORDNY.com
Kevin R Hull	Village of Stamford	607-434-5400	Kevin@Kwreynordinsurance.com
ADAM TRESCOTT	NYC DEP	845-340-7220	atrescott@dep.nyc.gov
Jesse Calia	Village DPW	518 291 7904	JCALIA.Gmail.Com
Graydon Dutcher	Delaware Co. SWCD	(607) 865-7090	graydon-dutcher@dcswcd.org

MEETING NOTES

TO:	Stamford Flood Advisory Committee
FROM:	Milone & MacBroom, Inc.
RE:	Stamford LFA Public Meeting #1
DATE:	January 16, 2020
MMI #:	5197-18

A public meeting for the Stamford Local Flood Analysis (LFA) was held on the evening of January 14, 2019 at the Stamford Town Hall. In attendance were Mark Carabetta, Miguel Castellanos and Ethan Ely from Milone and MacBroom (MMI), as well as members of the Stamford Flood Advisory Commission (FAC), and residents from the villages of Hobart and Stamford. FAC members included representatives from the village of Stamford, the New York City Department of Environmental Protection (NYCDEP), the Delaware County Soil and Water Conservation District (DCSWCD), Catskill Watershed Corporation (CWC), and local business owners and residents. A sign-in sheet, map, and presentation slides are appended.

The purpose of the meeting was to:

- Review the study areas
- Summary recap of the LFA process and project focus
- Amass information about flooding (i.e. flood damages, flow paths, and flood depths, etc.)
- Discuss next steps in the LFA process and set a date for next FAC meeting

The meeting began with brief introductions, and a presentation of the LFA process and intended outcomes followed. MMI presented on subjects including the focus watershed characteristics, recognized flood patterns in the Catskill region, stream crossings being evaluated in the study, and potential mitigation strategies that have been explored in other LFAs.

Throughout the presentation, members of the committee commented about their experiences with flooding. MMI provided large scale maps so that flood advisory members could identify areas where flood damage occurred. MMI staff collected information and took detailed notes.

The meeting concluded with a discussion of next steps and setting a date for the next FAC meeting, where preliminary hydraulic findings will be introduced and examined. This discussion is anticipated to take place in late February. DCSWCD will coordinate with FAC members to set a specific date for the next meeting.

Following is a summary of notes collected at the meeting:

<u>General Comments</u>

Village of Stamford

- Stamford Village Mayor stated that the stream crossings along Buntline Drive, South Street, and NYS Route 23 are of high priority. Pervasive issues at these structures motivated the village to pursue the LFA initiative.
- Both a sewer line and a water main run parallel in the direction of Buntline Drive. The pipes are situated in between the top of the Buntline culvert and the surface of the road.

- South Street culvert was overtopped during 1996 storm event. The culvert is 150 years old and was recently found to be structurally unsound, which led to closure of the road.
- There used to be a natural pond where the Stamford pool is currently found. This pond was spring-fed and drained to the WBDR. Due to the presence of soft soils and substantial moisture content at the site, the pool foundation is prone to cracking and ever since its inception the village has struggled to keep water from escaping the pool.

Village of Hobart

- The village was described as a popular site for mills, which explains the series of impoundments located along the WBDR within the village bounds.

Hamlet of South Kortright

- There was once an impounded lake on the WBDR, just upstream of the Bovina Center-South Kortright Road Bridge.

Comments Tied to Maps (see appended map):

Village of Stamford

A & B. Several residential buildings along Roosevelt Avenue have experienced flooding from the WBDR. One resident also mentions that their lawn has become progressively wetter over the several decades. Residents specifically mentioned experiencing flooding in 1996 and 2011.

C. The sidewalks and street lighting along Main Street and Harper Street are schedule for replacement in 2021.

D. The former gas station along Harper Street is being acquired by the village of Stamford. A clean-up has been performed at the site and the storage tanks were removed. The village plans to remove the building and create a greenspace at the property.

Village of Hobart

1. SMIP grant awarded to town for the stabilization of the left bank just upstream of the Maple Ave culvert over Grant Brook. It was mentioned that this was missed opportunity to use grant money to also fund for the replace the severely undersized culvert. A few homes upstream of the culvert are mapped within the FEMA designated Special Flood Hazard Area (SFHA) and would've benefited from upsizing the existing Maple Ave structure.
2. The backside of buildings at this location are shown to be partially within the bounds of the FEMA SFHA. A property owner expressed concern about the elevation of his first floor possibly being above the FEMA Base Flood Elevation (BFE) for the 100-year storm event at this location. If this were the case, the property owner would be excluded from the requirement for flood insurance for mortgaged homeowners. CWC provides flood risk assessments for individual property owners and may be able to assist with the preparation of an elevation certificate.
3. During Irene, the water surface was only a couple of inches above the gabions that run along the left bank of the WBDR. This flood stage was not abnormal and is also often seen during the spring season.
4. Location of beaver impoundment. No indication of whether problematic or not.

Hamlet of South Kortright

1. This building used to be a lake house for the McLean family. The structure is mapped inside the FEMA floodway.

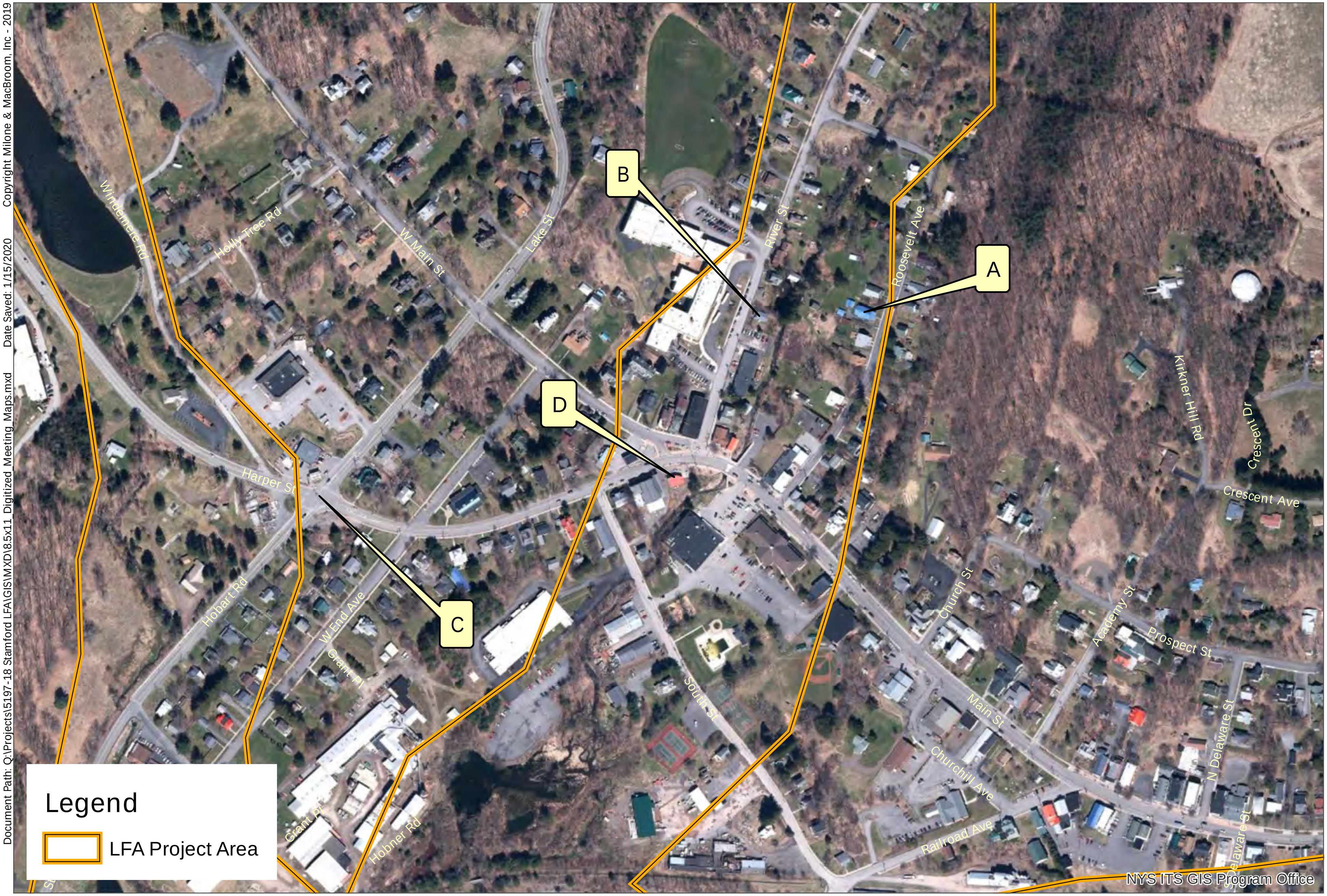
2. This barn experienced substantial flood damage sometime before 1998. The streambanks of the WBDR along this stretch have been disturbed and are covered with field stone that's been dumped throughout the years.

The following tasks will be performed in moving forward with the LFA:

- DCSWCD will coordinate with FAC members to set a specific date for the next FAC meeting.

- MMI will perform hydrologic and hydraulic analyses of various flood prone structures identified during the public meeting and kick-off FAC meeting. The capacities of these structures and potential flood mitigation scenarios will be evaluated.

- Due to the importance of the South Street culvert and its current poor condition, MMI will make this site a top priority in its hydraulic evaluation.



