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.

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.

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 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 aquatic-based rare or endangered species are located.

4.2.3 Levee and Floodwall Construction

Under certain circumstances, levees and floodwalls can be constructed for the purpose of protecting properties and structures from flood damage. Levees are typically constructed from impervious, compacted soil while floodwalls are made of concrete or other man-made materials. As part of this study, the construction of levees and/or floodwalls to protect populated areas was evaluated in the Middleburgh and Schoharie focus areas.

Levees and floodwalls often require interior drainage pump stations, use of removable panels at road crossings, and considerable maintenance. Use of such measures requires careful consideration and risk assessment, engineering design, and ongoing monitoring and maintenance. When subjected to flooding, floodwalls can become structurally unsound if they are not properly designed, as a result of sliding, overturning at the foundation toe, or failure due to excessive soil pressure. Levees can be subject to seepage or scouring (FEMA, 2012). In most instances, residential floodwalls or levees are practical up to a height of only 3 to 4 feet above existing grade although they can be engineered for greater heights.

Risks associated with levees and floodwalls include the potential to increase water surface elevations in the channel by cutting off the floodplain and the danger of a flood event that exceeds the design storm and overtops or breaches the levee. As an example, in the town of Schoharie, peak flows in Schoharie Creek during Tropical Storm Irene were approximately 33 percent greater than the 100-year storm flows, or 35,000 cfs greater. Under this scenario, it is likely that floodwaters would have overtopped a levee designed to protect structures and properties from flooding during the 100-year flood event. Once a levee has been overtopped, floodwaters can become trapped behind the levee, exacerbating flooding problems.

Placement of floodwalls in the FEMA floodway is not allowed under NFIP regulations. Additionally, under NFIP regulations, floodwalls and levees cannot be used to bring noncompliant structures into compliance (FEMA, 2012).

4.2.4 Natural Channel Design and Floodplain Enhancement

Historic settlement and human desire to build near water has led to centuries of development clustered along the banks of rivers all over the nation, including within the Lower Schoharie Creek basin and particularly along the Schoharie Creek and its larger tributaries. Dense development and placement of fill in the natural floodplain of a river can severely hinder a river's ability to convey flood flows without overtopping its banks and/or causing heavy flood damages.

A river in flood stage must convey large amounts of water through a finite floodplain. When a channel is constricted or confined, velocities can become destructively high during a flood, with dramatic erosion and damage. When obstructions are placed in the floodplain, whether they are in the form of structures, infrastructure, or fill, they are vulnerable to flooding and damage.

Natural channels are typically comprised of a compound channel whereby normal flow is conveyed in a low-flow channel that is flanked by an active floodplain, which is ideally a vegetated, undeveloped corridor at a slightly higher elevation that is able to convey high flows. Although rivers in their natural setting seem to be at their low-flow stage most often, the entire floodprone corridor is part of the river, and the importance of the floodplain only becomes evident on rare but extreme occasions.

In some locations, the natural floodplain along the Schoharie Creek and its tributaries has been built upon and in other locations has been filled. In certain instances, an existing floodplain can be altered through reclamation, creation, or enhancement to increase flood conveyance capacity. Floodplain *reclamation* can be accomplished by excavating previously filled areas, removing berms or obstructions from the floodplain, or removing structures. Floodplain *creation* can be accomplished by excavating land to create new floodplain where there is none today. Finally, floodplain *enhancement* can be accomplished by excavating within the existing floodplain adjacent to the river to increase flood flow conveyance. These excavated areas are sometimes referred to as floodplain benches. Figure 4-1 shows a typical cross section of compound channel with excavated floodplain benches on both banks. The graphic shows flood benches on both banks; however, flood benches can occur on either or both banks of a river.

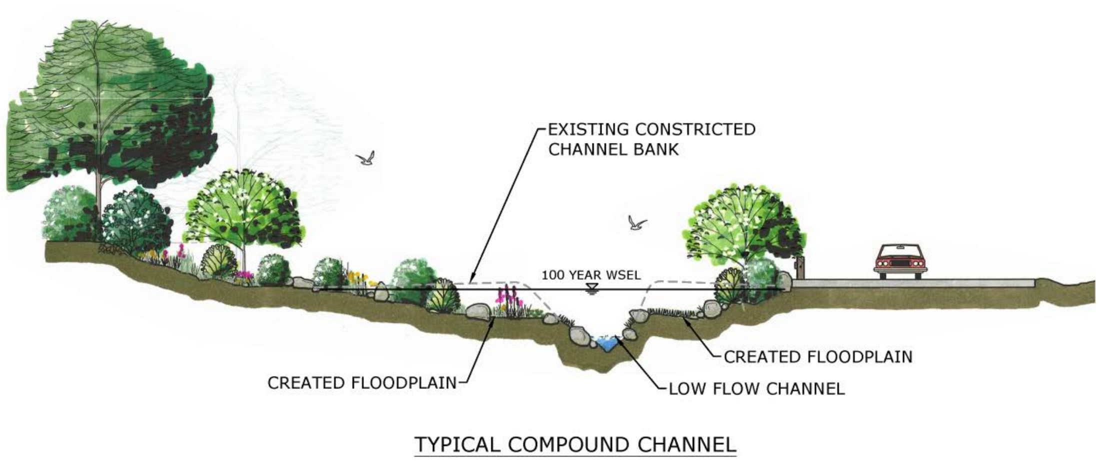


Figure 4-1
Typical Cross Section of a Compound Channel

4.2.5 Individual Property Flood Protection

A variety of measures is available to protect existing public and private properties from flood damage. 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.

Residents throughout the basin are encouraged to sign up for their county's emergency notification system, which provides notifications to affected residents in the event of an emergency such as a flood. In each of the counties, residents can receive information from some sort of emergency notification system.

- In Montgomery County, residents can sign up for the Code Red program in which you are notified by your local emergency response team via phone message or text message in the event of emergency situations or critical community alerts.

- Schenectady County currently utilizes an emergency call system to notify residents of emergency information. Currently, the call system can only automatically contact residents with listed land line phones. Residents with unlisted phone numbers or who use cell phones as their primary phone can now register with the Rapid Notify system online at: http://www.schenectadycounty.com/reverse911.htm.

- Otsego County maintains a "911 text messaging system" for which residents can sign up at: http://www.otsegocounty.com/depts/911/documents/Textingapplication2015_001.pdf.

- Schoharie County maintains the Schoharie County Emergency Notifications Registration System. This application allows citizens to receive emergency notifications to their cell phone or internet phone numbers. Residents can register at https://www2.schohariecounty-ny.gov/EmergencyNotifications/. Schoharie County also developed a Flood Education video that is aired on a cable network periodically and is available at local libraries for borrowing.

- Albany County maintains a list of radio stations to which residents should listen for emergency notifications. The list can be found at this website: http://www.albanycounty.com/Residents/Radio.aspx.

Towns within the basin should work to identify and remove vacant and abandoned structures to prevent future hazards. In areas where properties are vulnerable to flooding, 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 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 1 foot above the base flood elevation.

Figure 4-2
New elevated homes under construction

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 basin 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 can 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.

<u>Wet floodproofing of the structure to allow floodwaters to pass through the lower area of the structure unimpeded</u> – 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 100-year flood elevation.

<u>Performing other home improvements to mitigate damage from flooding</u> – 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 base flood elevation (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 HWM.

<u>Encouraging property owners to purchase flood insurance under the NFIP and to make claims when damage occurs</u> – 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.

4.2.6 <u>Road Closures</u>

Approximately 75 percent of all flood fatalities occur in vehicles. Shallow water flowing across a flooded roadway can be deceptively swift and wash a vehicle off the road, an example of which can be seen in Figure 4-3. Water over a roadway can conceal a washed out section of roadway or bridge. When a roadway is flooded, travelers should not take the chance of attempting to cross the flooded area. It is not possible to tell if a flooded road is safe to cross just by looking at it.

One way to reduce the risks associated with the flooding of roadways is their closure during flooding events, which requires effective signage, road closure barriers, and consideration of alternative routes.

Floodprone communities such as Austin, Texas, have implemented on-line warning systems that provide up-to-date flood information on local emergency road closures (Figure 4-4).

Figure 4-3
Car accident resulting from flooded road

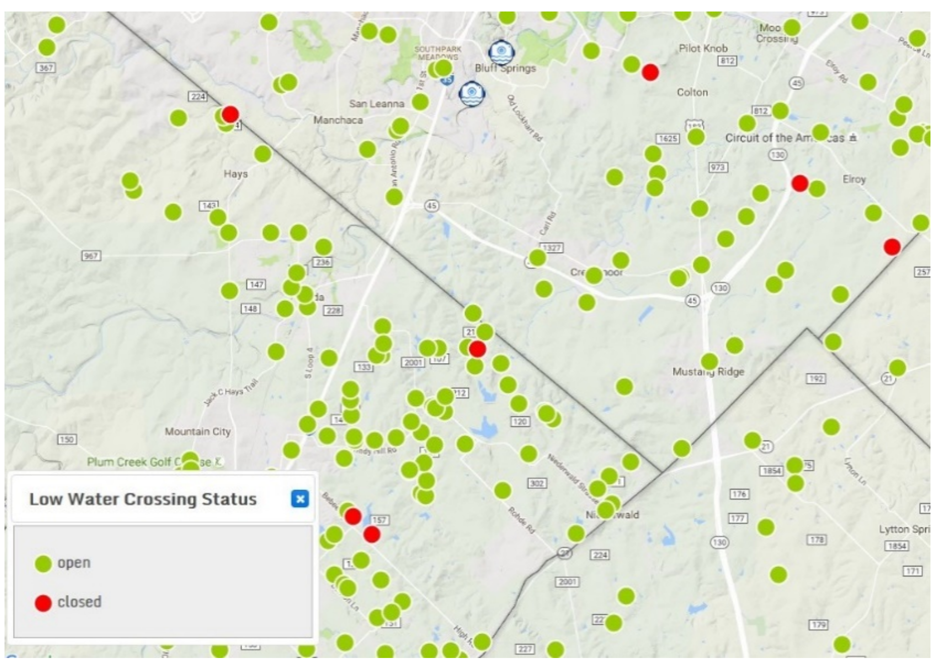


Figure 4-4
Graphic from ATX Floods (Austin, Texas)

4.2.7 Early Warning Systems

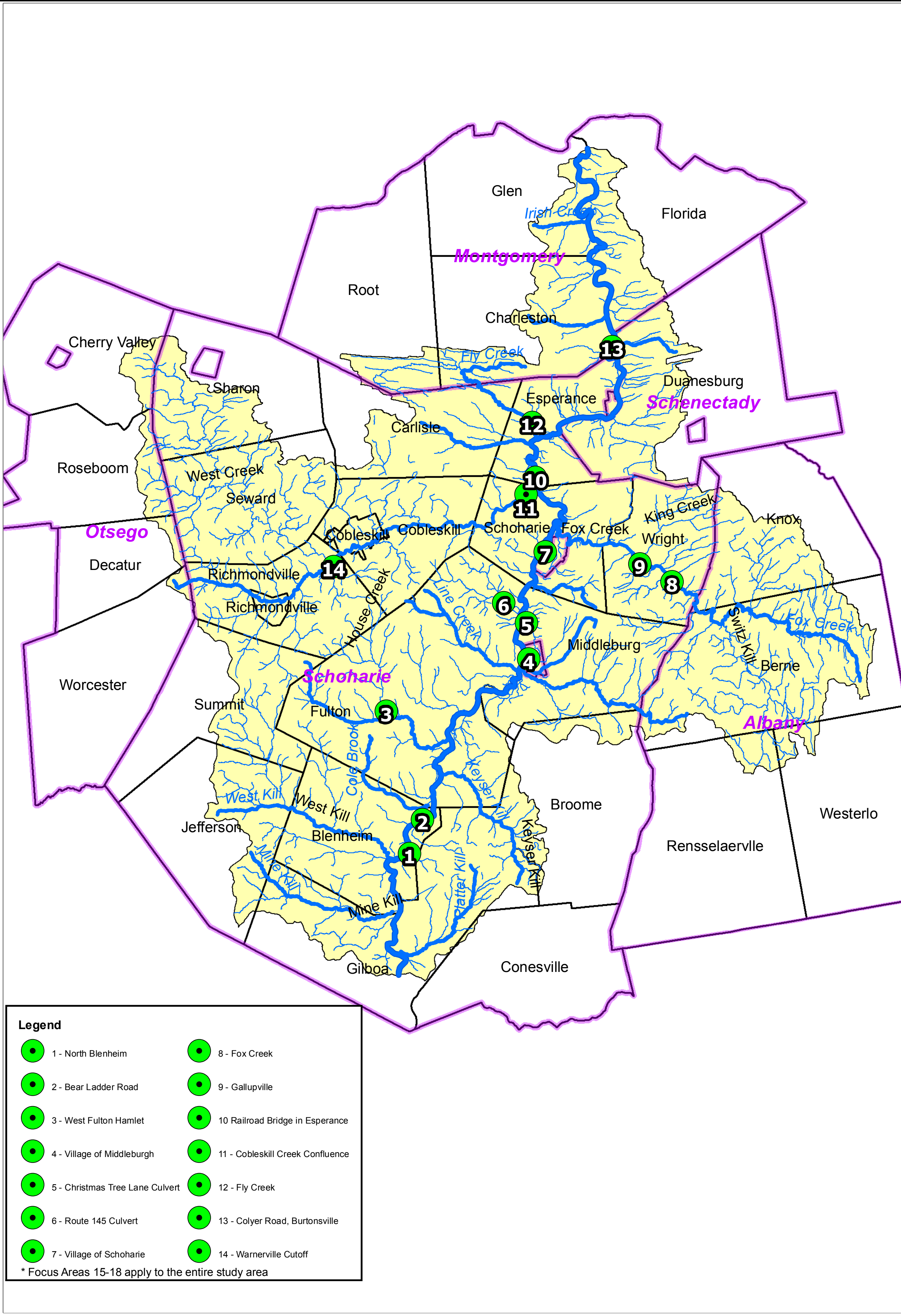
A reliable early warning system would provide community residents and business owners with a warning that flooding is likely while avoiding false alarms. The first and most important step is community flood preparedness. In order for any flood warning system to be successful, community members need to know what to do before, during, and after a flood. Accurate, reliable, and timely information on stream discharge or stage is essential to the success of a flood early warning system. SCSWCD has established devices that measure and record water surface elevations in 15-minute intervals. These devices are located on Schoharie Creek at Middleburgh and Esperance and on Fox Creek in Schoharie. They include radar level recorders, which measure the river stage without contacting the water surface. The devices are battery/solar powered so that they continue to operate during a power failure and are programmed to alert community officials via cell phone when water in Schoharie Creek or Fox Creek reaches a certain stage or when there is a rapid rate of change in river stage.

There are currently no stream gauges on many of the Schoharie Creek tributaries, making early warning systems at the onset of a flood and statistical analysis of flooding after a flood difficult. Installation of permanent stream gauges along floodprone tributaries to Schoharie Creek is recommended.

4.3 Focus Areas

For the purposes of this assessment, 18 focus areas have been identified within the Lower Schoharie Creek watershed. Fifteen of these areas are specific geographic locations while the remaining three areas are common throughout the watershed. A greater level of information was collected for the focus areas in order to assess potential flood mitigation projects. Figure 4-5 is a map showing the locations of the focus areas. They are listed below, and described in greater detail in the sections that follow.

