US Army Corps of Engineers ®

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

APPENDIX B: ECONOMICS

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PREPARED BY:

DEPARTMENT OF THE ARMY

CORPS OF ENGINEERS

NEW ENGLAND DISTRICT

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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1. INTRODUCTION

The Susquehanna River flows through Maryland, Pennsylvania, and New York. The Upper Susquehanna River Basin (USRB), the focus of this study, is located in New York and Pennsylvania. Only the New York portion of the watershed is included in this study. The USRB is a primarily rural basin with urbanized communities located along the rolling hills and steep floodplains of the Susquehanna and Chenango River, the major riverine systems of the basin. There are currently local and federal flood risk management (FRM) projects in the City of Binghamton and an additional 18 federally authorized projects throughout the basin. Communities in the watershed are primarily concentrated in and near riverine floodplains and are known to have historic flooding risk. Communities in the USRB remain at high residual risk for flooding as indicated by damages sustained in these communities from riverine flooding in a 2006 storm. In 2011, flooding from Tropical Storm Lee overwhelmed many of the FRM projects in the watershed including Binghamton, Vestal, and Johnson City resulting in over $500 million in property damage in Broome County alone.

The purpose of the USRB study is to evaluate the effectiveness of existing FRM infrastructure and to recommend structural and non-structural solutions to flood risk reduction in the USRB. The feasibility study is intended to inform decision-makers about flooding problems and feasible FRM actions that could be considered at the federal, state or local level. The study will provide a comprehensive watershed approach for FRM in the USRB including recommendations for further FRM investigations by USACE and other stakeholders.

The economic analysis in USRB is consistent with the Water Resources and Development Act (WRDA) of 1986 (P.L. 99-662) and Engineer Regulation ER 1105-2-100 of 22 April 2000.

2. DESCRIPTION OF THE STUDY AREA

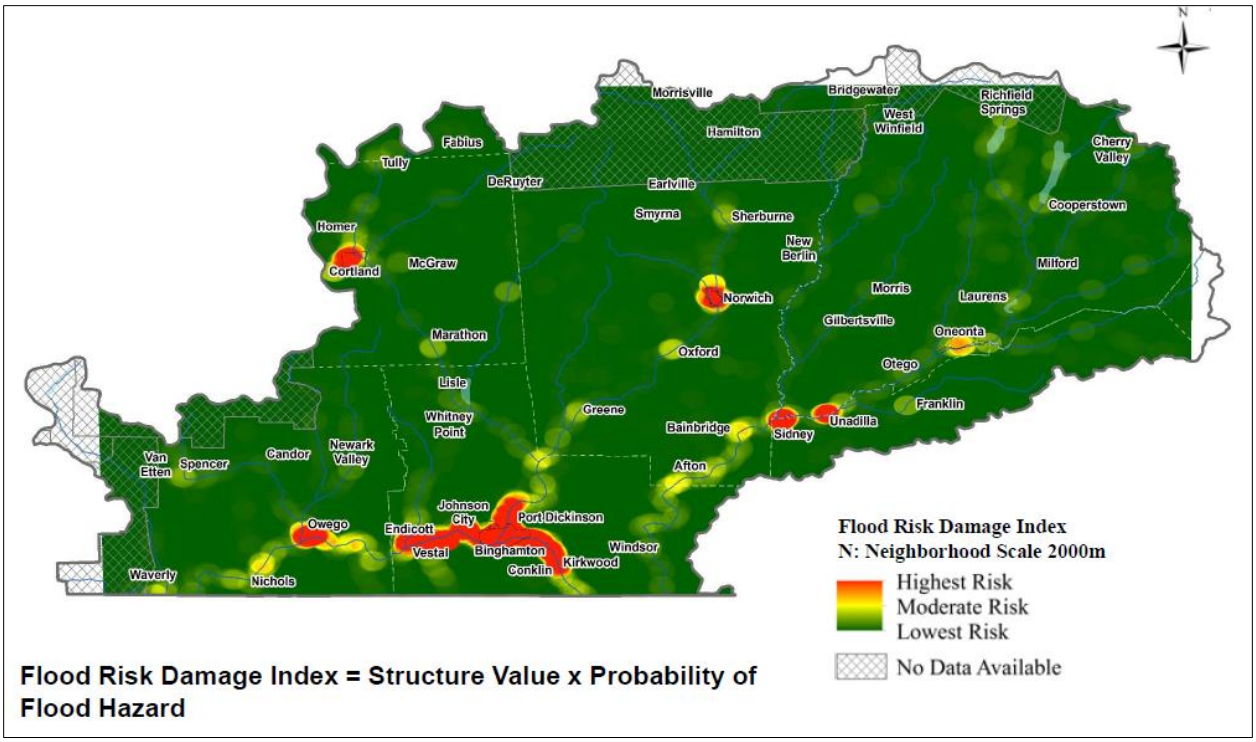
2.1 Location and Setting

The USRB drains approximately 4,520 square miles in the south central part of New York. The drainage area includes most of Broome, Chenango, Cortland, Otsego and Tioga Counties in New York; parts of Madison and Chemung Countries in Delaware; and small portions of Schuyler, Tompkins, Onondaga, Oneida, Herkimer and Schoharie Counties, also located in New York. The large subwatersheds include the Tioughnioga River subwatershed, which includes the Otselic River subwatershed, the Unadilla River subwatershed, the Owego Creek subwatershed, and the Cayuta Creek subwatershed. Otsego Lake, Canadargo Lake, and Whitney Point Reservoir are the largest lakes. The region is characterized by low rolling hills covered by hardwood forests and large wide

valleys scattered with agricultural activity. Twenty-five percent of the drainage area accounts for the agricultural land use and a large part is covered by forest. Binghamton is the largest city in the study area. Binghamton is located in Broome County, New York.

Figure 1 illustrates areas with higher relative flood risk based on preliminary economic damages of structures in those areas resulting from the 5 percent flood event.

Figure 1 Flood Risk Damage Index



2.1.2 County Descriptions

Table 1 below describes the counties in the full Upper Susquehanna River Basin.

Table 1 County Descriptions

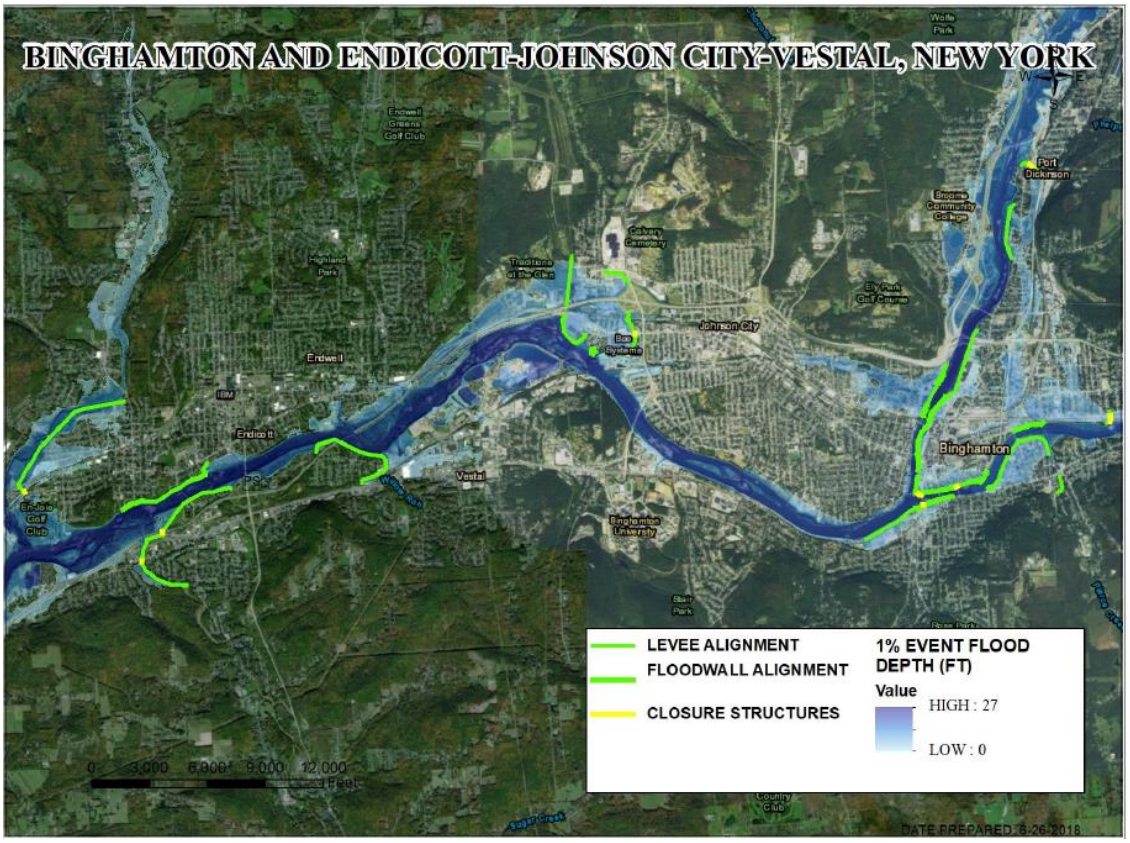
County	Description
Broome	Broome County is approximately 716 square miles and is located in south-central New York, directly north of the border with Pennsylvania in a section of the state called the Southern Tier. Of 716 square miles within the county, 706 square miles are land and 9.7 square miles are water. U.S. National Geodetic Survey benchmark, approximately 2087 feet above sea level, is the highest elevation. The lowest point is 864 feet above sea level, along the Susquehanna at the Pennsylvania line.
Chenango	Chenango County has approximately 899 square miles, of which 894 square miles is land and 5 square miles is water, and is located in the south-central section of the Southern Tier of New York. The Chenango River is a tributary of the Susquehanna River and flows southward through the county.
Cortland	Cortland County has approximately 502 square miles and is located in the Southern Tier region of New York. It is sometimes considered to be part of Central New York, Southwest of the center of New York State, south of Syracuse and north of Binghamton.
Otsego	Otsego County has approximately 1,016 square miles, of which 1,002 square miles is land and 14 square miles is water. Otsego County is in the central New York State and considered by some to belong to the Southern tier region of New York State.
Tioga	Tioga County has approximately 523 square miles and is located in Southern New York State. 519 square miles represents the land and 4 square miles is covered by water.
Delaware	Delaware County has approximately 97 square miles, of which 96 square miles are land and 0.6 square miles are water. The East Branch Delaware River flows from northeast to southwest across the town.
Madison	Madison County has approximately 661 square miles in area, of which 655 square miles are land and 6 square miles are water. Madison County is located in central New York State, just east of Syracuse and north of Binghamton.
Chemung	Chemung County has an approximately a total of 411 square miles, of which 407 square miles is land and 4 square miles is water. Chemung County is in the southwestern part of New York State, along the Pennsylvania border, in a part of New York called Southern Tier.
Schuyler	Schuyler County has approximately 342 square miles, of which 328 square miles is land and 14 square miles is water. Schuyler County is located in the western part of the New York State.
Tompkins	Tompkins County has approximately 492 square miles area, of which 475 square miles is land and 17 square miles is water. Tompkins County is in the west central part of the New York state but some locals consider themselves to be part of Central New York or the Southern Tier.
Onondaga	Onondaga County has approximately total area of 806 square miles, of which 778 square miles is land and 28 square miles is water. Onondaga County is located in the central portion of the New York State.
Herkimer	Herkimer County has a total area of 1,458 square miles, of which 1,411 square is land and 47 square miles is water. Herkimer County is located in the central portion of New York State.

