EMERGENCY TRANSPORTATION INFRASTRUCTURE RECOVERY WATER BASIN ASSESSMENT AND FLOOD HAZARD MITIGATION ALTERNATIVES

BELLINGER BROOK AT THE VILLAGE OF HERKIMER HERKIMER COUNTY, NEW YORK

April 2014

MMI #5231-01

Photo Source: Milone & MacBroom, Inc. (2013)

This document was prepared for the New York State Department of Transportation, in cooperation with the New York State Department of Environmental Conservation.

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TABLE OF CONTENTS

Page

TABLE OF CONTENTS (continued)

Page

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

ABBREVIATIONS/ACRONYMS

CFS	Cubic Feet per Second
CME	Creighton Manning Engineering
DART	Damage Assessment Response Team
FEMA	Federal Emergency Management Agency
FIRM	Flood Insurance Rate Map
FIS	Flood Insurance Study
FTP	File Transfer Protocol
GIS	Geographic Information System
HEC-RAS	Hydrologic Engineering Center – River Analysis System
LiDAR	Light Detection and Ranging
MMI	Milone & MacBroom, Inc.
NFIP	National Flood Insurance Program
NOAA	National Oceanic and Atmospheric Administration
NWS	National Weather Service
NYSDEC	New York State Department of Environmental Conservation
NYSDOT	New York State Department of Transportation
STA	River Station
USACE	United States Army Corps of Engineers
USGS	United States Geological Survey

1.0 INTRODUCTION

1.1 Project Background

A severe precipitation system in June 2013 caused excessive flow rates and flooding in a number of communities in the greater Utica region. As a result, the New York State Department of Transportation (NYSDOT) in consultation with the New York State Department of Environmental Conservation (NYSDEC) retained Milone & MacBroom, Inc. (MMI) through a subconsultant agreement with Creighton Manning Engineering (CME) to undertake an emergency transportation infrastructure recovery water basin assessment of 13 watersheds in Herkimer, Oneida, and Montgomery Counties, including the Bellinger Brook watershed. Prudent Engineering was also contracted through CME to provide support services, including field survey of stream cross sections.

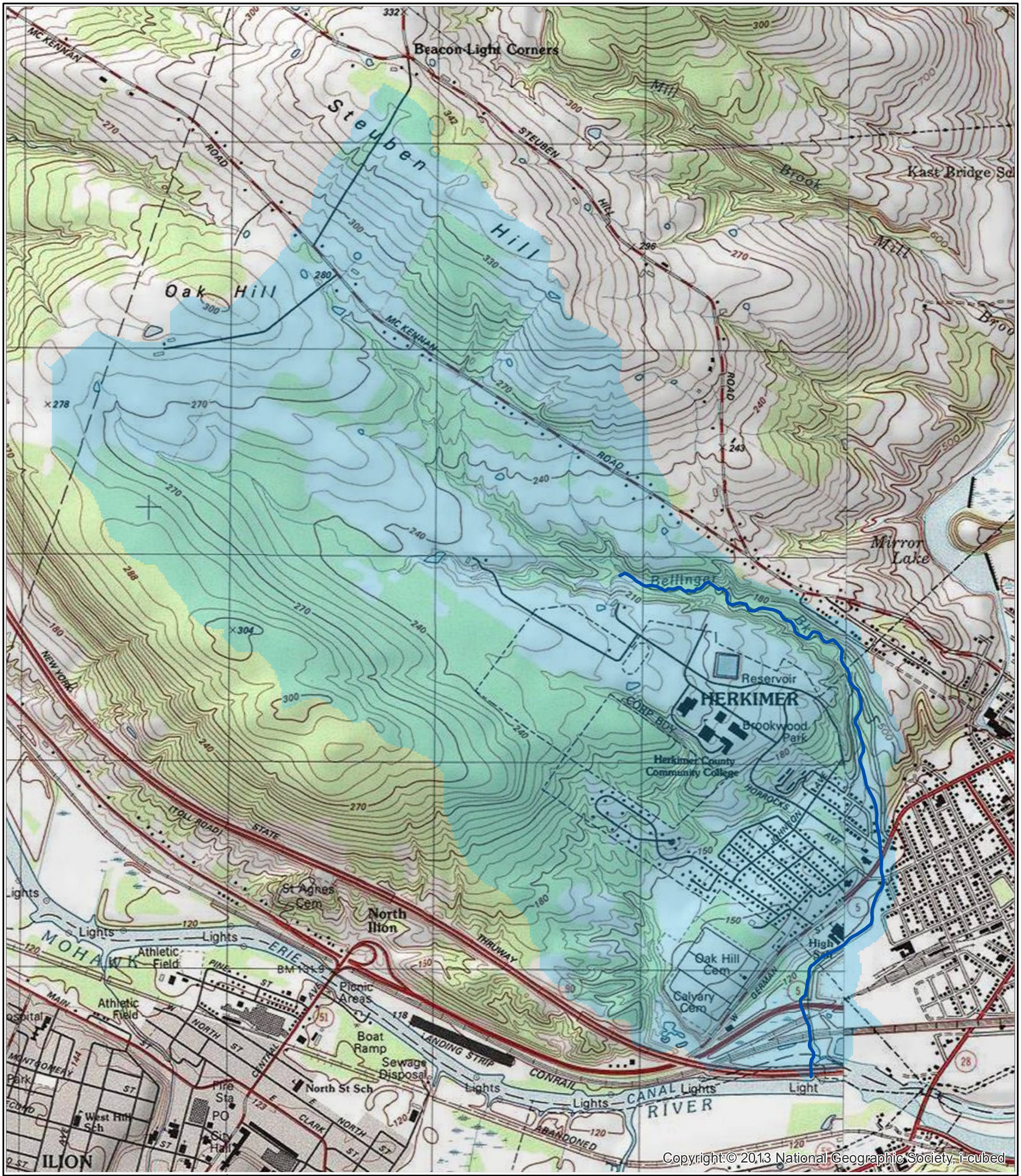
Work conducted for this study included field assessment of the watersheds, streams, and rivers; analysis of flood mitigation needs in the affected areas; hydrologic assessment; hydraulic modeling; and identification of long-term recommendations for mitigation of future flood hazards.

Bellinger Brook flows through the town and village of Herkimer in Herkimer County. The brook is 4.4 miles long with a contributing drainage basin of 3.7 square miles. Figure 1 depicts the contributing watershed. Bellinger Brook has an average slope of 2.3 percent over its entire length. The drainage basin is over 50 percent forested, with a mix of residential and commercial land uses concentrated in the lower part of the basin.

Bellinger Brook is a relatively steep watercourse that generates a substantial amount of stream power during high flows. The fundamental flood vulnerabilities associated with the brook stem from systematic floodplain constrictions, including a significant amount of vertical walled channelization that fully confines the watercourse. The channel is undersized with three roadway crossings that serve as pinch points. Areas of bank and bed instability contribute a substantial sediment load to the brook during high flow events, thus further restricting the channel and bridge capacity in depositional areas.

Compounding the poor stream hydraulics, land development (largely residential) occurs extensively in the floodplain, in many cases to within 20 feet of the edge of the stream. When the stream exceeds its low channel hydraulic capacity or becomes clogged with sediment and debris, it is prone to avulsion, finding new and destructive paths through the community and leaving widespread damages in its wake.

The storm event that occurred in June 2013 tells a compelling narrative about the flooding vulnerabilities of Bellinger Brook. The storm damaged homes, leaving property uninhabitable; damaged and/or destroyed bridges; and left the streambed and banks in unstable condition, at risk for further degradation and failure.



SOURCE(S):

Figure 1: Bellinger Brook Drainage Basin Location Map

LOCATION: **Herkimer County, New York**

NYDOT: Emergency Transportation Infrastructure Recovery

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Map By: CMP
MMI#: 5231-01
Original: 1/2/2014
Revision: 1/2/2014
Scale: 1 inch = 2,000 feet

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The goals of the subject water basin assessment were to:

1. Collect and analyze information relative to the June 2013 flood and other historic flooding events

2. Identify critical areas subject to flood risk

3. Develop and evaluate flood hazard mitigation alternatives for each high risk area within the stream corridor

1.2 Nomenclature

In this report and associated mapping, stream stationing is used as an address to identify specific points along the watercourse. Stationing is measured in feet, beginning at the mouth of Bellinger Brook at STA 0+00 and continuing upstream to STA 120+00. As an example, STA 73+00 indicates a point in the channel located 7,300 linear feet upstream of the mouth. Figure 2 depicts the stream stationing along Bellinger Brook.

All references to right bank and left bank in this report refer to "river right" and "river left," meaning the orientation assumes that the reader is standing in the river looking downstream.

2.0 DATA COLLECTION

2.1 Initial Data Collection

Public information pertaining to Bellinger Brook was collected from previously published documents as well as through meetings with municipal, county, and state officials. Data collected includes reports, photographs, newspaper articles, Federal Emergency Management Agency (FEMA) Flood Insurance Studies (FIS), aerial photographs, and geographic information system (GIS) mapping. Appendix A is a summary listing of data and reports collected.

2.2 Public Outreach

An initial project kickoff meeting was held in early October 2013 with representatives from NYSDOT and NYSDEC, followed by public outreach meetings held in the affected communities, including in the town of Herkimer. These meetings provided more detailed, firsthand accounts of past flooding events; identified specific areas that flooded in each community and the extent and severity of flood damage; and provided information on post-flood efforts such as bridge reconstruction, road repair, channel modification, and dredging. This outreach effort assisted in the identification of target areas for field investigations and future analysis.

SOURCE(S):

Figure 2: Bellinger Brook Watercourse Stationing

Location:

Herkimer County, New York

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NYDOT: Emergency Transportation Insfrastructure Recovery

Map By: CMP
MMI#: 5231-01
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2.3 Field Assessment

Following initial data gathering and outreach meetings, field staff from Prudent Engineering and MMI undertook field data collection efforts, with special attention given to areas identified in the outreach meetings. Initial field assessment of all 13 watersheds was conducted in October and November 2013. Selected locations identified in the initial phase were assessed more closely by multiple field teams in late November 2013. Information collected during field investigations included the following:

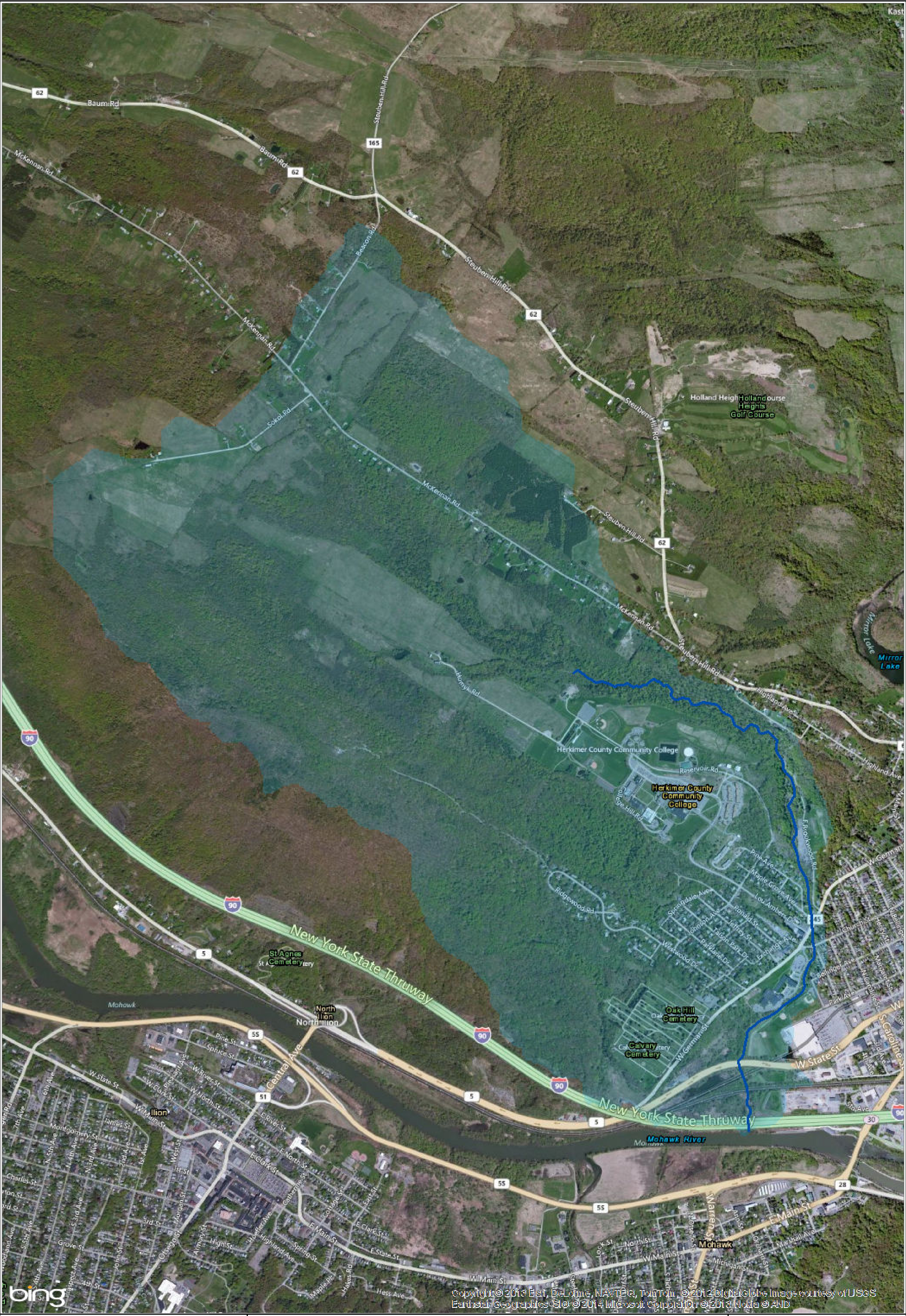
- Rapid "windshield" river corridor inspection
- Photo documentation of inspected areas
- Measurement and rapid hydraulic assessment of bridges, culverts, and dams
- Geomorphic classification and assessment, including measurement of bankfull channel widths and depths at key cross sections
- Field identification of potential flood storage areas
- Wolman pebble counts
- Cohesive soil shear strength measurements
- Characterization of key bank failures, headcuts, bed erosion, aggradation areas, and other unstable channel features
- Preliminary identification of potential flood hazard mitigation alternatives, including those requiring further analysis

Included in Appendix B is a copy of the River Assessment Reach Data Form, River Condition Assessment Form, Bridge Waterway Inspection Form, and Wolman Pebble Count Form. Appendix C is a photo log of select locations within the river corridor. Field Data Collection Index Summary mapping has been developed to graphically depict the type and location of field data collected. Completed data sheets, field notes, photo documentation, and mapping developed for this project have been uploaded onto the NYSDOT ProjectWise system and the project-specific file transfer protocol (FTP) site at MMI. The data and mapping were also provided electronically to NYSDEC.