- Focus Area #1 – North Blenheim
- Focus Area #2 – Bear Ladder Road
- Focus Area #3 – West Fulton Hamlet
- Focus Area #4 – Village of Middleburgh
- Focus Area #5 – Christmas Tree Lane Culvert
- Focus Area #6 – Route 145 Culvert
- Focus Area #7 – Village of Schoharie
- Focus Area #8 – Fox Creek
- Focus Area #9 – Gallupville
- Focus Area #10 – Railroad Bridge in Esperance
- Focus Area #11 – Cobleskill Creek Confluence
- Focus Area #12 – Fly Creek
- Focus Area #13 – Colyer Road, Burtonsville
- Focus Area #14 – Warnerville Cutoff
- Focus Area #15 –Potential for flood attenuation in upper watershed
- Focus Area #16 - General review of berms along farm fields
- Focus Area #17 – Potential for flood attenuation in reservoirs
- Focus Area #18 – Protection of wetlands, floodplains, and green infrastructure



SOURCE(S):
USGS StreamStats Version 3.0 (04/2016)
USGS National Hydrography Dataset (04/2016)
NYS GIS Clearinghouse (04/2016)

Figure 4-5: Focus Areas within Schoharie Creek Project Basin

Location: Schoharie Creek Watershed, NY

N

Schoharie Creek Flood Study

Map By: EMH
MMI#: 4805-05
MXD: Q:\Projects\4805-05 Schoharie Basin Flood Analysis\GIS\MDX\Focus Area Points 9272106.mxd
1st Version: 04/25/2016
Revision: 9/30/2016
Scale: 1 in = 31,970 ft

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4.3.1 Focus Area #1 – North Blenheim

Background

This focus area includes an approximately 1.5-mile reach of Schoharie Creek as it flows through the hamlet of North Blenheim and includes the NYS Route 30 Bridge (Bridge Identification Number [BIN] 1020940) as seen in Figure 4-6. The reach also includes the abutments of the historic Blenheim covered bridge, which was damaged during Tropical Storm Irene and is no longer in place. This reach of Schoharie Creek is subject to aggradation of sediments, much of it reportedly originating from West Kill Creek. The hamlet was severely damaged by flooding during Tropical Storm Irene.

Figure 4-6
Photos of NY Route 30

View of NY Route 30 bridge over Schoharie Creek in North Blenheim, with abutments of the former historic Blenheim covered bridge visible (left photo); view along NY Route 30 through hamlet of North Blenheim (right photo)

The North Blenheim focus area has a contributing drainage area of approximately 407 square miles. The creek flows across a section of bedrock channel as it approaches the hamlet. As it flows past North Blenheim and under the NYS Route 30 bridge, Schoharie Creek is somewhat confined within its river valley, making contact with the right valley wall just downstream of the bridge where the creek runs parallel to NYS Route 30.

According to the Schoharie County Region 5 Evacuation Route, residents in the North Blenheim area are directed to proceed to the Jefferson Central School shelter by way of North Road and NYS Route 10. For residents living to the north of North Blenheim, this would require traveling south along NYS Route 30 through North Blenheim.

This reach of Schoharie Creek has been evaluated by FEMA using approximate engineering methods only, meaning that identification of areas subject to flooding has been approximated. An existing conditions HEC-RAS hydraulic model was obtained from FEMA. The resulting FEMA FIRM indicates that the 100-year flood event inundates much of the developed area of the hamlet of North Blenheim along NYS Route 30, including the roadway itself (Figure 4-7). A FEMA floodway has not been designated in this reach.

SOURCE(S):

NYS GIS Clearinghouse Orthoimagery (accessed June 2016)

FEMA Schoharie County Special Flood Hazard Area

Figure 4-7: FEMA Flood Insurance Rate Map - North Blenheim

Location:

Blenheim, NY

N

Schoharie Basin Flood Analysis

Map By: EMH
MMI#: 4805-05
MXD: Q:\Projects\4805-05 Schoharie Basin Flood Analysis\GIS\MDX
1st Version: 6/6/2016
Revision: 9/22/2016
Scale: 1 in = 540 ft

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New survey was collected through this reach, including channel cross sections and detailed hydraulic survey of the Route 30 bridge. A hydraulic model was developed and run to evaluate potential flood mitigation alternatives. The model utilized a combination of new survey information and published information from FEMA.

The USGS *StreamStats* program was utilized to develop peak flow information at this location, which was compared against peak flows provided in the FEMA FIS. The FEMA flows are consistently higher than those reported by *StreamStats*. The FEMA flows were used for the hydraulic analysis since they are more conservative and represent the jurisdictional standard. *StreamStats* data was used to estimate bankfull characteristics of the creek through this reach. Table 4-1 presents a summary of peak flows as determined by FEMA and *StreamStats*. Table 4-2 presents watershed and stream channel characteristics through this reach.

TABLE 4-1
Summary of Peak Flows from FEMA at Two Flow Locations

Recurrence Interval	2.2 Miles Upstream of NYS Route 30 Bridge (cfs)		1.7 Miles Downstream of NYS Route 30 Bridge (cfs)	
	FEMA	*StreamStats*	FEMA	*StreamStats*
10-Year	39,927	36,100	41,583	39,800
50-Year	65,713	59,000	68,439	65,000
100-Year	79,207	70,800	82,493	77,900
500-Year	118,302	102,000	123,210	112,000

TABLE 4-2
Bankfull Characteristics (Based on USGS *StreamStats*)

	2.2 Miles Upstream of NYS Route 30 Bridge	1.7 Miles Downstream of NYS Route 30 Bridge
Watershed Area (square miles)	357	412
Bankfull Width (feet)	249	264
Bankfull Depth (feet)	6.7	6.9
Bankfull Discharge (cfs)	11,100	12,300

A total of five flood mitigation alternatives were evaluated for the North Blenheim focus area, including an assessment of replacing the historic covered bridge as well as various floodplain enhancement and sediment removal scenarios. These are described in detail below.

Alternative 1-1: Replacement of Historic Covered Bridge

This alternative assesses the impact of the historic Blenheim covered bridge, located just upstream (south) of the NYS Route 30 crossing over Schoharie Creek. Figure 4-8 is an aerial photograph of the bridge site. The timber superstructure of the bridge was destroyed during Tropical Storm Irene and had been damaged during previous flood events. The abutments sustained minor damage during Irene but remained in place after the flood receded. Local interest has been expressed in rebuilding the covered bridge by reusing the existing abutments. As envisioned, the replacement bridge would be a replica of the original bridge, but the deck would be set 10 feet higher than the former deck (Watershed Post, September 18, 2015, and June 23, 2016).

Three alternatives were analyzed to determine the impact of the bridge and its abutments on flooding in the hamlet of North Blenheim. First, an analysis was conducted to determine the impact of the bridge on water surface elevations if the deck were to be replaced at the same elevation as the former bridge deck. Second, an analysis was undertaken to determine whether a replacement bridge with the deck set at an elevation 10 feet higher than the former bridge would cause an increase in water surface elevations that would contribute to flooding in the North Blenheim hamlet. Third, an analysis was conducted to determine whether removal of the existing abutments from the channel would result in a decrease in flood elevations in the hamlet.

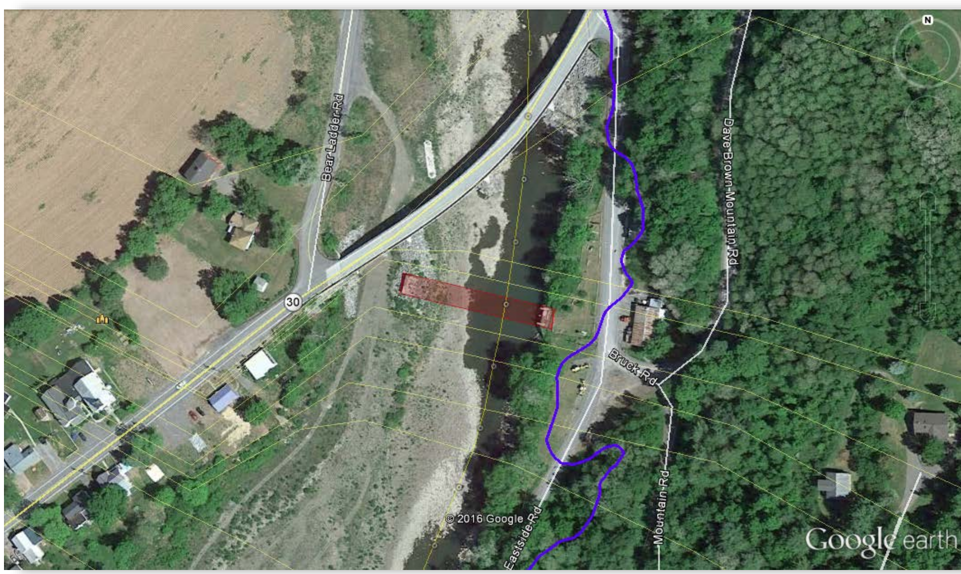


Figure 4-8
Aerial Photograph Showing Former Location of Blenheim Covered Bridge

Reconstructing the historic covered bridge at the same elevation as the former bridge would cause a 2.8-foot rise in the 100-year flood elevation at the bridge. The rise in water surface elevation would extend approximately 3,500 feet (three-quarters of a mile) upstream of the bridge and would cause increased flooding of structures in North Blenheim and along NYS Route 30 as it passes through the hamlet. The hydraulic opening of the covered bridge, if reconstructed at the same elevation as the former bridge on the existing abutments, would be substantially undersized for the 100-year flood, and floodwaters would reach the superstructure in all flows greater than or equal to the 10-year event. Under this scenario, the likelihood of the bridge being damaged or destroyed again during a flood would be high.

If the replacement bridge were to be set on the existing abutments and raised 10 feet higher than the elevation of the former covered bridge, hydraulic analysis indicates that the new bridge would safely pass the 100-year flood event with adequate freeboard. There would be no rise in water surface elevations at or upstream of the bridge. However, it is important to note that if larger abutments or piers were to be set in the channel, or if a roadway embankment were to be constructed to connect the replacement bridge to the bank on the left side of the channel, an increase in water surface elevations would result.

A hydraulic analysis was conducted to determine whether removal of the existing abutments from the channel would result in a decrease in flood elevations upstream of the bridge site. The abutments are small relative to the width of the channel, and their removal would result in only a small decrease (approximately 2 inches) in water surface elevations at and upstream of the former structure.

If the Blenheim covered bridge is replaced, the replacement deck should be set at an elevation that is 10 feet higher than the deck of the former historic bridge. The replacement bridge should be set on the existing abutments or on new abutments that do not occupy more space in the channel than the existing abutments. No roadway embankment should be constructed on the left side of the bridge to connect the bridge deck to the left bank. Detailed hydraulic modeling should be conducted as part of the engineering design to ensure that the new bridge does not cause an increase in water surface elevations at or upstream of the bridge.

Because the FEMA FIRMs for North Blenheim were developed when the former covered bridge was in place, preparation of a LOMR that documents the current condition either with no bridge or with a new bridge at a higher elevation is recommended.

Alternative 1-2: Floodplain Enhancement

Three scenarios involving the construction of an enhanced floodplain were assessed. Many factors contribute to whether or not construction of an enhanced floodplain will ultimately result in a meaningful decrease in flooding and flood-related damages in nearby, inhabited areas. For this reason, it is necessary to conduct hydraulic modeling for a range of floodplain enhancement configurations.

Alternative 1-2a – The first floodplain enhancement scenario evaluated involved the construction of a floodplain along the left bank of a meander bend in Schoharie Creek, just upstream of the Route 30 bridge. This alternative is depicted in Figure 4-9. Under this alternative, the floodplain would extend beneath the Route 30 bridge along with the removal of vegetated alluvial deposits that form a point bar on the inside of the meander bend. This alluvial deposit extends beneath the bridge. Excavation beneath the bridge was assumed to be possible for the purpose of this assessment but if pursued would need to be evaluated further relative to the footings of the bridge piers and their susceptibility to scour or undermining if excavation were performed.

Results of the modeling show a drop in the 100-year flood water surface elevations ranging between 2 and 3 feet extending approximately two-thirds of a mile upstream of the bridge. This reduction would lower flood elevations in the hamlet and would result in the elimination of approximately 18 to 20 properties from FEMA's mapped 100-year SFHA.

Figure 4-9
Alternative 1-2a

Scenario involving construction of enhanced floodplain scenario 1-2a, along the left bank in North Blenheim, near the NYS Route 30 bridge (Shaded area outlined in red represents area of enhanced floodplain.)

While the removal of these properties from the floodplain would be beneficial, the cost of such a project would be high. Implementation would involve the removal and off-site disposal of approximately 75,000 cubic yards of material and revegetation of the modified areas. This scenario would also require the removal of the existing abutments of the former covered bridge, which is not feasible if the bridge is to be replaced with a new structure as discussed above.

Alternative 1-2b – The second floodplain enhancement scenario in North Blenheim assessed the construction of a floodplain along the right bank of Schoharie Creek in an existing agricultural field as shown in Figure 4-10. The results of the hydraulic analysis show that this floodplain enhancement configuration would have only a small flood mitigation benefit within the North Blenheim hamlet. The hydraulic constriction driving flood elevations through the hamlet appears to be at or near the NYS Route 30 bridge, and because this alternative does not provide any widening of that area, the resulting reductions in water surface elevation are small.

Similar to the first floodplain enhancement scenario (Alternative 1-2a), the cost of this scenario would be high and is not likely justified due to the minimal reduction in flooding. This alternative would also involve the reconstruction and relocation of East Side Road, which would be impacted by the floodplain bench. For these reasons, this scenario was not pursued further.

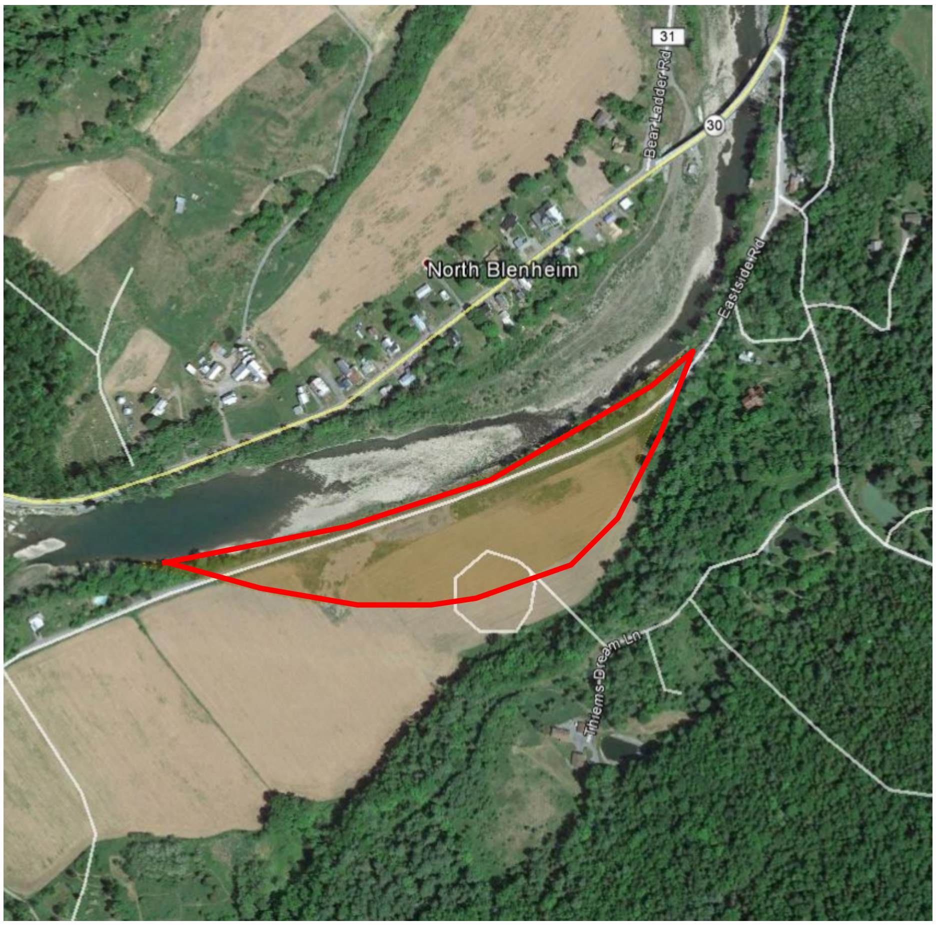


Figure 4-10
Alternative 1-2b

Scenario involving construction of enhanced floodplain scenario 1-2b, along the right bank of Schoharie Creek in North Blenheim (Shading area outlined in red represents area of enhanced floodplain.)

Figure 4-11
East Side Road in North Blenheim, with Schoharie Creek to the right

Alternative 1-2c – Based upon an iterative assessment using hydraulic modeling, a reduction in channel of conveyance in the area of the NYS Route 30 bridge was determined to be a hydraulic constriction contributing to a rise in water surface elevations that extend upstream through the North Blenheim hamlet. A floodplain enhancement and sediment removal scenario was assessed in the area of the NYS Route 30 bridge, starting approximately 175 feet upstream of the bridge and extending to 925 feet downstream of the bridge (Figure 4-12). Prior to this scenario being undertaken, further investigation will be necessary to determine whether the removal of the abutments for the former covered bridge would be required or whether they could be left in place (the possible replacement of the historic covered bridge is discussed under Alternative 1-1).