VILLAGE & TOWN OF STAMFORD

STAMFORD LOCAL FLOOD ANALYSIS
DELAWARE COUNTY, NY

0 200 400
Feet

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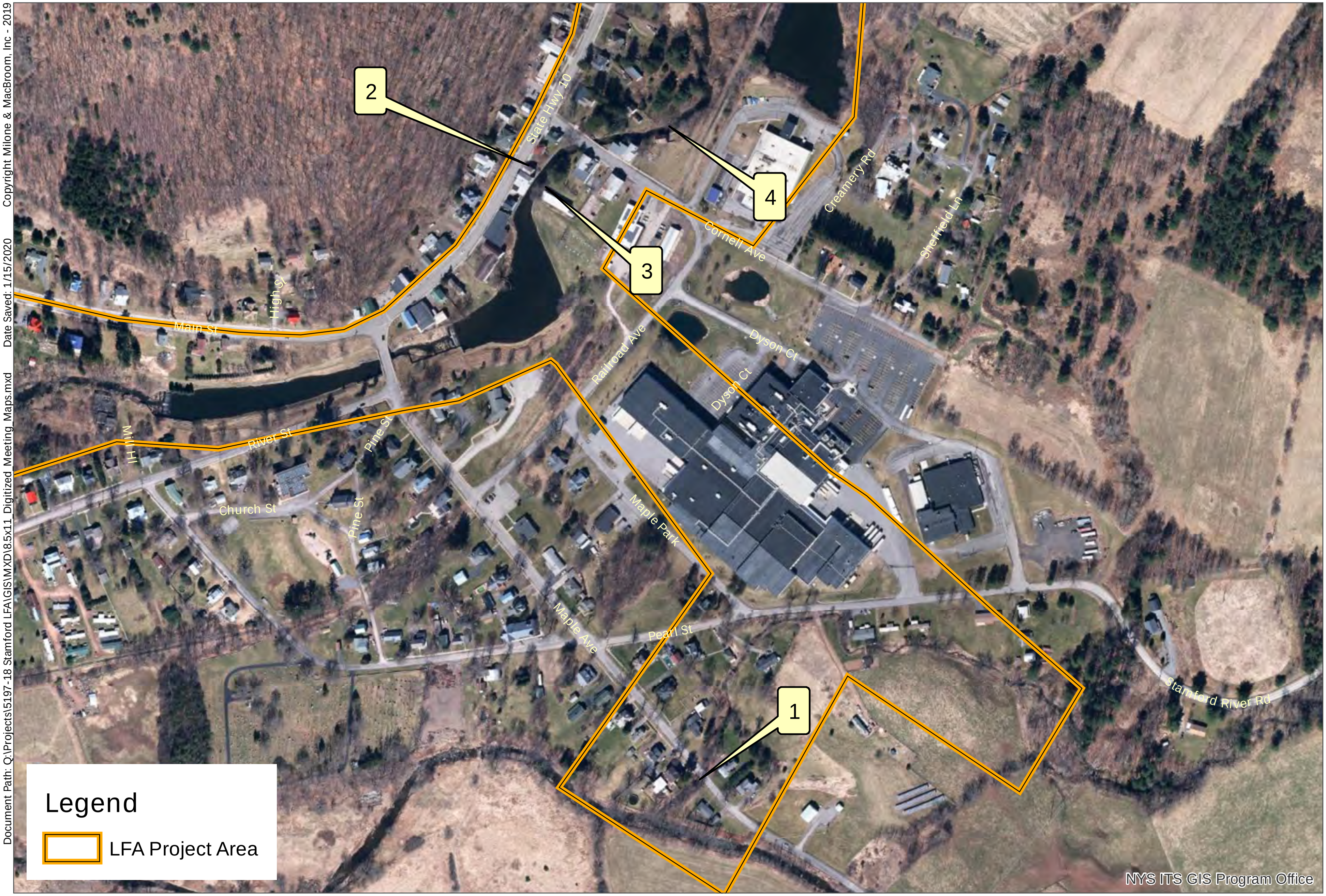

VILLAGE OF HOBART

STAMFORD LOCAL FLOOD ANALYSIS
DELAWARE COUNTY, NY

0 200 400
Feet

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HAMLET OF SOUTH KORTRIGHT

STAMFORD LOCAL FLOOD ANALYSIS
DELAWARE COUNTY, NY

0 200 400
Feet

MILONE & MACBROOM
231 MAIN STREET
SUITE 102
NEW PALTZ, NY 12561
845.633.8153
WWW.MMINC.COM

MEETING SIGN-IN SHEET

MILONE & MACBROOM		Meeting Date:	January 14, 2020 @ 7:00PM
Project:	Stamford LFA #5197-18	Place/Room:	Stamford Town Hall

Name	Company	Phone	E-Mail
Mark Carabetta	Milone & MacBroom	(845) 633-8153	mcarabetta@mminc.com
Ethan Ely	Milone & MacBroom	(845) 633-8153	eely@mminc.com
Miguel Castellanos	Milone & MacBroom	(845) 633-8153	mcastellanos@mminc.com
Tim Kopp	Village of Stamford	607-435-6918	Popkopp@verizon.net
Robert J. Schneider	Village of Stamford	607 547 1884	MAYOR@STAMFORDNY.COM
BEN DATES	DCSWCD	607-865-5223	ben-dates@dcswcd.org
DON DALES	HOBART, BOOK VILLAGE	607538 9788	ddales@STNY.RR.COM
ADAM TRESCOTT	NYC DEP	845-340-7220	atrescott@dep.nyc.gov
John Mathiesen	CWC	845 586-1400	jmathiesen@cwconline.org
Donna Prehn	private citizen	607-652-567	donna.prehn@gmail.com

MEETING NOTES

TO:	Stamford Flood Advisory Committee
FROM:	Milone & MacBroom, Inc.
RE:	Stamford LFA FAC Meeting #2
DATE:	February 24, 2020
MMI #:	5197-18

A second meeting for the Stamford Local Flood Analysis (LFA) was held on the evening of February 20, 2020 at the Stamford Village Hall. In attendance were Mark Carabetta and Miguel Castellanos from Milone & MacBroom (MMI), as well as members of the Stamford Flood Advisory Commission (FAC). FAC members included representatives from the village of Stamford, the New York City Department of Environmental Protection (NYCDEP), the Delaware County Soil and Water Conservation District (DCSWCD), and local business owners and residents. A sign-in sheet and presentation slides are appended.

The purpose of the meeting was to:

- Share initial hydraulic findings for the village and hamlet project areas
- Gather feedback from the committee about proposed flood mitigation alternatives

General Comments

- It was pointed out that the picture of flooding behind homes along Roosevelt Avenue, on slide #8 of the presentation, was taken during Tropical Storm Irene in 2011.
- DCSWCD has been working assiduously to resolve the closure of South Street. It was mentioned that in the meantime that the LFA study is completed and the final report is adopted, a temporary replacement culvert could be put in place. Alternatively, another suggestion made was to have MMI provide the village with a technical memorandum for recommendations at South Street, which the town could choose to adopt and proceed to acquire funds for a replacement structure.
- DCSWCD mentioned they would assist the town with submitting a Letter of Map Revision (LOMR) to FEMA if they decided to implement any flood mitigation projects that would reduce the existing extent of the designated 100-year floodplain.
- It was mentioned that the ground around the DPW garage is often underwater, although it is unclear whether this is due to riverine flooding.
- After the LFA report is adopted, individual homes along Main Street in the Village of Hobart will be eligible for a feasibility study to determine whether they are above the base flood elevation. CWC can assist property owners with filing for a FEMA elevation certificate, which would reduce flood insurance rates for stakeholders.

Required Action Items

MMI

- Perform channel survey along the WBDR reach between Main Street and South Street.
- Acquire first floor elevation data of homes within the inundation extent of the Rexmere Lakes dam beach analysis.

DCSWCD & Village

- Work together to schedule a date for the next FAC meeting.
- Reach out to the owner of 2 Graham Drive and invite to next LFA meeting.

MEETING SIGN-IN SHEET

MILONE & MACBROOM		**Meeting Date:**	February 20 @ 7:00PM
Project:	Stamford LFA #5197-18	**Place/Room:**	Stamford Village Hall

Name	Company	Phone	E-Mail
Mark Carabetta	Milone & MacBroom	(845) 633-8153	mcarabetta@mminc.com
Miguel Castellanos	Milone & MacBroom	(845) 633-8153	mcastellanos@mminc.com
Tomi Tompkins	village of stamford CEO	607-267-3767	TNTcodes00@yahoo.com
Jim Kopp	Village of Stamford	607 435 6918	PopKopp@Verizon.net
PHIL ESKELI	NYC DEP	845 340-7853	peskeli@dep.nyc.gov
ADAM TRESCOTT	NYC DEP	845 340-7220	atrescott@dep.nyc.gov
Graydon Dutcher	DC SWCD	607 865-6223	graydon-dutcher@[illegible]
John BRAY	Village of STAMFORD	607 651 4031	John.bray1964@gmail.com
Jean Kopp	Stamford Gables B&B	607-214-4196	JeanKopp@verizon.net
Robert Schneider	mayor, village of Stamford	6076524671	MAYOR@STAMFORDNY.com
Jesse Calia	Village D.P.W.	518 291 7904	JCalia@StamfordNY.com

MEETING NOTES

Milone & MacBroom — Now part of SLR

TO:	Stamford Flood Advisory Committee
FROM:	Milone & MacBroom, Inc.
RE:	Stamford LFA FAC Meeting #3
DATE:	May 12, 2020
MMI #:	5197-18

A third meeting for the Stamford Local Flood Analysis (LFA) was held beginning at 4:30 pm on May 7, 2020. The meeting was held by video conference. A sign-in sheet and presentation slides are appended.