2.2 Description of Focus Area

Following a preliminary analysis of cost and benefits as well as discussions with the local sponsors, specific urban areas within the USRB were selected as candidates for FRM projects. Given the expected damages after flood events, areas identified for potential FRM structural projects include Binghamton, Johnson City, and Endicott/Vestal. The Binghamton and Endicott-Johnson City-Vestal (EJV) areas lie within Broome County.

Nonstructural solutions were also investigated in the areas of Bainbridge, Cortland, Chenango, Greene, Norwich, Oneonta, Owego, Sidney, Unadilla, Waverly, and Whitney Point.

Figure 2 Binghamton and Endicott-Johnson City-Vestal



2.3 Land Use

Large population centers and urbanized areas are concentrated in the municipalities of Binghamton, Cortland, Johnson City, Oneonta, and Endicott. However, the overall character of the watershed is rural. The rural population is dispersed throughout the watershed in small villages. Forest land dominates steeply sloped hills and ridges.

Agricultural operations occupy the valleys. (SRBC, Subbasin information, USRB subbasin, 2017; NYSDEC 2009 Susquehanna River Basin Water Quality Assessment).

2.4 Socioeconomic and Regional Analysis

The socioeconomic information for the region are summarized in this section. The parameters used to describe the demographic and socioeconomic information include recent trends in population for the 19 towns and villages that make up the focus study area of the USRB, as well as trends in employment and income. Other social characteristics such as race, age distribution, and social vulnerability are also examined within the region.

2.4.2 Population

The population in the USRB has been on the decline with all counties in the watershed exhibiting drops in population between 2010 and 2017. Delaware County had the largest decrease in total population between 2010 and 2017, while Chenango and Tioga Counties are expected to have the most significant declines through 2030. The flight of those living in the region is attributed to the lack of employment opportunities. The region's shrinking manufacturing and industrial sector has reduced available job opportunities in the USRB. Many residents in the area are leaving the region in search of more and higher paying job opportunities elsewhere (Platsky, 2018).

Table 2 County Population

County	2010	2017	2020	2030	%change 2010-17	%change 2010-30
Broome	200,600	193,639	192,262	186,950	-3.5%	-3.5%
Chenango	50,477	47,863	47,099	44,197	-5.2%	-7.7%
Delaware	47,980	45,001	44,419	42,076	-6.2%	-6.5%
Otsego	62,259	60,094	59,778	59,008	-3.5%	-1.8%
Tioga	51,125	48,578	47,864	45,090	-5.0%	-7.2%

Source: 2010, 2017 data US Census Bureau Quick Facts, American Fact Finder; 2020, 2030 Cornell University https://pad.human.cornell.edu/counties/projections.cfm

Vestal, which is home to Binghamton University, is the only municipality with a population over 5,000 to not experience a decline in population from 2010 to 2017.

Table 3 Municipality Population

Municipality	2010	2013-2017 Average	% change
Binghamton (City)	47,376	45,179	-4.6%
Chenango (Town)	11,252	10,733	-4.6%
Conklin (Town)	5,441	5,215	-4.2%
Cortland (City)	19,204	18,698	-2.6%
Endicott (Village)	13,392	12,828	-4.2%
Johnson City (Village)	15,174	14,508	-4.4%
Kirkwood (Town)	5,857	5,600	-4.4%
Norwich (City)	7,190	6,718	-6.6%
Norwich (Town)	3,998	3,857	-3.5%
Oneonta (Town)	5,229	5,088	-2.7%
Owego (Town)	19,883	18,891	-5.0%
Owego (Village)	3,896	3,805	-2.3%
Union (Town)	56,346	54,033	-4.1%
Vestal (Town)	28,043	28,199	0.6%
Waverly (Village)	4,444	N/A	N/A
Unadilla (Village)	1,128	N/A	N/A
Bainbridge (Village)	1,355	N/A	N/A
Greene (Village)	1,580	N/A	N/A
Sidney (Village)	3,900	N/A	N/A
Port Dickinson (Village)	1,641	N/A	N/A
Whitney Point (Village)	964	N/A	N/A

Source: US Census Bureau Quick Facts 2017, American Fact Finder 2010

2.4.3 Industry and Commerce

According to a 2012 Census survey, retail trade had the highest number of commercial establishments between all counties in the USRB. Health care and social assistance; accommodation and food services; and professional, scientific, and technical services also have a significant presence in the region.

Table 4 County Number of Establishments by Industry

	Broome	Chenango	Delaware	Otsego	Tioga
Utilities	7	2	1	4	1
Manufacturing	173	74	36	58	44
Wholesale trade	196	24	30	46	25
Retail trade	719	170	183	290	132
Transportation and warehousing	101	19	28	21	18
Information	82	22	32	29	20
Finance and insurance	239	47	50	74	35
Real estate and rental and leasing	160	24	30	53	12
Professional, scientific, and technical services	312	64	75	116	55
Administrative and support and waste management and remediation services	194	30	39	50	47
Educational services	33	5	4	10	5
Health care and social assistance	435	107	114	170	68
Arts, entertainment, and recreation	70	27	27	39	27
Accommodation and food services	522	94	124	210	89
Other services (except public administration)	341	77	83	103	65

Source: U.S. Census Bureau, 2012 Economic Census, 2012 Economic Census of Island Areas, and 2012 Nonemployer Statistics

2.4.4 Employment and Income

Broome County has the largest labor force in the region with 94,186 individuals employed in the county. Tioga County enjoys the highest median household income in the region at $57,153, however it remains below the New York state average of $62,765. Educational services, health care and social assistance employs the largest portion of the population in the USRB followed by manufacturing and retail trade.

Table 5 County Employment and income

County	Broome	Chenango	Delaware	Otsego	Tioga
Unemployment Rate	7.2%	6.7%	7.1%	6.7%	6.5%
Labor Force	94,186	23,242	21,442	30,611	24,608
Median Household income (dollars)	49,064	48,567	47,921	51,254	57,153
Industry					
Agriculture, forestry, fishing and hunting, and mining	0.8%	4.4%	3.7%	2.8%	1.9%
Construction	5.1%	6.5%	8.6%	6.3%	6.9%
Manufacturing	10.4%	16.9%	13.9%	8.2%	13.6%
Wholesale trade	2.8%	1.7%	2.1%	1.1%	2.8%
Retail trade	12.8%	10.0%	10.9%	12.5%	13.5%
Transportation and warehousing, and utilities	4.3%	3.6%	3.8%	3.2%	3.6%
Information	1.7%	2.8%	1.7%	1.3%	1.5%
Finance and insurance, and real estate and rental and leasing	4.5%	6.5%	3.5%	5.1%	3.6%
Professional, scientific, and management, and administrative and waste management services	8.8%	4.9%	6.2%	6.0%	8.7%
Educational services, and health care and social assistance	30.8%	27.4%	26.2%	33.8%	26.7%
Arts, entertainment, and recreation, and accommodation and food services	9.4%	6.1%	9.6%	13.0%	8.9%
Other services, except public administration	4.6%	4.0%	4.6%	3.8%	4.0%
Public Administration	4.1%	5.2%	5.1%	2.8%	4.4%

Source: U.S. Census Bureau, 2013-2017 American Community Survey 5-Year Estimates

2.4.5 Socioeconomic Analysis

The region is predominantly white, with other races generally making up less than 20 percent of the population, which differs from the state average of 65 percent white and 35 percent other races.

Table 6 County Race Demographics

County	White (non-Hispanic/ Latino)	Black or African American	American Indian and Alaska Native	Asian	Native Hawaiian and Other Pacific Islander	Hispanic or Latino (of any race)	Two or More Races
Broome	83.1%	6.0%	0.3%	4.7%	0.1%	4.3%	2.8%
Chenango	94.7%	1.0%	0.4%	0.6%	0.0%	2.2%	1.4%
Delaware	92.2%	2.0%	0.3%	1.0%	0.0%	3.8%	1.3%
Otsego	91.2%	2.3%	0.3%	1.6%	0.1%	3.7%	1.7%
Tioga	94.9%	0.9%	0.2%	0.8%	0.0%	2.0%	1.4%

Source: US Census, Quick Facts 2017

Table 7 Municipality Race Demographics

Municipality	White (non-Hispanic/Latino)	Black or African American	American Indian and Alaska Native	Asian	Native Hawaiian and Other Pacific Islander	Hispanic or Latino (of any race)	Two or More Races
Binghamton (City)	72.3%	13.3%	0.4%	4.6%	0.0%	7.1%	4.9%
Chenango (Town)	94.7%	1.0%	0.4%	0.6%	0.0%	2.2%	1.4%
Conklin (Town)	95.0%	1.3%	0.1%	0.0%	0.0%	3.2%	0.4%
Cortland (City)	90.9%	3.0%	0.0%	0.6%	0.0%	2.8%	2.6%
Endicott (Village)	80.0%	8.4%	0.3%	1.2%	0.0%	6.7%	4.2%
Johnson City (Village)	76.7%	7.3%	0.2%	8.8%	0.2%	4.0%	4.0%
Kirkwood (Town)	91.8%	3.3%	0.0%	0.0%	0.0%	7.0%	0.9%
Norwich (City)	92.2%	1.4%	0.0%	0.7%	0.1%	4.2%	4.0%
Norwich (Town)	96.1%	1.0%	0.0%	1.7%	0.0%	0.4%	0.9%
Oneonta (Town)	85.4%	5.1%	0.2%	1.3%	0.0%	6.2%	2.2%
Owego (Town)	94.9%	0.6%	0.0%	1.5%	0.0%	1.9%	1.2%
Owego (Village)	90.6%	1.3%	0.0%	2.8%	0.0%	3.7%	1.8%
Union (Town)	84.4%	5.7%	0.1%	3.9%	0.1%	3.6%	3.0%
Vestal (Town)	76.1%	4.3%	0.2%	13.3%	0.0%	4.7%	2.0%
Waverly (Village)	96.1%	0.8%	0.3%	0.4%	0.0%	1.2%	1.4%
Unadilla (Village)	94.5%	1.1%	0.3%	0.7%	0.0%	2.2%	1.6%
Bainbridge (Village)	96.5%	0.2%	0.1%	0.3%	0.0%	2.4%	0.9%
Greene (Village)	98.3%	0.1%	0.0%	0.1%	0.0%	0.6%	1.0%
Sidney (Village)	97.7%	0.8%	0.1%	1.1%	0.0%	2.3%	1.4%
Port Dickinson (Village)	92.2%	6.5%	0.0%	0.8%	0.0%	0.4%	0.0%
Whitney Point (Village)	92.1%	1.2%	0.0%	0.2%	0.0%	6.5%	0.0%

Source: US Census, Quick Facts and American Fact Finder 2013-2017 estimates

The age distribution across the region is fairly evenly spread out with the median age generally being slightly higher than the state average of 38.4 years. Kirkwood and Chenango has the highest median age at 44.8 and 44.4 years respectably. Vestal, the home of Binghamton University, has the youngest median age at 26.4 years.