Figure 4-12
Route 30 Bridge

View from NYS Route 30 bridge over Schoharie Creek looking downstream toward location of proposed floodplain enhancement scenario 1-2c

The results of floodplain enhancement and sediment removal scenario 1-2c were found to be effective at lowering water surface elevations by up to 2 feet over a distance of two-thirds of a mile upstream, which includes the North Blenheim hamlet. Figure 4-13 shows the predicted existing (green line) and proposed (blue line) water surface elevations during the 100-year flood event, extending a significant distance upstream of the NYS Route 30 bridge.

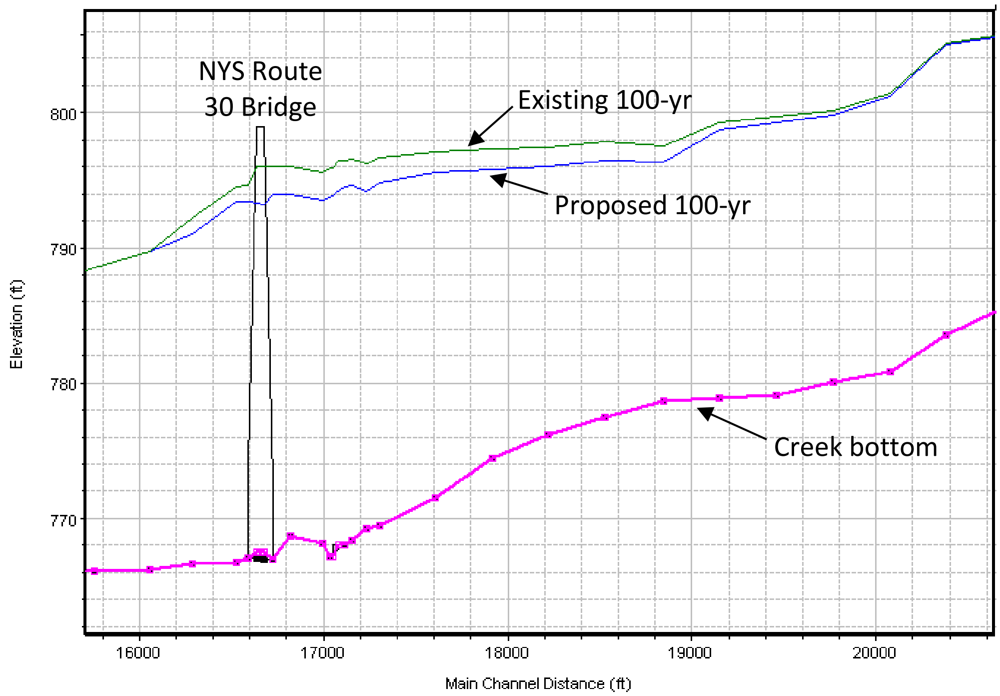


Figure 4-13
Existing and Proposed Water Surface Elevations for Scenario 1-2c

Profile showing existing (green) and proposed (blue) water surface elevations for scenario 1-2c during the 100-year flood event, extending up Schoharie Creek upstream of the NYS Route 30 bridge

Figure 4-14 shows the North Blenheim hamlet overlain with the existing (blue) and approximate proposed (red) FEMA SFHA under this scenario. Many structures would be removed from the FEMA SFHA while others remaining in the SFHA would see reductions in flood elevations. The construction of this scenario would impact 1,100 linear feet of Schoharie Creek and would require the removal of approximately 20,000 cubic yards of material.

The impacts on the channel and the construction costs associated with scenario 1-2c would be lower than the other two floodplain enhancement scenarios (1-2a and 1-2b) while the flood reduction results would be similar or better. Scenario 1-2c is believed to be viable and recommended for further consideration. It should be noted that a gas line is located near the downstream end of the proposed floodplain enhancement area (personal communication with Peter Nichols, Stream Program Manager, Delaware County Soil and Water Conservation District). This and other utilities would need to be identified and, if necessary, relocated.

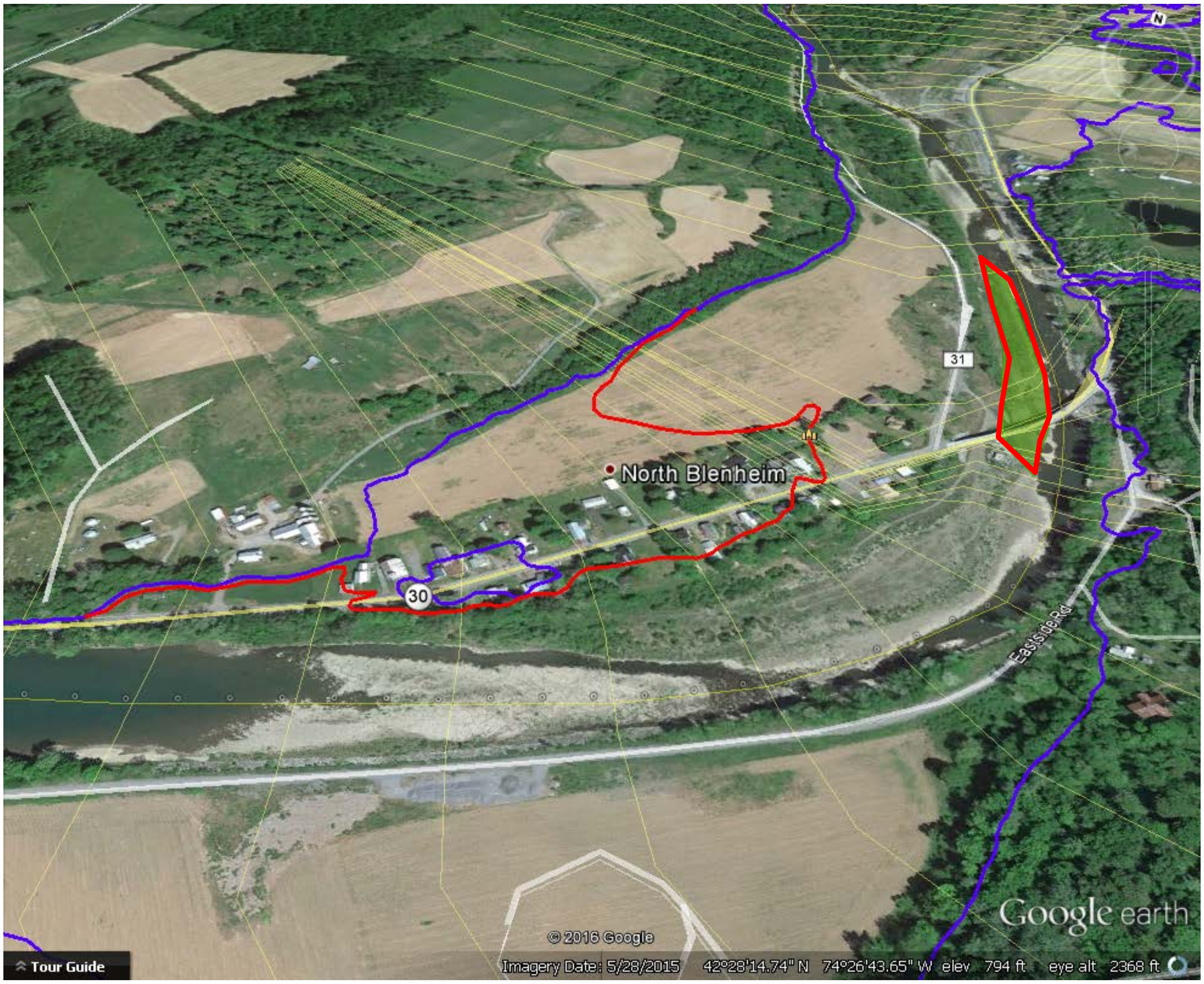


Figure 4-14
Scenario 1-2c

Aerial view of North Blenheim hamlet showing the location of floodplain enhancement scenario 1-2c (shaded area outlined in red), and existing (blue) and approximate proposed (red) FEMA SFHA

Alternative 1-3: Sediment Removal

Field investigations revealed that the Schoharie Creek channel just upstream of North Blenheim contains multiple mid-channel and lateral sediment bars. Removal of accumulated sediment in this area was investigated for its potential to reduce flooding. The hydraulic model was used to assess sediment removal over a half-mile length of Schoharie Creek, up to 4 feet in depth, across the approximately 200-foot width of the channel.

The hydraulic modeling results indicate that sediment removal would have a relatively minor impact on water surface elevations. Reductions in water surface elevations do not provide relief to properties located in the North Blenheim hamlet center. The estimated volume of sediment to be removed under this scenario would be approximately 35,000 cubic yards, requiring off-site material disposal as well as bank restoration and stabilization. Sediment removal is not likely to be sustainable and is likely to continue to aggrade in this area. As such, the sediment removal scenario is not recommended for further study.

Focus Area #1 Recommendations

The following recommendations are offered for Focus Area #1 in order of priority:

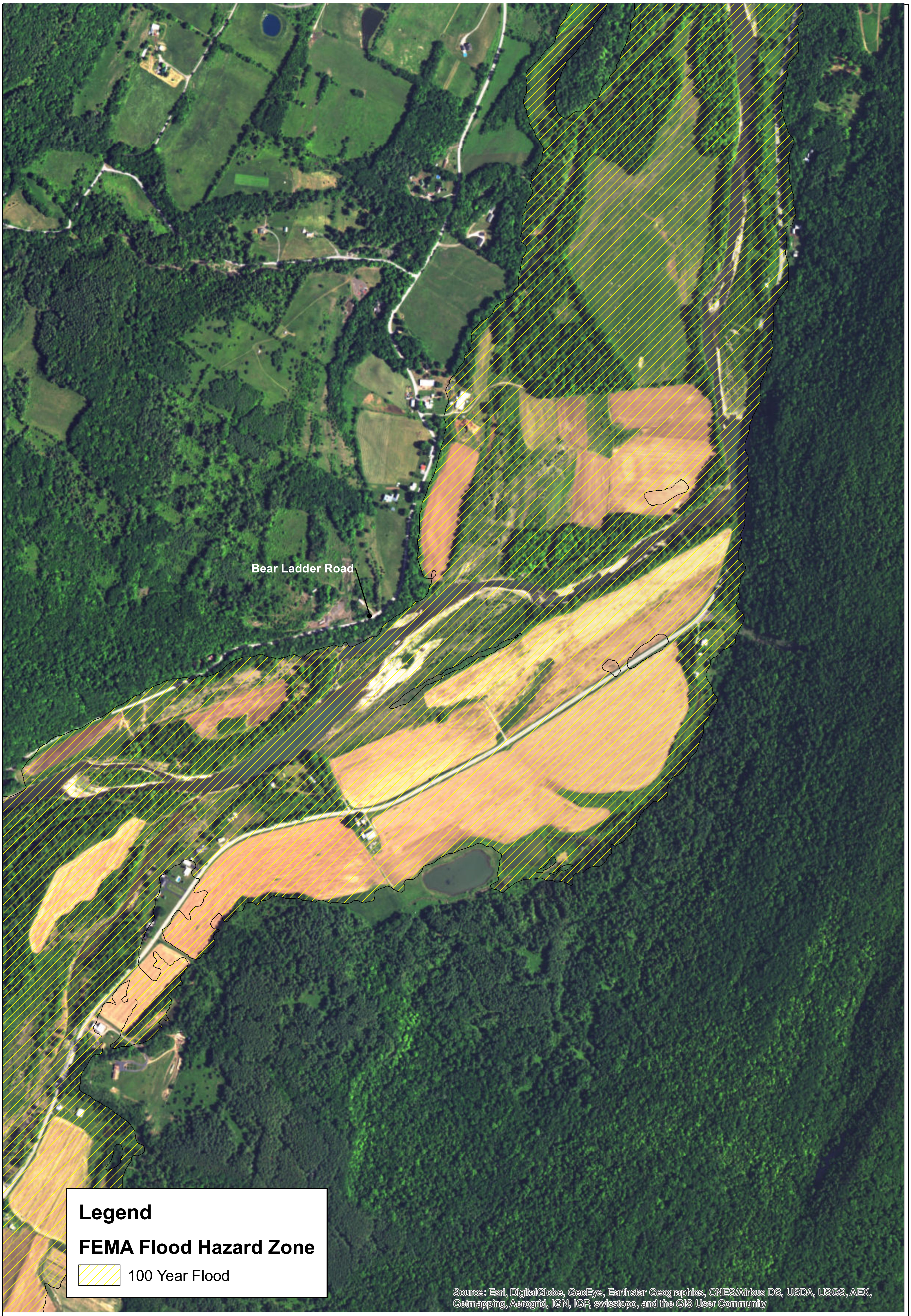
1. Alternative 1-2c Floodplain Enhancement – Floodplain enhancement and sediment removal scenario as described in Alternative 1-2c is recommended. This scenario was found to be effective at lowering water surface elevations by up to 2 feet over a distance of two-thirds of a mile upstream, which includes the North Blenheim hamlet. Many structures would be removed from the FEMA SFHA while those that would remain in the SFHA would see reductions in flood elevations. The construction of this enhancement and sediment removal scenario would impact approximately 1,100 linear feet of Schoharie Creek and would require the removal of approximately 20,000 cubic yards of material. Engineering design and permitting are anticipated on the order of $68,000 while construction would be anticipated on the order of $820,000. This estimate does not include the cost of any land acquisition or construction easements that may be required or the relocation of utilities.

2. Alternative 1-1 – Replacement of Covered Bridge – If the Blenheim Covered Bridge is to be replaced, the replacement deck should be set at an elevation that is 10 feet higher than the deck of the former historic bridge. The replacement bridge should be set on the existing abutments or on new abutments that do not occupy more space in the channel than the existing abutments, and no roadway embankment should be constructed on the left side of the bridge to connect the bridge deck to the left bank. Hydraulic modeling should be conducted as part of the engineering design to ensure that the new bridge does not cause an increase in water surface elevations. It is also recommended that a LOMR be prepared that reflects the current condition in North Blenheim either with no covered bridge or with a new bridge at a higher elevation.

4.3.2 Focus Area #2 – Bear Ladder Road

Background

Focus Area #2 is located where Bear Ladder Road (County Route 31) parallels Schoharie Creek, just north of the hamlet of North Blenheim. Frequent flooding is reported at a location approximately 2 miles downstream of the NYS Route 30 bridge coincident with a low spot in the road. When the area floods, travel becomes unsafe or impossible, and access is cut off to several residences. Reports of flooding are consistent with the FEMA 100-year SFHA mapping, which shows Bear Ladder Road overtopping at two separate locations during the 100-year flood event as depicted in Figure 4-15. The more southern area encompasses approximately 2,250 linear feet of road and the more northern about 1,500 feet.



SOURCE(S):	Figure 4-15: FEMA Flood Insurance Rate Map - Bear Ladder Road	Location: Blenheim, NY
NYS GIS Clearinghouse Orthoimagery (accessed June 2016) FEMA Schoharie County Special Flood Hazard Area	N Schoharie Basin Flood Analysis	Map By: EMH MMI#: 4805-05 MXD: Q:\Projects\4805-05 Schoharie Basin Flood Analysis\GIS\MXD 1st Version: 6/6/2016 Revision: 9/22/2016 Scale: 1 in = 675 ft

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Alternative 2-1 – Floodplain Modification

Hydraulic modeling and an assessment of digital elevation models were used to evaluate the nature and extent of existing flooding conditions along Bear Ladder Road. The roadway elevation varies, but at some of its lowest points, the elevation of the road is only slightly higher than the elevation of bankfull flows in the Schoharie Creek channel. These low areas in the road are predicted to be flooded by as much as 10 feet of floodwater during the modeled 100-year flood. The floodplain along this reach of Schoharie Creek is very broad, in some areas nearly half a mile wide. Given the topography and abundance of an existing floodplain, channel and/or overbank modification would provide little to no flood benefit and would not improve flooding conditions along Bear Ladder Road. No additional modeling was necessary.