2.4 Watershed Land Use

Figure 3 is a watershed map of Bellinger Brook. The brook flows through the town and village of Herkimer in Herkimer County. It drains an area of 3.7 square miles. The drainage basin is approximately 56 percent forested, with a mix of residential and commercial land uses concentrated in the lower part of the basin. The Herkimer County Community College campus is a significant facility within the basin and includes buildings, athletic fields, and paved parking lots. A second educational facility within the stream corridor is the Herkimer Junior/Senior High School, located in the lower part of the watershed.

The upper reaches of Bellinger Brook (upstream of STA 53+00) flow through forested land and sparse residential development, past the Herkimer County Community College campus, through Brookwood Park, and past a former landfill. A number of areas of bank



SOURCE(S):

Figure 3: Bellinger Brook Drainage Basin Aerial

Location: **Herkimer County, New York**

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NYDOT: Emergency Transportation Infrastructure Recovery

Map By: CMP
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erosion and minor bank failures were observed along Bellinger Brook (between STA 97+00 and STA 78+00), all of which are contributing to sediment load in the brook. There is evidence of high sediment load within these upper reaches, and it is evident that portions of the stream channel have been recently dredged in response to the 2013 storm.

2.5 Geomorphology

The total length of Bellinger Brook is 4.4 miles. It has an average slope of 2.6 percent from its headwaters to where it flows past Herkimer Junior/Senior High School (STA 31+00), a distance of 3.8 miles. The slope of the channel is relatively consistent over this length. From the school downstream to the mouth of Bellinger Brook (STA 0+00), the channel slope is much flatter at 0.4 percent. Steams with steep slopes generate more energy than low gradient streams and as a result have higher velocities and can carry more sediment.

For nearly 4,500 linear feet, from STA 73+00 upstream of Brookwood Park downstream to STA 31+00 near the high school, Bellinger Brook flows through a concrete-bottomed, stone-lined channel. Sections of the lined channel are deteriorating and are in poor condition. Between STA 65+75 and STA 53+50, the concrete and stone lining is absent although remnants of concrete observed in the channel indicate that this portion of Bellinger Brook may have been lined at one time.

A large erosional headcut has formed in Bellinger Brook and has been arrested in place by a concrete "jack" grade control structure near STA 65+75, just downstream of the Brookwood Park pavilion. The headcut is a point of severe instability, a progressive major source of sediment, and at high risk of becoming more severe if not repaired.

Downstream of the headcut, between STA 65+75 and STA 53+50, it appears that the stone and concrete that once lined this section of channel has been destroyed by the erosive action of the headcut, which has moved gradually upstream.

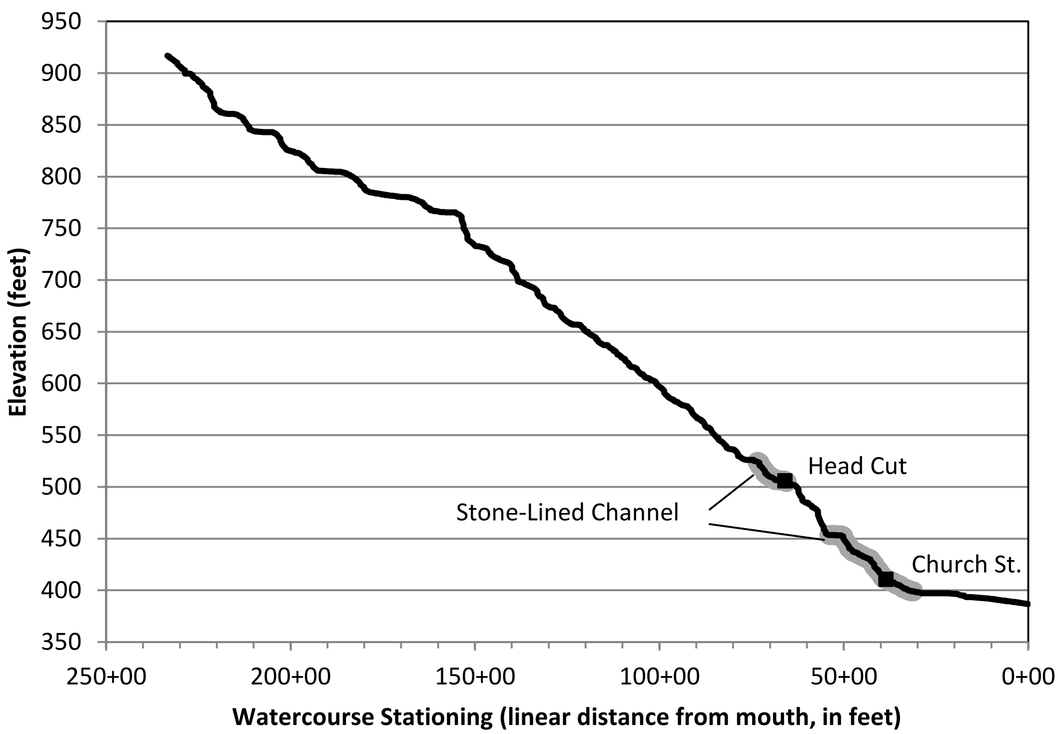
Downstream of Brookwood Park, the brook enters a mixed residential/commercial area and flows within its lined channel beneath three bridges, at Maple Grove Avenue (STA 43+50), West German Street (STA 42+00), and Church Street (STA 38+50). It is along this reach of Bellinger Brook where the most severe flooding and flood-related damage to homes, bridges, and property have occurred. It is reported that a high volume of coarse-grained sediment is transported through this reach during high flow events, which subsequently deposits under the downstream bridges.

Between Church Street (STA 38+50) and the Route 5 bridge (STA 12+50), Bellinger Brook flows between Herkimer Junior/Senior High School on the right bank and a residential area and athletic fields on the left. The gradient of the brook becomes much flatter at this point. A flood control levee is located along the left bank, between the athletic fields and the brook (from STA 32+00 to STA 16+00). The levee is showing signs of erosion at a number of locations. Two pedestrian footbridges cross the brook in this area, at STA 31+50 and STA 25+75.

Downstream of the Route 5 bridge, from STA 12+50 to STA 0+00, Bellinger Brook flows into a flood damage reduction project area, which consists of earth levees, control gates, ponding areas, and pump stations. According to municipal officials, the flood control system is operating as designed. No independent analysis has been conducted as part of the subject study to confirm the appropriateness of the design or its function.

Figure 4 presents a profile of Bellinger Brook, showing its elevation versus linear distance from the mouth of the watercourse, as well as the locations of the headcut, the Church Street bridge, and the stone-lined channel. The brook drops a total of 530 vertical feet over its 4.4-mile length, from an elevation of 916 feet above sea level at its headwaters to 386 feet at its outlet to the Mohawk River.

FIGURE 4
Bellinger Brook Channel Profile



2.6 <u>Hydrology</u>

Alluvial river channels adjust their width and depth around a long-term dynamic equilibrium condition that corresponds to "bankfull" conditions. Extensive data sets indicate that the channel-forming or bankfull discharge in specific regions is primarily a function of watershed area and soil conditions. The bankfull width and depth of alluvial channels represent long-term equilibrium conditions and are important geophysical criteria that are used for design. Table 1 below lists estimated bankfull discharge, width, and depth at several points along Bellinger Brook, as derived from the United States Geological Survey (USGS) *StreamStats* program.

TABLE 1
Estimated Bankfull Discharge, Width and Depth
(Source: USGS *StreamStats*)

Location Along Bellinger Brook	Station (ft)	Watershed Area, (sq. mi.)	Discharge (cfs)	Bankfull Width (ft)	Bankfull Depth (ft)
Upstream of Headcut in Park	66+00	2.23	98.0	28.7	1.38
Maple Grove Avenue Bridge	43+50	2.28	99.9	29.0	1.39
Church Street Bridge	38+75	3.08	129	32.3	1.53
FEMA Cross Section B	22+50	3.11	130	32.4	1.54
Railroad Bridge	7+50	3.22	134	32.8	1.56

In contrast to the average regional bankfull channel dimensions reported above, the actual measured width of the Bellinger Brook channel through the channelized reach ranges from 23 to 25 feet, with no floodplain, suggesting that it is narrower than an equivalent natural channel.

There are no USGS stream gauging stations on Bellinger Brook. Hydrologic data on peak flood flow rates are available from the FEMA FIS and from *StreamStats* regional statistical data.

The most current FEMA FIS for the village of Herkimer has an effective date of December 1977, and a revision date of June 17, 2002. A preliminary draft FIS is available for all of Herkimer County, which was issued September 30, 2011 but had not been formally approved as of the publication of the subject report. According to this more recent draft FIS, the hydraulic modeling for Bellinger Brook dates to December 1976, and it has been periodically republished for almost 40 years without updates.

The hydrologic analysis methods employed in the FEMA study used watershed characteristics such as drainage area, channel slope, channel length, available storage, rainfall intensity, vegetative cover, soil characteristics, and impervious area and were developed by the Soil Conservation Service (U.S. Department of Agriculture, 1973; Anderson, D. G., 1974; U.S. Department of Commerce, 1961). FEMA applied these predicted peak discharges in a hydraulic analysis on Bellinger Brook and compared the resulting water surface elevations with historical elevations and checked for reasonableness. The results were published in the FIS, and the resulting mapping was published as the effective Flood Insurance Rate Map (FIRM) for Bellinger Brook.

Estimated peak discharges for various frequency events were calculated by MMI using *StreamStats* and were then compared to peak discharges reported in the FEMA FIS. Table 2 lists estimated peak flows at FEMA cross section A, which is located at STA 21+50, just downstream of the high school. The drainage area at this location is reported in the FEMA FIS to be 3.2 square miles and by *StreamStats* to be 3.14 square miles.

TABLE 2
Bellinger Brook Peak Discharges at FEMA Cross Section A
(Station 21+50, Downstream of High School)

Frequency	FEMA Discharge (cfs)	*StreamStats* Discharge (cfs)
10-Yr	685	291
50-Yr	1,200	428
100-Yr	1,465	495
500-Yr	2,265	654

Table 3 lists estimated peak flows at FEMA cross section B, which is located at STA 28+75, just upstream of the high school. The drainage area at this location is reported in the FEMA FIS to be 2.55 square miles and by *StreamStats* to be 3.11 square miles. This is a substantial discrepancy. The basin area used by *StreamStats* appears more accurate based upon the USGS topography.

TABLE 3
Bellinger Brook Peak Discharges at FEMA Cross Section B
(MMI Station 28+75, Just Upstream of High School)

Frequency	FEMA Discharge (cfs)	*StreamStats* Discharge (cfs)
10-Yr	595	286
50-Yr	1,040	421
100-Yr	1,260	487
500-Yr	1,945	643

FEMA flood projections are more than twice (in some cases three times) those estimated by *StreamStats*. These large peak flow discrepancies exist between FEMA and *StreamStats* at both cross section locations. As further described in Section 3.3, both sets of flow data were modeled for existing conditions and compared to field observations during the June 2013 storm event. The analysis suggests that the FEMA flows more accurately represent the field conditions experienced in the June flood event. For this reason and in recognition that the FEMA flows are (a) more conservative; and (b) the jurisdictional standard, the FEMA flows were used in the subsequent analysis.

Because FEMA cross section A is located significantly downstream of some of the primary flooding areas, the ratios between the basin sizes at selected upstream locations were used to scale the FEMA flows at the corresponding areas. Table 4 presents the final data used in the hydraulic modeling of Bellinger Brook.

