Upper Susquehanna River Basin, New York Comprehensive Flood Damage Reduction Feasibility Study

APPENDIX A: PLAN FORMULATION

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DEPARTMENT OF THE ARMY

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DISCLAIMER

This draft feasibility report documents findings of the Upper Susquehanna River Basin Comprehensive Flood Damage Reduction Feasibility Study conducted jointly by the U.S. Army Corps of Engineers (USACE) and New York State Department of Environmental Conservation (NYSDEC). The study was conducted from 2009 through 2019. Progress was subject to funding, which was provided unevenly in the first few years, and subsequent evolution in study scope while the study was underway. The draft feasibility report is incomplete and has not been reviewed by USACE Headquarters. The draft feasibility report details all work completed for the USRB study leading up to the conclusion of no recommendation under the study authority

This draft report includes documentation of preliminary efforts undertaken to meet the requirements of the National Environmental Policy Act (NEPA) of 1969, as amended. While information on environmental consequences and NEPA efforts is provided, NEPA compliance work remains incomplete. Coordination of the proposed projects with agencies and citizens has not occurred. This draft report was prepared intermittently over the period from 2016-2019, but is not complete. Information presented in this existing conditions section may not be the most current, depending on when it was originally prepared and when it was last revised/updated.

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CHAPTER 1 PLANNING PROCESS

The Upper Susquehanna River Basin (USRB) Comprehensive Flood Damage Reduction Feasibility Study is conducted using a risk-informed planning process. Risk informed planning is an approach to planning in which decisions are made under uncertainty and risks are managed to reduce uncertainty. This approach is iterative and involves generating information and analysis to reduce uncertainty to support decision-making. By managing risks and reducing uncertainty in planning decisions, the project team can work towards supportable decisions without complete information, which may be attributed to uncertain future conditions or incomplete information resulting from not having the right stakeholders involved in the planning process. This planning approach is a response to increasing complexity and uncertainty inherent in a changing planning context as a result of climate change and a drive across the Federal government to reduce the length of time and costs of plans and studies.

The US Army Corp of Engineer's (USACE) risk informed planning framework combines the risk informed approach with the six-step planning process as outlined in Figure 1.

Figure 1: USACE Risk-Informed Planning Process (USACE Planning Manual II, 2017)

The USACE Risk Informed Planning Process steps include:

(1) ***Scoping*** – specifying the relevant water resources problems and opportunities associated with the Federal objectives and specific state and local concerns

(2) ***Inventory and forecast*** – analysis of existing information, existing conditions, and future conditions within the planning area relevant to the identified problems and opportunities

(3) ***Plan Formulation*** – development of alternative plans for addressing the problem and opportunities

(4) & (5) ***Deciding*** – the decision-making framework includes two related components; (4) evaluation of the effects of alternative plans and (5) comparison of alternative plans

(6) ***Implementation*** - selection of a recommended plan based on the comparison of alternative plans

The USRB study uses this planning process to formulate alternative flood risk management (FRM) plans for the watershed. These steps are iterated to reduce the level of uncertainty of decisions related to plan formulation as the process moves from selection of FRM measures, to an initial array of alternatives, to a focused array of alternatives. No focused array of alternatives were determined to be economically justifiable under this study authority at this time.

1.1 PUBLIC AND STAKEHOLDER COORDINATION

<u>USRB Study: Interagency, Academic Institution, and Public Meetings Summary</u>.
The summary below includes USRB study meetings organized by USACE and NYSDEC, as well as meetings organized by others at which USACE and NYSDEC participated and represented the study.

Sept 13, 2016: Living with Water, Resiliency Summit, Binghamton, New York. Meeting was organized by multiple academic institutions and civic organizations. Focused on disaster preparedness, flooding, and local rivers. USACE representatives gave presentations introducing the Upper Susquehanna River Basin Study and reviewing Baltimore District levee safety program. The meeting included presentations and was attended by multiple Federal, state, county, and municipal government agency representatives, academic institution representatives, and civic group representatives. Federal agencies participating/attending included Federal Emergency Management Agency (FEMA) Region II and National Oceanic and Atmospheric Administration (NOAA) National Weather Service. State agencies included NYS Department of Environmental Conservation (NYSDEC), Department of State, Department of Agricultural Markets, Division of Homeland Security and Emergency Services.

Sept 13, 2016: Study kick off meeting, Kirkwood, New York. USACE, NYSDEC, Broome County, and a staffer from Senator Charles Schumer’s office met in Kirkwood, and additional USACE staff participated remotely. Introduced study to attendees and discussed study scope issues.

October 14, 2016: Study stakeholder meeting. Conference Call. USACE and NYSDEC gave overview of the Upper Susquehanna River Basin Study. Discussed proposed H&H modeling associated with the study and applications and modifications to the base model. Federal agencies with representatives attending included Susquehanna River Basin Commission (SRBC), US Geological Service (USGS), FEMA, and NOAA.

November 21, 22, and 30, 2016: Study public scoping meetings. USACE and NYSDEC held meetings in Owego, Chenango, and Sidney to obtain input on flooding concerns, area-specific considerations important in formulating FRM plans, and associated impacts to the human environment. Summaries of those meetings are presented in separate public scoping meetings record. Meetings were attended by public, local officials, and representatives of county, state, and Federal agencies.

April 19, 2017: Study progress webinar meeting with government agencies. USACE provided updated information on FRM measures under consideration, hydrology/hydraulics investigations, watershed assessment to characterize flood risk areas, and economic analyses underway. Agencies with representatives participating included FEMA, NYSDEC, New York State Historic Preservation Office (NYSHPO), SRBC, US Fish and Wildlife Service (USFWS), and USACE.

July 20, 2017: Upper Susquehanna Conservation Alliance (USCA) meeting. Webinar presentation on study organized by USFWS. USFWS provided overview of USCA and their efforts relevant to FRM. USACE and NYSDEC staff gave presentation on study history and process. USCA involvement opportunities were discussed.

August 28, 2017: Study FEMA-USACE Coordination Meeting. FEMA Region 2 was looking to gain a better understanding of the Upper Susquehanna Study for the benefit of their engagement with levee communities in Broome County through the LAMP (Levee Analysis and Mapping Procedures) process. These communities have indicated that they are expecting the Upper Susquehanna Study to produce: new levee crest surveys, updated hydrology and hydraulics, and updated risk screenings.

November 8, 2017: USCA Meeting in Cortland, NY. NYSDEC staff gave overview presentation on the study. George Fowler of USCA gave presentation on use of green mitigation techniques in Delaware River Basin and example of where 40 acres of wetland restoration there produced 5% reduction in flood damages. Workgroups of the USCA (landscape, flood brook trout, various rare species, fields to forests) had breakout sessions and identified FRM information need and action priorities.

March 28, 2018: NYSDEC USRB Study meeting for local government officials. The local government stakeholders meeting was held in Broome County, New York and was attended by 70 officials representing 21 local municipalities, 5 county governments, and 10 agencies including state and Federal partners. The purpose of this meeting is for communities to review study work completed to date and to gather feedback from local decision-makers. The meeting was organized as a presentation followed by discussion/questions and a table breakout session for local stakeholders to discuss potential projects with USACE and NYSDEC staff. The discussion in this meeting primarily focused on the results of the watershed screening with questions focusing on FEMA mapping work, modeling tasks, project alternatives and whether they are likely/unlikely based on costs, to name a few. The table breakout sessions yielded community-focused feedback on analysis and project alternatives.

April 12, 2018: USCA meeting, Cortland, NY. Staff from USFWS, NYSDEC, SRBC, FEMA, local Soil and Water Conservation Districts, and consultants attended. NYSDEC staff gave presentation on screening process that will lead to selection of candidate areas and FRM measures. NYSDEC asked for comments from USCA members by April 27, 2018. USFWS gave presentation summarizing draft planning aid report USFWS has prepared for USRB study. USACE staff answered questions regarding USACE FRM planning procedures, potential environmental impacts of various FRM measures, and whether more environmentally sensitive FRM measures could be included. USCA members expressed concerns over alternatives that would involve FRM measures of dredging, snagging/clearing, and shoal removal.

May 14, 2018: Study FEMA-USACE Coordination Meeting (conference call). USACE Engineering, FEMA Staff & Contractors participated. Coordinated regarding Susquehanna River model being used for the Upper Susquehanna Watershed Screening study. Agenda included: reviewing any hydrologic and hydraulic updates made by USACE for the Susquehanna River model, reviewing the hydrologic updates made by FEMA for the levee analysis studies in Broome, and identifying how to coordinate or consolidate the models in the future.

May 7, 2019. USRB Study Update Stakeholder Meeting and Workshop. USACE presented the results of the evaluation of the focused array of alternatives including process for evaluation by discipline (H&H, civil engineering, structural engineering, cost engineering, economics). The PDT discussed concept design, cost estimation, and economic analysis assumptions and discussed a path forward for recommendations for technical assistance. The meeting was attended by representatives from Broome County, Village of Johnson City, City of Binghamton, Town of Vestal, Town of Union, Village of Port Dickinson, Village of Endicott, Tioga County, City of Oneonta, SRBC, USFWS, National Weather Service, and Congressional Representatives.

1.2 PREVIOUS STUDIES, REPORTS, AND EXISTING FLOOD RISK MANAGEMENT PROJECTS

The USRB has been extensively studied for the purposes of FRM by USACE with general investigations stretching back as early as 1935. These studies have resulted in authorization for 2 large reservoirs, 8 levee/floodwall projects, 5 projects for snagging and clearing in streams, 5 channel improvement projects, and 1 combination channel improvement with snagging/clearing. Table 1 lists FRM studies carried out by USACE in the USRB. Since the last round of comprehensive studies in 1981, the FRM projects at Binghamton and EJV have been impacted by storm damages in 2006 and in 2011 resulting in rehabilitation actions to FRM project by USACE on both occasions.

Table 1: USACE Flood Risk Management Studies in the USRB

Study	Year	Description
Survey of Streams in New York and Pennsylvania Affected by the Disastrous Flood of 6-7 July 1935	1935	Study examined the Susquehanna River Basin to recommend flood control solutions to flooding that occurred in 1935 and later in 1936.
US Army Corps of Engineers Susquehanna River Basin Construction Authorization in House Document No. 702, 77th Congress, Second Session	1936	Authorized by the Flood Control Act of 1936, as amended by the Flood Control Act of 1938, for the construction of detention reservoirs and related flood control works in southern New York. Resulted in construction of Binghamton Levee System
Definite Project Report for the Upper Susquehanna Basin	1939	Recommended projects for upstream detention reservoirs to manage flood risk in the USRB.
Report on Flood Control Project at Endicott, Johnson City, and Vestal, New York, authorized in House Document 500, 81st Congress, Second Session	1949	Recommended local flood control project to reduce damages and residual risk in Endicott, Johnson City, and Vestal, NY. Project was authorized for construction in 1954.
Storage Potential in the Susquehanna River Basin	1966	Examined flood storage locations throughout the Susquehanna River Basin including upstream and downstream of Binghamton, NY.
Susquehanna River Basin Flood Control Study	1970	Study examined FRM projects in the Susquehanna River Basin to provide recommendations for flood risk reduction.
Susquehanna River Basin Flood Control Review Study: Susquehanna River Reconnaissance Report for the Structural Local Flood Protection Project in Endicott, New York	1978	Study examined the raising of the Endicott FRM system. At the time, raising was not economically justified.
Report on the Review of the Endicott, Johnson City, and Vestal, New York Project	1979	USACE reviewed the operation and performance of the EJV project to determine if the project provides adequate protection under current conditions and to examine modifications as needed. Seepage and interior drainage were addressed in a rehabilitation, but raising was not deemed economically justifiable at the time.
Susquehanna River Basin Flood Control Review Study	1981	USACE reviewed existing reports and recommendations to determine if plans for modifying FRM projects within the Susquehanna River Basin are feasible. This study evaluated the feasibility of raising in EJV and found no economic justification for raising at the time. The review also included an examination of nonstructural measures in communities in the USRB.
Increasing the Level of the Local Flood Protection Project in Binghamton, New York	1981	Study to determine the feasibility of structural and nonstructural flood damage reduction alternatives including increasing levels of protection in Binghamton, New York. At the time, only Front Street (Ward 1) project was recommended for raising.
Flood Risk Management Analysis for the Village of Sidney, Delaware County, New York	2010	USACE evaluated structural and non-structural FRM measures for damage reduction in the Village of Sidney, New York under the technical assistance programs. Study found limited Federal interest related to proposed alternatives.

In addition to USACE studies, the NYSDEC, the SRBC, and local stakeholders have been extensively involved in FRM actions. After Hurricane Irene and Tropical Storm

Lee in 2011 and Superstorm Sandy in 2012, the State of New York paved the way for recovery by leading community initiatives for reconstruction and to improve community resilience to extreme weather events that will occur at increased frequency and magnitude as a result of climate change. Several of these studies along with county efforts to update Hazard Mitigation Plans and flood hazard maps were examined to inform formulation for the USRB study. Table 2 lists a handful of the various state and community reports where flood hazard are specifically addressed by state or local actions. The New York Rising Community Reconstruction Plans for Broome County, Tioga County, and Town of Chenango provided baseline conditions for many of the populated areas in the USRB. Additionally, the Hazard Mitigation Plans for Broome, Chenango, Tioga, Delaware, Oneida, Onondaga, Otsego, Schoharie, Schuyler, and Tompkins Counties were available to supplement other existing information on flood hazards and local activities for risk reductions.

Table 2: Recent Water Resource Reports in the USRB

Study	Year	Report Source
Susquehanna-Chemung Action Plan	2012	Southern Tier Central Regional Planning and Development Board, Southern Tier East Planning Development Board
Comprehensive Plan for the Water Resources of the Susquehanna River Basin	2013	Susquehanna River Basin Commission
Blueprint Binghamton (Binghamton, NY Comprehensive Plan)	2014	City of Binghamton
New York Rising Community Reconstruction Plan - Broome County	2014	Broome County
New York Rising Community Reconstruction Plan - Town of Chenango	2014	Town of Chenango
New York Rising Community Reconstruction Plan - Tioga County	2014	Tioga County
Broome County Watershed Flood Hazard Mitigation Plan	2016	Broome County
Building Resiliency Progress Report	2016	Broome County

1.3 EXISTING FLOOD RISK MANAGEMENT PROJECTS

The USRB has 20 federally authorized, USACE-built projects including 2 large reservoirs, 8 levee/floodwall projects, 5 projects for snagging and clearing in streams, 5 channel improvement projects, and 1 combination channel improvement with snagging/clearing. The Whitney Point Reservoir and Binghamton FRM Project – Levee/floodwall were the first of the projects authorized by the Flood Control Act of 1936 and amended Flood Control Act of 1938. All USACE built projects are listed in the main report. Other projects have been historically considered including multiple reservoirs on the Chenango River; Genegantslet and South Plymouth Reservoirs, which were authorized in the Flood Control Act of 1944 but never constructed, the Fabius Reservoir, which lacked economic justification at the time, and the Charlotte Creek Development Reservoir, which lacked support for implementation. This section provides a description of projects.

BAINBRIDGE, NEW YORK – CHANNEL IMPROVEMENT
Channel Improvement

The project consists of realignment of Newton Creek into a concrete trapezoidal chute for 2,335 feet with channel excavation upstream and downstream of the chute and spoil dikes built to contain the flow. The channel is designed to contain a flow of 2,500 cubic feet per second.

BINGHAMTON, NEW YORK
Levee/Floodwall

The FRM project in Binghamton, New York, consist of 20,700 feet of earth levee; 13,800 feet of concrete floodwalls; 3,100 feet of channel excavation; 1,060 feet of pressure conduit; a check dam, and channel construction on Park Creek; 645 feet of channel paving; and appurtenant drainage and closure structures along the Susquehanna and Chenango Rivers. The improvements provide FRM for Binghamton against the largest flood of record which occurred in July 1935 on the Chenango River and in March 1936 on the Susquehanna River. Two dams, one of which forms Whitney Point Lake controlling 16 percent of the drainage area of the Chenango River upstream from Binghamton, and the other which forms East Sidney Lake, controlling 5 percent of the drainage area of the Susquehanna River upstream from Binghamton provide additional flood risk reduction. Federal maintenance is provided for channels, levees, and walls along Park and Pierce Creeks, whereas the remainder of the project is maintained by the New York State Department of Environmental Conservation.

BINGHAMTON, NEW YORK
Snagging/Clearing

The project consists of the excavation of a pilot channel, and clearing and removing of portions of existing islands, in the Chenango River downstream from the Cutler Dam in Binghamton, New York.

CINCINNATUS, NEW YORK
Snagging/Clearing

The project consists of removal of snags, clearing, and channel excavation for one mile in the Otselic River in Cincinnatus.

CONKLIN - KIRKWOOD, NEW YORK
Channel Improvement

The project consists of channel improvement over a seven mile reach of the Susquehanna River extending from the junction of Snake Creek and the Susquehanna River upstream, past the Towns of Conklin and Kirkwood, to Binghamton downstream. The first feature included clearing of trees and brush from approximately 130 acres of channel, islands, and river banks. The second feature included the removal of bars and islands in the main stream of the Susquehanna at the mouths of four tributaries.

CORTLAND, NEW YORK
Channel Improvement

The channel improvement project consists of deepening and widening of 4,950 feet of the Tioughnioga River, 400 feet of the East Branch of theTioughnioga River, and 8,850 feet of the West Branch of the Tioughnioga River, including 1,800 of channel realignment in the mill race channel. The project also included the removal of a low dam, an overflow weir, and water-power facilities in the mill race. The channel is designed to contain a flow of 5,200 cubic feet per second the Tioughnioga River and 1,800 cubic feet per second on the West Branch of the Tioughnioga River.

EAST SIDNEY LAKE, NEW YORK
Reservoir

East Sidney Lake is located on Ouleout Creek, about five miles above the confluence of the creek with the Susquehanna River near Unadilla, New York. The dam is combined earthfill and concrete gravity type structure, 2,010 feet long, and rises 146 feet from firm rock and 130 feet above the streambed with a spillway and five gate-controlled outlets in the concrete section. The reservoir has a storage capacity of 33,550 acre-feet at spillway crest and has an area of 1,100 acres at capacity. The reservoir drains an area of 102 square miles or 5 percent of the watershed of the Susquehanna River Basin upstream from Binghamton, New York. The reservoir is part of the flood risk reduction system for Binghamton and it reduces water surface elevations throughout the Susquehanna River downstream from Ouleout Creek.

ENDICOTT, JOHNSON CITY, AND VESTAL, NEW YORK
Levee/Floodwall and Channel Improvement

The FRM project includes levees/floodwalls in Westover (Johnson City), Endicott, West Endicott, and Vestal (including Twin Orchards), New York, against a design flood of 126,000 cubic feet per second on the Susquehanna River and the back-water effects on Nanticoke Creek, Willow Run, and Big and Little Choconut Creeks. The project consists of approximately 39,400 linear feet of earth levees, 2,800 feet of concrete walls, channel improvements and relocation, channel clearing, drainage structures, pumping stations, highway and railroad closures, and other pertinent features.

GREENE, NEW YORK
Levee and Channel Improvement

The project consists of earth levee for 2,500 feet on both banks of Birdsall Creek and channel improvements to Birdsall Creek between Canal and Birdsall Streets in Greene. The project includes dumped riprap bank protection, a short section of steel sheet pile wall, and a maintenance roads. The existing culverts and wingwalls are not part of the authorized project.

LISLE, NEW YORK
Levee/Floodwall and Channel Improvement

The FRM project at Lisle consists of 4,150 feet of earth levee; 970 feet of concrete floodwall; 5,700 feet of channel relocation and realignment along the Tioughnioga River; relocation of about 3,000 feet of the Dudley Creek channel; raising of about 1,860 feet of the Erie-Lackawanna single track railroad over the levee; relocation of about 1,600 feet of Cortland Street; a new bridge over the relocated Dudley Creek; and construction of pertinent drainage structures. The improvements provide protection for Lisle against flood discharges of the maximum flood of record, which occurred in July 1935. Federal maintenance is provided for the channel improvements along Tioughnioga River and Dudley Creek.

NICHOLS, NEW YORK
Levee and Channel Improvement

The FRM project at the Village of Nichols consists of a levee along the left bank of Wappasening Creek to the confluence with the Susquehanna River and parallel to the Susquehanna River as part of State Highway 17 embankment and along the west side of Nichols where it ties to high ground. The state designed the highway embankment to serve as a levee providing flood risk reduction from the Susquehanna River. The improvements are designed to protect against 15 percent higher than the largest flood of record in March of 1936 for a total flow of 145,000 cubic feet per second on the Susquehanna River and 32,000 cubic feet per second on Wappasening Creek.

NORWICH, NEW YORK
Channel Improvement

The channel improvement project consists of relocation and clearing of 9,000 feet of the Chenango River adjacent to Norwich along with dumped riprap bank protection. The channel also includes a small portion of Canasawacta Creek up to the Erie-Lackawanna Railroad.

ONEONTA, NEW YORK
Snagging/Clearing

The snagging and clearing project reduces frequent flooding as a result of a clogged channel underneath the Main Street Bridge and inadequate channel capacity upstream and downstream of the bridge. The snagging/clearing area consists of approximately 14 acres of snagging and clearing and removal of 42,200 cubic yards of excavated material from a reach extending from 650 feet upstream of the Main Street Bridge to 850 feet downstream of the bridge.

OWEGO, NEW YORK
Channel Improvement

The channel improvement project consists of clearing of an approximately 70 acre area along Owego Creek extending from its confluence with the Susquehanna River upstream 1.7 miles to the upper dam. The project also includes clearing of a shoal at the confluence and Squaw Island downstream from the Creek.

OXFORD, NEW YORK
Levee and Channel Improvement

The FRM project at Oxford includes approximately 2,100 feet of earth levee on the left bank of the Chenango River; removal of an island, channel clearing, a pertinent drainage structure along the Chenango River; and raising of the Erie-Lackawanna Railroad over the levee. Federal maintenance is provided for the channel improvement on the Chenango River, downstream from Main Street Bridge.

PORT DICKINSON, NEW YORK
Snagging/Clearing

The project consists of the removal of foundation piling remaining from an abandoned dam, excavation to eliminate shoals in the channel of the Chenango River, and overbank clearing in the vicinity of Port Dickinson, New York.

SHERBURNE, NEW YORK
Snagging/Clearing

The project consists of removal of snags and clearing for a length of about 2 miles of the Chenango River including excavation and realignment of the channel at the upstream and downstream ends of the project.

UNADILLA, NEW YORK
Channel Improvement

The project in Martin Brook consists of 3,284 feet of concrete rectangular channel with a concrete weir, debris basin, a tie-in levee at the upstream end, and an energy dissipater at the downstream end. The channel drains an upstream drainage area of 3.1 square miles at a flow of 3,000 cubic feet per second with two feet of freeboard. This flow is equal to the maximum known flood for Martin Brook in July of 1961.

WHITNEY POINT VILLAGE, NEW YORK
Levee/Floodwall and Channel Improvement

The FRM project at Whitney Point Village consist of 7,100 feet of earth levee; 1,800 feet of channel realignment; a twin-barrel reinforced concrete culvert; and other pertinent drainage structures along the Tioughnioga River. The improvements, supplemented by Whitney Point Dam upstream from the area, reduce flood risk in Whitney Point Village against flood discharges approximately 20 percent greater than the maximum of record, which occurred in July 1935. Federal maintenance is provided for the channel improvement of Tioughnioga River.

WHITNEY POINT LAKE, NEW YORK
Reservoir

Whitney Point Lake is located near Whitney Point, New York on the Otselic River, a tributary of the Tioughioga River, which discharges into the Chenango River, which, in turn, discharges into the Susquehanna River at Binghamton, New York. The dam is an earthfill structure, 4,900 feet long, rising 95 feet above the streambed, with a concrete spillway and a gated outlet in the left abutment. The reservoir has a storage capacity of 86,440 acre-feet (28.2 billion gallons) at spillway crest and will extend about 12 miles upstream when filled to that level. The project controls a drainage area of 255 square miles, the entire watershed of Otselic River or 16 percent of the Chenango River watershed upstream from Binghamton. The project is part of the flood risk reduction system for Binghamton and reduces water surface elevations in the lower Chenango River and throughout the Susquehanna River Valley downstream from Binghamton.

1.4 PLANNING FORMULATION FRAMEWORK

The USRB Project Management Plan (October 2015) describes the overall scope of the USRB study. The study scope as defined in the Project Management Plan (PMP) includes; detailed hydraulic, economic, social, cultural, and engineering analysis of one (1) existing flood-risk management project with three alternatives plus a no-action alternative; and examination of project feasibility in three (3) areas with no existing flood-risk management project for determining conceptual project scope and Federal interest for proposed projects. This work is preceded by a comprehensive watershed screening analysis to determine areas of relatively high flood risk in the watershed, assess flood drivers, and develop a suite of approaches for addressing the FRM problem. The risk areas described in the watershed were intended to inform project area and alternatives selection based on the original study scope. This plan formulation strategy is shown in Figure 2.

The watershed screening concluded that 17 flood risk areas, which comprise the highest 10th percentile of flood risk areas in the USRB, account for 67 percent of estimated damages (for the 1 percent event) in the watershed. NYSDEC, the project sponsor, contributed local knowledge that supported these conclusions. For these flood risk areas, the PDT, in collaboration with the project sponsor, drafted a comprehensive list of management measures to address the flooding problems, which were included in an initial array of alternatives (>100 alternatives) for the 17 risk areas. This initial array of alternatives was examined using three screening criteria: feasibility from an engineering perspective (or engineering feasibility), preliminary Federal determination, and acceptability of impacts from an environmental, social, cultural, and historical perspective. The PDT examined each criteria using existing information about the focus risk areas and updated hydrology to estimate damages in risk areas throughout the watershed. The screening of the initial array of alternatives resulted in a focused array of six flood risk areas with the potential for one or more FRM project alternatives. From these six flood risk areas, the PDT formulated a focused array of alternatives for four flood risk areas after incorporating feedback from local stakeholders. The focused array of alternatives are detailed in main report. The engineering analysis and economic evaluation of the focused array of alternatives are included in Appendix C Engineering and Appendix B Economics respectively. The results for the evaluation of FRM measures and the initial array of alternatives are documented in Chapter 3 and Chapter 4 of this Appendix.

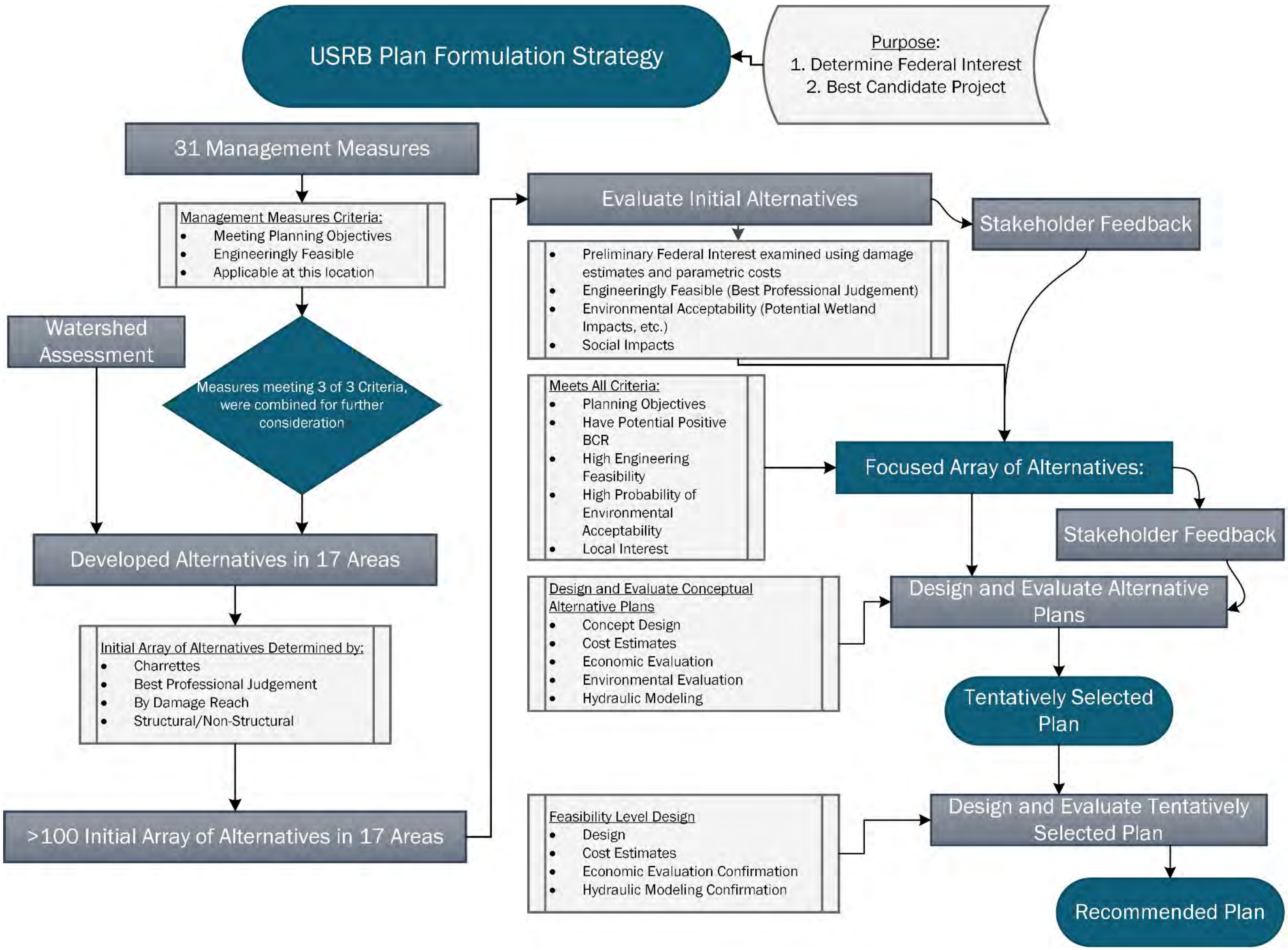

Figure 2: USRB Study Plan Formulation Strategy

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CHAPTER 2 WATERSHED SCREENING METHODS

This section will detail the methods used to analyze georeferenced locations of critical infrastructure assets and structures using gridded flood inundation data throughout the watershed. The type of analysis using in the watershed screening is intended to provide a comprehensive picture of flood risk "hot spots", which are areas where a concentration of potential damages to critical infrastructure and structures are present. Information generated in this analysis was cross-checked using local knowledge from USACE staff, the project sponsor, and subsequently using a stakeholder workshop.

The methods employed in the watershed screening were created after examining literature on flood hazard exposure, impact and vulnerability assessments, regional analysis tools, previous critical infrastructure assessments, and geospatial methods from various Federal, non-Federal, and academic sources. The broad watershed-scale of this analysis and availability of aggregated geospatial data indicates that geographic information systems (GIS) is an appropriate tool to complete the watershed screening in this study. This section will detail the GIS data and methods of analysis developed for completing the watershed screening analysis. This analysis includes creation of a geodatabase, processing and filtering of data, and incorporation of analytical assumptions and methodology. The process for developing the watershed screening was iterative and relied on feedback from various disciplines and the NYSDEC. During the evaluation process, the watershed screening was split into two components based on the nature of the available data. The first component of the watershed screening includes an analysis of riverine flooding risk to critical infrastructure and assets in the watershed. The second component examines flooding risk to structures in communities throughout the watershed. Each approach develops indices of relative flood risk to identify areas with higher risk in the watershed for the initial formulation of alternatives.

> *Critical Infrastructure "provides the essential services that underpin American society and serve as the backbone of our nation's economy, security, and health. We know it as the power we use in our homes, the water we drink, the transportation that moves us, the stores we shop in, and the communication systems we rely on to stay in touch with friends and family"*
>
> *(Department of Homeland Security, 2017)*

2.1 WATERSHED SCREENING PROCESS

The USRB watershed screening is conducted at various scales of analysis using national level data in the National Flood Hazard Characterization Tool followed by finer analysis using local data on critical infrastructure and structure (or buildings) inventories in the watershed.

. NATIONAL FLOOD HAZARD CHARACTERIZATION TOOL SUMMARY

Analysis using national level data was completed using the National Flood Hazard Characterization Tool, which uses readily available data to illustrate relative flood risk for the entire United States based on the 1 percent and 0.2 percent chance flood frequency events (USACE, 2014). The results of this tool present relative flood risk at the subwatershed scale (at the scale of hydrologic unit code, HUC, 8) and are presented for the three HUC8 subwatersheds in the USRB; the Upper Susquehanna, Chenango, and Owego-Wappasening subwatersheds. The results indicate higher exposure to riverine flooding in the Chenango subwatershed. However, the Owego-Wappasening subwatershed has a higher magnitude of total damages of approximately $200 million for the 1 percent chance flood frequency event. The tool also summarizes population and employment trends for the subwatersheds, which indicate a stagnating population with slight growths in employment in all three subwatersheds in the USRB. While these results provide an important starting point, there are some notable inconsistencies between the comparison results generated by the tool and the data sheets generated for each of the subwatersheds. Additionally, the rough granularity of this analysis provide little insight on the flood risk of local jurisdictions.

2.1.2 WATERSHED SCREENING SUMMARY

The USRB watershed screening study developed a geographic information system (GIS) methodology for examining relative flood risk for localities (cities, villages, towns) in the watershed using point data to represent critical infrastructure assets from the Homeland Security's Infrastructure Program (HSIP) Gold Dataset (2015) and a structure inventory that includes residential, commercial, and institutional buildings developed from the 2015 County parcel record centroids for 10 counties. These datasets were processed and overlaid with the CWMS model flood inundation depth grids described in Section 2.2. For the preliminary analysis, 4 flood frequency events are used to examine a range of flood risk for populated areas in the watershed, including the 5 percent, 2 percent, 1 percent, and 0.2 percent chance flood frequency events (or 20, 50, 100, and 500-year events). The critical infrastructure dataset and the structure dataset were separately processed and coded to assign numerical risk values for each data point in the datasets. The resulting risk values were then converted into a raster surface using a weighted point density tool to display "hot spots" of critical infrastructure and economic risk throughout the watershed. The resulting graphical analysis illustrates areas of higher flooding risk in the watershed. The results for this analysis are included in the main report for the critical infrastructure analysis and the flood damage analysis.

2.2 FLOOD HAZARD DATA

Data Sources and Data Processing

The watershed screening relies on the availability of flooding depth data for the study area. In the USRB study, hydrologic engineers developed raster inundation depth grids for the 5 percent, 2 percent, 1 percent, and 0.2 percent chance flood frequency events using the Corps Water Management System (CWMS) model for the study area including the Upper Susquehanna River and portions of the Chenango River. These raster data were processed and converted to polygons using the *round up*, *int*, and *raster to polygon* tools ensuring that all data were ultimately projected into NAD 1983 UTM Zone 18N. The watershed screening integrates flood inundation depth grids generated by the CWMS model, available for a majority of the USRB (shown in Figure 3), with available data from FEMA's National Flood Hazard Layer (NFHL) data for areas outside of the CWMS modeling extent. A limitation to this approach is that the portions of the watershed that used NFHL data only had data available for the 1 percent and 0.2 percent chance flood frequency event while CWMS inundation depth grids were available for most populated areas in the watershed for four flood frequencies. No Flood Hazard Area (FHA) data was made available for the counties of Madison, Herkimer, Tompkins, or Schuler in the USRB. The study team did not see the lack of data in these areas as a limitation to the screening analysis because these counties have limited land area and population in the USRB. An examination of existing studies and discussions with the project sponsor did not indicate that there are major concerns about flooding in upstream communities in the USRB within these counties.

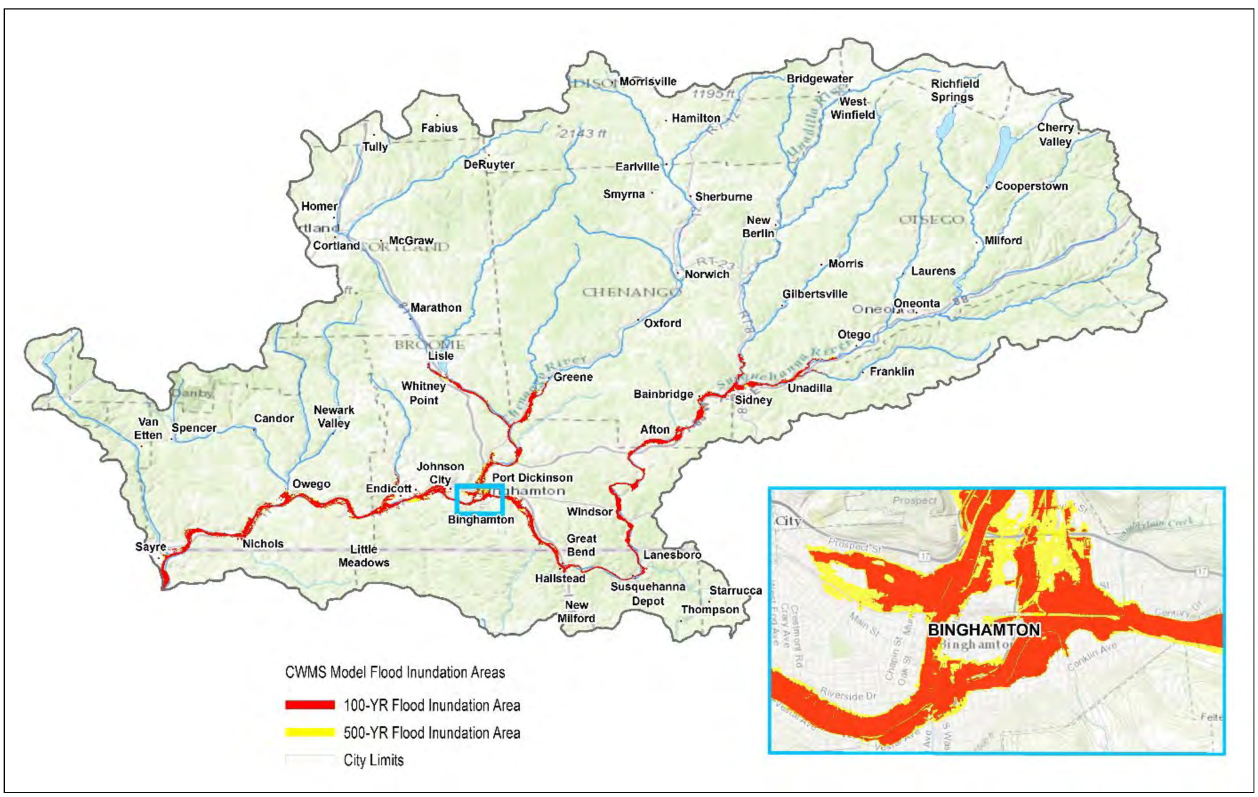


Figure 3: Upper Susquehanna River Basin CWMS Modeling Extent

The CWMS and NFHL data were aggregated into a single vector dataset with precedent given to CWMS modeling results as it represents the latest hydrology available for large portions of the USRB. Data was processed using the *merge* and *dissolve* tools, which aggregate different layers and reduce the level of detail to reduce processing time in subsequent analysis. Additional data fields were added to the polygon data to represent the flood hazard areas (depths, storm frequency) and shapes were divided using the *multipart to single part* tool. The resulting dataset, shown in Figure 4, illustrates the most comprehensive representation of flood hazard in the watershed. The CWMS and NFHL dataset were also available separately to support subsequent analysis. The FHA, used to represent both depth grids and NFHL combined data, are overlaid with the structure inventory to determine the depth of flooding of intersecting point locations representing critical infrastructure and structures within the watershed.

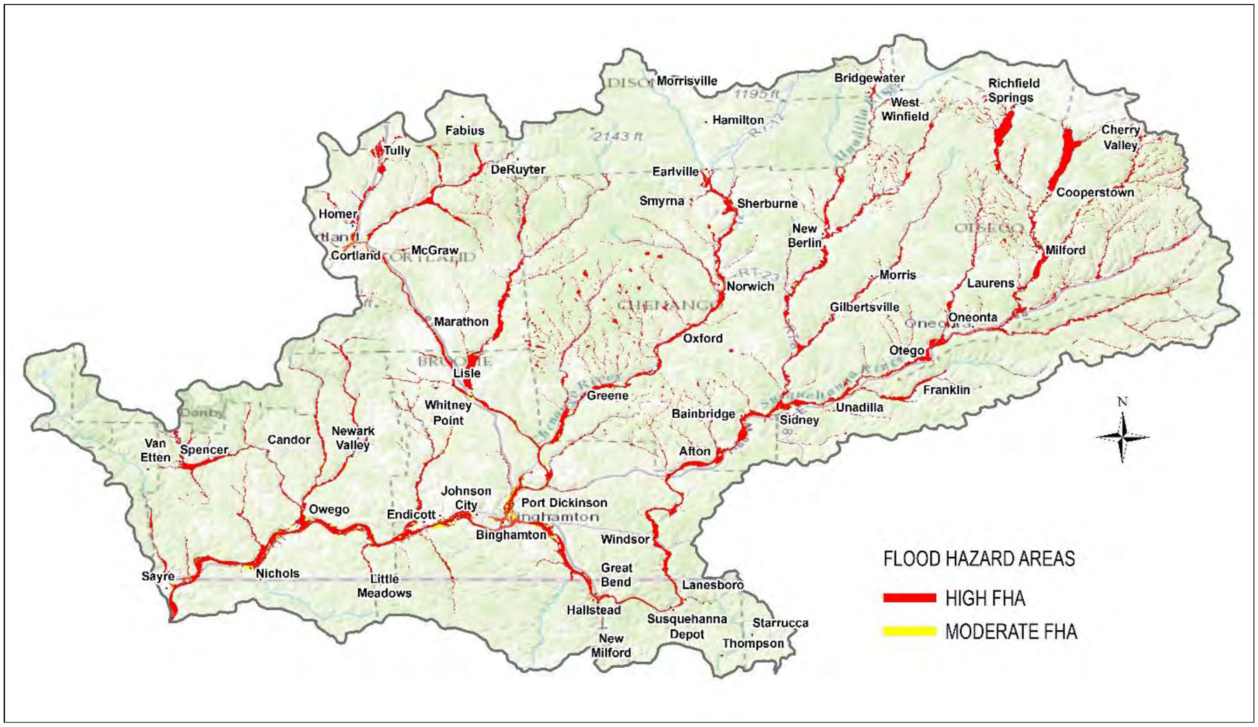


Figure 4: Combined Flood Hazard Area Extent in USRB

Flood Hazard Exposure: Overlaying Flood Inundation Probabilities

The FHA exposure was examined using the available data detailed in Table 3. The FHA were categorized based on FEMA classification in the NFHL including CWMS modeling data layers. The FHA data was overlaid with point data described in subsequent sections and attributed based on the location of points associated with critical infrastructure assets and structures in the watershed. The *select by location*, *spatial join*, and *intersect* tools were used to attribute point datasets.

Table 3: Flood Hazard Data Description

Flood Hazard Area Categories	Storm Frequencies	Data Source
-	The 5% and 2% flood inundation area are only available in the CWMS modeling extent and were only made available after completion of the critical infrastructure analysis.	CWMS
High	Includes the floodway and areas between the floodway and the 1% flood inundation area.	CWMS, NFHL
Medium	Includes areas between the 1% and 0.2% flood inundation areas.	CWMS, NFHL
Low	Includes areas outside of the mapped 0.2% inundation area and areas where flood mapping data is not available.	CWMS, NFHL

2.3 METHODS FOR CRITICAL INFRASTRUCTURE RISK ANALYSIS

Data Sources and Data Processing

The USRB critical infrastructure database is created from the Homeland Security Infrastructure Program (HSIP) GOLD 2015 data managed by the U.S. Department of Homeland Security and available to USACE. HSIP Gold 2015 contains nearly 200 layers of infrastructure data for the contiguous United States and includes geographically-referenced point locations of infrastructure locations with extensive attribute data for each infrastructure feature. Data layers with points locations referenced in the USRB watershed were selected for this analysis.

Each of the HSIP datasets are pre-processed to reduce the number of critical infrastructure layers and points down to relevant features located in the USRB study area using a dissolved polygon mask of the study area. These individual datasets contained thorough metadata and field data that facilitated coding of individual infrastructure data layers into infrastructure categories, public or private, functional categories, and to provide a summary assessment of importance of the critical infrastructure assets as they related to FRM (i.e. emergency response, disaster relief, post-disaster activities). Presentation of critical infrastructure can present operational security concerns. Therefore, the transformation of the data into refined datasets is required because some data may not be appropriate to present the data in a public forum, consistent with data-sharing agreements.

EXAMPLE: Public drinking water sources were categorized into permanent (serving a population regularly) and transient (serving a population intermittently) utilizing EPA definition of public water systems. In this instance, the permanent public water supply locations were categories as “Support – Essential” as they provide drinking water to a service population for six months or more out of the year. In high magnitude flood events, drinking water may be contaminated by flood waters or associated infrastructure may be damaged by flooding resulting in direct impacts to the human population of the Upper Susquehanna. Transient (non-community) public water supply infrastructure were similarly categorized as “Support – Nonessential” as they are unlikely to impact a significant portion of the population.

The HSIP datasets contain duplicate points and required further processing prior to conducting analysis (for instance, two different layers included a reference point each for a co-located fire station and EMS facility). The duplicate points were identified using the find identical tool with a buffer of 10 feet resulting in a report of duplicate facilities in each of the infrastructure categories. After examination of the metadata and field values to validate the presence of a duplicate, the delete identical tool with a buffer of 10 feet was used to delete duplicate data points. The resulting 9295-point USRB critical infrastructure database represents the combination of 112 layers containing critical infrastructure point locations within the USRB study area. The data layers which contained infrastructure points in the USRB are shown in Table 5.

Data Summary

The USRB critical infrastructure database includes a total of 9,295 critical infrastructure assets located in the watershed. These critical infrastructure assets were overlaid with flood hazard data. Out of the 9,295 assets, 347 are likely to be impacted by the 1 percent flood, while 458 are likely to be impacted by the 5 percent flood. These assets with potential impacts were checked against historical flood damage information. Some of the assets were impacted by the 2006 and 2011 flooding. During USRB charettes, it was also revealed that a small handful of assets with corresponding points in the database had already been demolished after suffering catastrophic damages from the 2011 flooding. These points were highlighted in the results section.

Methods

The first analysis in the watershed screening uses the USRB critical infrastructure database detailed in the previous section and flood inundation grids for the 5, 2, 1, and 0.2 percent chance flood frequency events to estimate the potential impacts of flooding to critical infrastructure assets. The level of detail incritical infrastructure data layers varied therefore existing literature and coordination between the study team and the sponsor provided the information needed to inform coding of critical infrastructure layers into categories and to assign ranking values to the various critical infrastructure categories based on their function in the FRM framework. An index for critical infrastructure flood risk was developed using this ranking, termed “asset value” (ranging from 1 to 10), and “hazard exposure”, expressed as the probability of flood inundation for structures using the various flood inundation grids for the watershed (ranging from 0 to 1). The conceptual diagram for the critical infrastructure risk index is shown in Figure 5. Each component of the index is described in subsequent sections along with a brief description of the process for calculating the critical infrastructure risk index.

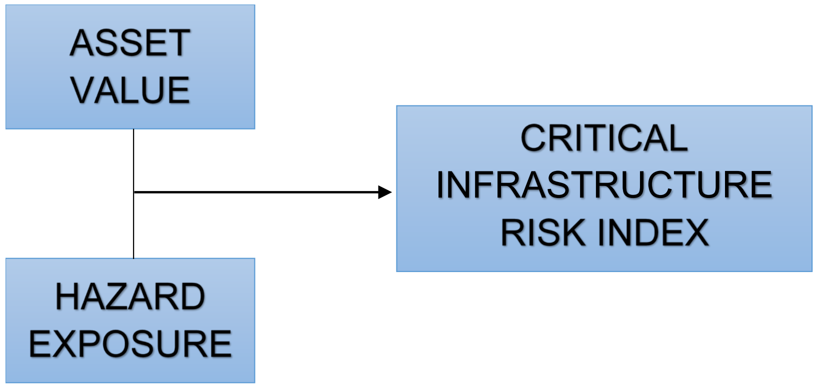


Figure 5: Conceptual Diagram for Calculating Critical Infrastructure Risk Index

Asset Value: Ranking Critical Infrastructure Assets

Critical infrastructure assets were initially ranked using information from the North Atlantic Coast Comprehensive Study (NACCS) with additional information from FEMA's risk assessment series to inform the ranking scale. The asset value scale is designed to create a rank of relative importance for critical infrastructure facilities, absent better information on the economic value of these assets in the HSIP Gold datasets. Essentially, asset value is a "weight" of relative importance of assets as it relates to FRM services and impacts to vulnerable populations. The ranking is intentionally weighted towards assets with functions related to immediate disaster response, recovery, and continuity of operations to highlight important assets that are essential to the public welfare in a flood risk emergency. The asset value ranks and descriptions are provided in Table 4. These asset value ranks were applied to the coded infrastructure data layers and categories and used in conjunction with exposure information developed using flood hazard areas from FEMA and flood inundation grids from the CWMS model to create a watershed-wide analysis that represent flood risk to critical infrastructure assets. The preliminary results of this analysis were discussed by the study team and the sponsor and refined using knowledge about the communities in the USRB.