The purpose of the meeting was to:

- Provide summary recap of February 20 meeting
- Share dam breach analysis findings
- Share refined hydraulic analysis findings
- Identify next steps & set date for next FAC meeting

Notes and Comments

- DCSWCD has collected survey of first floor elevations adjacent to lake in Hobart. These should be provided to MMI so that analysis in this area can be refined.
- MMI to conduct site walk of the West Branch Delaware River (WBDR) reach upstream of Roosevelt Ave and document any indication of sediment sources, which might be linked to regular flooding at the backyards of residences along River Street and Roosevelt Avenue.
- South Street in Stamford has been fitted with a temporary bridge that is working well.
- Comment was made that the Rexmere Lakes dams have never been overtopped. Calculated flood flows appear to be much larger than historical flows at the dams.
- Comment that removal of Rexmere Lakes would not be popular, supports annual fishing derby.
- MMI requested local flood law language from village.
- Town to provide information on basements of houses along Maple Avenue.
- Town to have discussions with landowners to see if they have experienced flood damages or flooded basements in the past. MMI has also requested for additional flood damage records at the Maple Ave culvert road crossing, if available. Other data that will help refine the Benefit Cost Analysis (BCA) includes records of previous road closure, records of average daily traffic counts, and information regarding the age of the culvert.
- MMI to provide general buyout recommendations in LFA report, not property specific.
- Ben and Jim to propose next FAC meeting date in June. At that time MMI will go through all LFA findings and recommendations.

MEETING SIGN-IN SHEET

MILONE & MACBROOM — Now part of SLR		Meeting Date:	May 7, 2020 @ 4:30PM
Project:	Stamford LFA #5197-18	Place/Room:	Virtual Meeting using Microsoft Teams

Name	Company	Phone	E-Mail
Mark Carabetta	Milone & MacBroom	(845) 633-8153	mcarabetta@mminc.com
Miguel Castellanos	Milone & MacBroom	(845) 633-8153	mcastellanos@mminc.com
Ethan Ely	Milone & MacBroom	(845) 633-8153	eely@mmin.com
Jim Kopp	Village of Stamford	(607) 435-6918	deputymayor@stamfordny.com
John Mark Bray	Village of Stamford Trustee	(607) 651-4031	jmbray@stamfordny.com
Phil Eskeli	NYCDEP	(845) 340-722	peskeli@dep.nyc.gov
Adam Trescott	NYCDEP	(845) 340-7220	atrescott@dep.nyc.gov
Ben Dates	Delaware Soil and Water Conservation District	(607) 435-6918	Ben.dates@dcswcd.org
Robert Schneider	Village of Stamford Mayor	(607) 652-6671	mayor@stamfordny.com
Graydon Dutcher	Delaware Soil and Water Conservation District	(607) 865-8223	Graydon.dutcher@dcswcd.org
Donna Prehna	Stamford Resident		

MEETING NOTES

TO:	Stamford Flood Advisory Committee
FROM:	Milone & MacBroom, Inc.
RE:	Stamford LFA FAC Meeting #4
DATE:	August 12, 2020
MMI #:	5197-18-01

A fourth meeting for the Stamford Local Flood Analysis (LFA) was held at 6:00 pm on August 11, 2020. The meeting was held by video conference. A sign-in sheet is appended. Presentation slides were circulated prior to the meeting.

The purpose of the meeting was to:

- Provide a summary of flood analysis findings
- Discuss and finalize LFA recommendations
- Plan to distribute draft LFA report
- Set timeline for report comments and finalizing
- Select date for public meeting, if necessary

Notes and Comments

- It was reported that the low-head dam upstream of Railroad Avenue is protecting a sewer line.
- Town officials decided not to schedule a second public meeting. Instead, the town will investigate other methods to make the draft LFA report widely accessible to the public to received input on the final recommendations.
- DCSWCD informed the committee that they had reached out to the landowner of the Graham Drive culvert, who currently uses the area for truck storage. It was reported that the roadway has been under water in the past and that the property owner is in favor of working out a solution to mitigate flooding. It was understood that the structure downstream at Buntline Drive would need to be addressed first before implementing any improvements at Graham Drive.
- Village of Hobart was looking to utilize "cured-in-place" pipe lining to rehab existing Maple Ave. culvert. This work was anticipated for 2020. Per discussions between DCSWCD and the Village, DCSWCD stated that the culvert could be replaced with a larger structure, per the recommendation in the on-going LFA, and would be funded and overseen by DCSWCD. Anticipated construction would be 2021. However, due to landowner concerns, DCSWCD has not surveyed the site and has notified the Village that without landowner "buy-in," this project will not be able to move forward.
- It was recommended for MMI to contact the Delaware County Planning Department to inquire about the Stamford Local Flood Damage Law.
- It was mentioned that there might be future funding sources from the Federal Government that would fund for the repair of high hazard dams. This will be mentioned in the final LFA report.
- A draft report will be circulated by MMI on or before August 31. Deadline for comments is September 30. MMI will address comments and circulate a final report by October 15.

MEETING SIGN-IN SHEET

MILONE & MACBROOM — Now part of SLR		Meeting Date:	August 11, 2020 @ 6:00PM
Project:	Stamford LFA #5197-18	Place/Room:	Virtual Meeting using Microsoft Teams

Name	Company	Phone	E-Mail
Mark Carabetta	Milone & MacBroom	(845) 633-8153	mcarabetta@mminc.com
Miguel Castellanos	Milone & MacBroom	(845) 633-8153	mcastellanos@mminc.com
Phil Eskeli	NYCDEP	(845) 340-722	peskeli@dep.nyc.gov
Adam Trescott	NYCDEP	(845) 340-7220	atrescott@dep.nyc.gov
Ben Dates	Delaware Soil and Water Conservation District	(607) 435-6918	Ben.dates@dcswcd.org
Graydon Dutcher	Delaware Soil and Water Conservation District	(607) 865-8223	Graydon.dutcher@dcswcd.org
Jessie Caia	Village DPW		JCalia@gmail.com
Donna Prehna	Stamford Resident		
Gabe	DEP K-9 intern		
Katie	DCSWCD K-9		

APPENDIX B

Hydrology and Hydraulic Validation

MILONE & MACBROOM

MEMORANDUM

TO: Stamford LFA
FROM: MMI
RE: FEMA FIS and hydraulic model comparison
DATE: November 2019
MMI #: 5197-18

Table of contents –

FIS Comparison and Validation

1. WEST BRANCH DELAWARE RIVER (WBDR)

Comparison of FEMA effective hydraulic mode to published 2016 Flood Insurance Study (FIS). On page 33 of the effective FIS report it is stated that a HEC-HMS hydrologic model was developed to derive peak flows for the 23 miles of WBDR mainstem that extends from the village Delhi, NY jurisdictional bound upstream to the Delaware County borderline.

Stamford, NY Study Area

Peak flow values are taken from Table 6 (page 55) of FIS.

SOURCE	LOCATION	Drainage Area (sq. miles)	PEAK FLOWS (cfs)				
			10-YR	25-YR	50-YR	*100-YR*	10-YR
HEC-RAS Model	126374		147	290	318	708	962
	125684		152	296	326	742	1023
	122996		158	305	335	789	1119
	121810		161	310	341	808	1161
	118554		162	313	343	795	1172
	118287		204	388	424	932	1412
	116700		206	391	429	939	1410
FEMA Delaware	End of Detailed Study at	3.85	147	290	318	708	962

County FIS (2016)	downstream of Utsanyantha Lake						
	Approximately 150 ft. upstream of confluence with West Branch Delaware River Tributary 3	4.06	152	296	326	742	1,023
	Approximately 100 ft. upstream of Roosevelt Avenue	4.37	157	305	335	789	1,119
	Approximately 1,200 ft. upstream of Railroad Avenue	4.56	161	310	341	808	1,161
	Approximately 180 ft. upstream of Confluence with West Branch Delaware River Tributary 2	4.63	162	313	343	795	1,172
	Approximately 410 ft. upstream of Axtell Road	5.99	204	388	424	932	1,412
	Just upstream of confluence with West Branch Delaware River Tributary 1	6.07	206	391	429	939	1,410
Flow Comparison			0	0	0	0	0
			0	0	0	0	0
			-1	0	0	0	0
			0	0	0	0	0
			0	0	0	0	0
			0	0	0	0	0

			0	0	0	0	0

Base Flood Elevations (without floodway):

FEMA FIS		HEC-RAS MODEL	
CROSS SECTIONS	*BASE FLOOD WSEL [WITHOUT FLOODWAY] (ft)*	*CROSS SECTION*	*100-YR WSEL (ft)*
DO	1,826.9	122898	1,826.92
DN	1,812.0	122108	1,812.04
DM	1,795.4	121169 WBDR109	1,795.40
DL	1,770.0	119529 WBDR102	1,770.04
DK	1,761.6	118554	1,761.61
DJ	1,747.3	116997 WBDR094	1,747.26

Notes: Using the online FEMA National Flood Hazard Layer (NFHL) Mapper and the HEC-RAS model with an aerial background, the corresponding FEMA FIS cross section was determined for the hydraulic model cross sections in the study reach. The base flood water surface elevations from Table 10 (page 119) of the Delaware County FIS were then compared to the HEC-RAS model water surface elevation output for the 100-YR storm. The plan that was evaluated was called Existing Conditions. Model and FIS base flood elevations within the Stamford project area are comparable.