Alternative 2-2 – Raise Roadway

Hydraulic modeling was undertaken to assess the scenario of raising Bear Ladder Road up and out of the floodplain with 1 foot of freeboard (a factor of safety usually expressed in feet above a flood level) above the 100-year water surface elevation. Raising the roadway was evaluated, assuming a 30-foot embankment and 3:1 side slopes to avoid expensive structural wall construction. The final elevation of the road would need to be increased by 1 to 7 feet, depending on location, over two sections totaling approximately 4,000 linear foot of roadway to effectively protect the road from flooding during the 100-year storm event (Figure 4-16).

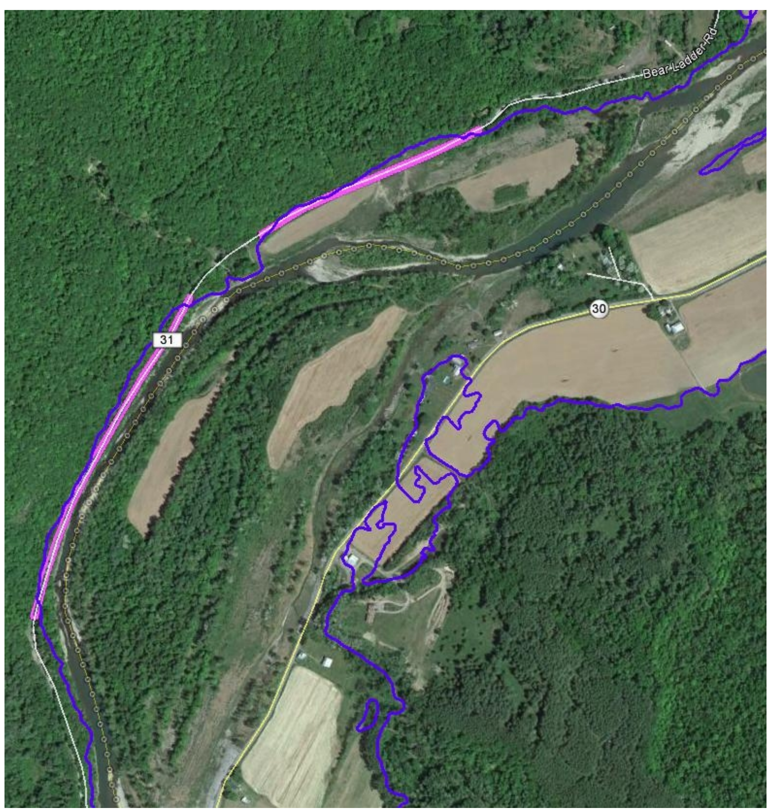

Figure 4-16
Aerial view of Bear Ladder Road (County Route 31) along Schoharie Creek showing limits of 100-year floodplain and proposed elevated areas of Bear Ladder Road (Alternative 2-2)

The cost of elevating Bear Ladder Road to 1 foot above the 100-year water surface elevation would be on the order of $1.9 million. This would involve reconstructing approximately 4,000 linear foot of road, and approximately 28,000 cubic yards of fill material would be required to elevate the road above the elevation of the 100-year flood. The cost of engineering design and permitting would be in the range of $150,000 to $200,000. This estimate does not include the cost of any land acquisition or construction easements that may be required in order to elevate the roadway.

Based on hydraulic analysis, the fill associated with raising the road would have a negligible impact on flood levels. Figure 4-17 is a cross section view of Schoharie Creek showing the proposed elevation of Bear Ladder Road along the left side of the valley and the resulting 0.05-foot rise in water surface elevations during the 100-year flood event.

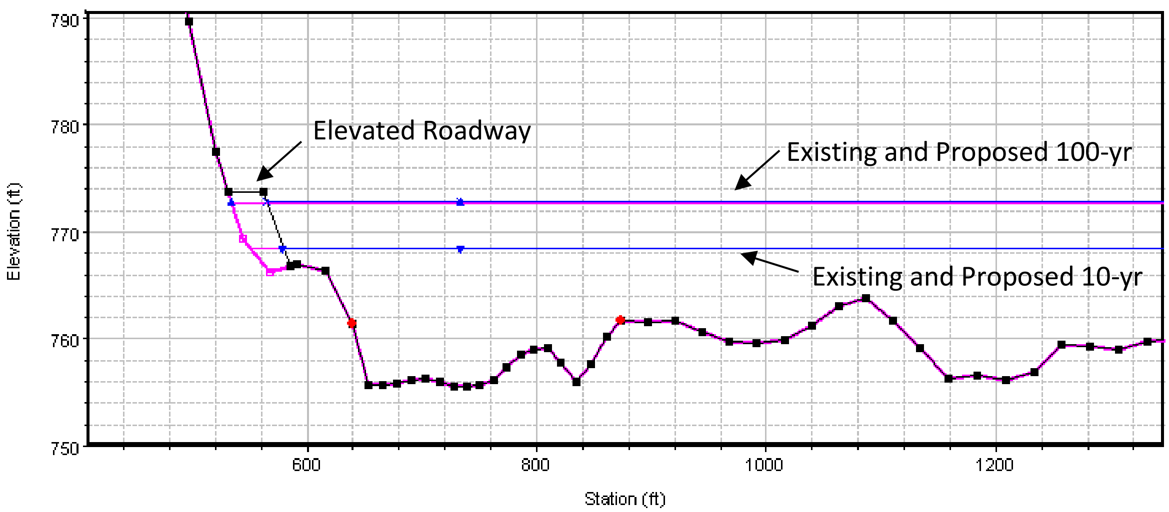

Figure 4-17
Cross Section View of Schoharie Creek

Alternative 2-3 – Roadway Signage and Closure

The most practical and low-cost solution to flooding of the roadway along Bear Ladder Road is its immediate closure during flooding events in combination with effective signage, barriers, and further consideration of alternative routes. Monitoring of the USGS stream gauge at Breakabeen can be accessed (http://waterdata.usgs.gov/nwis/uv?site_no=01350355) to provide highway superintendents and residents with a warning that floodwaters are rising, at which point signs and/or barriers should be put in place, and travel along the floodprone sections of Bear Ladder Road should be avoided.

Focus Area #2 Recommendations

The following recommendations are offered for Focus Area #2 in order of priority:

1. Alternative 2-3 – Roadway Signage and Closure – Immediate closure of Bear Ladder Road during flooding conditions, effective signage, and further consideration of alternative routes are recommended as described in Alternative 2-3.

2. Alternative 2-2 – Raising Bear Rock Road – While this alternative is potentially feasible, the cost of nearly $2.0M should be weighed against the benefit of unimpacted travel during major storm events. No homes or businesses will be removed from the floodplain under this alterative. Given the cost, likely need for land acquisition, and limited flood protection, this is not a high priority recommendation.

4.3.3 Focus Area #3 – West Fulton Hamlet

Background

Focus Area #3 is located in the hamlet of West Fulton and includes House Creek and Panther Creek, both of which are tributaries to Schoharie Creek. Two vehicular bridges located in the hamlet of West Fulton about 600 feet apart have been identified as being prone to debris jams and overtopping during flood events: the Patria Road bridge over House Creek and the West Fulton Road (County Route 4) bridge over Panther Creek. Hydraulic modeling was undertaken to evaluate both bridges and associated stream channels.

The West Fulton Fire Department station is located at 807 West Fulton Road, approximately one quarter of a mile east of the bridge over Panther Creek. The West Fulton Fire Department along with the Middleburgh Fire Department provides fire and rescue services for the town of Fulton. The West Fulton station is also a designated emergency shelter. According to the Schoharie County Region 9 Evacuation Route, residents in the Fultonham area are directed to proceed to the West Fulton Fire Department shelter by way of Pleasant Valley Road, Mallon Road, Patria Road, and West Fulton Road. This route crosses both the Patria Road bridge over House Creek and the West Fulton Road (County Route 4) bridge over Panther Creek. If these bridges were to be flooded or washed out during an emergency, access to and from the West Fulton Fire Department shelter would be impeded. Hydraulic analysis was conducted at both bridges to determine the likelihood that they would overtop or wash out during a flood.

No stream gauges are located on House Creek or Panther Creek near the project area, and a FEMA FIS has not been completed for West Fulton.

Alternative 3-1: Replace Patria Road Bridge over House Creek

Patria Road crosses over House Creek approximately 40 feet upstream of its confluence with Panther Creek (Figure 4-18). The bridge at this location reportedly becomes jammed with debris. According to the Schoharie County Department of Public Works, the dry hydrant pumpout located at Patria bridge was washed out during Tropical Storm Irene and was subsequently reinstalled. The bridge opening is 44 feet wide, with a 6.5-foot vertical distance between the bridge footing and the low chord on both sides. The channel along the left side of the bridge is somewhat scoured, resulting in the channel bed being 1 foot lower than the footing. The right side has a vegetated channel bar that covers the footing by approximately 1 foot, resulting in a distance of 5.5 feet between the top of the bar and the low chord. The bridge deck has a vertical height, or thickness, of 3.5 feet between the low chord and the base of the railing. The railing is open. The deck of the bridge is 24 feet wide. The channel substrate under the bridge is predominantly gravel with an area of sand. Sand is dominant moving downstream approaching the confluence with Panther Creek.

The bankfull width of House Creek measured in the vicinity of the bridge was found to be in the range of 50 to 55 feet. This is in close agreement with the regional regression equations utilized by *StreamStats*, which indicate a bankfull width of 55.8 feet.

Figure 4-18
Photos of Patria Road Bridge

Patria Road bridge over House Creek viewed from downstream (left photo) and looking east along Patria Road (right photo)

Peak flows were calculated for House Creek at this location using *StreamStats* and are reported in Table 4-3.

TABLE 4-3
Peak Flows for House Creek

Peak Flows	Discharge (cfs)
10-year flood	1,420
25-year flood	1,950
50-year flood	2,420
100-year flood	2,930
200-year flood	3,490
500-year flood	4,270

A HEC-RAS model was developed using 2014 Schoharie LiDAR mapping and flows generated from *StreamStats*. The Patria Road profile generated in the HEC-RAS model shows that the 50-year and 100-year floods do not overtop the bridge, but they do touch its low chord. The 200-year and 500-year floods overtop the bridge. The 44-foot span is narrower than the 55.8-foot bankfull width. Based on NYSDEC stream crossing standards, structures should span 1.25 times the channel's bankfull width. Bridges and culverts that do not span the bankfull width of the channel are more prone to debris jams and scour and are more likely to act as a barrier to aquatic organisms due to increased flow velocities through the structure.

The Patria Road bridge reportedly becomes filled with debris during flood events, leading to a reduction in hydraulic capacity and more frequent overtopping. A debris jam was simulated in the hydraulic model, creating a 30-percent blockage of the bridge opening. For the 100-year storm event, the water surface elevation increases by 2.75 feet upstream of the bridge when the bridge opening is blocked by 30 percent. The bridge is overtopped by the 25-year storm and all larger storms when debris blockage is simulated.

HEC-RAS modeling indicates that no buildings located near the Patria Road bridge would flood during the 100-year flood event. The building on Patria Road immediately west of the Patria Road bridge is at a ground elevation of 1,148 feet based on the 2014 LiDAR as shown in Figure 4-19. According to the HEC-RAS model, this building could experience minor flooding at an elevation of 1,148.15 feet in the 500-year flood without debris blockage. The buildings east of the bridge are at a higher elevation and would not experience flooding in the 500-year flood event.

Figure 4-19
Aerial View of Patria Road Bridge

Although predicted flooding associated with the Patria Road bridge devoid of blockage does not directly affect individual homes or businesses, overtopping of the road in the event of debris blockage would cause flooding and potentially dangerous conditions. When the Patria Road bridge is slated for replacement, the structure should be widened to better match the bankfull width of the channel, and detailed hydraulic analysis of the proposed structure should be conducted to ensure that the bridge is adequately sized to pass flows during large flood events.

The approximate cost of bridge replacement at the Patria Road bridge is in the range of $600,000 to $1M. Design and permitting costs would be anticipated on the order of $150,000.

Alternative 3-2: Replace West Fulton Road Bridge over Panther Creek

The West Fulton Road (County Route 4) bridge over Panther Creek was also identified as being prone to debris jams and overtopping during flood events (Figure 4-20). The bridge crosses the creek at a skew and has a hydraulic opening that measures 26 feet in width with a maximum height of 8 feet when measured from channel thalweg to low chord. When measured from the top of a gravel bar along the right bank to the low chord, the opening height is 5 feet. The bridge deck is approximately 2 feet thick. The travel lane on the bridge deck is 25 feet wide from edge to edge with open railings along both sides. A home is located very close to the edge of the creek along the left bank on the upstream side, and buildings are located very close to both banks downstream of the bridge.

Figure 4-20
Photos of West Fulton Road Bridge

West Fulton Road (CR 4) bridge over Panther Creek looking east along West Fulton Road (left photo) and looking downstream from bridge

The West Fulton Road bridge over Panther Creek has a drainage area of 8.8 square miles with a bankfull area of 96.8 square feet, a bankfull depth of 2.12 feet, a bankfull flow of 638 cfs, and a bankfull width of 46.5 feet. Table 4-4 presents peak flows as calculated for this location on Panther Creek. A HEC-RAS model was developed using 2014 Schoharie LiDAR and flows from *StreamStats*.

Elevation mapping indicates that there is a low spot on West Fulton Road located east of the bridge. In the 25-year and higher floods, the model predicts that floodwaters overtop the right bank of Panther Creek and flow over the low spot in the road as shown in Figure 4-21. Flows are predicted to return to Panther Creek at a point further downstream.

TABLE 4-4
Peak Discharges over Panther Creek at the West Fulton Bridge

Peak Flows	Discharge (cfs)
10-year flood	984
25-year flood	1,350
50-year flood	1,670
100-year flood	2,010
200-year flood	2,390
500-year flood	2,900

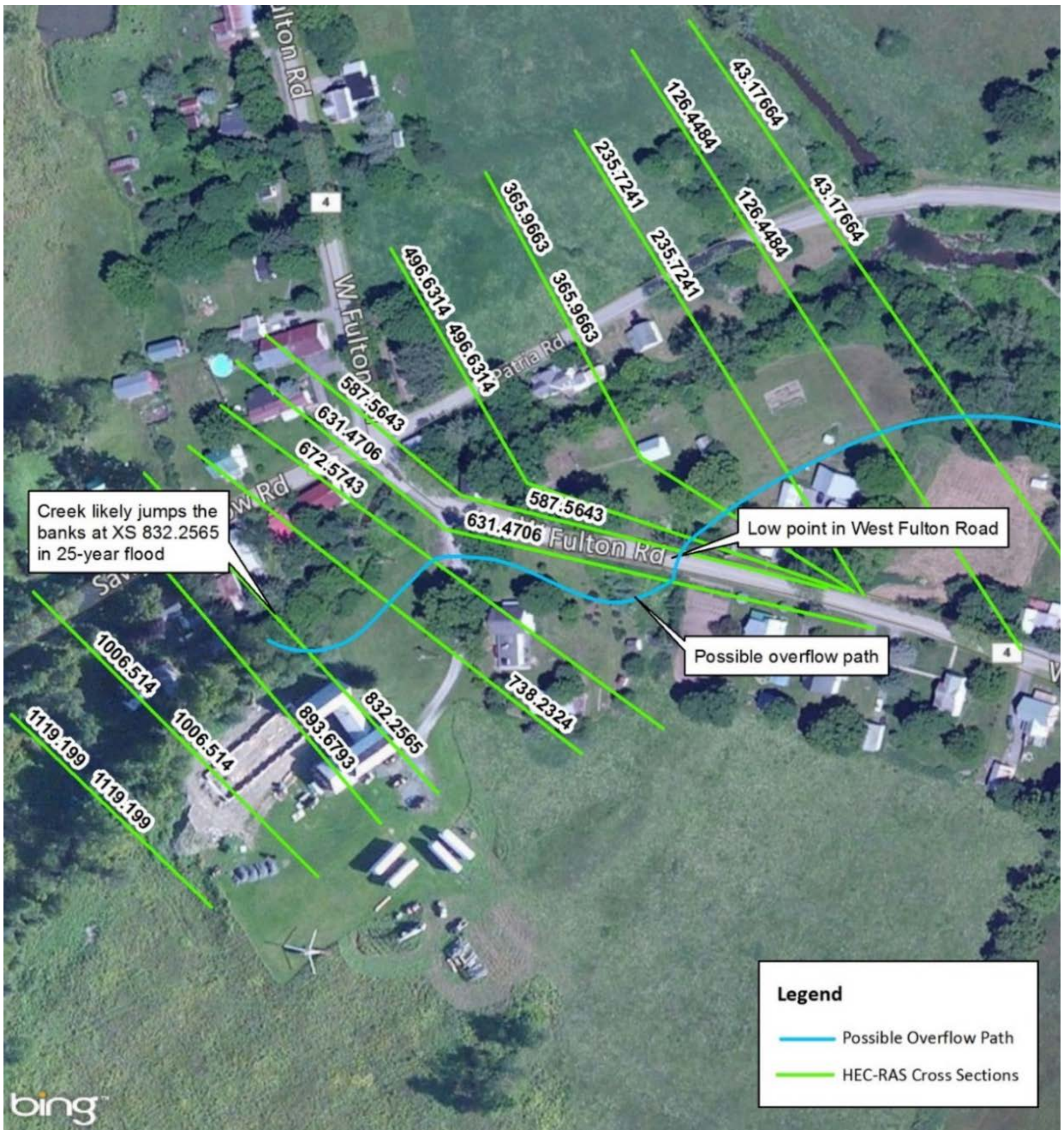

Figure 4-21
West Fulton Road Hydraulic Model

Hydraulic model indicates that flows could pass over the low spot along West Fulton Road during the 25-year flood and larger.