Table 4: Asset Value Ranks and Descriptions

QUALITATIVE RISK RANKING	ASSET VALUE	DESCRIPTION
VERY HIGH	10	Loss or damage of key asset would have exceptionally grave consequences, such as extensive loss of life, widespread severe injuries, or total loss of primary services and core functions and processes
HIGH	8-9	Loss or damage of key asset would have grave consequences, such as loss of life, severe injuries, loss of primary services, or major loss of core functions and processes for an extended period of time
MEDIUM HIGH	7	Loss or damage of key asset would have moderate to serious consequences, such as serious injuries, or impairment of core functions and processes for an extended period of time
MEDIUM	5-6	Loss or damage of the key asset would have moderate to serious consequences, such as injuries, or impairment of core functions and processes
MEDIUM LOW	4	Loss or damage of the key asset would have moderate consequences, such as minor injuries, or minor impairment of core functions and processes
LOW	2-3	Loss or damage of the key asset would have minor consequences or impact, such as slight impact on core functions and processes for a short period of time
VERY LOW	1	Loss or damage of the key assets would have negligible consequences or impact

Table 5: Critical Infrastructure Datasets in HSIP Gold 2015 with Asset Values

Infrastructure Type	Asset Value	Number of Assets Inundated by the 1% Flood	Number of Assets Inundated by the 0.2% Flood
Air Shipping and Mailing Centers	4	15	25
Air, Water and Solid Waste Management Plants	7	6	8
Aircraft Landing Facilities	6	1	2
All Places of Worship	3	4	7
AM Transmission Towers	2	1	1
Animal Food Manufacturing Facilities	4	0	1
Animal Processing Facilities	5	0	1
Antenna Structure Registrate	5	3	5
Apparel Manufacturing Facilities	5	6	7
Bakeries	5	12	15
Biological Products Manufacturing Facilities	5	0	1
Blood and Organ Banks	10	0	1
Bus Stations	3	1	2
Canneries	5	0	1
Center for Disease Control	8	6	8
Chemical Manufacturing Facilities	7	4	8
City Halls	6	9	12
Colleges and Universities	5	1	1
Community Centers	5	1	1
Computer and Electronic Product Manufacturing Facilities	5	18	26
Court Houses	3	1	1
Dairy Product Manufacturing Facilities	5	3	3
Day Care Centers	8	18	31
Defense Industrial Base Facilities	4	2	3
DHL Facilities	4	2	2
Drinking Water Sources	4 or 10	136	164
Drinking Water Treatment Plants	4 or 10	45	50
Electric Generating Units	8	4	5
Electrical Equipment Appliance and Component Manufacturing	5	3	5
Emergency Medical Service Stations	9	17	27
EPA Facility Registry Service Power Plants	8	1	1
EPA WasteWater Treatment Plants	6	9	10
Fabricated Metal Product Manufacturing Facilities	5	16	27
Federal Deposit Insurance Corporation Insured Banks	5	16	26
Fire Stations	9	18	24
FM Transmission Towers	5	1	2
Furniture and Related Products Manufacturing Facilities	5	7	13
Gas Stations	7	27	43
Hospitals	10	1	1
Hotels and Motels	5	14	32
Ice Manufacturing Facilities	5	1	1
Law Enforcement Locations	9	4	7
Leather and Applied Product Manufacturing Facilities	5	0	1
Libraries	4	6	10
Lubricating Oils and Grease Plants	5	1	1
Machinery Manufacturing Facilities	5	8	14
Major State Government Buildings	6	0	1
Medical Equipment and Supplies Manufacturing Facilities	5	4	6
Microwave Service Towers	2	6	7
Museums	5	2	2
National Bridge Inventory Bridges	7	841	889
National Shelter System Facilities	8	16	25
Non Gasoline Alternative Fueling Stations	4	1	1
Nonmetallic Mineral Product Manufacturing Facilities	5	6	7
Nursing Homes	10	3	6
Oil and Natural Gas Wells	5	8	8
Paper Manufacturing Facilities	5	4	7
Petroleum Pumping Stations	7	1	1
Pharmaceutical Preparation Manufacturing Facilities	5	1	1
Pharmacies	8	11	24
Plastics and Rubber Product Manufacturing Facilities	5	7	8

Infrastructure Type	Asset Value	Number of Assets Inundated by the 1% Flood	Number of Assets Inundated by the 0.2% Flood
Printing and Related Support Facilities	5	16	24
Private Schools	8	1	2
Propane Retailer Locations	4	10	22
Public Health Departments	7	1	2
Public Schools	8	6	7
Railroad Bridges	5	177	200
Railroad Yards	5	1	3
Shopping	2	87	161
Soft Drink Manufacturing Facilities	6	4	4
Steel Plants	5	2	2
Substations	8	4	4
Textile Plants	5	1	2
Textile Product Mills	5	6	11
Theater and Performing Arts Centers	5	1	3
Transportation Equipment Manufacturing Facilities	5	4	4
UPS Facilities	4	1	2
Urgent Care Facilities	9	1	2
US Postal Service Post Offices	4	13	18
Veterinary Service Facilities	5	12	14
Wood Manufacturing Facilities	5	7	9
TOTAL CRITICAL INFRASTRUCTURE ASSETS	**9295**	**1256**	**1475**

Critical Infrastructure Risk Index

The critical infrastructure risk index (CRIx) was generated by intersecting the ranked critical infrastructure asset points with the USRB FHA data. One important thing to note is that the 5 percent and 2 percent flood inundation data were unavailable at the time of this analysis. Additionally, flood hazard data for Chemung County, which is outside of the USRB, but hydraulically linked via the Chemung River, was not received at this time. The numeric critical infrastructure risk index was generated by multiplying asset value (1 to 10) times the probability of flood inundation (0 to 1). This index created an ordinal ranking of critical infrastructure assets based on the probability that the asset would be impacted and the relative importance of the asset in terms of FRM.

(Asset Value)*(Probability of Flood Inundation) = Critical Infrastructure Risk Index

The critical infrastructure risk index is developed into a map by using the *weighted point density* tool using the risk index as the weight. The methods for creating this map are detailed in Section 2.5 in this document.

2.4 METHODS FOR FLOOD DAMAGE RISK ANALYSIS FOR STRUCTURES

The second component of the watershed screening includes an analysis of structures to estimate flood risk in the USRB using the economic value of structures including residential and non-residential buildings. This analysis includes development of a structure inventory using parcel information for 10 counties, intersecting flood inundation data, and subsequent calculations using ArcGIS and Microsoft Excel. This section details the methods used for this flood damage risk estimation analysis for the USRB. The methods detailed in this section are used to develop rapid economic analyses over a large area and are intended to supplement not supplant economic analysis based on established models. The analysis presented here is used for preliminary analysis to identify areas where more detailed economic analysis is needed using established models. This section includes steps for: (1) data processing and structure inventory development, (2) depth-damage function calculations, (3) flood damage risk index, and (4) aggregation of damage reaches. Each of the aforementioned sections will also address analytical assumptions, risks, data needs, and how this study dealt with limitations to aggregate economic analyses.

Data Sources and Data Processing

Data for this analysis was collected for 10 counties representing most of the populated areas in the USRB. These counties include Broome, Chemung, Chenango, Cortland, Delaware, Oneida, Onondaga, Otsego, Schoharie, and Tioga. The data used for this analysis includes the CWMS depth grids and NFHL flood hazard areas (in locations where CWMS modeling was not available) and the 2015 county property appraiser’s parcel centroids.

Processing of the Structure Inventory

The structure inventory for the watershed study is developed from parcel centroid data available for every county in the USRB. The parcel centroids provide a generally reliable geographic location for structures in small and medium sized parcels, but larger parcels required minor post-processing, using ortho-imagery as reference, to relocate centroids closer to the actual location of the structure in the parcel. This dataset includes detailed parcel attributes including information about the type of structure, square footage, property value, land value, and land use codes – information later used in damage-depth calculations for residential and non-residential properties.

The structure inventory was post-processed by projecting the data into NAD 1983 UTM Zone 18N. Additionally, the following land use categories (LUC) were removed from the dataset: agricultural (LUC 100s), vacant (LUC 300s), wild/forest/conservation (LUC 900s) and LUC 821, 842 & 843, which represent flood control and railroad parcels. The centroids in these land use categories generally lacked buildings except for agricultural, which had buildings often sited adjacent to prime farmland in the floodplain skewing risk estimations for the entire watershed towards largely rural/undeveloped areas. The final structure inventory contains 16,744 properties with an additional 11 properties being added after completion of the watershed screening for use in the HEC-FDA modeling.

Structure value and content value fields were added to the structure inventory and are estimated based on existing information provided by the property rolls. The structure value was calculated using the improvement values on parcels of land available in the

(Assessed Value – Land Value)*(Market Value/Assessed Value) = Structure Value

attribute fields. Several iterations of this analysis indicated a large difference between market value and assessed value in the property rolls, particularly in rural areas. This difference in values was confirmed by the project sponsor. The study team used a weight by averaging the market and assessed value to estimate structure value for this analysis. This calculation for structure value is applicable to all areas in the watershed except Binghamton, where market value more closely matched assessed value, therefore the assessed value is used. During the more detailed economic analysis, depreciated replacement costs were calculated using RSMeans. For more information on depreciated replacement refer to Appendix B: Economics.

Flood inundation can also affect the contents of a structure and total value of these contents can vary based on the use of the structure. Content value is estimated from the structure value based on established content-to-structure ratios and other assumptions developed by the study team. The content value of residential structures is estimated at fifty percent of the value of the structure based on insurance industry averages cited in IWR Report 93-R-7, “Guidelines to Estimating Existing Future Residential Content Values”, June 1993. For non-residential structures, content value is estimate at one hundred percent the value of the structure. The content-to-structure ratio for estimating content value are based on work in previous USACE studies. The ratio for residential content value is based on the residential content-to-structure value ratios documented in the Catalog of Residential Depth-Damage Functions (IWR Report 92-R-3, 1992). The ratio for nonresidential content value was selected by the study team based on professional experience since the source data lacked the necessary North American Industry Classification System (NAICS) information needed to adequately sort the various non-residential properties.

Flood inundation depth information is added to the structure inventory by intersecting the structure inventory point data with the 5 percent, 2 percent, 1 percent, and 0.2 percent flood inundation depth grids, which adds corresponding attributes from flooding data to the structure inventory. In areas where CWMS flood inundation depth grids were unavailable, this analysis used FEMA's flood hazard area designations to determine structures in flooded areas within the 1 percent and 0.2 percent FHAs. All attribute data was then exported to Microsoft Excel to estimate the percent damage to structure value and percent damage to content value using standard depth-damage functions employed by USACE.

Depth Damage Function Calculations

Flood damage estimation requires an approximation of the proportion of structure damage resulting from flood inundation. The watershed screening used depth damage functions to estimate the proportion of structure and content damage using the flood depth information for the four flood events in the CWMS model. Additionally, an approach was developed to extrapolate proportional damage estimates for areas outside of the CWMS modeling extent for structures impacted by the 1 percent and 0.2 percent flood frequencies based on the sample means of each structure type with available flood inundation information. The functions used in this analysis are USACE depth-damage functions for structure and content values detailed in IWR Report 96-R-12 (May 1996) & IWR Report 92-R-3 (May 1992). The full depth-damage function tables for residential structures were derived from the *Stage 2 Report Passaic River Basin Study, Appendix B: Economic Analysis* (June 1983). The structure inventory used in the Passaic River had similar attributes to the structures in this study due to the geographic proximity and similarity of building characteristics and construction. The depth-damage function tables were applied to the flooding depths by building type for residential structures. For non-residential, a general depth-damage function in IWR Report 96-R-12 (May 1996) is used as there was limited information on non-residential structures available in the parcel data. All depth-damage calculations were conducted in Microsoft Excel and imported into ArcGIS where they were *appended* to the structure inventory feature class using the ObjectID field. Depth-damage functions are included in Tables 7 and 8 for residential structures and in Tables 9 and 10 for non-residential structures.

Structures that did not have flood inundation depth information were attributed based on whether they were located in the 1% or 0.2% floodplain using the NFHL data. The proportion of structure damage for these structures was extrapolated based on the sample mean of structures with existing depth grids information in the 1% and 0.2% flood hazard areas. These means were collated using building type, with the assumption that structurally similar buildings will be impacted by flood inundation in similar ways and experience similar magnitudes of damages. A “population” mean, the mean for all structures affected by that storm events, was used for building types with sample sizes too small to develop a reliable sample mean. Outliers were removed from the residential structure mean calculations including 3 mansions. The study team believes the mean provides a reliable aggregate estimation for damages in these flood hazard areas despite the relatively inaccurate estimation at the level of the individual structure. The means by building type are shown in Table 6.

Table 6: Means for Proportion of Structure and Content Damages by Building Type

Building Type	1% Flood Event		0.2% Flood Event	
	Mean Proportion of Structure Damage	Mean Proportion of Content Damage	Mean Proportion of Structure Damage	Mean Proportion of Content Damage
Unclassified	0.303	0.593	0.336	0.669
A Frame	Sample too Small		Sample too Small	
Bungalow	0.298	0.587	0.351	0.699
Cape Cod	0.248	0.546	0.279	0.616
Colonial	0.223	0.449	0.249	0.521
Contemporary	Sample too Small		0.342	0.680
Cottages	0.317	0.633	0.357	0.711
Duplex	0.304	0.596	0.348	0.690
Log Cabin	Sample too Small		Sample too Small	
Mansions	Sample too Small		Sample too Small	
Mobile Home	0.687	0.623	0.774	0.706
Old Style	0.303	0.587	0.335	0.657
Other	Sample too Small		Sample too Small	
Raised Ranch	0.322	0.711	0.331	0.757
Ranch	0.286	0.657	0.305	0.716
Row	Sample too Small		Sample too Small	
Split Level	0.235	0.561	0.264	0.654
Town House	0.244	0.490	0.307	0.608
All Building Types	0.295	0.587	0.324	0.657
Total Building Sample Count	4601		7852	

Table 7: Percent of Structure Damage for Residential Structures and Flood Inundation from Residential Depth-Damage Functions

Depth Damage Function Building Types	Flood Inundation Depth in Feet																													USRB Structure Inventory Building Type
	-8	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
1 Story, No Basement	0	0	0	0	0	0	0	0	7	10	14	26	28	29	41	43	44	45	46	46	46	46	46	46						1 Story, No Basement
1 Story, With Basement	0	0	0	0	0	0	4	8	11	18	20	23	28	33	38	44	49	51	53	53	53	53	53	53						1 Story, With Basement
Split Level	0	0	1	1	2	4	6	7	8	16	16	19	22	25	26	27	27	30	31	32	33	34	34	34						
2 or More Stories, No Basement	0	0	0	0	0	0	0	0	5	9	13	18	20	22	24	26	31	36	38											2 or More Stories, No Basement, Mansions
2 or More Stories, With Basement	0	0	0	0	0	0	3	5	7	11	17	22	28	33	35	38	40	44	46	46	48	49	50	52	53	54	55	56	57	2 or More Stories, With Basement
Mobile Home	0	0	0	0	0	0	0	0	0	39	42	59	76	93	93	93	93	93	93	93	93	93	93	93						Mobile Home, Manufactured Home
Ranch	0	1	1	2	2	3	4	5	7	24	25	26	28	30	31	33	33	36	36	36	36	36	36	37						Ranch
Cape Cod	0	0	1	1	2	2	3	5	7	20	21	23	24	26	28	29	29	32	34	34	36	37	40	42					40	Cape Cod
Colonial	0	0	1	1	1	1	3	4	5	17	18	20	21	23	24	26	26	29	31	31	33	36	38	41					37	Colonial
Bi-Level	1	4	8	9	10	11	13	14	15	29	29	30	31	32	33	34	36	36	36	36	36	36	36	36						Raised Ranch
Two Family	0	0	1	1	2	2	4	5	6	17	18	20	22	23	25	27	29	30	32	32	35	37	41	44					38	Town House/Row
Other	0	1	2	2	3	4	5	6	8	23	24	27	29	31	33	35	35	39	40	41	42	43	44	45						*

*Other/Contemporary/Old Style/ Log Cabin/ Unclassified Building Type/Duplex/A Frame/ Bungalows Cottages
*Residential Depth-Damage Functions used are from the Federal Insurance Administration (1973) and Passaic River Feasibility Study (1983).

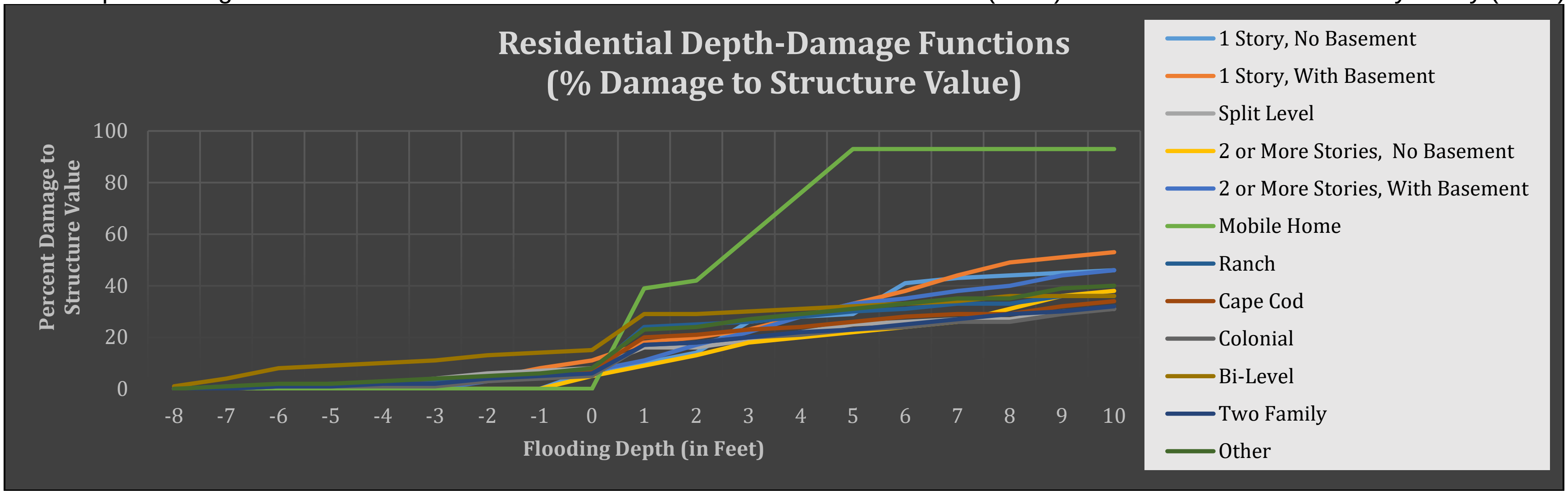


Table 8: Percent of Content Damage for Residential Structures and Flood Inundation from Residential Depth-Damage Functions

Depth Damage Function Building Types	Flood Inundation Depth in Feet																													USRB Structure Inventory Building Type
	-8	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
1 Story, No Basement	0	0	0	0	0	0	0	0	5	35	50	60	68	74	78	81	83	85	85	85	85	85	85	85						1 Story, No Basement
1 Story, With Basement	0	0	0	0	0	5	7	8	15	20	22	28	33	39	44	50	55	60	60	60	60	60	60	60						1 Story, With Basement
Split Level	0	0	1	2	3	7	11	15	18	30	40	46	52	58	63	68	68	79	80	80	82	84	86	87						
2 or More Stories, No Basement	0	0	0	0	0	0	0	0	7	9	17	22	28	33	39	44	50	55	58											2 or More Stories, No Basement, Mansions
2 or More Stories, With Basement	0	0	0	0	0	5	6	9	11	17	22	28	33	39	44	49	55	61	64	64	66	68	69	71	72	74	75	76	78	2 or More Stories, With Basement
Mobile Home	0	0	0	0	0	0	0	0	0	27	53	62	72	81	81	81	81	81	81	81	81	81	81	81						Mobile Home, Manufactured Home
Ranch	0	1	2	3	4	4	6	9	10	32	53	63	73	82	83	83	83	83	84	85	85	85	85	85						Ranch
Cape Cod	0	1	2	3	3	4	7	10	12	29	45	52	59	65	66	66	66	66	70	75	77	79	81	88						Cape Cod
Colonial	0	1	1	2	2	3	6	8	9	24	36	42	48	53	54	54	54	55	61	66	71	75	79	89						Colonial
Bi-Level	1	4	10	14	15	16	17	19	20	38	58	66	74	83	83	83	83	83	83	83	83	83	83	84						Raised Ranch
Two Family	0	0	2	2	3	3	5	6	7	20	33	39	46	52	53	54	55	56	61	66	71	76	80	89						Town House/Row
Other	0	1	3	4	5	6	7	8	9	28	46	54	62	70	71	71	71	73	75	79	82	84	86	87						*

*Other/Contemporary/Old Style/ Log Cabin/ Unclassified Building Type/Duplex/A Frame/ Bungalows Cottages
*Residential Depth-Damage Functions used are from the Federal Insurance Administration (1973) and Passaic River Feasibility Study (1983).

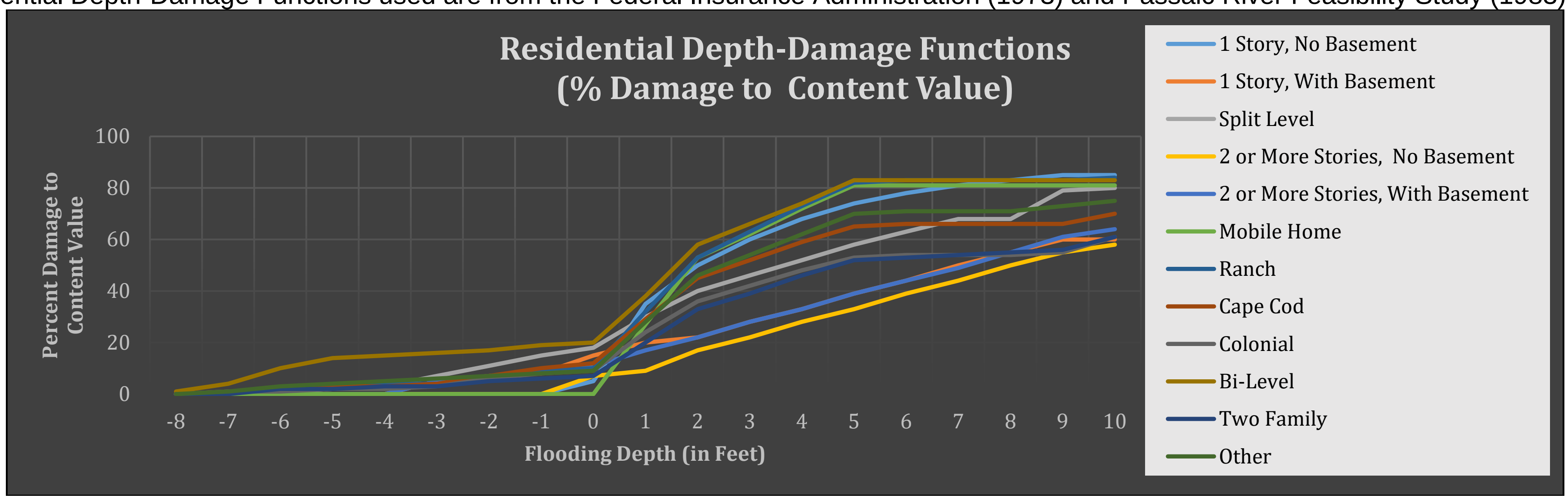


Table 9: Percent of Structure Damage for Non-Residential Structures and Flood Inundation from General Depth-Damage Functions

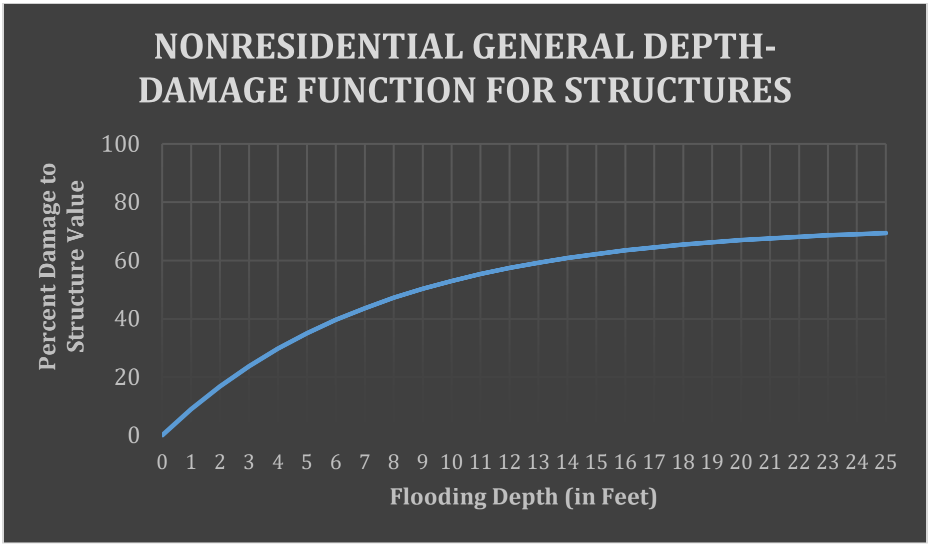
Building Type	Flood Inundation Depth in Feet																									
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
All Nonresidential*	0	9	17	24	30	35	40	44	47	50	53	55	57	59	61	62	63	65	65	66	67	68	68	69	69	69

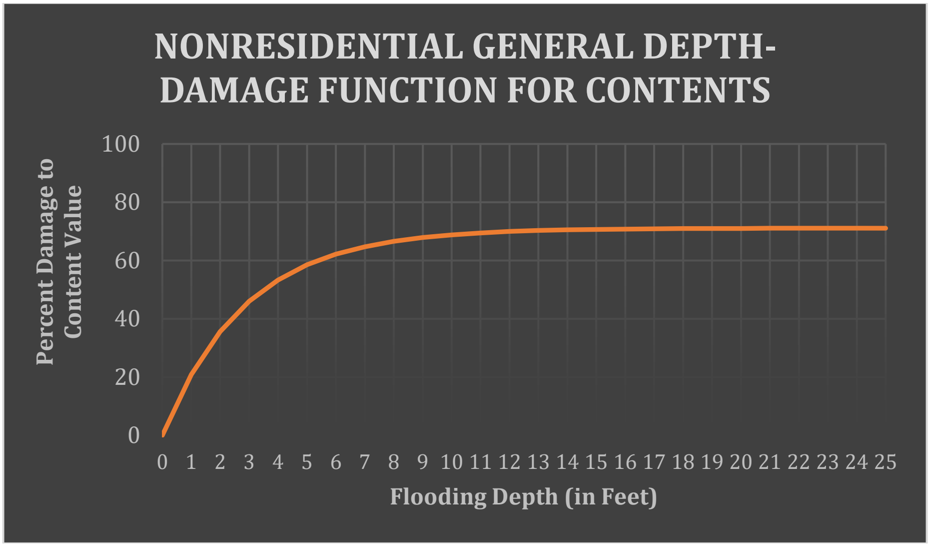
Table 10: Percent of Content Damage for Non-Residential Structures and Flood Inundation from General Depth-Damage Functions

Building Type	Flood Inundation Depth in Feet																									
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
All Nonresidential*	0	21	36	46	53	59	62	65	67	68	69	69	70	70	71	71	71	71	71	71	71	71	71	71	71	71

*Assumes no basement for non-residential. Percent damage to content value utilizes the mean of both functions (single story and multistory) in the report.

**Source for non-residential depth damage functions is *Analysis of Nonresidential Content Value and Depth-Damage Data for Flood Damage Reduction Studies*, IWR Report 96-R-12 (May 1996) in Pages 35-38.





Early analysis included an examination of means for the proportion of damage estimates for residential and non-residential structures based on the height of structure available in the parcel data. The smaller total sample, with only 5,837 residential structures containing the needed structure attribute information, and the lack of variability in proportional estimates based on flood depth and type of structure resulted in this information not being used further in the analysis. However, the information was used to validate flooding ranges in later iterations of this analysis (previously presented).

Table 11: Mean of Proportion of Structure Damage Estimates for Various Flood Events

Residential Structures	Mean of Proportion of Damage Estimates for 5% Flood	Mean of Proportion of Damage Estimates for 2% Flood	Mean of Proportion of Damage Estimates for 1% Flood	Mean of Proportion of Damage Estimates for 0.2% Flood
1 Story Structures (12-15 Feet)	0.311	0.336	0.418	0.594
1.5 Story Structures (~18 Feet)	0.206	0.223	0.254	0.395
2 Story Structures (20-28 Feet)	0.094	0.154	0.221	0.361
3 Story Structures (36-40 Feet)	0.082	0.114	0.102	0.140
Mean for All Residential Structures	0.241	0.258	0.319	0.479
Mean for All Non Residential Structures	0.251	0.272	0.316	0.384

Flood Damage Risk Index

Damage estimates for structures located in the floodplain in the USRB were generated for the 1 percent flood (~11,968 structures) and 0.2 percent flood (~16,744 structures). Additionally, structures in areas with CWMS modeling also included a 5 percent flood (~1388 structures) and 2 percent (~2,086 structures) flood damage estimate. These damage estimates are a summation of the structure and content value damage estimates for each structure. In order to assess flood risk for structures in the USRB, a flood damage risk index (FRIx) was developed using these damage estimates. The flood damage risk index is calculated by multiplying the damage estimates (in dollars) times the probability of flood inundation (ranging from 5% to 0.02%).

(Economic Damages)*(Probability of Flood Inundation) = Flood Damage Risk Index

Aggregation of damage reaches in the USRB

Damage reaches were developed for areas with and without existing FRM projects in the USRB. The damage reaches were used to aggregate damage estimates for structures, including a summation of residential and non-residential damages, for all areas with available data in the USRB. These damage reaches were created using aerial imagery, floodplain data (CWMS and FEMA), and the National Levee Database (NLD) as it includes inventoried FRM projects in the USRB. Damage reaches correspond to likely project areas based on hydrology and concentration of flooded structures. In the watershed screening, these reaches were further aggregated into a local municipality to examine flood risk at the community scale. After damage reaches were created, properties corresponding to the flooded area are manually selected and a "Damage Reach" field is populated with the corresponding name of the damage reach. The updated file is then exported to Microsoft Excel for summation of all of the structures within each reach by using the *Subtotal* feature for each of the four flood frequency events. Both levels of aggregation of damage estimates were used in the screening and subsequent formulation of alternatives.

2.5 METHODS FOR MAP CREATION FROM POINT DATASETS

The watershed screening uses neighborhood analysis functions to create maps that highlight hot spots of relative flood risk in the USRB. This study used a simplified ArcGIS tool of neighborhood analysis called the *point density* tool. The point density tool uses point data and weighs the value of each point based on a moving neighborhood window of specified size by the analyst. Each point is thus weighted based on the full intersection of points within its neighborhood such that the areal measure for that point's neighborhood is an aggregate of all of the values of intersecting neighborhoods (summation) divided by the areal extent of the neighborhood, which is a fixed value specified by the analyst.

In the critical infrastructure risk analysis maps, the critical infrastructure risk index was used to generate maps. In the flood damage risk analysis maps, the flood damage risk index was used to generate maps. In both analyses, several neighborhood sizes were tested by iteration for sensitivity, concurrence with statistical patterns examined in cluster analysis and Moran's I, and ease of interpretation at the various levels of aggregation. The project team and the sponsor decided to select two neighborhood sizes for interpreting risk analyses results: the 500m and the 2000m (circle - radius). Results were cross-checked by iterating other neighborhood functions including various interpolation tools, cluster analysis, hot spot analysis, and other statistical analysis methods in ArcGIS. Final maps were generated using the raster statistics with standard deviations as breakpoints for the display of the data. These maps were discussed by the project team and the project sponsor and updated with feedback from the PDT.

Neighborhood functions are a procedure used "to characterize each object as part of a larger neighborhood of objects based on some shared attribute" (DeMers, 2005). There are two primary approaches for neighborhood function analyses. One is a total analysis of neighborhood, also known as extended neighborhood analysis, which can be used to classify features based on an attribute for an entire area. The second is a targeted analysis or immediate neighborhoods, which can be used to classify features based on only the locations or features adjacent to the target feature (DeMers 2005). The analysis for this type of function can also be conducted all at once using the static neighborhood function, described as within "the framework of a window that moves across the coverage", or roving window neighborhood functions (DeMers 2005). The use of these functions is detailed by DeMers in Fundamentals of Geographic Information Systems (2005).

CHAPTER 3 EVALUATION OF FLOOD RISK MANAGEMENT MEASURES

A measure is a feature or activity at a site that addresses one or more of the planning objectives. Throughout the watershed, specific management measures, either a feature or an activity, can be implemented at specific geographic sites or across broad areas of the watershed to achieve desired effects. A feature is a physical element that generally requires site construction (for example, a levee or floodwall). An activity is an institutional (drainage district, city, or county) action that causes a change without immediate physical change, which may be a one-time occurrence or ongoing (for example, changes in floodplain regulations). Several alternative measures were identified for consideration in evaluating future possible actions in the USRB. Each measure was assessed using screening criteria and a determination was made regarding whether it should be retained in the formulation of alternative plans. Analyses for identification of the NED plan involved identifying an array of measures to achieve the stated objectives and then determining the most cost-effective combination of those measures that fully address the identified problems. Measures become part of alternatives, making each alternative unique in how measures are formulated together.

FRM measures are either structural or nonstructural. Structural alternatives modify the flood and “take floods away from people” by features such as channels, levees, and dams. Nonstructural alternatives basically “take people away from floods,” leaving the flood to pass unmodified. Nonstructural measures include both features and activities. Example nonstructural activities include land use regulations, redevelopment and relocation policies, disaster preparedness, flood warning and forecasting systems, flood plain information, flood plain acquisition and easements. Nonstructural measures also include features such as flood proofing, and onsite detention of flood waters by protection of natural storage areas or in human-made areas. Documenting the full menu of measures will contribute to better FRM in the watershed. The evaluation of FRM measures is detailed in Table 12.

More importantly, the public must be educated about FRM risks and actions that can be taken to reduce these risks. Because of this complex arrangement of responsibilities, only a life-cycle, comprehensive, and collaborative watershed perspective enables communities to sustain an effective reduction of risks from flooding.

3.1 STRUCTURAL FRM MEASURES

Structural FRM measures are constructed physical features that counteract a flood event to reduce the consequences of flooding by influencing the natural course of flooding and reducing the probability of occurrence of the flood event. Structural measures include levees, floodwalls, gates, and channel modifications that can reduce the frequency or impacts of flooding to people and property.

Levees consist of earthen-work features made of impervious materials that are built along the floodplain to reduce risk for communities in areas at high flood risk. Levees are generally designed as a trapezoid earthen feature, building a continuous line of protection to a design flood elevation, which is determined based on historical flooding records. Well-maintained levees can be an effective means of reducing flood risk for generations, but also have an adverse impact on altering the flow and natural course of flood waters, which may increase risk to communities downstream or upstream of the levee.

Floodwalls are constructed concrete, masonry, or stone features built in the floodplain to provide a vertical line of protection that withstand the loads of floodwaters. Floodwalls are similar to levees except that they can be constructed in areas with constraints on land to provide structural protection to communities at risk of flooding. Floodwall construction can be magnitudes more expensive than levee and can deteriorate over time requiring continuous maintenance and repairs.

Pump stations are intended to provide a mechanical means of moving floodwater from an undesirable location including within communities. Pump stations provide interior drainage for smaller areas and can be effective in draining ponding areas behind a levee or floodwall system helping reduce interior flooding.

Channel projects include routine clearing and snagging removal projects and channel improvements, which may include realignment, widening, and deepening of streams to improve channel capacity and flow. Channel projects can be used in combination with other measures to reduce flood risk along a specific reach of a stream. The cost effectiveness and environmental impacts of channel projects is a source of contention because they have high operation and maintenance costs for routine clearing or dredging to maintain channel capacity, which can have significant impact on benthic and fish habitat in the stream. Channel projects are generally effective at reducing risk for higher frequency events but may be overwhelmed by high flow events, which can scour channel banks and debris that can further adversely impact the channel capacity.

Other common structural measures include flood control dams, diversions, and ice jam structures. Flood control dams are man-made earthen or concrete structures designed to detain water that can slowly be released, reducing risk to downstream communities. USACE has built several flood control dams in the USRB including the Whitney Point and East Sidney Dams. Diversion is the relocation of the flow of streams and rivers to move water quickly out of high risk areas. Ice jam structures are features designed to reduce the impact of ice jams, accumulations of ice that restrict the flow of water increasing flood elevations, which can result in damage and flooding to structures.

3.2 NON-STRUCTURAL FRM MEASURES

Nonstructural FRM measures are proven methods and techniques for reducing flood risk and flood damages by adapting to the natural characteristics of flooding within the floodplain. Nonstructural measures are permanent or contingent measures applied to a structure and/or its contents that prevent or provide resistance to damage from flooding. Nonstructural measures differ from structural measures in that they focus on reducing the consequences of flooding instead of focusing on reducing the probability of flooding. In addition to being very effective for both short and long term flood risk and flood damage reduction, nonstructural measures can be very cost effective when compared to other FRM techniques.

Nonstructural FRM can be categorized as a set of physical or nonphysical measures utilized for mitigating loss of life as well as existing and future flood damages. The physical measures determined to be most commonly implemented are those which adapt to the natural characteristics of the floodplain without adversely affecting or changing those natural flood characteristics. Because of their adaptive characteristics to flood risk, wherein these measures support the National Flood Insurance Program (NFIP) as administered by FEMA and generally cause no adverse effects to the floodplain, flood stages, velocities, or the environment, these measures may also be referred to as Flood Risk Adaptive Measures (FRAM) and can be incorporated into existing or new structures to mitigate for potential future flood damages.

Elevation of structures is a common FRM measure that requires raising of the structure in place above the design flood elevation. Elevation is most suitable for single family houses with good structural integrity. Buildings are elevated by raising on temporary framing followed by extending foundation walls or structural fill up to the design elevation. Another option common in coastal areas is to elevate buildings on pilings, which may not be suitable for low flood elevations.

Flood proofing involves reducing damage to buildings by waterproofing, shields, or other means that allow floodwaters to pass through or around the building unimpeded. Flood proofing offers the opportunity to reduce flood damages to structures and contents for an individual structure-by-structure basis or for a group of structures. Flood proofing costs can vary substantially depending on the type of flood proofing method being considered and the type, size, age, and location of the structure(s).

Dry flood proofing of existing structures is a common flood proofing technique applicable for flood depths of three (3) feet or less on buildings that are structurally sound. Dry flood proofing involves sealing building walls by waterproofing preventing the entry of floodwaters into a structure. Installation of temporary closures or flood shields is a commonly used flood proofing technique. A flood shield is a watertight barrier designed to prevent the passage of floodwater though doors, windows, ventilating shafts, and other openings of the structure exposed to flooding. Such shields are typically made of steel or aluminum and are installed on structures only prior to anticipated flooding. However, flood shields can only be used on structures with walls that are strong enough to resist the flood-induced forces and loadings. Exterior walls must be made watertight in addition to the use of flood shields. This technique is not applicable to areas subject to flash flooding (less than one hour) or where flow velocities are greater than three (3) feet per second. It would also not be applicable to mobile homes, due to the type of construction and typical lack of anchoring to a foundation. Aside from the cost, dry flood proofed homes and businesses can still suffer flood damages due to the potentially incomplete nature of the solution. Enclosures for windows and doors require human intervention in order to fully implement the solution, and this action would have to occur in a relatively short timeframe.

Wet flood proofing is also a common way of reducing flood damages for structures with an uninhabited basement or other subgrade portion of a building. Wet flood proofing involves modifications of structures to allow for flood waters to enter and inundate portions of the building to minimize structural damage. This type of flood proofing can include raising of utilities, raising building contents above the flood elevation or moving to higher floors, using flood damage-resistant materials in the building interior and exterior, and installing flood opening in the structure foundation walls to reduce water pressure on the structure. This approach can minimize but will not eliminate flood damages to the structure and requires extensive cleanup and maintenance. Wet flood proofing may not be feasible in certain areas based on the velocity and volume of the flood source.

Relocation involves physically moving a building at-risk of flooding to an area of lower risk, typically outside of the floodplain. This measure can eliminate flood risk while restoring the floodplain, but it can be costly and time consuming.

Acquisition consists of buying out of buildings and associated land parcels located within the floodplain. After acquisition, the building is demolished or relocated outside of the floodplain reducing flood risk to communities. Acquisitions are generally implemented to structures at extreme risk of flooding that have been flooded one or more times. Historically, riverine communities have developed in the floodplain due to their proximity to water routes that facilitate transportation of goods for commerce. While acquisition with demolition or relocation reduces flood risk and restore floodplains, it can have a negative impact on neighborhood cohesion and the vitality of historic riverine communities.

Table 12: FRM measures considered in USRB study

Measure	Considerations									Screening Criteria			Meets All Criteria?	Discussion
	Flood Conveyance Impacts	Socioeconomic Impacts	Environmental Impacts	Mitigation Needed	Residual Risk Remaining	Cost	Recreation Opportunity	Regional Benefits	Measure in Place	Meets Planning Objectives	Applicable at this Location	Engineeringly Feasible		
Relocation	Unlikely	Likely	Unlikely	Likely	Low	TBD	Likely	Yes	Yes	TBD	Yes	Yes	TBD	Need number of structures within the damage area to determine cost
Acquisition/ Demolition	Unlikely	Likely	Unlikely	Likely	Low	TBD	Likely	Yes	Yes	Yes	Yes	Yes	Yes	Need number of structures within the damage area to determine cost
Strategic Acquisition	Unlikely	Likely	Unlikely	Likely	Low	TBD	Likely	Yes	Yes	Yes	Yes	Yes	Yes	Need number of structures within the damage area to determine cost
Land Use Regulations	Unlikely	Likely	Unlikely	Unlikely	Low	Low	Likely	Yes	Yes	No	Yes	Yes	No	
Zoning	Unlikely	Likely	Unlikely	Unlikely	Low	Low	Unlikely	Yes	Yes	No	Yes	Yes	No	
Building/Housing Codes	Unlikely	Likely	Unlikely	Unlikely	Low	Low	Unlikely	Yes	Yes	Yes	Yes	Yes	Yes	
Flood Insurance	Unlikely	Likely	Unlikely	Unlikely	High	Low	Unlikely	Yes	Yes	N/A	Yes	Yes	No	
Wet Flood Proofing	Unlikely	Unlikely	Unlikely	Unlikely	Medium	TBD	Unlikely	Yes	Yes	Yes	Yes	Yes	Yes	Need number of structures within the damage area to determine cost
Dry Flood Proofing	Unlikely	Unlikely	Unlikely	Unlikely	Medium	TBD	Unlikely	Yes	Yes	Yes	Yes	Yes	Yes	Need number of structures within the damage area to determine cost
Elevating Structures	Unlikely	Unlikely	Unlikely	Unlikely	Low	TBD	Unlikely	Yes	Yes	Yes	Yes	Yes	Yes	Need number of structures within the

Measure	Considerations									Screening Criteria			Meets All Criteria?	Discussion
	Flood Conveyance Impacts	Socioeconomic Impacts	Environmental Impacts	Mitigation Needed	Residual Risk Remaining	Cost	Recreation Opportunity	Regional Benefits	Measure in Place	Meets Planning Objectives	Applicable at this Location	Engineeringly Feasible		
														damage area to determine cost
Elevating Major Roads for Evacuation	Unlikely	Unlikely	Likely	Unlikely	Low	High	Unlikely	Yes	Yes	TBD	Yes	Yes	TBD	
Evacuation Plan	Unlikely	Unlikely	Unlikely	Unlikely	Low	Low	Unlikely	Yes	Yes	Yes	Yes	Yes	Yes	Consider enhancing existing plans
Flood Emergency Preparedness Plans	Unlikely	Unlikely	Unlikely	Unlikely	Low	Low	Unlikely	Yes	Yes	Yes	Yes	Yes	Yes	Consider enhancing existing plans
Temporary Flood Barriers	Unlikely	Unlikely	Unlikely	Unlikely	Mediu m	Low	Unlikely	Yes	Yes	Yes	Yes	Yes	Yes	
Flood Warning Systems	Unlikely	N/A	N/A	N/A	N/A	NA	NA	Yes	Yes	N/A	Yes	Yes	No	Already in place - Binghamton AHPS
Floodable Development	Likely	Unlikely	Unlikely	Likely	Mediu m	TBD	Likely	Yes	Yes	No	Yes	Yes	No	Does not meeting planning objectives
Flood Plain Regulations	Unlikely	Unlikely	Unlikely	Unlikely	Mediu m	Low	Likely	Yes	Yes	Yes	Yes	Yes	Yes	
Modify/Remove Structures	Unlikely	Likely	Unlikely	Unlikely	Mediu m	High	Likely	Yes	Yes	TBD	Yes	No	TBD	Leaving open for further consideration due to bridge capacity (low cord)
Dredging Channels	Likely	Unlikely	Likely	Likely	Mediu m	High	Unlikely	Yes	Yes	Yes	Yes	Yes	Yes	Public concerns.
Clearing, Snagging and Shoal Removal	Likely	Unlikely	Likely	Likely	Mediu m	Mediu m	Unlikely	Yes	Yes	Yes	Yes	Yes	Yes	
Channel Modifications	Likely	Unlikely	Likely	Likely	Low	High	Unlikely	No	Yes	No	Yes	No	No	Existing FRM infrastructure already in place to reduce

Measure	Considerations									Screening Criteria			Meets All Criteria?	Discussion
	Flood Conveyance Impacts	Socioeconomic Impacts	Environmental Impacts	Mitigation Needed	Residual Risk Remaining	Cost	Recreation Opportunity	Regional Benefits	Measure in Place	Meets Planning Objectives	Applicable at this Location	Engineeringly Feasible		
														damages from more frequent events.
Floodwalls (new structure)	Likely	Likely	Likely	Likely	Low	High	Likely	Yes	Yes	Yes	Yes	Yes	Yes	
Levee Embankments (new structure)	Likely	Likely	Likely	Likely	Low	High	Likely	Yes	Yes	Yes	Yes	Yes	Yes	
Levee Embankment Modification	Likely	Unlikely	Unlikely	Unlikely	Low	High	Unlikely	No	Yes	Yes	Yes	Yes	Yes	
Floodwall Modification	Likely	Unlikely	Unlikely	Unlikely	Low	High	Unlikely	No	Yes	Yes	Yes	Yes	Yes	
Diversions	Likely	Likely	Likely	Likely	Low	High	Unlikely	No	Yes	No	Yes	No	No	Not enough space available in highly urbanized area; high environmental mitigation requirements
Pump Stations	Unlikely	Unlikely	Unlikely	Unlikely	Low	Medium	Unlikely	No	Yes	Yes	Yes	Yes	Yes	Evaluate existing systems
Conduits for Interior Drainage	Unlikely	Unlikely	Unlikely	Unlikely	Medium	Medium	Unlikely	No	Yes	TBD	Yes	Yes	TBD	
Bridges and Culverts	Likely	Likely	Likely	Likely	Medium	High	Unlikely	Yes	Yes	TBD	Yes	Yes	TBD	
Revetment/ Retaining Wall	Likely	Unlikely	Unlikely	Unlikely	High	Medium	Unlikely	No	Yes	No	Yes	Yes	No	Does not meeting planning objectives
Stormwater Management Features/ Retrofits	Unlikely	Unlikely	Likely	Unlikely	High	Medium	Unlikely	Yes	Yes	TBD	Yes	No	No	

Measure	Considerations									Screening Criteria			Meets All Criteria?	Discussion
	Flood Conveyance Impacts	Socioeconomic Impacts	Environmental Impacts	Mitigation Needed	Residual Risk Remaining	Cost	Recreation Opportunity	Regional Benefits	Measure in Place	Meets Planning Objectives	Applicable at this Location	Engineeringly Feasible		
Dams (new structure)	Likely	Likely	Likely	Likely	TBD	High	Likely	Yes	Yes	Yes	Yes	Yes	Yes	Previous recommendations (older reports)
Dam Modifications	Unlikely	Likely	TBD	Likely	TBD	High	Likely	Yes	Yes	TBD	Yes	No	No	Per PMP not to be evaluated.
Debris Control Structures	Likely	Unlikely	Likely	Unlikely	Medium	Low	Unlikely	Yes	Yes	TBD	No	No	No	No flooding issue on the mainstem. Not locally applicable
Ice Jam Structures	Likely	Unlikely	Likely	Unlikely	Medium	Low	Unlikely	Yes	Yes	TBD	No	No	No	No flooding issue on the mainstem

CHAPTER 4 FORMULATION OF THE INITIAL ARRAY OF ALTERNATIVES FOR FOCUS RISK AREAS

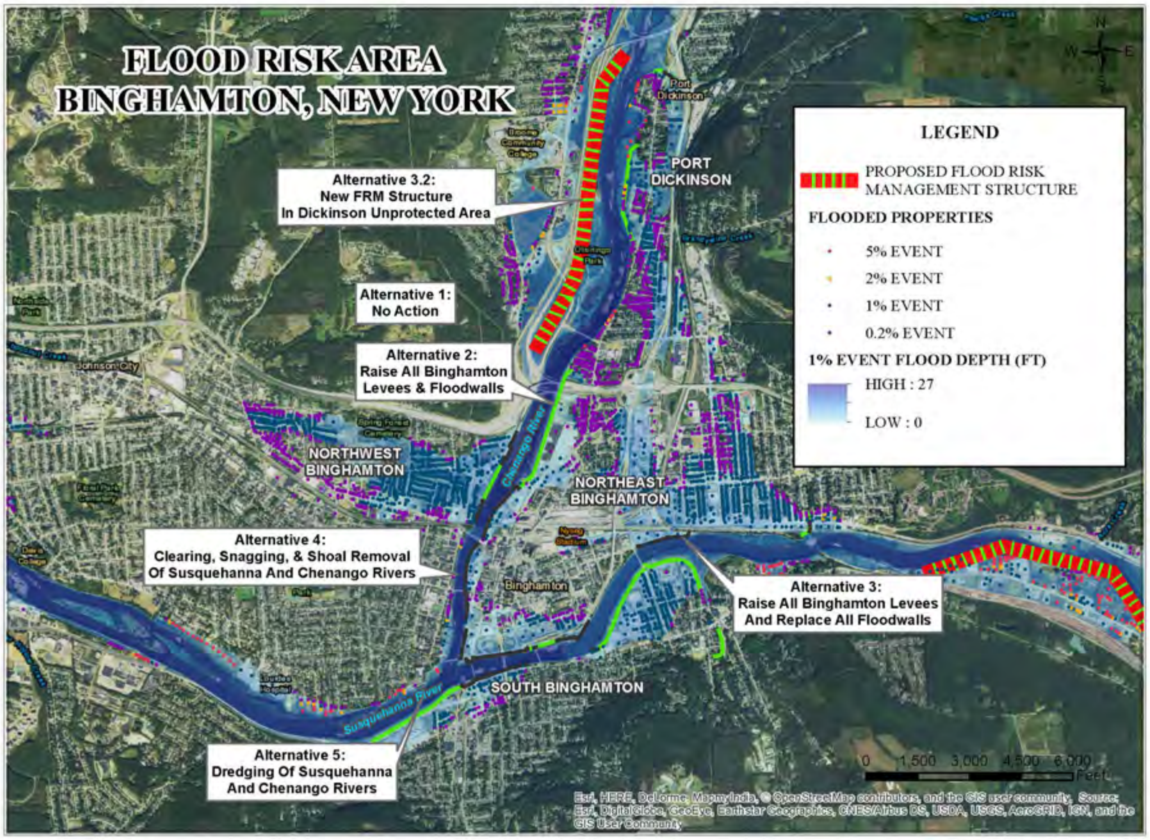
The alternative formulation process was carried out in planning charettes following the screening of FRM measures. Alternatives formulation consists of an iterative process of alternative development, evaluation, and deliberation, which can broadly be characterized by two formulation phases and a process to categorize the remaining alternatives based on whether they would be analyzed in Alternative Plans in the feasibility study or provided as programmatic recommendations. The level of detail was increased in each stage of the analysis to reduce the level of uncertainty with associated decisions.