Table 8 County Age Demographics

County	Median age (years)	Persons under 5	Under 18 years	18 to 64	65 and over
Broome	39.6	5.2%	19.6%	62.5%	17.9%
Chenango	44.4	5.3%	21.2%	59.6%	19.2%
Delaware	47.0	4.1%	17.6%	59.6%	22.8%
Otsego	42.0	4.2%	16.6%	64.1%	19.3%
Tioga	44.0	5.2%	21.7%	59.8%	18.5%

Source: US Census, American Fact Finder 2013-2017 estimates

Table 9 Municipality Age Demographics

Municipality	Median age (years)	Persons under 5	Under 18 years	18 to 64	65 and over
Binghamton (City)	**36.4**	6.0%	19.3%	63.7%	17.0%
Chenango (Town)	**44.4**	4.2%	20.0%	61.7%	18.3%
Conklin (Town)	**43.4**	6.4%	23.8%	60.5%	15.7%
Cortland (City)	**27.9**	4.8%	16.5%	69.9%	13.6%
Endicott (Village)	**39.5**	5.1%	20.2%	61.6%	18.2%
Johnson City (Village)	**35.5**	6.9%	22.3%	61.5%	16.2%
Kirkwood (Town)	**44.8**	4.7%	23.2%	56.8%	20.0%
Norwich (City)	**34.8**	8.3%	24.3%	57.300%	18.4%
Norwich (Town)	**42.6**	5.9%	20.4%	63.0%	16.6%
Oneonta (Town)	**43.8**	3.0%	17.4%	60.4%	22.2%
Owego (Town)	**45.6**	5.5%	22.8%	60.600%	16.6%
Owego (Village)	**37.8**	6.3%	21.0%	62.1%	16.9%
Union (Town)	**41.6**	5.4%	20.0%	60.3%	19.7%
Vestal (Town)	**26.4**	3.7%	15.9%	68.0%	16.1%
Waverly (Village)	**39.7**	6.8%	24.0%	58.1%	17.9%
Unadilla (Village)	**43**	6.4%	24.4%	61.1%	14.5%
Bainbridge (Village)	**40.1**	7.5%	23.5%	60.6%	15.9%
Greene (Village)	**42.5**	5.4%	21.6%	58.4%	20.0%
Sidney (Village)	**41.5**	6.6%	23.6%	55.4%	21.0%
Port Dickinson (Village)	**36.6**	7.3%	23.7%	64.2%	12.1%
Whitney Point (Village)	**31.9**	7.2%	29.4%	50.2%	20.4%

Source: US Census, American Fact Finder 2013-2017 estimates

The region is relatively well educated with 90 percent of the population having a high school degree or higher. All municipalities with the exception of Binghamton and Norwich are more educated than the New York state average of 86.1 percent.

Table 10 County Education Demographics

	Education (25 years old +)								
County	**Less than 9th grade**	**9th to 12 grade, no diploma**	**High school graduate (includes**	**Some college, no degree**	**Associate's degree**	**Bachelor's degree**	**Graduate or professional degree**	**% high school graduate or higher**	**% bachelor's degree or higher**
Broome	2.7%	6.9%	31.4%	18.5%	12.6%	15.7%	12.4%	90.4%	28.0%
Chenango	3.1%	9.0%	38.9%	18.3%	12.0%	10.3%	8.3%	87.8%	18.6%
Delaware	3.2%	9.1%	37.6%	16.1%	12.3%	12.1%	9.5%	87.7%	21.6%
Otsego	2.5%	6.5%	32.7%	16.9%	11.9%	15.3%	14.3%	91.0%	29.6%
Tioga	2.2%	7.8%	35.6%	18.4%	11.3%	15.7%	9.1%	90.0%	24.7%

Source: US Census, American Fact Finder 2013-2017 estimates

Table 11 Municipality Education Demographics

	Education (25 years old +)								
Municipality	Less than 9th grade	9th to 12 grade, no diploma	High school graduate (includes equivalency)	Some college, no degree	Associate's degree	Bachelor's degree	Graduate or professional degree	% high school graduate or higher	% bachelor's degree or higher
Binghamton (City)	4.7%	10.2%	32.9%	19.4%	9.3%	12.8%	10.7%	85.6%	23.5%
Chenango (Town)	1.8%	3.9%	28.8%	17.4%	14.8%	20.1%	13.2%	94.3%	33.3%
Conklin (Town)	0.3%	6.9%	39.0%	18.4%	12.3%	12.6%	10.5%	92.8%	23.1%
Cortland (City)	3.3%	6.8%	31.1%	19.1%	13.0%	14.7%	12.0%	89.9%	26.7%
Endicott (Village)	3.6%	8.2%	35.3%	20.2%	12.6%	13.4%	6.7%	88.2%	20.0%
Johnson City (Village)	4.4%	6.6%	31.3%	19.2%	14.0%	15.6%	8.9%	88.9%	24.5%
Kirkwood (Town)	2.1%	8.6%	35.7%	23.8%	11.0%	10.2%	8.6%	89.4%	18.8%
Norwich (City)	4.2%	9.1%	34.8%	16.6%	10.3%	13.3%	11.9%	86.7%	25.1%
Norwich (Town)	2.6%	12.8%	34.3%	22.4%	12.7%	8.6%	6.5%	84.6%	15.1%
Oneonta (Town)	1.8%	7.1%	20.9%	20.5%	11.9%	18.6%	19.3%	91.1%	37.8%
Owego (Town)	1.6%	6.2%	28.7%	16.9%	12.8%	21.1%	12.4%	92.2%	21.2%
Owego (Village)	2.7%	7.7%	30.8%	21.6%	9.1%	16.5%	11.6%	89.6%	28.1%
Union (Town)	3.0%	5.4%	28.2%	18.5%	14.6%	18.4%	11.9%	91.6%	30.3%
Vestal (Town)	1.2%	3.2%	23.1%	16.5%	12.0%	20.9%	23.2%	95.6%	44.0%
Waverly (Village)	3.7%	8.1%	47.6%	18.2%	6.8%	8.9%	6.7%	88.1%	15.6%
Unadilla (Village)	1.0%	9.0%	31.6%	18.8%	14.2%	14.7%	10.8%	90.0%	25.5%
Bainbridge (Village)	4.7%	5.2%	37.3%	14.7%	11.5%	15.1%	11.5%	90.1%	26.5%
Greene (Village)	3.6%	3.7%	30.7%	16.3%	15.9%	16.2%	13.7%	92.7%	29.9%
Sidney (Village)	3.4%	10.4%	39.3%	13.0%	14.9%	12.1%	7.0%	86.2%	19.0%
Port Dickinson (Village)	20.0%	2.1%	29.1%	19.4%	19.4%	17.2%	12.7%	97.8%	29.9%
Whitney Point (Village)	9.6%	6.2%	37.0%	15.4%	9.9%	13.8%	10.7%	86.8%	24.5%

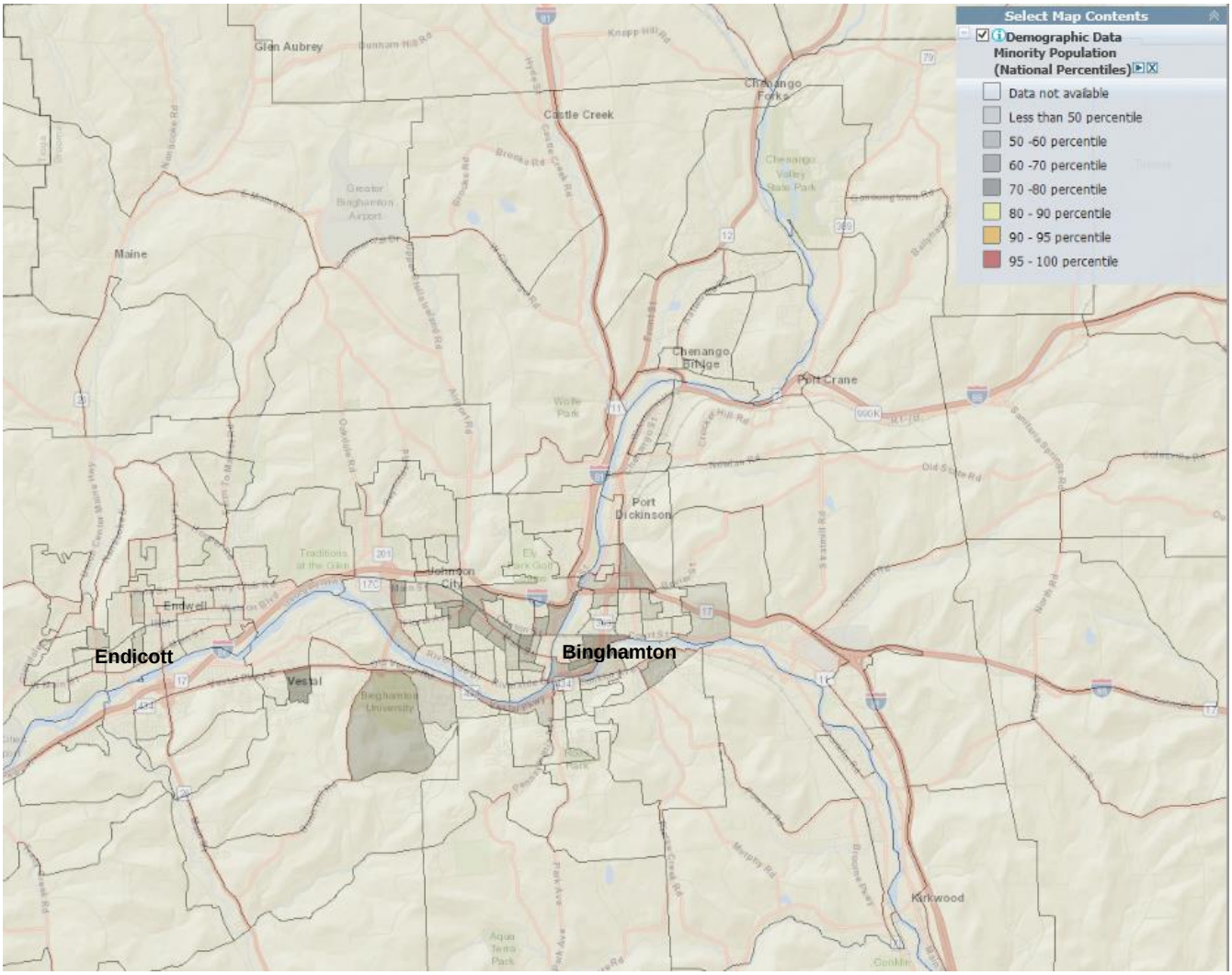
Source: US Census, American Fact Finder 2013-2017 estimates

2.5 Social Vulnerability

The Environmental Protection Agency (EPA) has a tool, EJSCREEN, which is an environmental justice screening and mapping tool. Additionally, EJSCREEN has mapping at the census block level for social vulnerability statistics. The statistics are viewed as a national percentile. The national percentiles exhibit what percent of the US population has an equal or lower value, meaning less potential vulnerability. Figure 3 through Figure 8 display the social vulnerability in the study area.