Neighbors have reported that in the recent past, including during the Tropical Storm Irene flood, Panther Creek has flooded the area around the barns to the south of the West Fulton Road bridge but has not overtopped the bridge or the low spot in the road east of the bridge. It is possible that West Fulton Road was not overtopped during Tropical Storm Irene because flooding may not have reached the 25-year storm event at this location. This would explain the discrepancy between individual observations and the hydraulic model predictions.

With a hydraulic opening of just 26 feet, the West Fulton Road bridge over Panther Creek is undersized when compared to the bankfull width of 46.5 feet. When the bridge is slated for replacement, the structure should be widened to better match the bankfull width of the channel, and hydraulic analysis should be conducted to ensure that the bridge is adequately sized to pass large flood events.

The approximate cost of bridge replacement at the West Fulton Road bridge is in the range of $600,000 to $1M. Design and permitting costs would be anticipated on the order of $150,000.

Alternative 3-3: Create Compound Channel with Floodplain along Panther Creek

This alternative evaluated creation of a compound or multistage channel upstream of the West Fulton Road bridge where the channel is overly narrow. A created floodplain along the right bank in combination with a larger bridge structure was modeled. Results indicate that such a modification would add sufficient capacity to convey flood flows without overtopping and would reduce the flooding risk to structures located along the left bank close to the creek.

The cost of engineering design and permitting for the compound channel and floodplain along Panther Creek upstream of the West Fulton Road bridge is anticipated to be on the order of $60,000 to $75,000 while construction is anticipated to be on the order of $150,000 to $200,000. This estimate does not include the cost of any land acquisition or construction easements that may be required.

Focus Area #3 Recommendations

The following recommendations are offered for Focus Area #3 in order of priority:

1. Alternatives 3-2 and 3-3 – Bridge Replacement and Compound Channel at West Fulton Road – This bridge is undersized as is the upstream channel and thus is inadequate for conveyance of flood flows and debris. When the bridge is slated for replacement, the structure should be widened to improve debris movement and conveyance of flood flows.

2. Alternative 3-1 – Bridge Replacement at Patria Road – Near-term bridge replacement is not likely warranted; however, when the Patria Road bridge is slated for replacement, the structure should be widened to improve debris movement and conveyance of flood flows.

4.3.4 Focus Area #4 – Village of Middleburgh

Background

Schoharie Creek flows north through Middleburgh between Route 30 and Route 145. According to *StreamStats*, Schoharie Creek at the Route 30 bridge in Middleburgh has a drainage area of 534 square miles with a bankfull area of 2,280 square feet, a bankfull depth of 7.6 feet, a bankfull flow of 15,400 cfs, and a bankfull width of 301 feet. Schoharie Creek flows across a wide, flat-bottomed valley with an extensive floodplain as it approaches and flows past the town of Middleburgh. In some locations, the floodplain is over a mile wide.

The flows from the FEMA HEC-RAS model with the addition of 2-year flows from *StreamStats* were used to conduct hydraulic modeling analysis and evaluate flood mitigation alternatives. Table 4-5 presents peak flows used in the hydraulic model at this location.

TABLE 4-5
Peak Flow Rates of Schoharie Creek at the Route 30 Bridge in Middleburgh

Peak Flows	Discharge (cfs)
2-year flood	19,800
10-year flood	41,817
50-year flood	68,824
100-year flood	82,957
500-year flood	123,903

Figure 4-22 shows that many buildings along River Street in Middleburgh are located within the 100-year floodplain. River Street is lined with a mix of uses including single-family homes, community services such as churches, and a range of businesses. The businesses include a farm, stores, a mechanics shop, and a karate dojo as well as several abandoned businesses including the former Grand Union on the west side of the road closest to the river. Hydraulic modeling was used to predict flooding depths at various locations in Middleburgh during the 10-year and 100-year flood events. Table 4-6 presents a summary.

TABLE 4-6
Floodwater Depths in Middleburgh during the 10-year and 100-year Floods

Location	10-Year Depth of Flooding (feet)	100-Year Depth of Flooding (feet)
Baseball field behind Middleburgh Junior/Senior High School	0.0	2.9
Intersection of Baker Avenue and Main Street	0.0	2.1
Griebel Lane	0.0	3.8
Intersection of Milk Can Lane and Route 30	0.0	2.4

Alternative 4-1: Modify/Replace the NYS Route 30 Bridge

The area around the NYS Route 30 bridge and approximately 6,000 feet downstream was analyzed with hydraulic modeling. The existing conditions model shows that the NYS Route 30 bridge is overtopped during the 100- and 500-year floods. Modeling predicts that the bridge does not create a significant backwater under the modeled flow conditions and that replacement of the bridge with a wider or taller structure *would not* reduce flooding at nearby buildings.

SOURCE(S):	Figure 4-22: FEMA Flood Insurance Rate Map - Village of Middleburgh		Location: Middleburgh, NY
NYS GIS Clearinghouse Orthoimagery (accessed June 2016) FEMA Schoharie County Special Flood Hazard Area	Schoharie Basin Flood Analysis	Map By: EMH MMI#: 4805-05 MXD: Q:\Projects\4805-05 Schoharie Basin Flood Analysis\GIS\MDX 1st Version: 6/6/2016 Revision: 9/22/2016 Scale: 1 in = 667 ft	MILONE & MACBROOM 231 Main Street, Suite 102 New Paltz, NY 12561 (845) 633-8153 Fax: (845) 633-8162 www.miloneandmacbroom.com

Alternative 4-2: Floodplain Enhancement

Hydraulic modeling was undertaken to evaluate several different floodplain enhancement configurations along the floodprone section of Schoharie Creek as it flows through Middleburgh. Floodplain enhancement scenarios were modeled within the agricultural fields along the left bank between Schoharie Creek and Route 145 and along the right bank where River Street bends away from Schoharie Creek. Figure 4-23 depicts locations where floodplain enhancement scenarios were evaluated as shown in the red outlines.

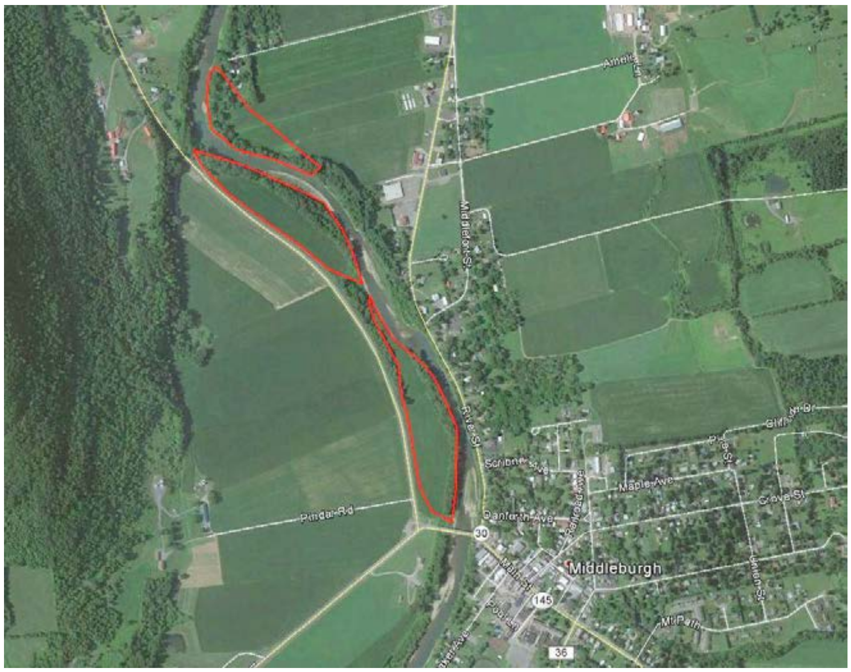

Figure 4-23
View showing locations in Middleburgh where floodplain enhancement scenarios were evaluated

Given the broad, flat nature of the Schoharie Creek floodplain in this area and the fact that the fields along the left bank are already quite frequently flooded, little flow capacity is predicted to be gained and little flood reduction benefit as a result of floodplain enhancement.

Alternative 4-3: Right Bank Floodplain Enhancement

Floodplain enhancement was assessed along the right bank of the creek approximately 1 mile downstream of the NYS Route 30 bridge as depicted in Figure 4-24. The proposed floodplain enhancement scenario resulted in predicted water surface elevation decreases of approximately 0.2 feet in the 10-, 50-, 100-, and 500-year floods. Benefits diminish moving upstream toward the NYS Route 30 bridge. This resulting decrease in water surface elevation does not significantly change the extent of flooding in Middleburgh and along River Street and would only moderately decrease flooding depths by as much as 0.27 feet at some structures located along River Street north of Middleburgh. Such improvements may reduce flooding occurrences during smaller events or possibly bring flood elevations below the level of first floors during larger floods; however, large-scale flood mitigation will not be achieved with this alternative.

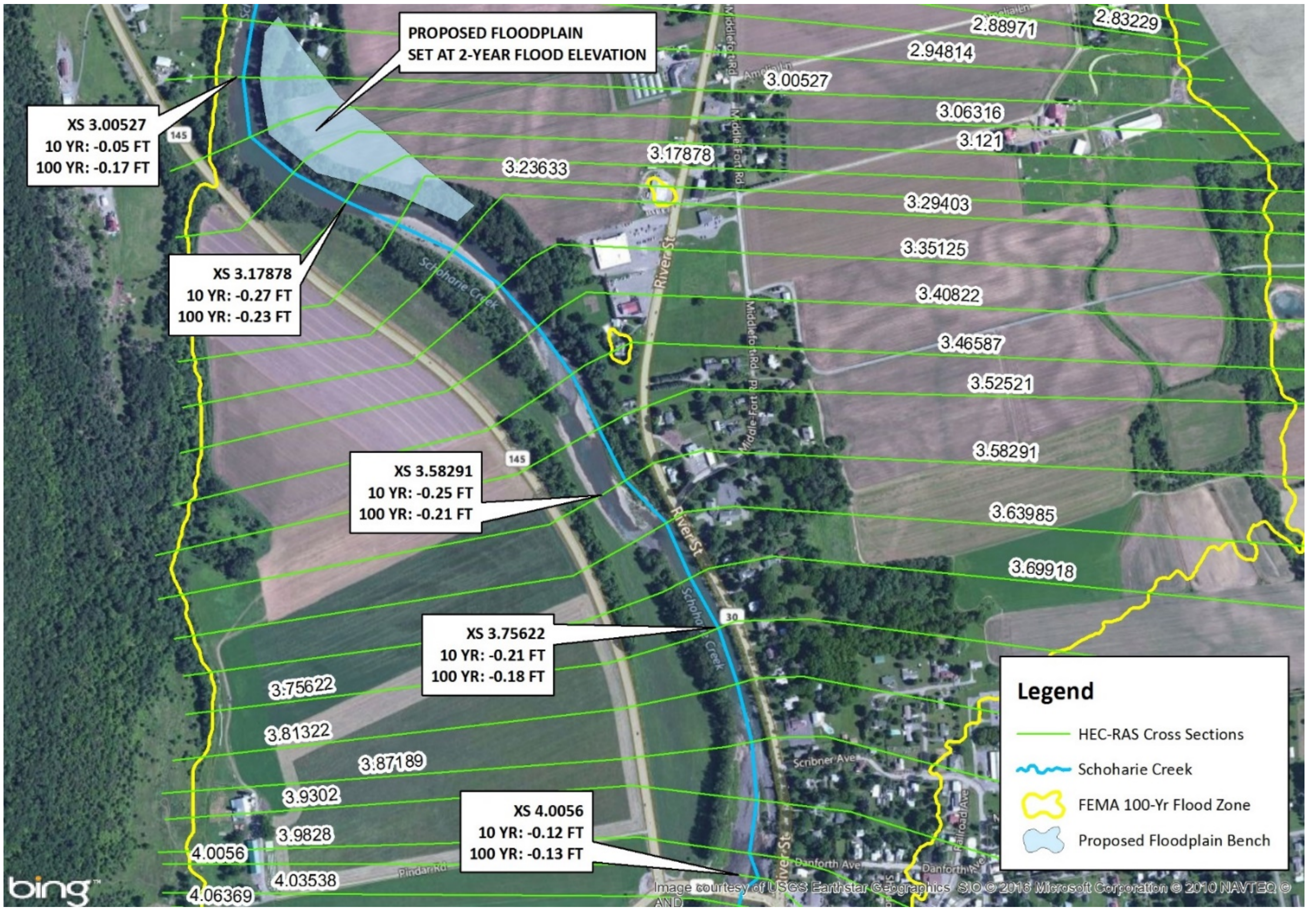

Figure 4-24
Alternative 4-3

Aerial view showing water surface elevation reductions for floodplain enhancement

Construction of the modeled flood bench would require approximately 57,500 cubic yards of excavation and would disturb an area of approximately 9.3 acres along 1,800 linear feet of Schoharie Creek. Due to the large volume of material excavation, construction costs would be anticipated to be on the order of $3M and would not likely justify the minimal reduction in water surface elevations.

<u>*Alternative 4-4: Dredging*</u>

Hydraulic modeling was conducted to evaluate a dredge scenario in which 2 feet of the Schoharie Creek channel bottom would be dredged from a point located 2,600 feet upstream of the Route 30 bridge to 4,900 feet downstream of the bridge. Hydraulic modeling predicts that dredging would provide only minimal flood reduction benefit with a maximum decrease in water surface elevation of only 0.3 feet during the 10-year event and 0.2 feet during the 100-year event. Approximately 95,500 cubic yards of material (over 5,000 truckloads) would need to be removed with an anticipated cost on the order of $2.3M. Figure 4-25 depicts the extent of the modeled dredging.

Figure 4-25
Aerial view of Middleburgh showing the extent of proposed dredging under Alternative 4-4

Alternatives 4-5a and 4-5b: Flood Control Levee and Wall

Two scenarios were investigated in which a combination of an earthen flood control levee and a flood control wall would be constructed to prevent flooding of portions of Middleburgh. Under the first scenario, a levee would begin behind (south of) the Middleburgh Junior/Senior High School, run north along River Street along Schoharie Creek, then turn east away from the creek north of Scribner Avenue. The proposed levee was evaluated at an average height of 5 feet. Figure 4-26 shows the location of the proposed floodwall and levee.

Because the area between River Street and the creek is too narrow to accommodate the width of an earthen levee, a vertical floodwall would be required. The levee/floodwall would need to be set at least 1 foot above the 100-year water surface elevation, potentially higher. The proposed levee would be approximately 3,200 feet long and would require 13,500 cubic yards of fill. The proposed floodwall would be about 1,500 feet long. Floodgates would be required at locations where roads pass through the floodwall or levee such that the gates would normally be open but then be closed during flood events. Approximately 20 property parcels would be impacted by the construction of the levee/floodwall. Conceptual engineering sketches of the proposed floodwall and levee, including volume calculations, are appended to this report.