Alternatives formulation was iterative with initial formulation followed by evaluation of alternatives using screening criteria that were informed by the results from preliminary analysis. The screening criteria were agreed upon by USACE and NYSDEC in planning charettes. The screening criteria for the initial evaluation of alternatives include:

- **Preliminary federal interest calculation**
- **Feasible from an engineering perspective**
- **Acceptability of environmental, social, cultural, and historical impacts**

A contextual evaluation of the results of the preliminary analysis was implemented to justify the analysis with narrative support. Alternatives in the initial array that did not meet screening criteria were eliminated from consideration in the focused array of alternatives. Alternatives in the initial array that were eliminated early in the plan formulation process may have a lower level of detail in environmental and cultural evaluation presented in this Appendix, due to the fact that they were not evaluated further following initial screening. The focused array of alternatives is detailed in the main report. The economic evaluation and engineering analysis of the focused array of alternatives are included in Appendix B Economics and Appendix C Engineering respectively. Annex 1 contains additional information on environmental screening considerations.

4.1 THE CITY OF BINGHAMTON AND VILLAGE OF PORT DICKINSON



DATE PREPARED: 2-9-2018

Figure 6: Mapped Initial Array of Alternatives for Binghamton/Port Dickinson

4.1.1 INITIAL ARRAY OF ALTERNATIVES

The following initial alternatives were formulated to address flood risk problems in Binghamton/Port Dickinson:

- Alternative 1: No Action
- Alternative 2: Raise all levees & floodwalls in the Binghamton FRM Project
- Alternative 2.1: Raise Northeast Binghamton levee segment along the left bank of the Chenango River
- Alternative 2.2: Raise Northwest Binghamton levee segment along the right bank of the Chenango River
- Alternative 2.3: Raise South Binghamton levee segment along the left bank of the Susquehanna River
- Alternative 2.4: Raise Northeast Binghamton levee segment along the right bank of the Susquehanna River
- Alternative 3: Raise all levees & rebuild all floodwalls to a higher elevation in the Binghamton FRM Project
- Alternative 3.1: Rebuild all floodwalls to a higher elevation in the Binghamton FRM Project
- Alternative 3.2: New levee segment in Dickinson unprotected area between Dickinson north boundary & Dickinson Town Court

- Alternative 3.3: New levee segment in Binghamton unprotected area from Front Street to Ackley Street along the right bank of the Susquehanna River
- Alternative 3.4: New levee segment in Binghamton unprotected area from Home Avenue to Iva Avenue along the left bank of the Susquehanna River
- Alternative 3.5: New levee segment in Binghamton unprotected area from Binghamton eastern boundary to Northwest Binghamton levee along the right bank of the Susquehanna River
- Alternative 3.6: New levee segment in Binghamton unprotected area from the Binghamton southeast boundary to tributary stream along the left bank of the Susquehanna River
- Alternative 3.7: New levee segment in Binghamton unprotected area from Edgebrook Road to Service Road along the right bank of the Susquehanna River
- Alternative 4: Clearing, snagging, & shoal removal of Susquehanna and Chenango Rivers in Binghamton
- Alternative 5: Dredging of Susquehanna & Chenango Rivers in Binghamton
- Alternative 5.1: Dredging of Chenango River in Binghamton only
- Alternative 5.2: Dredging of Susquehanna River in Binghamton only
- Alternative 6: Non-structural measures in Binghamton

4.1.2 PRELIMINARY FEDERAL INTEREST

Preliminary federal interest is evaluated by comparing annualized preliminary damage estimates from the watershed screening versus annualized parametric costs estimates for the proposed alternatives. Both assumptions for damage reduction are used to examine the feasibility of proposed alternatives based on their damage reduction potential. It is important to note that these values represent an attempt to characterize the potential for federal interest based on the magnitude of damage reduction from proposed actions and do not represent benefit-cost ratios since there is greater uncertainty with damage estimates and cost estimates at this stage of the analysis. Federal interest will be confirmed and validated using USACE's HEC-FDA modeling in the evaluation of the focused array of alternatives. Values greater than 1 indicate that the damage reduction potential of the proposed alternative is greater than the cost for each damage reduction category. Results for Binghamton are illustrated in Table 13.

Table 13: Preliminary Federal interest screening for Binghamton Initial Array of Alternatives

Initial Alternatives	Preliminary Federal Interest	
	Assuming 50% Damage Reduction	Assuming 66% Damage Reduction
Alternative 1: No Action	X	X
Alternative 2: Raise all levees & floodwalls in the Binghamton Project	1.7	2.3
Alternative 2.1: Raise Northeast Binghamton levee segment along the left bank of the Chenango River	2.1	2.8
Alternative 2.2: Raise Northwest Binghamton levee segment along the right bank of the Chenango River	4.0	5.4
Alternative 2.3: Raise South Binghamton levee segment along the left bank of the Susquehanna River	0.3	0.4
Alternative 2.4: Raise Northeast Binghamton levee segment along the right bank of the Susquehanna River	3.9	5.2
Alternative 3: Raise all levees & rebuild all floodwalls to a higher elevation in the Binghamton System	0.5	0.6
Alternative 3.1: Rebuild all floodwalls to a higher elevation in the Binghamton System	0.6	0.8
Alternative 3.2: New levee segment in Dickinson unprotected area between Dickinson North Boundary & Dickinson Town Court	2.0	2.7
Alternative 3.3: New levee segment in Binghamton unprotected area from Front St to Ackley St along the right bank of the Susquehanna River	0.9	1.1
Alternative 3.4: New levee segment in Binghamton unprotected area from Home Avenue to Iva Avenue along the left bank of the Susquehanna River	0.3	0.4
Alternative 3.5: New levee segment in Binghamton unprotected area from Binghamton Eastern Boundary to Northwest Binghamton Levee along the right bank of the Susquehanna River	0.6	0.7
Alternative 3.6: New levee segment in Binghamton unprotected area from the Binghamton Southeast Boundary to Tributary Stream along the left bank of the Susquehanna River	0.1	0.2
Alternative 3.7: New levee segment in Binghamton unprotected area from Edgebrook Rd to Service Rd along the right bank of the Susquehanna River	0.1	0.1
Alternative 4: Clearing, Snagging, & Shoal Removal of Susquehanna and Chenango Rivers in Binghamton*	2.1	2.7
Alternative 5: Dredging of Susquehanna & Chenango Rivers in Binghamton*	0.7	0.9
Alternative 5.1: Dredging of Chenango River in Binghamton Only*	0.6	0.8
Alternative 5.2: Dredging of Susquehanna River in Binghamton Only*	0.7	0.9
Alternative 6: Non-Structural Measures in Binghamton**	X	X

**Parametric cost estimate do not include O&M costs.*
***Evaluated in the focused array of alternatives only.*

4.1.3 ENGINEERING FEASIBILITY

- (Alternative 2.0) Raise all levees & floodwalls in the Binghamton FRM Project–Feasible

- (Alternatives 2.1 to 2.4) Raise levee segments in Binghamton FRM Project – Likely not feasible, raising one segment or system will have induced flooding impacts in hydraulically linked components of the project, which will have to be raised to mitigate impacts from flooding.
- (Alternatives 3.0 to 3.1) Raising levees and/or floodwall with floodwall replacement – Feasible
- (Alternative 3.2) New levee segment in Dickinson unprotected area - Insufficient information available to make a determination. Hydraulic modeling may not be considering the impacts of the interstate highway on flood inundation results.
- (Alternative 3.3) New levee segment in Binghamton unprotected area from Front Street to Ackley Street – Not feasible, the hydraulic modeling assumes that Lourdes Hospital is not protected (existing floodwall), which contains a majority of the damages in this reach.
- (Alternatives 3.4 to 3.7) New levee segments – Feasible
- (Alternative 4) Clearing, snagging & shoal removal in Susquehanna and Chenango Rivers (large extent) – Maybe feasible, this is likely feasible but would realize limited flood reduction benefits and disproportionate environmental impacts
- (Alternatives 5.0 to 5.2) Dredging of Susquehanna and Chenango Rivers – Not feasible, large scale dredging is unlikely to realize the expected flood damage reduction benefits

4.1.4 ENVIRONMENTAL ACCEPTABILITY

The environmental acceptability criteria is intended to highlight the potential for environmental impacts that may be deemed unacceptable by USACE or the public. In the environmental screening, the PDT assessed the level of concern (low to high) of proposed alternatives and documented this assessment with information from maps and online sources (USFWS, 2018).

Table 14: Preliminary evaluation of environmental concerns for Binghamton Initial Array of Alternatives

Proposed Project	Farmland (Direct Impacts)	HTRW (Direct or Indirect Impacts)	Streams/Rivers (Waters) (Direct Impacts)	Wetlands (Direct Impacts)
(Alternatives 2.0 to 2.4) Raising existing levee/ floodwall	Low	Low	Low	Low
(Alternatives 3.2 and 3.3) New FRM Structures (Levees) in Dickinson; and south bank Susquehanna River in Conklin Town	Low	Low	Low	Low opposite Port Dickinson, Moderate on south bank - avoid wetlands at Temple Israel Riverside Cemetery
(Alternative 4) Clearing/snagging/shoal removal Chenango and Susquehanna Rivers	Low	Low	High - need detailed evaluation of aquatic environmental impacts	Moderate - avoid wetlands on Susquehanna River islands and shoreline downstream of Chenango River confluence.
(Alternatives 5.0 to 5.2) Dredging of Susquehanna and Chenango Rivers	Low	Low	High - need detailed evaluation of aquatic environmental impacts	Moderate - avoid wetlands on Susquehanna River islands and shoreline downstream of Chenango River confluence.

4.1.5 CULTURAL/HISTORICAL IMPACTS

- (Alternative 2) - Modifying an existing levee or raising existing floodwalls would require an assessment of visual impacts on historic properties. Unless the modifications call for excavation outside of the already-existing limits of disturbance, effects to archaeological or direct physical impacts to architectural resources should be nonexistent or minimal. Depending on the height increase, visual effects to historic properties should result in no adverse effects. According to the New York CRIS database, a small portion of the floodwall is included within the Binghamton Court Street Historic District. Consultation with the NYSHPO would be necessary to determine the nature and extent of impacts the proposed floodwall raising will have on this historic district.

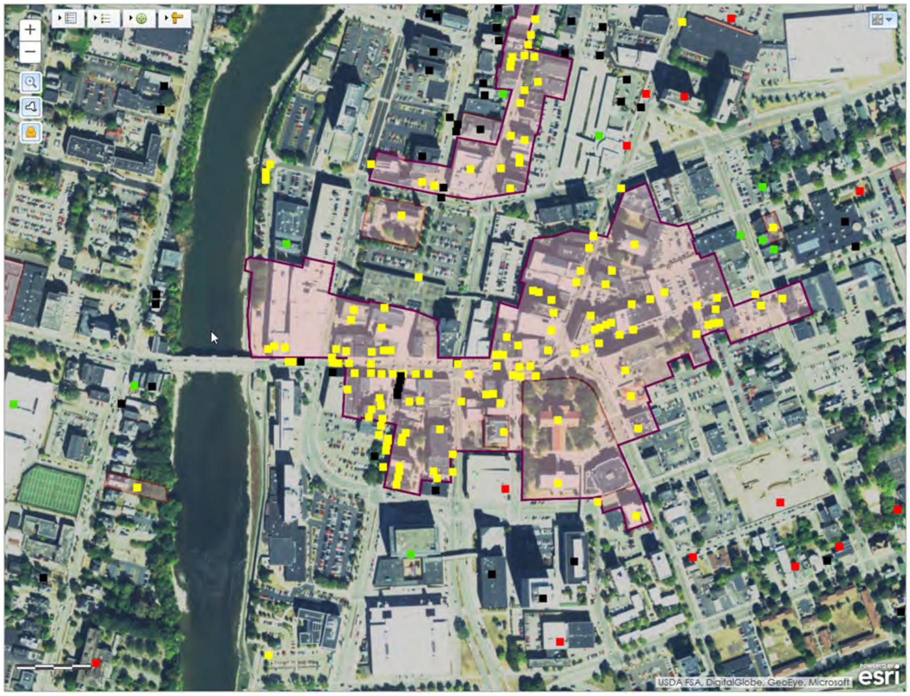


Figure 7: Court Street Historic District, City of Binghamton

- (Alternative 6) Non-structural measures - There do not appear to be any architectural resources that are listed, eligible, or undetermined for listing in the National Register of Historic Places (NRHP) within the area designated for non-structural measures. There is one prehistoric archaeological site, the Rogan Site, within this area, but effects to this resource should be minimal or non-existent depending on the non-structural measure.

Figure 8: Potential non-structural measures areas, City of Binghamton and Town of Vestal

4.1.6 SOCIAL IMPACTS

The potential for social impacts from proposed alternatives were examined using social vulnerability metrics for each focus risk area examined to determine potential impacts to historically disadvantaged communities including children, the elderly, minority, and low income populations. A short discussion on social impacts is detailed below for Binghamton. For other flood risk areas, social vulnerability is detailed in Appendix B Economics.

Binghamton has higher percentages of minority and low-income populations when compared to other communities in the USRB. The north side neighborhood, located north of the rail yards and west of New York State Highway 7, has specific challenges related to poverty and inequity (Blueprint Binghamton, 2014). Binghamton also has one home for the elderly at moderate risk of flooding, meaning that they may be directly impacted by the 0.2 percent chance flood event; the Lincoln Court Apartments in South Binghamton.

4.2 THE TOWN OF UNION AND ENDICOTT-JOHNSON CITY-VESTAL

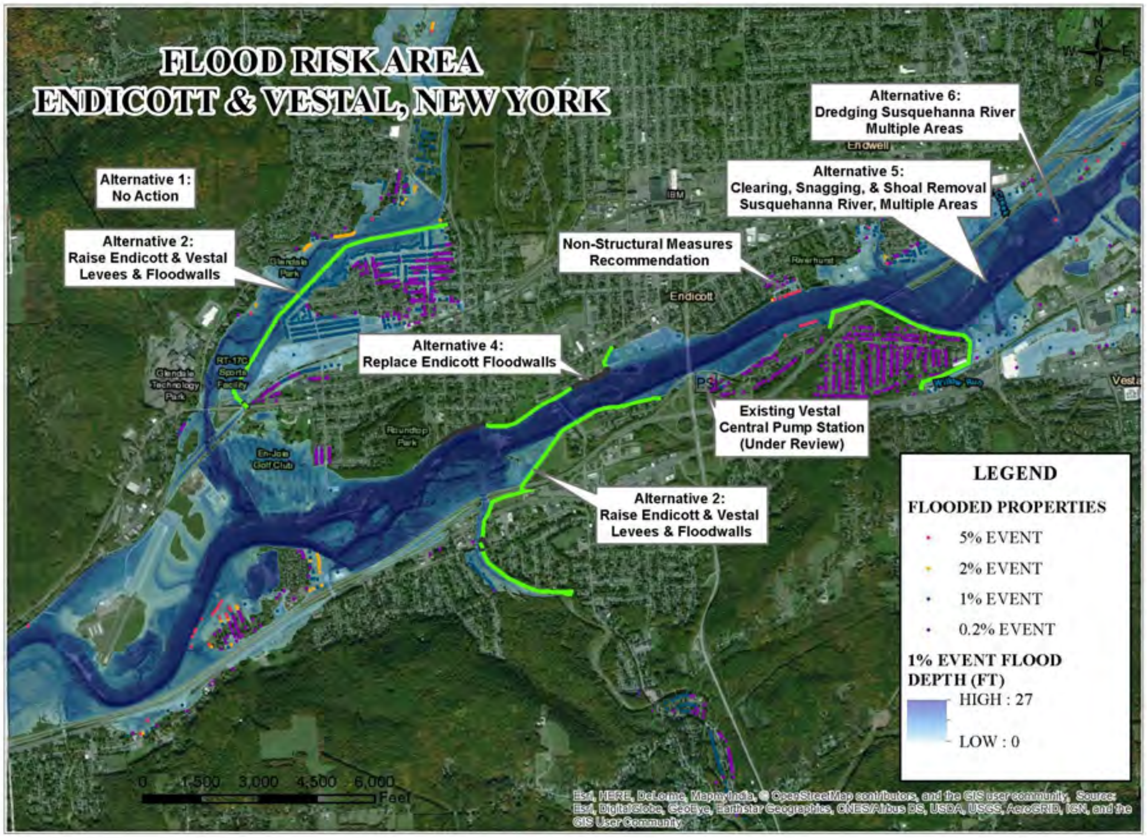


Figure 9: Mapped Initial Array of Alternatives for Endicott, Town of Vestal, and Town of Union

4.2.1 INITIAL ARRAY OF ALTERNATIVES

The following initial alternatives were formulated to address flood risk problems in Endicott-Johnson City-Vestal and the Town of Union:

- Alternative 1: No Action
- Alternative 2: Raise all levees & floodwalls in the Endicott and Vestal Systems
- Alternative 2.1: Raise all levees & floodwalls in the Endicott System
- Alternative 2.2: Raise all levees in the West Vestal levee segment (Twin Orchards)
- Alternative 2.3: Raise all levees and floodwalls in the East Vestal levee segment (Big Choconut Creek segment)
- Alternative 3: Raise all levees & floodwalls in the Johnson City System
- Alternative 3.1: Relocate and replace existing levee segment by former BAE plant site in Johnson City (Little Choconut Creek segment)
- Alternative 4: Rebuild all existing floodwalls to a higher elevation in the Endicott System

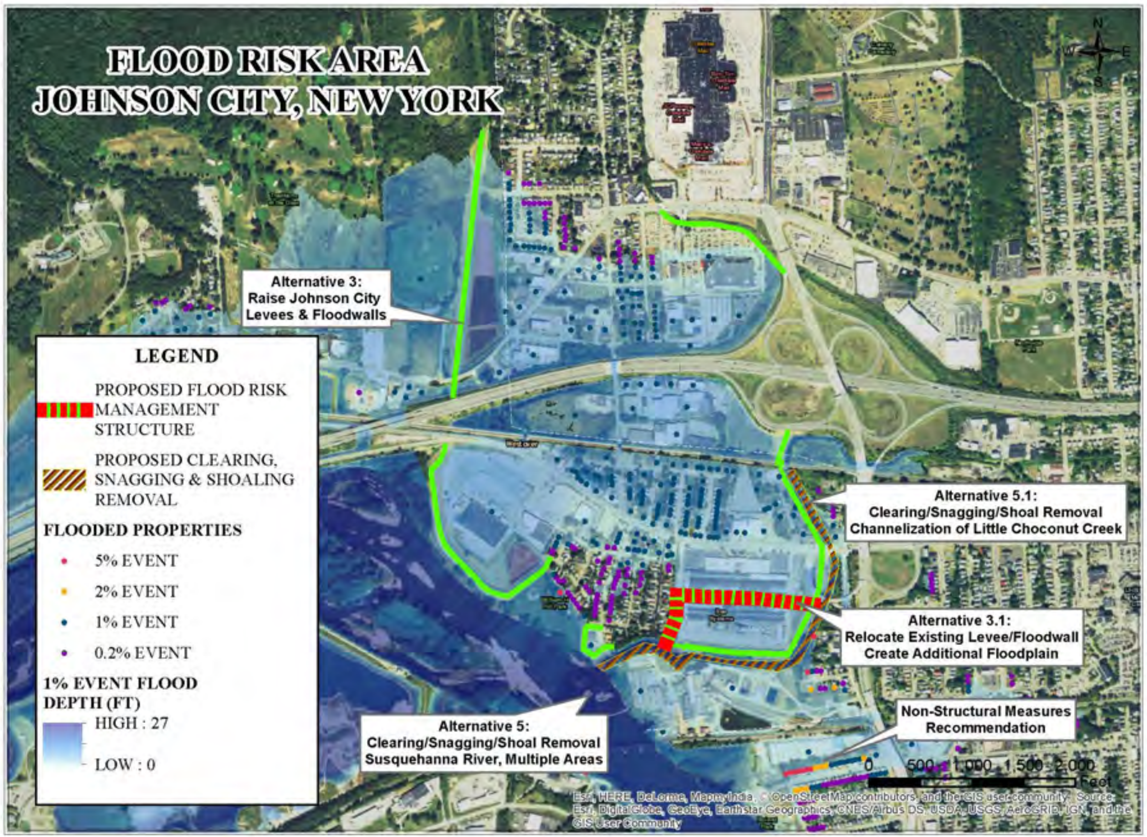


Figure 10: Mapped Initial Array of Alternatives for Johnson City and Town of Union

- Alternative 5: Clearing, Snagging, & Shoal Removal of Susquehanna River between Johnson City & Endicott-Vestal
- Alternative 5.1: Clearing, Snagging, & Shoal Removal of Little Choconut Creek (Johnson City)
- Alternative 6: Dredging of Susquehanna River between Johnson City & Endicott-Vestal
- Alternative 7: Pump Station at various locations in the EJV system
- Alternative 8: Non-Structural Measures in Endicott, Johnson City, Vestal, and Town of Union

4.2.2 PRELIMINARY FEDERAL INTEREST

The results of the preliminary federal interest screening analysis for EJV are illustrated in Table 15.

Table 15: Preliminary Federal interest screening for EJV Initial Array of Alternatives

Initial Alternatives	Preliminary Federal Interest Assuming 50% Damage Reduction	Preliminary Federal Interest Assuming 66% Damage Reduction
Alternative 1: No Action	X	X
Alternative 2: Raise all levees & floodwalls in the Endicott and Vestal Systems	0.1	0.2
Alternative 2.1: Raise all levees & floodwalls in the Endicott System	0.3	0.4
Alternative 2.2: Raise all levees in the West Vestal levee segment (Twin Orchards)	0.0	0.0
Alternative 2.3: Raise all levees and floodwalls in the East Vestal levee segment (Big Choconut Creek)	0.2	0.2
Alternative 3: Raise all levees & floodwalls in the Johnson City System	0.7	0.9
Alternative 3.1: Relocate and replace existing levee segment by former BAE plant site in Johnson City (Little Choconut Creek)	1.9	2.5
Alternative 4: Rebuild all existing floodwalls to a higher elevation in the Endicott System	0.0	0.0
Alternative 5: Clearing, snagging, & shoal removal of Susquehanna River between Johnson City & Endicott-Vestal*	3.0	4.1
Alternative 5.1: Clearing, snagging, & shoal removal of Little Choconut Creek (Johnson City)*	4.6	6.2
Alternative 6: Dredging of Susquehanna River between Johnson City & Endicott-Vestal*	1.0	1.4
Alternative 7: Pump station at various locations in the EJV system**	X	X
Alternative 8: Non-structural measures in Endicott, Johnson City, Vestal, and Town of Union***	X	X

**Parametric cost estimate do not include O&M costs.*
***Pump stations were only evaluated if levee raising was proposed as a feasible alternative.*
****Evaluated in the focused array of alternatives only.*

4.2.3 ENGINEERING FEASIBILITY

- (Alternative 2) Raise all levees & floodwalls in the Endicott and Vestal Systems - Feasible
- (Alternative 2.1 to 2.3) Raise all levees & floodwalls in Endicott or Vestal levee segments – Likely not feasible, raising one segment or system will have induced

flooding impacts in hydraulically linked components of the FRM project, which will have to be raised to mitigate impacts from flooding.

- (Alternative 3) Raise all levees & floodwalls in the Johnson City System – Feasible, hydraulic modeling would have to be examined to determine if raising would result in induced flooding impacts in Endicott-Vestal downstream or Binghamton upstream
- (Alternative 3.1) Relocate and replace existing levee segment by former BAE plant site in Johnson City (Little Choconut Creek segment) - Feasible
- (Alternative 4) Rebuild all existing floodwalls to a higher elevation in the Endicott System – Feasible with raising elsewhere to avoid induced flooding impacts
- (Alternative 5) Clearing, snagging, & shoal removal of Susquehanna River between Johnson City & Endicott-Vestal – Maybe feasible, this is likely feasible but would realize limited flood reduction benefits and disproportionate environmental impacts
- (Alternative 5.1) Clearing, snagging, & shoal removal of Little Choconut Creek (Johnson City) – Feasible due to smaller project area and likelihood of reducing WSE from backflooding in the Susquehanna River
- (Alternative 6) Dredging of Susquehanna River between Johnson City & Endicott-Vestal - Not feasible, large scale dredging is unlikely to realize the expected flood damage reduction benefits
- (Alternative 7) Pump station at various locations in the EJV system – Feasible where interior drainage is an issue. A preliminary cost estimate for pump stations was prepared for preliminary analysis but no detailed analysis for interior drainage issues, pump capacity/size, pump locations or prospective needs have been examined at this preliminary stage.

4.2.4 ENVIRONMENTAL ACCEPTABILITY

The environmental acceptability for EJV alternatives is shown in Table 16.

Table 16: Preliminary evaluation of environmental concerns for EJV Initial Array of Alternatives

Proposed Project	Farmland (Direct Impacts)	HTRW (Direct or Indirect Impacts)	Streams/Rivers (Waters) (Direct Impacts)	Wetlands (Direct Impacts)
(Alternatives 2.0) Raising existing levee/floodwall in Endicott and Vestal	Low	High - evaluate whether Endicott Dump on Anson Road could constrain improvement designs	Low	Low
(Alternatives 3.0) Raising existing levee system in Johnson City	Low	High - determine whether Air Force Plant 59 superfund site could affect project designs	Low	Low
(Alternative 5) Clearing/snagging/shoal removal - Susquehanna River	Low	Low	High - need detailed evaluation of aquatic environmental impacts	Moderate - avoid wetlands on Susquehanna River islands
(Alternative 6) Dredging of Susquehanna River	Low	Low	High - need detailed evaluation of aquatic environmental impacts	Moderate - avoid wetlands on Susquehanna River islands

4.2.5 CULTURAL/HISTORICAL IMPACTS

- (Alternative 2.1) Raising existing levee/floodwall system (Endicott) - Modifying an existing levee or raising existing floodwalls would require an assessment of visual impacts on historic properties. Unless the modifications call for excavation outside of the already-existing limits of disturbance, effects to archaeological or direct physical impacts to architectural resources should be nonexistent or minimal. Depending on the height increase, visual effects to historic properties should result in no adverse effects. The only buildings near the northern most

Endicott levee are situated near its eastern terminus. There are approximately eight buildings eligible for the NRHP that could be visually impacted by the proposed modifications. Although there are four archaeological sites (no closer than 350 ft.) near the existing levee, these should not be affected by the proposed modifications.

Near the levee on the south side of Endicott is one eligible building, an eligible bridge, an eligible archaeological site, and an NRHP listed cemetery. Levee modifications should only affect these properties visually, however, the archaeological site should be approached with caution. Named the Chambers Site, it is a prehistoric habitation site noted on the New York CRIS database as containing human remains. Its respective archaeological inventory form, however, does not mention human remains and notes that the area had been previously disturbed. This site is located near the intersection of the existing levee and the Vestal Avenue Bridge.

Figure 11: Historic buildings, Village of Endicott (North)

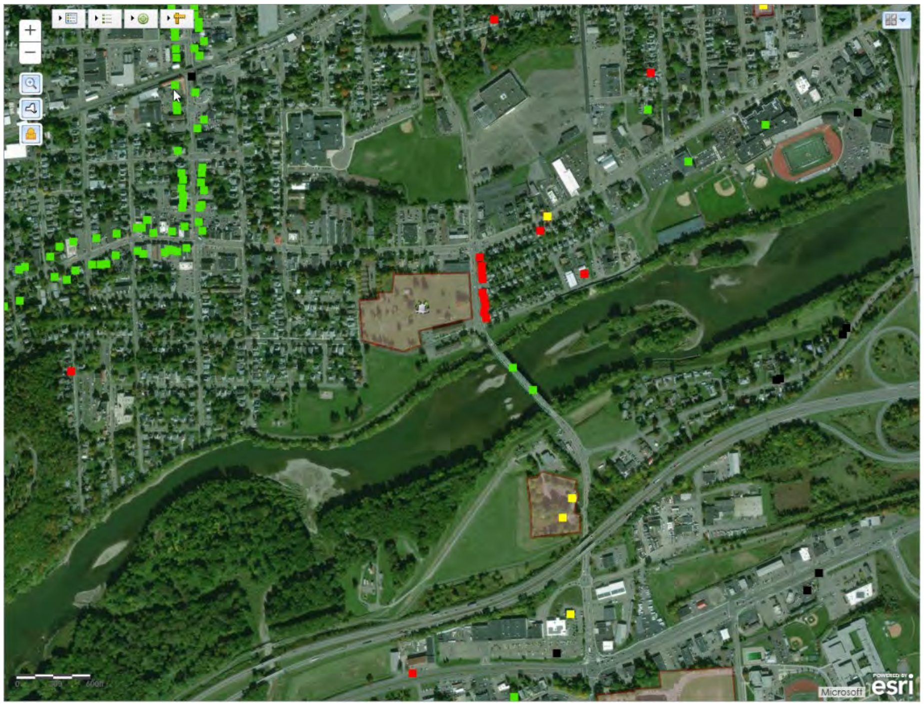


Figure 12: Historic buildings, Village of Endicott (South)

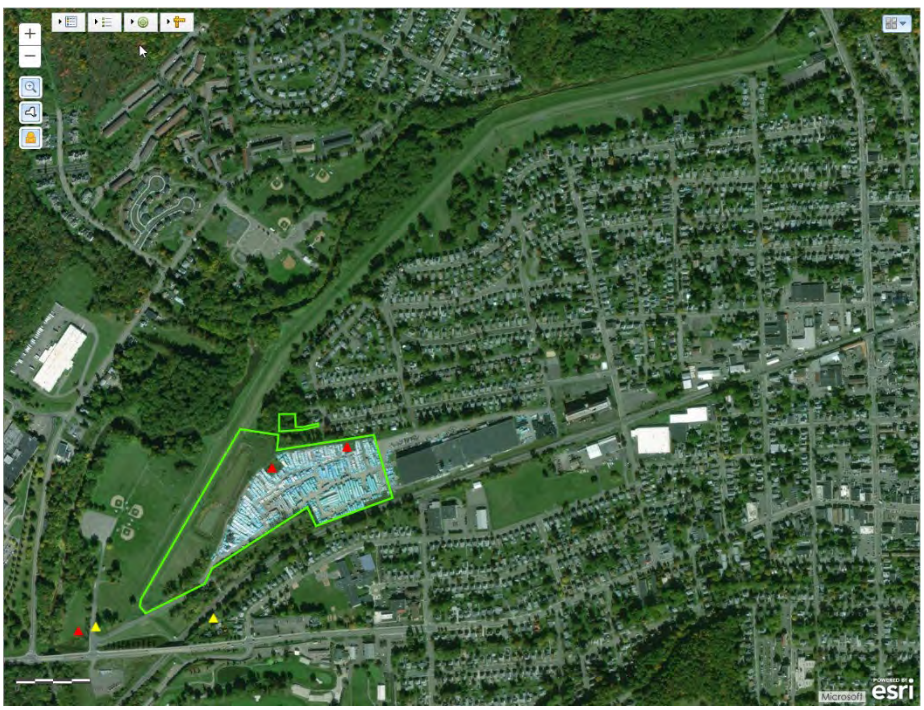


Figure 13: Inventoried cultural resources (archaeological sites/surveys), Village of Endicott (North)

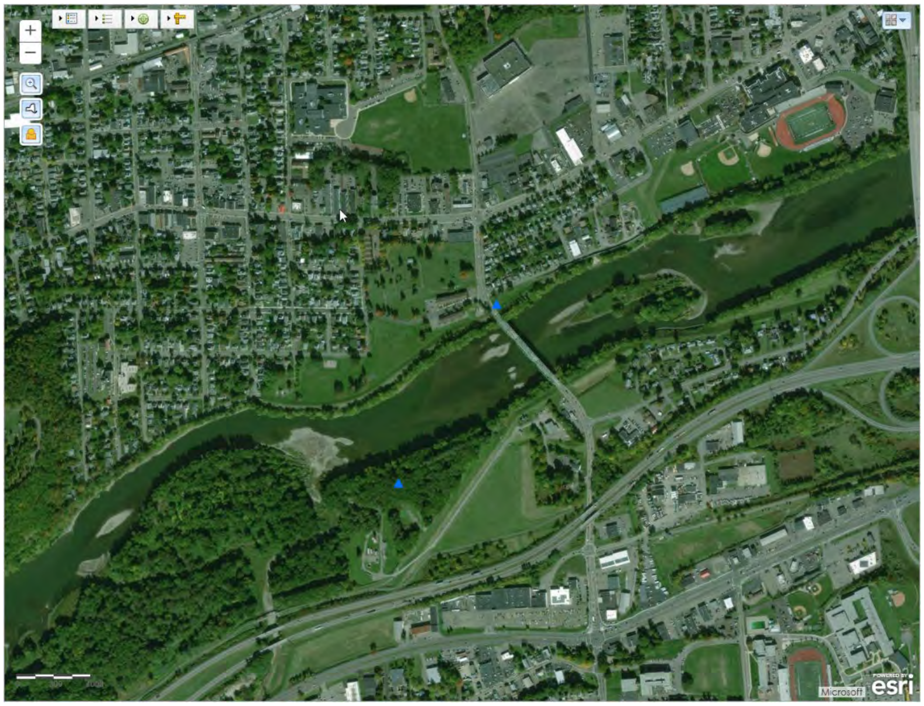


Figure 14: Inventoried cultural resources (archaeological sites/surveys), Village of Endicott (South)

- (Alternative 2.2) Raising an existing levee segment (West Vestal) - Modifying an existing levee or raising existing floodwalls would require an assessment of visual impacts on historic properties. Unless the modifications call for excavation outside of the already-existing limits of disturbance, effects to archaeological or direct physical impacts to architectural resources should be nonexistent or minimal. Depending on the height increase, visual effects to historic properties should result in no adverse effects. The only historic buildings near the west vestal levee are the Rounds Family Residence and Drovers Inn, both listed on the National Register. Modifying the existing levee may have an effect on the viewshed of these properties. The levee is also in the viewshed of the NRHP eligible Vestal Avenue Bridge.

Figure 15: Historic buildings, West Vestal (Town)

Figure 16: Inventoried cultural resources (archaeological sites/surveys), West Vestal (Town)

- (Alternative 2.3) Raising an existing levee segment (East Vestal) - The East Vestal levee is in close proximity to two historic properties, an NRHP Undetermined prehistoric archaeological site and an NRHP eligible 19th century barn complex. Modifying the existing levee would have a visual impact on the barn complex, but it is unclear what effect it would have on the archaeological site since it is just within 50 feet of the levee.

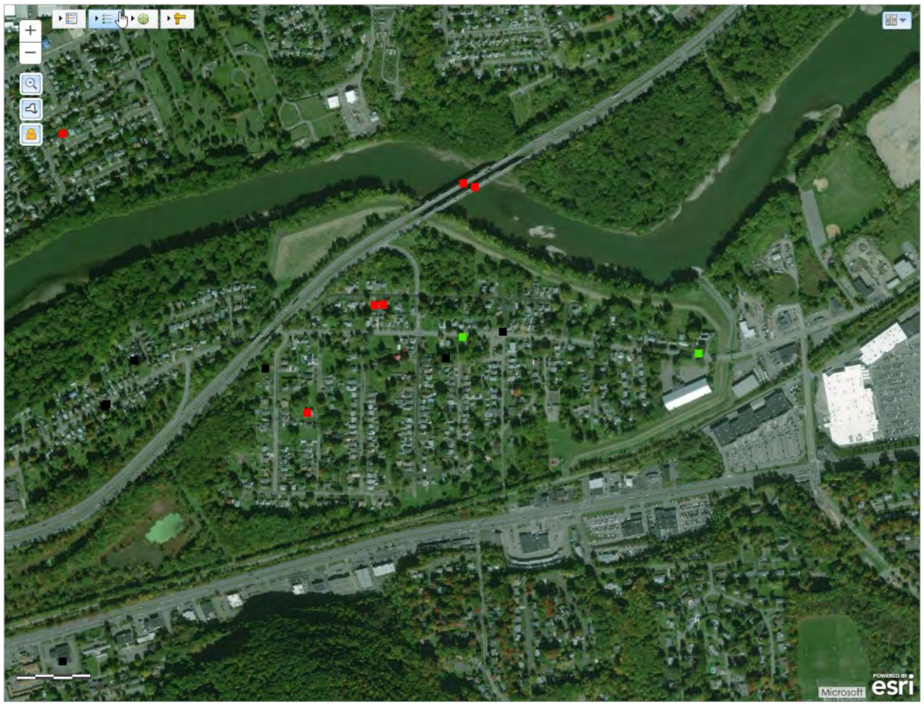


Figure 17: Historic buildings, East Vestal (Town)

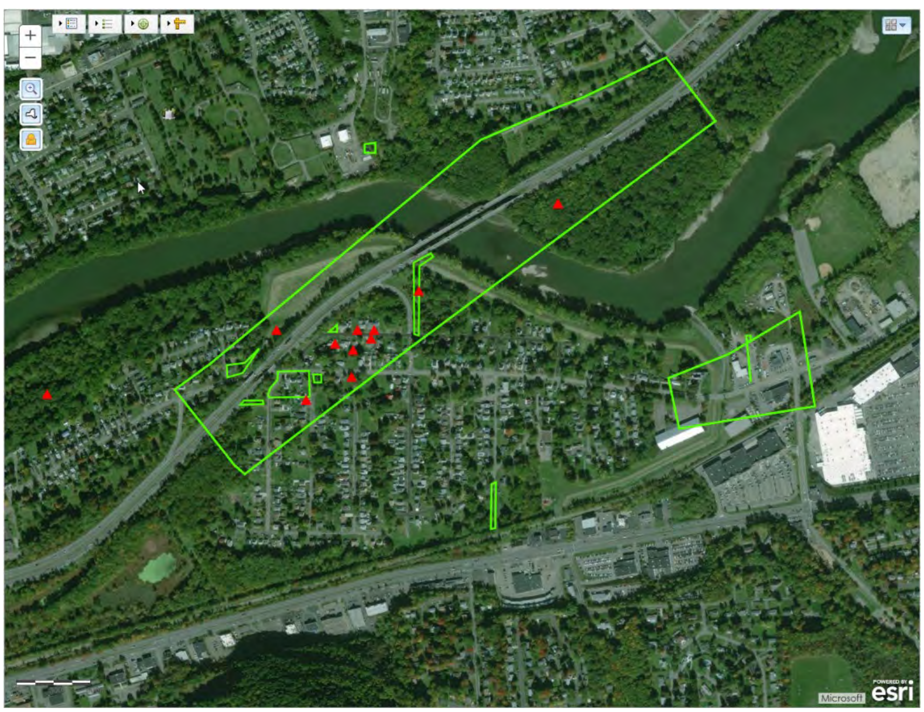


Figure 18: Inventoried cultural resources (archaeological sites/surveys), East Vestal (Town)

- (Alternative 3) Raising an existing levee system (Johnson City) - Modifying an existing levee or raising existing floodwalls would require an assessment of visual impacts on historic properties. Unless the modifications call for excavation outside of the already-existing limits of disturbance, effects to archaeological or direct physical impacts to architectural resources should be nonexistent or minimal. Depending on the height increase, visual effects to historic properties should result in no adverse effects. The only historic property that could be affected by modifying the existing levee is the NRHP eligible Air Force Plant at 600 Main St, which was demolished after catastrophic damage in the 2011 flooding.
- (Alternative 3.1) Relocate and replace existing levee near BAE plant in Johnson City - A floodwall relocated to this location would not adversely impact the NRHP eligible Air Force Plant at 600 Main St since it was demolished following the 2011 flooding.

Figure 19: Historic buildings, Village of Johnson City

- (Alternative 4) Raising Endicott floodwalls - No historic properties are documented near the Endicott floodwalls.
- (Alternative 5 and 6) Clearing/snagging removal and dredging of the Susquehanna River - If this action is occurring in existing channels then the areas have already been disturbed. There are no recorded submerged archaeological sites, but there is a lack of prior survey.
- (Alternative 8) Non-structural measures (Endicott) - Adverse effects to historic properties from implementation of non-structural measures are specific to the historic property treated. There do not appear to be any known historic properties eligible or potentially eligible for listing in the NRHP. The nearest

historic property is an undetermined prehistoric/historic archaeology site with human remains situated near Highway 26 to the west.

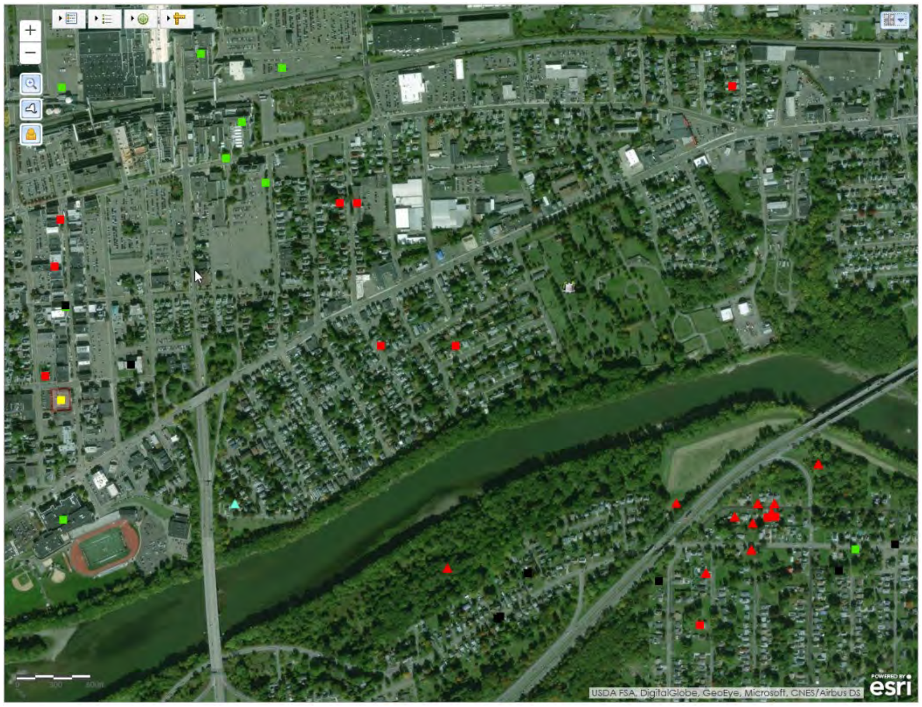


Figure 20: Potential non-structural measures areas, Town of Union

- (Alternative 8) Non-structural measures (Vestal) - Adverse effects to historic properties from implementation of non-structural measures are specific to the historic property treated. Within the area for non-structural measures, there is one NRHP eligible building, one NRHP undetermined building, and one NRHP undetermined historic archaeological site.
- (Alternative 8) Non-structural measures (Johnson City) - Adverse effects to historic properties from implementation of non-structural measures are specific to the historic property treated. Within the area of proposed non-structural measures there are 50 NRHP undetermined buildings and one NRHP eligible building.

Figure 21: Potential non-structural measures areas, Town of Vestal

Figure 21: Potential non-structural measures areas, Village of Johnson City and Town of Union

4.3 THE CITY OF ONEONTA

4.3.1 EXISTING CONDITIONS

The City of Oneonta is primarily affected by residual flood risk from infrequent, high intensity events, which can result in overtopping of the non-federal Mill Race levee in Oneonta. Additionally, the City of Oneonta also has increased risk to flooding due to backflow of water into Mill Race from the mainstem of the Susquehanna River through the I-88 culverts, which need large flap gates to prevent this flow.

4.3.2 INITIAL ARRAY OF ALTERNATIVES

The following initial alternatives were formulated to address flood risk problems in Oneonta:

- Alternative 1: No Action
- Alternative 2: Raise existing non-federal Mill Race levee at Neahwa Pl
- Alternative 3: Pump station at Mill Race levee
- Alternative 4: Clearing, snagging, & shoal removal of Susquehanna River in Oneonta
- Alternative 5: Dredging of Susquehanna River in Oneonta
- Alternative 6: Raising of Neahwa Place Bridge
- Alternative 7: Non-structural measures for Oneonta

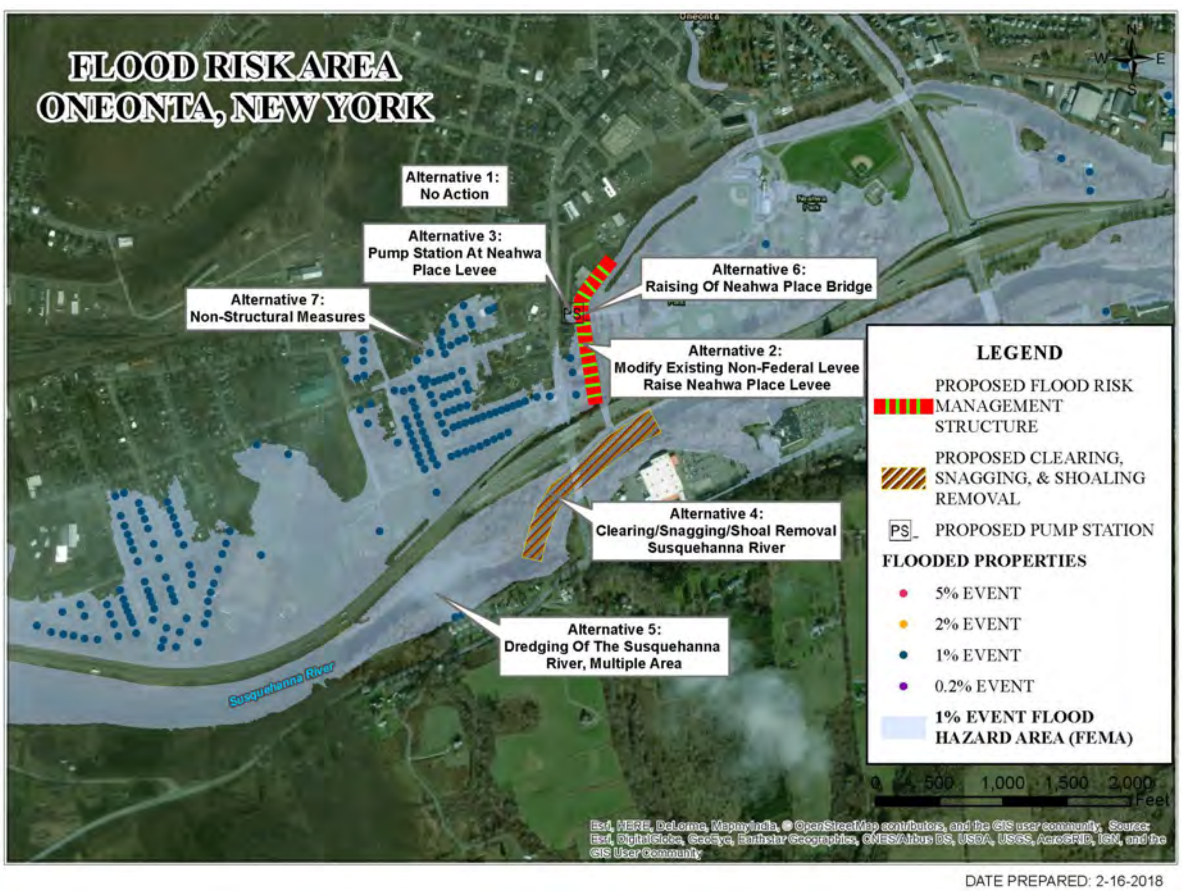


Figure 22: Mapped Initial Array of Alternatives for Oneonta

4.3.3 PRELIMINARY FEDERAL INTEREST

The results of the preliminary federal interest screening analysis for Oneonta are illustrated in Table 17.