Hobart, NY Study Area

SOURCE	LOCATION	Drainage Area (sq. miles)	PEAK FLOWS (cfs)				
			10-YR	25-YR	50-YR	100-YR	500-YR
HEC-RAS Model	99580		425	828	914	1936	2989
	96006		425	829	915	1939	2991
FEMA Delaware County FIS (2016)	Approximately 250 ft. upstream of Maple Avenue	15.98	425	828	914	1936	2989
	Just downstream of Hobart Dam	16.02	425	829	915	1939	2991

Flow Comparison			0	0	0	0	0
			0	0	0	0	0

Base Flood Elevations (without floodway):

FEMA FIS		**HEC-RAS MODEL**	
CROSS SECTIONS	*BASE FLOOD WSEL [WITHOUT FLOODWAY] (ft)*	*CROSS SECTION*	*100-YR WSEL (ft)*
DE	1,599.4	93948 WBDR054	1,599.40

South Kortright, NY Study Area

SOURCE	LOCATION	Drainage Area (sq. miles)	PEAK FLOWS (cfs)				
			10-YR	25-YR	50-YR	100-YR	500-YR
HEC-RAS Model	73127		2244	3924	4250	8162	11415
	67246		2447	4282	4635	8632	12062
FEMA Delaware County FIS (2016)	Approximately 150 ft. upstream of confluence with Betty Brook	48.7	2244	3924	4250	8162	11415
	Just upstream of confluence with unnamed tributary	58.44	2447	4282	4635	8632	12062
Flow Comparison			0	0	0	0	0
			0	0	0	0	0

Base Flood Elevations (without floodway):

FEMA FIS		**HEC-RAS MODEL**	
CROSS SECTIONS	*BASE FLOOD WSEL [WITHOUT FLOODWAY] (ft)*	*CROSS SECTION*	*100-YR WSEL (ft)*
CZ	1,514.8	74141	1,514.75
CY	1,495.9	69349	1,495.88

WBDR Conclusion: Aside from the 1 cfs difference at one of the change points in the Town of Stamford for the 10-year discharge, all other peak flow values between the hydraulic model and the effective FEMA FIS are comparable. A D*uplicate_Corrected_Effective* version of the model was created to correct for this flow data discrepancy and to update the model with additional cross sections in the proximity of the Bridge Street bridge and the South Street culvert located in the Village of Stamford. For the added cross sections, in-channel surveyed sections will be supplemented on the overbanks with LiDAR data collected in 2007, published in 2013-06-17, for the Delaware & Susquehanna River Basin.

WBDR FIS-Model Structures: Flood profiles from the FIS were printed and compared to the low cord and bridge deck elevations in the hydraulic model. Water surface elevations were also quickly compared and there were no apparent discrepancies between the two.

2. WEST BRANCH DELAWARE RIVER TRIBUTARY 1 (WBDR_T1)

USACE hydrologic modeling software HEC-HMS was utilized to calculate peak discharges for Tributary 1. LFA scope highlights the structures carrying Graham Drive and Buntline Drive as key areas of concern. FEMA cross sections bounding these locations were compared to the published FIS and the FEMA duplicate model.

Peak flow values came from Table 6 – Summary of Discharges (page 59) of the effective FIS report.

SOURCE	LOCATION	Drainage Area (sq. miles)	PEAK FLOWS (cfs)				
			10-YR	25-YR	50-YR	100-YR	500-YR
HEC-RAS Model	6247		86	175	194	435	583
	5359		65	113	118	138	146
	2845		100	191	209	436	572
	1451		103	201	219	458	623

FEMA Delaware County FIS (2016)	Approximately 450 ft. downstream of Beaver Street	1.35	85	175	194	433	576
	Upstream of S Delaware Street	1.41	86	175	194	435	583
	Upstream of confluence with unnamed tributary	2.76	100	186	205	430	863
	Upstream of confluence with West Branch Delaware Study Reach 2	2.95	103	196	215	453	911
Flow Comparison			1	0	0	2	7
			-21	-62	-76	-297	-437
			0	5	4	6	-291
			0	5	4	5	-288

Cross sections base flood elevation without floodway (feet NAVD) data from Table 10 of the FEMA FIS.

FEMA FIS		**HEC-RAS MODEL**		
CROSS SECTIONS	*BASE FLOOD WSEL [WITHOUT FLOODWAY] (ft)*	*CROSS SECTION*	*100-YR WSEL (ft)*	*Difference*
L	1,807.7	6085 INTER1	1,807.7	0.0
K	1,806.9	5572 WBDR1_22X	1,806.9	0.0
J	1,800.5	5359 WBDR1_20X	1,800.5	0.0
I	1,794.7	5151 WBDR1_17X	1,794.7	0.0
H	1,780.5	4713 WBDR1_16x	1,780.5	0.0
G	1,764.4	3918 WBDR1_14	1,764.4	0.0
F	1,764.4	3580 WBDR1_12X	1,764.4	0.0
E	1,764.4	3153 WBDR1_10X	1,764.4	0.0
D	1,757.1	2845 WBDR1_08X	1,757.1	0.0

<u>WBDR T1 Conclusions:</u> Comparison of the FEMA FIS with the model indicated that the incorrect peak flow values were used in the hydraulic modeling and should be adjusted to match the change point location and peak flows reported in the FIS. This might result in changes to WSEL at individual cross sections. A

Duplicate_Corrected_Effective version of the model will be created for the purpose of the Stamford LFA. It's also worth pointing out that 10-, 25-, and 50-year discharges for the first two change point locations listed in the FIS are identical although there is a large change in basin area between the two. This is outside the project area extent of this study.

WBDR T1 FIS-Model Structures: FIS flood profiles were printed, and low cord and bridge deck elevations were compared to those in the hydraulic model. Water surface elevations were also quickly compared and there were no apparent discrepancies for either of the two.

3. WEST BRANCH DELAWARE RIVER TRIBUTARY 2 (WBDR_T2)

USACE hydrologic modeling software HEC-HMS was utilized to calculate peak discharges for Tributary 2. The LFA scope doesn't mention any structures of concern along Tributary 2. This model would be utilized to create an unsteady model for a dam breach analysis.

Peak flow values came from Table 6 – Summary of Discharges (page 59) of the effective FIS report.

SOURCE	LOCATION	Drainage Area (sq. miles)	PEAK FLOWS (cfs)				
			10-YR	25-YR	50-YR	100-YR	500-YR
HEC-RAS Model	3127		36	71	77	167	210
	2669		72	133	143	302	367
	2096		93	170	183	381	463
FEMA Delaware County FIS (2016)	Downstream of Rexmere Lake	0.97	36	71	77	167	210
	Upstream of confluence with Harpersfield Tributary 2	1.15	72	133	143	302	367
	Just upstream of confluence with West Branch Delaware River main stem	1.27	93	170	183	381	463
Flow Comparison			0	0	0	0	0
			0	0	0	0	0
			0	0	0	0	0
			0	0	0	0	0

Cross sections base flood elevation without floodway (feet NAVD) data from Table 10 of the FEMA FIS.

FEMA FIS		**HEC-RAS MODEL**		*Difference*
CROSS SECTIONS	*BASE FLOOD WSEL [WITHOUT FLOODWAY] (ft)*	*CROSS SECTION*	*100-YR WSEL (ft)*	
I	1,819.2	3033 WBDR2_13X	1,819.3	0.0

H	1,809.7	2669 WBDR2_11X	1,809.7	0.0
G	1,805.7	2400 INTERP	1,805.7	0.0
F	1,798.2	2096 WBDR2_09X	1,798.2	0.0
E	1,790.4	1666 WBDR2_06X	1,790.4	0.0
D	1,784.8	1284 INTERP	1,784.8	0.0
C	1,774.5	764 WBDR2_04X	1,774.2	0.3
B	1,769.7	635 WBDR2_02X	1,769.6	0.1
A	1,763.1	289 INTER4	1,763.1	0.0

WBDR_T2 Conclusions: Aside from small base flood water surface elevations discrepancies, no other glaring issues are present with the model regarding its hydrology data. It should be noted that the water surface elevations reported in the FEMA FIS do not match the base flood elevation shown in the FEMA's online NFHL viewer for cross sections C, B, and A. The differences are minor and marked in red in the table above.

4. TOWN BROOK

USACE hydrologic modeling software HEC-HMS was utilized to calculate peak discharges for Town Brook. The Stamford LFA scope only requests evaluation of the structures carrying County Route 18 and the Catskill Scenic Trail. Only cross sections between these structures will be compared between the FEMA FIS report and the hydraulic model.

Peak flow values came from Table 6 – Summary of Discharges (page 52) of the effective FIS report

SOURCE	LOCATION	Drainage Area (sq. miles)	PEAK FLOWS (cfs)				
			10-YR	25-YR	50-YR	100-YR	500-YR
HEC-RAS Model	9724		2029	3173	3410	5933	7978
	9537		2037	3184	3422	5977	8040
	7783		2028	3179	3416	5965	8049
	4643		2067	3253	3517	6145	8339
	2859		2077	3256	3547	6179	8342
	1130		2079	3253	3553	6182	8342
	1064		2079	3253	3553	4468	8342
FEMA Delaware	Approximately 9300 ft. downstream of Narrow Notch Road	14.07	2029	3173	3410	5933	7978

County FIS (2016)	**USGS Gage 01421618 Town Brook just upstream of Clove Road**	**14.28**	**2037**	**3184**	**3422**	**5977**	**8040**
	Just upstream of confluence with Town Brook Tributary 1	**14.63**	**2028**	**3179**	**3416**	**5965**	**8049**
	Approximately 1850 ft. upstream of County Route 18	15.69	2067	3253	3517	6145	8339
	Just upstream of County Route 18	15.99	2077	3256	3547	6179	8342
	Just upstream of confleunce with West Branch Delaware River	16.02	2079	3253	3553	6182	8343
Flow Comparison			0	0	0	0	0
			0	0	0	0	0
			0	0	0	0	0
			0	0	0	0	0
			0	0	0	0	0
			0	0	0	0	-1
			2,079	3,253	3,553	4,468	8,342

Cross sections base flood elevation without floodway (feet NAVD) data from Table 10, page 109, of the FEMA FIS.