The focus area is predominately white with most census blocks having minorities less than 50 percentile of the national average. There are a few areas in downtown Binghamton, and one census block in vestal in the percentiles of 60-70 or 70-80. Therefore the study area population as a whole does not indicate social vulnerability based on the characteristics of race and ethnicity.

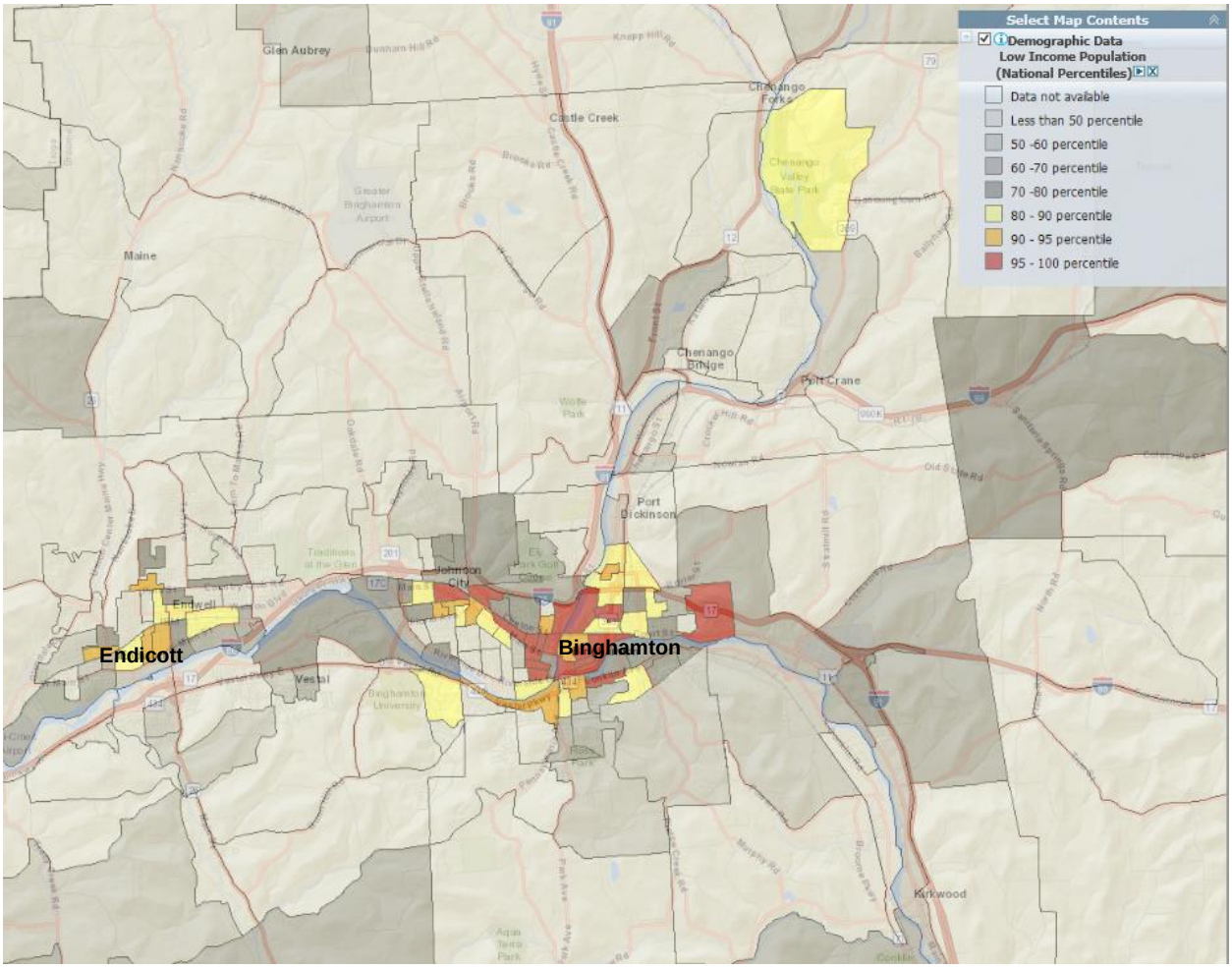
Figure 3 Minority Population



Source: EPA

The study area does exhibit social vulnerability characterized by a low income population. Downtown Binghamton and Johnson City in particular have sections where the percent of low income population is in the 95-100 percentile of the nation. Other areas with elevated low income populations are in Chenango and Endicott.

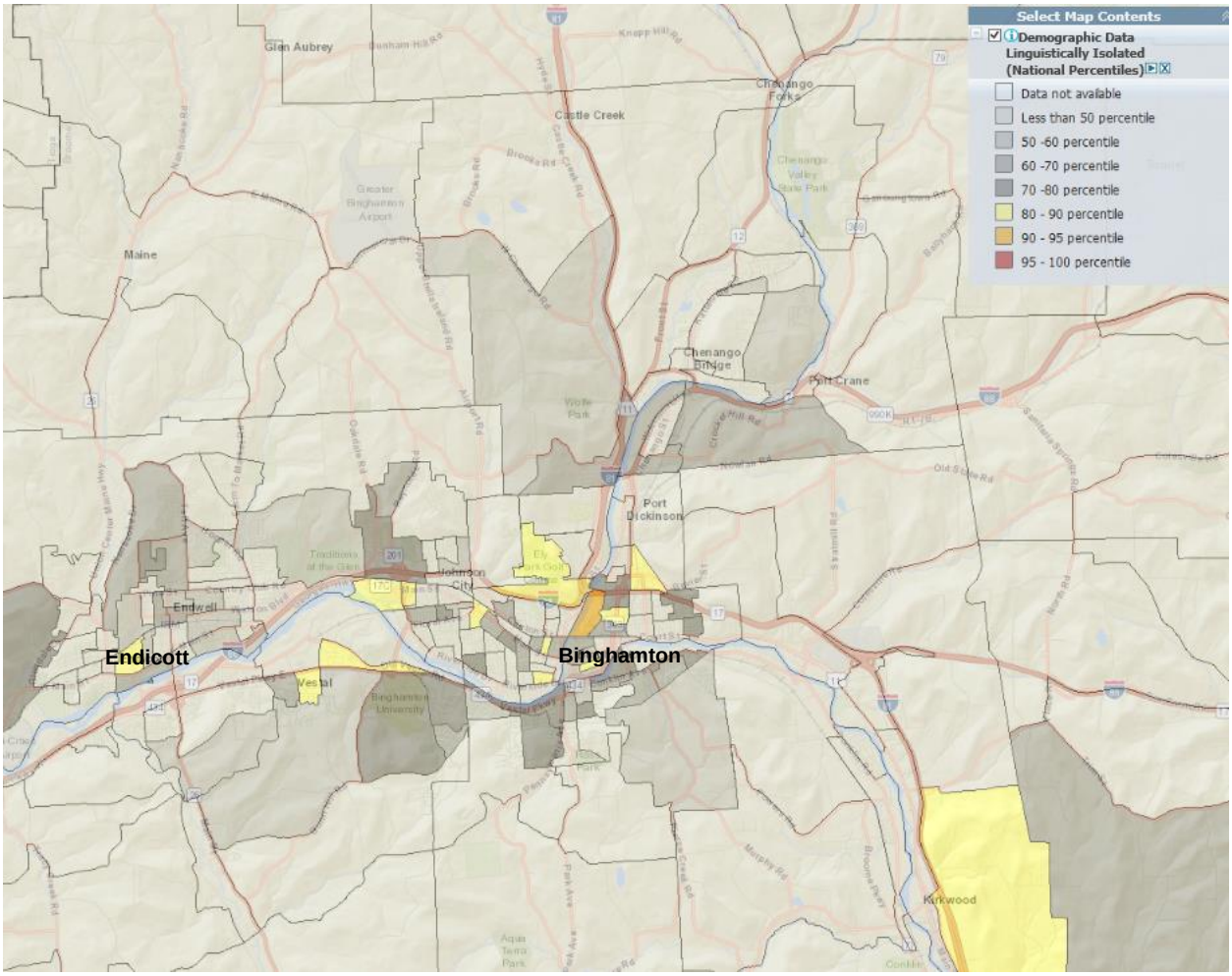
Figure 4 Low Income Population



Source: EPA

The study area is not particularly linguistically isolated but there are a few areas with elevated vulnerability in Binghamton, Endicott, and Kirkwood.