Table 17: Preliminary Federal interest screening for Oneonta Initial Array of Alternatives

Initial Alternatives	Preliminary Federal Interest Assuming 50% Damage Reduction	Preliminary Federal Interest Assuming 66% Damage Reduction
Alternative 1: No Action	X	X
Alternative 2: Raise existing non-federal levee Mill Race levee at Neahwa Pl	1.6	2.1
Alternative 3: Pump station at Mill Race levee**	X	X
Alternative 4: Clearing, snagging, & shoal removal of Susquehanna River in Oneonta*	0.4	0.6
Alternative 5: Dredging of Susquehanna River in Oneonta*	0.4	0.6
Alternative 6: Raising of Neahwa Place Bridge	0.0	0.0
Alternative 7: Non-structural measures for Oneonta***	X	X

**Parametric cost estimate do not include O&M costs.*
***Pump stations were only evaluated if levee raising was proposed as a feasible alternative.*
****Evaluated in the focused array of alternatives only.*

4.3.4 ENGINEERING FEASIBILITY

- (Alternative 2) Raise existing non-federal Mill Race levee at Neahwa Pl – Feasible, closure structure will need to be raised (not part of parametric costs)
- (Alternative 3) Pump Station at Mill Race levee – Feasible, if needed.
- (Alternative 4) Clearing, Snagging, & Shoal Removal of Susquehanna River in Oneonta – Feasible, existing clearing/snagging project in areas with the most need
- (Alternative 5) Dredging of Susquehanna River in Oneonta - Not Feasible, large scale dredging is unlikely to realize the expected flood damage reduction benefits
- (Alternative 6) Raising of Neahwa Place Bridge – Not feasible, as this alternative must take place in conjunction with levee raising, this alternative would likely not yield the desired benefits. A higher closure structure at the existing closure location will likely product the desired benefits without the added cost.

4.3.5 ENVIRONMENTAL ACCEPTABILITY

The environmental acceptability for Oneonta alternatives is shown in Table 18.

Table 18: Preliminary evaluation of environmental concerns for Oneonta Initial Array of Alternatives

Proposed Project	Farmland (Direct Impacts)	HTRW (Direct or Indirect Impacts)	Streams/Rivers (Waters) (Direct Impacts)	Wetlands (Direct Impacts)
(Alternative 2) Raise existing non-federal Mill Race levee at Neahwa Pl	Low	Low	Moderate - consider impacts to adjacent stream (east of new levee)	Low

4.3.6 CULTURAL/HISTORICAL IMPACTS

The flood risk area for structural measures is the same so cultural and historical resources were examined for areas protected by Mill Race levee at Neahwa Place. The identified resources are listed in Table 19 below.

Table 19: Preliminary evaluation of cultural sites and historical properties in Oneonta Initial Array of Alternatives

Type	Status	Name/Title	Within APE?	Recommendations/Notes
Archaeological Site	Undetermined	Sash and Blind Factory Historic Site	Maybe	Historic site 168 ft. east of Mill Race levee, on the other side of stream.
Archaeological Site	Undetermined	J. Goodyear Grist and Sawmill Foundry	Maybe	Historic site 168 ft. east of Mill Race levee, on the other side of stream.
Survey	-	Moyer and Moyer 2009 - Phase IA/IB Cultural Resources Survey, Neahwa Park Memorial Walkway Project	No	No archaeological sites documented 505 ft. east of levee
Survey	-	Hartgen 2005 - Phase IB Arch Field Recon, Multiuse Pedestrian Path, Oneonta Susquehanna Greenway Project	No	Three prehistoric sites documented. Sites are not within alternative APE, they are 170 ft. south of area, on I-88
Historic District	Listed in National Register	Oneonta Downtown Historic District	Maybe	Possible visual impacts, 57 contributing resources.
Historic District	Listed in National Register	Oneonta Armory	Maybe	Possible visual impacts.

4.4 THE VILLAGE OF GREENE

4.4.1 EXISTING CONDITIONS

The primary flood risk drivers in the Village of Greene include overbank flooding from the Chenango River in more infrequent, high magnitude flood events, backflooding from the Chenango River along Birdsall Brook, and fast moving flood waters from upland areas down Birdsall Creek, which are mitigated by the Birdsall Creek FRM project.

4.4.2 INITIAL ARRAY OF ALTERNATIVES

The following initial alternatives were formulated to address flood risk problems in Greene:

- Alternative 1: No Action
- Alternative 2: Build a new levee system in Greene along the Chenango River
- Alternative 2.1: Build a new levee segment in Greene along the Chenango River (left bank)
- Alternative 2.2: Build a new levee segment in Greene along the Chenango River (right bank)
- Alternative 3: Clearing, snagging, & shoal removal along Chenango River in Greene
- Alternative 4: Pump station in Greene
- Alternative 5: Non-structural measures in Greene

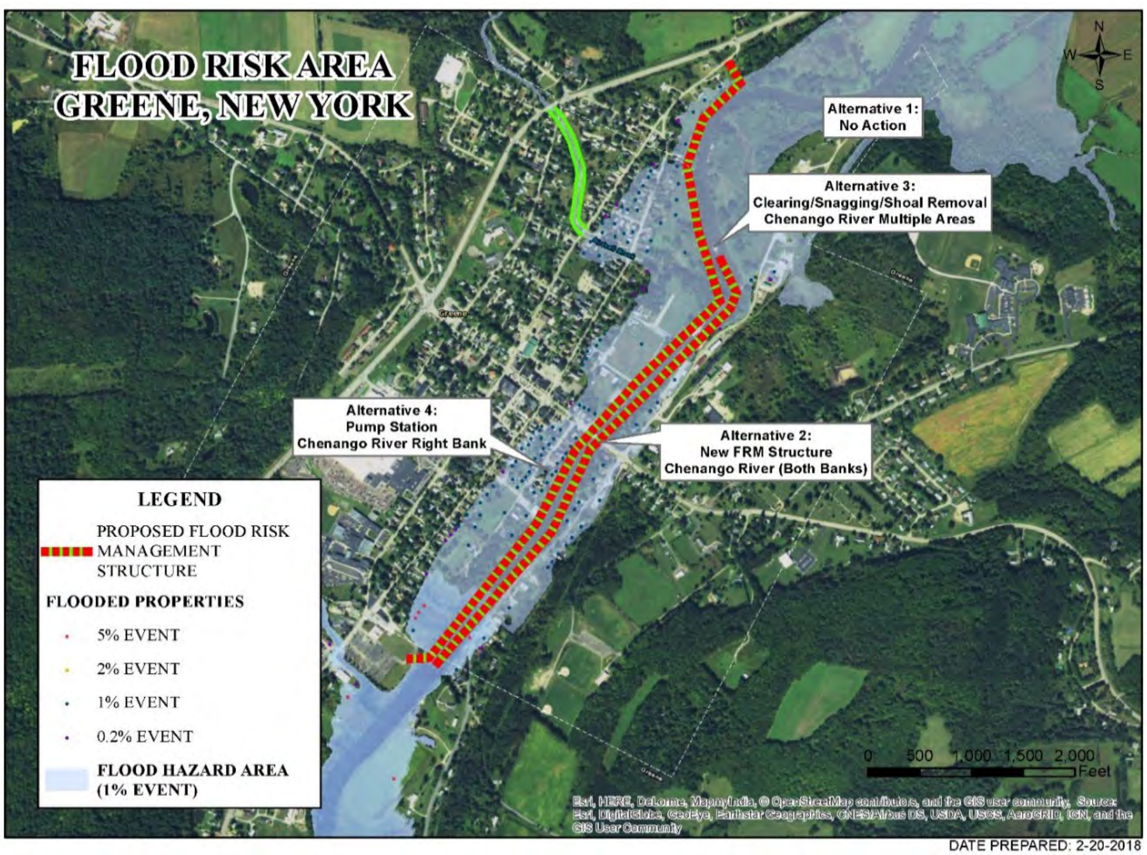


Figure 23: Mapped Initial Array of Alternatives for the Village of Greene

4.4.3 PRELIMINARY FEDERAL INTEREST

The results of the preliminary federal interest screening analysis for Greene are illustrated in Table 20.

Table 20: Preliminary Federal interest screening for Greene Initial Array of Alternatives

Initial Alternatives	Preliminary Federal Interest Assuming 50% Damage Reduction	Preliminary Federal Interest Assuming 66% Damage Reduction
Alternative 1: No Action	X	X
Alternative 2: Build a new levee system in Greene along the Chenango River	0.1	0.1
Alternative 2.1: Build a new levee segment in Greene along the Chenango River (left bank)	0.0	0.0
Alternative 2.2: Build a new levee segment in Greene along the Chenango River (right bank)	0.2	0.2
Alternative 3: Clearing, snagging, & shoal removal along Chenango River in Greene*	0.1	0.2
Alternative 4: Pump station in Greene**	0.0	0.0
Alternative 5: Non-structural measures in Greene***	X	X

**Parametric cost estimate do not include O&M costs.*
***Pump stations were only evaluated if levee raising was proposed as a feasible alternative.*
****Evaluated in the focused array of alternatives only.*

4.4.4 ENGINEERING FEASIBILITY

- (Alternative 2 to 2.2) Build a new levee system in Greene along the Chenango River – Not feasible, flooding is diffuse and development is spread out along the length of the riverbank, a levee is not the most feasible solution
- (Alternative 3) Clearing, snagging, & shoal removal along Chenango River in Greene – Not feasible, clearing/shoal removal unlikely to realize damage reduction benefits for higher magnitude, lower frequency events
- (Alternative 4) Pump station in Greene – Not feasible, flooding is diffuse with no apparent ponding areas or interior drainage issues identified
- (Alternative 5) Non-structural measures in Greene – Feasible, likeliest alternative to reduce risk to properties in the floodplain since structures are too spread out for a structural solution

4.4.5 ENVIRONMENTAL ACCEPTABILITY

The environmental acceptability for Greene alternatives is shown in Table 21.

Table 21: Preliminary evaluation of environmental concerns for Greene Initial Array of Alternatives

Proposed Project	Farmland (Direct Impacts)	HTRW (Direct or Indirect Impacts)	Streams/Rivers (Waters) (Direct Impacts)	Wetlands (Direct Impacts)
(Alternative 2 to 2.2) Build a new levee system in Greene along the Chenango River	Low	Low	Moderate - evaluate impacts to Birdsall Creek which levee would cross	Low
(Alternative 3) Clearing/snagging/shoal removal Chenango River	Low	Low	High - need detailed evaluation of aquatic environmental impacts	Low

4.4.6 CULTURAL/HISTORICAL IMPACTS

- (Alternative 2 to 2.2) Build a new levee system in Greene along the Chenango River - Constructing a new levee system on both banks has the potential to cause multiple adverse effects to historic properties. If buyouts or demolitions were necessary for NRHP eligible or listed properties then mitigation would be required. There are four of these that could be within the footprint of a new levee (two are eligible and two are listed). Also potentially within the footprint are 19 NRHP undetermined buildings that would need determinations of eligibility before proceeding.

  Near the NRHP listed Genesee St. Bridge is the eastern extent of the Greene Historic District. The proposed levee would move through this boundary and visually impact both the district and the surrounding buildings. Lastly, there are four NRHP eligible archaeological sites that could be within the footprint of a proposed levee. While most of the area is residentially and industrially developed, there are some undisturbed areas of archaeological potential that could be impacted by a new levee.
- (Alternative 3) Clearing, Snagging, & Shoal Removal along Chenango River in Greene - If this alternative is occurring in existing channels, then the areas have already been disturbed. There are no recorded submerged archaeological sites, although there is a lack of prior survey.

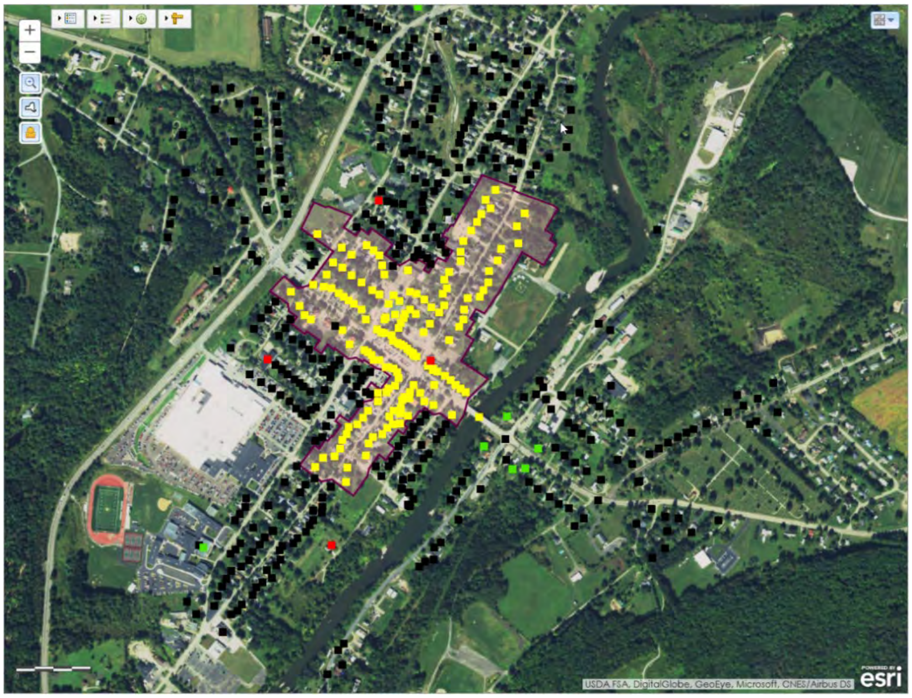


Figure 24: Historic Buildings, Village of Greene

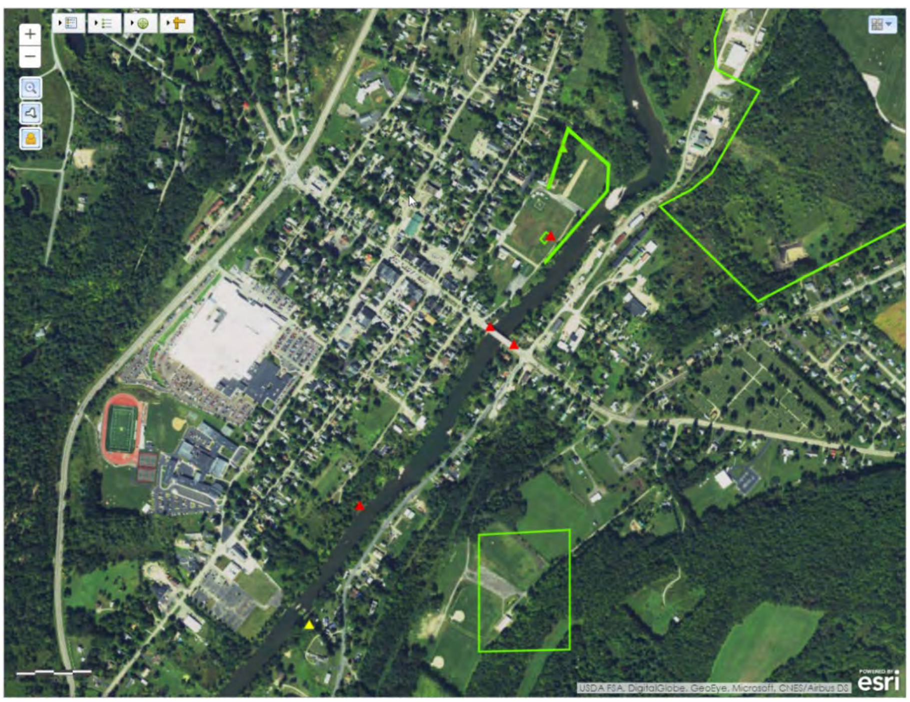


Figure 25: Inventoried cultural resources (archaeological sites/surveys), Village of Greene

4.5 THE CITY OF CORTLAND

4.5.1 EXISTING CONDITIONS

The City of Cortland is primarily impacted by overbank flooding from the Tioughnioga River West Branch, in the north of the City and in the Village of Homer, and flooding near the Erie-Lackawanna railroad bridge, where Dry and Otter Creek drain immediately upstream of the bridge. Shoaling in the existing clearing/snagging project were also identified as a risk driver for flooding in this area. Dry and Otter Creek are both channelized streams through the City of Cortland that were identified as driving flood risk in the City. Historic flooding has also occurred downstream of the Erie-Lackawanna railroad bridge along the left bank, which has impacted existing commercial development and apartment communities located along the floodplain at this location.

4.5.2 INITIAL ARRAY OF ALTERNATIVES

The following initial alternatives were formulated to address flood risk problems in Cortland:

- Alternative 1: No Action
- Alternative 2: Build a new levee system in Cortland along Dry and Otter Creeks
- Alternative 2.1: Build a new levee segment in Cortland along Dry Creek
- Alternative 2.2: Build a new levee segment in Cortland along Otter Creek
- Alternative 3: Pump station in Cortland at the confluence of Dry and Otter Creeks
- Alternative 4: Clearing, snagging, & shoal removal Federal channel along Tioughnioga River East, West, and Main Branches, Otter Creek Confluence in Cortland
- Alternative 4.1: Clearing, snagging, & shoal removal Federal channel along Tioughnioga River Main Branch in Cortland
- Alternative 4.2: Clearing, snagging, & shoal removal Federal channel along Tioughnioga River East Branch in Cortland
- Alternative 4.3: Clearing, snagging, & shoal removal Federal channel along Tioughnioga River West Branch in Cortland
- Alternative 4.4: Clearing, Snagging, & Shoal Removal Federal channel at the confluence of Otter Creek & Tioughnioga River in Cortland
- Alternative 5: Debris removal structure along Dry & Otter Creek in Cortland
- Alternative 6: Non-structural measures in Cortland

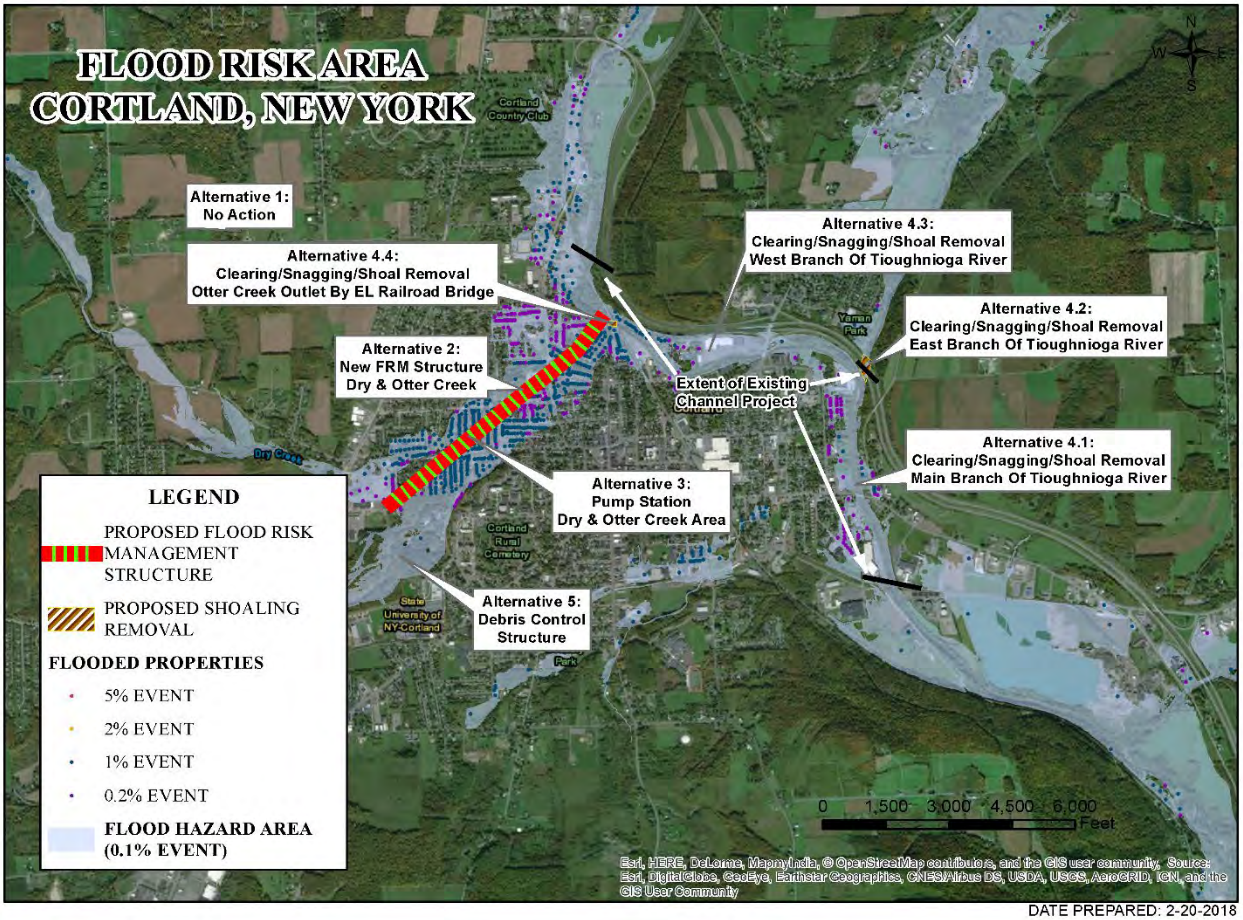


Figure 26: Mapped Initial Array of Alternatives for Cortland

4.5.3 PRELIMINARY FEDERAL INTEREST

The results of the preliminary Federal interest screening analysis for Cortland are illustrated in Table 22.

Table 22: Preliminary Federal interest screening for Cortland Initial Array of Alternatives

Initial Alternatives	Preliminary Federal Interest Assuming 50% Damage Reduction	Preliminary Federal Interest Assuming 66% Damage Reduction
Alternative 1: No Action	X	X
Alternative 2: Build a new levee system in Cortland along Dry and Otter Creeks	0.3	0.4
Alternative 2.1: Build a new levee segment in Cortland along Dry Creek	0.4	0.5
Alternative 2.2: Build a new levee segment in Cortland along Otter Creek	0.3	0.3
Alternative 3: Pump station in Cortland at the confluence of Dry and Otter Creeks**	0.0	0.0
Alternative 4: Clearing, snagging, & shoal removal Federal channel along Tioughnioga River East, West, and Main Branches, Otter Creek Confluence in Cortland*	0.5	0.6
Alternative 4.1: Clearing, snagging, & shoal removal Federal channel along Tioughnioga River Main Branch in Cortland*	0.2	0.2
Alternative 4.2: Clearing, snagging, & shoal removal Federal channel along Tioughnioga River East Branch in Cortland*	0.0	0.0
Alternative 4.3: Clearing, snagging, & shoal removal Federal channel along Tioughnioga River West Branch in Cortland*	0.3	0.4
Alternative 4.4: Clearing, snagging, & shoal removal Federal channel at the confluence of Otter Creek & Tioughnioga River in Cortland*	X	X
Alternative 5: Debris removal structure along Dry & Otter Creek in Cortland	X	X
Alternative 6: Non-structural measures in Cortland***	X	X

**Parametric cost estimate do not include O&M costs.*
***Pump stations were only evaluated if levee raising was proposed as a feasible alternative.*
****Evaluated in the focused array of alternatives only.*

4.5.4 ENGINEERING FEASIBILITY

- (Alternative 2 to 2.2) Build a new levee system in Cortland along Dry and Otter Creeks – Levee system is not a feasible solution based on limited space and existing channel diversion.
- (Alternative 3) Pump station in Cortland – Not Feasible, flooding is diffuse with no apparent ponding areas or interior drainage issues identified

- (Alternative 4) Clearing, snagging, & shoal removal along Tioughnioga River in Cortland – Not feasible, Clearing/channel project may not provide substantial damage reduction for the 1 percent chance flood event. Existing clearing/snagging project provides damage reduction for higher frequency events.
- (Alternative 5) Debris removal structure along Dry & Otter Creek in Cortland – Not feasible, a sediment basin may address shoaling problems but the greater problem is flash flooding from Dry and Otter Creek – this component does not make sense without removing existing material. The feasibility of this alternative may be limited by low levels of flooding in this location. This alternative was not cost estimated as it is outside of the extent of modeling completed for this area.

4.5.5 ENVIRONMENTAL ACCEPTABILITY

The environmental acceptability for Cortland alternatives is shown in Table 23.

Table 23: Preliminary evaluation of environmental concerns for Cortland Initial Array of Alternatives

Proposed Project	Farmland (Direct Impacts)	HTRW (Direct or Indirect Impacts)	Streams/Rivers (Waters) (Direct Impacts)	Wetlands (Direct Impacts)
(Alternative 2) Build a new levee system in Cortland along Dry and Otter Creeks	Low	Low	Moderate - evaluate impacts to Dry and Otter Creeks which levee could cross	Low

4.5.6 CULTURAL/HISTORICAL IMPACTS

- (Alternative 2 to 2.2) Build a new levee system in Cortland along Dry and Otter Creeks - The proposed levee for the Cortland study area appears to move through highly developed residential and industrial areas. Because of this, there is a lower chance for adverse effects to archaeological sites. The most prevalent risk is to architectural resources within the area. There appear to be four buildings that are eligible for listing in the NRHP that could be physically impacted by a new levee, while there is one that is deemed undetermined for NRHP listing.

  Another main concern for a new levee is its visual impact on historic properties and districts. There are approximately 15 properties that could be impacted visually. Of these, seven are eligible for the NRHP and 8 are undetermined. The nearest historic districts are the Madison-Jewett and North Main-East Main districts, located approximately 840 ft. and 430 ft. from the proposed levee, respectively.

- (Alternative 4 to 4.4) Clearing, snagging, & shoal removal Federal channel along Tioughnioga River East, West, and Main Branches, Otter Creek Confluence in Cortland - If this alternative is occurring in existing channels, then the areas have already been disturbed. There are no recorded submerged archaeological sites, although there is a lack of prior survey.

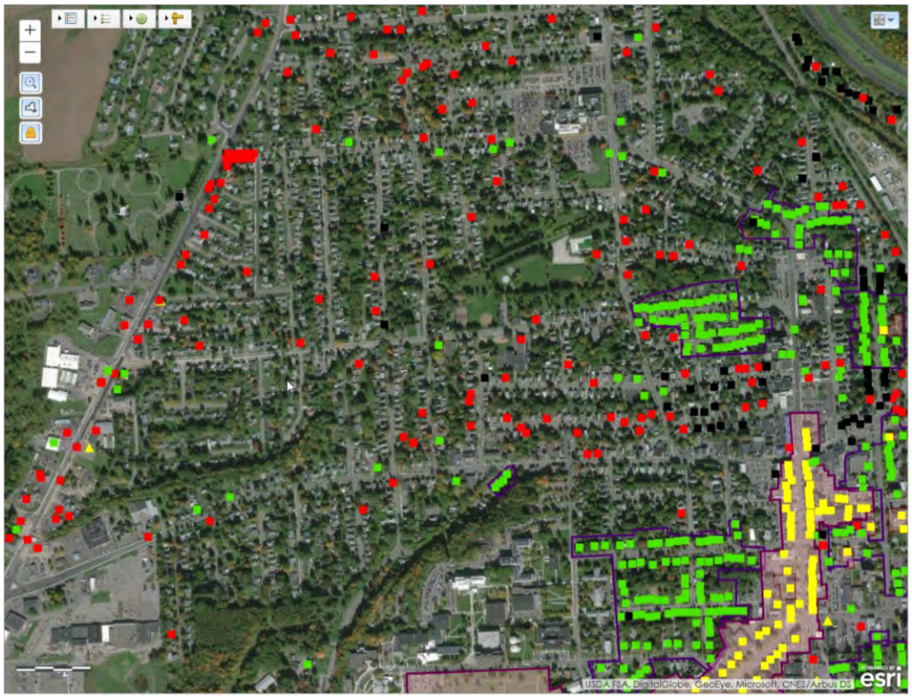


Figure 27: Historic Buildings, City of Cortland (Center)

Figure 28: Historic Buildings, City of Cortland (North)

4.6 THE CITY OF NORWICH

4.6.1 EXISTING CONDITIONS

The primary risk driver in Norwich is overbank flooding, which occurs from the Chenango River (east and south) and Cannasawacta Creek (west). Backflooding at the confluence of Cannasawacta Creek and the Chenango River is also a likely risk driver in this area. Ice jams have been identified as a concern in this flood risk area, which has been confirmed using the Cold Regions Research and Engineering Laboratory's (CRREL) Ice Jams Database.

4.6.2 INITIAL ARRAY OF ALTERNATIVES

The following initial alternatives were formulated to address flood risk problems in Norwich:

- Alternative 1: No Action
- Alternative 2: Build a new levee system in Norwich from Rexford Street to south of the Fairgrounds along the Chenango River
- Alternative 3: Pump station in Norwich
- Alternative 4: Clearing, snagging, & shoal removal Federal channel along Chenango River and Canasawacta Creek in Norwich
- Alternative 5: Bridge raising for Rexford Street, East Main Street, and Hale Street along the Chenango River in Norwich
- Alternative 6: Ice jam structures along Canasawacta Creek in Norwich
- Alternative 7: Non-structural measures in Norwich

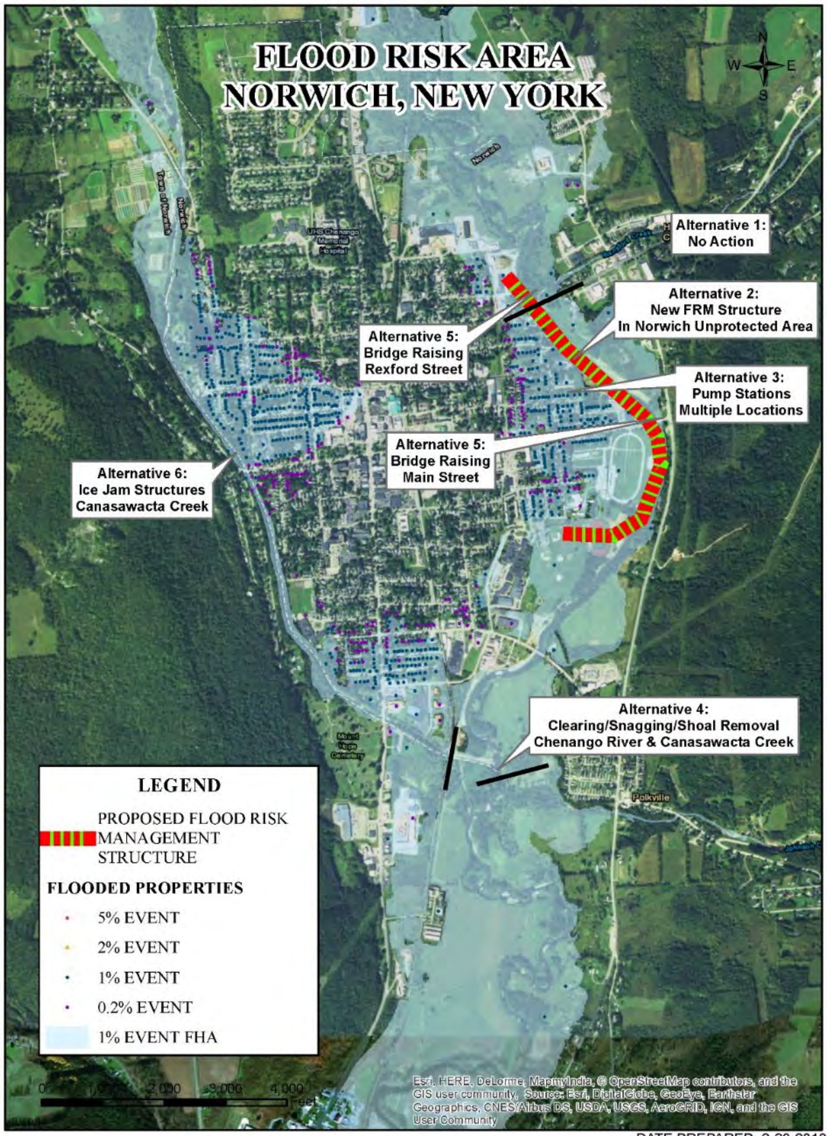


Figure 29: Mapped Initial Array of Alternatives for Norwich

4.6.3 PRELIMINARY FEDERAL INTEREST

The results of the preliminary Federal interest screening analysis for Norwich are illustrated in Table 24.

Table 24: Preliminary Federal interest screening for Norwich Initial Array of Alternatives

Initial Alternatives	Preliminary Federal Interest	
	Assuming 50% Damage Reduction	Assuming 66% Damage Reduction
Alternative 1: No Action		
Alternative 2: Build a new levee system in Norwich from Rexford Street to south of the Fairgrounds along the Chenango River	0.2	0.2
Alternative 3: Pump Station in Norwich**	X	X
Alternative 4: Clearing, snagging, & shoal removal federal channel along Chenango River and Canasawacta Creek in Norwich*	0.7	1.0
Alternative 5: Bridge raising for Rexford Street, East Main Street, and Hale Street along the Chenango River in Norwich****	X	X
Alternative 6: Ice jam structures along Canasawacta Creek in Norwich****	X	X
Alternative 7: Non-structural measures in Norwich***	X	X

**Parametric cost estimate do not include O&M costs.*
***Pump stations were only evaluated if levee raising was proposed as a feasible alternative.*
****Evaluated in the focused array of alternatives only.*
*****Parametric cost estimates not developed for these alternatives due to lack of information.*

4.6.4 ENGINEERING FEASIBILITY

- (Alternative 2) Build a new levee system in Norwich from Rexford Street to south of the Fairgrounds along the Chenango River – Not feasible, levee systems must include FRM downstream at Norwich High School and near the confluence with Cannasawacta Creek to avoid induced flooding
- (Alternative 3) Pump station in Norwich – Not feasible, flooding is diffuse along three areas of Norwich (west, east, south), no ponding areas or interior drainage issues identified.
- (Alternative 4) Clearing, snagging, & shoal removal Federal channel along Chenango River and Cannasawacta Creek in Norwich – Not feasible, clearing/channel project may not provide substantial damage reduction for the 1 percent chance flood event. Existing clearing/snagging project provides damage reduction for higher frequency events.
- (Alternative 5) Bridge raising for Rexford Street, East Main Street, and Hale Street along the Chenango River in Norwich – Not feasible, likely cost prohibitive due to

raising multiple bridges, would not address overbank flooding, the primary risk driver.

- (Alternative 6) Ice jam structures along Cannasawactra Creek – More detailed analysis required. Ice jam was only identified as a problem once in the database with limited information about the impacts or the nature of the flooding problem at this location. CRREL is investigating approaches to evaluating and mitigating ice jam issues, but guidance is not available at this time.

4.6.5 ENVIRONMENTAL ACCEPTABILITY

The environmental acceptability for Norwich alternatives is shown in Table 25.

Table 25: Preliminary evaluation of environmental concerns for Norwich Initial Array of Alternatives

Proposed Project	Farmland (Direct Impacts)	HTRW (Direct or Indirect Impacts)	Streams/Rivers (Waters) (Direct Impacts)	Wetlands (Direct Impacts)
(Alternative 2) Build a new levee system in Norwich from Rexford Street to south of the Fairgrounds along the Chenango River	Low	Low	Low	Low

4.6.6 CULTURAL/HISTORICAL IMPACTS

- (Alternative 2) Build a new levee system in Norwich from Rexford Street to south of the Fairgrounds along the Chenango River - A new levee system is being proposed for construction on the east and west sides of Norwich. The east levee has the potential to visually impact one NRHP eligible property, the Chenango County Fairground. The majority of the east side of Norwich is residentially developed, although there is a small portion north of the fairground that could have archaeological potential.

  The proposed west levee could directly impact five NRHP undetermined buildings and five NRHP eligible buildings. There is one prehistoric and historic archaeological site within the footprint, but it has been noted as not eligible for the NRHP. Speaking to visual impacts, there are three NRHP undetermined buildings that would be within the viewshed of the proposed levee.

- (Alternative 4) Clearing, snagging, & shoal removal Federal channel along Chenango River and Cannasawacta Creek in Norwich – If this alternative is occurring in existing channels, then the areas have already been disturbed. There are no recorded submerged archaeological sites, although there is a lack of prior survey.

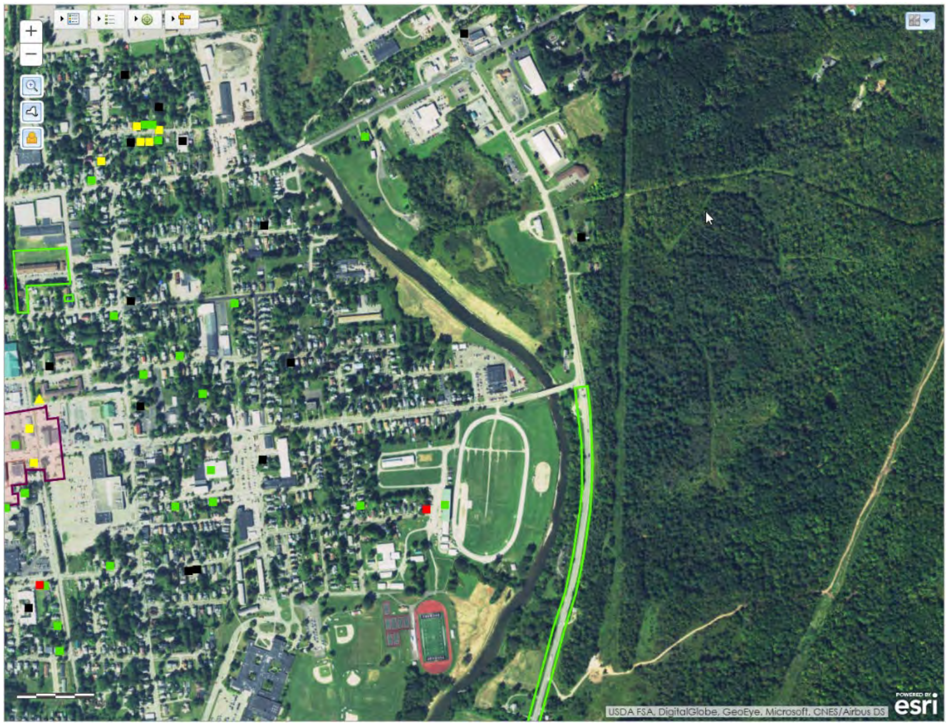


Figure 30: Historic buildings, City of Norwich (East)

Figure 31: Historic buildings, City of Norwich (West)

Figure 32: Historic Buildings, City of Norwich (South)

4.7 THE TOWNS OF CONKLIN AND KIRKWOOD

4.7.1 EXISTING CONDITIONS

Conklin has been identified as a higher risk developed area with persistent flooding at higher frequency flooding events (0.05 and 0.02 percent chance flood frequency; or 20 and 50 year flood events). While there is an existing channel clearing/snagging removal project extending for seven miles along the Susquehanna River, this area continues to experience repetitive damages from a range of storm events. The primary flooding risk problem in Conklin is overbank flooding, which occurs at a higher frequency in developed areas immediately east of Binghamton.

4.7.2 INITIAL ARRAY OF ALTERNATIVES

The following initial alternatives were formulated to address flood risk problems in Conklin/Kirkwood:

- Alternative 1: No Action
- Alternative 2: Build a new levee system in Conklin along all three damage areas
- Alternative 2.1: Build new levee in Conklin along the northern damage area
- Alternative 2.2: Build new levee in Conklin along the central damage area
- Alternative 2.3: Build new levee in Conklin along the southern damage area
- Alternative 3: Clearing, snagging, & shoal removal of Susquehanna River along Conklin-Kirkwood area
- Alternative 4: Dredging of Susquehanna River along Conklin-Kirkwood area
- Alternative 5: Non-structural measures in Conklin and Kirkwood

4.7.3 PRELIMINARY FEDERAL INTEREST

The results of the preliminary Federal interest screening analysis for Conklin-Kirkwood are illustrated in Table 26.

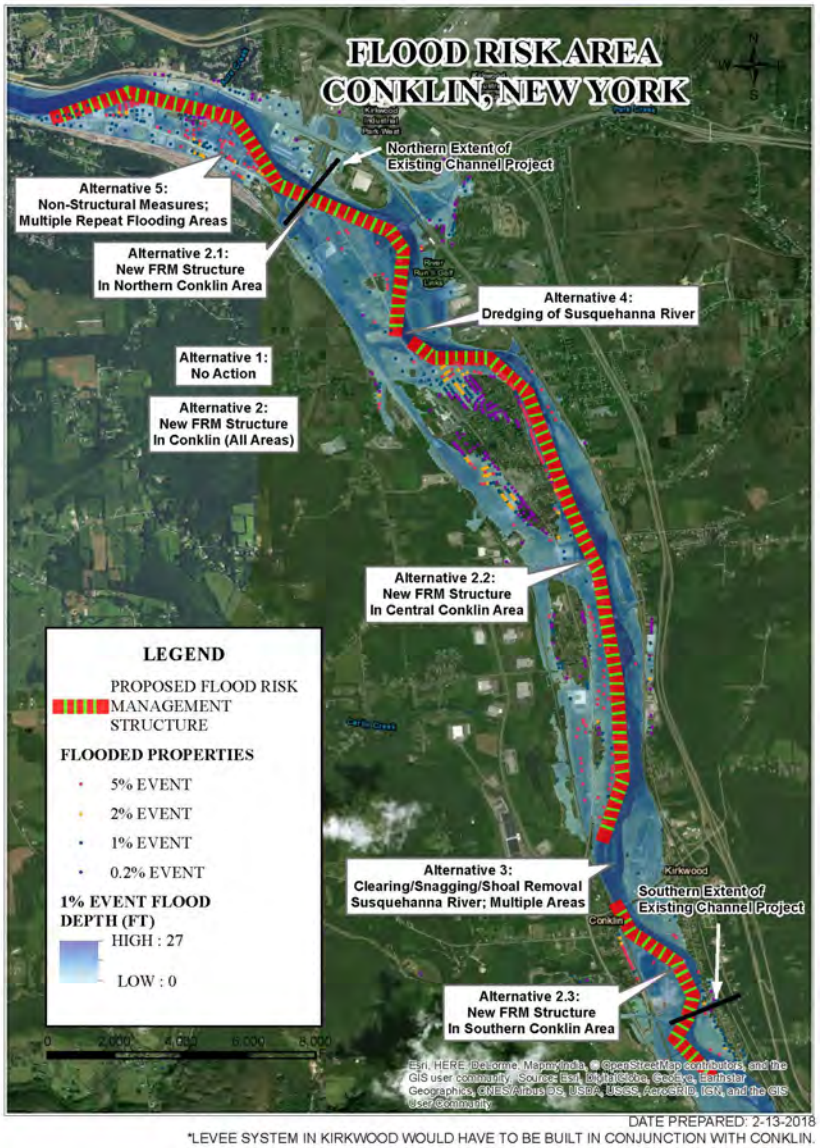


Figure 33: Mapped Initial Array of Alternatives for Conklin-Kirkwood

Table 26: Preliminary Federal interest screening for Conklin/Kirkwood Initial Array of Alternatives

Initial Alternatives	Preliminary Federal Interest Assuming 50% Damage Reduction	Preliminary Federal Interest Assuming 66% Damage Reduction
Alternative 1: No Action		
Alternative 2: Build a new levee system in Conklin along all three damage areas	1.9	2.6
Alternative 2.1: Build new levee in Conklin along the northern damage area	2.6	3.4
Alternative 2.2: Build new levee in Conklin along the central damage area	1.9	2.5
Alternative 2.3: Build new levee in Conklin along the southern damage area	0.2	0.3
Alternative 3: Clearing, snagging, & shoal removal of Susquehanna River along Conklin-Kirkwood area*	15.8	21.2
Alternative 4: Dredging of Susquehanna River along Conklin-Kirkwood area*	5.3	7.1
Alternative 5: Non-structural measures in Conklin and Kirkwood**	X	X

**Parametric cost estimate do not include O&M costs.*
***Evaluated in the focused array of alternatives only.*

4.7.4 ENGINEERING FEASIBILITY

- (Alternative 2 to 2.3) Build a new levee system in Conklin along all three damage areas – Not feasible on its own as levee system would result in significant flooding impacts in Kirkwood and raise water surface elevations in Binghamton. Conklin is hydraulically linked to downstream levee systems (Binghamton, Endicott-Johnson City-Vestal) therefore any projects in this area would require complex hydraulic analysis of possible downstream impacts. Additionally, flooding impacts would have to be examined in Kirkwood, located on the opposite bank of the Susquehanna River, as this area includes significant commercial development in flood risk areas. More detailed hydraulic analysis is required to determine feasibility of the proposed alternative with mitigation in Kirkwood and Binghamton.
- (Alternative 3) Clearing, snagging, & shoal removal of Susquehanna River along Conklin-Kirkwood area – Feasible, existing 7 mile clearing/snagging Federal project through flood risk area.
- (Alternative 4) Dredging of Susquehanna River along Conklin-Kirkwood area – Not feasible, dredging of the channel is unlikely to result in significant benefits to flood reduction for lower frequency events (1 percent chance flood event).

4.7.5 ENVIRONMENTAL ACCEPTABILITY

The environmental acceptability for Conklin-Kirkwood alternatives is shown in Table 27.

Table 27: Preliminary evaluation of environmental concerns for Conklin-Kirkwood Initial Array of Alternatives

Proposed Project	Farmland (Direct Impacts)	HTRW (Direct or Indirect Impacts)	Streams/Rivers (Waters) (Direct Impacts)	Wetlands (Direct Impacts)
(Alternative 2 to 2.3) Build a new levee system in Conklin along all three damage areas	High – multiple farmed parcels located in floodplain on west bank in proposed new FRM structure area	High - evaluate whether Conklin Dumps superfund site would affect FRM feature position or design	High - evaluate whether topographic lows in floodplain contain perennial or intermittent streams	High – multiple parcels located in floodplain on west bank in proposed new FRM structure area

4.7.6 CULTURAL/HISTORICAL IMPACTS

- (Alternative 2 to 2.3) Build a new levee system in Conklin along all three damage areas – The path of the proposed levee moves through both undisturbed and residential areas. Levee construction could impact archaeological resources in undisturbed areas, since some prehistoric and historic sites have been documented throughout the area. In more highly developed areas, there is a low potential for intact sites, meaning there is a minimal potential to cause adverse effects. Towards the southern portion of the Conklin area, the proposed levee moves through the viewshed of the NRHP listed Conklin town hall.

  Along the entire proposed levee, there appear to be only 10 buildings that could be directly impacted by its construction. All of these are undetermined for listing in the NRHP. There are also properties that could be visually impacted by the alternative. Of these, 2 are eligible for the NRHP, but each is located approximately 1,100 ft. west of the embankment. The remaining properties are undetermined for listing in the NRHP and number approximately 39. None of these undetermined properties are ever closer than 140 ft. from the embankment.

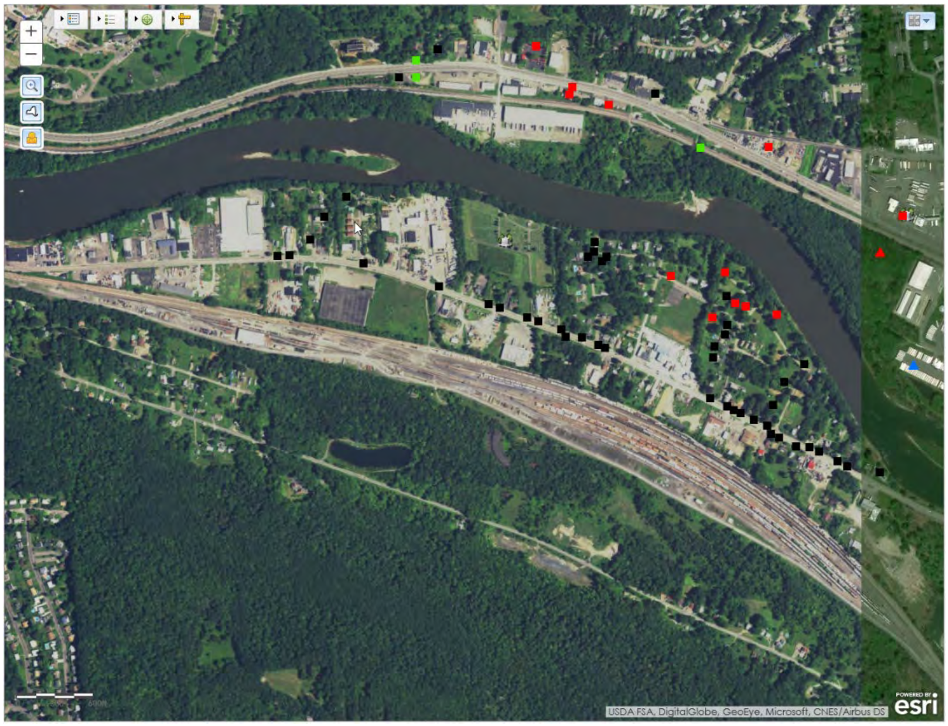


Figure 34: Historic buildings, Town of Conklin (North)

In the northern-most portion of the Conklin study area, there is a cemetery that is separated from the river by a line of trees and an access road.