FEMA FIS		HEC-RAS MODEL		
CROSS SECTIONS	*BASE FLOOD WSEL [WITHOUT FLOODWAY] (ft)*	*CROSS SECTION*	*100-YR WSEL (ft)*	*Difference*
C	1,621.6		1,621.6	0.0
B	1,616.1		1,616.1	0.0
A	1,603.1		1,602.6	0.5

Town Brook Conclusions: Comparison of the effective model and FEMA FIS indicated that there are minor discrepancies in peak flow data and resulting base flood elevations. Considering that the discrepancies are within the LFA project area, a *Duplicate_Corrected_Effective* model was created to remove the 7th flow data change point that currently in the model's flow data file. In addition, the change points that are in **BOLD** on the table above are in the incorrect order; they are decreasing in discharge value as watershed area increases. This was also corrected for in the *Duplicate_Corrected_Effective* model.

Town Brook FIS-Model Structures: Flood profiles from the FIS were printed and compared to the low cord and bridge deck elevations in the hydraulic model. Water Surface elevations were also quickly compared and there were no apparent discrepancies between the two.

5. TOWN BROOK TRIBUTARY 1 (GRANT BROOK)

USACE hydrologic modeling software HEC-HMS was utilized to calculate peak discharges for Tributary 1 to Town Brook. Only the crossing under Maple Avenue was evaluated in this study. Peak flow values will be assessed for accuracy for the entire reach, although only cross sections near the structure of interest will be checked.

Peak flow values came from Table 6 – Summary of Discharges (page) of the effective FIS report

SOURCE	*LOCATION*	*Drainage Area*	*PEAK FLOWS (cfs)*				
		(sq. miles)	*10-YR*	*25-YR*	*50-YR*	*100-YR*	*500-YR*
HEC-RAS Model	1730		154	303	346	767	964
FEMA Delaware County FIS (2016)	Just upstream of confluence with Town Brook	0.97	154	319	346	767	964
Flow Comparison			0	-16	0	0	0
			0	0	0	0	0
			0	0	0	0	0
			0	0	0	0	0

Cross sections base flood elevation without floodway (feet NAVD) data from Table 10, page 110, of the FEMA FIS.

FEMA FIS		**HEC-RAS MODEL**		*Difference*
CROSS SECTIONS	*BASE FLOOD WSEL [WITHOUT FLOODWAY] (ft)*	*CROSS SECTION*	*100-YR WSEL (ft)*	
D	1,656.0	609	1,656.0	0.0
C	1,651.5	424	1,651.4	0.1
B	1,651.5	236	1,651.4	0.1
A	1,642.9	133	1,642.9	0.0

Town Brook Tributray Conclusions: Comparison of the effective model and FEMA FIS indicate that there is a 16 cfs discrepancy for the 25-year in peak discharge. There are also small differences in base flood elevations at cross sections B and C. A *Duplicate_Corrected_Effective* model that corrects the flow data from the 25-year discharge was created.

Town Brook tributary 1 FIS-Model Structures: Flood profiles from the FIS were printed and compared to the low cord and bridge deck elevations in the hydraulic model. Water Surface elevations were also quickly compared and there were no apparent discrepancies between the two.

CONCLUSION

Corrected Duplicate Effective Models will need to be created for the models of the watercourses listed above. The following table summarizes which models needed correction:

Watercourse	***Corrected_Dup_Effect***	***Correction Notes***
WBDR	Yes	Shift in flow data change point locations; cross sections added upstream of Bridge Street bridge and South Street culvert; hydraulic modeling approach changed from culvert to bridge method @ Bridge street bridge – V. of Stamford
WBDR T1	Yes	Adjustment to Multiple Profile flow data peak discharges
WBDR T2	No	
Town Brook	Yes	Removal of 7th profile from the Multiple Profile flow data file
Town Brook T1	Yes	25-year peak discharge updated to match FIS

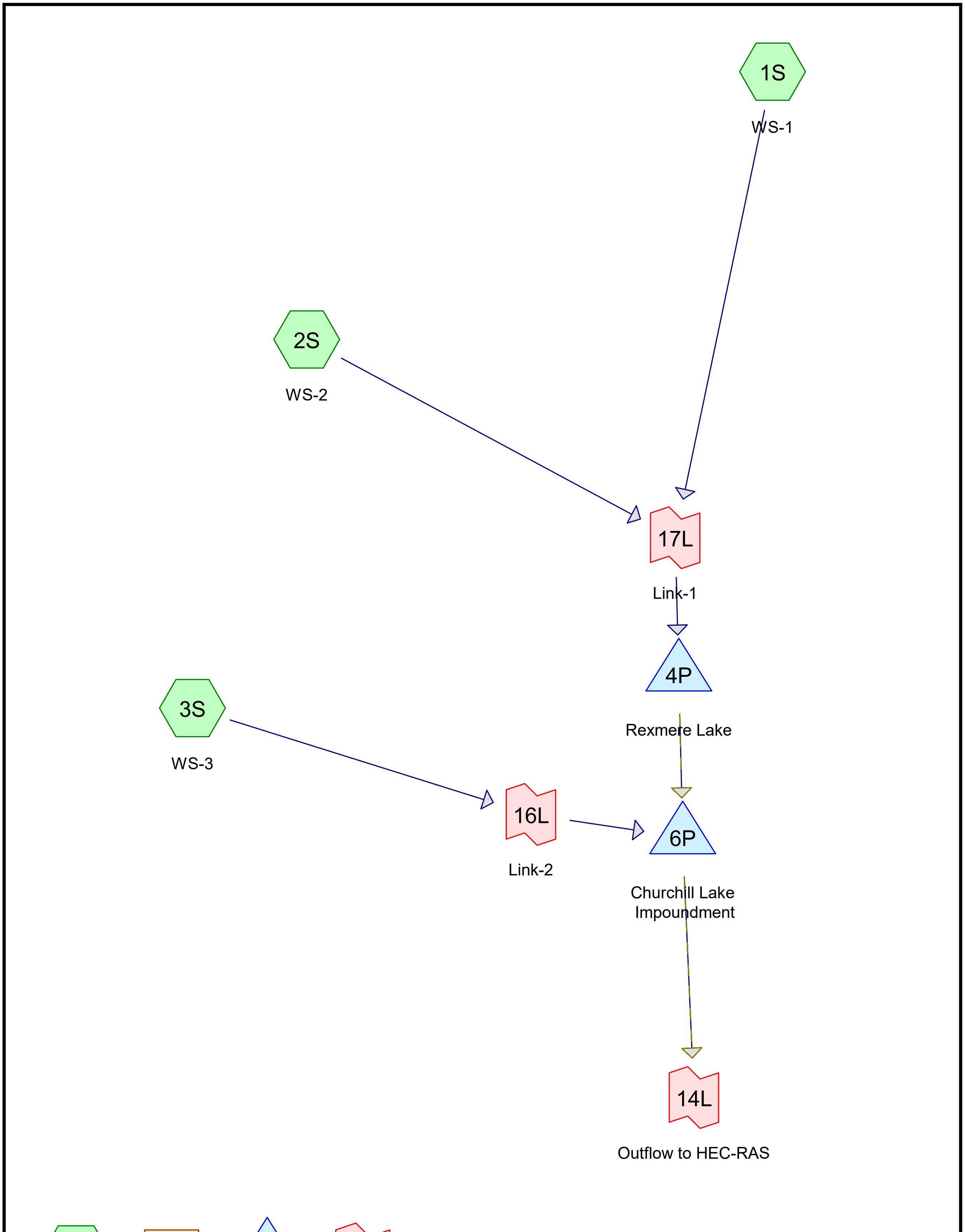
APPENDIX C

Dam Breach Analysis Details

Stamford LFA Dam Breach Parameters

Parameters	Dam Breach Scenario			
	Sunny-Day Dam Breach		Rainy-Day Dam Breach	
	Rexmere Dam	Churchill Dam	Rexmere Dam	Churchill Dam
Failure Type	Soil Piping	Overtopping	Overtopping	Overtopping
Top Elevation of Breach Opening (ft)	1866.7	1841.5	1866.7	1841.5
Bottom Elevation of Breach Opening (ft)	1845.0	1821.0	1840.0	1821.0
Breach Height (ft)	21.7	20.5	26.7	20.5
Bottom Width of Breach (ft)	47.0	62.0	35.0	69.0
Breach Side Slope (H:V)	0.5:1	0.5:1	1:1	0.5:1
Weir/Orifice Coefficient	0.6	2.6	2.5	2.54
Breach Starting Elevation (ft)	1856.0	1842.0	1867.0	1844.5
Breach Development Time (hr)	0.34	0.38	0.31	0.39
Breach Parameter Method	Von Thun & Gillete	Von Thun & Gillete	Froehlich 2008	Von Thun & Gillete

Hydrologic Model



Routing Diagram for RexmereLakesDams_VelocityMethod
Prepared by {enter your company name here}, Printed 10/29/2020
HydroCAD® 10.00-25 s/n 11053 © 2019 HydroCAD Software Solutions LLC