TABLE 4
Final Hydrology for Hydraulic Modeling of Bellinger Brook

River Station	Bankfull (cfs)	100-Year USGS (cfs)	Watershed Area (sq. mi.)	Watershed Area Ratio	100-Year FEMA (cfs)
21+50 FEMA "A"	131	495	3.15	-	1,465
40+50	129	477	3.07	0.97	1,421*
68+35	97	333	2.21	0.72	1,023*
108+90	88	290	1.97	0.89	9,11*

** Note: Ratios developed based upon scaling of flows from FEMA "A" based upon ratio of watershed area at each location.*

2.7 Infrastructure

Bridge spans and heights were measured as part of the 2013 field investigations. Table 5 summarizes the bridge measurements collected. For purposes of comparison, estimated bankfull widths at each structure are also included in the table. All of these bridges, with the exception of the pedestrian bridge at STA 25+75, were found to be insufficiently sized even to span bankfull flows.

TABLE 5
Summary of Stream Crossing Data

Roadway Crossing	Station	BIN	Measured Width (ft)*	Measured Height (ft)	Bankfull Width (ft)
Maple Grove Ave.	43+50	000000002266830	16.5	4.3	29.0
West German St.	42+00	000000002266820	28.0 (19.0)	6.0	29.0
Church Street	38+50	---	16.0	4.0 - 5.5	32.3
Pedestrian Bridge	31+50	---	26.0 (21.0)	6.5	32.4
Pedestrian Bridge	25+75	---	55.0	12.2	32.5

** Note: Figures in parentheses represent the functional hydraulic width of the bridge.*

Bridges at Maple Grove Avenue and West German Street were inspected in 2012 by the NYSDOT and found to be in poor structural condition (a rating of 3 to 4 out of 9), and both were recommended for replacement. The Maple Grove Avenue bridge was destroyed during the June 2013 flood. During field inspections conducted by MMI in November 2013, work was being undertaken to replace the bridge using the same span width but with a higher deck.

Flood profiles published in the FEMA FIS indicate that the three vehicle bridges that span Bellinger Brook at Church Street, West German Street, and Maple Grove Avenue all act to restrict flows during the 10-year frequency storm event (the smallest event modeled by FEMA), as well as during the 50-, 100-, and 500-year frequency events. The profiles also indicate that flood flows overtop the Church Street bridge during the 100-year storm event. Only the more upstream of the two pedestrian bridges is shown on the FEMA FIS flood profiles. The downstream pedestrian ridge appears to have been constructed after December 1976, the date that the FEMA hydraulic model was completed. The FEMA flood profile indicates that the upper bridge acts to restrict flows during the 10-year frequency and larger storm events.

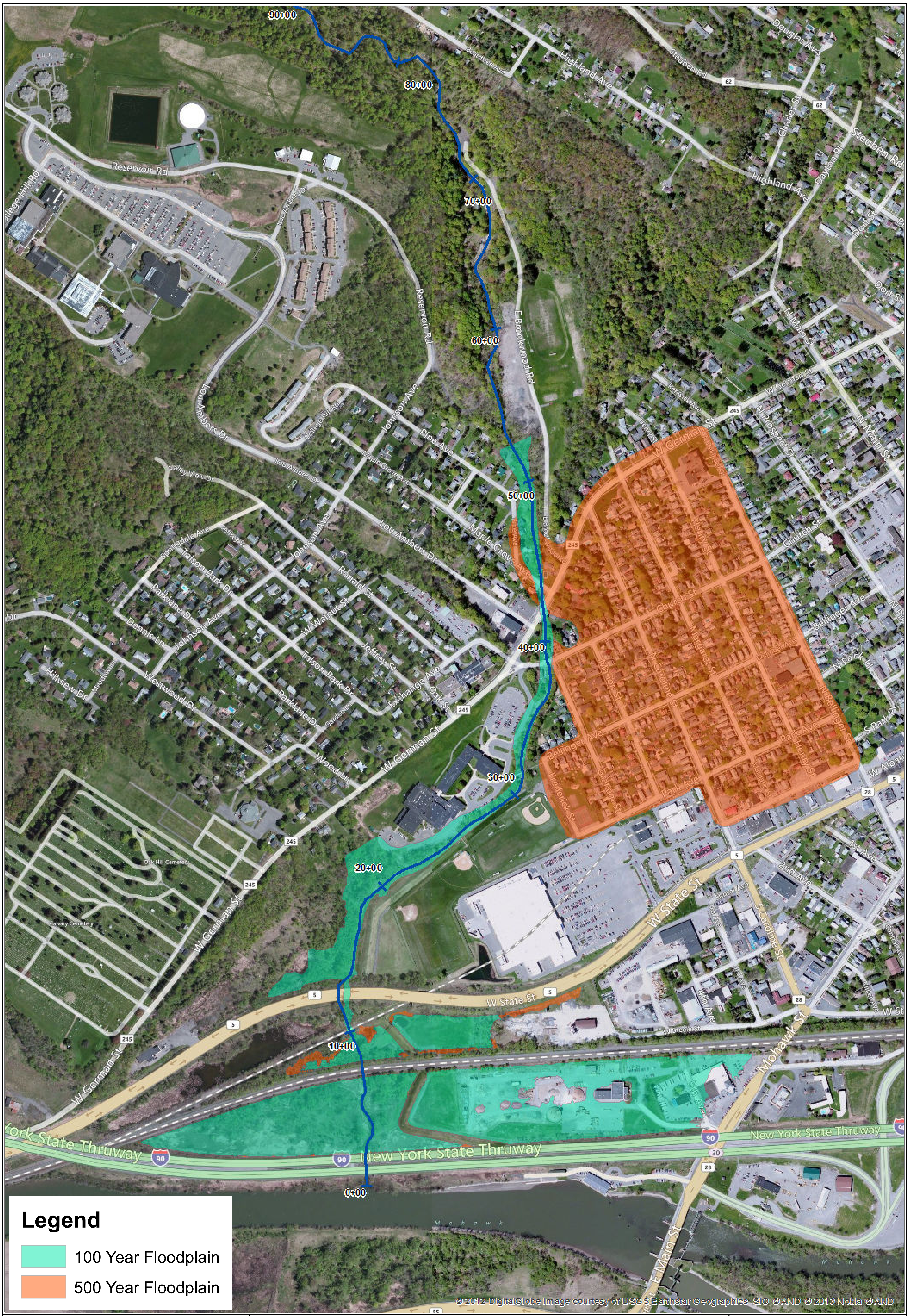
3.0 FLOODING HAZARDS AND MITIGATION ALTERNATIVES

3.1 Flooding History Along Bellinger Brook

According to NYSDEC, in October 1945 a severe flood caused damage throughout the Mohawk Valley. Subsequently in the late 1950s, Congressional authorization was given for corrective measures. Plans and specifications for a flood control project along Bellinger Brook were issued in 1962, and the project was constructed in 1964. It included levees, control gates, pump stations, and manipulation of the historic hydraulic canal near the center of the village of Herkimer. At the time of implementation, the flood control project was designed to provide protection for up to 515 cubic feet per second (cfs) of flow in Bellinger Brook.

The most severe flooding on Bellinger Brook has historically occurred in the area of the Church Street, West German Street, and Maple Grove Avenue bridges and in the neighborhood in the vicinity of these three bridges. Large volumes of sediment and large woody debris are conveyed down the brook from higher in the watershed during high flow events. This material is deposited in the channel at the bridges, which reduces the channel capacity and exacerbates flooding. Floodwaters overtop the channel during flood events and flow overland through the neighborhood, causing extensive damage to nearby homes and properties. According to FEMA, ice jams have also contributed to flooding on Bellinger Brook in the vicinity of Church and West German Streets. The FEMA FIS reports that serious flooding has occurred in this area in 1948, 1949, and 1971 as a result of ice jams at the Church Street bridge.

FEMA FIRMs are available for the village of Herkimer but do not include areas outside of the village in the town of Herkimer. FEMA mapping (Figure 5) indicates that during a 500-year frequency event, waters from Bellinger Brook overtop the channel in the vicinity of Maple Grove Avenue and West German Street and flood an extensive area of houses to the east. However, when these bridges become clogged and overtop, this area is at risk of flooding in much lower intensity storm events, as evidenced in the June 2013 event.



SOURCE(S):	Figure 5: Bellinger Brook FEMA Floodlines	Location: Herkimer County, New York
N	NYDOT: Emergency Transportation Infrastructure Recovery	Map By: CMP MMI#: 5231-01 MXD: Y:\5231-01\GIS\Maps\FEMA FIRM Maps\Bellinger FEMA Floodlines.mxd 1st Version: 01/02/2014 Revision: 2/21/2014 Scale: 1 in = 530 ft

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In mid to late June and early July of 2013, a severe precipitation system caused excessive flow rates and flooding in a number of communities in the greater Utica region, including in the Bellinger Brook basin. Because rainfall across the region was highly varied and rainfall information is limited, it is not possible to determine exact rainfall amounts within the Bellinger Brook basin.

Historic records on the National Oceanic and Atmospheric Administration's (NOAA) National Weather Service (NWS) Advanced Hydrologic Prediction Service website indicate that the village of Herkimer area received between 10 and 15 inches of rainfall in the month of June and an additional 5 to 8 inches in July 2013. Much of this rainfall occurred over several storm events that dropped between 3.5 and 4.5 inches of rain between June 11 and June 14; 5.5 to 8.5 inches between June 24 and June 28; and 1.5 to 2.0 inches on July 2. In between these more severe rain events were a number of smaller rain showers that dropped trace amounts of precipitation, preventing soils from drying out between the larger rain events.

Damage Assessment Response Team (DART) reports and mapping compiled after the June 2013 flood indicate that the actual area of flooding associated with this storm event was more widespread than the 100-year floodplain delineated on the FIRMs. Flooded areas extended east beyond North Main Street and south across Route 5 to the railroad tracks.

According to news accounts during and after the June 2013 flood, the flood control levee along the left bank of Bellinger Brook, between Herkimer Junior/Senior High School and the athletic fields, was compromised and in danger of failure when flows crested. However, the levee did not overtop during this flood event.

On January 14, 2014, news reports indicated that an ice jam at the Church Street bridge resulted in flooding and the closure of Church Street. Crews set up concrete blocks and sandbags to prevent water from flooding the neighborhood and used heavy equipment to break up the ice jam.

3.2 Post-Flood Community Response

Following the heavy flooding in June 2013 along Bellinger Brook, the Village of Herkimer implemented a number of temporary repairs. The Maple Grove Avenue bridge over Bellinger Brook was completely destroyed during the flood. At the time of field investigations in October and November 2013, the bridge was being replaced with a structure of similar size, with a one-foot increase in height.

Homes adjacent to the Maple Grove Avenue bridge that were heavily damaged have been repaired, but no attempts to correct flooding in the area have been made. Upstream of Maple Grove Avenue and its concrete-lined channel (beginning at STA 50+00), Bellinger Brook was dredged after the flood. The sediment that was removed was placed on the adjacent banks and remains at risk for remobilization during a high flow event. This post-flood repair appears to extend at least a mile upstream.

3.3 Flood Mitigation Analysis

Hydraulic analysis of Bellinger Brook was conducted using the HEC-RAS program. The HEC-RAS computer program (*River Analysis System*) was written by the United States Army Corps of Engineers (USACE) Hydrologic Engineering Center (HEC) and is considered to be 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.

Hydraulic modeling that was originally generated by FEMA as part of its 1976 study of Bellinger Brook was obtained and used as a starting point for the current analysis. It can be assumed that conditions have significantly changed since the FEMA study and, for that reason, updated cross sections were surveyed as part of the subject analysis. The updated survey information was incorporated into the hydraulic model in order to better characterize and understand modern flooding risks and causes.

The survey effort included the wetted area (within bankfull elevation) of 25 stream cross sections, plus the survey of six bridges/culverts and one grade control structure. These data were combined with countywide light detection and ranging (LiDAR) data provided by the NYSDEC to develop sufficient model geometry such that existing conditions flooding up to and including the 100-year recurrence interval could be modeled.

As described in Section 2.6, hydrology data reported by FEMA is significantly higher than data that was derived by the USGS *StreamStats* program. Both flows were modeled in the existing conditions HEC-RAS model and compared to field observations reported during the June 2013 storm. Anecdotal reports indicate that the levee protecting the Herkimer High School athletic fields near STA 30+00 was close to overtopping at the peak of the storm. Based upon other anecdotal reports in the region, the June flooding event is believed to represent the 100-year or greater event. Flows in the HEC-RAS model were iterated until the levee near STA 30+00 almost overtopped, yielding a flow of 1,600 cfs. This is reasonably similar to the FEMA flow of 1,412 cfs. For this reason, FEMA flows were used as the basis for the hydraulic modeling.

The model of existing conditions was used to analyze certain alternatives, described in more detail in the report sections that follow. Model input and output files have been uploaded onto the NYSDOT ProjectWise site and delivered electronically to NYSDEC.

3.4 High Risk Area #1 – Headcut in Brookwood Park Near STA 65+75

Figure 6 is a location plan of High Risk Area #1. This area is located in Brookwood Park and includes a deteriorating grade control structure at STA 65+75 and a large (11-foot-high) headcut extending downstream from the grade control structure approximately 275 feet, to STA 63+00. The headcut is contributing to downstream sediment loads and causing channel instability. The concrete-bottomed channel upstream of the deteriorating grade control structure is being undermined and is unstable.

Alternatives evaluated for this stream reach include the removal of the existing grade control structure and concrete-lined channel, the construction of a sediment settling basin just downstream of the grade control structure, and stabilization of the existing grade control structure in place.