- (Alternative 3) Clearing, snagging, & shoal removal of Susquehanna River along Conklin-Kirkwood area – If this alternative is occurring in existing channels, then the areas have already been disturbed. There are no recorded submerged archaeological sites, although there is a lack of prior survey.
- (Alternative 5) Non-structural measures in Conklin and Kirkwood - Adverse effects to historic properties from implementation of non-structural measures are specific to the historic property treated. For the Conklin study area, there are two areas (north and south) designated for non-structural measures. The north area contains 43 properties that are listed as undetermined for listing in the NRHP. The south area contains nine properties that are listed as undetermined, and one that is eligible, the Susquehanna Valley Middle/High School Complex.

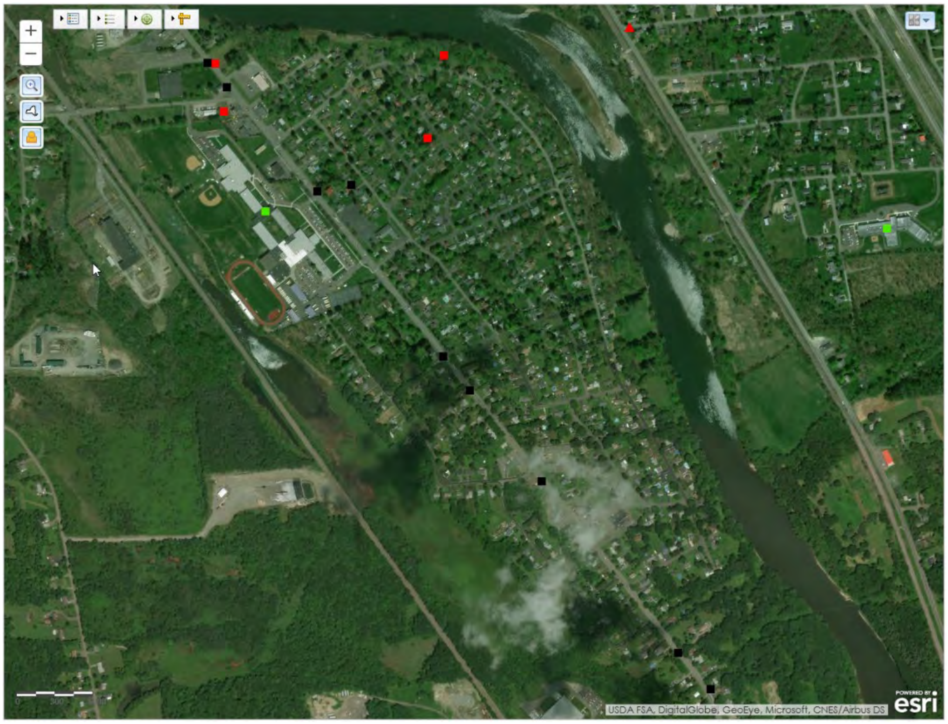


Figure 35: Historic buildings, Town of Conklin (South)

Figure 36: Historic buildings - Conklin Town Hall

4.8 THE VILLAGE OF OWEGO

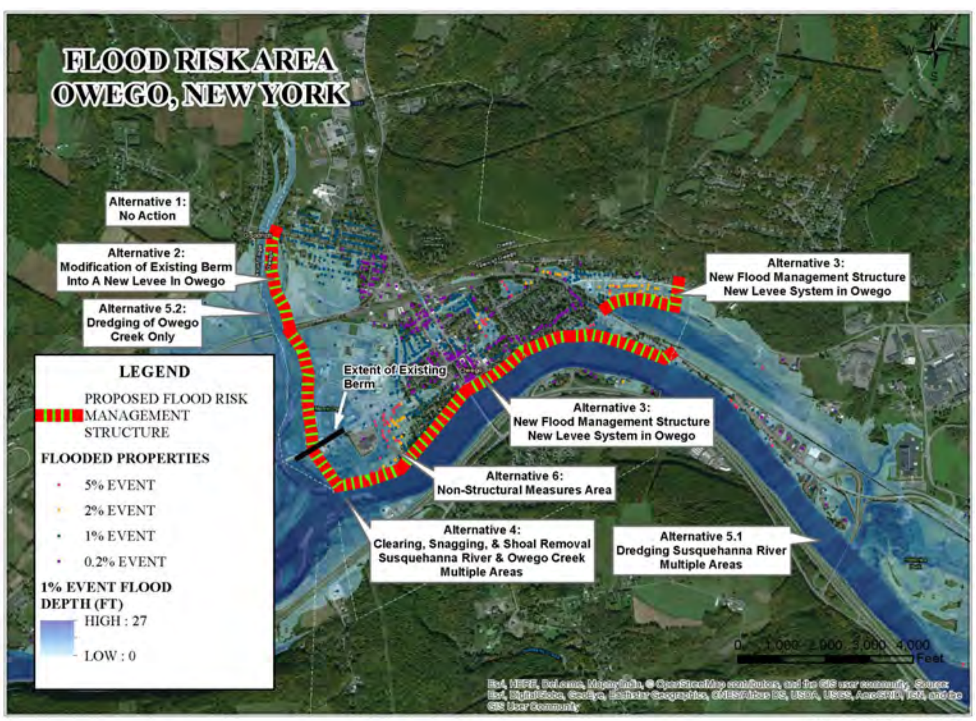
4.8.1 EXISTING CONDITIONS

The village of Owego experiences multiple flooding issues along the Susquehanna River and Owego Creek. The primary risk drivers are overbank flooding from the Susquehanna River at catastrophic low frequency events (0.01 percent chance frequency flood or 100-year or higher) and back-flooding along Owego Creek. Owego Creek also has shoaling and debris accumulation issues resulting in extensive neighborhood flooding in the west side of the village.

4.8.2 INITIAL ARRAY OF ALTERNATIVES

The following initial alternatives were formulated to address flood risk problems in Owego:

- Alternative 1: No Action
- Alternative 2: Modification and extension of existing berm along Owego Creek
- Alternative 3: Build a new levee system in Owego along the historic district and the Brick Pond area
- Alternative 3.1: Build new floodwalls in Owego along the historic district and Brick Pond area
- Alternative 4: Clearing, snagging, & shoal removal of Susquehanna River and Owego Creek
- Alternative 5: Dredging of Susquehanna River and Owego Creek
- Alternative 5.1: Dredging of Susquehanna River only
- Alternative 5.2: Dredging of Owego Creek only
- Alternative 6: Non-structural measures in Owego



DATE PREPARED: 2-16-2018

Figure 37: Mapped Initial Array of Alternatives for Owego

4.8.3 PRELIMINARY FEDERAL INTEREST

The results of the preliminary Federal interest screening analysis for Owego are illustrated in Table 28.

Table 28: Preliminary Federal interest screening for Owego Initial Array of Alternatives

Initial Alternatives	Preliminary Federal Interest	
	Assuming 50% Damage Reduction	Assuming 66% Damage Reduction
Alternative 1: No Action		
Alternative 2: Modification and extension of existing berm along Owego Creek	0.7	1.0
Alternative 3: Build a new levee system in Owego along the historic district and the Brick Pond area	1.3	1.7
Alternative 3.1: Build new floodwalls in Owego along the historic district and Brick Pond area	0.6	0.9
Alternative 4: Clearing, snagging, & shoal removal of Susquehanna River and Owego Creek*	1.1	1.4
Alternative 5: Dredging of Susquehanna River and Owego Creek*	0.5	0.7
Alternative 5.1: Dredging of Susquehanna River only*	0.9	1.1
Alternative 5.2: Dredging of Owego Creek only*	0.4	0.5
Alternative 6: Non-structural measures in Owego***	X	X

**Parametric cost estimate do not include O&M costs.*
***Evaluated in the focused array of alternatives only.*

4.8.4 ENGINEERING FEASIBILITY

- (Alternative 2) Modification and extension of existing berm along Owego Creek – Feasible, project costs were derived from Tioga County documents
- (Alternative 3) Build a new levee system in Owego along the Historic District and the Brick Pond area – Feasible, more detailed analysis is needed to determine whether a levee or floodwall is needed along the proposed levee alignment and to optimize the level of protection for this alternative. Levee may require real estate acquisition in developed areas.
- (Alternative 3.1) Build a new floodwall system in Owego along the historic district and the Brick Pond area – Not feasible in some locations including Brick Pond due to soil conditions (existing wetlands). Floodwall may not be feasible due to existing topography and soils along the banks of downtown Owego.
- (Alternative 4) Clearing, snagging, & shoal removal of Susquehanna River and Owego Creek – Not feasible at proposed scale on the Susquehanna River and Owego Creek, existing channel clearing/snagging removal project along Owego Creek.

- (Alternative 5 to 5.2) Dredging of Susquehanna River and Owego Creek – Not feasible, alternative is not likely to provide significant damage reduction for the 1 percent chance flood event or higher, which drives flood damages in Owego.

4.8.5 ENVIRONMENTAL ACCEPTABILITY

The environmental acceptability for Owego alternatives is shown in Table 29.

Table 29: Preliminary evaluation of environmental concerns for Owego Initial Array of Alternatives

Proposed Project	Farmland (Direct Impacts)	HTRW (Direct or Indirect Impacts)	Streams/Rivers (Waters) (Direct Impacts)	Wetlands (Direct Impacts)
(Alternative 2) Modification and extension of existing berm along Owego Creek	Moderate – avoid farmed parcel on east side of Owego north of East Front Street	High - Evaluate whether IBM Superfund site on Route 17C could affect project design	Low	Moderate - avoid wetlands along Owego Creek and East Front Street
(Alternative 3) Build a new levee system in Owego along the historic district and the Brick Pond area	Low	Low	High - need detailed evaluation of aquatic environmental impacts	Moderate - avoid wetlands along Susquehanna River islands and shoreline downstream of Owego Creek confluence.

4.8.6 CULTURAL/HISTORICAL IMPACTS

The Owego flood risk area was evaluated for structural and non-structural measures to determine if any cultural and historical resources were located in areas of proposed work. The identified resources are listed in Table 30 below.

Table 30: Preliminary evaluation of cultural sites and historical properties in Owego Initial Array of Alternatives

Type	Status	Name/Title	Within APE?	Recommendations/Notes
Building	Undetermined	Delaware, Lackawana, and Western Railroad Bridge Abutment - William St.	Yes	Would need Determination of Eligibility (DOE) for alterations.
Historic District	Listed	Owego Central Historic District	Maybe	Alterations could cause adverse effect to district or contributing buildings.
Building	Listed	James C. Beecher House	Maybe	560 fifth Ave. alterations would have adverse effect.
Building	Undetermined	548 Fifth Ave.	Maybe	Would need DOE for alterations.
Building	Undetermined	542 Fifth Ave.	Maybe	Would need DOE for alterations.

- (Alternative 3 and 3.1) Build a new levee or floodwall system in Owego along the historic district and the Brick Pond area – The proposed levee would have adverse direct impacts on the Owego Central Historic District including potential impacts resulting from construction, visual impacts, and alterations to historic properties along the riverfront to allow for real estate for a levee or floodwall system.

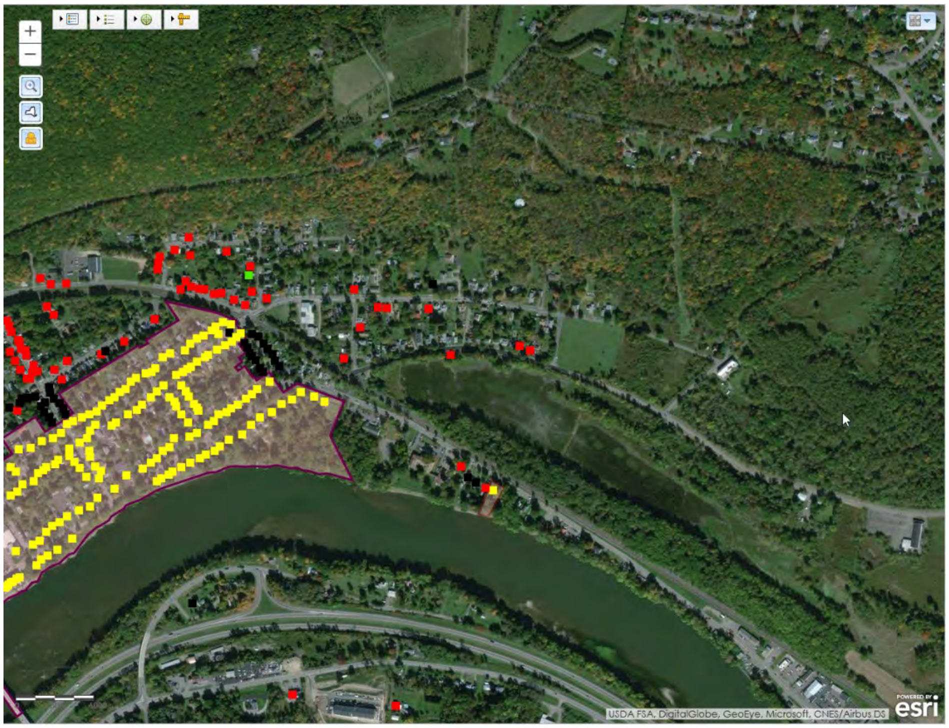


Figure 38: Historic buildings, Village of Owego (East)

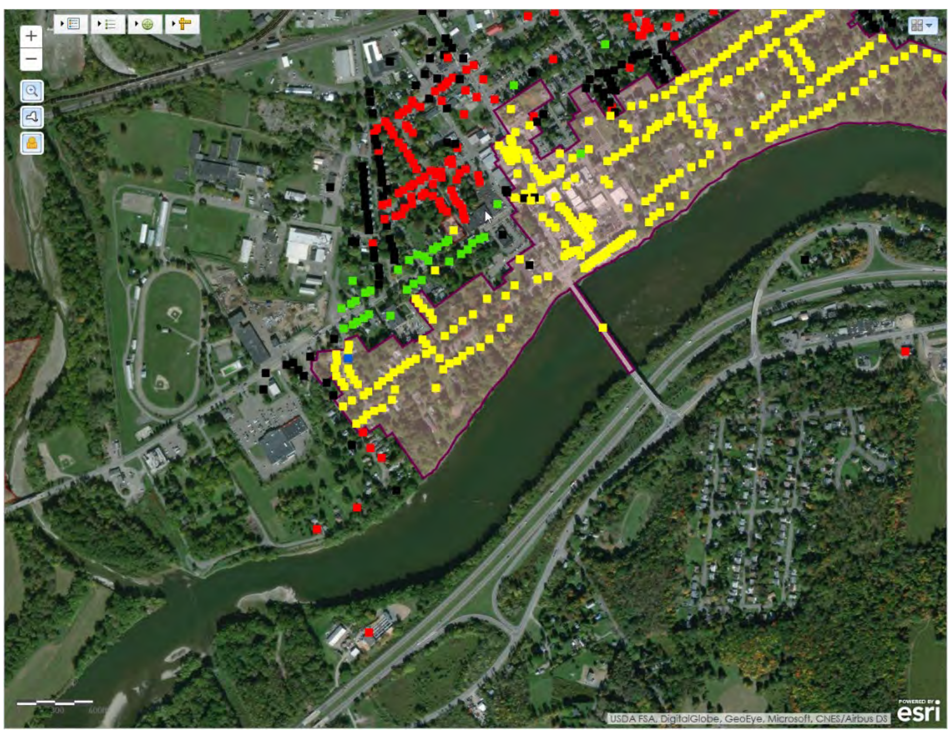


Figure 39: Historic buildings, Village of Owego (West)

4.9 THE VILLAGE OF BAINBRIDGE

4.9.1 EXISTING CONDITIONS

The primary flood risk driver in Bainbridge is overbank flooding along the Susquehanna River.

4.9.2 INITIAL ARRAY OF ALTERNATIVES

The following initial alternatives were formulated to address flood risk problems in Bainbridge:

- Alternative 1: No Action
- Alternative 2: Build a new levee system in Bainbridge along the Susquehanna River (right bank)
- Alternative 3: Pump station in Bainbridge
- Alternative 4: Clearing, snagging, & shoal removal along Susquehanna River in Bainbridge
- Alternative 4.1: Clearing, snagging, & shoal removal along Newton Creek in Bainbridge
- Alternative 5: Non-structural measures in Bainbridge

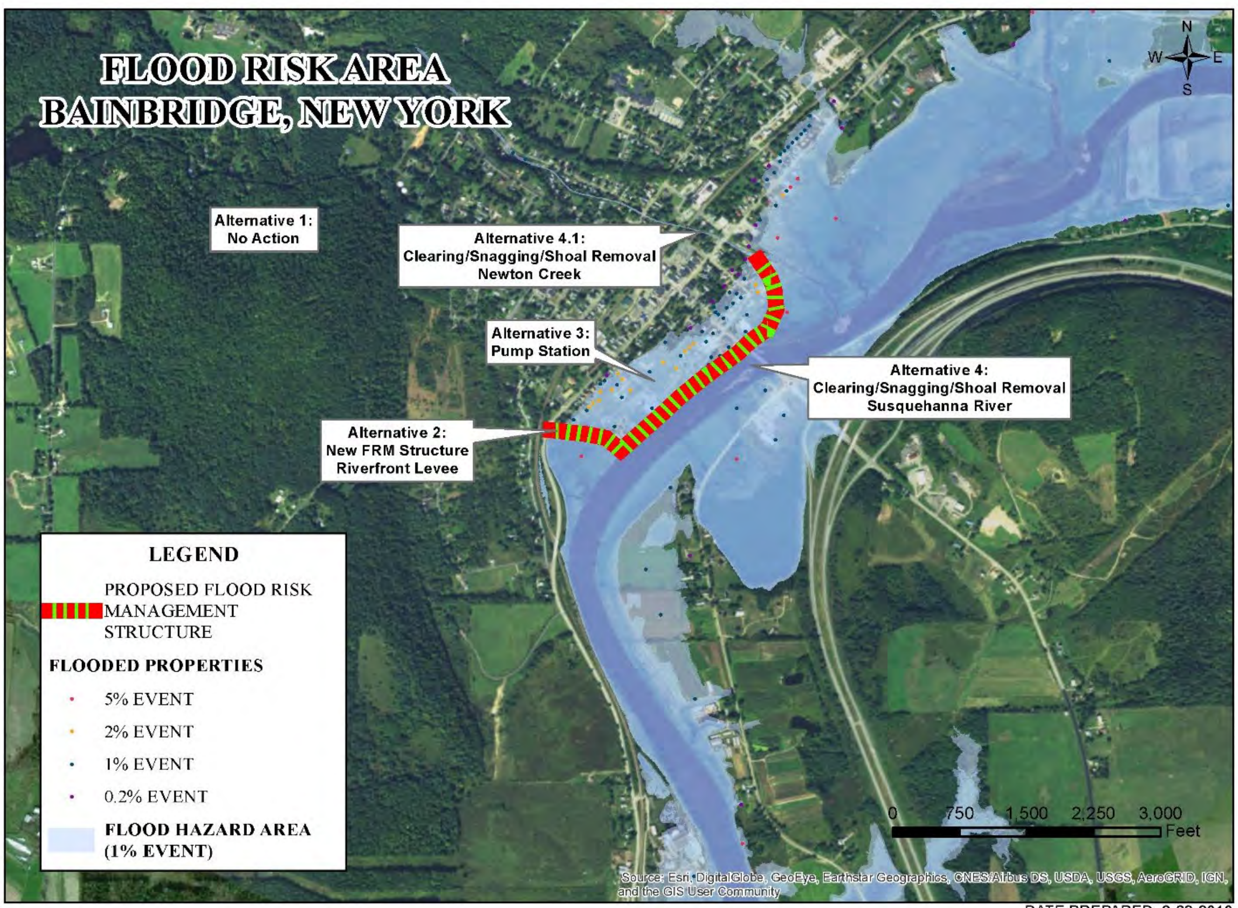


Figure 40: Mapped Initial Array of Alternatives for Bainbridge

4.9.3 PRELIMINARY FEDERAL INTEREST

The results of the preliminary Federal interest screening analysis for Bainbridge are illustrated in Table 31.

Table 31: Preliminary Federal interest screening for Bainbridge Initial Array of Alternatives

Initial Alternatives	Preliminary Federal Interest	
	Assuming 50% Damage Reduction	Assuming 66% Damage Reduction
Alternative 1: No Action		
Alternative 2: Build a new levee system in Bainbridge along the Susquehanna River (right bank)	0.3	0.4
Alternative 3: Pump station in Bainbridge**	X	X
Alternative 4: Clearing, snagging, & shoal removal along Susquehanna River in Bainbridge	X*	X*
Alternative 4.1: Clearing, snagging, & shoal removal along Newton Creek in Bainbridge	X*	X*
Alternative 5: Non-structural measures in Bainbridge***		

**Damage reduction benefits were not able to be appropriately estimated for the proposed clearing/snagging project.*
***Pump stations were only evaluated if levee raising was proposed as a feasible alternative.*
****Evaluated in the focused array of alternatives only.*

4.9.4 ENGINEERING FEASIBILITY

- (Alternative 2) Build a new levee system in Bainbridge along the Susquehanna River (right bank) – Not feasible, needed levee length is over one mile to protect a handful of properties, may be more suitable for non-structural.
- (Alternative 3) Pump station in Bainbridge – Not feasible, flooding is diffuse along Susquehanna River bank, no specific interior drainage issue was identified

4.9.5 ENVIRONMENTAL ACCEPTABILITY

The environmental acceptability for Bainbridge alternatives is shown in Table 32.

Table 32: Preliminary evaluation of environmental concerns for Bainbridge Initial Array of Alternatives

Proposed Project	Farmland (Direct Impacts)	HTRW (Direct or Indirect Impacts)	Streams/Rivers (Waters) (Direct Impacts)	Wetlands (Direct Impacts)
(Alternative 2) Build a new levee system in Bainbridge along the Susquehanna River (right bank)	Moderate – avoid farmed parcels along Newton Creek downstream of North Main Street to near Susquehanna River confluence	Uncertain - Determine whether Perry Builders superfund site near Newton Creek has any implications for levee. Determine whether tank & spill at East Main Street/Front Street has any implications for levee.	Low	Moderate - avoid wetlands along Newton Creek and near western levee terminus
(Alternative 4) Clearing, snagging, & shoal removal along Susquehanna River in Bainbridge	Low	Uncertain - Determine whether Perry Builders superfund site has any implications for in-channel work	Moderate - already channelized, but need detailed evaluation of aquatic environmental impacts	High – Newton Creek flows through wetland parcel located in floodplain immediately upstream of Susquehanna River confluence
(Alternative 4.1) Clearing, snagging, & shoal removal along Newton Creek in Bainbridge	Low	Low	High - need detailed evaluation of aquatic environmental impacts	Low

4.9.6 CULTURAL/HISTORICAL IMPACTS

No cultural or historical impacts were examined for this area in the preliminary analysis.

4.10 THE VILLAGE OF UNADILLA

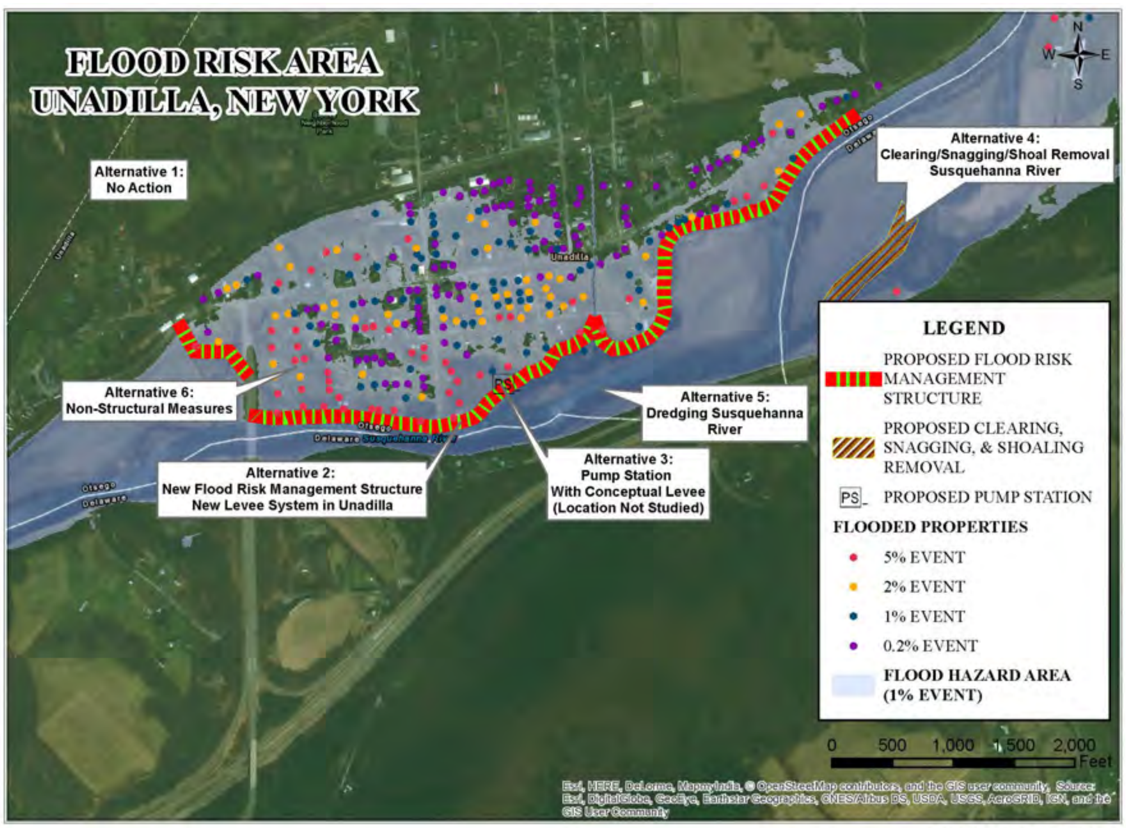
4.10.1 EXISTING CONDITIONS

The Village of Unadilla is located downstream of the East Sidney Dam receiving substantial benefits in flood risk reduction from this major civil works project. Unadilla also has a federal channel improvement project along Martin Brook. The primary flood risk driver for Unadilla is overbank flooding with more frequent flooding occurring in riverfront neighborhoods south of Route 7.

4.10.2 INITIAL ARRAY OF ALTERNATIVES

The following initial alternatives were formulated to address flood risk problems in Unadilla:

- Alternative 1: No Action
- Alternative 2: Build a new levee and floodwall system in Unadilla
- Alternative 2.1: Build a new levee system in Unadilla
- Alternative 3: Pump station in Unadilla
- Alternative 4: Clearing, snagging, & shoal removal of Susquehanna River upstream and riverfront in Unadilla
- Alternative 5: Dredging of Susquehanna River upstream and riverfront near Unadilla
- Alternative 6: Non-structural measures in Unadilla



DATE PREPARED: 2-16-2018

Figure 41: Mapped Initial Array of Alternatives for Unadilla

4.10.3 PRELIMINARY FEDERAL INTEREST

The results of the preliminary Federal interest screening analysis for Unadilla are illustrated in Table 33.

Table 33: Preliminary Federal interest screening for Unadilla Initial Array of Alternatives

Initial Alternatives	Preliminary Federal Interest	
	Assuming 50% Damage Reduction	Assuming 66% Damage Reduction
Alternative 1: No Action		
Alternative 2: Build a new levee and floodwall system in Unadilla	0.7	1.0
Alternative 2.1: Build a new levee system in Unadilla	1.3	1.8
Alternative 3: Pump station in Unadilla***	0.0	0.0
Alternative 4: Clearing, snagging, & shoal removal of Susquehanna River upstream and riverfront in Unadilla**	6.1	8.2
Alternative 5: Dredging of Susquehanna River upstream and riverfront near Unadilla	X*	X*
Alternative 6: Non-structural measures in Unadilla****	X	X

**Damage reduction benefits were not able to be appropriately estimated for the proposed clearing/snagging project.*
***Parametric cost estimate do not include O&M costs.*
****Pump stations were only evaluated if levee raising was proposed as a feasible alternative.*
*****Evaluated in the focused array of alternatives only.*

4.10.4 ENGINEERING FEASIBILITY

- (Alternative 2 to 2.1) Build a new levee and floodwall system in Unadilla – Feasible, levee alignment and damage reduction benefits will need to be examined including developing cost estimates for a closure structure
- (Alternative 3) Pump station in Unadilla – Maybe feasible if levee system is justifiable
- (Alternative 4) Clearing, snagging, & shoal removal of Susquehanna River upstream and riverfront in Unadilla – Not feasible, acreage appears to reference specific shoaling removal which may reduce risk of flooding. Further study needed to determine the resulting decrease in water surface elevation and damages. From reviewing the Sidney study, it appears there was limited impact from channel dredging and shoaling removal on WSE on the mainstem of the Susquehanna River.
- (Alternative 5) Dredging of Susquehanna River upstream and riverfront near Unadilla – Not feasible, dredging of the channel is unlikely to result in significant

benefits to flood reduction for lower frequency events (1 percent chance flood event).

4.10.5 ENVIRONMENTAL ACCEPTABILITY

The environmental acceptability for Unadilla alternatives is shown in Table 34.

Table 34: Preliminary evaluation of environmental concerns for Unadilla Initial Array of Alternatives

Proposed Project	Farmland (Direct Impacts)	HTRW (Direct or Indirect Impacts)	Streams/Rivers (Waters) (Direct Impacts)	Wetlands (Direct Impacts)
(Alternative 2.1) Build a new levee system in Unadilla	Moderate – avoid farmed parcels east of Mills Street	Uncertain - Determine whether Nutters Flat/Route 7 archived superfund site has any implications for levee position or design	Moderate - evaluate impacts to Martin Brook which levee could cross	Low
(Alternative 4 and 5) Clearing, snagging, & shoal removal or Dredging of Susquehanna River upstream and riverfront in Unadilla	Low	Uncertain - Determine whether Nutters Flat/Route 7 archived superfund site presents risks	High - need detailed evaluation of aquatic environmental impacts	Low

4.10.6 CULTURAL/HISTORICAL IMPACTS

- (Alternative 2 and 2.1) Build a new levee and floodwall system in Unadilla - The western portion of the proposed levee moves through an NRHP undetermined prehistoric and historic archaeological site before tying into Route 7. For most of the path of the levee, it is south of the Unadilla Historic District, but towards the east, the levee encroaches on the southern border of the district. The proposed levee may visually impact the historic district, eight NRHP undetermined buildings, and potentially nine NRHP listed buildings. In undeveloped areas, there could be the potential for intact archaeological sites given the presence of prehistoric and historic sites in the area.

- (Alternative 3) Pump station in Unadilla - There is an NRHP undetermined prehistoric archaeological site within 100 feet near the conceptual location of the pump station. Further investigations would probably be required to ensure that no intact deposits could be affected by construction of the pump station.

- (Alternative 4) Clearing, snagging, & shoal removal of Susquehanna River upstream and riverfront in Unadilla - If this alternative is occurring in existing channels, then the areas have already been disturbed. There are no recorded submerged archaeological sites, although there is a lack of prior survey.

- (Alternative 6) Non-structural measures in Unadilla - Adverse effects to historic properties from implementation of non-structural measures are specific to the historic property treated. Some of the properties chosen for non-structural measures could be within the Unadilla Historic District, which contains 114 contributing resources and 119 total NRHP eligible or listed resources. Mitigation would be required for any measures occurred on building listed or eligible for the NRHP, or contributing to the Unadilla Historic District.

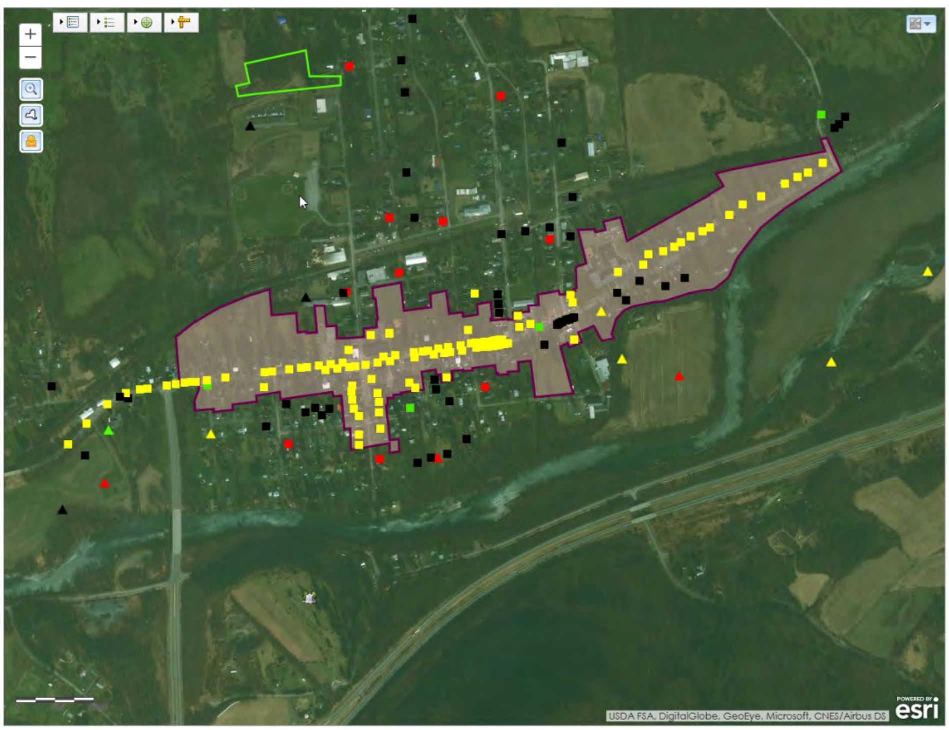


Figure 42: Historic buildings and archaeological sites, Village of Unadilla

4.11 THE VILLAGE OF SIDNEY

4.11.1 EXISTING CONDITIONS

Sidney experiences overbank flooding from the Susquehanna River along its historic downtown and residential neighborhoods in the floodplain.

4.11.2 INITIAL ARRAY OF ALTERNATIVES

The following initial alternatives were formulated to address flood risk problems in Sidney:

- Alternative 1: No Action
- Alternative 2: Build a new levee system in Sidney along the Susquehanna riverfront
- Alternative 2.1: Build a new floodwall in Weir Creek in Sidney
- Alternative 3: Combination FRM project for Sidney including channel improvement along the Susquehanna River and raising of the Route 8 and Main Street Bridges
- Alternative 4: Pump station in Sidney
- Alternative 5: Upstream detention in Weir Creek in Sidney
- Alternative 6: Dredging of Susquehanna River in Sidney
- Alternative 7: Non-structural measures in Sidney

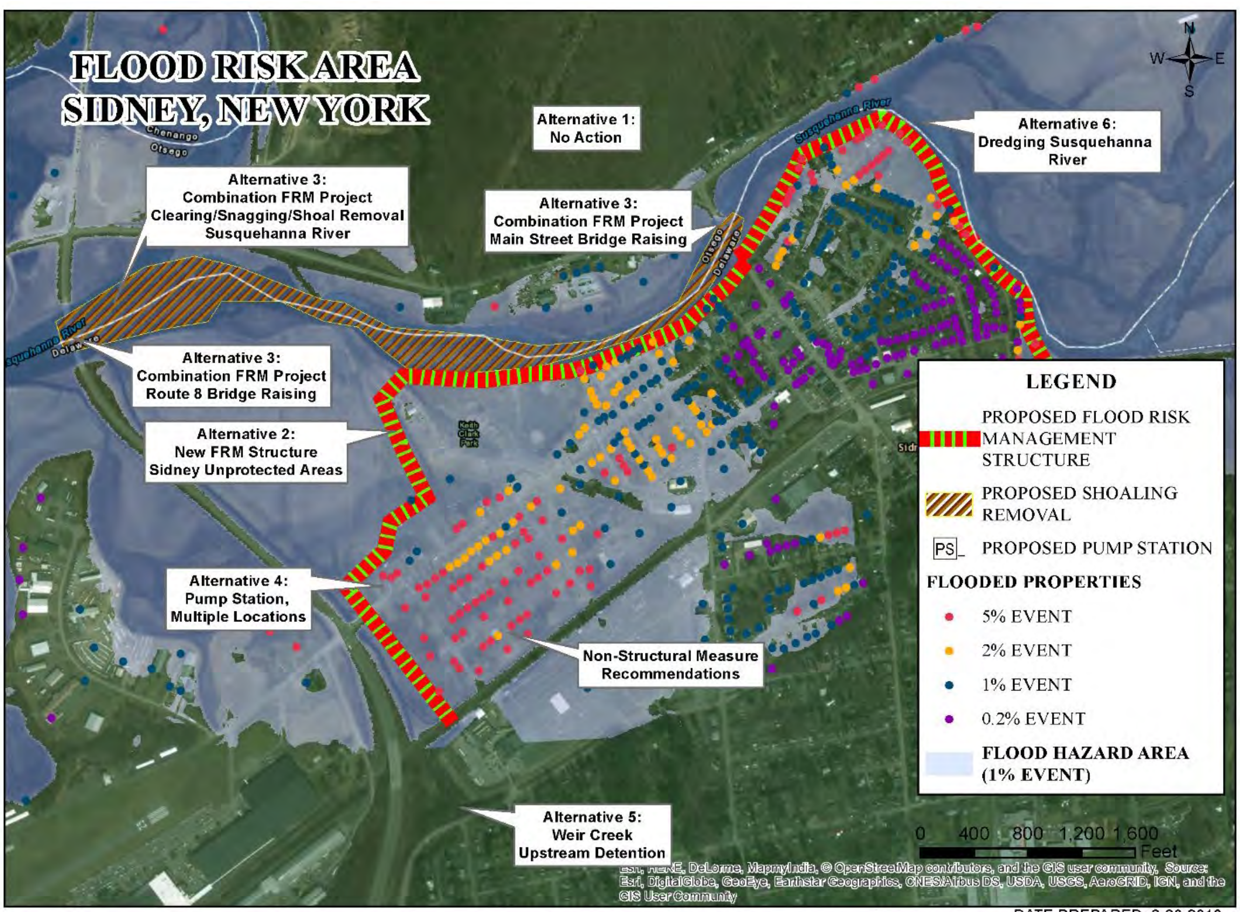


Figure 43: Mapped Initial Array of Alternatives for Sidney

4.11.3 PRELIMINARY FEDERAL INTEREST

The results of the preliminary Federal interest screening analysis for Sidney are illustrated in Table 35.

Table 35: Preliminary Federal interest screening for Sidney Initial Array of Alternatives

Initial Alternatives	Preliminary Federal Interest	
	Assuming 50% Damage Reduction	Assuming 66% Damage Reduction
Alternative 1: No Action		
Alternative 2: Build a new levee system in Sidney along the Susquehanna riverfront	0.59	0.79
Alternative 2.1: Build a new floodwall in Weir Creek in Sidney	0.00	0.00
Alternative 3: Combination FRM project for Sidney including channel improvement along the Susquehanna River and raising of the Route 8 and Main Street Bridges** *(Road/bridge raising costs not included)*	2.10	2.81
Alternative 4: Pump station in Sidney	0.00	0.00
Alternative 5: Upstream detention in Weir Creek in Sidney	0.00	0.00
Alternative 6: Dredging of Susquehanna River in Sidney*	0.70	0.94
Alternative 7: Non-structural measures in Sidney***		

**Parametric cost estimate do not include O&M costs.*
***Cost estimates did not include bridge raising, only channel improvement costs.*
****Evaluated in the focused array of alternatives only.*

4.11.4 ENGINEERING FEASIBILITY

All alternatives were deemed feasible from an engineering perspective as they were previously examined in the Village of Sidney Flood Risk Management Analysis (USACE, 2010). Cost estimates were not generated for bridge raising in Alternative 3 so the analysis does not capture this cost in preliminary calculations.

4.11.5 ENVIRONMENTAL ACCEPTABILITY

The environmental acceptability for Sidney alternatives is shown in Table 36.

Table 36: Preliminary evaluation of environmental concerns for Sidney Initial Array of Alternatives

Proposed Project	Farmland (Direct Impacts)	HTRW (Direct or Indirect Impacts)	Streams/Rivers (Waters) (Direct Impacts)	Wetlands (Direct Impacts)
(Alternative 2) Build a new levee system in Sidney along the Susquehanna riverfront	Moderate – avoid farmed parcels on west side of Sidney	High - Evaluate whether Gcl Tie and Treating superfund site on Delaware Ave and tank/spill site at Route 8/RR track intersection would have any bearing on levee design or position	Low	Low
(Alternative 3) Combination FRM project for Sidney including channel improvement along the Susquehanna River and raising of the Route 8 and Main Street Bridges**	Low	Low	High - need detailed evaluation of aquatic environmental impacts	Low

4.11.6 CULTURAL/HISTORICAL IMPACTS

- (Alternative 2) Build a new levee system in Sidney along the Susquehanna riverfront - The proposed levee would move through the Sidney Historic District, directly impacting the district, approximately 25 NRHP listed buildings, three NRHP undetermined buildings, and one NRHP undetermined prehistoric archaeological site. On the western side of the levee, there may be intact archaeological deposits given its undeveloped character and proximity to documented archaeological sites. The levee would also encroach on the northern boundary of the Congregational Church Cemetery.

  Speaking to visual impacts, much of the northern portion of the district and its contributing resources would be affected. There are also 10 NRHP undetermined and 12 NRHP eligible buildings across the river that could be visually impacted.

More detailed project designs and consultation with the NY SHPO would be required to determine the full nature and extent of these impacts.

- (Alternative 3) Combination FRM project for Sidney including channel improvement along the Susquehanna River and raising of the Route 8 and Main Street Bridges - The Main St. Bridge is listed as undetermined for listing in the NRHP. A determination of eligibility would be required for this proposal. The raising could also visually impact surrounding properties, including the historic district and approximately 10 NRHP listed buildings, one NRHP eligible building, and 12 NRHP Undetermined buildings.

  If clearing/snagging and shoal removal is occurring in existing channels, then the areas have already been disturbed. There are no recorded submerged archaeological sites, although there is a lack of prior survey.

- (Alternative 4) Pump station in Sidney - The proposed pump station is located within the Sidney Historic District and within the viewshed of approximately six NRHP listed buildings. There are multiple prehistoric archaeological sites nearby, so there may be potential for intact archaeological sites in the vicinity of the proposed pump station.

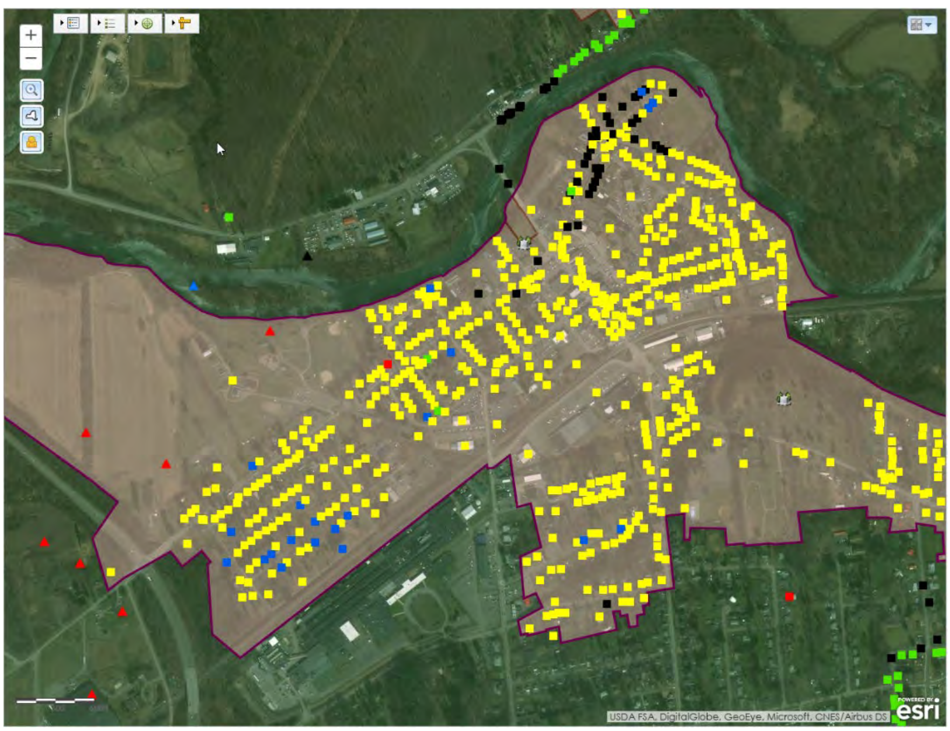


Figure 44: Historic buildings, Village of Sidney

- (Alternative 7) Non-structural measures in Sidney - Adverse effects to historic properties from implementation of non-structural measures are specific to the historic property treated. The area selected for non-structural measures is within the Sidney Historic District. It has 912 contributing resources, with approximately 82 in the western portion of the district.

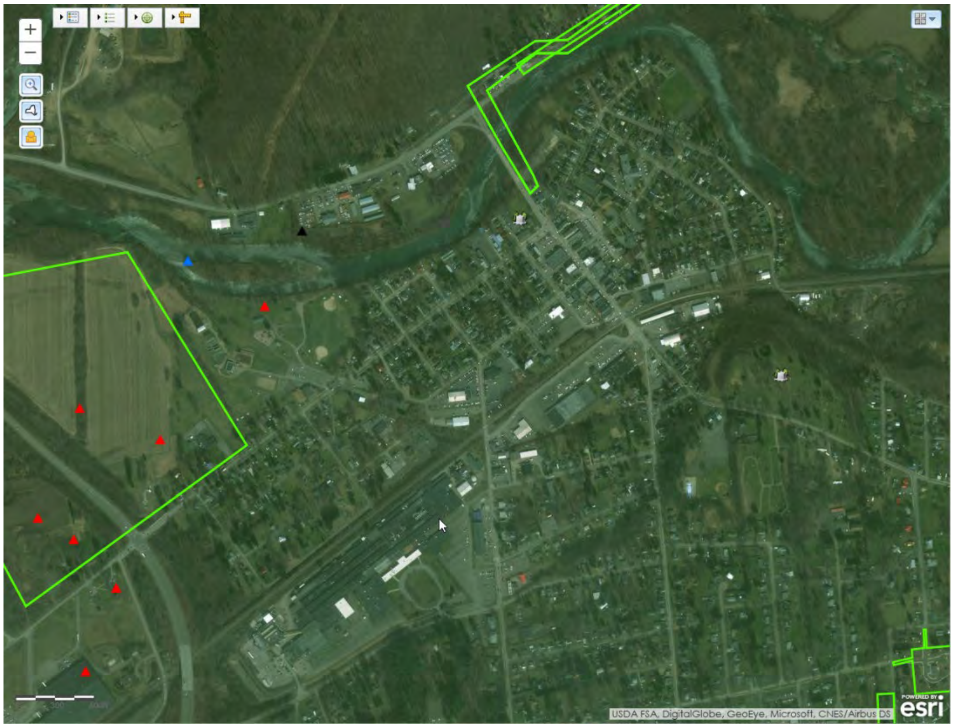


Figure 45: Archaeological sites and **s**urveys, Village of Sidney

4.12 THE TOWN OF CHENANGO

4.12.1 EXISTING CONDITIONS

The primary flood risk driver in Chenango is overbank flooding along the Chenango River.

4.12.2 INITIAL ARRAY OF ALTERNATIVES

The following initial alternatives were formulated to address flood risk problems in Chenango:

- Alternative 1: No Action
- Alternative 2: Build a new levee system in Chenango (Town) along the Chenango River (right bank)
- Alternative 2.1: Build a new levee segment in Chenango Bridge area along the Chenango River (right bank)
- Alternative 3: Pump station in Chenango
- Alternative 4: Clearing, snagging, & shoal removal along Chenango River in Chenango
- Alternative 5: Non-structural measures in Chenango

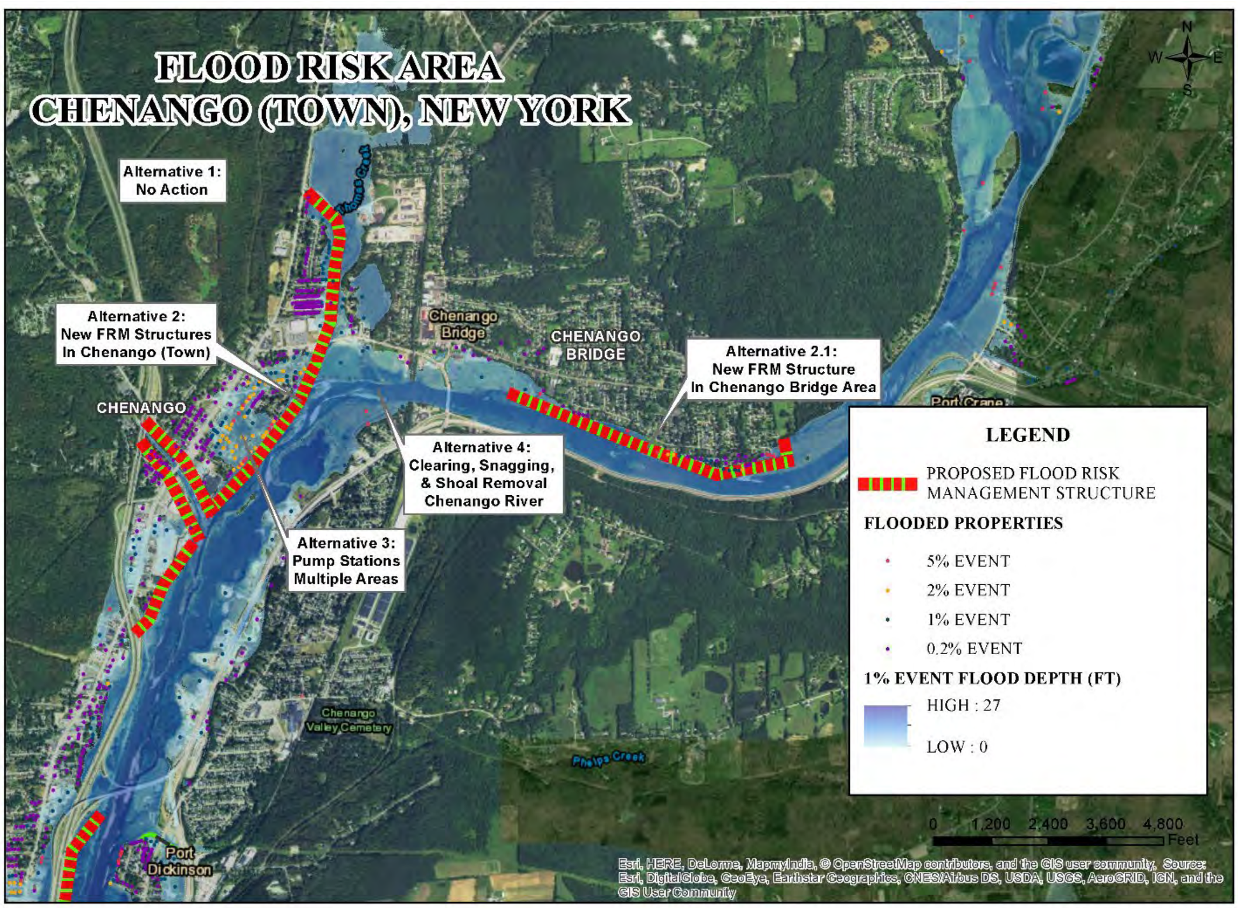


Figure 46: Mapped Initial Array of Alternatives in Town of Chenango

4.12.3 PRELIMINARY FEDERAL INTEREST

The results of the preliminary Federal interest screening analysis for Chenango are illustrated in Table 37.