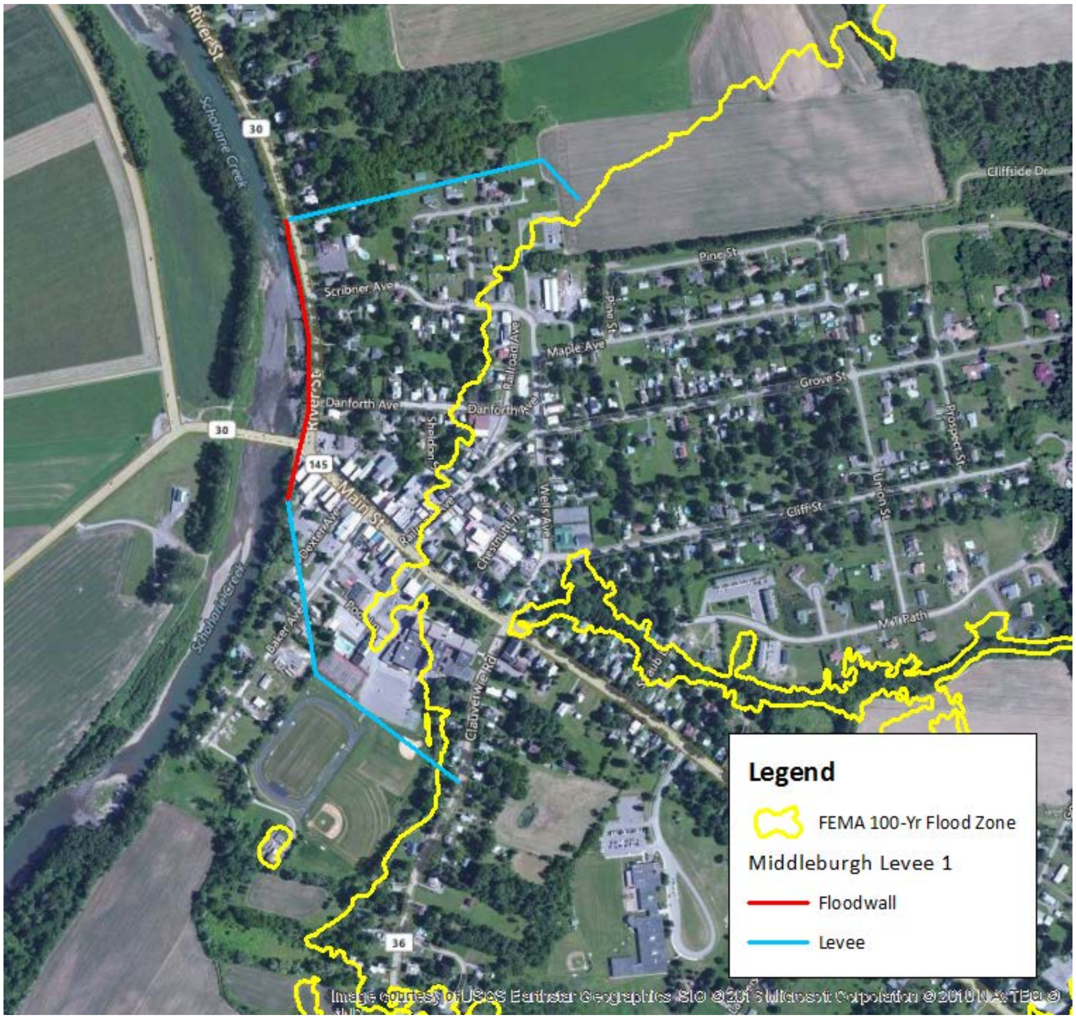

Figure 4-26
Aerial view showing the location of levee 1 in Middleburgh

Under this scenario, a land area of approximately 45 acres that is currently inundated during the 100-year flood would be protected from flooding including areas along Main Street, Railroad Avenue, Danforth Avenue, and Scribner Avenue. Modeling of the levee indicates that increases in water surface elevation in the Schoharie Creek channel adjacent to the levee would be negligible.

Under a second levee/floodwall scenario, the levee would begin behind the Middleburgh Junior/Senior High School, run north along River Street to Milk Can Lane, then turn east. Figure 4-27 shows the location of the proposed levee.

As with the first scenario, a vertical floodwall would be required between River Street and the creek. The levee/floodwall would be set at least 1 foot above the 100-year water surface elevation. Under this scenario, the proposed levee would be approximately 4,900 feet long and would require 21,000 cubic yards of fill. The proposed floodwall would be about 4,700 feet long. As with the first levee scenario above, floodgates would be required at locations where roads pass through the floodwall or levee, which would be closed during flood events. Approximately 35 property parcels would be impacted by the construction of this levee/floodwall. Conceptual engineering sketches of the proposed floodwall and levee, including volume calculations, are appended to this report.

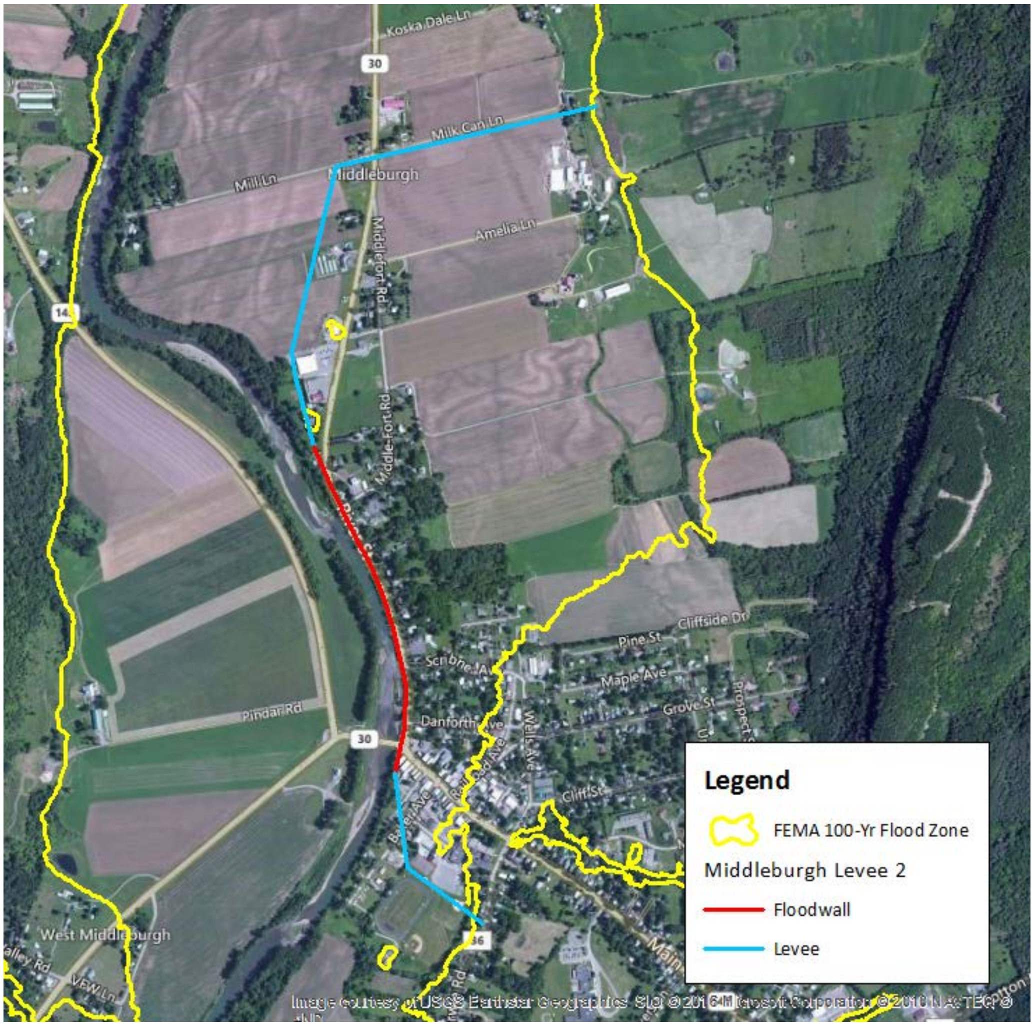

Figure 4-27
Aerial view showing the location of levee scenario 2 in Middleburgh

Under this scenario, a land area of approximately 330 acres that is currently inundated during the 100-year flood would be protected from flooding, including all areas described under the first scenario plus the area extending north of town along River Street and Middle Fort Street. Modeling of this levee/floodwall scenario indicates that increases in water surface elevation in the Schoharie Creek channel adjacent to the levee would be negligible.

The levee and floodwall scenarios described above would require a considerable amount of private property acquisition or construction easements and would require interior drainage pump stations, use of removable panels at road crossings, and considerable maintenance. A risk associated with these scenarios is the danger of a flood event that exceeds the design storm and overtops or breaches the levee or floodwall and is then trapped. In Middleburgh, peak flows in Schoharie Creek during Tropical Storm Irene exceeded the predicted 100-year storm event. Under such a scenario, it is possible that floodwaters from the creek would have overtopped a levee or floodwall designed to protect structures and properties. Once a levee has been overtopped, floodwaters can become trapped behind it, thus exacerbating flooding problems.

The anticipated cost of design and permitting for Alternative 4-5a, the first levee and floodwall scenario, is anticipated to be around $150,000. Construction of the levee and floodwall structure would be on the order of $1.5M. The cost of design and permitting for Alternative 4-5b, the second levee and floodwall scenario, is estimated at $210,000 while construction costs would be anticipated around $2.8M. These figures assume that the floodgates at each of the points where a road would need to pass through the levee would be operated manually. The cost of automated floodgates would substantially increase the cost. Also not included in the estimates is the cost of the required property acquisition, structure demolition, and construction easements to make room for the levee. Approximately 20 property parcels would be impacted by the construction of the first levee/floodwall scenario, and approximately 35 parcels would be impacted by the second levee/floodwall scenario. The cost of a pump operation to remove stormwater from behind the levee has not been included. When all of these cost factors are taken into consideration, it is likely that the cost of the levee/floodwall scenarios would likely be in excess of $5M.

Alternative 4-6: Individual Building Floodproofing

Floodwater depths in Middleburgh during the 100-year flood event range from just under 3 feet at the playing fields behind Middleburgh Junior/Senior High School to nearly 4 feet along Greibel Lane. Water at this depth can be dangerous, capable of knocking an adult off their feet, sweeping away a vehicle, or severely damaging a building.

A variety of measures are available to protect existing public and private properties in floodprone areas from damage. On a case-by-case basis where structures are at risk, individual floodproofing can be explored. This may range from elevation of structures, to construction of barriers, floodwalls, and earthen berms, to dry or wet floodproofing, to other improvements to mitigate damage from flooding. Emphasis should be placed on critical facilities. Costs will vary depending on what measures are implemented. The following approximate costs are provided for individual structures:

- Elevating a residential structure: $175,000
- Protecting homeowner utilities from flooding: $1,500 to $2,000
- Implementing a variety of measures to protect a small business: $6,000 to $50,000

Focus Area #4 Recommendations

The following recommendations are offered for Focus Area #4:

1. Seek to acquire, and relocate where feasible, the most flood-vulnerable properties where there is owner interest and programmatic funding available FEMA or other sources of funding.

2. Move existing structures out of the floodway.

3. Disallow any new development in the floodway and require new construction to meet NFIP criteria.

4. Some of the homes located toward the periphery of the floodplain may be only rarely flooded. Residents and businesses may benefit from minor individual property improvements. Providing

landowners with information regarding individual property protection is recommended (see Individual Property Flood Protection measures described in Section 4.2 of this report).

4.3.5 Focus Area #5 - Christmas Tree Lane Culvert

Background

Located in the town of Middleburgh just south of Christmas Tree Lane, a culvert traverses NYS Route 30 and conveys a small unnamed tributary to Schoharie Creek. This culvert is reported to overtop frequently, flooding Route 30. According to the Schoharie County Region 13 and 16 Evacuation Routes, residents in the Middleburgh area are directed to proceed to the Rock Road Chapel shelter, which would require travel north on NYS Route 30.

Schoharie Creek flows across a wide, flat-bottomed valley with an extensive floodplain as it flows under NYS Route 30 in the vicinity of Christmas Tree Lane. At this location, the FEMA 100-year floodplain is approximately 1.6 miles wide. According to FEMA's FIRMs, NYS Route 30 in this area is extensively flooded during the 100-year event. As depicted in Figure 4-28, the culvert is a small concrete box 5.0 feet wide by 3.2 feet high and 40 feet long. The watercourse passing through the culvert under NYS Route 30 is a grass swale. Figure 4-29 depicts the FEMA floodplain at the culvert. The USGS *StreamStats* program was utilized to gather hydrologic information at this location. Table 4-7 presents peak flows.

Figure 4-28
Inlet of culvert under NYS Route 30 south of Christmas Tree Lane

Figure 4-29: FEMA Flood Insurance Rate Map - Christmas Tree Lane Culvert

Location: **Middleburgh, NY**

SOURCE(S):
NYS GIS Clearinghouse Orthoimagery (accessed June 2016)
FEMA Schoharie County Special Flood Hazard Area

N

Schoharie Basin Flood Analysis

Map By: EMH
MMI#: 4805-05
MXD: Q:\Projects\4805-05 Schoharie Basin Flood Analysis\GIS\MXD
1st Version: 6/6/2016
Revision: 9/22/2016
Scale: 1 in = 417 ft

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TABLE 4-7
Peak Flow Rates at Inlet NYS Route 30 South of Christmas Tree Lane

Peak Flows	Discharge (cfs)
10-year flood	125
25-year flood	179
50-year flood	228
100-year flood	282
200-year flood	344
500-year flood	431

Alternative 5-1: Increase Culvert Capacity

The Christmas Tree Lane culvert was analyzed with the use of the HY-8 program and field measurements, hydrologic information derived from *StreamStats* data, and elevations determined from 2014 USGS 3-County LiDAR. NYS Route 30 is predicted to overtop due to excessive flows at the culvert between the 10-year and 25-year storm events. However, based on analysis using the FEMA model for Schoharie Creek, the entire area in the vicinity of the culvert would be inundated by floodwaters from Schoharie Creek during the 10-year flood. Therefore, improvements to this culvert would not provide substantial flood reduction benefits to NYS Route 30.

Alternative 5-2: Raise Roadway

Elevation of Christmas Tree Lane was evaluated as a means to reduce the occurrence of NYS Route 30 being overtopped. Approximately 10,900 feet, or 2.1 miles of roadway would need to be raised. The increase would vary from 0 feet to 8 feet, with an average of about 5 feet.

Due to the broad, flat configuration of the Schoharie Creek floodplain in this area coupled with the predicted depth of flooding during the 100-year flood, sufficiently elevating the roadway to prevent its overtopping during the 100-year flood event would result in the confinement of the available floodplain to nearly 50 percent of its current width. This confinement would cause flood elevations and flow velocities to increase along Schoharie Creek. Additionally, the cost of elevating NYS Route 30 above the 100-year flood elevation would be approximately $4.3M. This would involve reconstructing approximately 10,900 feet, or 2.1 miles, of roadway, and approximately 50,500 cubic yards of fill material would be required. The cost of engineering design and permitting would likely be in the range of $350,000 to $400,000. This estimate does not include the cost of the land acquisition or construction easements that would be required in order to elevate the roadway.

Alternative 5-3: Relocate Roadway

An alternative to raising the roadway as described in Alternative 5-2 would be to construct a new roadway parallel and further east of the current Route 30 outside of the Schoharie Creek floodplain to serve as an evacuation route during periods of flooding. Such an endeavor would cost significantly more than raising the roadway and is not anticipated to be financially feasible, particularly given the associated area of impact. As such, this alternative was not evaluated in any further detail.

Alternative 5-4: Roadway Signage and Closure

A low-cost approach to flooding of the roadway along NYS Route 30 in the vicinity of Christmas Tree Lane would be to close the road during flooding events. This would need to be done in combination with effective signage, barriers, and further consideration of alternative routes. Monitoring of the USGS stream gauge along Schoharie Creek would provide highway superintendents and residents with a warning that floodwaters are rising, at which point signs and/or barriers could be put in place, and travel along the floodprone sections of NYS Route 30 could be avoided.

Focus Area #5 Recommendations

Closure of NYS Route 30 during flooding conditions along with effective signage and further consideration of alternative routes would provide a low-cost alternative.