Alternative 1-1: Armor the Existing Grade Control Structure to Create Riprap Cascade

This alternative is intended as a stabilization solution to prevent the failure of the existing grade control structure. It does not involve disassembly of the existing grade control structure that has arrested the headcut in place. Rather, it seeks to place fill against the structure and stabilize it from further erosion/failure. This alternative involves the following elements:

a) Placement of fill against the headcut and armoring with large stone and/or sheet piling grade control structures to create a cascade

b) Filling of the headcut area with stone

c) Stabilization of deteriorating concrete channel upstream of the grade control structure

The proposed alternative was modeled in HEC-RAS to determine what level of benefit could be obtained from the improvements. Figure 7 presents a profile and typical cross section of existing and proposed conditions.

The model predicts that velocities will be reduced slightly during the 100-year flood and, with proper armoring, it is anticipated that a channel can be made to be structurally stable throughout this reach. However, this method of stabilization would require up to 13 feet of fill and the importation of large stone in order to construct a new channel at a sustainable slope. The channel and banks would also require armoring sufficient to protect the channel from further erosion.

SOURCE(S):

Figure 6: Bellinger Brook High Risk Area #1

Location: **Herkimer County, New York**

N

NYDOT: Emergency Transportation Infrastructure Recovery

MXD: Y:\5231-01\GIS\Maps\High Risk Areas\Bellinger High Risk #2.mxd

Map By: CMP
MMI#: 5231-01-02
1st Version: 01/02/2012
Revision: 4/10/2014
Scale: 1 in = 105 ft

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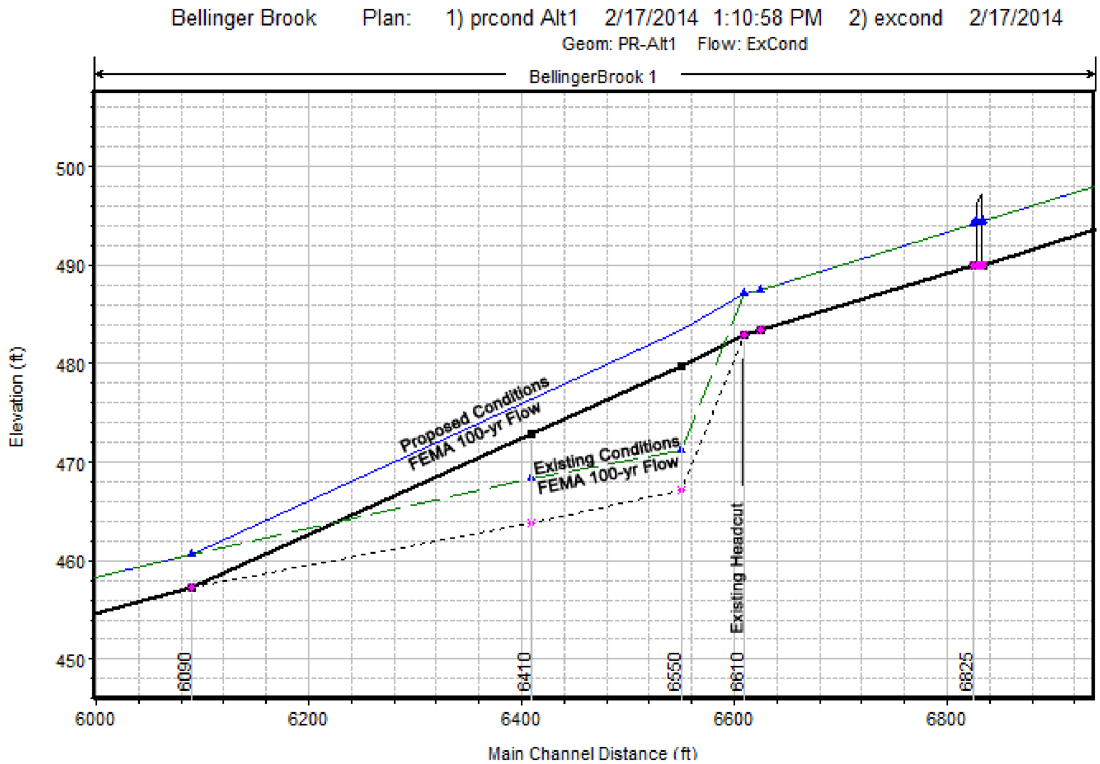
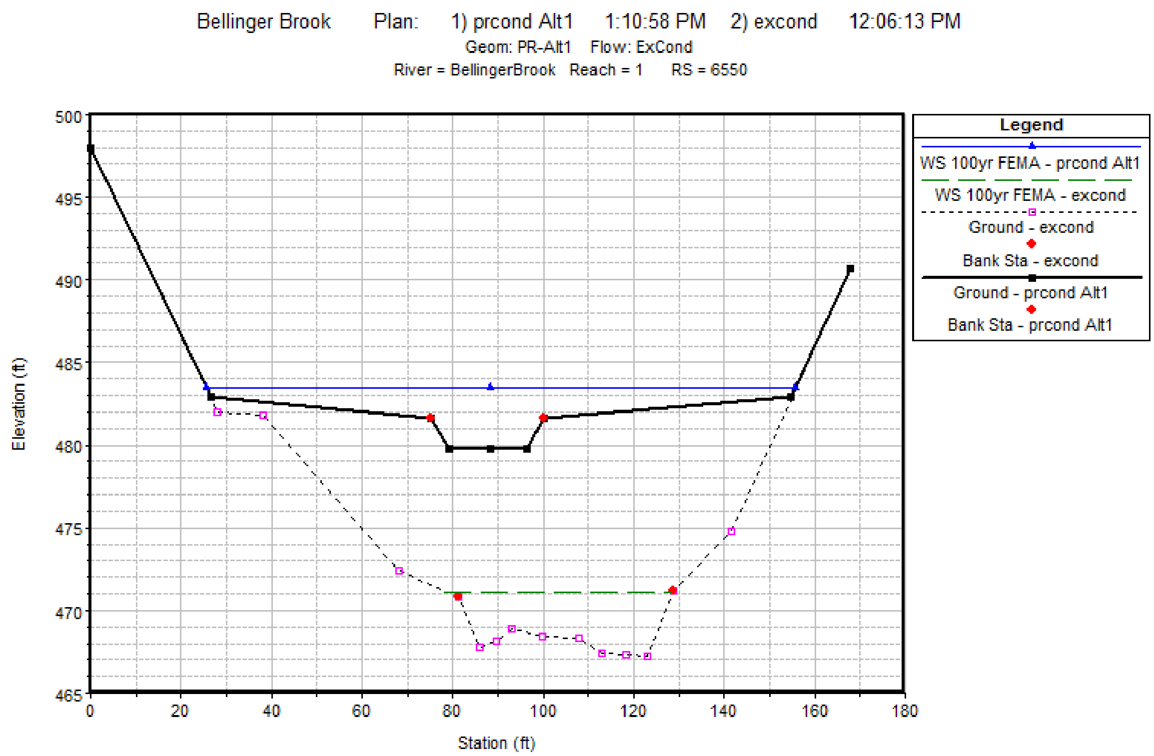
FIGURE 7
Bellinger Brook HEC-RAS Modeling Results





Alternative 1-2: Rock Ramp Stabilization

A temporary repair/stabilization of the headcut could be implemented to protect the existing grade control structure against future erosion or scour by armoring the existing grade control structure with rock fill at a steep slope. Figure 8 is a photograph of a rock ramp. The armoring would need to be adequately designed to mitigate erosion at the site and stabilize the grade. It may require maintenance in the future as repeated floods could damage the stability of such a steep channel.

FIGURE 8
Example Rock Ramp

Alternative 1-3: Remove Existing Grade Control Structure and Restore Channel

This alternative involves the full removal of the existing grade control structure, cut and fill of areas upstream and downstream, removal of the concrete-lined channel, and construction of grade control structures throughout the area of restoration. Specific elements of the alternative include the following actions:

a) Removal of the existing deteriorating grade control structure

b) Raising the elevation of the channel bed downstream of STA 65+75, in combination with lowering the elevation of the channel bed upstream of STA 65+75, so that the upstream and downstream grades meet

c) Installation of a series of grade control or drop structures over a distance of 1,000 feet, between STA 73+00 and STA 63+00

Removal of the existing structure would involve the regrading of Bellinger Brook over 2,000 linear feet in the upstream direction starting at the grade control structure in order to meet grade at a sustainable channel slope of 3.5 percent. This alternative would require the removal of a large amount of fill in order to lower the channel and construct a floodplain of adequate capacity to prevent further erosion and degradation. The pavilion and the pedestrian bridge in Brookwood Park would likely need to be removed or relocated and the concrete-lined channel removed in its entirety in order to meet the grading requirements of such an alternative.

Alternative 1-4: Construct a Sediment Trapping Basin

Bellinger Brook is a steep watercourse that conveys a large, coarse-grained sediment load. These sediments originate in the upper and mid basin and are deposited in the lower reaches, reducing channel capacity and contributing to flooding in the village. A sediment trapping alternative was assessed to evaluate the option of collecting and managing sediment upstream of the floodprone areas. It involves using the scoured area downstream of the headcut as a sediment settling area by constructing a flow control structure at the downstream end.

Incorporating a sediment trapping basin in the design of the headcut repair would trap sediments and prevent them from moving downstream. The site could be accessed and maintained by public works vehicles from within the park to perform regularly scheduled sediment removal. Such a structure could provide benefit by encouraging bed load sediments to settle out of transport before being brought into more densely developed areas. However, its construction would require a large flow control structure such as a dam and would require a maintenance agreement to be developed and followed for as long as the structure is in operation. The costs associated with the construction and continued operation and maintenance could be significant and may not provide enough benefit to warrant the high costs.

Recommendation

Alternative 1-1 is recommended as the preferred alternative due to the effectiveness of arresting the headcut and the ability to prevent future erosion. If a limited amount of time and funding exist, Alternative 1-2 may be considered.

3.5 High Risk Area #2 – Stone-Lined Channel and West German Street Vicinity (STA 31+00 to STA 73+00)

Figure 9 is a location plan of High Risk Area #2. This area extends 4,200 linear feet, from STA 73+00 downstream to STA 31+00. Between these stations, Bellinger Brook flows through a channel with a concrete-lined bottom and mortared stone walls along its banks. The channel passes through a residential area where it flows beneath three roadway crossings, all of which have been identified as undersized and act as restrictions to flow during severe flood events.

SOURCE(S):	Figure 9: Bellinger Brook High Risk Area #2		Location: Herkimer County, New York
N	NYDOT: Emergency Transportation Infrastructure Recovery	Map By: CMP MMI#: 5231-01-02 1st Version: 01/02/2012 Revision: 4/10/2014 Scale: 1 in = 300 ft	MILONE & MACBROOM 99 Realty Drive Cheshire, CT 06410 (203) 271-1773 Fax: (203) 272-9733 www.miloneandmacbroom.com
	MXD: Y:\5231-01\GIS\Maps\High Risk Areas\Bellinger High Risk #1.mxd		

From upstream to downstream, the three bridges that cross Bellinger Brook are Maple Grove Avenue, West German Street, and Church Street. The FEMA FIRM and FIS indicate that the 500-year flows from Bellinger Brook overtop the channel in the vicinity of Maple Grove Avenue and West German Street and flood an extensive residential area to the east. However, when the bridges become clogged and overtop, this area is at risk of flooding in much lower intensity storm events, as evidenced in the June 2013 event.

At the time of field inspections in October and November 2013, the Maple Grove Avenue bridge was in the process of being replaced due to damage sustained during the June 2013 flood event. DART reports and mapping indicate that the actual area of flooding associated with the June 2013 storm event was more widespread than the 100-year floodplain delineated on the FIRMs, suggesting that the flooding experienced may have been more severe than a 100-year recurrence interval.

Alternatives evaluated for this stream reach include channel modifications as well as bridge modification and/or removal.