Table 37: Preliminary Federal interest screening for Chenango Initial Array of Alternatives

Initial Alternatives	Preliminary Federal Interest	
	Assuming 50% Damage Reduction	Assuming 66% Damage Reduction
Alternative 1: No Action	X	X
Alternative 2: Build a new levee system in Chenango (Town) along the Chenango River (right bank)	0.2	0.3
Alternative 2.1: Build a new levee segment in Chenango Bridge area along the Chenango River (right bank)	0.5	0.6
Alternative 3: Pump station in Chenango*	X	X
Alternative 4: Clearing, snagging, & shoal removal along Chenango River in Chenango***	5.3	7.1
Alternative 5: Non-structural measures in Chenango**	X	X

**Pump stations were only evaluated if levee raising was proposed as a feasible alternative.*
***Evaluated in the focused array of alternatives only.*
****Unlikely to account for 10% of damage reduction based on the diffuse location of flooding in this area. Costed with 10% damage reduction not likely to be economically justifiable.*

4.11.4 ENGINEERING FEASIBILITY

- (Alternative 2) Build a new levee system in Chenango (Town) along the Chenango River (right bank) – Not evaluated.
- (Alternative 3) Pump station in Chenango - Pump stations would be required at minimum at two to three locations north of Dickinson all the way to Thomas Creek. This is only included for costing purposes if a levee project is shown to have potential benefits.
- (Alternative 4) Clearing, snagging, & shoal removal along Chenango River in Chenango - the proposed shoaling removal area will only provide marginal benefits to these areas. Unlikely to account for 10% of damage reduction based on the diffuse location of flooding in this area.

4.12.5 ENVIRONMENTAL ACCEPTABILITY

The environmental acceptability for Chenango alternatives is shown in Table 38.

Table 38: Preliminary evaluation of environmental concerns for Chenango Initial Array of Alternatives

Proposed Project	Farmland (Direct Impacts)	HTRW (Direct or Indirect Impacts)	Streams/Rivers (Waters) (Direct Impacts)	Wetlands (Direct Impacts)
(Alternative 2) Build a new levee system in Chenango (Town) along the Chenango River (right bank)	Uncertain. Determine whether parcel at Thomas Creek/Chenango Creek farmed. Soil is prime farmland.	Low	Low	Moderate - avoid wetlands along Chenango River in Chenango Bridge, along west bank Thomas Creek at northern levee terminus, and at southern terminus of levee on west bank Chenango River
(Alternative 4) Clearing, snagging, & shoal removal along Chenango River in Chenango	Low	Low	High - need detailed evaluation of aquatic environmental impacts	Low

4.12.6 CULTURAL/HISTORICAL IMPACTS

No cultural or historical impacts were examined for this area in the preliminary analysis.

4.13 THE VILLAGE OF WAVERLY

4.13.1 EXISTING CONDITIONS

The primary flood risk driver in Waverly is tributary flooding in Cayuta Creek and overbank flooding along the Susquehanna River.

4.13.2 INITIAL ARRAY OF ALTERNATIVES

The following initial alternatives were formulated to address flood risk problems in Waverly:

- Alternative 1: No Action
- Alternative 2: Build a new levee system in Waverly along Cayuta Creek (both banks)
- Alternative 3: Pump station in Waverly
- Alternative 4: Clearing, snagging, & shoal removal along Susquehanna River in Waverly
- Alternative 5: Non-structural measures in Waverly

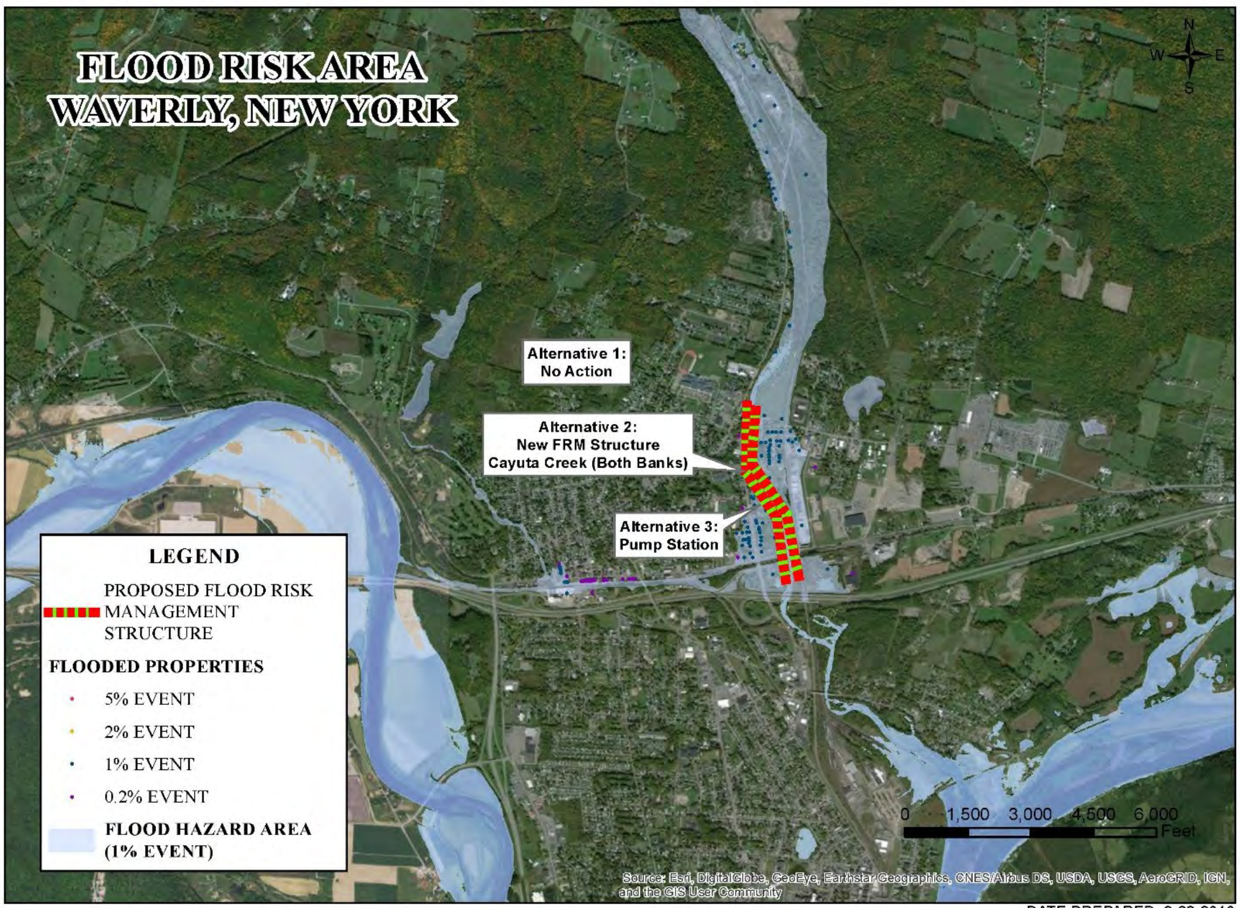


Figure 47: Mapped Initial Array of Alternatives for Waverly

4.13.3 PRELIMINARY FEDERAL INTEREST

The results of the preliminary Federal interest screening analysis for Waverly are illustrated in Table 39.

Table 39: Preliminary Federal interest screening for Waverly Initial Array of Alternatives

Initial Alternatives	Preliminary Federal Interest Assuming 50% Damage Reduction	Preliminary Federal Interest Assuming 66% Damage Reduction
Alternative 1: No Action	X	X
Alternative 2: Build a new levee system in Waverly along Cayuta Creek (both banks)	0.2	0.3
Alternative 3: Pump station in Waverly*	X	X
Alternative 4: Clearing, snagging, & shoal removal along Susquehanna River in Waverly***	1.5	2.0
Alternative 5: Non-structural measures in Waverly**	X	X

**Pump stations were only evaluated if levee raising was proposed as a feasible alternative.*
***Evaluated in the focused array of alternatives only.*
****Unlikely to account for 10% of damage reduction based on the diffuse location of flooding in this area. Costed with 10% damage reduction not likely to be economically justifiable.*

4.1 . ENGINEERING FEASIBILITY

- (Alternative 2) Build a new levee system in Waverly along Cayuta Creek (both banks) - Flooding is primarily from tributaries not modeled in this effort.
- (Alternative 4) Clearing, snagging, & shoal removal along Susquehanna River in Waverly - Flooding is primarily from tributaries not modeled in this effort.

4.13.5 ENVIRONMENTAL ACCEPTABILITY

The environmental acceptability for Waverly alternatives is shown in Table 40.

Table 40: Preliminary evaluation of environmental concerns for Waverly Initial Array of Alternatives

Proposed Project	Farmland (Direct Impacts)	HTRW (Direct or Indirect Impacts)	Streams/Rivers (Waters) (Direct Impacts)	Wetlands (Direct Impacts)
(Alternative 2) Build a new levee system in Waverly along Cayuta Creek (both banks)	Uncertain. Determine whether parcel along Cayuta Ave farmed. Soil is prime farmland.	Uncertain - Determine whether tank & spill west of Cayuta Creek of concern.	Low	Low

4.13.6 CULTURAL/HISTORICAL IMPACTS

No cultural or historical impacts were examined for this area in the preliminary analysis.

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ANNEX 1: ENVIRONMENTAL ANNEX

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1.0 SCREENING PROCESS

To inform screening and selection of candidate areas, maps and aerial imagery from a variety of online sources were reviewed to characterize magnitude of several environmental concerns that could potentially have important bearing on project location and design, and thus on project cost and benefits. Landscape-scale environmental concerns considered included presence of wetlands, streams/rivers, farmland, and hazardous/toxic/radioactive waste.

Structural Measures – General Concerns

Structural Flood Risk Management (FRM) would raise direct environmental concerns by potential need to have FRM structures in locations where sensitive environmental or social concerns are present and could be directly impacted, as well as indirect concerns from altering pathways of water or sediment movement, or access for fish, wildlife, or people. Ideally, FRM structures would be positioned to avoid/minimize direct and indirect impacts to sensitive environmental resources and human communities. Accordingly, it is necessary to generally identify environmental and social concerns in the areas where FRM structures are being considered so as to facilitate avoidance/minimization of impacts.

Non-structural Measures – General concerns

Non-structural FRM could possibly raise environmental concerns associated with relocation or removal or alteration of buildings (particularly regarding pollutants associated with the structures and supporting infrastructure). The buildings and structures would be connected to water, sanitary sewer, and power supply infrastructure that would need to be disconnected. The process of disconnection would have to be done carefully to minimize risk of environmental harm from liberating pollutants. Removal and transport of building materials would pose risk of exposing people and workers to pollutants contained in building materials as well as from transport of the materials. However, environmental concerns of these pollutants could be effectively managed provided infrastructure is properly disconnected and presence of various pollutants anticipated in planning for building structure relocation, removal or alteration. (Thus, investigations of the buildings/structures in advance would be required). However, negative impacts to natural habitats (particularly wetlands or forests) and waters (both physical crossing and water quality impacts) could be managed through physical avoidance. Social concerns could arise in implementing buyouts by further reducing population of areas already in decline. However, these areas are generally inherently risky to life and property. Highly site-specific information would be needed related to potential structures. This information would be appropriately gathered in the future when individual structures are identified. At this time, general concerns though can be identified by types and ages of structures in areas where relocation/modification/removal would occur.

2.0 STUDY AREA

Following selection of specific urban areas within the Upper Susquehanna River Basin (USRB) as candidates for FRM plan formulation, it became necessary to characterize existing conditions in those identified areas. Areas where FRM projects appeared likely to produce favorable benefit-cost ratios (BCRs) included Binghamton, Johnson City, and Endicott/Vestal. The Binghamton and Endicott-Johnson City-Vestal (EJV) areas lie within Broome County. This section includes an overview of existing conditions for these municipalities, as well as somewhat more detailed consideration of the area where FRM features would potentially be improved or constructed based on concept designs presented at the local government stakeholders meeting in March, 2018.

"Area of Interests" for each candidate project area in Oneonta and Owego were coarsely determined to establish rough boundaries within which screening would be done. In many cases, multiple alternatives are being evaluated within the same general area that include combinations of different locations and lengths of measures. For this initial environmental screening, an area of interest was identified that roughly included the area generated by merging various on-land or in-channel activities as appropriate for each area.

2.1 BINGHAMTON CITY/PORT DICKINSON VILLAGE

The Binghamton area of interest in this study includes Binghamton City, Port Dickinson Village, Town of Conklin, and Town of Chenango. These municipalities lie in Broome County in the Southern Tier region of New York State. Binghamton is the county seat of Broome County. Binghamton and adjacent municipalities constitute the most populated urban area within the USRB.

The Binghamton area of interest focuses on locations where existing levees and floodwalls occur that could be modified, as well as areas where new FRM features could be constructed. This is generally the urban area in the vicinity of the confluence of the Chenango and Susquehanna Rivers on both banks. However, the area of interest varies somewhat by topic of consideration as a function of where direct or indirect project impacts could occur.

Existing levees of interest lie discontinuously along about 3 miles of the south bank of the Susquehanna River, and along about 3.5 miles of the Chenango River. The existing levees and floodwalls are located in urban land (commercial, residential, and transportation infrastructure right-of-way land use) in Binghamton with a high concentration of impervious surfaces in the vicinity. The levees on the north and south bank of the Susquehanna River generally have one row of trees on the riverward side of the levee, but urban conditions on the landward side of the levee. On the west and east banks of the Chenango River in Binghamton, land use is primarily commercial or transportation infrastructure. In Port Dickinson, land use on the east side of the river in the existing levee area is residential and wooded riparian. These woodlands are presumably private land as there is no indication that the woods in the levee area of Port Dickinson are preserved as parkland.

Additional areas of interest exist where new FRM structures are proposed along the west bank of the Chenango River opposite Port Dickinson and along the south bank of the Susquehanna River. New FRM structures are proposed on the south bank of the Susquehanna River between the east side of Sandy Beach Park eastward to where Route 7 (Conklin Road) intersects with the Susquehanna River (immediately downstream of the Conklin-Kirkwood Road bridge). This area of interest lies partly in Binghamton City, but mostly within the Town of Conklin. The proposed FRM structure across from Port Dickinson lies along the west bank of the Chenango River between the Interstate 88 Bridge downstream to the Route 17/Interstate 81 bridge. This area lies in the Town of Chenango.

2.2 ENDICOTT-JOHNSON CITY-VESTAL

Johnson City is a village within the Town of Union located on the eastern side of the town adjacent to Binghamton City. The levee system partially encircles Johnson City on its eastern, southern, and western side. The eastern and southeastern part of the levee system lie just west (uphill) from Little Choconut Creek and its tributaries, discontinuously along about 1.2 miles (including sections lacking FRM features). The southernmost and southwesternmost part of the levee system is about 0.4 miles long along the Susquehanna River shoreline. The western side of the levee system lies along a southward flowing ditched stream that lies immediately west and outside of the Village of Johnson City municipal boundary.

Endicott lies in the vicinity of the confluence of the Susquehanna River and Nanticoke Creek. The area of interest as defined by locations of existing levee system includes features on the north and south side of the Susquehanna River, as well as along the south side of Nanticoke Creek. The north side of the Susquehanna River, including the Nanticoke Creek area, lies in the Town of Union. The Town of Union forms the western suburbs of Binghamton, and contains the Village of Endicott. On the south side of the Susquehanna River, the area of interest lies within the Town of Vestal from Choconut Creek at the downstream end then proceeds upstream to the vicinity of Willow Run.

The area of interest where new levees or floodwalls might be constructed or existing FRM structures modified extends approximately 1.5 miles along Nanticoke Creek, discontinuously along about 2.5 miles of the Susquehanna River, about 1 mile along Choconut Creek, and about 0.4 miles along Willow Run. No new snagging and clearing or dredging is currently proposed, thus in-channel areas are not identified in the area of interest. The existing levee along the Nanticoke Creek runs on the southeast side of the creek from West Main Street (Route 17C) to Nanticoke Avenue (Route 26).

2.3 ONEONTA

The area of interest is the existing levee that lies along the east side of Main Street (Main Street is perpendicular to the Susquehanna River) on the north bank of the river in Oneonta from the river to about the railroad crossing of Main Street that lies about 1/3 mile north of the river. The levee has primarily commercial land uses on its western side. On its eastern side, the levee is bordered by a channelized stream about 0.3 miles long with open space of Neahwa Park immediately east of the stream.

2.4 OWEGO

The Owego area of interest lies along the Susquehanna River and Owego Creek. New work proposed lies on land on the east bank of Owego Creek and north bank of the Susquehanna River where existing berms may be modified or new levees constructed. The north bank of the Susquehanna River includes Owego itself, which has characteristics typical of an older small town. Residential and commercial land uses occur in close proximity along gridded streets. The south bank of the river is in transportation land use, with Route 17 lying immediately inland from the Susquehanna River. Further inland, land south of the Susquehanna River is mostly rural in character, although small communities occur immediately south of Owego. The west bank of Owego Creek is rural in character.

3.0 PHYSIOGRAPHY/TOPOGRAPHY

The areas of interest all lie within the Allegheny Plateau, described in the Main Report. The areas of interest are similar topographically. All the municipalities consist primarily or even entirely relatively flat areas in river valleys. The valleys are generally bounded by steeper slopes which then become gradually flatter uphill once they reach the elevation of the regional plateau.

3.1 PHYSIOGRAPHY/TOPOGRAPHY IN BINGHAMTON/PORT DICKINSON

The City of Binghamton lies primarily within the valleys of the Susquehanna and Chenango Rivers, but also includes adjacent high ground above the valley. Elevations in the city range from lows of about 815 feet above sea level along the Susquehanna River at its downstream end within Binghamton to about 835 feet along the Susquehanna River at its upstream end within Binghamton. The Chenango River has an elevation of about 825 feet at its upstream end within the City of Binghamton. The flat valley area of Binghamton generally lies at elevations ranging from about 830 to 860 feet. The maximum elevation within the city is about 1515 feet, east of Ely Park Blvd (USGS 2018, Google Earth, 2018).

The village of Port Dickinson lies in the valley of the Chenango River. Elevations range from lows of about 825 feet along the Chenango River to highs of about 1100 feet along the railroad tracks south of Rogers Mountain Way (USGS HTMC, Google Earth, 2018).

3.2 PHYSIOGRAPHY/TOPOGRAPHY IN ENDICOTT-JOHNSON CITY-VESTAL

The village of Johnson City lies in the Susquehanna River valley, and valley of Little Choconut Creek, a tributary to the Susquehanna River, but also includes adjacent high ground above the valley. Maximum elevations within Johnson City are about 1400 feet in the northeastern part of Johnson City. Minimum elevations of about 800 feet occur along the Susquehanna River. The majority of Johnson City within the valley flat lies at elevations ranging from about 820 to 840 feet (USGS, 2018; Google Earth, 2018).

Endicott Village lies on the north side of the Susquehanna River, while Vestal lies on the south side of the river. Endicott lies primarily in a flat valley landscape position, although includes a hill that rises above the valley flat known of as "Roundtop" that rises to about 1100 ft elevation. The low elevation in Endicott Village is about 800 ft on the eastern edge of the village on the Susquehanna River. Elevations otherwise range up to about 850 feet generally, except in the vicinity of Roundtop. The area of the Town of Vestal along the Susquehanna River in the area of interest lies entirely in a flat valley landscape position. Elevations in this area generally range from about 810 ft to about 840 ft (USGS, 2018; Google Earth, 2018).

4.0 GEOLOGY AND SOILS

4.1 BINGHAMTON/PORT DICKINSON

Mapped soils in the Binghamton area reflect the urban character of the area. Soils along the east bank of the Chenango River from its confluence with the Susquehanna River upstream to the vicinity of Phelps Creek (about 1,000 feet south of the Interstate 88 bridge) are mapped as "Cut and Fill Lands" soil map units. North of Binghamton in Port Dickinson (Bromley Avenue North), soils along the Chenango River are mapped as "Made Land" but also as a natural soil, "Tioga silt loam." At the northern end of Port Dickerson, soils along the river are mapped as "Cut and Rill Lands." On the west bank of the Chenango River, soils along the river from Prospect Street (immediately south of Route 17) south to East Clinton Street also are mapped as consisting of "Cut and Fill Lands" soil map units (NRCS soil mapper, 2018).

4.2 OWEGO AND ONEONTA

For areas of interest with farms within the potential project footprint or in close proximity to the project, determination of soils being farmed would be important to determine how important avoidance or minimization of impacts to these soils would be in FRM planning. Important farmed soils maintain the nation's food supply and provide fiber for many uses. Generally, it is desirable to avoid or minimize importance to these important farm soils when in agricultural use.

Table A-1: Farmland Soils in Owego and Oneonta

Project Area	Active Farming In Footprint	Active Farming in Close Proximity but not in Footprint
Oneonta	No	No
Owego	No	Yes (opposite on west bank of Owego Creek, and north bank of Susquehanna River, downstream of Owego Creek)

An imagery analysis shows that land is farmed on the eastern side of Owego north of East Front Street and east of Division Street (Google Earth, 2019). This farmed land is mapped by NRCS soil mapper as consisting of Bg (Braceville gravelly silt loam). This soil is classified as a prime farmland soil if drained. (This soil is somewhat poorly drained, but not classified as a hydric soil). This farmed land could lie within or in close proximity to initial concept design for levee there.

Land along the west side of Owego Creek opposite Owego is farmed, but presumably snagging, clearing, or dredging could be conducted in such a manner as to minimize impacts to farming there.

5.0 HYDROLOGY

5.1 BINGHAMTON/PORT DICKINSON

Binghamton and vicinity lie at the confluence of the Chenango and Susquehanna Rivers. The Binghamton area lies within three 8-digit HUC watersheds (DMA 2000 Haz Mit Plan Update – Broome Co, NY Feb 2013).

Table A-2: HUC 8 Watersheds in the USRB

HUC 8 Digit	Watershed Name	States Watershed Extends Into
02050101	Upper Susquehanna	NY, PA
02050102	Chenango	NY
02050103	Owego-Wappasening	NY, PA

Brandywine Creek flows westward into Binghamton City north of Route 17, but displayed on topographic maps moving underground in the city. The PDT is not certain where Brandywine Creek daylights at this time, it likely flows west out to Chenango River north of Interstate 81. Chamberlain Creek flows southward through Binghamton City into the Susquehanna River just east of the railroad bridge that crosses onto north side of river at about Bigelow Street (USGS, 2018).

North-flowing Bayless Creek parallels Park Avenue on the south side of the Susquehanna River. The stream goes underground near Vestal Avenue and presumably flows north into Susquehanna River. Also on the south side of Susquehanna River, north-flowing Pierce Creek flows roughly parallel to Burr Avenue then enters Susquehanna River as an above-ground stream (i.e., not depicted as piped) (USGS, 2018).

2018-07-24 engineering field notes
South Binghamton:
-floodwall crosses Park Creek at sta. 46+00, in photo appears to be concrete channel.
-drainage pipe near Crowley's Building (~84+30), historic creek put into pipe?
Port Dickinson.
On southern edge of Port Dickinson, Phelps Creek flows westward into Chenango River. Within the Chenango River in Port Dickinson, minor channels and islands on the east bank of river.

5.2 OWEGO AND ONEONTA

Wetlands in floodplains are often problematic to identify from a soils perspective because rapid deposition hasn't allowed time for hydric soil character development. In addition, sandy soils may lack color because of lack of minerals that display hydric character, and because of potentially high oxygen levels much of the time.

Reviewed variety of maps to determine whether proposed FRM measures as presented in concept designs looked likely to directly impact (physically cross) mapped wetlands or waters. Also, considered indirect impacts that could result.

<u>Oneonta:</u>
USFWS NWI wetlands mapper depicts multiple parcels of palustrine wetlands along a creek that flows south of Route 23 and west of Main Street and eventually flows southward into the Susquehanna River just east of Route 205 ("State Fishing Access Road"). This creek is not named on USFWS NWI or on Google Maps. The creek appears to include numerous channelized segments based on map and aerial image channel straightness (Google Maps and USFWS NWI), however it historically was presumably a meandering channel of the Susquehanna River. USFWS NWI depicts minimal to no wetlands along the Susquehanna River channel. One relatively large parcel is present on the north bank of the river in the vicinity of where the creek that flows south of Route 23 enters into the Susquehanna River. An additional relatively large wetland parcel is mapped south of the river along Route 28 just east of Home Depot.

The area of interest for a proposed levee poses no risk of directly impacting mapped wetlands. New FRM features could indirectly impact mapped vegetated wetlands on the south bank of the Susquehanna River by increasing flood and sediment flows. Snagging and clearing in the Susquehanna River in the vicinity of Main Street would not likely directly impact any mapped vegetated wetlands as none are present in the vicinity. Snagging and clearing could indirectly impact mapped vegetated wetlands on the south bank of the Susquehanna River in the floodplain, however.

The proposed new levee could presumably be constructed in such a manner as to avoid impacts to the unnamed creek.

<u>Owego</u>
Vegetated wetlands are mapped to occur along the east bank of Owego Creek within Owego in the area identified for berm improvement and new levee construction, as well as on the opposite west bank of Owego Creek outside of Owego. The north bank of the Susquehanna River within Owego immediately along the river is not mapped to have vegetated wetlands. Additionally, vegetated wetlands are mapped to occur within Owego on the eastern side of the municipality parallel to the Susquehanna River, but somewhat inland along the north side of Route 17C (5th Avenue) and south of East Front Street. These mapped wetlands extend southeastward along the north side of the railroad tracks to outside of the municipality of Owego. These mapped wetlands lie in close proximity to the area south of East Front Street proposed for new levees.

Modification of the existing berm or construction of new levees on the west side of Owego would need to consider location of existing wetlands, and new levees would likely need to lie to the east of existing vegetated wetlands in that area. Construction of a new levee along East Front Street would need to consider existing vegetated wetlands in levee siting.

Areas identified for new snagging/clearing/dredging if they extend into the Susquehanna River downstream of the Owego Creek confluence possess mapped vegetated wetlands along the shoreline and in islands in the river. These wetlands could be directly impacted by new dredging, however they are already within the authorized federal snagging/clearing area so it is uncertain how new impacts would differ.

The non-structural areas of interest within Owego (south side) and southeast of the municipality appear to pose minimal risk of requiring to consider wetlands in plan formulation.

Downstream of Owego, Google Earth depicts what appear to be gravel mines located on the north bank. These potentially present opportunities as wetland restoration sites, although the gravel mines abandonment plans, etc. would need to be researched to evaluate whether there is need for government involvement.

No streams are mapped to flow through Owego on either Google Earth, USFWS NWI, or Google Maps in the areas of interest for berm improvement and new levee construction.

5.3 ENDICOTT-JOHNSON CITY-VESTAL

Johnson City Tributaries: Finch Hollow Run and Little Choconut Creek, Susquehanna River
Endicott Tributaries: Nanticoke Creek, Susquehanna River
Vestal Tributaries: Big Choconut Creek, Susquehanna River

6.0 WATER QUALITY

NYSDEC (2009) reports that the lower Chenango River is impaired by the pollutants mercury and silt/sediment. Additionally, nutrients, thermal changes, and salt also may be important pollutants. These pollutants originate from agriculture, combined sewer overflow, habitat modification, and urban/storm runoff. These pollutants may also originate from atmospheric deposition and hydrologic modification.

NYSDEC (2015) suggested based on biological surveys that Susquehanna River water quality is non-impacted immediately upstream of the Binghamton Johnson City Treatment Plant (sewage), moderately to severely impacted within a mile downstream of the plant, then recovers to slightly impacted 5 to 6 miles downstream, and is again non-impacted 11 miles downstream of the plant. NYSDEC (2015) states that agricultural activity, municipal wastewater discharge and urban storm runoff are the primary source of significant nutrient concentrations to the river reach covered in this survey. The BJCSTP wastewater treatment capabilities were impaired in 2011 by system failure and then subsequently by inundation of Tropical Storm Lee floodwaters.

Fish consumption within the lower Chenango River is under a health advisory due to mercury contamination (NYSDEC 2009).

7.0 AIR QUALITY

Certain population groups are considered more sensitive to air pollution and odors than others; in particular, children, elderly, and acutely ill and chronically ill persons, especially those with cardio-respiratory diseases such as asthma and bronchitis. Sensitive receptors (land uses) indicate locations where such individuals are typically found, namely schools, daycare centers, hospitals, convalescent homes, residences of sensitive persons, and parks with active recreational uses, such as youth sports.

Persons engaged in strenuous work or physical exercise also have increased sensitivity to poor air quality. Residential areas are considered more sensitive to air quality conditions than commercial and industrial areas, because people generally spend longer periods of time at their residences, resulting in greater exposure to ambient air quality conditions. Recreational uses such as parks are also considered sensitive, due to the greater exposure to ambient air quality conditions and because the presence of pollution detracts from the recreational experience.

8.0 AQUATIC HABITATS

The Lower Chenango River is highly channelized within Binghamton (NYSDEC 2009). NYSDEC (2015) contains an assessment of stream benthic macroinvertebrates from the Binghamton Johnson City Joint Sewage Treatment Plant to about 12 miles downstream along the Susquehanna River. The survey shows non-impacted conditions above the plant, moderate impact below the plant, and benthic community recovery 11 miles below the plant.

9.0 VEGETATION

The City of Binghamton’s 2010 “Urban Forest Management Plan” provides information on city vegetation. Limited sampling conducted in 2006 identified Norway Maple, cherry, and honey locust as the city’s most abundant trees. The city has relatively few ash trees, so emerald ash borer does not appear to pose a major threat to the city’s trees. Asian long-horned beetle which feeds on maple may be a future concern. Tree cover in the city as measured in 2006 varied from 0 in intensely built area to greater than 50 percent. All photos referenced in this section were collected by USACE during a field visit and are included in Chapter 5 of Appendix C Engineering.

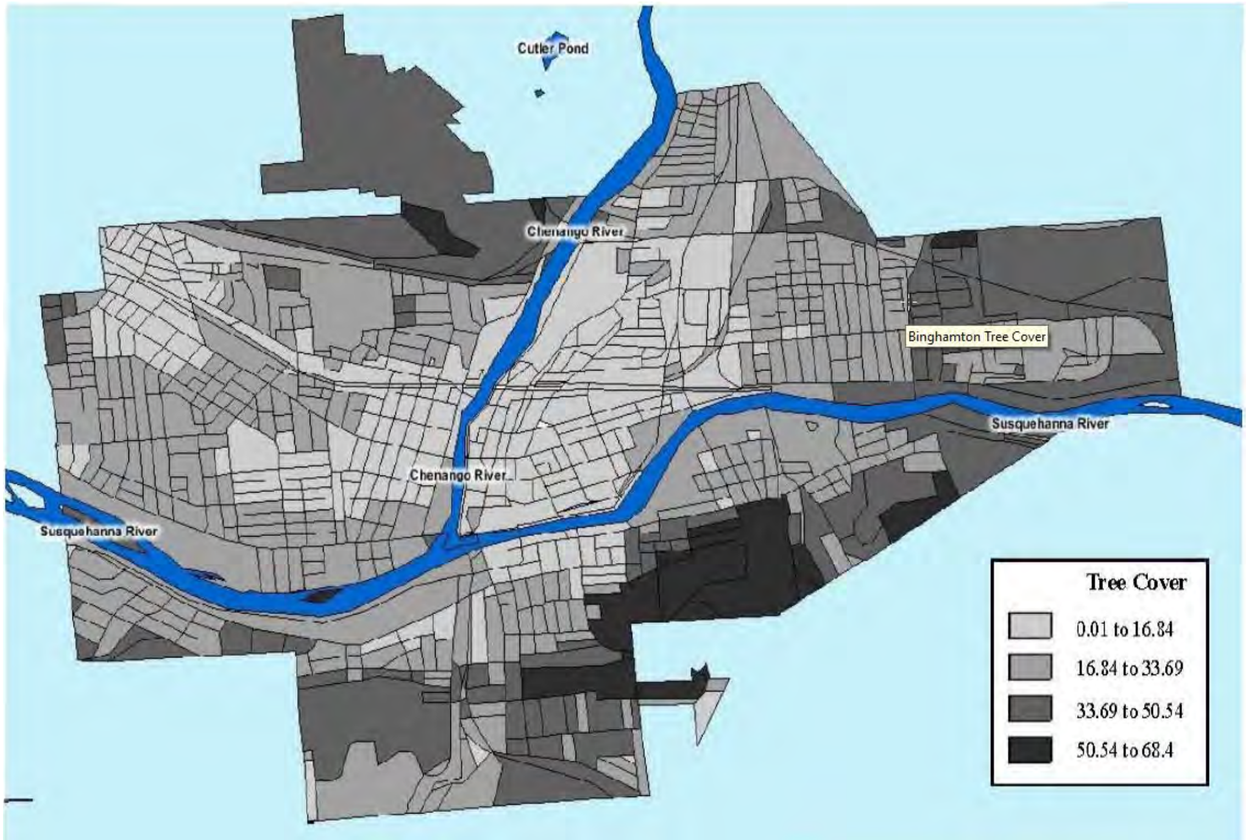

Figure A-1: Tree cover in Binghamton in 2006 (Urban Forest Management Plan, 2010)

2018-07-24 engineering field notes

-South Binghamton: photos of levees and floodwalls show predominantly mowed lawns on top of and immediately adjacent to levees and floodwalls. However, in some cases woody vegetation is close enough off the structure that it appears like it could be impacted. No Forest Conservation Act in NY State, so this would be quantified but there's no laws restricting tree work (unless other environmental issue also: wetlands, ET spp, etc.). Floodwall along the river at Crowley Building (not sure how much of floodwall is along river) have limited riparian vegetation on river side of floodwall. However, presumably much of substrate already consists of manmade materials associated with floodwall construction, and presumably vegetation lots of invasive exotics (Japanese knotweed in photo?) and or species tolerant of scour and disturbance.

-NW Binghamton: photos of levees and floodwalls appear to show predominantly mowed lawn or even unvegetated impervious surface on/adjacent to levees/floodwalls. However, appear to show riparian wooded area adjacent to floodwall in some locations (e.g., 10+00)

10.0 FISH AND WILDLIFE

The online tool New York Nature Explorer was consulted to identify animals, plants, and habitats in Broome County. This errs by identifying habitats, plants, and animals throughout the county while the areas of interest lie primarily in close proximity to the Susquehanna and Chemung Rivers in urban areas. The NY Nature Explorer online tool provides only minimal information on mammals. It identifies two bats occurring in the study area.

11.0 LAND USE AND LAND COVER

Broome County has a distinctive development pattern that consists of a densely populated urban core with associated suburban fringe, narrow transportation corridors that follow the river valleys, rural village points, and open spaces found in the rural areas. The development patterns of the county were initially defined by the county's steep slopes and fertile river valleys (Broome County Comprehensive Plans, 2013).

Land use in Binghamton is controlled by city zoning. Binghamton City contains commercial, community service, industrial, multi-residential, parking, public service, recreational, and residential land uses. Commercial and industrial land uses dominate through the center of the city proceeding from north to south and east to west. Substantial commercial land and community service land occurs along the Chenango River. Land use along the Susquehanna River west of its confluence with the Chenango River is largely residential with some land in community service use. East of its confluence with the Chenango River, land use along the Susquehanna River is predominantly a mix of commercial, industrial, and residential land (Binghamton, 2014).

12.0 CULTURAL AND HISTORIC RESOURCES

Binghamton was within lands occupied and controlled by multiple Native American tribes over time. Federally recognized Indian Nations currently maintaining an interest in the Broome County area because of historic potential use and occupation include the Delaware Tribe, Delaware Nation, Onondaga, Tuscarora, Oneida (NYS Office of Parks, Rec, Hist Preserv, 2018). The first known European settlers to the area were troops of the Sullivan Expedition in 1779 during the Revolutionary War. Binghamton incorporated as a village in 1834 and then became a city in 1867 (DMA 2000 Hazard Mitigation Plan Update – Broome County, NY 2013).

Native Americans and early European settlers utilized the rivers for navigation and used the valley soils for farming. The urban core of the community first formed around the confluence of the Chenango and Susquehanna Rivers and then spread along the river valleys. As development increased, roads, canals, and railroads were constructed in the river valleys that connected Broome County communities with the remainder of New York State and the developing U.S. The construction of the Erie Canal, which spanned the northern tier of the state, initiated the building of a canal roughly following the Chenango River's course. The Chenango Canal operated between 1834 and 1878 and cut shipping times between the Cities of Binghamton and Albany. It also connected the growing manufacturing base with the port of New York City via the Hudson River. By 1848, railroads reached the County and replaced the Chenango Canal. Industrial development in the river valleys flourished due to the rail lines (Broome County Comprehensive Plans, 2012).

13.0 HAZARDOUS, TOXIC, AND RADIOACTIVE WASTE (HTRW)

Current activities are regulated by EPA to protect human health and the environment. Thus, active regulated activities conducted in accordance with the EPA permit would be acceptable by current environmental law. Historic activities in the area of interest conducted prior to modern environmental regulations though released a variety of contaminants and pollutants into the environment that do pose a hazard to human health and the environment. No detailed HTRW analysis was completed for this feasibility study at this time.

13.1 BINGHAMTON

EPA “EnviroMapper” identifies 189 sites of interest in the Binghamton area under their “Air Pollution,” “Toxic Releases,” “Hazardous Waste,” and “Water Dischargers” categories, as well as numerous additional sites in the municipalities up and downstream (USEPA, EnviroMapper).

13.2 OWEGO AND ONEONTA

Concerns over soil contamination focus on health risks from direct contact with the contaminated soil and vapors from contaminants, as well as escape of contaminants into the environment. Soil contamination is typically caused by industrial activity, agricultural chemicals, or improper disposal of waste. Goundwater contamination may also pose concerns.

A desktop review for pollutant and contaminant concerns was conducted in August 2017 by reviewing the EPA website Enviromapper and the private website “Homefacts.” The Enviromapper website provides information about EPA-regulated hazardous waste, toxic and air releases, and water discharges, as well as impaired surface waters. Facilities generating pollutants (such as gas stations and municipal public works departments) as well as contaminated sites (such as superfund and brownfields) are included. “Homefacts” utilizes EPA data to provide locations of sites of concern in four categories: superfund sites, brownfields, polluters (permitted), and tank related leaks & spills (Homefacts, 2017). Because many of the settled areas have industrial histories, further investigation is appropriate in most cases as detailed designs are developed for selected areas.

<u>Oneonta</u>
HomeMapper maps no superfund sites, brownfield sites, registered polluters, or tanks & spills in the vicinity of the proposed levee modification.

<u>Owego</u>
HomeMapper maps two superfund sites in Owego. One (IBM) is located along Route 17C East close to the Susquehanna River. This site could be of concern with respect to proposed new levee on the north bank of the Susquehanna River. HomeMapper maps no brownfield, registered polluter, or tanks & spill sites in Owego in the vicinity of the potential dredging areas.

14.0 TRANSPORTATION AND NAVIGATION

Interstates 81, 86 (NY State Highway 17), and 88 cross through Binghamton City. Interstate 88 touches the northern boundary of Port Dickinson. New York State Route 7 passes through Binghamton and Port Dickinson. Major state and local roads in Binghamton City include New York State Route 363 (North Shore Drive), New York State Route 434 (Vestal Parkway), New York State Route 17C (Main Street), and Court/Front Streets (US Route 11).

Rail lines are an important means of transportation for high volume industrial users (Broome County). Railroad tracks cross the city from east to west, as well as from Binghamton northward.

The Susquehanna River and Chenango River presumably have minimal to no active commercial navigation.

The Greater Binghamton Airport provides commercial passenger service. The airport lies about eight miles northwest of downtown Binghamton.

Broome County Transit has public bus service with regular passenger service extending from Endicott in the west through Johnson City to Binghamton, and then southeast to Kirkwood. Public bus service also extends, between Binghamton City and Chenango Bridge, running north to south. Public busses along the east side of the Chenango River pass though Port Dickinson.

Major freight rail lines from the east/west and north cross through Binghamton. Rail lines lay along the north bank of the Susquehanna River in Binghamton City east of the Tompkins Street Bridge. Rail lines are an important means of transportation for high volume industrial users (Broome County Comprehensive Plans, 2012). There is no passenger rail (Amtrak) service to Binghamton, NY.

15.0 INFRASTRUCTURE

15.1 WASTEWATER AND SEWAGE TREATMENT

Sewage from Binghamton is treated at the Binghamton-Johnson City Sewage Treatment Plant and released into the Susquehanna River downstream. The City of Binghamton Hazard Mitigation Plan Update – Broome County, New York February 2013: has information on sanitary sewer system septic pumps located within city within 1% and 0.2% annual chance floodplains.

15.2 ELECTRICITY

City of Binghamton: electric system. No vulnerability to flooding identified in the February 2013 Broome County Hazard Mitigation Plan update.

15.3 WATER SUPPLY SYSTEM

Port Dickinson purchases its water from Hillcrest (unincorporated area to the north) and Binghamton (to the south). Hillcrest water comes from three wells. The City of Binghamton's primary source is the Susquehanna River. The water is withdrawn and treated at a modern, recently renovated water filtration facility. Binghamton also has a back-up groundwater supply (Village of Port Dickinson, 2017).

15.4 SCHOOLS

Table A-3: Schools in Binghamton near FRM project

School Name	Location	Notes
Benjamin Franklin Elementary	South side of Susquehanna River, west of Pierce Creek	Near new wall at eastern end of system on south side of river
MacArthur Elementary	South side of Susquehanna River, west of Chenango R confluence	Protected by existing levee/wall near western end of system on south side of river.

16.0 RECREATION

16.1 RECREATION IN BINGHAMTON/PORT DICKINSON

The Binghamton area of interest contains two waterfront parks. Sandy Beach Park, located on Conklin Avenue, lies along the Susquehanna River at the upstream end of the river within the city on south bank. This park provides waterfront access and has a hard surfaced boat launch. Port Dickinson Community Park lies in Port Dickinson Village immediately north of the northernmost levee on the east bank of the Chenango River. This 17-acre park has walking trails along the water, athletic fields and picnic facilities (NY State Dept of State, 2011).

The City of Binghamton has a network of bicycle and pedestrian trails. The Binghamton Metropolitan Greenway Study completed in 1999 provides information on existing and proposed trails. Trails occur or are proposed along both banks of the Chenango River through much of Binghamton City. Trails are also proposed or existing along both banks of the Susquehanna River in the vicinity of the Chenango and Susquehanna Rivers confluence. In 2017, construction of a major bicycle and pedestrian trail linking the South Side of Binghamton to Binghamton University's main campus in Vestal.

The Metropolitan Greenway Study (1999) depicts the Port Dickinson Trail Network along the east bank of the Chenango River passing through Port Dickinson.

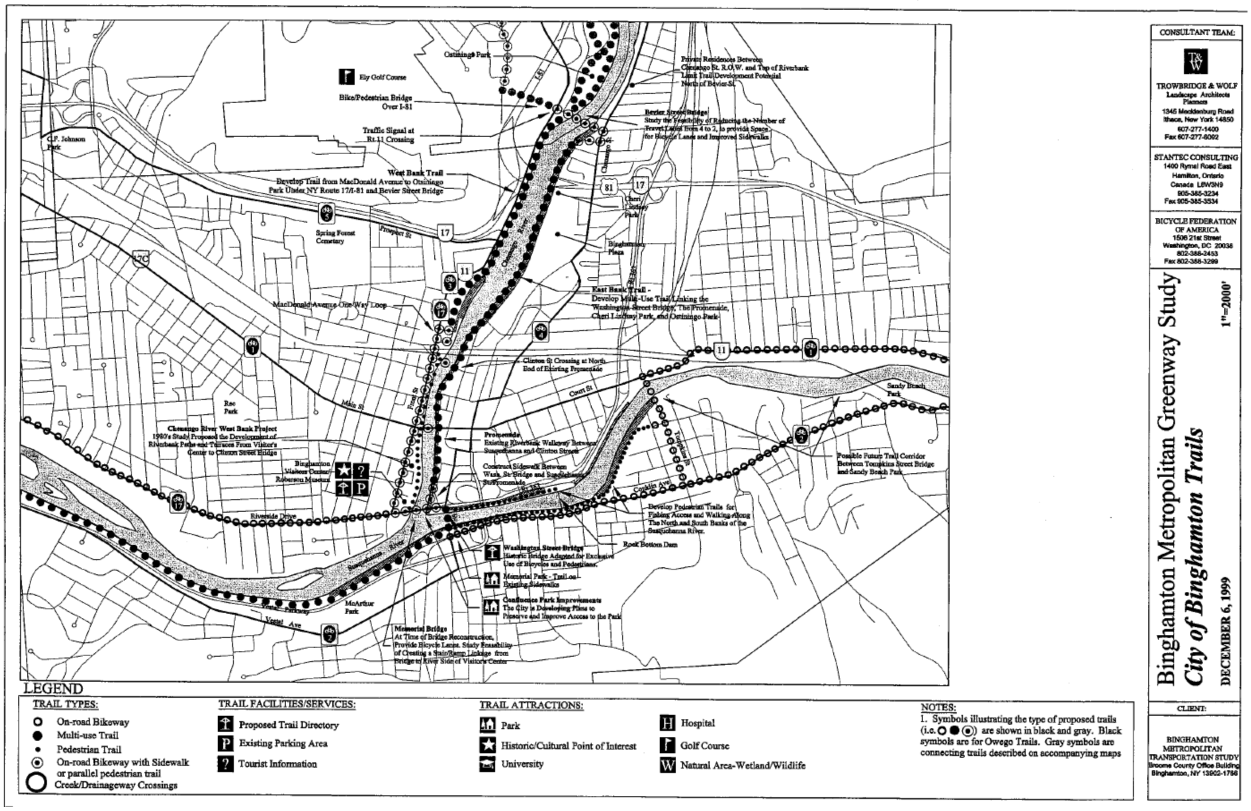

Figure A-2: City of Binghamton Trail System

July 2018 engineering field notes photos
-<u>NE Binghamton, Susquehanna River</u>: show pedestrian walkways and bike paths in vicinity of Washington Street Bridge but appear to just be bridge itself. Informal trails (dirt paths) apparent on grassed levees and sidewalks in high density urban areas and sometimes along floodwalls. Gravel or paved roads along some floodwalls.
-<u>NE Binghamton, Chenango R</u>: walkway/pedestrian path along river or land side of floodwall along Chenango River (photos show paths on either side depending on location), paved walkway along top of levee.
-<u>NW Binghamton</u>: some informal trails along levee/floodwall, but no apparent organized network.
-<u>South Binghamton</u>: some informal trails along levee/floodwall, but no apparent organized network.

17.0 PUBLIC SAFETY

Various planning documents prepared by local government were relied upon heavily to prepare this report section. The Disaster Mitigation Act of 2000 (DMA 2000) required counties and towns to develop hazard mitigation plans to reduce the risks from natural hazards. Documents prepared by local governments to meet requirements of DMA 2000 were an important source of information for this section.

The Sandy Recovery Improvement Act (SRIA) of 2013 amended DMA 2000. The SRIA 2013 acknowledges that flooding has a tremendous impact on land use patterns in Broome County.

The City of Binghamton joined the NFIP in 1977 and is currently an active member of the NFIP. Flood Insurance Rate Maps have been in effect for the community since 1977. The City of Binghamton is proactive in floodplain management. The current Flood Damage Prevention Ordinance meets the requirements of the NFIP program (DMA 2000 Hazard Mitigation Plan Update, Feb 2013).