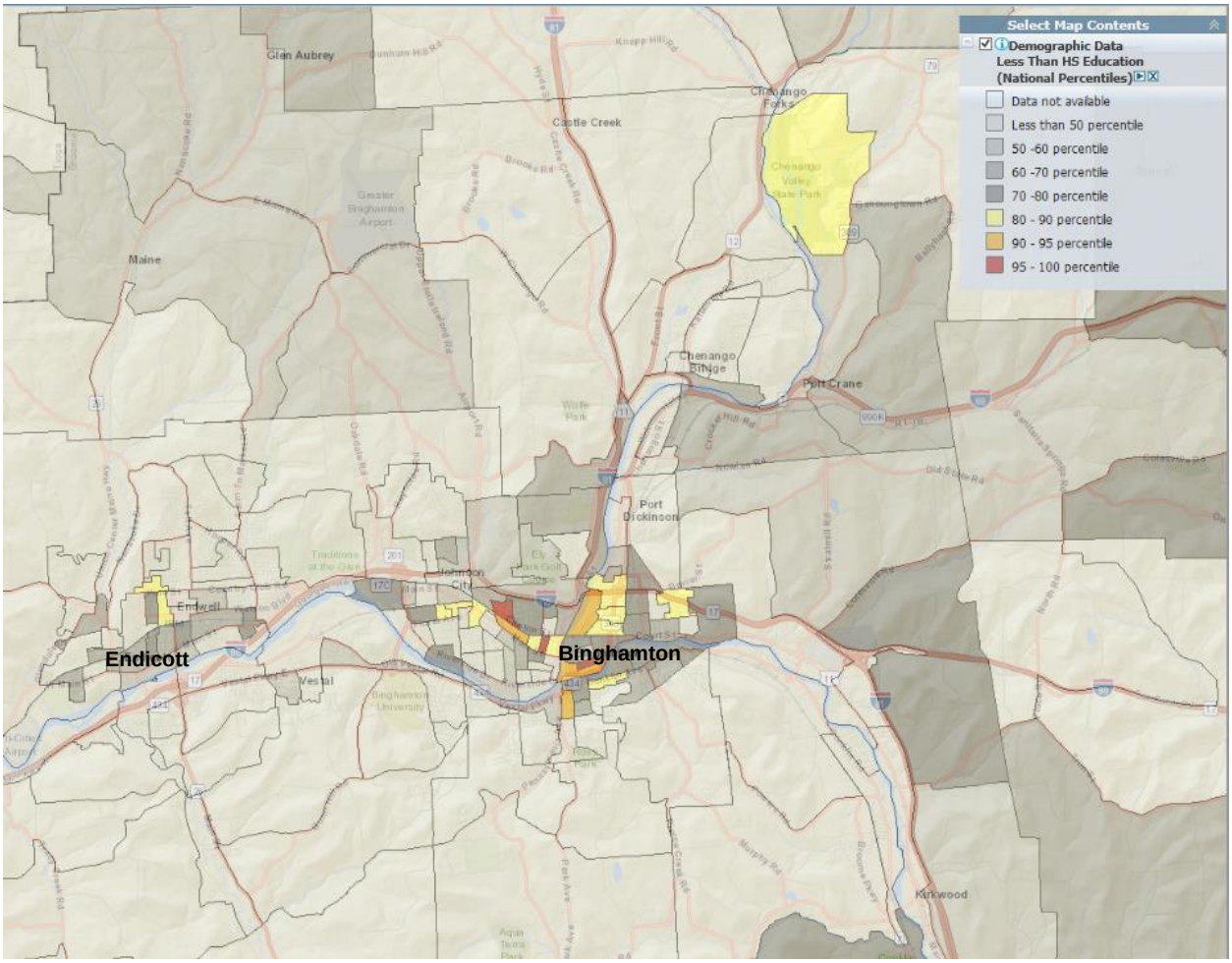
Figure 5 Linguistically Isolated



Source: EPA

Educational attainment is diverse in the region, especially with the presence of colleges including Binghamton University. However there are pockets of the population with higher levels of socially vulnerable populations with no high school graduation attainment. Areas include Binghamton, Endicott, and Chenango.

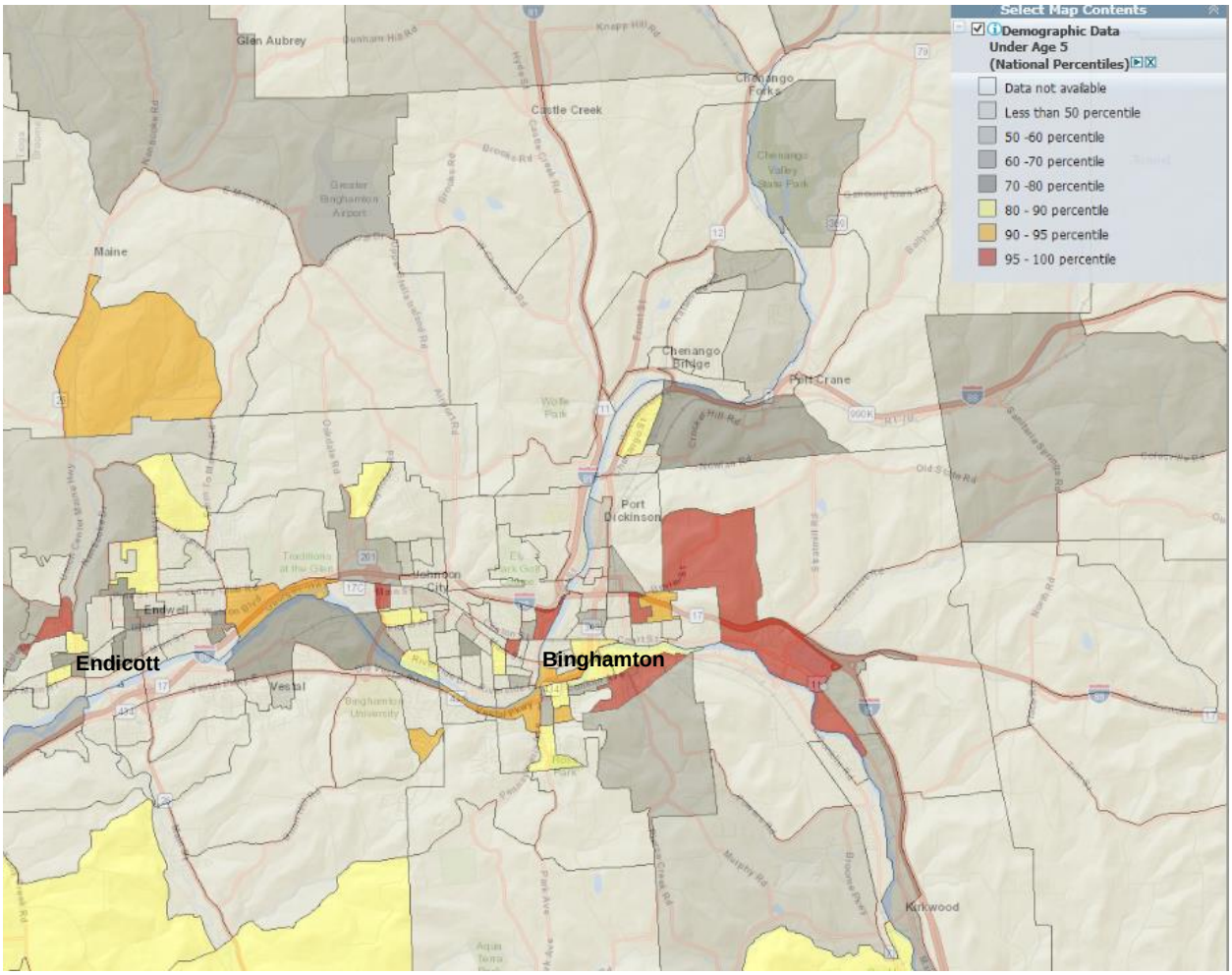
Figure 6 Less than High School Education



Source: EPA

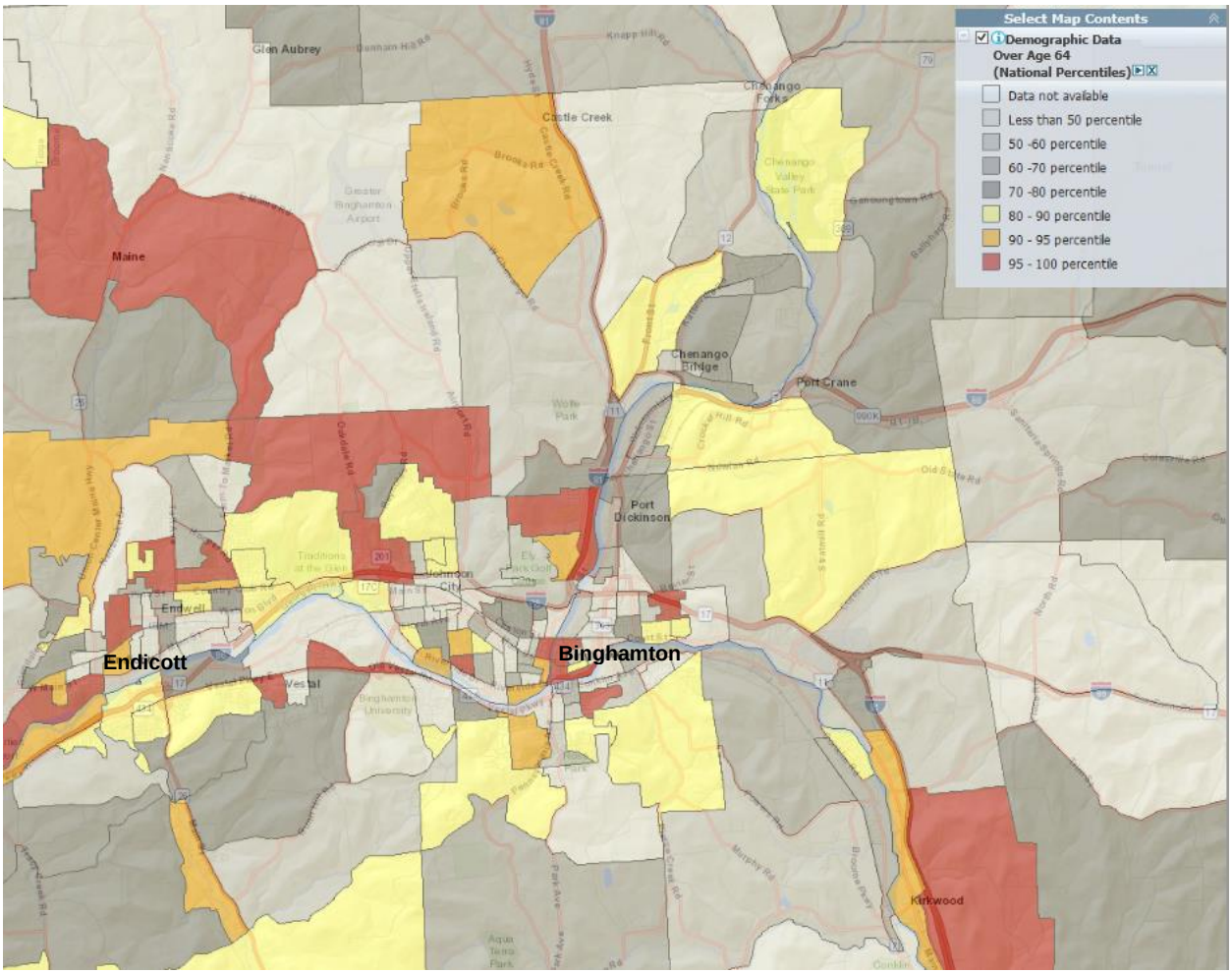
Age is an important indicator of social vulnerability. Those under the age of 5 and over the age of 65 are more likely to be vulnerable and dependent on the working age population. Figure 7 below shows the under age 5 population as a percentile of the nation. The study area is diverse. Figure 8 below exhibits the over age 65 population as a percentile of the nation. Many census blocks in Binghamton and the surrounding towns are socially vulnerable due to older populations.