Alternative 2-1: Channel Widening and Bridge Replacement STA 50+50 to STA 36+50

This alternative involves the permanent removal of one roadway crossing and the replacement of two more, as well as the modification of 865 linear feet of channel to accommodate flood flows through the area. This alternative would also require the acquisition of three properties due to their encroachment into the floodplain of Bellinger Brook. The following is a summary of design elements associated with this alternative:

a) Removal of 865 linear feet of concrete-bottomed, stone-lined channel and replacement with more natural sand/gravel/cobble substrate

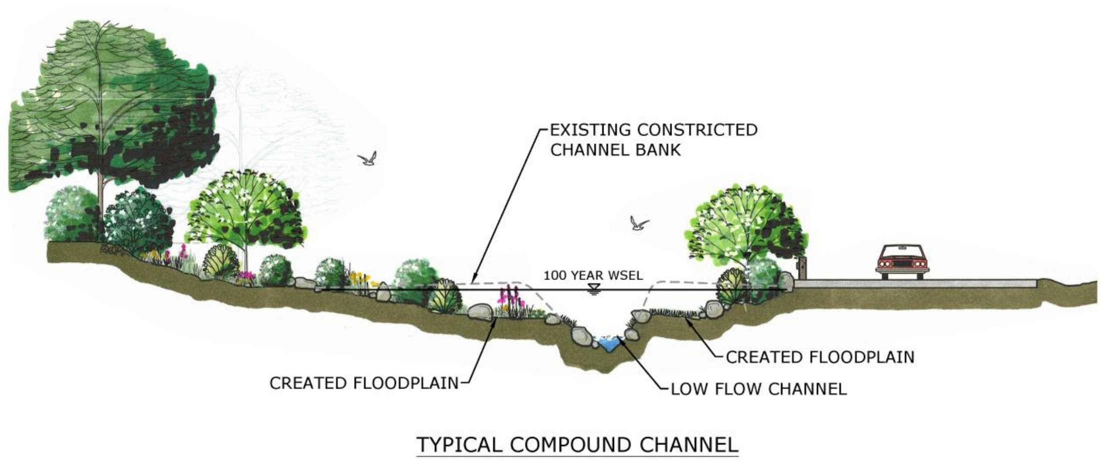
b) Channel modification from the existing dimensions of approximately 20 feet wide by five feet deep to a multistage compound channel, including an inner 25-foot-wide by two-foot-deep bankfull channel and a minimum of 10 feet of floodplain on both sides, to be created through excavation and regrading. Figure 10 is a cross section of a typical compound channel.

c) Permanent removal of the Maple Grove Avenue bridge

d) Replacement and widening of both the West German Street bridge and the Church Street bridge with new 45-foot minimum span bridges

e) Acquisition and removal of at least three floodprone structures: (1) single-family house at the northwest corner of Maple Grove Avenue and West German Street; (2) single-family house at the southwest corner of Maple Grove Avenue and West German Street; and (3) single-family house on the south side of Church Street, between Bellinger Brook and the entrance to the high school parking lot.

FIGURE 10
Typical Cross Section of a Compound Channel



The proposed alternative was modeled in HEC-RAS to determine what level of benefit could be offered from the improvements. Figure 11 presents a profile of existing and proposed conditions.

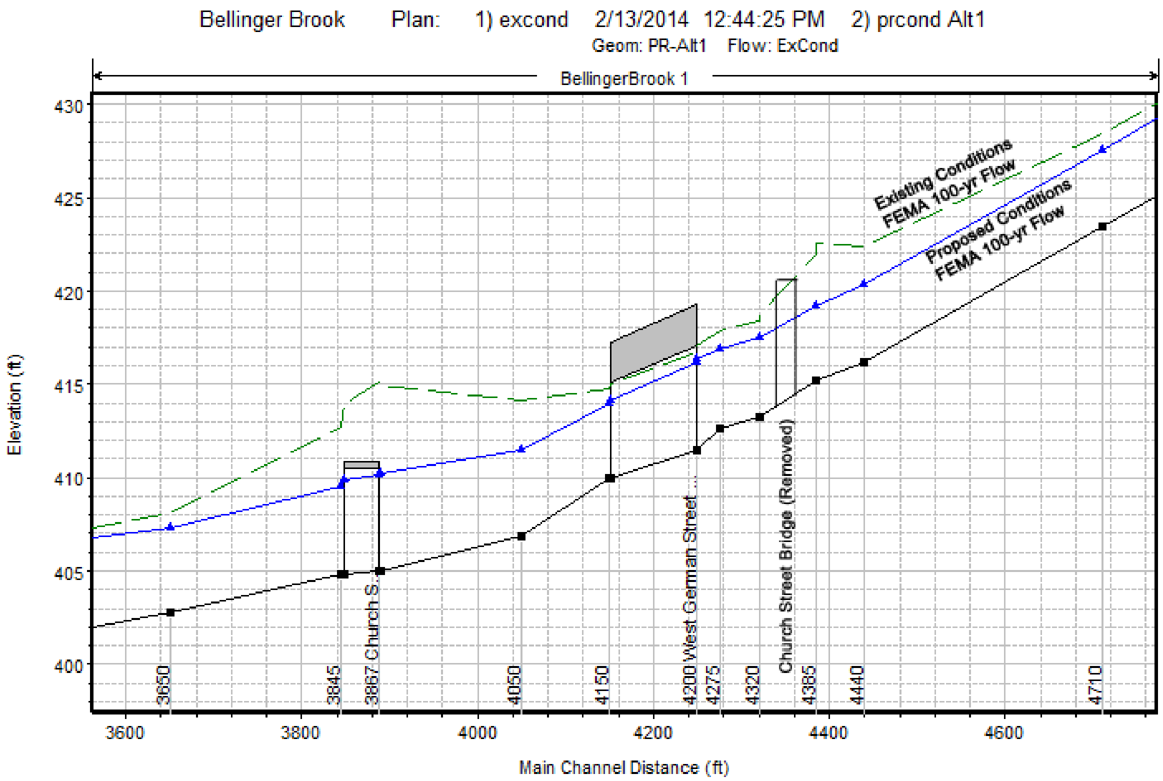
The model predicts that water surface elevations during the 100-year FEMA flow can be completely contained within the compound channel, with a maximum decrease in water surface elevation of 5.2 feet upstream of the Church Street bridge crossing. This will significantly decrease the frequency and severity of flooding where water overtops the channel and bridges and floods the adjoining residential areas.

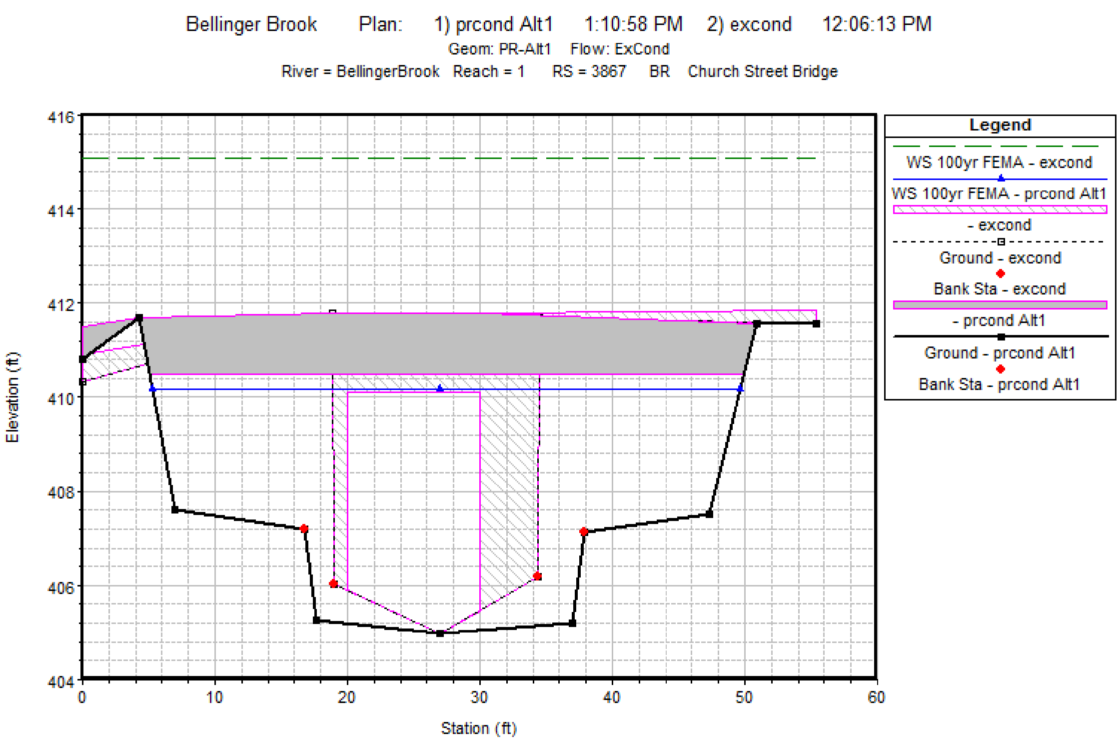
Recognizing that the existing bridges act as hydraulic constrictions and contribute heavily to flooding of the area, removal of all roadway crossings is not viable. Although a formal traffic study was not conducted, the average daily traffic on West German Street and Church Street appeared too high on these roadways to consider rerouting traffic patterns. Maple Grove Avenue, however, provides access to a residential area that has multiple other access points less than a quarter mile away.

Alternative 2-2: Channel Dredging

Dredging (specifically lowering) Bellinger Brook through this reach was assessed but led to an over-steepening of the upstream channel, with an overly flat downstream channel, a condition that would disrupt sediment transport through the reach, cause upstream bank/channel scour conditions, and encourage additional downstream sediment deposition. Such a condition is likely to exacerbate flooding on a long-term basis.

FIGURE 11
Bellinger Brook HEC-RAS Modeling Results





The need for sediment excavation within Bellinger Brook can be reduced by reducing the sediment load at its source (i.e., by repairing bank failures and headcuts and reducing erosion) and by improving sediment transport. Bellinger Brook is a steep, high-energy watercourse, and sediments will continue to be transported downstream regardless of what actions are taken to control sediments in the upper reaches. These sediments are prone to depositing in the lower reaches, thus reducing channel capacity and contributing to flooding in the village of Herkimer.

Dredging is often the first response to sediment deposition and clogging of the stream channel or bridge openings; however, over-widening or over-deepening through dredging can initiate headcutting, foster poor sediment transport, result in low habitat quality, and not necessarily provide significant flood mitigation. Dredging can further isolate a stream from its natural floodplain, disrupt sediment transport, expose erodible sediments, cause upstream bank/channel scour, and encourage additional downstream sediment deposition. Improperly dredged stream channels often show signs of severe instability, which can cause larger problems after the work is complete. Such a condition is likely to exacerbate flooding on a long-term basis.

A sediment management program should involve the development of standards to delineate how, when, and to what dimensions sediment excavation should be performed. It will also require the proper regulatory approval, as well as budgetary considerations to allow the work to be funded on an ongoing or as-needed basis as prescribed by the standards to be developed.

Conditions in which active sediment management should be considered include:

- Situations where the channel is confined, without space in which to laterally migrate
- For the purpose of infrastructure protection
- At bridge openings where hydraulic capacity has been compromised
- In reaches with low habitat value

In cases where sediment management of the stream channel is necessary, a methodology should be developed that would allow for proper channel sizing and slope. The following guidelines are provided:

1. Maintain the original channel slope and do not overly deepen or widen the channel. Excavation should not extend beyond the channel's estimated bankfull width unless it is to match an even wider natural channel. Estimated bankfull widths on Bellinger Brook are provided in Table 1 of this report and range from 28.7 feet in Brookwood Park to 32.8 feet at the railroad bridge.

2. Sediment management should be limited in volume to either a single flood's deposition or to the watershed's annual sediment yield in order to preclude downstream bed degradation from lack of sediment. Annual sediment yields vary, but one approach is to use a regional average of 50 cubic yards per square mile per

year unless a detailed study is made. The estimated annual sediment yield of Bellinger Brook is 185 cubic yards.

3. Excavation of fine-grain sediment releases turbidity. Best available practices should be followed to control sedimentation and erosion.

4. Sediment excavation requires regulatory permits. Prior to initiation of any in-stream activities, NYSDEC should be contacted, and appropriate local, state, and federal permitting should be obtained.

5. Disposal of excavated sediments should always occur outside of the floodplain. If such materials are placed on the adjacent bank, they will be vulnerable to remobilization and redeposition during the next large storm event.

6. No sediment excavation should be undertaken in areas where rare or endangered species are located.

Alternative 2-3: Floodproofing and Flood Protection of Individual Properties

In areas where properties are vulnerable to flooding and repeatedly flood, improvements to individual properties and structures may be appropriate. Potential measures for property protection include the following:

Elevation of the structure. Home elevation involves the removal of the building structure from the basement and elevating it on piers to a height such that the first floor is located above the 1 percent annual chance flood level. 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.

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.

Dry floodproofing of the structure to keep floodwaters from entering. 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. Wet floodproofing should only be used as a last resort. If considered, furniture and electrical appliances should be moved away or elevated above the 1 percent annual chance flood elevation.

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

- Relocate valuable belongings above the 1 percent annual chance 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 high water mark (if the ceiling permits). A wooden platform of pressure-treated wood can serve as the base.
- Anchor the fuel tank to the wall or floor with noncorrosive metal strapping and lag bolts.
- Install a backflow valve to prevent sewer backup into the home.
- Install a floating floor drain plug at the lowest point of the lowest finished floor.
- Elevate the electrical box or relocate it to a higher floor and elevate electric outlets to at least 12 inches above the high water mark.

Encouraging property owners to purchase flood insurance under the National Flood Insurance Program (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 in order to increase the eligibility of the property for projects under the various mitigation grant programs.

Recommendation

Alternative 2-1 is recommended as the preferred alternative due to its effectiveness at mitigating flooding while minimizing the impact on adjoining infrastructure and development. Until such time as long-term flood improvements can be made, individual property protection measures, as described in Alternative 2-3, may be appropriate.

3.6 High Risk Area #3 – School Levee (STA 16+00 to STA 36+50)

Figure 12 is a location plan of High Risk Area #3. Due to the floodplain encroachment associated with the Herkimer Junior/Senior High School and athletic field complex, Bellinger Brook is excessively incised and channelized from STA 36+50 to STA 16+00. It does not have a floodplain. This 1,650-linear-foot reach of channel experiences deep waters flowing at high velocities during flood events, which cause very high shear forces along the channel and bank.

Bellinger Brook is lined on its left bank through this reach by a flood control levee. The levee shows signs of erosion at various points along its length. The brook is spanned by two pedestrian bridges that cross between the high school and the athletic fields, one at STA 31+50 (referred to as Bridge 1) and one at STA 25+75 (referred to as Bridge 2).