4.3.6 Focus Area #6 – Route 145 Culvert in Middleburgh

Background

A concrete box culvert is located at the crossing of NYS Route 145 over an unnamed tributary to Schoharie Creek in the town of Middleburgh. The culvert is located along Route 145 northwest of the village of Middleburgh just north of School House Road and Ecker Hollow Road. The unnamed creek parallels Ecker Hollow Road, flows eastward through the culvert under Route 145, then continues east parallel to School House Road toward Schoharie Creek. Based on information collected at the public meeting, the culvert is undersized, floods frequently, and is prone to debris jams. NYS Route 145 serves as an important travelway that is outside of the floodprone Schoharie Valley during large flood events. According to the Schoharie County Region 10, Region 14, and Region 15 evacuation routes, residents in the Middleburgh area are directed to proceed to the Richmondville High School shelter in Cobleskill by traveling north on Route 145.

This focus area was not included in the FEMA study for Schoharie County, and therefore no FEMA hydraulic model or FIRMs are available. The unnamed tributary at the Route 145 culvert has a drainage area of 7.6 square miles with the following hydraulic characteristics: a bankfull area of 86.5 square feet, a bankfull depth of 2.0 feet, a bankfull flow of 570 cfs, and a bankfull width of 43.4 feet (*StreamStats*). Table 4-8 presents peak flows for this location.

TABLE 4-8
Peak Flow Rates at Route 145 Culvert in Middleburgh

Peak Flows	Discharge (cfs)
1.25-year flood	183
1.5-year flood	236
2-year flood	316
5-year flood	560
10-year flood	770
25-year flood	1,090
50-year flood	1,380
100-year flood	1,690
200-year flood	2,050
500-year flood	2,550

Based on observations and field measurements, the Route 145 culvert is a concrete box with a slope of approximately 3.0 to 3.5 percent. Approximately 22 feet of earth is present between the top of the culvert and the Route 145 road surface. The length of the culvert is 220 feet, with a rise of 10 feet and a span of 10 feet. The channel upstream and downstream of the culvert is tightly confined with no natural floodplain. The channel upstream of the culvert consists of cobble with no bedrock. The channel downstream of the culvert consists of exposed bedrock, boulder, and cobble.

Figure 4-30
Downstream face of culvert passing beneath NYS Route 145

The culvert was modeled using the HY-8 program with data from field measurements, *StreamStats*, and the Schoharie 2014 USGS LiDAR. The HY-8 results indicate that a flood between the 200-year and 500-year flows would overtop the roadway. NYSDOT guidelines state that culverts with a height of over 5 feet must have a HW/D ratio of less than 1.0 and be designed for the 50-year flood. Table 4-9 summarizes the HW/D results of the HY-8 analysis.

TABLE 4-9
HW/D for Existing Culvert

Peak Flows	Discharge (cfs)	HW/D
2-year flood	316	0.68
5-year flood	560	0.82
10-year flood	770	0.92
25-year flood	1,090	1.08
50-year flood	1,380	1.24
100-year flood	1,690	1.45
200-year flood	2,050	1.75
500-year flood	2,550	1.96

Alternative 6-1: Replace Route 145 Culvert

The NYSDOT HW/D requirements are exceeded at this culvert during the 25-year flood event. In order to pass the 100-year flow with a HW/D ratio less than 1.0, a replacement culvert could have dimensions of 15-foot rise and 10-foot span, or 10-foot rise and 18-foot span. Since the bankfull width of the channel at this location is 43.4 feet and the span of the culvert is 10 feet, the Route 145 culvert does not come close to spanning the bankfull width of the channel. In order to reduce flooding and debris jams, the culvert would need to be replaced with a larger structure that can adequately pass the 50- or 100-year flood event. A replacement culvert with a size in the range of a 10-foot rise and 18-foot span is recommended. A more detailed hydraulic analysis would be required to determine the appropriate sizing.

The estimated construction cost to replace the existing Route 145 culvert with a four-sided box culvert with a 10-foot rise, an 18-foot span, and a length of 220 feet would be in the range of $1.5M to $1.75M. The cost of engineering design, survey, geotechnical engineering, and regulatory permitting would be on the order of $150,000.

Alternative 6-2: Program of Debris Management

When the Route 145 culvert becomes clogged with debris, its hydraulic capacity is reduced. A program to periodically remove debris from the culvert opening and from the channel upstream of the culvert would reduce the volume of debris and thereby reduce the likelihood of the culvert becoming clogged. However, based on hydraulic analysis, the culvert under Route 145 is fundamentally undersized to pass the required volume of water during large flood events even when it is not clogged with debris. Instituting a program of debris management would help to reduce the frequency of debris jams; however, it would not solve the fundamental problem of the undersized culvert.

Focus Area #6 Recommendations

The following recommendations are offered for Focus Area #6 in order of priority:

1. Alternative 6-2 – Debris Management – The development of a debris management program would reduce the volume of upstream debris being mobilized and delivered to the culvert and is recommended for immediate implementation.

2. Alternative 6-1 – Route 145 Culvert Replacement – As a first step, confirmation should be obtained from NYSDOT, Schoharie County DPW, or local highway superintendents as to the frequency of flooding associated with this culvert. If the culvert has a history of flooding, scour, and/or clogging, it is recommended that the culvert be replaced with a larger structure that can adequately pass the 50- or 100-year flood event with acceptable HW/D ratio requirements.

4.3.7 Focus Area #7 – Village of Schoharie

Background

The village of Schoharie is located in Schoharie County, the county seat. Schoharie Creek flows west of the village and under the Bridge Street bridge. As was the case in Middleburgh, Schoharie Creek flows across a wide, flat-bottomed valley with an extensive floodplain as it flows past the village of Schoharie. In some locations, the floodplain is close to three-quarters of a mile wide. According to the FEMA FIRMs, the village of Schoharie along Main Street is subject to inundation during the 100-year flood event as depicted in Figure 4-31. Figure 4-32 is a photograph taken from the Bridge Street bridge. The expansive flood zone associated with the 100-year flood event extends into the village of Schoharie, inundating portions of Main Street and affecting neighborhoods to the west of Main Street and portions of the village to the east of Main Street.

Under the 500-year flood event, all of Main Street is predicted to flood as well as an area to the west of Main Street. The area inundated during a 500-year flood event includes many structures and facilities that are critical to the function of village, town, and county governance and business. These include the Town Clerk's office, the Village offices, the County Courthouse complex, the County Mental Health facility, and several churches.

Hydraulic modeling was undertaken to determine flooding depths at various locations in Schoharie during the 10-year and 100-year flood events. Table 4-10 reports flooding depths. While many areas remain dry during the 10-year event, they are inundated by floodwaters of up to 2.4 feet deep during the 100-year flood event.

TABLE 4-10
Floodwater Depths in Schoharie during the 10-year and 100-year Floods

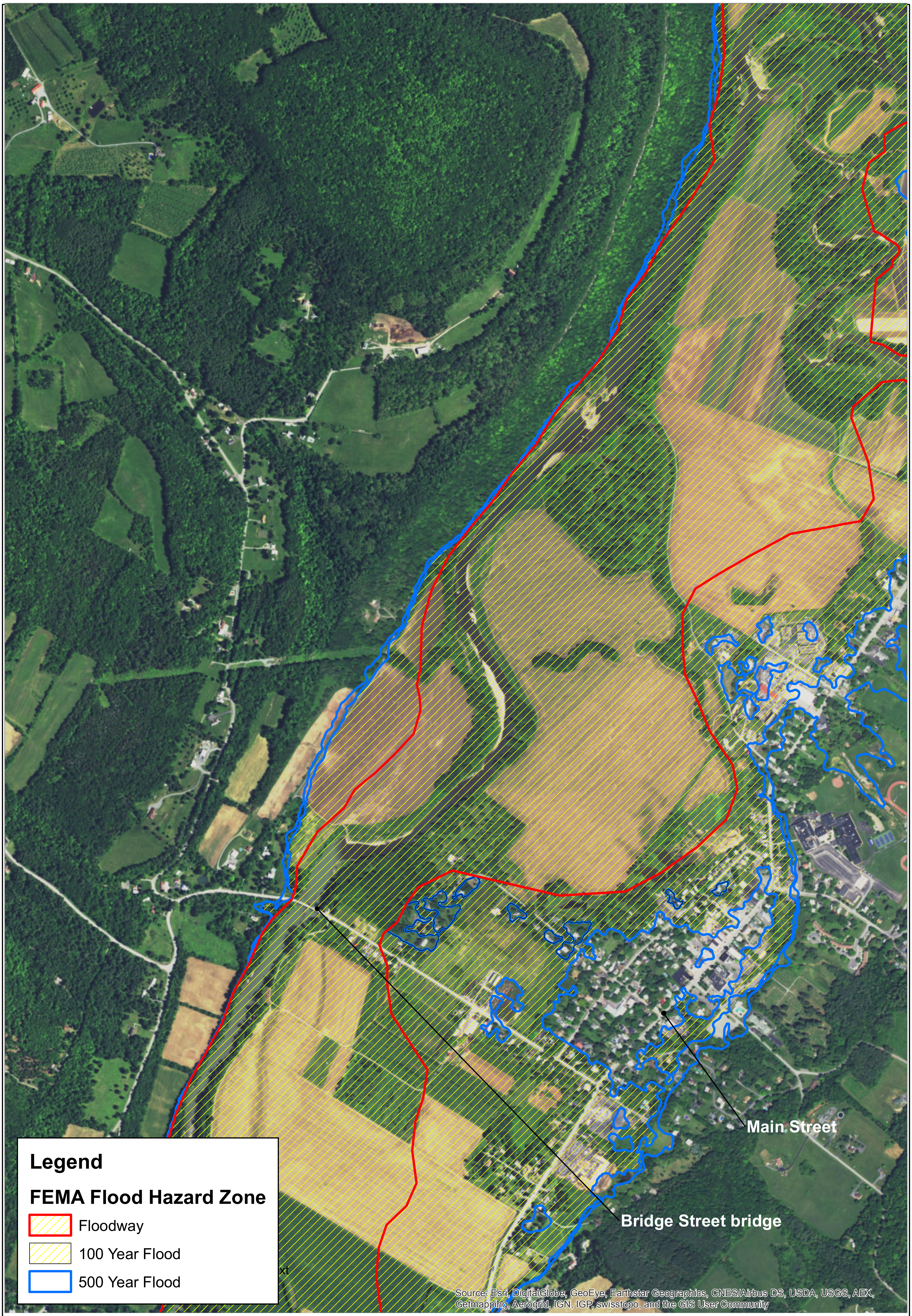
Location	10-Year Depth of Flooding (feet)	100-Year Depth of Flooding (feet)
Intersection of Sunset Drive and Main Street	0.0	1.8
Intersection of Bridge Street and Main Street	0.0	2.4
Intersection of Prospect Street and Main Street near High School	0.0	0.5
Schoharie County Sheriff	0.0	1.4

Alternative 7-1: Floodplain Enhancement

Hydraulic modeling of the study area was undertaken in HEC-RAS using new survey points from field survey combined with information from the FEMA model, *StreamStats* data, and elevations from 2014 USGS 3-County LiDAR. The FEMA HEC-RAS model was updated using surveyed cross sections. Two-year storm flows were added to the model using data from *StreamStats*.

Many factors contribute to whether or not floodplain enhancement will result in a meaningful decrease in flooding and flood-related damages in nearby, inhabited areas. For this reason, it was necessary to conduct hydraulic modeling for a range of floodplain enhancement configurations along Schoharie Creek. One such configuration is illustrated in Figure 4-33, which shows a wide enhanced floodplain along the right bank of Schoharie Creek downstream of the Bridge Street bridge.

The fields along Schoharie Creek downstream of the Bridge Street bridge are frequently flooded under existing conditions. Based on hydraulic modeling, enhancements to the floodplains in this area would provide only minimal flood reduction benefits within the village of Schoharie.



SOURCE(S):
NYS GIS Clearinghouse Orthoimagery (accessed June 2016)

FEMA Schoharie County Special Flood Hazard Area

Figure 4-31: FEMA Flood Insurance Rate Map - Village of Schoharie

Location:
Schoharie, NY

N

Schoharie Basin Flood Analysis

Map By: EMH
MMI#: 4805-05
MXD: Q:\Projects\4805-05 Schoharie Basin Flood Analysis\GIS\MXD
1st Version: 6/6/2016
Revision: 9/22/2016
Scale: 1 in = 810 ft

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Figure 4-32
View of Schoharie Creek and its broad floodplain looking downstream from Bridge Street bridge in Schoharie

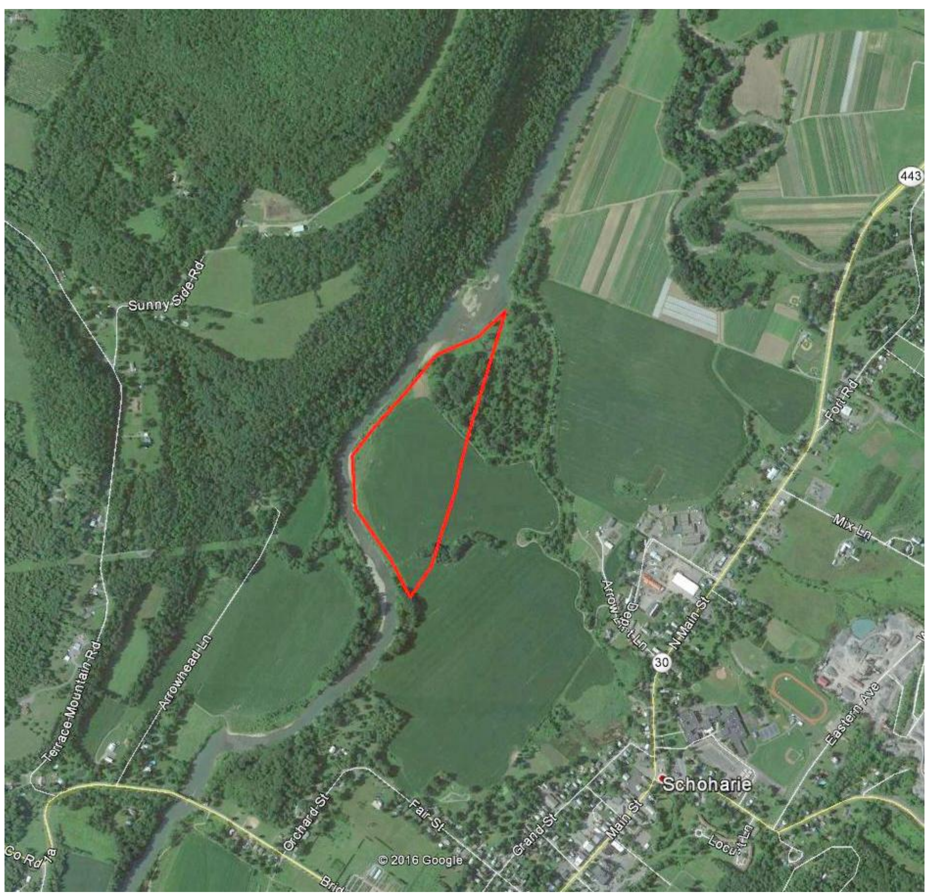

Figure 4-33
Aerial view showing one possible configuration of an enhanced floodplain along the right bank of Schoharie Creek

Alternative 7-2: Dredging

A proposed dredge alternative removes a rise in the channel slope from a point in the channel approximately 2,000 feet downstream of the Bridge Street bridge to immediately downstream of the bridge. Hydraulic modeling predicts that dredging will provide minimal benefit, with a maximum decrease in water surface elevation of 0.4 feet in the 10-year flood and 0.3 feet in the 100-year flood. Approximately 106,500 cubic yards of material would need to be removed from the channel, or nearly 6,000 truckloads. Figure 4-34 depicts the extent of proposed dredging. Under this alternative, approximately 106,500 cubic yards of material would need to be removed, resulting in an estimated cost of $2.8M with little flood mitigation improvement.