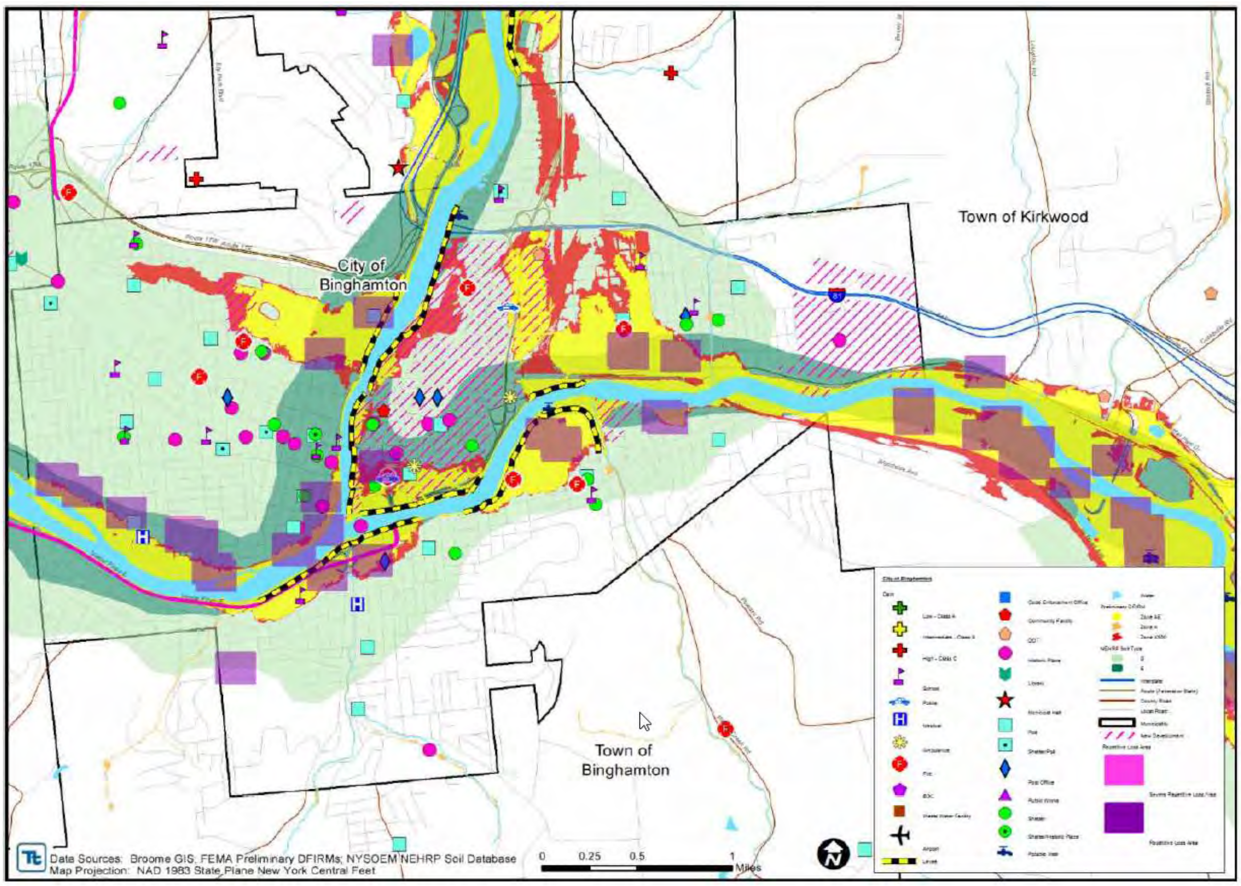

Figure A-3: Binghamton hazard extent and location map (Feb 2013 update)

18.0 NOISE

In many portions of the study area, the existing noise environment is effected by transportation-related uses, including airplanes flying overhead from the Binghamton Airport and vehicles traveling on local and regional roadways, and public transit.

Table A-4: Typical ambient noise levels based on population density

Population Density Category	dBA, L_{dn}
Rural	40–50
Suburban	
Quiet suburban residential or small town	45–50
Normal suburban residential	50–55
Urban	
Normal urban residential	60
Noisy urban residential	65
Very noisy urban residential	70
Downtown, major metropolis	75–80
Under flight path at major airport, 0.5 to 1 mile from runway	78–85
Adjoining freeway or near a major airport	80–90
Sources: Cowan 1984; Hoover and Keith 1996.	

Some land uses are generally regarded as being more sensitive to noise than others due to the types of population groups or activities involved. Sensitive population groups generally include children and the elderly. Noise sensitive land uses typically include all residential uses (single- and multi-family, mobile homes, dormitories, and similar uses), hospitals, nursing homes, schools, and parks.

19.0 AESTHETICS

The project area landscape is a mixture of urban communities with interspersed parkland surrounded by a distant vista of forests and of agricultural fields. Through this landscape flows the Susquehanna River.

Viewers of the project area include motorists traveling on roads that intersect area streams, those who use the levees and streamside parks for recreation, visitors to local parks, and residents of the area with views of the river from their private residences. Motorists typically view the streams only for short periods, but recreational users and residents would experience the views for longer periods.

The commercial areas are situated so that they are not oriented to any public views and, therefore, would also have a low sensitivity. Homeowners often choose their residences based on their location and surrounding visual landscape. Outdoor activities are closely tied to surrounding environment, such as hiking and sightseeing and parks.

Residential communities and parks can be sensitive to visual changes in the landscape because these views are intricately related to the surrounding environment. The project area can be viewed from several public parks and facilities.

20.0 WILD AND SCENIC RIVERS/AMERICAN HERITAGE RIVERS

According to the National Wild and Scenic River System website, there are no identified wild and scenic rivers in the USRB (NWSRS, 2019). No American Heritage Rivers are designated in the USRB in New York, although the Upper Susquehanna in Pennsylvania is considered an American Heritage River (White House, 1998).

21.0 POPULATION/SOCIOECONOMICS

See Appendix B Economics.

22.0 FUTURE WITHOUT PROJECT

Absent a project that addresses FRM in Binghamton, areas of the city vulnerable to flooding from the one percent annual chance event would remain vulnerable.

Floodwaters often contain pollutants from failed sewage treatment plants, oil spills, and combined sewer overflows. Water quality concerns associated with flooding are typically short term in duration in rivers and streams. However, delivery of pollutants in floodwaters onto settled areas is a longer-term problem for people living in and using floodplain areas. Binghamton can receive pollutants delivered from upstream population centers, including sewage plants that fail under flood conditions. Sewage plants upstream of Binghamton that could deliver pollutants to Binghamton under flood conditions include Cortland, Marathon, Whitney Point, Oneonta, Bainbridge, Sherburne, Norwich, Oxford, and Greene. The 2006 event delivered substantial pollutants to Binghamton from failure of the upstream Oneonta sewage plant and other sources (SRBC, 2006 June 2006 Flood, A summary of the flood and performance of the Susquehanna Flood Forecast and Warning System). Since that time, infrastructure of the Oneonta sewage plant has been raised above the one percent annual chance level. Greene has upgraded its sewer plant. The other plants of these identified settled areas are built above the 1% annual chance event. Accordingly, in the event of severe flooding in the future in the absence of improved FRM in Binghamton, floodwaters delivered from upstream would have reduced sewage quantities compared to previous recent large events.

REFERENCES CITED

Binghamton Metropolitan Transportation Study. 1999? Or updated since then?. http://www.bmtsonline.com/

Broome County. 2013. Broome County Comprehensive Master Plan – Building Our Future. Available online at <http://gobroomecounty.com/comprehensiveplan?_ga=2.137913399.606230250.1509131838-1525906964.1509131838>

City of Binghamton. 2010. Urban Forest Management Plan. Prepared August 2010. Prepared by Urban Forestry, LLC. Available online at <http://www.binghamton-ny.gov/sites/default/files/files/City%20of%20Binghamton%20NY%20Urban%20Forest%20Management%20Plan%202010.pdf>

City of Binghamton. 2014. Blueprint Binghamton: Forward Together. 2014 Comprehensive Plan [adopted August 4, 2014]. Accessed April 2018. http://www.binghamton-ny.gov/blueprint-binghamton-comprehensive-plan

Broome County. 2013. DMA 2000 Hazard Mitigation Plan Update – Broome County. February 2013. Prepared by Tetra Tech.

National Wild and Scenic River Systems. (2019). Available online at <https://www.rivers.gov/new-york.php>

NRCS. 2018. Web Soil Survey. Accessed 2017 and 2018. https://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm

NY State Department of State. 2011. Broome County Intermunicipal Waterfront Public Access Plan. Final Report December 2011. 86 pages plus appendices.

NYSDEC. 2009. Lower Chenango River Watershed (020501208) WI/PWL Fact Sheet. http://www.dec.ny.gov/chemical/36734.html

NYSDEC. 2015. Lower Susquehanna River, Broome and Tioga Counties, NY. Susquehanna River Biological Stream Assessment. October 1, 2015. Stream Biomonitoring Unit.

US Geological Survey. 2018. “US Topo” topographic maps. https://www.usgs.gov/core-science-systems/national-geospatial-program/us-topo-maps-america?qt-science_support_page_related_con=0/index.html

Village of Port Dickinson. 2017. Annual Drinking Water Quality Report. Port Dickinson. https://www.portdickinsonny.us/wp-content/uploads/2018/06/Port-Dickinson-V-AWQR-2017-Final.pdf

Homefacts. 2017. https://www.homefacts.com/

U.S. Environmental Protection Agency. EnviroMapper. Web Site w/HTRW, etc.: http://www.epa.gov/emefdata/em4ef.home

USFWS. 2018. National Wetlands Inventory. Wetlands Mapper

White House. 1998. American Heritage Rivers Initiative. Available online at <https://clintonwhitehouse2.archives.gov/CEQ/Rivers/>

Final Fish and Wildlife Coordination Act Report
Upper Susquehanna Comprehensive
Flood Damage Reduction Study

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EXECUTIVE SUMMARY

Flooding in the Upper Susquehanna watershed of New York State frequently causes damage to infrastructure that has been built within flood-prone areas. This report identifies a suite of watershed activities, such as urban development, wetland elimination, stream alterations, and certain agricultural practices that have contributed to flooding of developed areas. Structural flood control measures, such as dams, levees, and floodwalls have been constructed, but are insufficient to address all floodwater-human conflicts. The U.S. Army Corps of Engineers (USACE) is evaluating a number of new structural and non-structural measures to reduce flood damages in the watershed. The New York State Department of Environmental Conservation (NYSDEC) is the "local sponsor" for this study and provides half of the study funding. New structural flood control measures that USACE is evaluating for the watershed largely consist of new levees/floodwalls, rebuilding levees/floodwalls, snagging and clearing of woody material from rivers and removing riverine shoals. Non-structural measures being evaluated include elevating structures, acquisition of structures and property, relocating at-risk structures, developing land use plans and flood proofing. Some of the proposed structural measures, if implemented as proposed, have the potential to adversely impact riparian habitat, wetlands, and riverine aquatic habitat.

In addition to the alternatives currently being considered by the USACE, the U.S. Fish and Wildlife Service proposes environmentally beneficial "watershed restoration" flood control measures. These watershed restoration measures include reconnecting streams to floodplains, wetland restoration, creation of detention basins, planting winter cover crops, reforestation, and environmentally sensitive roadside ditch management. These measures are designed to intercept precipitation closer to where it falls, encourage water infiltration into soils, and slow downstream flows. Although these types of projects are not traditionally considered by the USACE and may fall outside of the USACE Flood Risk Management mission and project authorization, they are consistent with the USACE and NYSDEC environmental principles that support sustainable use, stewardship and restoration of natural resources. We recommend these measures be evaluated as part of the study in order to identify opportunities for watershed-based flood reduction to be considered by the USACE and other stakeholders. The Upper Susquehanna Conservation Alliance membership, including the NYSDEC, Nature Conservancy, Otsego Land Trust, some local municipalities and members of the general public have also expressed support for watershed-based flood reduction measures as described in this report. The U.S. Fish and Wildlife Service has identified four pilot watersheds in the Upper Susquehanna watershed, Wharton Creek, Upper Chenango River, Charlotte Creek and West Branch Tioughnioga, that are characterized by low slopes, a high percentage of agriculture and hydric soils. We recommend these watersheds as candidates for these types of watershed restoration flood control measures.

In addition to recommending the evaluation of watershed restoration flood control measures, we recommend that design alternatives minimize levee footprints and clearly identify the flood benefits of clearing, snagging, and shoal removal. We also recommend that the cost/benefit analysis provide costs of the proposed non-structural options (e.g., buyouts and flood elevation) and determine the economic value of environmental and human use recreational features affected by any structural flood control project.

This report discusses watershed restoration flood mitigation methods that both reduce flood flows and are **environmentally restorative.** They are designed to restore and protect habitat and water quality, while also providing flood water reduction in some flood prone areas. It is understood that these measures alone may not resolve issues related to flooding of human infrastructure, but we recommend that they be fully evaluated along with more traditional flood reduction measures, such as levees and floodwalls, and that their benefits be factored into cost/benefit ratios for various flood control alternatives.

Contents

A. INTRODUCTION

The Upper Susquehanna watershed has experienced a large number of flood events over the last hundred years that have damaged property and infrastructure. Floods in Binghamton, Hornell, and other upstate New York communities spurred the development of the Flood Control Acts of 1936 and 1938 that empowered the U.S. Army Corps of Engineers (USACE) and other agencies to undertake structural flood control projects, including in the study area (Arnold 1986). These structural flood control projects have included measures such as floodwalls and levees along the Susquehanna and Chenango Rivers at Binghamton, Endicott, Vestal, and Johnson City, federal or state flood control dams, such as Whitney Point, Genegantslet, and East Sidney Reservoir and a series of PL 566 flood control dams[1] (Figures 1, 2 and 5; Table 1).

Figure 1. Floodwall along Susquehanna River at Binghamton (Google Earth)

Figure 2. East Sidney Flood USACE Control Dam, Ouleout Creek. Photo by Anne Secord

[1] PL 566 flood control dams were installed by the Natural Resource Conservation Service in the latter half of the 20 century under Public Law 566.

Table 1. Existing USACE Flood Risk Management Projects in Upper Susquehanna Watershed, New York		
Bainbridge	Chenango	Channel improvement
Binghamton	Broome	Levee/floodwall
Binghamton	Broome	Snagging/clearing
Cincinnatus	Cortland	Snagging/clearing
Conklin-Kirkwood	Broome	Channel improvement
Cortland	Cortland	Channel improvement
East Sidney Lake	Delaware	Reservoir
Endicott, Johnson City, Vestal	Broome	Levee/floodwall
Greene	Chenango	Channel improvement/levee
Lisle	Broome	Levee/floodwall/channel improvement
Nichols	Tioga	Levee/floodwall/channel improvement
Norwich	Chenango	Channel improvement
Oneonta	Otsego	Snagging/clearing
Owego	Tioga	Snagging/clearing/channel improvement
Oxford	Chenango	Levee/floodwall/channel improvement
Port Dickinson	Broome	Snagging/clearing
Sherburne	Chenango	Snagging/clearing
Unadilla	Otsego	Channel improvement
Whitney Point Village	Broome	Levee/floodwall/channel improvement
Whitney Point Lake	Broome	Reservoir

Although structural measures such as levees and floodwalls have provided significant protection to infrastructure from some damaging floods, they have not been adequate to provide comprehensive protection during major rainfall events such as in 1993, 2006, and 2011 (Figures 3 and 4).

Figure 3. Flooding in Owego, NY 2011.

Figure 4. Washington Street Bridge, Binghamton 2006. Photo from National Weather Service

This report, in addition to providing comments on new structural flood management measures evaluated by the USACE for the study area, serves to offer restoration-based measures within the watershed that may be used to further mitigate flood damage by keeping precipitation closer to where it falls, encouraging water infiltration into soils, storing water, and slowing downstream flows. This type of watershed approach to flooding, in which land management to encourage water infiltration is a critical component of flood management, is being promoted broadly across Europe (Environment Agency 2017; SEPA 2015; UNECE 2000) and the United States (NYRCR 2014; Ahilan et al. 2016; Interagency Floodplain Management Review Committee 1994 {IFMRC} 1994).

> "By controlling runoff, managing ecosystems for all of their benefits, planning the use of the land and identifying those areas at risk, many hazards can be avoided."
> Galloway Report (IFMRC 1994)

B. PROJECT PURPOSE, SCOPE, AUTHORITY, AND STUDY AREA

The USACE is comprehensively evaluating flood reduction management (FRM) needs and opportunities in the Upper Susquehanna River Basin in New York, in partnership with the New York State Department of Environmental Conservation (NYSDEC). Study efforts are being coordinated with the Federal Emergency Management Agency (FEMA) and other federal and state agencies and local governments.

The Susquehanna River Basin is the second largest river basin – next to the Ohio River Basin – east of the Mississippi River and the largest on the Atlantic seaboard. The 444-mile Susquehanna River drains 27,500 square miles covering portions of New York, Pennsylvania and Maryland before emptying into the Chesapeake Bay. The Upper Susquehanna River Basin begins at Canadarago and Otsego Lakes near Cooperstown, New York, and flows southward and westward where it meets the Chemung River in Sayre, Pennsylvania, near Waverly, New York. The FRM study area includes only the Upper Susquehanna River Basin within New York State (4,520 square miles of land area) and excludes the Chemung River Basin. The study area includes most of Broome, Chenango, Cortland, Otsego, and Tioga Counties, portions of northern Delaware, southern Madison, and eastern Chemung Counties, and small parts of Schuyler, Tompkins, Onondaga, Oneida, Herkimer, and Schoharie Counties (Figure 5).

The USACE is preparing a feasibility report and Environmental Impact Statement (EIS) for the study. A Notice of Intent to Prepare an EIS for the study was published in the Federal Register on November 4, 2016. The notice provided a preliminary overview of anticipated study scope and outcome. In November 2016, the USACE and NYSDEC held public/agency scoping meetings for the study, followed by a March 2018 stakeholder meeting, at which input from public officials was solicited. An initial conceptual effort is being completed using existing information to identify locations in the study area that currently do not have FRM infrastructure in place. These locations are being screened for structural and non-structural flood risk reduction opportunities. The study will then evaluate the level of FRM currently provided by existing FRM infrastructure (i.e., levees and floodwalls) under current conditions and projected future conditions.

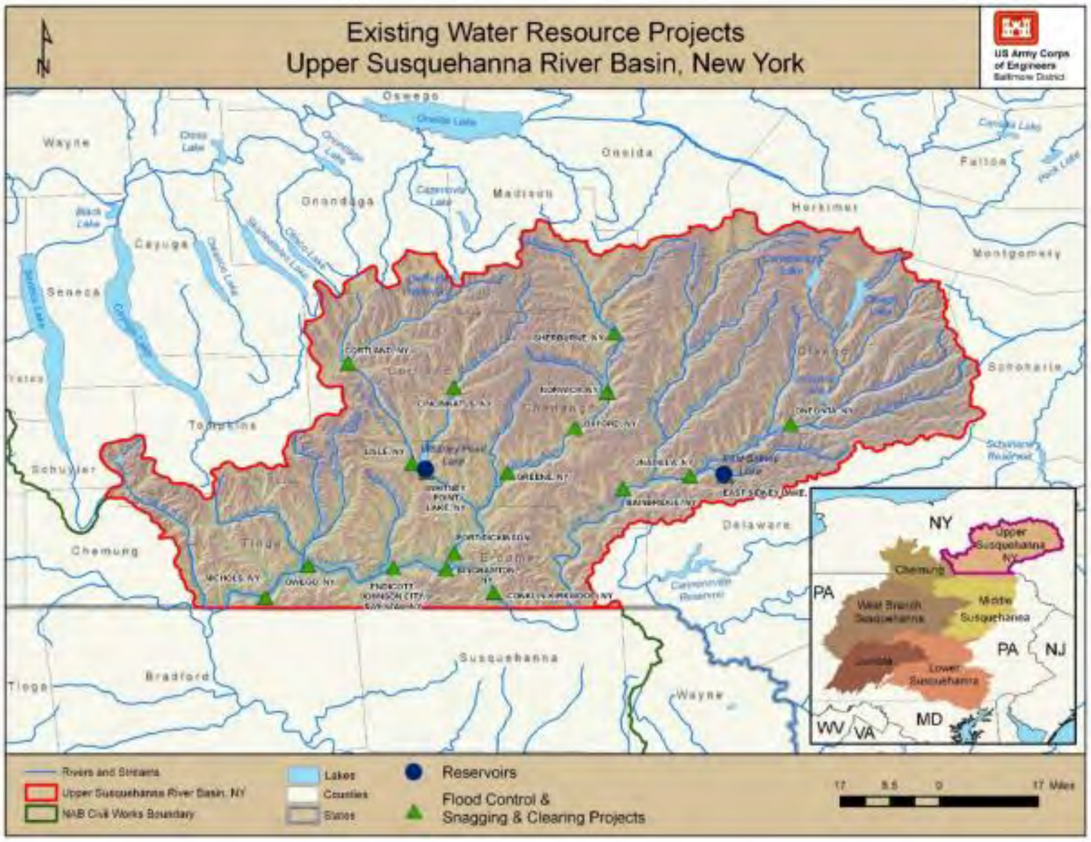


Figure 5. Existing FRM Projects within Upper Susquehanna River Basin

Within the study area, there are 20 existing USACE FRM projects (Table 1, Figure 5), as well as other non-federal FRM projects. The study will investigate FRM strategies to reduce flood and residual risk in densely populated areas within the study area, including structural and nonstructural FRM. The USACE is currently evaluating FRM measures in six "Flood Risk Candidate Areas", in which structural work is proposed and an additional six "Flood Risk Focus Areas", in which no structural work is proposed. These 12 Flood Risk Areas will be described in Section D of this report. Hydrologic and hydraulic modeling will be developed for the majority of the Susquehanna River main stem and major tributaries in the basin to aid plan formulation. It is anticipated that the study will take three years to complete and lead to the future implementation of one or more FRM projects by the USACE and recommendations for future actions (including non-structural measures) to be addressed by other agencies and entities.

It is anticipated that any recommended USACE construction would be in densely populated areas. It is not anticipated that any new dams would be recommended for FRM purposes because preliminary economic analyses have demonstrated inadequate benefits while environmental and social impacts pose substantial concerns. According to the USACE, although minimal effects on U.S. Fish and Wildlife Service (USFWS) trust resources are anticipated from any proposed USACE FRM projects, impacts to wetlands in the floodplains and structure encroachment into waterways may occur.

C. Fish and Wildlife Resources and Recreational Uses in the Study Area

Flooding is a natural process and floodplains are a part of a functioning river system. River and stream flooding transfers water, energy, nutrients and sediment to floodplains. The nutrients and sediment contribute to fertile habitat for wildlife in floodplains and sometimes spawning or nursery habitat for fish such as northern pike. Floodplains serve to recharge aquifers and restore water back to the river during drier times of the year.

1. Fisheries

The Susquehanna River supports fish species such as walleye (*Sander vitreus*), smallmouth bass (*Micropterus dolomieu*), northern pike (*Esox lucius*), muskellunge (*E. masquinongy*), channel catfish (*Ictalurus punctatus*), rock bass (*Ambloplites rupestris*), crappie (*Pomoxis spp*.), yellow perch (*Perca flavescens*), suckers (*Catostomus spp*.), sunfish (*Lepomis spp*.), and darters. The Susquehanna River and tributaries also support the catadromous American eel (*Anguilla rostrata*). This species has suffered severe declines due to the cumulative impacts of habitat loss, dam construction, turbine mortality, and over-fishing. Multiple dams in Pennsylvania, Maryland and New York block the passage of eels into their historic range (MacGregor et al. 2009). The Susquehanna River in New York used to support American shad (*Alosa sapidissima*) prior to impacts from human activities, primarily dam building. It is the goal of natural resource management agencies to restore the American shad, American eel, and other migratory species to their historic ranges within the Susquehanna watershed (SRAFRC 2010).

2. Freshwater Mussels

There are about a dozen species of unionid mussels in the Upper Susquehanna watershed (Strayer and Fetterman 1999). Species commonly found include eastern elliptio (*Elliptio complanata*), triangle floater (*Alismadonta undulata*), elktoe (*A. marginata*), creeper (*Strophitus undulatus*), and yellow lampmussel (*Lampsilis cariosa*). Mussels in many parts of the country (including the Susquehanna River watershed) are declining due to a host of factors, such as impaired water quality (e.g., sediment, dissolved oxygen, un-ionized ammonia), lost habitat connectivity, lack of fish hosts, sediment instability, mining, and oil extraction (Richter et al. 1997; Strayer and Fetterman 1999; Strayer and Malcolm 2012).

There is habitat in the Susquehanna watershed for the brook floater (*Alismidonta varicosa*), a New York State listed threatened mussel species. The brook floater has experienced significant declines (including in the Upper Susquehanna watershed) due to altered river flows, loss and fragmentation of habitat, siltation and sedimentation from dams and surface run-off, water pollution, and invasive non-native mussels (http://www.acris.nynhp.org/guide.php?id=8378&part=1).

3. AMPHIBIANS

A number of river/stream amphibians and reptiles may occur in the Upper Susquehanna watershed study area. These include New York State Species of Greatest Conservation Need (SGCN) such as the longtail salamander (*Eurycea longicauda*), eastern ribbonsnake (*Thamnophis sauritus*), wood turtle (*Glyptemys insculpta*), and the eastern hellbender (*Cryptobranchus a. alleganiensis*). According to the 2003 "Eastern Hellbender Status Assessment" (Mayasich et al. 2003), hellbenders are found in habitats with swift running, fairly shallow, highly oxygenated water. Hellbenders have experienced declines due to destruction and modification of habitat, influenced by factors such as siltation, chemical pollution, thermal pollution, stream channelization, impoundment, agricultural runoff, and mining activities. In the study area, impacts may include the reduction of forest cover and changes to stream physical and chemical parameters (Pugh et al. 2015).

4. BIRDS

The Susquehanna River supports wintering waterfowl such as American coots (*Fulica americana*), common and hooded mergansers (*Mergus merganser, Lophodytes cucullatus*), American black ducks (*Anas rubripes*), and Canada geese (*Branta canadensis*). A variety of passerines (e.g., belted kingfisher –*Megaceryle alcyon*, willow flycatcher - *Empidonax traillii*), wading birds (e.g., great blue heron –*Ardea herodias*, green heron – *Butorides virescens*), and raptors (e.g., osprey – *Pandion haliaetus*) breed in the riparian zones of the Susquehanna River and forage in or over the river. A number of SGCN riparian bird species may occur in the Flood Risk Candidate Areas. These include the Cooper's hawk (*Accipiter cooperii*), red-shouldered hawk (*Buteo lineatus*), common nighthawk (*Chordeiles minor*), American woodcock (*Scolopax minor*), willow flycatcher, wood thrush (*Hylocichla mustelina*), blue-winged warbler (*Vermivora cyanoptera*), golden-winged warbler (*V. chrysoptera*), prairie warbler (*Setophaga discolor*), and black-billed cuckoo (*Coccyzus erythropthalmus*) (https://www.dec.ny.gov/docs/wildlife_pdf/susquehannatxt.pdf).

Bald eagles (*Haliaeetus leucocephalus)* may nest, forage, or over-winter in the study area. Under the Bald and Golden Eagle Protection Act (BGEPA; 16 U.S.C. 668 et seq.), take of bald eagles is prohibited unless otherwise permitted by the USFWS. The BGEPA defines take to include "pursue, shoot, shoot at, poison, wound, kill, capture, trap, collect, molest or disturb." If bald eagles are determined to occur in the vicinity of a USACE FRM project proposed for implementation, we recommend that the USACE visit the USFWS New York Field Office's project review page and determine if a permit is required under BGEPA [website: https://www.fws.gov/northeast/nyfo/es/step6.htm].

In addition, the USFWS 2007 National Bald Eagle Management Guidelines can be found at: https://www.fws.gov/northeast/ecologicalservices/eaglenationalguide.html. The guidelines provide recommendations for avoiding disturbance at nest sites, including activity-specific guidelines (i.e., development). The guidelines recommend that no activities be conducted with 330 feet of the nest site; however activities can be conducted between 330 feet and 660 feet of a nest outside the breeding season (January-August). We also recommend that you contact the

New York State Natural Heritage Program and the regional NYSDEC office for more information on eagle activity/nests, as bald eagles are listed as threatened by the state.

5. THREATENED AND ENDANGERED SPECIES

The federally listed as threatened northern long-eared bat (*Myotis septentrionalis*) occurs in the Upper Susquehanna watershed. This species spends the winter hibernating in caves and mines. During the summer, these bats roost singly or in colonies underneath bark, in cavities or in crevices of both live and dead trees. Northern long-eared bats may be adversely affected by the proposed activities, especially if tree removal is proposed during the summer months while bats are foraging and roosting and the females are forming maternity colonies and raising their pups. Tree removal during the winter while bats are hibernating (October 31 – March 31) would minimize adverse impacts to bats.

6. WATER-BASED RECREATION

The Susquehanna River in New York is an important recreational river, with over 100 boat launches and river access sites that provide access for boaters and anglers http://www.chemungriverfriends.org/launches_srw.php). Flood control efforts may conflict with other uses if they impede access to rivers and streams, modify hydrology or impact fish and wildlife habitat. Boat launches within or adjacent to the proposed Flood Risk Candidate Areas include:

Flood Risk Candidate Area	**Boat Launches/Fishing Access Sites**
Binghamton	Washington St. Bridge, River Plaza, Port Dickinson Community Park, Sandy Beach Park
Conklin	Schnerbush Park, Sullivan Park, Kirkwood Veterans River Park
Endicott-Johnson-Vestal	Grippen Park, Harold Moore Park
Oneonta	West Oneonta DEC # 145 just downstream of study area
Owego	Hickories Park
Unadilla	Unadilla DEC #148

D. PROPOSED FLOOD REDUCTION MANAGEMENT INFRASTRUCTURE

The USACE is considering six "Flood Risk Candidate Areas" for flood reduction measures:

1. **Binghamton**
2. **Conklin**
3. **Endicott/Johnson City/Vestal**
4. **Oneonta**
5. **Owego**
6. **Unadilla**

Other USACE “Flood Risk Focus Areas” include: **Bainbridge, Chenango Bridge, Cortland, Greene, Norwich, Sidney, and Waverly**.
Projects under consideration for the various Flood Risk Candidate Areas include:

- Constructing new levees and floodwalls
- Raising or extending berms/levees/floodwalls
- Clearing, snagging, and shoal removal
- Dredging of the Susquehanna River
- Constructing pumping stations
- Installing ice jam structures
- Nonstructural measures, including elevating structures, acquisition of structures and property, relocating at-risk structures and flood-proofing

1. General Impacts of Proposed USACE Flood Reduction Projects on Fish and Wildlife Resources

Certain aspects of the six Candidate Flood Risk projects will have impacts on fish and wildlife resources. The impacts of levees and floodwalls, snagging, clearing, shoal removal and dredging are discussed below, with more specific impacts discussed after the Flood Risk Candidate Area project descriptions.

a. Levees and Floodwalls

Levees and floodwalls are intended to restrict water to the river channel and as such, they disconnect the river from its floodplain. This can reduce nutrient and sediment transport to the floodplain, cut off wetlands from riverine inputs of water and nutrients, and reduce the recharge of aquifers. Levee and floodwall construction removes shoreline vegetation, thereby eliminating fish and wildlife habitat and riverine shading (Franklin et al. 2009; Makhdoom 2013). Levees tend to have a larger footprint than floodwalls and may, therefore, contribute to greater habitat loss than a vertical floodwall structure. Although levees may be more aesthetically pleasing than floodwalls, they provide little habitat value since vegetation is generally maintained as a mowed grass cover. The construction of the levee may remove habitat, including riparian shoreline, tributaries, swales and wetlands.

The habitat likely to be impacted by levees and floodwalls is riparian corridor habitat that is important for a number of nesting and migrating birds, such as warblers, flycatchers, woodpeckers, and raptors. Riparian habitat also provides shade that maintains cooler stream temperatures for fish and other aquatic species and the river banks provide water access and habitat for terrestrial species of wildlife such as deer (*Odocoileus virginianus*), fox (*Vulpes vulpes; Urocyon cinereoargenteus*), mink (*Neovison vison*), fisher (*Martes pennanti*) and river otter (*Lontra canadensis*). The loss of habitat caused by levee and floodwall construction may also adversely affect the threatened northern long-eared bat.

While levees and floodwalls may provide flood protection to adjacent lands and structures, these structures may contribute to flooding and erosion in areas upstream and downstream of levee/floodwall construction. As the river is forced into a narrow channel by the levee/floodwall, it backs up, raising water levels upstream. Water is subject to less friction as it flows through a leveed section vs. a section with a sloped and vegetated bank, gaining velocity and contributing to flooding and erosion downstream. Consequently, upstream and downstream flooding exacerbated by levees or floodwalls may result in the call for additional levee and floodwall construction upstream or downstream. Levees may trap water on the landward side, which can cause flooding behind the levee without the maintenance and adequate capacity of pumping stations. Levees also may encourage additional floodplain development, potentially exacerbating damages from future flooding events. Levees may also be overtopped during storms exceeding design protection levels, often with disastrous consequences, as with the levee failures during hurricane Katrina.

b. Minimizing Levee Impacts

An option to minimize the adverse impacts of levees on the riparian corridor is to consider vegetative options other than mowed grass. Prior to 2005, the USACE policy for vegetation on levees was generally supportive of vegetation and allowed for regional considerations, so long as the structural integrity and functionality of the levee system was retained. In April 2009, the USACE vegetation-free policy was formally adopted. The USACE issued the Engineering Technical Letter (ETL) 1110-2-571[2], establishing a uniform nationwide vegetation policy that applied to all levees under direct USACE control (Figure 6 - left). This policy established vegetation-free and root-free zones for levees throughout the entire country. The USACE ETL 1110-2-571 maintains that vegetation on levees can harm the structural integrity of levees, obscure visibility, impede access for maintenance and inspection and hinder emergency flood fighting operations. The minimum acceptable vegetation-free zone is defined as including the levee itself plus a corridor fifteen feet in width on either side of the levee. The vegetation-free zone applies to all vegetation except for grass (Tuel 2017). In accordance with ETL 1110-2-571, if the levee structure is not compromised, the local sponsor may request a variance from the standard vegetation guidelines to enhance environmental values or meet state or federal laws or regulations.

This relatively new levee vegetation policy has been researched and debated by levee maintenance officials and natural resource agencies (Shields 2016, Tuel 2017). For example, the USACE ETL 1110-2-571 indicates that trees and other woody vegetation can create structural and seepage instabilities. However, Shields (2016) pointed out that it can be difficult to determine the role of vegetation in levee stability or failure in the event of a breach because physical evidence is often washed away or altered during the high-water event. Section 3013 of the 2014 Water Resources Reform and Development Act required the USACE to carry out a comprehensive review of their vegetation management guidelines for levees, taking into consideration the benefits of woody vegetation and protection, preservation, and enhancement of natural resources. The USACE has determined that until the review and update of the vegetation guidelines is complete, USACE will take the following interim actions to comply with Section 3013 (g)(1), namely that "… the Secretary shall not require the removal of existing vegetation as a condition or requirement for any approval or funding of a project, or any action, unless the specific vegetation has been demonstrated to present an unacceptable safety risk."

[2] https://www.publications.usace.army.mil/Portals/76/Publications/EngineerTechnicalLetters/ETL_1110-2-583.pdf

((http://cdm16021.contentdm.oclc.org/utils/getfile/collection/p16021coll5/id/1213).
Tuel (2017) maintains that although there are certain areas where more research on levee vegetation is needed, research to date has not shown a causal link between levee vegetation and substantial increased risk to levee integrity.

Some communities have been exploring vegetation management on levees that differs from the USACE "mowed grass" policy pursuant to ETL 1110-2-571. Pierce County in Washington State has developed a levee vegetation management strategy that balances the needs of flood risk reduction with the habitat needs of aquatic and riparian species (PCPW 2016). The Pierce County strategy operates under a system-wide improvement framework (called a SWIF) that is essentially a variance under the auspices of the USACE ETL (Figure 6 - right).

California has developed a strategy that newly constructed levees must meet the guidelines of the ETL (vegetation-free zones) on the entirety of the levee, but for existing levees, woody vegetation on the lower waterside slope is generally retained and additional woody vegetation is allowed to grow. For this portion of the levee, woody vegetation is only removed when it poses an unacceptable threat to levee integrity (Cowin and Bardini 2012; Tuel 2017).

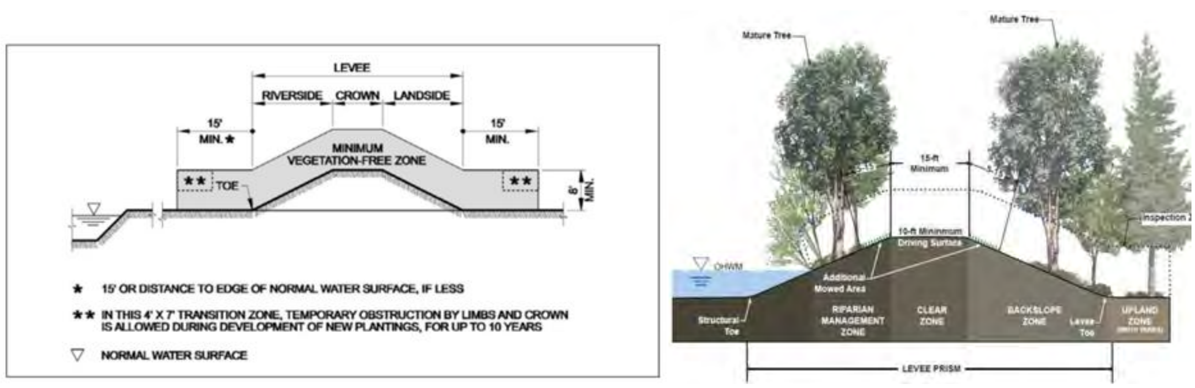


Figure 6. Vegetation Free Zone Proposed by USACE in ETL 1110-2-581 (left) and Conceptual Levee Design, Pierce County, WA (PCPW 2016) (right)

We recommend that the USACE evaluate the literature on the effects of vegetation management on levee function, including any review that occurs as part of the Water Resources Reform and Development Act of 2014, and use that information to consider more environmentally beneficial alternatives for vegetation management on levees.

c. Clearing and Snagging

Clearing and snagging of woody material from rivers and streams would have negative direct and indirect effects on fish and wildlife resources. Downed trees and other woody material in streams and rivers provide habitat for fish and other aquatic organisms and also serve to dissipate energy and capture and retain sediment (Saldi-Caromile et al. 2004; Lassettre and Kondolf 2012). Clearing of trees from river banks may cause destabilization and erosion of sediments into the waterway, which may impair water quality. Removal of woody material from rivers and streams removes foraging, reproductive, and sheltering habitat for fish and other aquatic resources, including the eastern hellbender.

Although large woody material in streams may increase roughness and collect at bridges, thereby contributing to local upstream flooding of structures, the influence of woody material on infrastructure flooding is not always significant and the wood removal may be a short term solution (Young 1991; Lassettre and Kondolf 2012). In Australia, a flume study of the hydraulic effects of large woody material found that the levels of woody material commonly occurring in the lowland rivers of southeastern Australia seldom cause any significant effect on flood levels (Young 1991). Any flood reduction benefits predicted from the removal of woody material from rivers and streams should be weighed against the impacts to aquatic habitat.

d. Dredging

Dredging of rivers is conducted to reduce flood risk by increasing channel capacity. The effectiveness of dredging, however, may be temporary in that subsequent flood flows often transport a large amount of sediment that can fill the dredged channel, eliminating any increased channel capacity and adversely impacting aquatic habitat. Dredging may need to be more routinely conducted to achieve the desired channel capacity, thereby repeatedly degrading water quality, causing biological disturbance along the bed and banks of the river (alteration of fish and benthic habitat; disturbance of riparian communities that support birds, amphibians, and reptiles), and increasing costs (https://www.sepa.org.uk/media/151049/wat-sg-26.pdf). Turbidity caused by dredging may adversely impact fish species, amphibians like the eastern hellbender, and freshwater mussels, including the brook floater, which could be smothered by sediment or crushed during dredging. Dredging may also contribute to channel instability and increase flooding downstream. The USACE has determined that dredging is currently highly unlikely for all Flood Risk Areas. If dredging ultimately becomes a proposed flood control option, we recommend that it be adequately justified as part of a sustainable flood reduction strategy, with consideration for environmental consequences and the impacts to river stability.

e. Shoal Removal

River shoals (shallow, gravelly, or rocky reaches) can cause increased roughness and a reduction in channel capacity, both of which are considered as contributing to flooding of structures. Shoals develop in rivers as a result of sediment supply exceeding the transport capacity of the river. If a new shoal or gravel bar forms, it may be due to an increase in sediment washed into the stream or a local reduction in the stream's energy and its ability to transport sediment. Shoal removal, like dredging, is a temporary way to increase channel capacity. Shoal removal may impact river stability and contribute to erosion (SEPA 2012).

Shoals provide unique riverine habitat, often supporting a different fish assemblage than is found in deeper water (Marcinek et al. 2003). Underwater shoals provide spawning habitat for species such as walleye, suckers, and darters (Lane et al. 1996). Exposed shoals provide loafing and feeding habitat for bird species such as geese, gulls, and herons. Shoals are also important habitat for freshwater mussels, providing a stable substrate and variety of flow conditions (Sherer 2011; Garner and McGregor 2001). For example, 60% of the mussel fauna of the Big Sunflower River in Mississippi was located on two shoals within the river, prompting a change in river dredging to avoid shoal habitat (Miller and Payne 2004). Shoal removal may contribute to turbidity and impaired water quality, and impact fish species, amphibians like the eastern hellbender, and freshwater mussels, including the brook floater.

2. Specific Impacts of Proposed USACE Flood Reduction Projects on Fish and Wildlife Resources

a. Binghamton Flood Risk Area

Major Features:

- Raising all levees and floodwalls deemed feasible (~ 4-5 miles)
- New levee along unprotected area near Dickinson (~ 9,000 feet) - more detailed analyses required
- Clearing, snagging, and shoal removal (65 acres) deemed maybe feasible
- Non-structural measures including elevating, acquisition, and flood-proofing deemed feasible

Raising levees may have some environmental impacts if the base of the levee would need to be widened, potentially impacting riparian habitat and wetlands within the footprint. Raising levees and floodwalls also increases flood peak flow, which can exacerbate flooding upstream and downstream. The USACE guidance requires induced flooding impacts be examined and mitigated when economically feasible. Replacing existing floodwalls and levees would create temporary disturbance, but long-term impacts would be no greater than those caused by the original levee or floodwall. Clearing, snagging, and shoal removal of 65 acres of the Chenango River would negatively impact fish and wildlife resources, as described above.

The proposed new levee segment between the Dickinson North Boundary and Dickinson Town Court appears to be approximately 9,000 feet long and extends along the western bank of the Chenango River along Otsiningo Park. If the levee footprint is 130 feet wide[3], approximately 27 acres of riparian habitat would be impacted by levee construction. Otsiningo Park is a mixture of riparian woods, grassy playing fields, and biking/pedestrian paths. The riparian habitat would be significantly affected and the levee may serve to disconnect the river from recreational users at Otsiningo Park.

b. Conklin Flood Risk Area

Major Features:

- New levee system being analyzed (4 sections ~ 7 miles in length)
- Clearing, snagging, and shoal removal along Susquehanna River (7 miles) deemed feasible

[3] Assumes a levee height of 20 feet with a top width of 10 feet and a 3:1 side slope, yielding an approximate levee footprint of 130 feet

- Non-structural measures including elevating, acquisition, and flood-proofing deemed feasible

The Conklin FRM project will have significant impacts on fish and wildlife resources. The levee project examined at Conklin extends along approximately 6 – 7 miles of the western shore of the Susquehanna River and would be expected to significantly affect this stretch of riverine habitat by eliminating all riparian habitat along one bank of the Susquehanna River. Assuming a levee footprint (width) of 130 feet and a levee length of 7 miles, levee construction would impact 110 acres of riparian habitat.

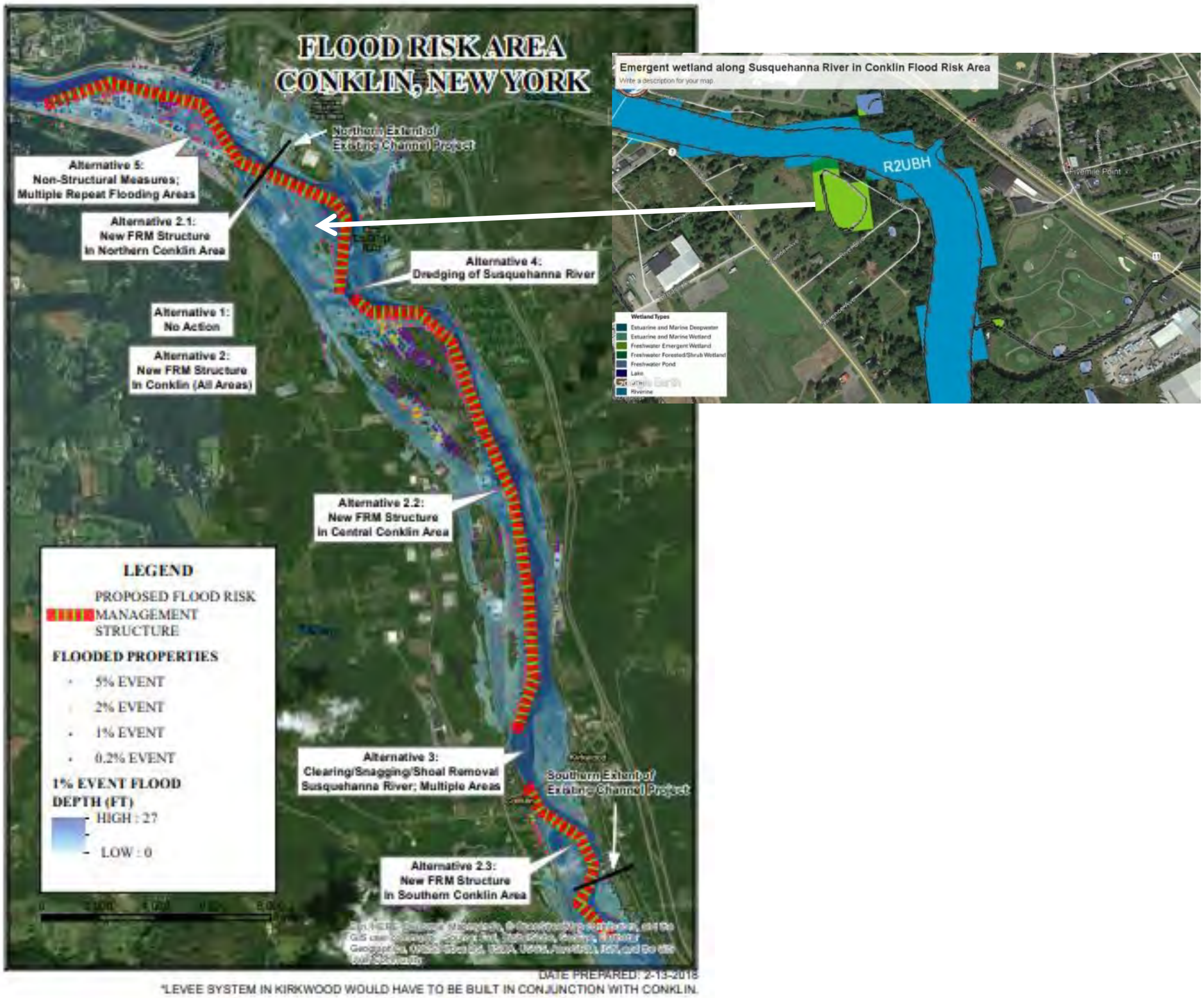
The Breeding Bird Atlas for New York State documents breeding activity of a number of SGCN in the block associated with the Conklin flood risk area. These species include the Cooper's hawk, red-shouldered hawk, common nighthawk, American woodcock, willow flycatcher, wood thrush, blue-winged warbler, golden-winged warbler, prairie warbler, and black-billed cuckoo. The proposed levee may eliminate habitat for a number of these species, if present – notably the willow flycatcher, Cooper's hawk, and black-billed cuckoo.

There are a few emergent wetlands along this reach of the Susquehanna River that may be adversely affected by the proposed levee under Alternative 2.1 (See Figure 7). Either the wetlands would fall within the footprint of the levee or their hydrology may be impacted by the levee.

Clearing, snagging, shoal removal, and dredging of approximately 7 miles of the Susquehanna River would have negative direct and indirect effects on fish and wildlife resources, as described above.

The USACE project proposal acknowledges the potential for impacts to downstream flooding, as well as flooding in Kirkwood, located on the opposite bank of the Susquehanna River, a consequence that may result in the call for additional levee construction.

We have recently been advised that further evaluation of measures for Conklin has been discontinued because local officials did not express interest in them to NYSDEC and USACE following the March, 2018 stakeholder meeting.



c. Endicott/Johnson City/Vestal Flood Risk Area

Major Features:

- Raising existing levee system feasible
- Replacing or relocating existing floodwalls/levees feasible
- Clearing, snagging, and shoal removal in Susquehanna River (66 acres) maybe feasible
- Levee modifications in Nanticoke Creek
- Clearing, snagging, shoal removal, and levee modification in Little Choconut Creek (3.8 acres) feasible
- Pump stations at various locations feasible
- Non-structural measures including elevating, acquisition, and flood-proofing deemed feasible

Raising levees may have some environmental impacts if the base of the levee would need to be widened, potentially impacting riparian habitat within the footprint. Raising levees and floodwalls also increases flood peak flow, which can exacerbate flooding upstream and downstream. Replacing existing floodwalls and levees would create temporary disturbance, but long-term impacts would be no greater than those caused by the original levee or floodwall. Clearing, snagging, and shoal removal of ~ 66 acres of the Susquehanna River would negatively impact fish and wildlife resources, as described above. There are a few emergent wetlands along this reach of the Susquehanna River that may be adversely affected by the proposed levee modifications if the levee footprint is increased (Figure 8).