SOURCE(S):

Figure 12: Bellinger Brook High Risk Area #3

Location: **Herkimer County, New York**

NYDOT: Emergency Transportation Infrastructure Recovery

MXD: Y:\5231-01\GIS\Maps\High Risk Areas\Bellinger High Risk #3.mxd

Map By: CMP
MMI#: 5231-01-02
1st Version: 01/02/2012
Revision: 2/20/2014
Scale: 1 in = 125 ft

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The FEMA flood profile shows a hydraulic constriction at Bridge 1. The downstream bridge is not included in the FEMA profile. According to FEMA mapping, the 100-year flood event does not overtop the levee. Anecdotal accounts indicate that the levee was compromised and in danger of failure during the June 2013 floods; however, it did not actually overtop.

Two alternatives were evaluated to alleviate the scour and erosion potential associated with high velocities in confined channels within Hazard Area #3. The first involves floodplain restoration and reconnectivity; the second involves bank armoring.

Alternative 3-1: Channel Widening and Floodplain Restoration

This alternative involves the following elements:

a) Creation of a larger channel and floodplain for the 1,650-foot confined reach of Bellinger Brook

b) Removal and/or replacement of both pedestrian bridges

c) Replacement of the levee

Under this two-part alternative, a modified channel would be sized to convey the brook's bankfull discharge, which has been estimated to be 130 cfs. This would require a channel with a width of approximately 33 feet and a depth of approximately 1.5 feet. Larger, peak flood flows would be conveyed on a created floodplain, approximately 145 feet in width, which would be dry under normal conditions. One or both of the pedestrian bridges would need to be replaced with a larger bridge long enough to span the channel and floodplain.

This alternative would encroach into a portion of the athletic fields, likely making the athletic fields unusable in their current configuration and requiring reconstruction.

Alternative 3-2: Repair Levee and Replace Pedestrian Bridges.

This alternative involves the following elements:

a) Repair and armoring of the levee that was damaged during the June 2013 floods

b) Replacement or removal of the pedestrian bridge at STA 31+50

Hydraulic modeling indicates that the downstream-most pedestrian bridge at STA 25+80 (Bridge 2) is adequately sized for the 100-year flow event. This alternative includes replacement of the pedestrian bridge at STA 31+50 (Bridge 1) with a structure that is of similar size to Bridge 2. Table 6 summarizes existing conditions of the two bridges.

TABLE 6
Summary of Pedestrian Bridge Data

Waterway Crossing	Station	Width (ft)	Height (ft)
Pedestrian Bridge (Bridge 1)	31+50	24	7
Pedestrian Bridge (Bridge 2)	25+80	60	12

The existing conditions model predicts velocities ranging between 12 and 14 feet per second in the area of erosion along the levee banks and channel bottom. Riprap over 2 feet in diameter may be necessary to stabilize the area from such highly erosive forces.

Recommendation

Alternative 3-1 is the most naturalistic solution but has a significant impact on the school athletic fields. As such, Alternative 3-2 is recommended due to its effectiveness at mitigating flooding while minimizing the impact on adjoining infrastructure and development. Repair of the existing levee in its current location will minimize impacts on the surrounding school and athletic fields, and the replacement of the pedestrian bridge at STA 31+50 will lower velocities and help control erosion in the area.

4.0 RECOMMENDATIONS

The following recommendations are offered:

1. *Stabilize Headcut and Restore Channel at Brookwood Park* – Stabilize the headcut in Brookwood Park near STA 65+75 to eliminate a major source of sediment and prevent further degradation of the streambed and banks. Stabilization can be achieved by placing fill against the headcut and armoring the downstream channel with large stone and/or sheet piling grade control structures.

2. *Increase Channel Capacity and Connectivity to Floodplain* – The Bellinger Brook channel is significantly undersized through its middle section where it is concrete lined and bound by stone walls on both banks without a floodplain. Modifying the channel from the existing dimensions of approximately 20 feet wide by five feet deep to a multistage compound channel, including an inner 25-foot-wide by two-foot-deep bankfull channel and a minimum of 10 feet of floodplain on both sides would provide the needed capacity and reconnect the stream to its floodplain. This approach is recommended from STA 50+50 to STA 36+50.

3. *Acquire and Remove Residential Properties* – Expansion of the channel as described above will impact numerous properties along the brook, portions of which will need to be acquired. Acquisition and removal of at least three floodprone structures will be required as follows: (1) single-family house at the northwest corner of Maple Grove Avenue and West German Street; (2) single-

family house at the southwest corner of Maple Grove Avenue and West German Street; and (3) single-family house on the south side of Church Street, between Bellinger Brook and the entrance to the high school parking lot.

4. *Remove the Bridge at Maple Grove Avenue* – Maple Grove Avenue creates a significant hydraulic pinch point in Bellinger Brook, as evidenced by the severe damage during the June 2013 flood event. Unlike the bridges at West German Street and Church Street, which carry higher volumes of traffic, the Maple Grove Avenue bridge provides access to a residential area that has multiple other access points less than a quarter mile away. Its removal and conversion of Maple Grove Avenue to a cul-de-sac would provide substantial flood benefit for a relatively small cost of demolition and is recommended.

5. *Replace the Bridges at West German Street and Church Street* – The West German and Church Street bridges hydraulically constrict the flow in Bellinger Brook. Replacement and widening are recommended with new 45-foot minimum span bridges. Adequately sized stream crossings not only have the potential to reduce flooding, but they also provide a range of environmental benefits by allowing aquatic organisms, sediment, and debris to be conveyed through the stream corridor.

6. *Replace the Pedestrian Bridge Near the Herkimer Junior/Senior High School* – Two pedestrian bridges are located adjacent to the Herkimer Junior/Senior High School. Replacement of the upstream bridge at STA 31+50 (Bridge 1) is recommended with a structure that is of similar size to Bridge 2, which has a span of 60 feet and a height of 12 feet.

7. *Armor the Levee Adjacent to the Herkimer Junior/Senior High School* – Repair and armoring are recommended along the levee adjacent to the Herkimer Junior/Senior High School to stabilize erosion that has occurred and protect it from future erosion.

8. *Adopt Sediment Management Standards* – When excavation of depositional areas is necessary, it should be undertaken in a manner that maintains channel stability, avoiding over-widening and/or over-deepening the channel. Development of sediment management standards is recommended to provide guidance to contractors and local municipal and county public works departments on how to maintain proper channel sizing and slope as well as the application of best practices.

9. *Monitor Minor Bank Failures* – Several areas of eroding banks, minor bank failures, and slumping hill slopes were observed along Bellinger Brook in the upper reaches (STA 78+00 and upstream). These are of low to moderate severity, appear to be relatively stable, and at the time of the field visits were not contributing a large amount of sediment to the channel. It is recommended that these sites be monitored periodically and stabilized as necessary.

10. *Develop a Watershed Management Plan* – Existing and future land uses and activities within the Bellinger Brook watershed can impact water quantity as well as water quality. To address issues relating to land use practices and stormwater management, development of a watershed management plan is recommended.

11. *Evaluate Floodplain Regulations* – A critical evaluation of existing floodplain law and policies should be undertaken to evaluate the effectiveness of current practices and requirements. Identification of a floodplain coordinator and development of a detailed site plan review process for all proposed development within the floodplain would provide a mechanism to quantify floodplain impacts and ascertain appropriate mitigation measures.

12. *Install and Monitor a Stream Gauge* – There is currently no stream gauge on Bellinger Brook, making statistical analysis difficult. Installation of a permanent stream gauge is recommended.

13. *Develop Design Standards* – There is currently no requirement to design stream crossings to certain capacity standards. For critical crossings such as major roadways or crossings that provide sole ingress/egress, design to the 50- or 100-year storm event may be appropriate whereas less critical crossings in flat areas where flood velocities are low may be sufficient to pass only the 10-year event. Crossings should always be designed in a manner that does not cause flooding. When a structure that is damaged or destroyed is replaced with a structure of the same size, type, and design, it is reasonable to expect that the new structure will be at risk for future damage as well. Development of design standards is recommended for all new and replacement structures.

14. *Protect Individual Properties* – A variety of measures are available to protect existing public and private properties from flood damage, including elevation of structures, construction of barriers, floodwalls and earthen berms, dry or wet floodproofing, and utility modifications within the structure. While broader mitigation efforts are most desirable, they often take time and money to implement. On a case-by-case basis, where structures are at risk, individual floodproofing should be explored. Property owners within FEMA delineated floodplains should also be encouraged to purchase flood insurance under the NFIP and to make claims when damage occurs.

Table 7 presents anticipated cost ranges for key recommendations. These are graphically depicted on the following pages.

TABLE 7
Cost Range of Recommended Actions

	Approximate Cost Range				
Bellinger Brook Recommendations	< $100k	$100k-$500k	$500k-$1M	$1M-$5M	>$5M
Stabilize Headcut and Restore Channel at Brookwood Park		X			
Increase Channel Capacity and Connectivity to Floodplain				X	
Acquire and Remove Residential Properties				X	
Remove the Bridge at Maple Grove Avenue			X		
Replace the Bridges at West German Street and Church Street					X
Replace the Pedestrian Bridge Near the Herkimer Junior/Senior High School		X			
Armor the Levee Adjacent to the Herkimer Junior/Senior High School		X			
Undertake Study of Hydrology and Land Use	X				
Install and Monitor a Stream Gauge	X				

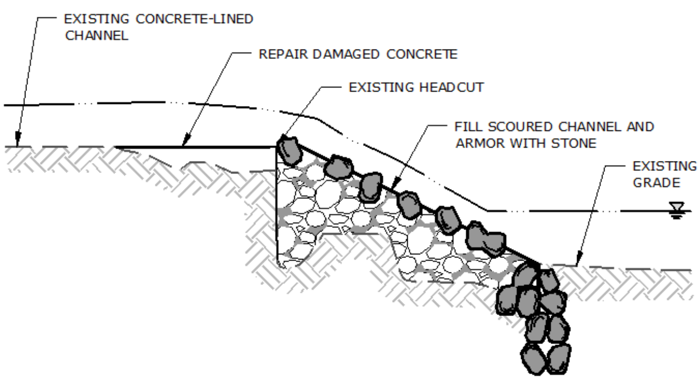
WATER BASIN ASSESSMENT AND FLOOD HAZARD MITIGATION ALTERNATIVES
BELLINGER BROOK, HERKIMER COUNTY, NEW YORK

High-Risk Area #1 – Head Cut in Brookwood Park

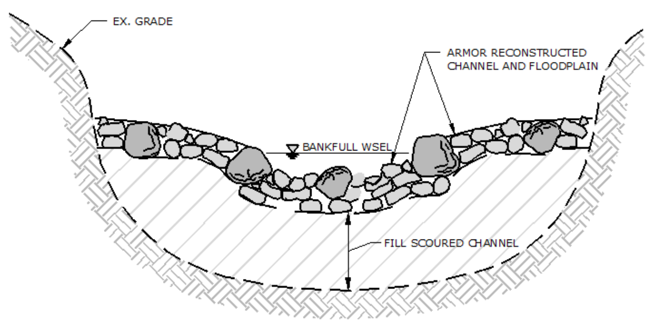
Site Description: Located in Brookwood Park, this site includes a deteriorating grade control structure and a large (11-foot' high) head cut extending downstream approximately 275 feet. The head cut is contributing to downstream sediment loads and causing channel instability. The concrete-bottomed channel just upstream of the deteriorating grade control structure is being undermined.

Recommendations:

- Place appropriately sized rock fill against the head cut and armor with large stone and/or sheet pile grade control structures.
- Stabilize the deteriorating concrete channel upstream of the grade control structure.



HEADCUT STABILIZATION - PROFILE



HEADCUT STABILIZATION - SECTION

	BENEFITS
✓	Improve safety
✓	Stabilize channel
✓	Reduce sediment load

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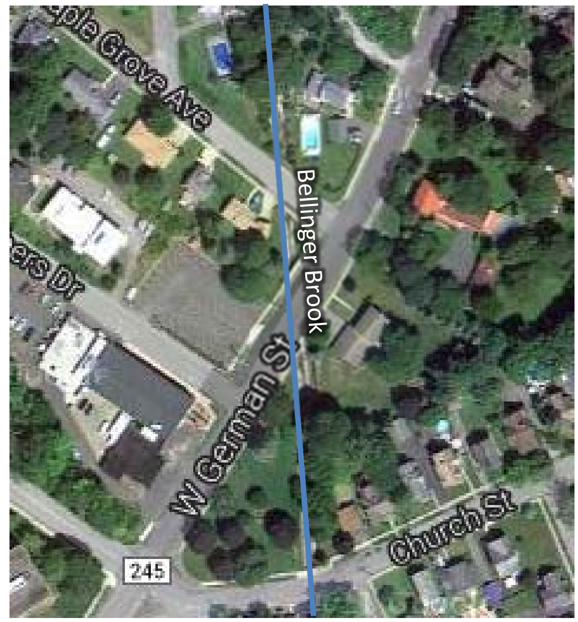
WATER BASIN ASSESSMENT AND FLOOD HAZARD MITIGATION ALTERNATIVES
BELLINGER BROOK, HERKIMER COUNTY, NEW YORK

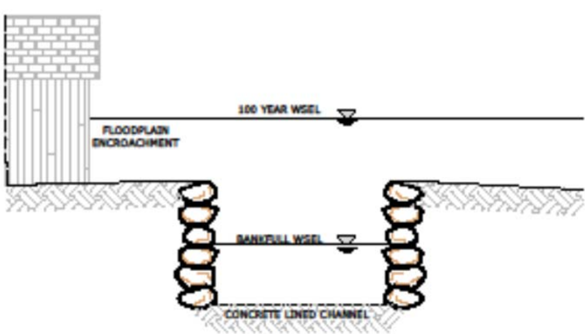
High-Risk Area #2 – Concrete Lined Channel

Site Description: Beginning at station 46+00 downstream to station 31+00, is a concrete lined channel that routes Bellinger Brook through the developed town of Herkimer. The channel is deteriorated at many points and highly constricts floodwaters, with no floodplain to accommodate flood flows.