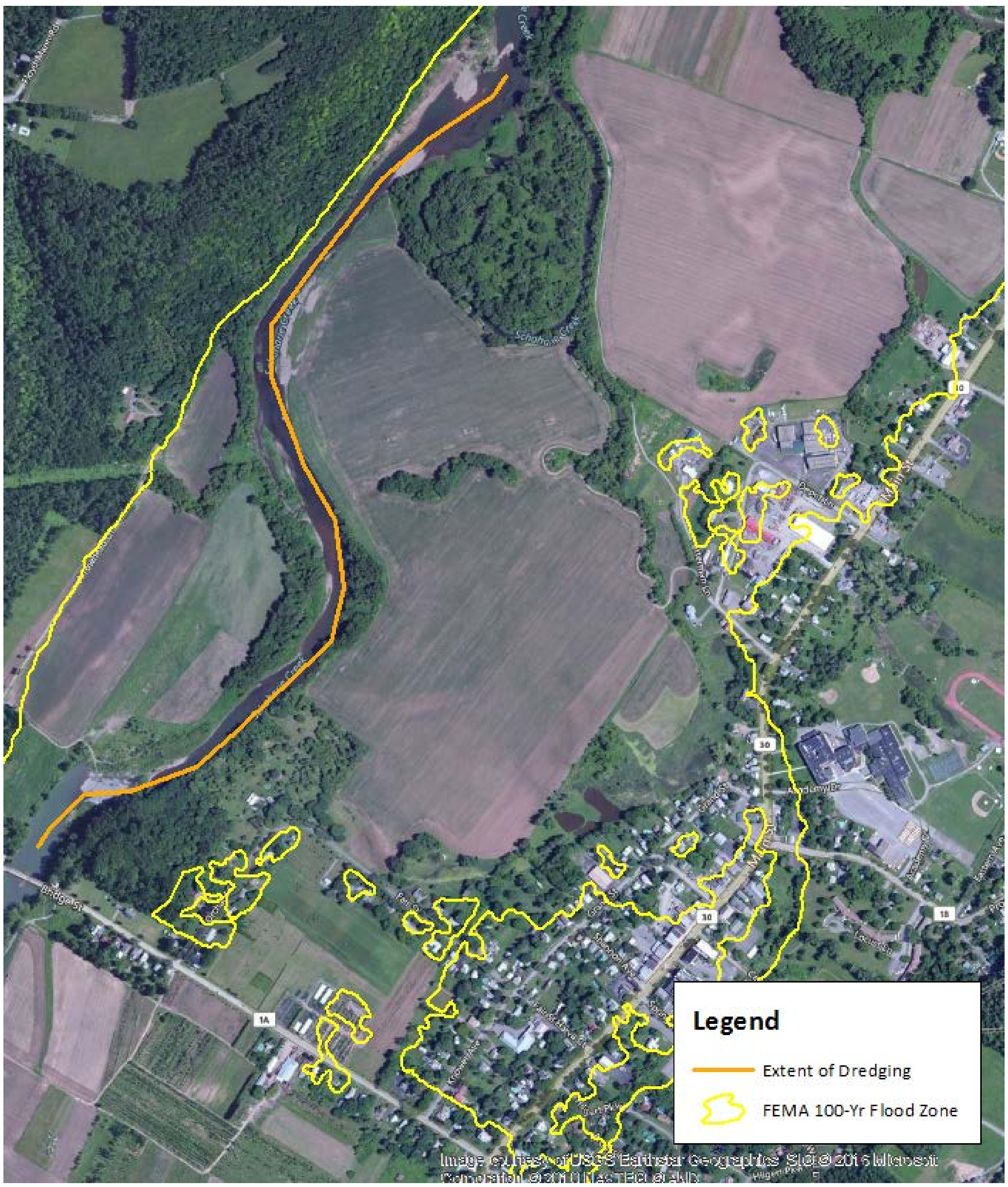

Figure 4-34
Aerial view showing the proposed extent of dredging in Schoharie under Alternative 7-2

<u>Alternatives 7-3a and 7-3b: Levee Scenarios</u>

<u>Alternative 7-3a</u> – The first levee scenario in Schoharie would extend around a substantial portion of the village area. The proposed levee would range in height between 2 feet and 6 feet at an elevation 1 foot above the 100-year water surface elevation. Under this scenario, the levee would be approximately 9,350 feet in length. Automatic or manually operated floodgates would be required at locations where roads pass through the levee, and roads would be closed during flood events.

Under this scenario, a land area of approximately 150 acres that is currently inundated during the 100-year flood would be protected from flooding. Modeling of the levee indicates that increases in water surface elevation in the Schoharie Creek channel adjacent to the levee would be negligible. Figure 4-35 depicts the location of the proposed levee.

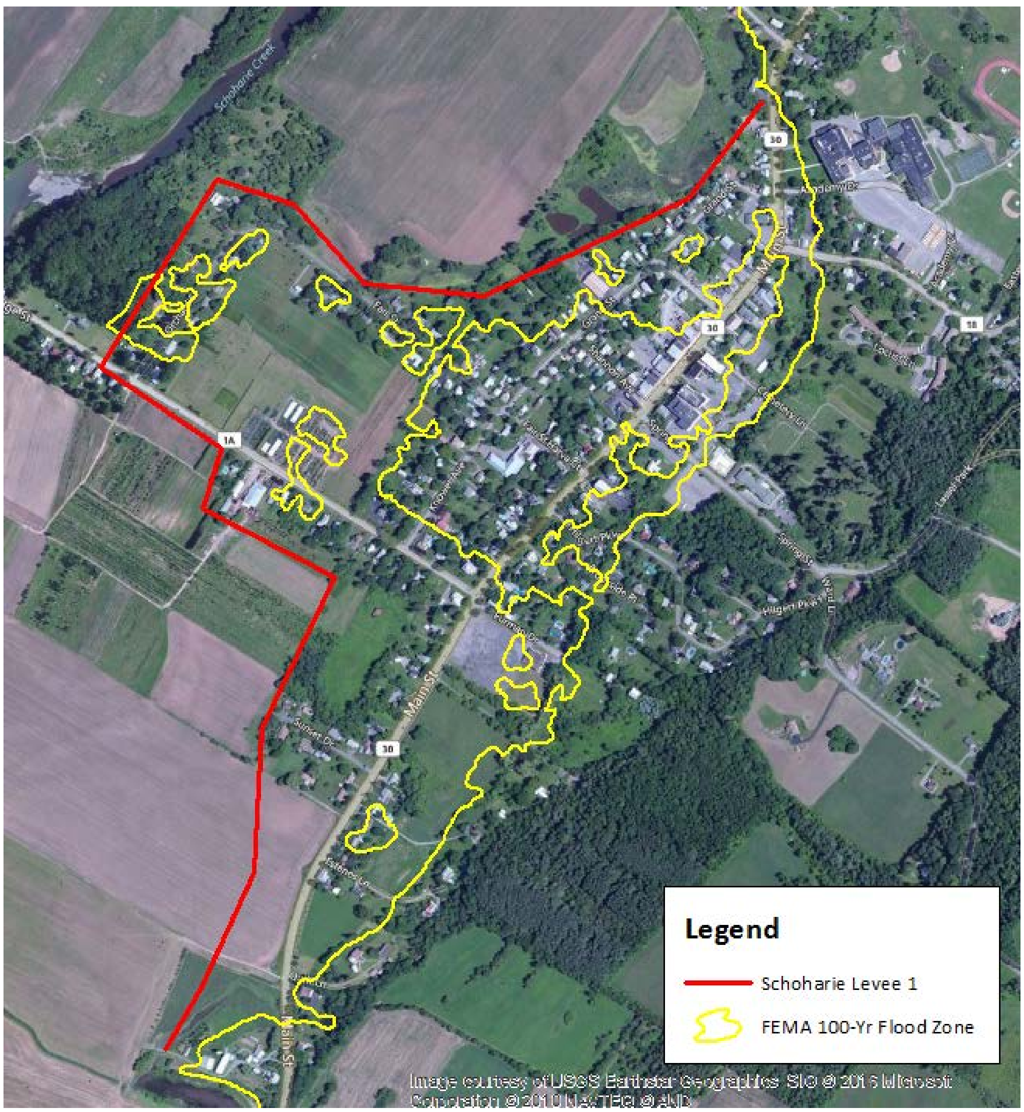

Figure 4-35
Aerial view showing the location of proposed levee scenario 1 in the village of Schoharie

The cost of design and permitting for the Alternative 7-3a levee is approximately $220,000. The construction costs for the levee is estimated at $2.2M.

Alternative 7-3b – A second levee scenario was evaluated in the village of Schoharie that would extend around a smaller area than in Alternative 7-3a and would not protect the area of Bridge Street, Orchard Street, and Fair Street. The proposed levee would range in height between 2 feet and 6 feet at an elevation 1 foot above the 100-year water surface elevation. Under this scenario, the levee would be approximately 6,297 feet in length. Floodgates would be required at locations where roads pass through the levee. Conceptual engineering sketches of the proposed levee and volume calculations are appended. A land area of approximately 100 acres that is currently inundated during the 100-year flood would be protected from flooding. Modeling of the levee indicates that increases in water surface elevation in the Schoharie Creek channel adjacent to the levee would be negligible. Figure 4-36 depicts the location of the proposed levee.

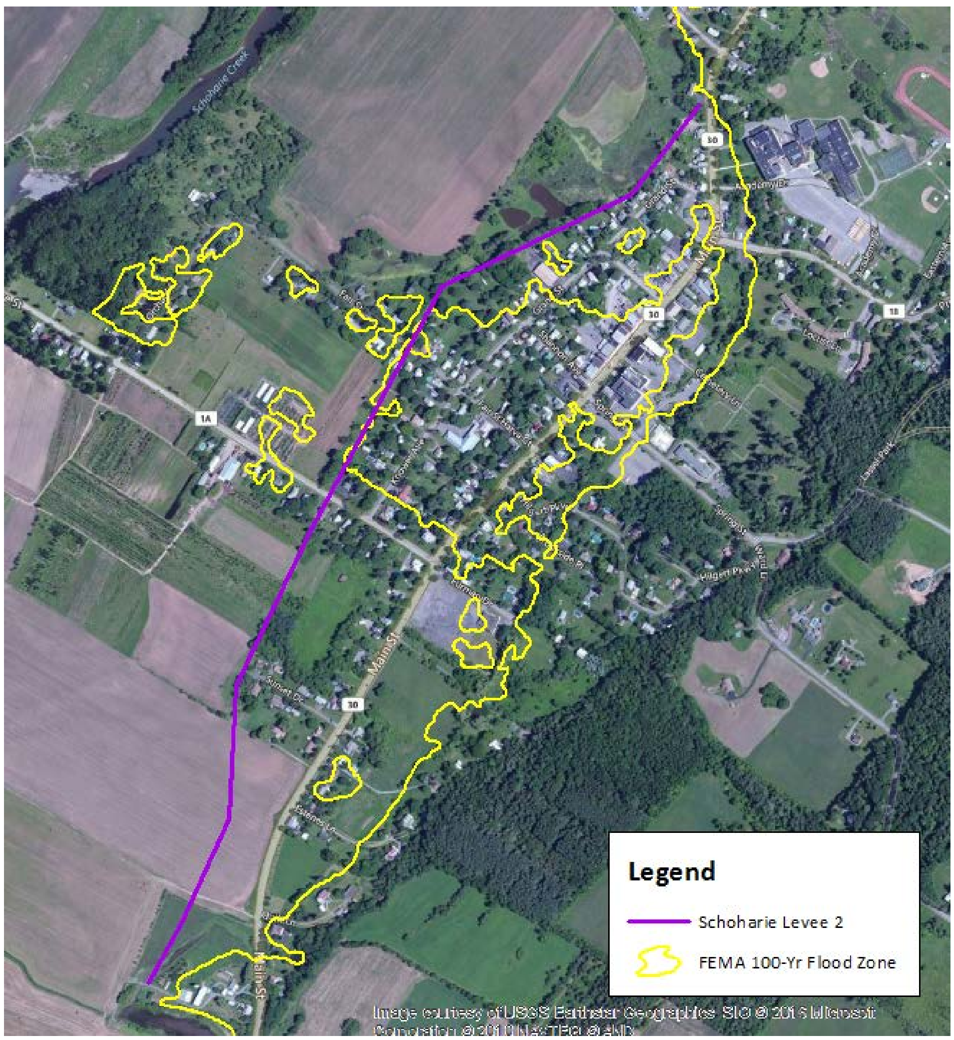

Figure 4-36
Aerial view showing the location of proposed levee scenario 2 in the village of Schoharie

The cost of design and permitting for this alternative is approximately $160,000 while the construction costs would be on the order of $1.6M. As with the cost estimates for a levee in Middleburgh, these figures assume that the floodgates at each of the points where a road would need to pass through the levee would be operated manually. The cost of automated floodgates would substantially increase the cost. Also not included in the estimates is the cost of the required property acquisition, structure demolition, and construction easements to enable construction of the levee. Approximately 25 to 30 property parcels would be impacted by the construction of the levee scenarios. The cost of a pump operation to remove stormwater from behind the levee has not been evaluated. When all of these factors are taken into consideration, it is likely that the cost of the Schoharie levee scenarios would be in excess of $4M.

Alternative 7-4: Individual Building Floodproofing

Floodwater depths in Schoharie during the 100-year flood event range from less than a foot at the intersection of Prospect Street and Main Street near the High School to 2.4 feet at the intersection of Bridge Street and Main Street. Water at this depth can be dangerous, capable of knocking an adult off their feet, sweeping away a vehicle, or severely damaging a building.

A variety of measures are available to protect existing public and private properties in floodprone areas of the village of Schoharie from damage. On a case-by-case basis where structures are at risk, individual floodproofing should be explored. This may range from elevation of structures, to construction of barriers, floodwalls, and earthen berms, to dry or wet floodproofing, to other improvements to mitigate damage from flooding. Emphasis should be placed on critical facilities. Costs will vary depending on what measures are implemented. The following approximate costs are provided:

- Elevating a residential structure: $175,000
- Protecting homeowner utilities from flooding: $1,500 to $2,000
- Implementing a variety of measures to protect a small business: $6,000 to $50,000

Focus Area #7 Recommendations

In the village of Schoharie, the following actions are recommended:

1. Seek to acquire, and relocate where feasible, the most flood-vulnerable properties where there is owner interest and programmatic funding available through FEMA or other sources of funding. Top priority should be placed on critical facilities such as firehouses and schools.

2. Move existing structures out of the floodway. For example, there are several structures along Bridge Street just east of Schoharie Creek that are located within the floodway.

3. Disallow any new development in the floodway and require new construction to meet NFIP criteria.

4. Some of the homes located toward the periphery of the floodplain may be only rarely flooded. Residents and businesses may benefit from minor individual property improvements. Providing landowners with information regarding individual property protection is recommended (see Individual Property Flood Protection measures described in Section 4.2 of this report).

4.3.8 Focus Area #8 – Fox Creek

Background

Focus Area #8 includes an approximately 3.5-mile-long reach of Fox Creek beginning downstream of the County Route 9 bridge in the hamlet of West Berne, town of Berne, in Albany County and extending downstream to the NYS Route 443 crossing in Schoharie County. This section of Fox Creek runs along or crosses Route 443 for its entire length and passes under a total of six bridges. At a public meeting held on October 26, 2015, numerous members of the public commented on this section of Fox Creek with reports of flooding, sediment aggradation, and debris jams, especially at the bridges. Table 4-11 lists the bridges within this reach from upstream to downstream.

TABLE 4-11
Bridges within Focus Area #8

Bridge Name	Jurisdiction	Bridge Identification Number (BIN)
State Route 443 (upper)	State	1025250
Schell Road	Town	2228690
Schoonmaker Road	Town	3354690
Zimmer Road	Town	3354680
Sholtes Road	Town	3354670
State Route 443 (lower)	State	1025240

In contrast to the broad floodplain along Schoharie Creek, Fox Creek flows through a steep, narrow valley. The creek exhibits flashy behavior as illustrated by the hydrograph in Figure 4-37 from May 29 and 30, 2016, showing an increase in stage of over 6 feet during a period of less than 2 hours and within this period an increase of 5.4 feet in just 30 minutes.

This reach of Fox Creek has been evaluated by FEMA using approximate engineering methods only, meaning that identification of areas subject to flooding has been approximated, and no water surface elevations are provided (see Figure 4-38).

Bankfull width measurements were made in the field at several locations along this reach of Fox Creek and ranged from 90 feet to 120 feet. Hydraulic analysis along this section of Fox Creek focused primarily on determining the adequacy of the six existing bridges.

For the purpose of this study, new survey was collected, including channel cross sections and detailed hydraulic survey of the six bridges. A hydraulic model was developed and run to evaluate potential flood mitigation alternatives. Table 4-12 presents a summary of peak flows at three locations within this reach.