The more significant impacts to fish and wildlife may result from the proposed clearing, snagging, shoal removal, and levee modifications under consideration in Little Choconut Creek and levee raising in Nanticoke Creek. There are emergent and forested wetlands along Nanticoke Creek in the vicinity of the proposed levee modifications that could be impacted by filling or altered hydrology (Figure 8). Little Choconut Creek supports annually stocked rainbow trout (*Oncorhynchus mykiss*), largemouth bass (*Micropterus salmoides*), and brown bullhead (*Ameirus nebulosus*). A NYSDEC regulated forested wetland exists at the mouth of Little Choconut Creek (Figure 8). Clearing, snagging, and shoal removal may adversely impact these wetland and fishery resources.

We note that there are a number of river blockages downstream of Binghamton that may affect water flow. These include the Rock Bottom dam and Willow Point dam, and two utility crossings (Figure 9). We recommend that the USACE evaluate the impact of these barriers on river flows.

Figure 8. EJV Flood Risk Area -Wetlands Nanticoke Creek (left) & Choconut Creek (right)

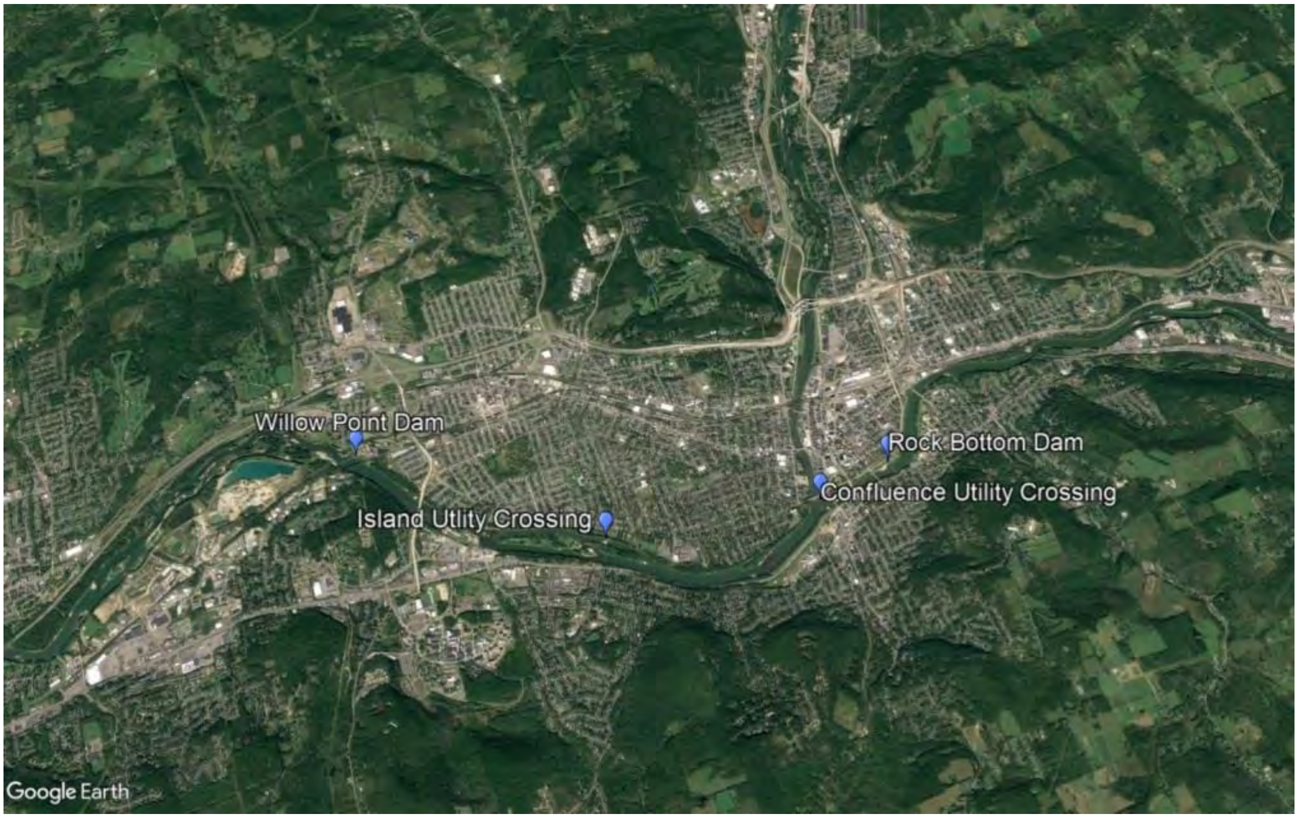


Figure 9. Barriers on Susquehanna River downstream of Binghamton

d. Oneonta Flood Risk Area

Major Features:

- Levee modification feasible
- Pump station feasible
- Non-structural measures including elevating, acquisition, and flood-proofing deemed feasible

Raising the levee may have some environmental impacts if the base of the levee would need to be widened, potentially impacting habitat within the footprint. There appears to be limited space to expand the levee at the proposed location, with development existing to the west and a side channel of the Susquehanna River to the east of the existing levee. Raising levees and floodwalls also increases flood peak flow, which can exacerbate flooding upstream and downstream. No wetlands are likely to be impacted by the proposed levee or pump station. There may be an opportunity with this project to enhance river capacity and facilitate fish passage by restoring the channel that connects the Susquehanna River near the proposed levee modification to the river upstream of the Southside dam.

e. Owego Flood Risk Area

Major Features:

- Modification of existing berm along Owego Creek feasible
- Construction of new levee system along Downtown Owego and Brick Pond Park feasible (includes 2,600 feet of floodwall and 10,000 feet of levee)
- Clearing, snagging, shoal removal in Susquehanna River and Owego Creek (70 acres) with potential but likely not feasible
- Non-structural measures including elevating, acquisition, and flood-proofing deemed feasible

Modification of the existing berm along Owego Creek may impact habitat if the width of the berm/levee is increased. Habitat in the potential footprint includes riparian forested wetland (Figure 10). The construction of a 10,000 foot long levee would eliminate about 30 acres of riparian habitat (assuming a levee width of 130 feet). There would likely be some tree removal for levee/floodwall construction along the Owego waterfront and potential impacts to forested wetland associated with levee construction at Brick Pond Park. Clearing, snagging, and shoal removal of approximately 70 acres of the Susquehanna River and Owego Creek would negatively impact fish and wildlife resources, as described above. According to the USACE, Owego Creek, near its mouth, has an existing channel project where regular maintenance shoal removal and clearing takes place.

Within the Upper Susquehanna watershed, Owego Creek is the only watershed designated by the Eastern Brook Trout Joint Venture as a "watershed best for protection." Owego Creek received Trout Unlimited's highest Conservation Success Index score for brook trout conservation. These designations indicate that not only does the Owego Creek watershed remain intact enough to support viable wild brook trout populations, but also that brook trout populations persisting here are relatively robust. The status of Owego Creek as a stronghold for wild brook trout production in the Southern Tier is confirmed by the regional state fisheries biologists (FLLT 2012).
The brook trout has recently been found to serve as a host for the brook floater mussel. The importance of Owego Creek is further supported by designation of its headwater streams as Ecoregional priority aquatic systems by The Nature Conservancy (http://www.landscope.org/new-york/priorities/). The proposed berm modification, clearing, snagging, and shoal removal in and along Owego Creek may adversely impact brook trout in Owego Creek.

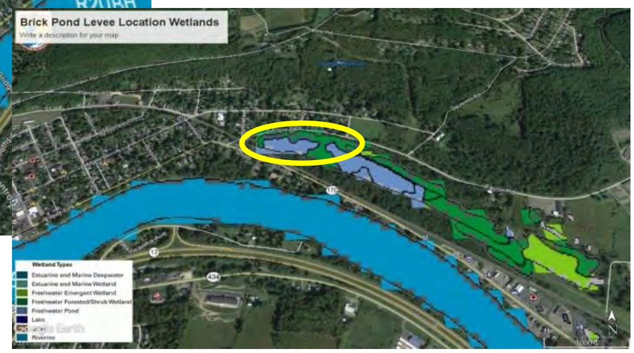


Figure 10. Owego Flood Risk Area - Wetlands

f. Unadilla Flood Risk Area

Major Features:

- New levee system feasible
- Clearing, snagging, and shoal removal Susquehanna River upstream and riverfront Unadilla feasible
- Pump station feasible
- Non-structural measures including elevating, acquisition, and flood-proofing deemed feasible

Forested shoreline riparian habitat would be eliminated by the proposed levee system. One mile of levee with a footprint of 130 feet would eliminate 16 acres of riparian habitat. Clearing, snagging, and shoal removal would have impacts to fish and wildlife, as described above.

The downstream Village of Sidney is proposing to use home buy-outs, elevating or moving structures, and environmentally restorative methods to reduce flood risk. They are discussing interdependent needs for flood hazard mitigation with Bainbridge, Afton, and Unadilla (https://stormrecovery.ny.gov/sites/default/files/crp/community/documents/sidney nyrcr_plan.pdf).
It is, therefore, important that the USACE communicate with adjacent communities regarding any work proposed in Unadilla.

g. Other Flood Risk Focus Areas

For all of the following Flood Risk Focus Areas, flood control measures such as levees, clearing, snagging, and shoal removal were considered by the USACE. For all areas, according to draft project alternatives submitted to us by the USACE in February, 2018, these measures were considered to have no potential for federal interest or were deemed not feasible by the USACE. There are no significant environmental issues associated with these proposals, as presented by the USACE.

Bainbridge

- Non-structural measures including elevating, acquisition, and flood-proofing deemed feasible.

Chenango

- Non-structural measures including elevating, acquisition, and flood-proofing deemed feasible.

Cortland

- Debris removal in Dry and Otter Creek was considered but not examined in detail because it extended beyond the hydraulic modeling scope of the study.
- Non-structural measures including elevating, acquisition, and flood-proofing deemed feasible.

Greene

- A pump station was deemed feasible and more detailed analysis required.
- Non-structural measures including elevating, acquisition, and flood-proofing deemed feasible.

Norwich

- A pump station was deemed feasible and more detailed analysis required.
- Non-structural measures including elevating, acquisition, and flood-proofing deemed feasible.
- An ice jam structure along Canasawacta Creek needed more detailed analysis and may be referred to the Continuing Authorities Program 205 Cold Regions Program.

Sidney

- A pump station was deemed feasible and more detailed analysis required.
- Non-structural measures including elevating, acquisition, and flood-proofing deemed feasible.

Waverly

- Non-structural measures including elevating, acquisition, and flood-proofing deemed feasible.

E. WATERSHED FACTORS CONTRIBUTING TO INCREASED FLOODING

Flooding is a natural phenomenon that is important for the regeneration of natural habitats; however, it can create significant problems for human infrastructure (e.g., buildings, highways, bridges, and culverts), depending on severity, timing, duration, and location of flood waters. The Binghamton area has a history of flooding-human conflicts due to the historical pattern of development in low-lying areas at the confluence of two major rivers – the Susquehanna and Chenango. Other communities along the Upper Susquehanna River have also been developed within the flood-prone area, increasing the potential for flooding damage to structures, roads and other infrastructure. Flooding impacts have been exacerbated by watershed land use practices that change the landscape (e.g., development including urbanization, energy delivery, and agriculture), all of which can alter hydrology by increasing the amount of water entering our rivers. Climate change is influencing the frequency and intensity of precipitation events, causing an increase in the frequency, intensity and duration of flood events. Flood amelioration is best achieved with a multi-faceted approach that includes (1) not developing new infrastructure in flood-prone areas, (2) removing existing infrastructure in flood-prone areas, (3) implementing engineered alternatives like levees as barriers between the river and infrastructure, (4) flood-proofing or elevating structures and (5) utilizing a watershed restoration approach to better manage rainfall, runoff and stream flow. This last approach precludes or minimizes negative human-flooding interactions by keeping rain and snow as close to where it falls as possible, increasing the ability of soils to absorb and retain water, increasing the cross-sectional area of floodplains, and slowing the downstream flow of water (Dadson et al. 2017; Hey and Philippi 1995). Activities that reduce water infiltration, evaporative loss, and habitat roughness, and increase overland flow and downstream flow of water may contribute to downstream flooding (Table 2). The following section focuses on a watershed approach to minimize flooding impacts to human infrastructure.

Table 2. Watershed Activities that May Contribute to Flooding Conflicts							
Activity	Reduces infiltration	Reduces roughness	Reduces evaporative loss	Increases overland flow	Increases downstream volume of water	Reduces biodiversity	Impairs water quality
Timber harvest	✓	✓	✓	✓		✓	✓
Vegetation removal	✓	✓	✓	✓		✓	✓
Hedgerow removal	✓	✓	✓	✓		✓	
Narrow or no riparian corridors	✓	✓	✓	✓	✓	✓	
Urbanization – impermeable surfaces	✓			✓		✓	✓
Waterway channelization		✓			✓	✓	✓
Removal of in-water woody material & vegetation		✓			✓	✓	
Wetland draining or ditching	✓	✓	✓	✓		✓	✓
Soil compaction or loss	✓			✓			✓
Some agricultural tillage				✓			✓
Some roadside ditch management		✓			✓	✓	✓
Inappropriately designed or sized culverts					✓	✓	

1. Vegetation Removal

Vegetation removal in the watershed (e.g., tree harvesting, hedgerow removal, removal of riparian vegetation) may exacerbate flooding via a number of mechanisms. Trees and other plants serve to intercept rain, thereby reducing the amount of water reaching the ground surface. Trees also increase evaporative loss (Hynicka et al. 2017). Vegetation (either on land or in streams/rivers) increases roughness in the watershed, slowing water down and allowing it more time to infiltrate into the ground (Dadson et al 2017; SEPA 2015). Vegetation contributes to soil and slope stability; its removal increases sedimentation and transport of pollutants (Dadson et al. 2017; SEPA 2015). Hynicka et al. (2017) calculated that compared to turf grass, medium and large broadleaf deciduous trees planted in the northeastern United States reduce runoff by approximately 68%.

2. Urbanization

Urbanization in the watershed creates impermeable surfaces (e.g., buildings, roads, parking lots), thereby reducing infiltration of rain into the ground and increasing overland flow of water to low-lying areas (Dadson et al. 2017). Urban stormwater may contain contaminants such as polycyclic aromatic hydrocarbons, metals, and salt, thereby contributing to impaired water quality in receiving streams and rivers.

3. Stream Channelization and Wetland Drainage

Channelization of waterways, including removing woody material, decreases hydraulic resistance and increases downstream velocity, potentially reducing flooding of infrastructure in the channelized reach, but increasing infrastructure flooding downstream (SEPA 2015). Waterway channelization also creates slope instability, thereby increasing sedimentation and decreasing water quality in the channelized and down-gradient streams or rivers (Dadson et al. 2017; SEPA 2015). Ditching and draining of wetlands decreases water infiltration and increases water flow to low-lying areas (SEPA 2015).

4. Agricultural Practices

Agricultural practices, such as the use of heavy machinery and livestock, may compact soils and reduce infiltration of rain water. Tillage may impair soil structure, contributing to a loss of organic matter that may inhibit rainwater absorption into soils (Hey and Philippi 1995; SEPA 2015).

Tillage or crop harvesting during the rainy season or leaving fields without cover crops in winter may contribute to increased overland flows and soil erosion and decreased water quality and biodiversity in down-gradient waterways (Dadson et al. 2017; SEPA 2015).

5. Roadside Ditch Management

Roadside ditch management may contribute to down-gradient flooding. Removal of vegetation in ditches reduces hydraulic resistance, speeding water to receiving streams. By reducing residence time within the ditch, infiltration of rain is reduced. Soil instability within excavated ditches may increase erosion of sediments (that may contain a variety of highway, residential, and agricultural pollutants), contributing to siltation and reduced water quality in receiving waters. Roadside ditches may contribute to increased peak stream heights (Schneider and Boomer 2016).

6. Climate Change

Climate change is contributing to increased frequency and intensity of precipitation events (Mallakpour and Villarini 2015; Ning et al. 2015; Thibeault and Seth 2014). The U.S. Environmental Protection Agency (USEPA) concluded, based on an evaluation of river flooding in the United States over the past 50 years, that floods have become larger in rivers and streams across large parts of the Northeast and Midwest and large floods have become more frequent across the Northeast, Pacific Northwest, and northern Great Plains (https://www.epa.gov/climate-indicators/climate-change-indicators-river-flooding). Climate models predict an increase in the magnitude of the estimated 100-year flood in the Northeastern United States (Arnell and Gosling 2014).

F. Watershed Restoration Measures to Improve Flood Resiliency

1. General Measures

This section of the report discusses watershed restoration methods that both reduce flood flows and are **environmentally restorative.** They are designed to restore and protect habitat and water quality, while also providing flood water reduction in some flood prone areas. It is understood that these measures alone may not resolve issues related to flooding of human infrastructure, but we recommend that they be fully evaluated along with more traditional flood reduction measures, such as levees and floodwalls, and that their benefits be factored into cost/benefit ratios for various flood control alternatives.

Table 2. Watershed Restoration Flood Reduction Measures *

Measure	Benefits
Re-forestation Plant trees in urban areas	Canopy intercepts water Greater evaporative loss than grassland Increases roughness Improves habitat
Retain or plant in field buffer strips and hedges	Slows overland runoff Increases infiltration Increases roughness Improves habitat
Use measures such as permeable paving, stormwater retention and storage basins, rain gardens, bioswales, green roofs, filter strips, infiltration basins	Increases water absorption & retention Improves water quality
Restore natural stream channel morphology; reconnect stream to floodplain; online flow storage in lakes and backwaters on course of river; offline flow storage in wetlands	Creates stable streams Reduces sedimentation Improves water quality Improves habitat & biodiversity Slows down water & increases infiltration
Retain or restore riparian buffer strips	Capture pollutants Provide shade – habitat Increases infiltration Increases roughness
Improve soil structure: make more porous, minimize compaction, replenish organic content, plant deeply rooted species	Increases water infiltration Reduces erosion
Plant cover crops	Reduces soil loss Increases organic matter Increases roughness

Avoid unnecessary dredging of water courses	Improves water quality Reduces sedimentation Maintains stable streams Maintains biodiversity
Block or break wetland drainage Protect wetlands	Reduces flow peaks Increases infiltration & water storage
Create woody material and engineered log jams for hydraulic resistance	Increases roughness Increases habitat and biodiversity
Avoid bare fields during rainy season; alternate deep rooted and shallow rooted plants; use no till and low till methods; plant cover crops	Decreases erosion and sedimentation Improves soil structure and fertility Increases roughness
Stream bank fencing of livestock	Reduces erosion, sedimentation, & nutrient input Reduces compaction near water course
Use agricultural practices such as terracing, contour plowing, buffer strips, CRP, EQIP, WRP, appropriate livestock densities	Reduces erosion and sedimentation Improves soil structure and fertility Reduces soil compaction Increases roughness
Enhance roadside ditch design and maintenance	Reduces erosion and sedimentation Improves water quality (nutrients, pollutants) in receiving waters Increases infiltration Reduces stream peak heights Improves habitat
Appropriately size, install, and maintain culverts	Maintains aquatic connectivity Maintains stable stream flow
Create off channel storage (riparian wetlands; side channels)	Increases water storage and infiltration Attenuates flood peaks
Dispersed upland stormwater retention & detention	Increases water storage and infiltration Attenuates flood peaks
* Information sources: Dadson et al. 2017; Environment Agency 2017; Schneider & Boomer 2016; SEPA 2015; STAC 2014; Hey & Philippi 1995; https://cpb-us-e1.wpmucdn.com/blogs.cornell.edu/dist/0/5949/files/2016/08/RoadsideDitches-fact-sheet-pdf-2j1nacx.pdf	

2. Application of Watershed Restoration Flood Mitigation Measures

a. Cover Crops

The planting of cover crops increases organic matter and water infiltration and reduces runoff and soil loss. Archuleta (2014) indicated that for every 1% increase in soil organic matter, an additional 17,000 to 25,000 gallons of water per acre infiltrates into the soil. In a hypothetical example modelled for the Upper Cedar River in Iowa, planting winter cover crops on all agricultural areas increased water infiltration by 0.2 to 0.3 inches for four design storms (10, 25, 50, 100 year events). For a storm of 5.89 inches of rain in 24 hours (50 year event), the cover crop scenario predicted peak discharge reductions of 7-10% (IFC 2014).

b. Reconnection of Streams to Floodplains

The East Lents Reach project is an example of how reconnection of a stream to its floodplain can reduce downstream flooding. Johnson Creek is a tributary to the Willamette River near Portland, Oregon. It is a largely urban stream that is known for frequent flooding and that contains sections that do not meet water quality standards under the Clean Water Act (Ahilan et al. 2016). In 2011 and 2012, floodplain restoration (floodplain reconnection, riparian restoration, and wetland restoration) was carried out on approximately 64 acres at the East Lents Reach along Johnson Creek. A hydro-morphodynamic model using simulation scenarios of 10, 50, 100, and 500 year flood events found that the restored floodplain reduces the downstream flood peak by up to 25%. Results also show that approximately 20% - 30% of sediment from upstream is deposited in the East Lents floodplain. Sediment retention at the East Lents floodplain is predicted to reduce the annual sediment loading of Johnson Creek to the Willamette River by 1%. The East Lents floodplain restoration provides flood storage, improves fish and wildlife habitat, affords recreational opportunities, and provides flood resilience downstream (Ahilan et al. 2016). Other stream restoration techniques, such as restoring stream morphology (e.g., recreating natural stream meander patterns), will also achieve flood control benefits by slowing water down.

c. Wetlands, Bioswales, Detention Basins

Habitat features such as wetlands, bioswales, and detention basins all serve to mitigate flooding by storing and slowing floodwater so that it moves downstream more slowly. Smith et al. (2015) modelled a system of detention basins in the 14 km^2 urban Dead Run watershed in Maryland. The entire modelled detention basin network in Dead Run decreased peak discharges by a median of 11% for the flood events included in the study. Watson et al. (2016) estimated the economic value of floodplains and wetlands to the Town of Middlebury, Vermont. They determined that wetlands and floodplains along Otter Creek reduced flood-related damages associated with 10 storm events[4] by 54 - 78%.

d. Improve Soil Structure

A study in the Upper Cedar Creek watershed in Iowa evaluated the benefits to soil structure that can be achieved by converting row crops to native tall grass prairie feet (IFC 2014). Prairie grass species are deeply rooted and associated with deep, loosely packed soils. Modelling conducted for the Upper Cedar Creek watershed in Iowa predicted that changes from an agricultural to native tall grass prairie landscape would increase water infiltration by 0.8 inches for a 10 year event and 1.8 inches for a 100 year event, thereby reducing runoff. Peak discharges at the seven modelled index locations were reduced by 18-25%; flood stages were reduced by up to 2.5 inches. These authors did caveat that while the restored tall grass prairie landscape would significantly reduce flood severity and frequency, there may be substantial flooding with extreme rainfall events (such as in 2008) because of saturated initial conditions and persistent rainfall.

e. Re-forestation

The Center for Watershed Protection in Maryland evaluated the effectiveness of urban tree planting for reducing runoff, nutrients, and sediment and developed a tool to estimate stormwater reduction "credits" for tree planting (CWP 2017). Using this tool, the planting of 1,000 broad-leaved deciduous trees in the Syracuse, New York, area would achieve a runoff reduction of

[4] 10 storm events included Tropical Storm Irene and nine historic flooding events

29,000 cubic feet from a 0.9 inch rainfall event (https://owl.cwp.org/mdocs-posts/stormwater-performance-based-credit-calculator/).

We recommend that the USACE conceptually evaluate the watershed restoration measures discussed in this section of the report as part of a comprehensive flood regulation strategy.

3. Example of a Comprehensive Watershed Restoration Flood Control Project

Sidney, New York

> *"Sidney accepts that flooding is inevitable, but devastation is not. This plan works with nature, giving the river and streams space to spread out into areas where people, infrastructure, and community investments are not in danger and giving residents new choices"*
> NY Rising Community Reconstruction Plan for Sidney, March 2014

The New York Rising Community Reconstruction (NYRCR) program was developed in 2013 by New York State to provide rebuilding and resiliency assistance to communities severely damaged by hurricanes Irene, Lee, and Sandy. Delaware County, in conjunction with the Villages of Sidney and Sidney Center, is proposing a flood management program under NYRCR called "Sidney GreenPlain" that would include the elevation or acquisition and demolition of 136 structures in flood hazard areas, in conjunction with environmentally restorative non-structural flood control measures. Areas in which structures are removed would be graded, seeded, and maintained as open space. Approximately 140 acres of floodplain would be turned into a wetland, stream, and pond complex for flood storage and water quality improvement. The GreenPlain area is predicted to provide an additional 22.8 million cubic feet of flood storage, which would reduce or slow downstream flows. The estimated cost for full implementation is approximately $22 million (NYRCR 2014).

The GreenPlain proposal was developed in response to severe floods in 2006 and 2011, as an alternative to a 2006 USACE flood control proposal for Sidney that included construction of a levee/floodwall system, flap gates on Weir Creek, river dredging, pumping stations, and acquisition of about 20 properties (Corps 2010). Although the USACE proposal was predicted to eliminate flooding during a 100 year storm event for much of the Village of Sidney, it was considered expensive to construct ($35 - $50 million), with high operating and maintenance costs, and adverse environmental impacts due to tree removal and wetland impacts. It also would have contributed to a slight increase in flooding in Unadilla Township (FEMA & GOSR 2016).

The GreenPlain is predicted to reduce flooding in downstream areas[5], restore water quality, increase health and wellness, attract visitors, and expand jobs at half the cost of the 2006 USACE flood control proposal (NYRCR 2014).

[5] The GreenPlain project would provide an additional 22.8 million cubic feet of flood storage and would be expected to reduce flooding downstream

G. PILOT WATERSHEDS FOR APPLICATION OF WATERSHED RESTORATION FLOOD CONTROL MEASURES

The USFWS has identified four pilot watersheds in the Upper Susquehanna Watershed in which we recommend consideration of the watershed restoration-based flood mitigation measures discussed above. The identification of these pilot watersheds is the first step at developing watershed restoration flood mitigation measures for the Susquehanna watershed. We recommend that, as part of this study, the USACE conceptually evaluate these pilot watersheds as areas in which a suite of landscape actions may be considered and implemented as part of a comprehensive flood regulation strategy. As suggested by the USACE, investigation of the pilot watersheds could potentially be explored further by USACE through the Chesapeake Bay Comprehensive Plan currently being developed and by other stakeholders. https://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/national/programs/initiatives/?cid=stelprdb1047323

These pilot watersheds were selected using the following criteria:

- **Target areas upstream of flood-prone areas, as shown in Figure 11.**

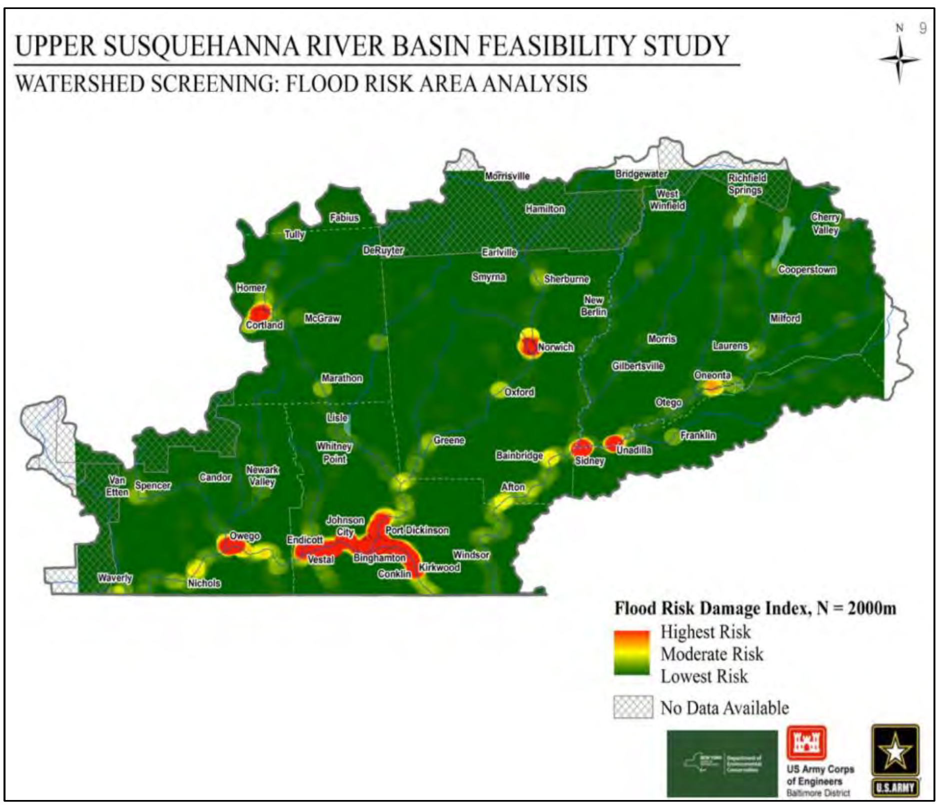


Figure 11. USACE Flood Risk Map

➢ **Identify locations in the Upper Susquehanna watershed with environmentally sensitive species – brook trout, eastern hellbender, and brook floater (Figure 12).**

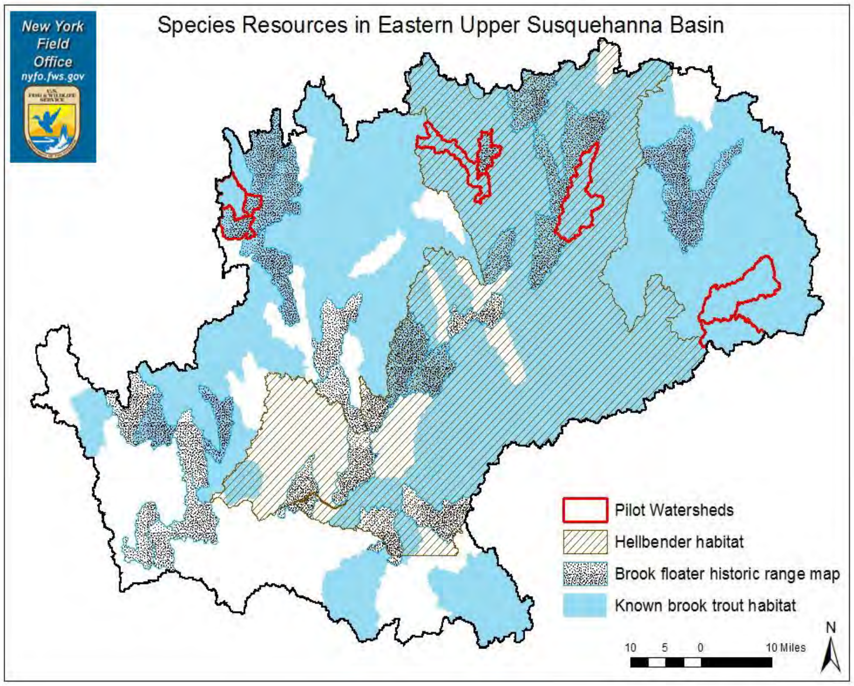


Figure 12. Environmentally Sensitive Resources

➢ **Identify low slope watersheds with high levels of agriculture and/or hydric soils in riparian areas. The assumption is that these areas may afford opportunities for restorative measures such as reconnecting streams to floodplains, wetland restoration, and reforestation (Figure 13, 14).**

The pilot watersheds illustrated in red in Figure 13 and at a greater resolution in Figure 14 are:

- Wharton Creek
- Upper Chenango River
- Charlotte Creek
- West Branch Tioughnioga River

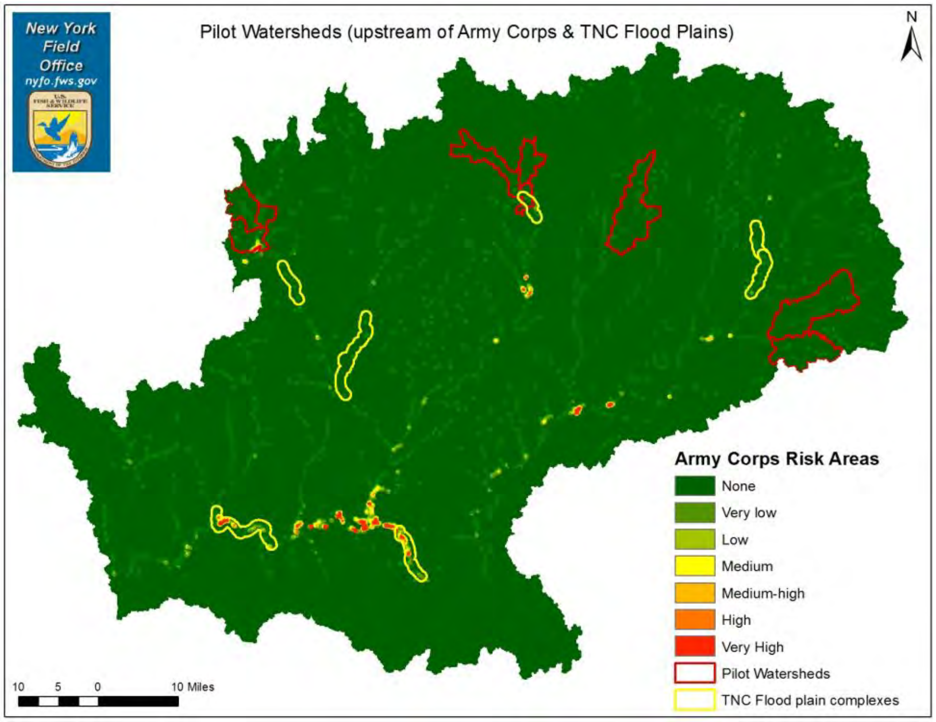


Figure 13. Pilot Watersheds

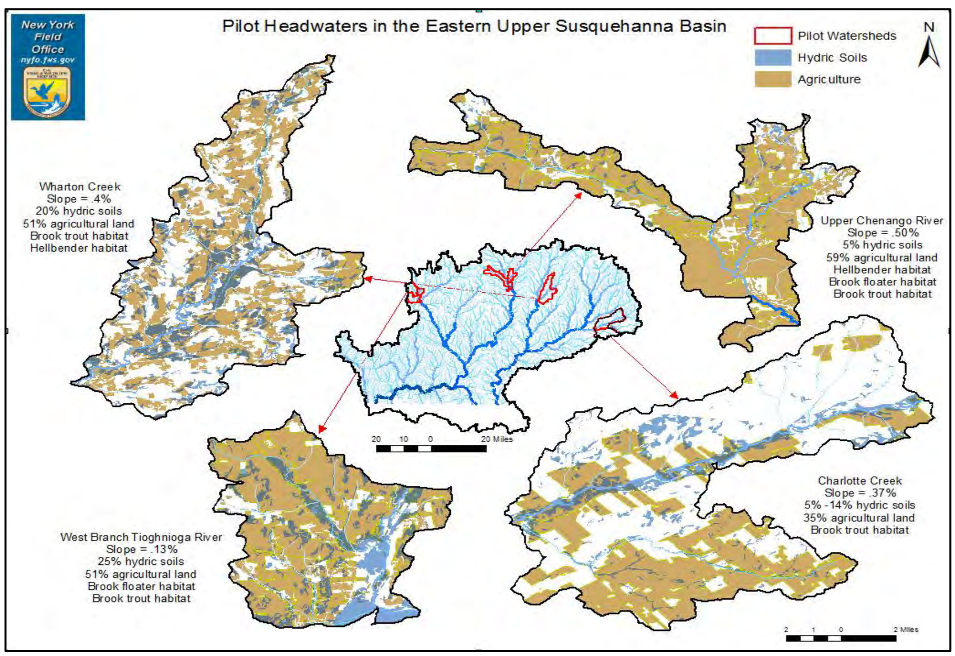


Figure 14. Pilot Watersheds

- **Consider the application of a suite of environmentally restorative flood mitigation strategies, in conjunction with other non-structural measures such as acquisition and structure elevation, to assess potential flood benefits achievable.**

H. U.S. FISH AND WILDLIFE SERVICE RECOMMENDATIONS

1. ALTERNATIVES

We recommend that the following be considered in the development of alternatives for flood reduction management.

- Fully develop a watershed restoration flood control alternative. Include environmentally restorative measures as a separate fully vetted alternative or within project alternatives that may be used to further mitigate flood damage by keeping rain closer to where it falls, encouraging water infiltration into soils, enhancing stormwater detention, and slowing downstream flows. Consider evaluating the use of these methods in the pilot watersheds as proposed in Section G of this report (Figures 13 and 14).

- Select alternatives and design options that minimize the footprint of levees and minimize snagging, clearing, shoal removal, and dredging of rivers and streams.

- Provide the costs of non-structural infrastructure improvements (acquisition, flood proofing, etc.) to enable a cost/benefit comparison with structural alternatives.

- In addition, any future alternatives evaluation should quantify the ecological benefits along with the ecosystems services (e.g., carbon and nutrient removal or sequestration; reduced flood risk) that connected and reconnected floodplains provide to society in order to fully assess the costs and benefits of flood-control projects.

- Any future alternative should also determine the valuation of human-use services such as angling, boating, or hiking, that may be adversely impacted by proposed structural projects.

2. MINIMIZATION AND MITIGATION MEASURES

In order to minimize impacts to fish and wildlife and mitigate for unavoidable impacts, we recommend that the USACE:

- Evaluate and quantify habitat lost as part of levee construction. This includes riparian habitat and floodplain wetlands that may be adversely impacted by levee construction. Mitigation should be provided for these losses.

- Consider vegetative options for levees other than maintained grass in order to provide greater habitat value (Shields 2016; PCPW 2016).

- Remove woody material from rivers and streams only if it is demonstrated that it will achieve measurable flood benefits. Provide mitigation for adverse environmental effects.

- Excavate river shoals only if it is demonstrated that it will achieve measurable flood benefits that will persist over time. Provide mitigation for adverse environmental effects. The USACE should evaluate the causes and the likelihood of shoal re-development in the future and assess options to address the cause. Addressing the cause will minimize the need for repetitive shoal removal costs, especially to local communities.

- Seek to improve fish passage wherever possible when it can be accomplished in conjunction with flood reduction measures.

- Avoid and minimize impacts to the federally listed, threatened Northern long-eared bat by leaving suitable trees on the landscape if feasible, or if not, conduct tree removal during the winter while bats are hibernating (October 31 and March 31).

- Avoid removing wetlands and floodplains from the landscape as they are ecologically beneficial and can store floodwater and provide wildlife habitat. Consider restoring wetlands and floodplains that have been impacted in the past to build resiliency and provide recreational space for communities.

- Identify alternate authorities to address recommendations that do not fall within the current authority for this project.

I. Literature Cited

Ahilan, S., M. Guan, A. Sleigh, N. Wright, and H. Chang. 2016. The influence of floodplain restoration on flow and sediment dynamics in an urban river. Journal of Flood Risk Management 11:S986-S1001.

Archuleta, R. 2014. Cedar River Watershed Coalition Meeting – Cover Crops and Other Conservation practices – personal interview, as cited in IFC 2014.

Arnell, N.W. and S.N. Gosling. 2014. The impacts of climate change on river flood risk at the global scale. Climatic Change 134: 387 – 401.

Arnold, J.L. 1986. The evolution of the 1936 Flood Control Act. Office of History, United States Army Corps of Engineers, Fort Belvoir, Virginia. http://www.publications.usace.army.mil/Portals/76/Publications/EngineerPamphlets/EP_870-1-29.pdf

CWP. Center for Watershed Protection. 2017. Documentation for stormwater performance-based credit. Crediting framework product #7 for the project, *Making urban trees count: A project to demonstrate the role of urban trees in achieving regulatory compliance for clean water*. Center for Watershed Protection, Ellicott City, MD.

Corps (U.S. Army Corps of Engineers) 2010 . Flood risk management analysis, Village of Sidney, Delaware County. Prepared by U.S. Army Corps of Engineers, Baltimore District, August 2010.

Cowin, M.W. and G.B. Bardini. 2012. Central Valley flood protection plan. A path for improving public safety, environmental stewardship and long-term economic stability. https://www.water.ca.gov/LegacyFiles/floodsafe/fessro/docs/flood_tab_cvfpp.pdf

Dadson, S.J., J.W. Hall, A. Murgatroyd, M. Acreman, P. Bates, K. Beven, L. Heathwaite, J. Holden, I.P. Holman, S.N. Lane, E. O'Connell, E. Penning-Rowsell, N. Reynard, D. Sear, C. Thorne, and R. Wilby. 2017. A restatement of the natural science evidence concerning catchment-based 'natural' flood management in the U.K. Proc R Soc A 473: 20160706. http://dx.doi.org/10.1098/rspa.2016.0706

Environment Agency (U.K.). 2017. Natural Flood Management Toolbox. Guidance for working with natural processes in flood management schemes. https://www.catchmentbasedapproach.org/images/PDFS/NFM/EA-NFM-Toolbox-Final-Draft.pdf

FEMA and GOSR (Federal Emergency Management Agency and Governor's Office of Storm Recovery). 2016. Draft Environmental Assessment, Community Development Block Grant – Disaster Recovery, Hazard Mitigation Grant Program Global Match and Acquisition & Elevation. Village of Sidney and Sidney Center, Delaware County, New York. FEMA-4020-DR-NY.

FLLT (Finger Lakes Land Trust). 2012. Conservation focus areas of the Upper Susquehanna watershed within the Finger Lakes Land Trust's service area. http://www.fllt.org/content/uploads/2015/02/Conservation-Plan-Upper-Susquehanna.pdf

Franklin, S.B., J.A. Kupfer, S.R. Pzeshki, R. Gentry, and R.D. Smith. 2009. Complex effects of channelization and levee construction on western Tennessee floodplain forest function. Wetlands 29(2):451-464.

Garner, JT and SW McGregor. 2001. Current status of freshwater mussels (Unionidae, Margaritiferidae) in the Muscle Shoals area of Tennessee River in Alabama (Muscle Shoals revisited again). American Malacological Bulletin 16(1/2): 155-170.

Hey, D.L. and N.S. Philippi. 1995. Flood reduction through wetland restoration: the upper Mississippi River basin as a case history. Restoration Ecology 3 (1): 4-17.

Hynicka, J. and D. Caraco. 2017. Relative and absolute reductions in annual water yield and non-point source pollutant loads of urban trees. Crediting framework Product #2 for the project Making Urban Trees Count: A Project to Demonstrate the Role of Urban Trees in Achieving Regulatory Compliance for Clean Water. Center for Watershed Protection, Ellicott City, MD.

IFC (Iowa Flood Center). 2014. Hydrologic assessment of the Upper Cedar River watershed. Iowa Flood Center and IIHR- Hydroscience and Engineering, University of Iowa. IIHR Technical Report No. 489.

IRMRC (Interagency Floodplain Management Review Committee). 1994. Sharing the Challenge: Floodplain Management into the 21st Century. Prepared for Administration Floodplain Management Task Force. Washington. D.C. 1994. "The Galloway Report"

Lane, J.A., C.B. Portt, and C.K. Minns. 1996. Spawning habitat characteristics of Great Lakes fishes. Canadian Manuscript Report of Fisheries and Aquatic Sciences No. 2368.

Lassettre, N.S. and G.M. Kondolf. 2012. Large woody debris in urban stream channels: redefining the problem. River Research and Applications 28:1477-1487.

MacGregor, R., J.M. Casselman, W.A. Allen, T. Haxton, J.M. Dettmers, A. Mathers, S. LaPan, T.C. Pratt, P. Thompson, M. Stanfield, L. Marcogliese, and J-D Dutil. 2009. Natural heritage, anthropogenic impacts, and biopolitical issues related to the status and sustainable management of American eel: A retrospective analysis and management perspective at the population level. Am. Fisheries Society Symposium 69:713-740.

Makhdoom, M.T. 2013. Impacts of levees on floodplain ecosystems. Online presentation. https://vaflood.files.wordpress.com/2012/09/levee-impacts-on-floodplain-ecosystems.pdf

Mallakpour, I. and G. Villarini. 2015. The changing nature of flooding across the central United States. Nature Climate change 5: 250 - 254.

Marcinek, P.A., M.C. Freeman, and B.J. Freeman. 2003. Distribution and abundance of three endemic fishes in shoals of the upper Flint River system. Proceedings of the 2003 Georgia Water Resources Conference, April 23-24, 2003, University of Georgia.

Mayasich, J., D. Grandmaison, and C. Phillips. 2003. Eastern hellbender status assessment. U.S. Fish and Wildlife Service.

Miller, AC and BS Payne. 2004. Reducing risks of maintenance dredging on freshwater mussels (Unionidae) in the Big Sunflower River, Mississippi. J Environ Manage 73(2): 147-154.

Ning, L., E.E. Riddle, and R.S. Bradley. 2015. Projected changes in climate extremes over the Northeastern United States. American Meteorological Society, April 2015. https://doi.org/10.1175/JCLI-D-14-00150.1

NYRCR (New York Rising and Community Reconstruction Program). 2014. NYRCR Sidney. https://stormrecovery.ny.gov/sites/default/files/crp/community/documents/sidney_nyrcr_plan.pdf

PCPW (Pierce County Public Works). 2016. Levee vegetation management – strategy. https://www.co.pierce.wa.us/ArchiveCenter/ViewFile/Item/4622

Pugh, W.W., M. Hutchins, M. Madritch, L. Siefferman, and M.M. Gangloff. 2015. Land-use and local physical and chemical habitat parameters predict site occupancy by hellbender salamanders. Hydrobiologia: DOI 10.1007/s10750-015-2570-0.

Richter, B.D., D.P. Braun, M.A. Mendelson, and L.L. Master. 1997. Threats to imperiled freshwater fauna. Conservation Biology 11(5): 1081-1093.

Saldi-Caromile, K., K. Bates, P. Skidmore, J. Barenti, D. Pineo. 2004. Stream Habitat Restoration Guidelines: Final Draft. Co-published by the Washington Departments of Fish and Wildlife and Ecology and the U.S. Fish and Wildlife Service. Olympia, Washington. Washington State Aquatic Habitat Guidelines Program.

Schneider, R. and K. Boomer. 2016. Re-plumbing the Chesapeake Watershed: Improving roadside ditch management to meet TMDL water quality goals. STAC Publication Number 16-001, Edgewater, MD. 43 pp.

SEPA (Scottish Environment Protection Agency). 2015. Natural Flood Management Handbook. https://www.sepa.org.uk/media/163560/sepa-natural-flood-management-handbook1.pdf

SEPA. 2012. Supporting guidance (WAT-SG-78). Sediment management authorization. https://www.sepa.org.uk/media/151062/wat-sg-78.pdf

Sherer, D. 2011. Mussels important in birth of Shoals. Times Daily, November 13, 2011. Florence, Alabama.

Shields D.F. 2016. Synthesis of levee vegetation research results (2007-2014). Prepared for California Levee Vegetation Research Program. https://www.water.ca.gov/LegacyFiles/floodsafe/leveeveg/levee_documents/2016-0127-Levee-Veg-Synthesis-Report-FINAL.pdf

Smith, B.K., J.A. Smith, M.L. Baeck, and A.J. Miller. 2015. Exploring storage and runoff generation processes for urban flooding through a physically based watershed model. Water Resources Research 51, 1552-1569, doi:10.1002/2014WR016085.

SRAFRC (Susquehanna River Anadromous Fish Restoration Cooperative). 2010. https://www.dec.ny.gov/docs/fish_marine_pdf/r7fsrafcfinal.pdf

STAC (Scientific and Technical Advisory Committee). 2014. Re-plumbing the Chesapeake watershed: improving roadside ditch management to meet TMDL water quality goals. STAC Workshop Report October 9-10, 2014. STAC Publication 16-001.

Strayer, D.L. and A.R. Fetterman. 1999. Changes in the distribution of freshwater mussels (Unionidae) in the Upper Susquehanna River basin, 1955-1965 to 1996-1997. American Midland Naturalist 142(2):328-339.

Strayer, D. and H. Malcom. 2012. Causes of recruitment failure in freshwater mussel populations in southeastern New York. Ecological Applications 22(6):1780-1790.

Thibeault, J.M. and A. Seth. 2014. Changing climate extremes in the Northeastern United States: observations and projections from CMIP5. Climatic Change 127:273-287.

Tuel, A.L.B.. 2017. Levee vegetation management in California: An overview of law, policy and science, and recommendations for addressing vegetation management challenges. http://www.westcoast.fisheries.noaa.gov/publications/Central_Valley/Sacramento%20River/levee_vegetation_management_in_california.pdf

UNECE (United Nations Economic and Social Council). 2000. Sustainable Flood Prevention. http://www.unece.org/fileadmin/DAM/env/water/publications/documents/guidelinesfloode.pdf

Watson, K.B., T. Ricketts, G. Galford, S. Polasky, and J. O'Niel-Dunne. 2016. Quantifying flood mitigation services: the economic value of Otter Creek wetlands and floodplains to Middlebury, VT Ecological Economics 130:16-24.

Young, W.J. 1991. Flume study of the hydraulic effects of large woody debris in lowland rivers. River Research and Applications 6(3): 203-211