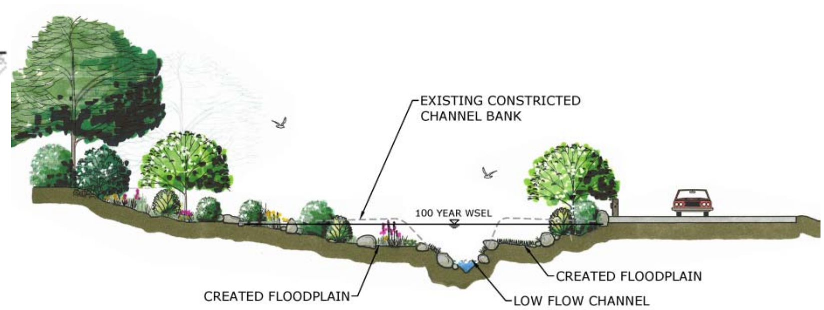


Recommendations:

- Modify the channel to a multi-stage compound channel, including an inner 25-foot wide by two-foot deep bankfull channel with a minimum of 10 feet of floodplain bench on both sides.
- Acquire easements and several high risk residential properties near Maple Grove Avenue, West German Street, and Church Street to accommodate the larger stream corridor.



TYPICAL CONSTRAINED CROSS SECTION



TYPICAL COMPOUND CHANNEL

	BENEFITS
✓	Mitigate flooding
✓	Reconnect floodplain
✓	Improve sediment transport

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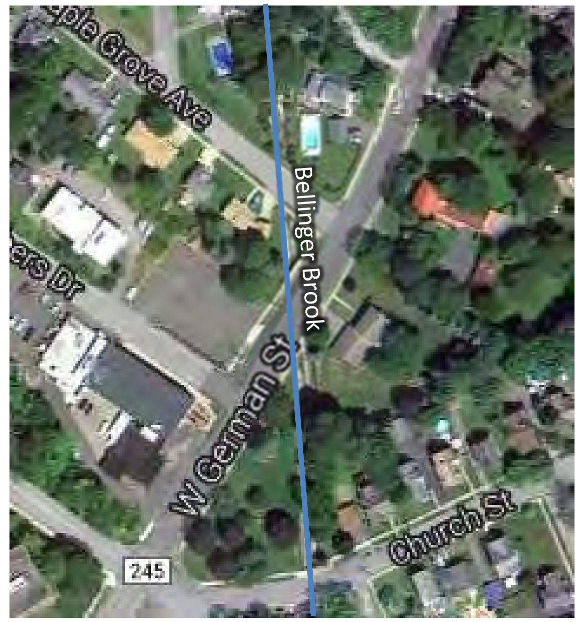
WATER BASIN ASSESSMENT AND FLOOD HAZARD MITIGATION ALTERNATIVES
BELLINGER BROOK, HERKIMER COUNTY, NEW YORK

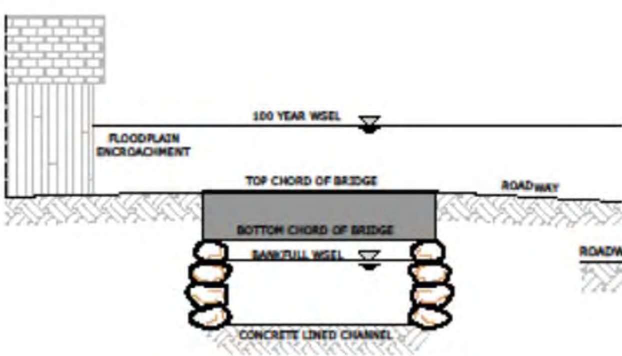
High-Risk Area #2 – Undersized Bridges

Site Description: Bridge crossings at Maple Grove Avenue, West German Street, and Church Street severely constrict hydraulic flows, are subject to ice jams and debris clogging, and are a major factor in area-wide flooding.

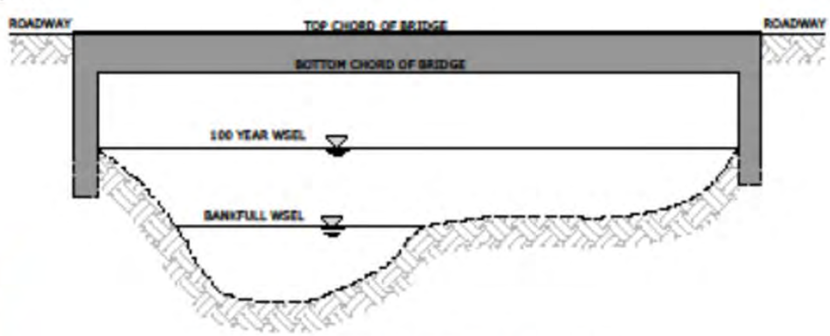


Recommendations:

- Remove the Maple Grove Avenue Bridge and convert the road to a cul-de-sac.
- Replace the West German and Church Street bridges with new 45-foot minimum span bridges.



TYPICAL CONSTRAINED BRIDGE CROSSING



TYPICAL UNCONSTRAINED BRIDGE CROSSING

	BENEFITS
✓	Mitigate flooding
✓	Mitigate ice jamming
✓	Improve sediment transport

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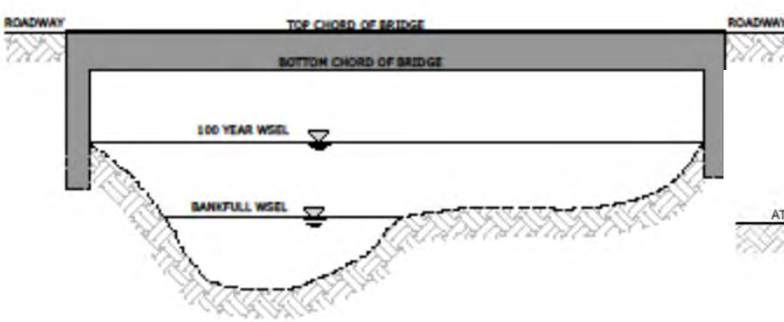
WATER BASIN ASSESSMENT AND FLOOD HAZARD MITIGATION ALTERNATIVES BELLINGER BROOK, HERKIMER COUNTY, NEW YORK

High-Risk Area #3 – Leveed Channel at High School

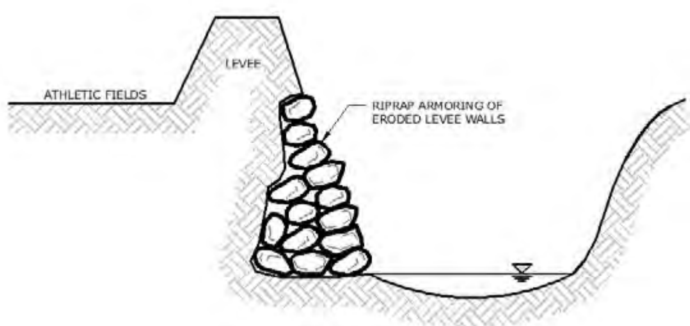
Site Description: Located just south of Herkimer High School along the athletic fields is a man made levee designed to contain flows of Bellinger Brook. The levee runs from station 32+00 downstream to station 16+00 and shows signs of linear erosion at some sections along the channel. Two pedestrian bridges span the river just upstream of the levee and midway, creating a hydraulic constriction at the upstream point.

Recommendations:

- Replace the pedestrian bridge near the Herkimer Junior/Senior High School with a larger structure with one of approximate 60-foot span.
- Repair and armor the levee to stabilize erosion and protect against future erosion.



TYPICAL UNCONSTRAINED BRIDGE CROSSING



TYPICAL LEVEE EROSION REPAIR

	BENEFITS
✓	Improve hydraulic conveyance
✓	Stabilize levee
✓	Maintain athletic fields

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APPENDIX A

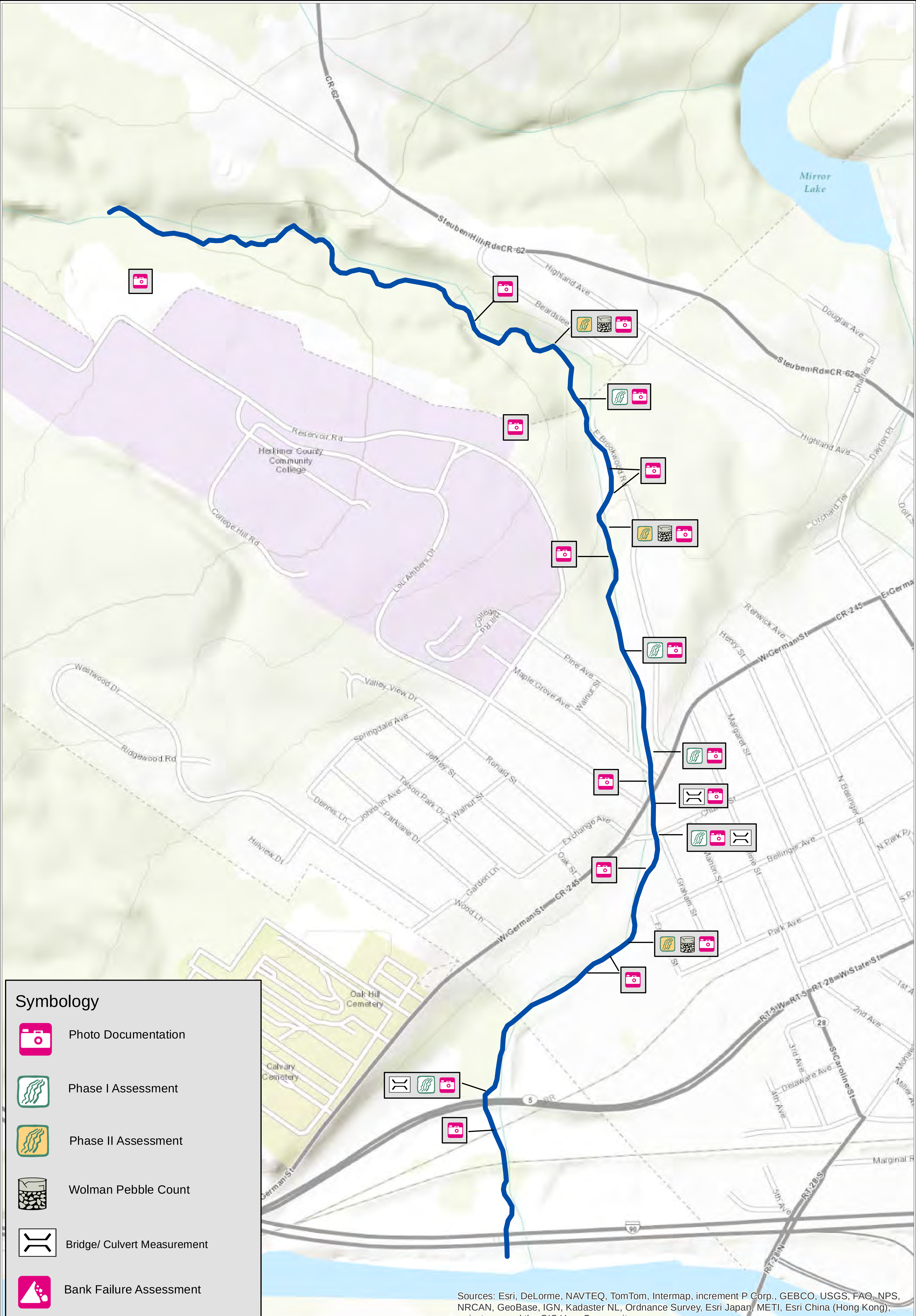
Summary of Data and Reports Collected

ATTACHMENT A: DATA INVENTORY

Year	Data Type	Document Title	Author
2013	Presentation	Flood Control Study for Fulmer Creek	Schnabel Engineering
2012	Map	Sauquoit Creek Watershed/Floodplain Map	Herkimer-Oneida Counties Comprehensive Planning Program
2011	Report	Oriskany Creek Conceptual Plan and Feasibility Study for Watershed Project	Oneida County SWCD
2009	Presentation	Ice Jam History and Mitigation Efforts	National Weather Service, Albay NY
2007	Report	Cultural Resources Investigations of Fulmer, Moyer, and Steele Flood Control Projects	United States Army Corps of Engineers (USACE)
2006	Report	Riverine High Water Mark Collection, Unnamed Storm	Federal Emergency Management Agency (FEMA)
2005	Report	Fulmer Creek Flood Damage Control Feasibility Study	United States Army Corps of Engineers (USACE)
2005	Report	Steele Creek Flood Damage Control Feasibility Study	United States Army Corps of Engineers (USACE)
2004	Report	Fulmer Creek Basin Flood Hazard Mitigation Plan	Herkimer-Oneida Counties Comprehensive Planning Program
2004	Report	Moyer Creek Basin Flood Hazard Mitigation Plan	Herkimer-Oneida Counties Comprehensive Planning Program
2004	Report	Steele Creek Basin Flood Hazard Mitigation Plan	Herkimer-Oneida Counties Comprehensive Planning Program
2003	Report	Fulmer, Moyer, Steele Creek - Stream Bank Erosion Inventory	Herkimer-Oneida Counties Comprehensive Planning Program
1997	Report	Sauquoit Creek Watershed Management Strategy	Herkimer-Oneida Counties Comprehensive Planning Program
2011	Report	Flood Insurance Study (FIS), Herkimer County	Federal Emergency Management Agency (FEMA)
2011	Report	Flood Insurance Study (FIS), Montgomery County	Federal Emergency Management Agency (FEMA)
2013	Report	Flood Insurance Study (FIS), Oneida County	Federal Emergency Management Agency (FEMA)
2010	Report	Bridge Inspection Summaries, Multiple Bridges	National Bridge Inventory (NBI)
2002	Hydraulic Models	Flood Study Data Description and Assembly - Rain CDROM	New York Department of Enviromental Conservation (NYDEC)
2013	Data	June/July 2013 - Post-Flood Stream Assessment	New York State Department of Transportation (NYSDOT)
2013	GIS Data	LiDAR Topography, Street Mapping, Parcel Data, Utility Info, Watersheds	Herkimer-Oneida Counties Comprehensive Planning Program
2013	GIS Data	Aerial Orthographic Imagery, Basemaps	Microsoft Bing, Google Maps, ESRI
2011	GIS Data	FEMA DFIRM Layers	Federal Emergency Management Agency (FEMA)
2013	Data	Watershed Delineation and Regression Calculation	US Geological Survey (USGS) - Streamstats Program