Figure 7 Under Age 5



Source: EPA

Figure 8 Over age 65



Source: EPA

When evaluating the nonstructural solutions in the non-focus areas, social vulnerability was also evaluated in the table below displays social vulnerability statistics.

Table 12 Rest of Area Social Vulnerability

Damage Reach Name	% Below Poverty	% Unemployed	% over Age 65	% Disabled	% Age Under 17	% Minority	% Households with no vehicle	Comparison to state average (1=compatible to state average, <1=less socially vulnerable, >1=more socially vulnerable)
Bainbridge-1	21.2	5.6	17.2	N/A	28.4	4.6	N/A	1.09
Chenango-1	11.9	3.9	17.3	13.0	21.0	4.2	3.2	0.79
Greene-1	14.4	5.2	17.5	N/A	23.5	5.9	N/A	0.94
Greene-2	14.4	5.2	17.5	N/A	23.5	5.9	N/A	0.94
Norwich-1	23.9	4.4	18.6	17.2	24.3	6.3	16.2	1.19
Norwich-2	23.9	4.4	18.6	17.2	24.3	6.3	16.2	1.19
Norwich-3	23.9	4.4	18.6	17.2	24.3	6.3	16.2	1.19
Oneonta-1	19.5	4.4	10.4	10.1	10.5	16.2	14.4	0.89
Owego-1	17.3	5.0	15.8	15.3	19.9	10.7	15.3	1.07
Sidney-1	25.8	9.4	13.0	N/A	27.0	5.8	N/A	1.28
Unadilla-1	27.3	10.0	18.0	N/A	25.3	3.9	N/A	1.38
Waverly-1	20.9	7.9	18.3	20.1	21.3	5.2	10.0	1.22
Whitney Point-1	21.5	7.7	20.4	N/A	29.1	4.3	16.2	1.30
New York State Average	**15.1**	**3.9**	**14.7**	**11.1**	**21.5**	**43.6**	**10.8**	

3 STORM HISTORY

The Susquehanna River flooded 48 times from 1789 to July 2018. Table 12 below shows the ten most significant floods recorded.

Table 13 Top Ten Flood Events

Date	Crest (feet)	Streamflow (cfs)
March 3, 1902	22.94	449,000
September 27, 1975	23.82	529,000
September 19, 2004	24.40	557,000
March 18, 1865	24.60	573,000
January 20, 1996	25.08	568,000
September 9, 2011	25.17	590,000
May 22, 1894	25.70	613,000
June 2, 1889	26.80	654,000
March 19, 1936	29.23	740,000
June 24, 1972	33.27	1,020,000

Source: Hasco, 2018

A history of storm events and flooding that have impacted the USRB, specifically in the state of New York, is shown in Table 13 below.

Table 14 FEMA Disaster and Emergency Declarations, NY

Disaster Number	Date	Incident Description	Declaration Type
4397	8/13/2018	Severe Storms and Flooding	Major Disaster
4348	8/6/2017	Flooding	Major Disaster
4322	3/14/2017	Severe Winter Storm and Snowstorm	Major Disaster
4180	5/13/2014	Severe Storms and Flooding	Major Disaster
4129	6/26/2013	Severe Storms and Flooding	Major Disaster
3351, 4085	10/27/2012	Hurricane Sandy, Severe Storms and Flooding	Emergency Declaration, Major Disaster
3341, 4031	9/7/2011	Remnants of Tropical Storm Lee	Major Disaster
3328, 4020	8/25/2011	Hurricane Irene	Emergency Declaration, Major Disaster
1993	4/26/2011	Severe Storms, flooding, tornadoes, winds	Major Disaster
1899	3/13/2010	Severe Storms and Flooding	Major Disaster
1857	8/8/2009	Severe Storms and Flooding	Major Disaster
3299, 1827	12/11/2008	Severe Winter Storm	Emergency Declaration, Major Disaster
1710	6/19/2007	Severe Storms and Flooding	Major Disaster
1670	11/16/2006	Severe Storms and Flooding	Major Disaster
1650	6/26/2006	Severe Storms and Flooding	Major Disaster
3262	8/29/2005	Hurricane Katrina Evacuation	Emergency Declaration
1586	4/2/2005	Severe Storms and Flooding	Major Disaster
1565	9/16/2004	Tropical Depression Ivan	Major Disaster
1564	8/13/2004	Severe Storms and Flooding	Major Disaster
1534	5/13/2004	Severe Storms and Flooding	Major Disaster

Disaster Number	Date	Incident Description	Declaration Type
1486	7/21/2003	Severe Storms, Tornadoes and Flooding	Major Disaster
1467	4/3/2003	Ice Storm	Major Disaster
1335	5/3/2000	Severe Storms	Major Disaster
3149, 1296	9/16/1999	Hurricane Floyd	Emergency Declaration, Major Disaster
1233	6/25/1998	Severe Storms and Flooding	Major Disaster
1196	1/5/1998	Severe Winter Storms	Major Disaster
1148	11/8/1996	Severe Storms/Flooding	Major Disaster
1146	10/19/1996	Severe Storms/Flooding	Major Disaster
1095	1/19/1996	Severe Storms/Flooding	Major Disaster
1083	1/6/1996	Blizzard	Major Disaster
3107	3/13/1993	Severe Blizzard	Emergency Declaration
918	8/19/1991	Hurricane Bob	Major Disaster
898	3/3/1990	Severe Winter Storm	Major Disaster
801	10/4/1987	Severe Winter Storm	Major Disaster
792	4/3/1987	Flooding	Major Disaster
750	9/27/1985	Hurricane Gloria	Major Disaster
734	3/22/1985	Snow Melt, Ice Jams	Major Disaster
733	3/20/1985	Flooding	Major Disaster
725	9/25/1984	Severe Storms, Flooding	Major Disaster
520	9/3/1976	Hurricane Belle	Major Disaster
512	6/29/1976	Flash Flooding	Major Disaster
494	3/19/1976	Ice Storm, Severe Storms, Flooding	Major Disaster
487	10/2/1975	Severe Storms, Heavy Rain, Landslides, Flooding	Major Disaster
447	6/23/1974	Severe Storms, Flooding	Major Disaster
401	7/20/1973	Severe Storms, Flooding	Major Disaster
367	3/21/1973	High Winds, Wave Action, Flooding	Major Disaster
338	6/23/1972	Tropical Storm Agnes	Major Disaster
311	9/13/1971	Severe Storms, Flooding	Major Disaster
290	7/22/1970	Heavy Rains, Flooding	Major Disaster
275	8/26/1969	Heavy Rains, Flooding	Major Disaster
233	10/30/1967	Severe Storms, Flooding	Major Disaster
158	8/23/1963	Heavy Rains, Flooding	Major Disaster
129	3/16/1962	Severe Storm, High Tides, Flooding	Major Disaster
52	3/29/1956	Flood	Major Disaster
26	10/7/1954	Hurricanes	Major Disaster

Source: FEMA, Disasters

3.1 Recent Major Flood Events

2006 Flood Event

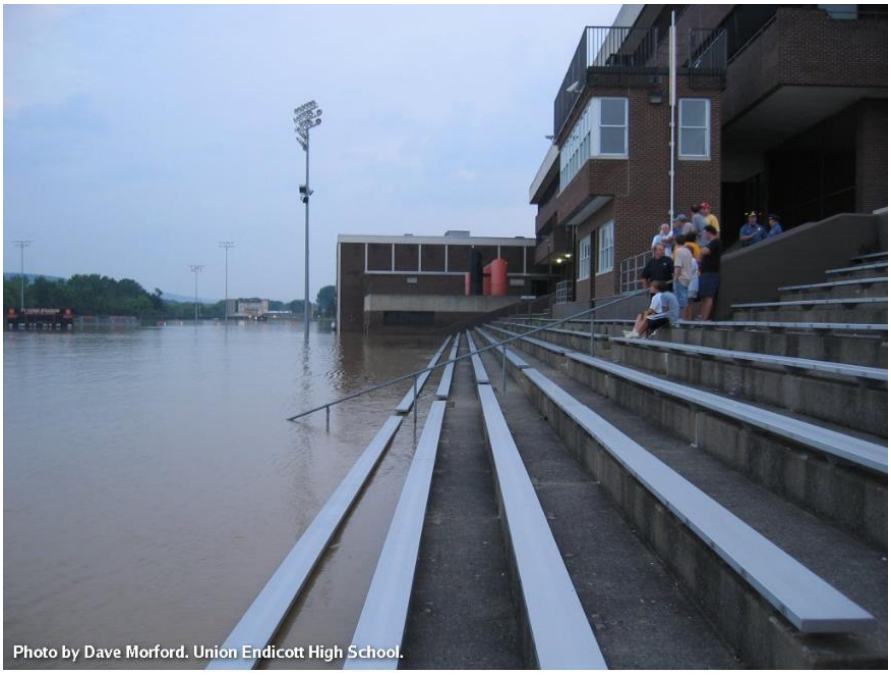
Between June 26 and June 28, sections of the USRB along with the Delaware and Chenango River Basins flooded. The flash floods were caused by a combination of tropical moisture and a stalled cold front (National Weather Service, 2006). The 2006 floods were greater than the 100-year flood and in some areas exceeded the 500-year flood (SRBC, 2007). Twelve counties were declared Federal disaster areas in New York. More than 15,500 residents applied for disaster assistance and more than $227 million was awarded to individuals and businesses impacted by the floods (Suro, Firda, Szabo, 2009).

Figure 9 2006 Floods

Source: National Weather Service

Source: National Weather Service

Binghamton along the Chenango River, 2006 Source: National Weather Service



Source: National Weather Service

2011 Flood Events

Heavy flooding was experienced between September 7 and 8, 2011 caused by remnants of Tropical Storm Lee interacting with a frontal system to the west as well as additional moisture being drawn into New York and Pennsylvania from Hurricane Katia. Rainfall of 6-12 inches fell over most of the USRB. The flooding claimed 1 life, injured another, and caused nearly $1 billion in damages (National Weather Service, 2011).