Time span=0.00-30.00 hrs, dt=0.01 hrs, 3001 points x 3
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

Subcatchment 1S: WS-1 Runoff Area=449.380 ac 0.00% Impervious Runoff Depth=21.54"
Flow Length=9,185' Tc=118.2 min CN=76 Runoff=4,137.12 cfs 806.757 af

Subcatchment 2S: WS-2 Runoff Area=183.794 ac 0.00% Impervious Runoff Depth=21.20"
Flow Length=2,979' Tc=49.7 min CN=74 Runoff=3,217.92 cfs 324.674 af

Subcatchment 3S: WS-3 Runoff Area=138.407 ac 0.00% Impervious Runoff Depth=21.20"
Flow Length=4,134' Tc=49.8 min CN=74 Runoff=2,417.45 cfs 244.498 af

Pond 4P: Rexmere Lake Peak Elev=1,867.03' Storage=161.783 af Inflow=2,610.98 cfs 565.719 af
,325.55 cfs 536.032 af Secondary=1,717.56 cfs 88.602 af Tertiary=149.19 cfs 1.655 af Outflow=11,325.55 cfs 626.289 af

Pond 6P: Churchill Lake Peak Elev=1,845.16' Storage=37.579 af Inflow=11,705.90 cfs 749.891 af
.86 cfs 558.584 af Secondary=3,629.90 cfs 148.876 af Tertiary=1,591.37 cfs 57.561 af Outflow=12,801.36 cfs 765.021 af

Link 14L: Outflow to HEC-RAS Inflow=12,801.36 cfs 765.021 af
Primary=12,801.36 cfs 765.021 af

Link 16L: Link-2 x 0.50 Inflow=2,417.45 cfs 244.498 af
Primary=1,208.72 cfs 122.249 af Secondary=1,208.72 cfs 122.249 af

Link 17L: Link-1 x 0.50 Inflow=5,221.96 cfs 1,131.431 af
Primary=2,610.98 cfs 565.716 af Secondary=2,610.98 cfs 565.716 af

Total Runoff Area = 771.581 ac Runoff Volume = 1,375.929 af Average Runoff Depth = 21.40"
100.00% Pervious = 771.581 ac 0.00% Impervious = 0.000 ac

Summary for Pond 4P: Rexmere Lake

Rexmere Lake is an impoundment along an unnamed tributary to the West Branch of the Delaware River and is upstream of Churchill Lake impoundment.

[56] Hint: Dam Breach started at 3.95 hrs WSE=1,867.01'
[95] Warning: Outlet Device #5 rise exceeded
[58] Hint: Peaked 0.53' above defined flood level

Inflow Area = 633.174 ac, 0.00% Impervious, Inflow Depth = 10.72" for PMP, 6-hr Flood event
Inflow = 2,610.98 cfs @ 3.70 hrs, Volume= 565.719 af, Incl. 0.00 cfs Base Flow
Outflow = 11,325.55 cfs @ 4.24 hrs, Volume= 626.289 af, Atten= 0%, Lag= 32.0 min
Primary = 11,325.55 cfs @ 4.24 hrs, Volume= 536.032 af
Secondary = 1,717.56 cfs @ 3.97 hrs, Volume= 88.602 af
Tertiary = 149.19 cfs @ 3.97 hrs, Volume= 1.655 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs / 3
Starting Elev= 1,860.15' Surf.Area= 9.093 ac Storage= 60.570 af
Peak Elev= 1,867.03' @ 3.97 hrs Surf.Area= 24.288 ac Storage= 161.783 af (101.213 af above start)
Flood Elev= 1,866.50' Surf.Area= 22.644 ac Storage= 149.308 af (88.738 af above start)

Plug-Flow detention time= 14.9 min calculated for 565.531 af (100% of inflow)
Center-of-Mass det. time= 7.0 min (284.2 - 277.2)

Volume	Invert	Avail.Storage	Storage Description
#1	1,840.00'	325.628 af	**Custom Stage Data (Conic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)	Wet.Area (acres)
1,840.00	0.030	0.000	0.000	0.030
1,850.00	1.970	7.477	7.477	1.975
1,856.00	5.830	22.378	29.855	5.840
1,862.00	10.780	49.075	78.930	10.798
1,864.00	13.910	24.624	103.554	13.930
1,866.00	21.150	34.808	138.362	21.172
1,868.00	27.430	48.444	186.806	27.454
1,870.00	34.680	61.968	248.775	34.706
1,872.00	42.300	76.854	325.628	42.329

Device	Routing	Invert	Outlet Devices (Turned on 1 times)
#1	Primary	1,860.15'	**66.0" W x 39.6" H, R=34.5"/99.3" Pipe Arch Left Culvert - Primary Outlet** L= 30.4' CMP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 1,860.15' / 1,858.72' S= 0.0470 '/' Cc= 0.900 n= 0.025 Corrugated metal, Flow Area= 14.16 sf
#2	Primary	1,860.14'	**66.0" W x 40.8" H, R=34.5"/99.3" Pipe Arch Right Culvert - Primary Outlet** L= 30.4' CMP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 1,860.14' / 1,858.65' S= 0.0490 '/' Cc= 0.900 n= 0.025 Corrugated metal, Flow Area= 14.67 sf
#3	Secondary	1,862.60'	**70.0' long x 60.0' breadth Emergency Spillway** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.68 2.70 2.70 2.64 2.63 2.64 2.64 2.63

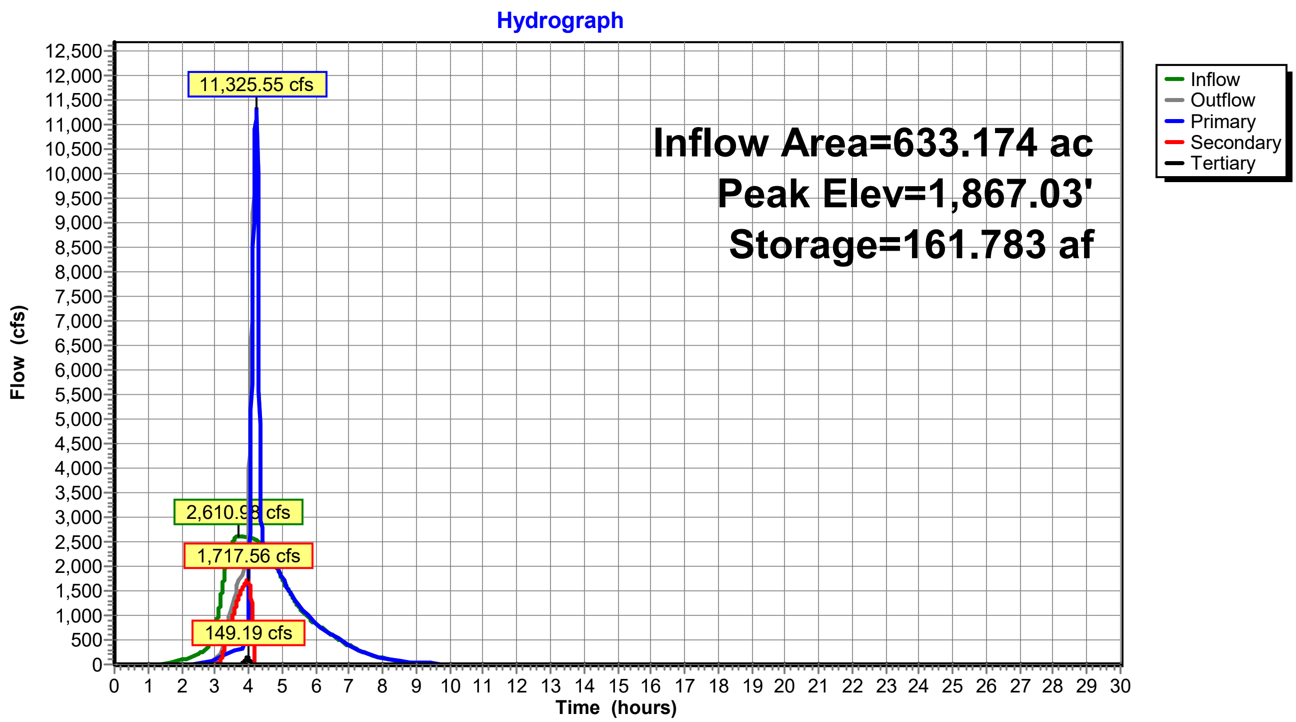
#4	Tertiary	1,866.70'	**300.0' long x 12.0' breadth Top of Dam** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.57 2.62 2.70 2.67 2.66 2.67 2.66 2.64	
#5	Primary	1,840.00'	**90.0 deg x 35.0' wide x 26.70' high Rainy Day Dam Breach** Top of breach = 1,866.70' Bottom of breach = 1,840.00' Breach starts at 1,867.00' WSE and develops over 0.31 hrs	C= 2.50

Primary OutFlow Max=11,316.03 cfs @ 4.24 hrs HW=1,859.68' TW=1,844.14' (Dynamic Tailwater)
1=Left Culvert - Primary Outlet (Controls 0.00 cfs)
2=Right Culvert - Primary Outlet (Controls 0.00 cfs)
5=Rainy Day Dam Breach (Weir Controls 11,316.03 cfs @ 12.19 fps)

Secondary OutFlow Max=1,717.08 cfs @ 3.97 hrs HW=1,867.03' TW=1,843.47' (Dynamic Tailwater)
3=Emergency Spillway (Weir Controls 1,717.08 cfs @ 5.54 fps)