APPENDIX B

Field Data Collection Forms



SOURCE(S):

Figure 1-1: Bellinger Brook Data Collection Points

Location: **Herkimer County, New York**

N

NYDOT: Emergency Transportation Infrastructure Recovery

MXD: Y:\5231-01\GIS\Maps\Phase II Icon Maps\Bellinger 1-1.mxd

Map By: CMP
MMI#: 5231-01-02
1st Version: 12/4/2013
Revision: 12/12/2013
Scale: 1 in = 667 ft

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www.miloneandmacbroom.com

MMI Project #5231-01 Phase I River Assessment Reach Data

River ________________ Reach _____________ U/S Station _______________ D/S Station ___________

Inspectors __________________ Date ______________ Weather ___________________________________

Photo Log ____

A) Channel Dimensions: Bankfull
Width (ft) __________
Depth (ft) __________

Watershed area at D/S end of reach (mi^2) ___________

B) Bed Material:

Bedrock	Boulders	Cobble
Gravel	Sand	Clay
Concrete	Debris	Riprap

Notes: ____

C) Bed Stability: Aggradation Degradation Stable Note: __________________

D) Gradient: Flat Medium Steep Note: __________________

E) Banks: Natural Channelized Note: ________________

F) Channel Type: Incised Colluvial Alluvial Bedrock Note: __________

G) Structures: Dam Levee Retaining Wall Note: _______________

H) Sediment Sources: ____

I) Storm Damage Observations: ____

____

J) Vulnerabilities: Riverbank Development Floodplain Development Road Trail Railroad

Utility Bridge Culvert Retaining Wall Ball field Notes: ________________

K) Bridges: Structure # ____________ Inspection Report? Y N Date ________________

Notes: ____

Record span measurements if not in inspection report: ____

Damage, scour, debris: ____

L) Culverts: complete culvert inspection where necessary. Size: ____

Type: ________________ Notes: ____

____

Phase II River Assessment
Reach Data

River ____________________ Reach ____________ Road _____________ Station ______________

Inspector _________________ Date _____________ Town ____________ County _____________

Identification Number ____________________ GPS # ________________ Photo # ________________

A) River Reach ID _________________________ Drainage Area, sm _________________________
D/S Boundary ____________________________, U/S Boundary ____________________________
D/S STA ________________________________, U/S STA ________________________________
D/S Coordinates __________________________, U/S Coordinates __________________________

B) Valley Bottom Data:

Valley Type (Circle one)	Confined >80% L	Semiconfined 20-80%	Unconfined <20%
Valley Relief	<20'	20-100'	>100
Floodplain Width	<2 W_b	2-10 W_b	>10 W_b

	Left Side	Right Side
Natural floodplain	_______%	_______%
Developed floodplain	_______%	_______%
Terrace	_______%	_______%
Floodplain Land Use	___________	___________

C) Pattern: Straight S=1-1.05 Sinuous S=1.05 – 1.25 Meanders S=1.25 – 2.0 Highly Meandering S>2.0 Braided Wandering Irregular

D) Channel Profile Form: (Percent by Class in Reach)

Cascades	_________	Alluvial	_________	Channel Transport
Steep Step/Pool	_________	Semi Alluvial	_________	Sed. Source Area
Fast Rapids	_________	Non Alluvial	_________	Eroding
Tranquil Run	_________	Channelized	_________	Neutral
Pool & Riffle	_________	Incised	_________	Depositional
Slow Run	_________	Headcuts	_________	

E) Channel Dimensions (FT):

	Bankfull	Actual Top of Bank	Regional HGR
Width	_________	_________	_________
Depth	_________	_________	_________
Inner Channel Base Width	_________		
W/D Ratio	_________		

F) Hydraulic Regime:
Mean Bed Profile Slope _______________ Ft/Ft
Observed Mean Velocity ____________________ FPS

G) Bed Controls:

Bedrock	Weathered Bedrock	Dam
Static Armor	Cohesive Substrate	Bridge
Boulders	Dynamic Armor	Culvert
Debris	Riprap	Utility Pipe/Casing

Overall Stability ______________________

H) Bed Material:

	Bedrock	_________	Sand	_________	Riprap	_________
	Boulders	_________	Silt and Clay	_________	Concrete	_________
D50 _________	Cobble and Boulder	_________	Glacial Till	_________		
	Gravel and Cobble	_________	Organic	_________		
	Sand and Gravel	_________				

I) Flood Hazards:

Developed Floodplains	Bank Erosion
Buildings	Aggradation
Utilities	Sediment Sources
Hyd. Structures	Widening

Bridge Waterway Inspection Summary

River ____________________ Reach ____________ Road _____________ Station ______________

Inspector _________________ Date _____________ NBIS Bridge Number ____________________

NBIS Structure Rating _____________________ Year Built __________________________________

Bridge Size & Type _______________________ Skew Angle ________________________________

Waterway Width (ft) ______________________ Waterway Height (ft) _________________________

Abutment Type (circle) Vertical Spill through Wingwalls

Abutment Location (circle) In channel At bank Set back

Bridge Piers _____________________________ Pier Shape __________________________________

Abutment Material ________________________ Pier Material _________________________________

Spans % Bankfull Width ____________________ Allowance Head (ft) __________________________

Approach Floodplain Width _________________ Approach Channel Bankfull Width _______________

Tailwater Flood Depth or Elevation ___________ Flood Headloss, ft ____________________________

	Left Abutment	Piers	Right Abutment
Bed Materials, D_{50}			
Footing Exposure			
Pile Exposure			
Local Scour Depth			
Skew Angle			
Bank Erosion			
Countermeasures			
Condition			
High Water Marks			
Debris			

Bed Slope	Low	Medium	Steep
Vertical Channel Stability	Stable	Aggrading	Degrading
Observed Flow Condition	Ponded	Flow Rapid	Turbulent

Lateral Channel Stability ____

Fish Passage ____

Upstream Headwater Control ____

Project Information

Project Name	
Project Number	
Stream / Station	
Town, State	
Sample Date	
Sampled By	
Sample Method	Wolman Pebble Count

Particle Distribution (%)

silt/clay	
sand	
gravel	
cobble	
boulder	
bedrock	

Sample Site Descriptions by Observations

Channel type	
Misc. Notes	

Particle Sizes (mm)

D16	
D35	
D50	
D84	
D95	

(Bunte and Abt, 2001)

Particle Name	Size Limits (mm) lower	upper	Tally	Count	Percent Passing	Cumulative % Finer
silt/clay	0	**0.063**			0.0	0.0
very fine sand	0.063	**0.125**			0.0	0.0
fine sand	0.125	**0.250**			0.0	0.0
medium sand	0.250	**0.500**			0.0	0.0
coarse sand	0.500	**1**			0.0	0.0
very coarse sand	1	**2**			0.0	0.0
very fine gravel	2	**4**			0.0	0.0
fine gravel	4	**5.7**			0.0	0.0
fine gravel	5.7	**8**			0.0	0.0
medium gravel	8	**11.3**			0.0	0.0
medium gravel	11.3	**16**			0.0	0.0
coarse gravel	16	**22.6**			0.0	0.0
coarse gravel	22.6	**32**			0.0	0.0
very coarse gravel	32	**45**			0.0	0.0
very coarse gravel	45	**60**			0.0	0.0
small cobble	60	**90**			0.0	0.0
medium cobble	90	**128**			0.0	0.0
large cobble	128	**180**			0.0	0.0
very large cobble	180	**256**			0.0	0.0
small boulder	256	**362**			0.0	0.0
small boulder	362	**512**			0.0	0.0
medium boulder	512	**1024**			0.0	0.0
large boulder	1024	**2048**			0.0	0.0
very large boulder	2048	**4096**			0.0	0.0
bedrock	4096	**-**			0.0	0.0
			Total	0	0.0	-

(Wenthworth, 1922)

F-T Particle Sizes (mm)

F-T n-value	0.5
D16	
D5	

(Fuller and Thompson, 1907)

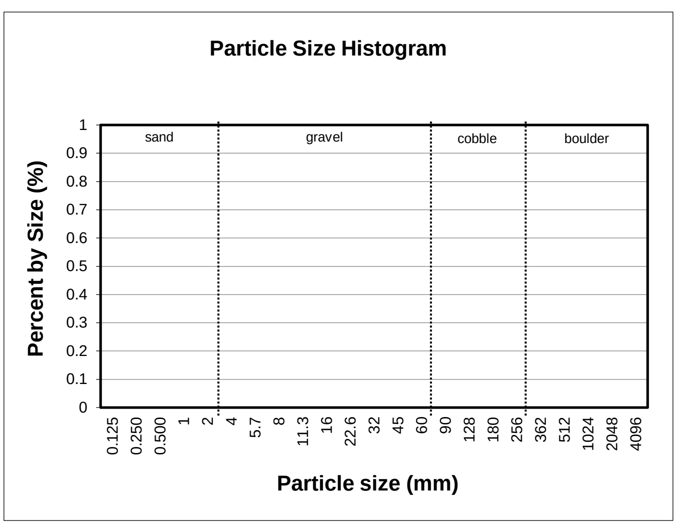
D (mm) of the largest mobile particles on bar

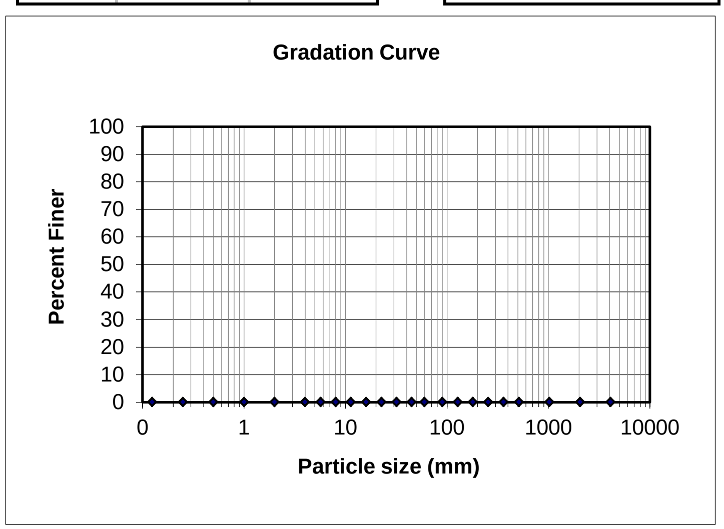
Mean	

Riffle Stability Index (%)

(Kappesser, 2002)

Notes





APPENDIX C

Bellinger Brook Photo Log

Engineering,
Landscape Architecture
and Environmental Science
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99 Realty Drive
Cheshire, Connecticut 06410
(203 271-1773

MMI# 5231-01
NYDOT
January 2014

PROJECT PHOTOS

PHOTO NO.: **1** DESCRIPTION: Upper concrete channel lining failure located approximately 200 feet upstream of large head cut.	
PHOTO NO.: **2** DESCRIPTION: Head cut and grade control structure failure at Brookwood Park.	

PHOTO NO.: **3** DESCRIPTION: Concrete lined channel between Church Street and W German Street crossings	
PHOTO NO.: **4** DESCRIPTION: Reconstructed section of concrete lined channel where Maple Grove Ave had been washed out in the summer of 2013 flooding events.	

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PHOTO NO.: **5** DESCRIPTION: Straight run between the high school and ball fields detained by a levee on the left bank. Note the degrading along the leveed bank.	
PHOTO NO.: **6** DESCRIPTION: Looking downstream of photo 5, the levee can be seen along the left bank