Figure 10 2011 Flooding in Johnson City destroyed the BAE system facility pictured here

Source: National Weather Service

Source: National Weather Service

Source: National Weather Service

Source: National Weather Service

4 EXISTING CONDITIONS

Under the existing conditions, the USRB in New York is subject to residual risk of flooding damages caused by storms. Current FRM projects provide risk reduction from substantial flooding but residual damages continue to occur in the region. Damages include destruction of buildings as well as damages to roads and utilities. Homeowners and businesses make individual efforts to repair damages after each storm event.

5 FUTURE WITHOUT-PROJECT CONDITIONS

The future without project conditions serves as the baseline to use as a comparison for alternatives. In the absence of a Federal project, homeowners and businesses will continue individual efforts to repair damages after flooding events, using emergency funding or personal resources when available. The future without-project conditions within the period of analysis is identified as continued damages to floodplain structures and property from future storm events.

No future growth or development in the study area was projected for this analysis, therefore structure inventory and values were kept the same as those under the existing conditions. With stagnant or declining population in the region, there is likely to be limited additional future development.

Hydrologic and hydraulic data are not expected to change in the future condition. Therefore, given that the water surface profile used in the economic analysis remains constant and the structure inventory did not change over time, the existing and future conditions are the same and annual damages are consistent across years.

6 ECONOMIC ANALYSIS METHODS

A Federal project is considered economically justified if the benefits of the project equal or exceed the costs. The economic benefits of a FRM project are measured by the degree to which the project reduces expected annual storm damages. Damages in the without- and future with-project conditions were calculated using the USACE flood damage analysis tool, HEC-FDA (Hydrologic Engineering Center – Flood Damage Analysis).

6.1 HEC-FDA

The USACE flood damage analysis tool, HEC-FDA Version 1.4.2, was used to model all inundation damages. The HEC-FDA analysis incorporated inputs that include the project reaches, the depreciated replacement costs and content values, and the use of

appropriate stage-damage functions. The project reaches describes how the structures are grouped and analyzed according to town, presence or absence of existing projects, and consistent hydrologic/hydraulic profile. The depreciated replacement cost is the cost to replace the existing structure according to structure type, condition, and age. RSMeans was used to calculate the depreciated replacement value of each structure. The content value is the value of contents within the structure and is calculated as a percentage of the depreciated replacement cost. Finally, stage-damage functions calculate the percent damage to structures and content based on the stage height (ie. water depth).

6.2 Delineation of Project Reaches

The study area was divided into three areas for economic analysis: Binghamton area, Endicott-Johnson City-Vestal (EJV), and a non-structural analysis of other towns in the watershed. The reaches were determined by the presence or absence of existing projects, municipality (to make for an easier review of town or village cost) and are consistent with hydrologic/hydraulic modeling. A summary of the economic reaches is presented in Table 14 through Table 16.

Table 15 Summary of Economic Reaches – Binghamton Area

Damage Reach Name	Stream Name	Beginning Station	Ending Station	Bank	Index Location Station	Description
Binghamton-1	Chenango River	513	4632	Right	2000	Binghamton-1 Chenango Unprotected
Binghamton-10	Susquehanna River	253543	258223	Right	256336	Binghamton-10 Susquehanna River protected
Binghamton-11	Susquehanna River	255474	257230	Left	256826	Binghamton-11 Susquehanna River protected
Binghamton-12	Susquehanna River	258657	262117	Right	260361	Binghamton-12 Susquehanna River protected
Binghamton-13	Susquehanna River	259962	265569	Right	262895	Binghamton-13 Susquehanna River protected
Binghamton-14	Susquehanna River	261782	265240	Left	264854	Binghamton-14 Susquehanna River unprotected
Binghamton-15	Susquehanna River	265569	266607	Right	265837	Binghamton-15 Susquehanna River unprotected
Binghamton-16	Susquehanna River	265240	268540	Left	268540	Binghamton-16 Susquehanna River unprotected
Binghamton-2	Chenango River	513	11257	Right	8500	Binghamton - 2 Chenango protected
Binghamton-3	Susquehanna River	257230	262117	Left	260559	Binghamton-3 Susquehanna River unprotected
Binghamton-4	Pierce Creek	480	1975	Both	1453	Binghamton-4 Pierce Creek unprotected
Binghamton-5	Chenango River	4632	8000	Right	5239	Binghamton - 5 Chenango protected
Binghamton-6	Chenango River	10000	14137	Left	11853	Binghamton-6 Chenango unprotected
Binghamton-7	Susquehanna River	243148	252935	Right	249000	Binghamton-7 Susquehanna River unprotected
Binghamton-8	Susquehanna River	250521	252935	Left	251939	Binghamton-8 Susquehanna River protected
Binghamton-9	Susquehanna River	250521	255760	Left	252537	Binghamton-9 Susquehanna River protected
Chenango-2	Chenango River	19207	30500	Right	26500	Chenango-2 Chenango Unprotected
Conklin-1	Susquehanna River	305503	310297	Left	306760	Conklin-1 Susquehanna Unprotected
Conklin-2	Susquehanna River	283916	310999	Left	292322	Conklin-2 Susquehanna Unprotected
Conklin-3	Susquehanna River	268853	283387	Left	274329	Conklin-3 Susquehanna Unprotected
Dickinson-1	Chenango River	8000	19207	Right	13500	Dickinson-1 Chenango Unprotected
Kirkwood-1	Susquehanna River	266607	324767	Right	296060	Kirkwood-1 Susquehanna Unprotected
Port Dickinson-1	Chenango River	10000	14137	Left	13500	Port Dickinson-1 Chenango River Unprotected
Port Dickinson-2	Chenango River	14137	17500	Left	16500	Port Dickinson-2 Chenango River Protected
Port Dickinson-3	Chenango River	17000	19589	Left	18500	Port Dickinson-3 Chenango River Protected

Figure 11 Binghamton Area Reaches

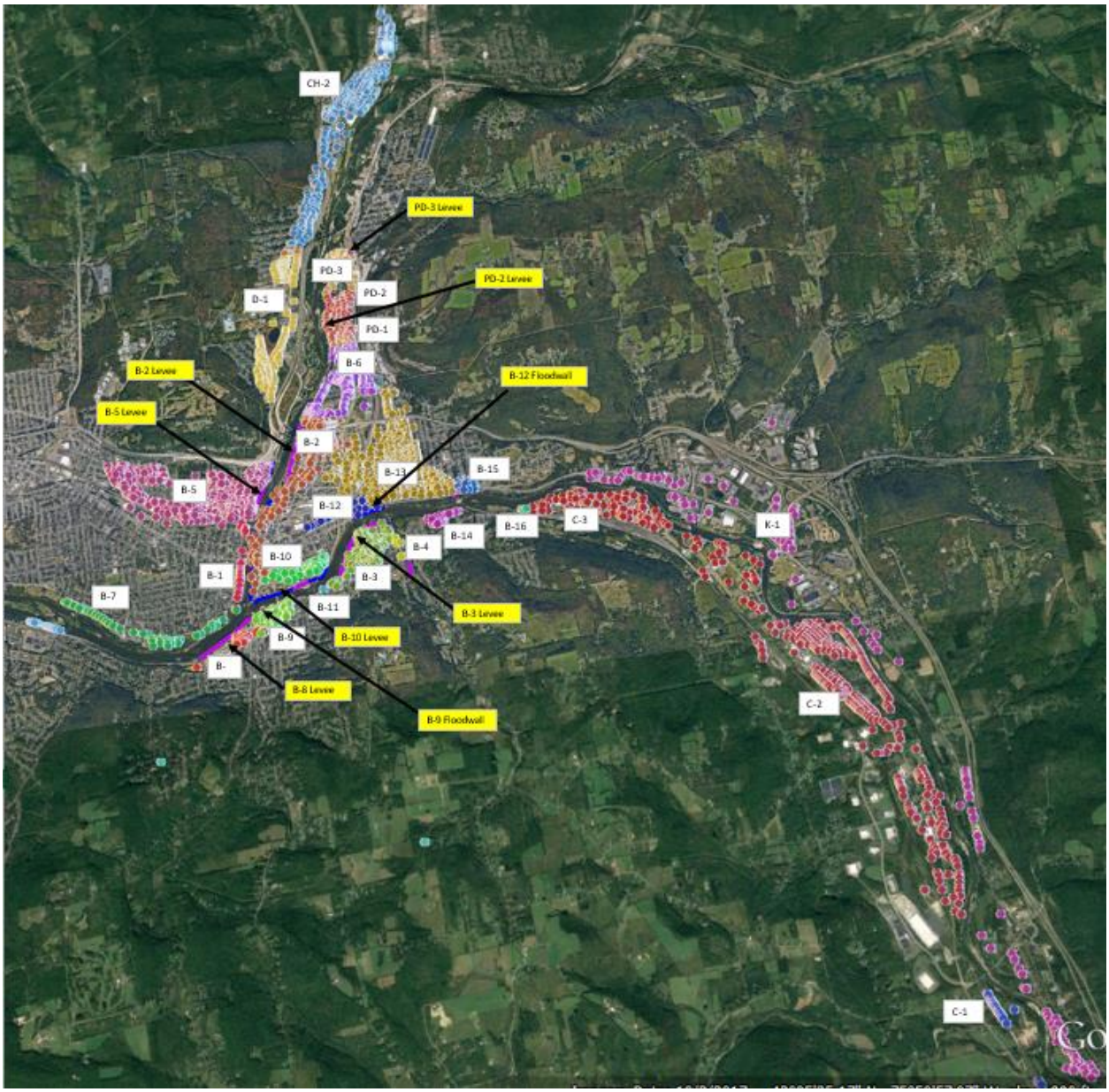


Table 16 Summary of Economic Reaches – Endicott, Johnson City, Vestal

Damage Reach Name	Stream Name	Beginning Station	Ending Station	Bank	Index Location Station	Description
Endicott-1	Nanticoke Creek	900	2822	Left	1500	Endicott-1 Nanticoke unprotected
Endicott-2	Nanticoke Creek	9300	12900	Left	10157	Endicott-2 Nanticoke protected
Endicott-3	Nanticoke Creek	12900	12900	Right	12900	Endicott-3 Nanticoke unprotected