Tertiary OutFlow Max=148.63 cfs @ 3.97 hrs HW=1,867.03' TW=1,843.47' (Dynamic Tailwater)
4=Top of Dam (Weir Controls 148.63 cfs @ 1.50 fps)

Pond 4P: Rexmere Lake



Summary for Pond 6P: Churchill Lake Impoundment

[56] Hint: Dam Breach started at 4.06 hrs WSE=1,844.65'
[95] Warning: Outlet Device #4 rise exceeded
[58] Hint: Peaked 3.66' above defined flood level

Inflow Area = 771.581 ac, 0.00% Impervious, Inflow Depth = 11.66" for PMP, 6-hr Flood event
Inflow = 11,705.90 cfs @ 4.24 hrs, Volume= 749.891 af, Incl. 0.55 cfs Base Flow
Outflow = 12,801.36 cfs @ 4.25 hrs, Volume= 765.021 af, Atten= 0%, Lag= 1.1 min
Primary = 10,846.86 cfs @ 4.28 hrs, Volume= 558.584 af
Secondary = 3,629.90 cfs @ 4.13 hrs, Volume= 148.876 af
Tertiary = 1,591.37 cfs @ 4.13 hrs, Volume= 57.561 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs / 3
Starting Elev= 1,838.65' Surf.Area= 2.572 ac Storage= 15.129 af
Peak Elev= 1,845.16' @ 4.13 hrs Surf.Area= 4.278 ac Storage= 37.579 af (22.450 af above start)
Flood Elev= 1,841.50' Surf.Area= 3.351 ac Storage= 23.619 af (8.490 af above start)

Plug-Flow detention time= (not calculated: outflow precedes inflow)
Center-of-Mass det. time= 1.5 min (278.4 - 276.9)

Volume	Invert	Avail.Storage	Storage Description
#1	1,821.00'	61.143 af	**Custom Stage Data (Conic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)	Wet.Area (acres)
1,821.00	0.000	0.000	0.000	0.000
1,840.00	2.980	18.873	18.873	2.993
1,842.00	3.480	6.454	25.327	3.497
1,844.00	3.980	7.454	32.781	4.001
1,846.00	4.500	8.475	41.256	4.526
1,848.00	4.950	9.446	50.702	4.982
1,850.00	5.495	10.440	61.143	5.532

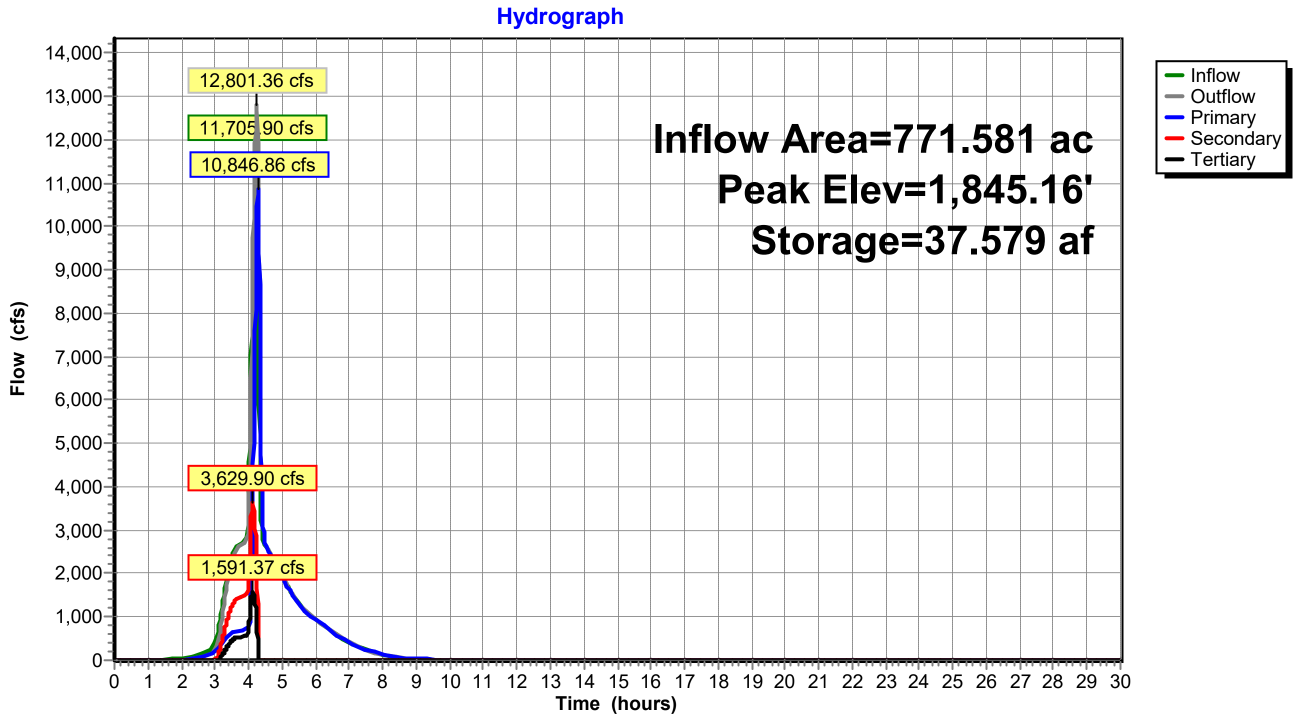
Device	Routing	Invert	Outlet Devices (Turned on 1 times)
#1	Primary	1,838.60'	**20.0' long x 3.0' breadth Primary Outlet** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 4.50 Coef. (English) 2.44 2.58 2.68 2.67 2.65 2.64 2.64 2.68 2.68 2.72 2.81 2.92 2.97 3.07 3.32
#2	Secondary	1,841.20'	**175.0' long x 25.0' breadth Top of Dam - Part 1** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.68 2.70 2.70 2.64 2.63 2.64 2.64 2.63
#3	Tertiary	1,841.60'	**90.0' long x 25.0' breadth Top of Dam - Part 2** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.68 2.70 2.70 2.64 2.63 2.64 2.64 2.63
#4	Primary	1,821.00'	**53.0 deg x 69.0' wide x 20.50' high Dam Breach** C= 2.54 Top of breach = 1,841.50' Bottom of breach = 1,821.00' Breach starts at 1,844.50' WSE and develops over 0.39 hrs

Primary OutFlow Max=10,840.36 cfs @ 4.28 hrs HW=1,842.56' TW=0.00' (Dynamic Tailwater)
—**1=Primary Outlet** (Weir Controls 481.76 cfs @ 6.09 fps)
—**4=Dam Breach** (Orifice Controls 10,358.60 cfs @ 11.90 fps)

Secondary OutFlow Max=3,628.71 cfs @ 4.13 hrs HW=1,845.16' TW=0.00' (Dynamic Tailwater)
—**2=Top of Dam - Part 1** (Weir Controls 3,628.71 cfs @ 5.23 fps)

Tertiary OutFlow Max=1,590.79 cfs @ 4.13 hrs HW=1,845.16' TW=0.00' (Dynamic Tailwater)
—**3=Top of Dam - Part 2** (Weir Controls 1,590.79 cfs @ 4.96 fps)

Pond 6P: Churchill Lake Impoundment

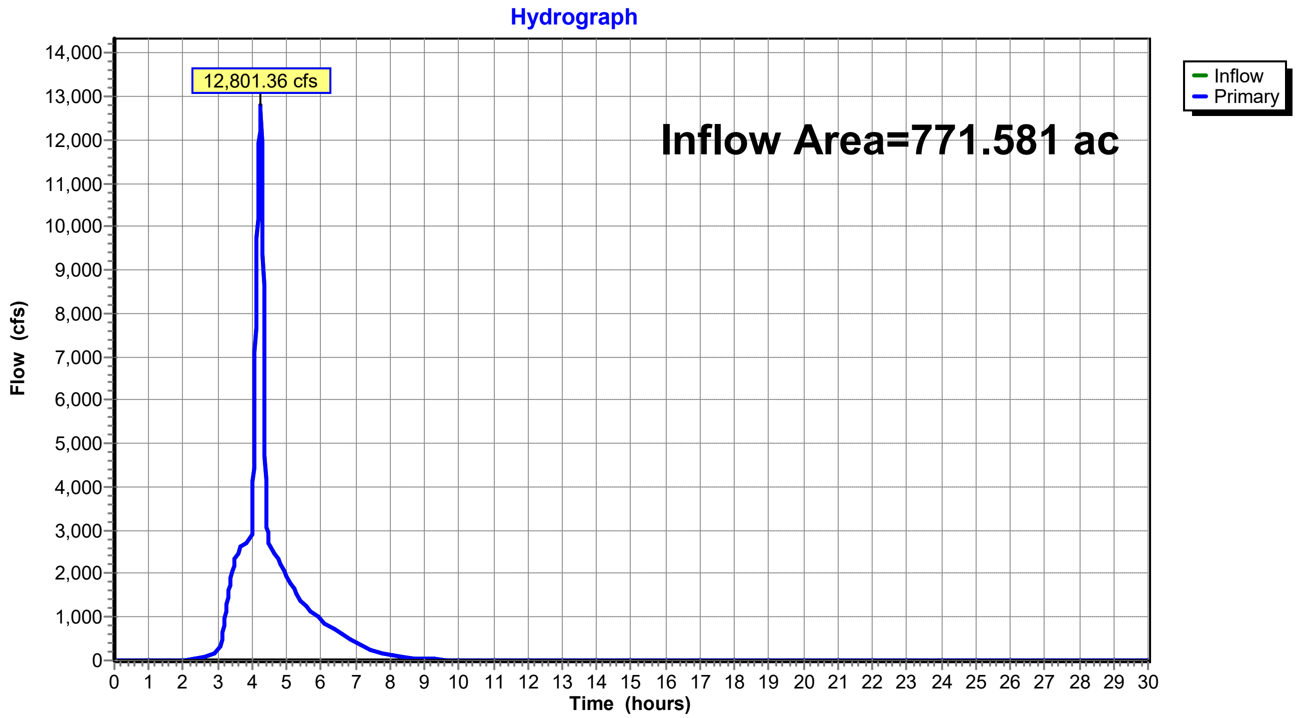


Summary for Link 14L: Outflow to HEC-RAS

Inflow Area = 771.581 ac, 0.00% Impervious, Inflow Depth = 11.90" for PMP, 6-hr Flood event
Inflow = 12,801.36 cfs @ 4.25 hrs, Volume= 765.021 af
Primary = 12,801.36 cfs @ 4.25 hrs, Volume= 765.021 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs

Link 14L: Outflow to HEC-RAS



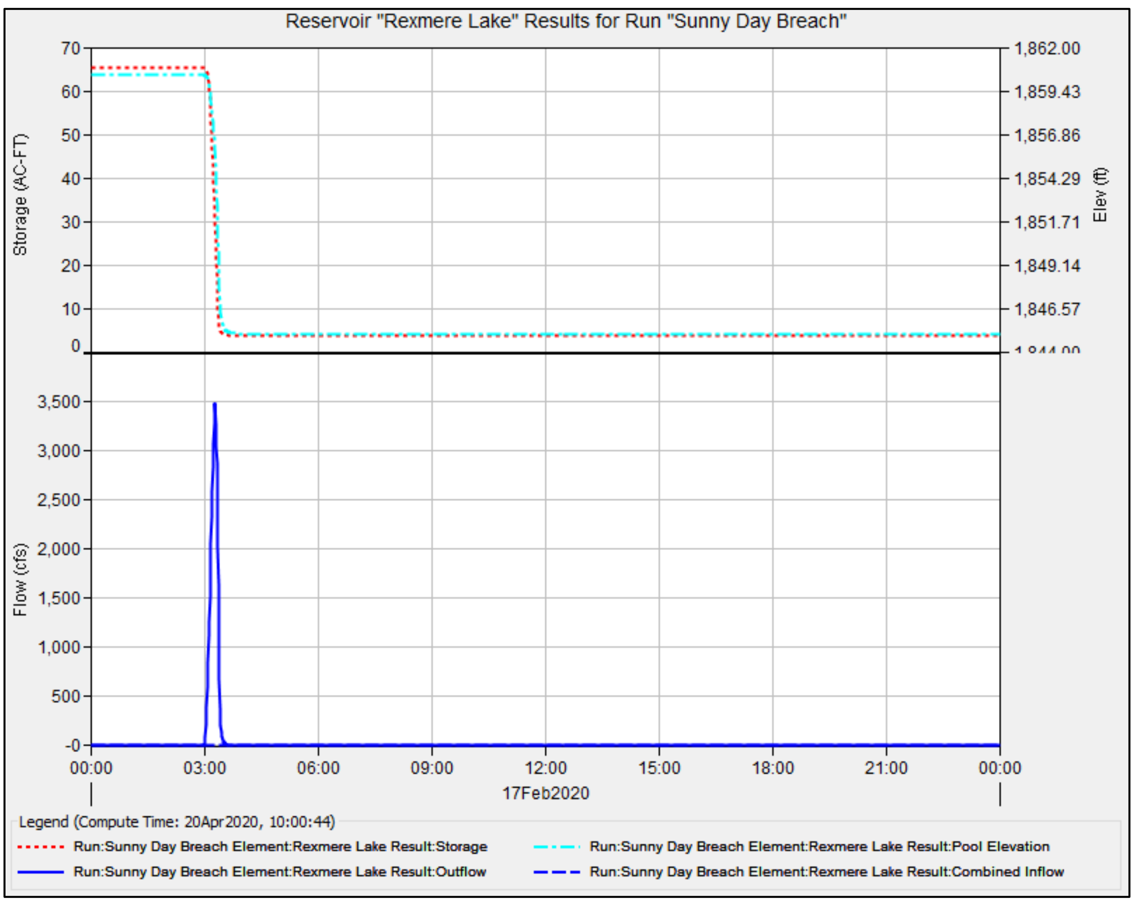
Sunny-Day Dam Breach – Model Output

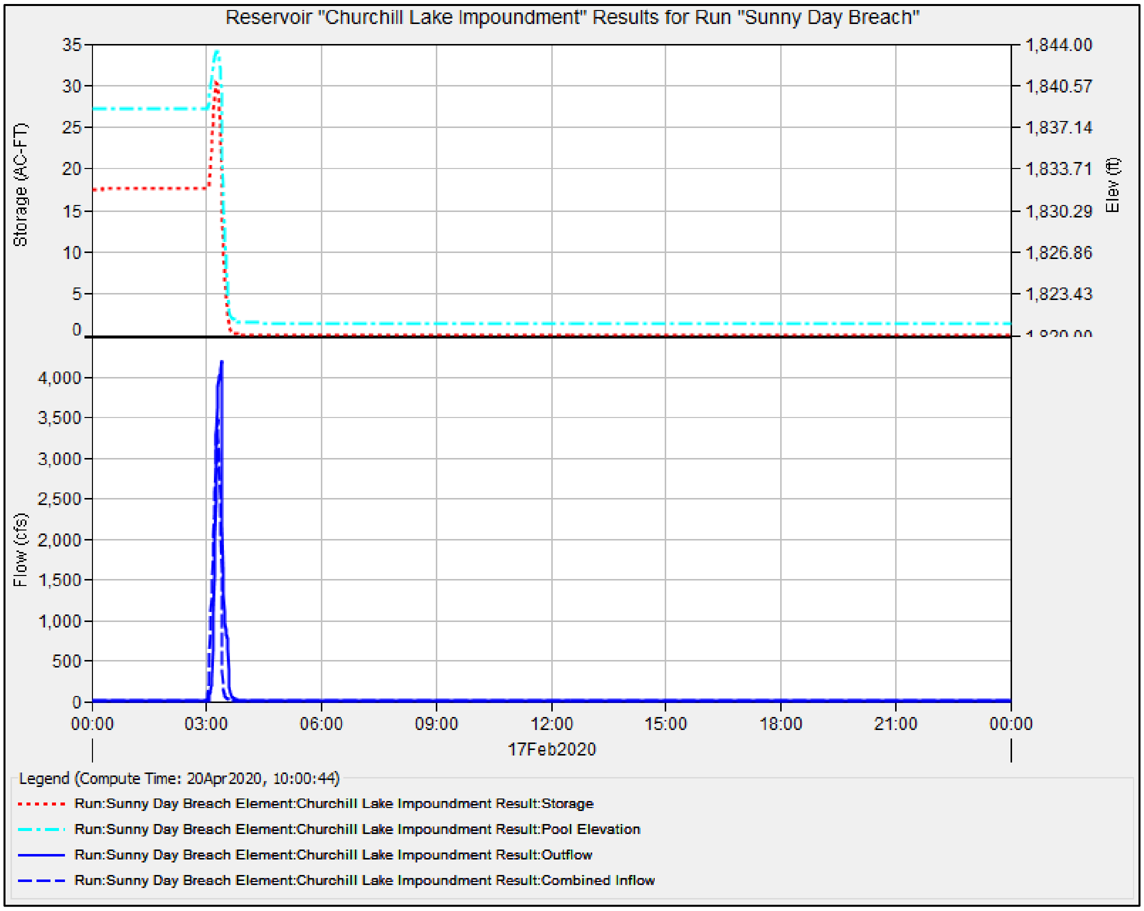
Project: Rexmere Lakes Dams   Simulation Run: Sunny Day Breach

Start of Run:	17Feb2020, 00:00	Basin Model:	Rexmere Lakes Watershed
End of Run:	18Feb2020, 00:00	Meteorologic Model:	Sunny Day Scenario
Compute Time:	20Apr2020, 10:00:44	Control Specifications:	Control 1

Show Elements: All Elements   Volume Units: IN ◉ AC-FT   Sorting: Hydrologic

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (AC-FT)
Subbasin-2	0.48	1.0	17Feb2020, 00:00	1.9
Subbasin-1	0.33	0.7	17Feb2020, 00:00	1.3
Rexmere Lake	0.81	3489.7	17Feb2020, 03:17	64.9
Subbasin-3	0.19	0.4	17Feb2020, 00:00	0.8
Churchill Lake Impoundment	1.00	4215.1	17Feb2020, 03:23	83.2





Reservoir "Churchill Lake Impoundment" Results for Run "Sunny Day Breach"
Storage (AC-FT)
35
30
25
20
15
10
5
0
Elev (ft)
1,844.00
1,840.57
1,837.14
1,833.71
1,830.29
1,826.86
1,823.43
Flow (cfs)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
00:00
03:00
06:00
09:00
12:00
15:00
18:00
21:00
00:00
17Feb2020
Legend (Compute Time: 20Apr2020, 10:00:44)
Run:Sunny Day Breach Element:Churchill Lake Impoundment Result:Storage
Run:Sunny Day Breach Element:Churchill Lake Impoundment Result:Pool Elevation
Run:Sunny Day Breach Element:Churchill Lake Impoundment Result:Outflow
Run:Sunny Day Breach Element:Churchill Lake Impoundment Result:Combined Inflow