Damage Reach Name	Stream Name	Beginning Station	Ending Station	Bank	Index Location Station	Description
Endicott-4	Susquehanna River	199557	204291	Right	200500	Endicott-4 Susquehanna unprotected
Endicott-5	Susquehanna River	201631	211000	Right	207476	Endicott-5 Susquehanna protected
Endicott-6	Susquehanna River	210423	227714	Right	211421	Endicott-6 Susquehanna unprotected
Johnson City-1	Little Choconut	2400	12900	Both	3296	Johnson City-1 Little Choconut unprotected
Johnson City-2	Little Choconut	4483	4801	Right	4801	Johnson City-2 Little Choconut protected
Johnson City-3	Susquehanna River	235007	237500	Right	236944	Johnson City-3 Susquehanna unprotected
Maine-1	Nanticoke Creek	34800	35700	Right	34800	Maine-1 Nanticoke Creek unprotected
Owego-1	Susquehanna River	149222	186350	Left	161584	Owego-1 Susquehanna unprotected
Owego-2	Susquehanna River	150533	198355	Right	170141	Owego-2 Susquehanna unprotected
Union-1	Little Choconut	648	4801	Right	1041	Union-1 Little Choconut protected
Union-2	Little Choconut	1800	4155	Right	2400	Union-2 Little Choconut unprotected
Union-3	Nanticoke Creek	2400	12600	Left	8284	Union-3 Nanticoke protected
Union-4	Nanticoke Creek	3336	13298	Right	7500	Union-4 Nanticoke unprotected
Union-5	Nanticoke Creek	21000	33300	Left	28800	Union-5 Nanticoke unprotected
Union-6	Susquehanna River	190104	190104	Right	190104	Union-6 Susquehanna unprotected
Union-7	Susquehanna River	199557	204291	Right	201232	Union-7 Susquehanna unprotected
Union-8	Susquehanna River	214000	225558	Right	220000	Union-8 Susquehanna unprotected
Union-9	Susquehanna River	227714	229997	Right	228827	Union-9 Susquehanna protected
Union-10	Susquehanna River	22997	230370	Right	230370	Union-10 Susquehanna unprotected
Union-11	Susquehanna River	232320	232320	Right	232320	Union-11 Susquehanna unprotected
Union-12	Susquehanna River	233192	232320	Right	233384	Union-12 Susquehanna unprotected
Union-13	Nanticoke Creek	13389	16645	Right	14400	Union-13 Susquehanna protected
Union-14	Nanticoke Creek	18000	32714	Right	25200	Union-14 Susquehanna unprotected
Vestal-1	Susquehanna River	192759	204291	Left	196549	Vestal-1 Susquehanna unprotected
Vestal-2	Susquehanna River	199557	203680	Left	200187	Vestal-2 Susquehanna unprotected
Vestal-3	Susquehanna River	199557	210423	Left	206458	Vestal-3 Susquehanna protected

Damage Reach Name	Stream Name	Beginning Station	Ending Station	Bank	Index Location Station	Description
Vestal-4	Susquehanna River	210423	215409	Left	212350	Vestal-4 Susquehanna unprotected
Vestal-5	Susquehanna River	214000	219062	Left	217995	Vestal-5 Susquehanna protected
Vestal-6	Susquehanna River	219062	242036	Left	220000	Vestal-6 Susquehanna unprotected
Vestal-7	Susquehanna River	233697	239966	Left	238072	Vestal-7 Susquehanna unprotected
Vestal-8	Susquehanna River	242036	250040	Left	243148	Vestal-8 Susquehanna unprotected

Figure 12 EJV Area Reaches

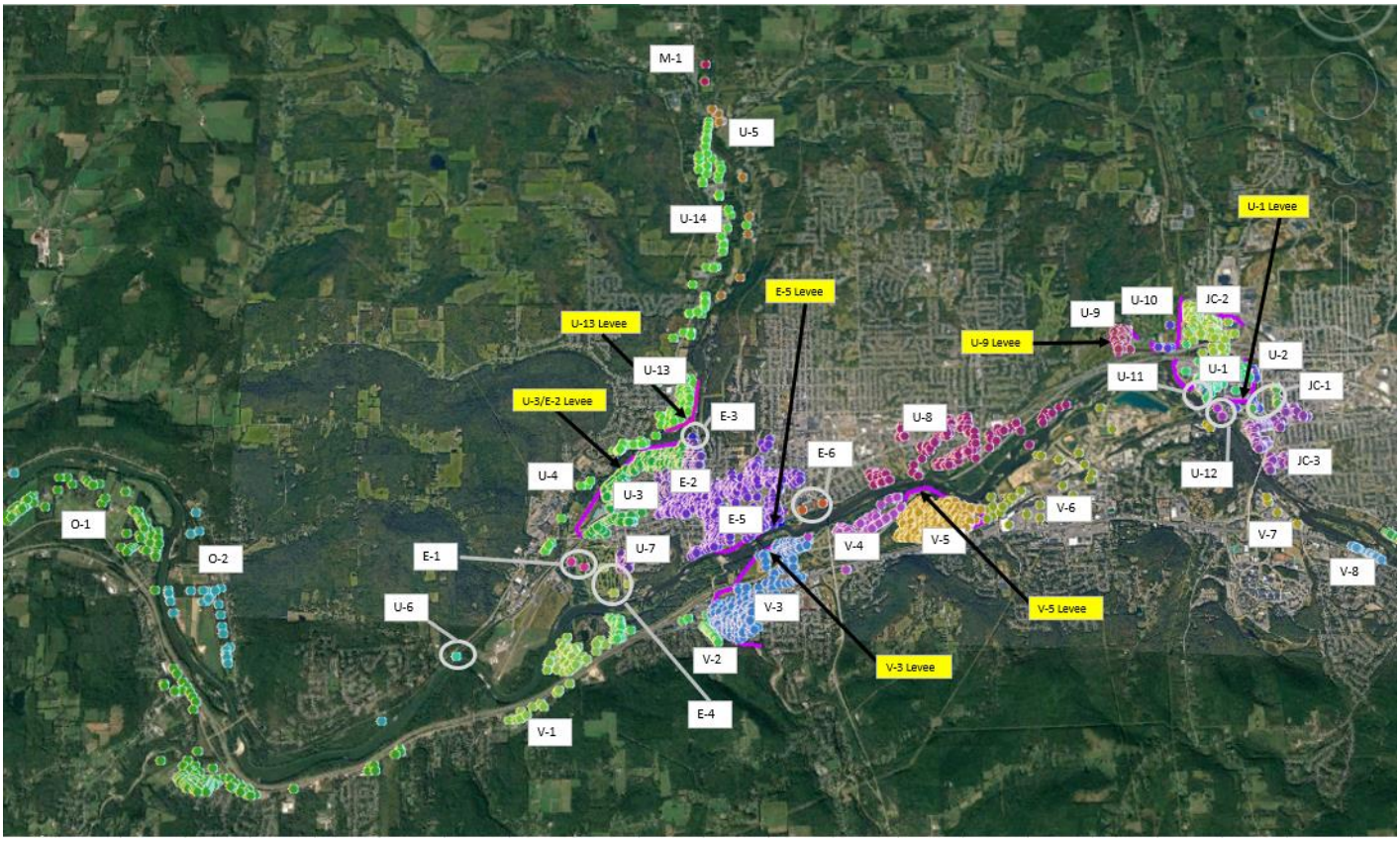
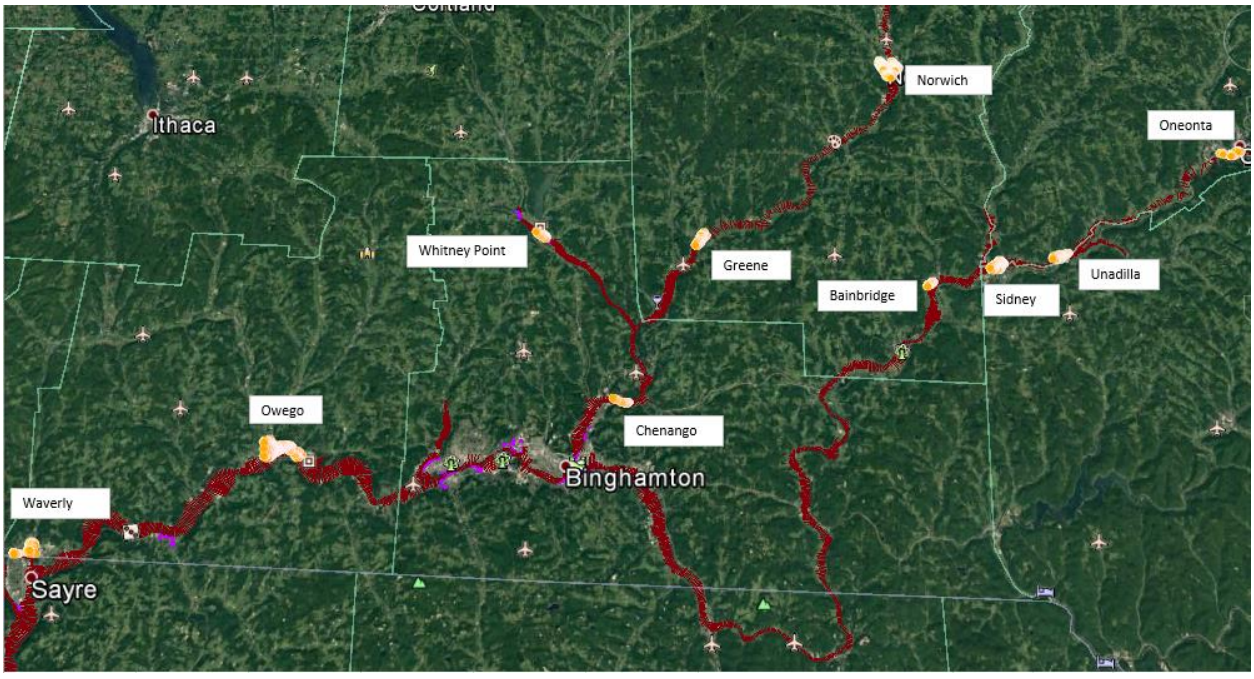


Table 17 Summary of Economic Reaches – Rest of Focus Area

Damage Reach Name	Stream Name	Beginning Station	Ending Station	Bank	Index Location Station	Description
Bainbridge-1	Susquehanna River	577946	581074	Right	580234	Bainbridge-1 SusquehannaRV Unprotected
Chenango-1	Chenango River	34000	40000	Right	38000	Chenango-1 Chenango Unprotected
Greene-1	Chenango River	117000	123741	Left	119396	Greene-1 Chenango Unprotected
Greene-2	Chenango River	117000	123741	Right	119396	Greene-2 Chenango Unprotected
Norwich-1	Chenango River	263826	270078	Right	267050	Norwich-1 Chenango Unprotected
Norwich-2	Chenango River	259776	262262	Right	261706	Norwich-2 Chenango Unprotected
Norwich-3	Chenango River	262262	276573	Right	268935	Norwich-3 Chenango Unprotected
Oneonta-1	Susquehanna River	734557	743524	Right	739819	Oneonta-1 Susquehanna Protected by non-fed project
Owego-1	Susquehanna River	127203	138721	Right	132204	Owego-1 Susquehanna Unprotected
Sidney-1	Susquehanna River	606668	613060	Left	609861	Sidney-1 Susquehanna Unprotected
Unadilla-1	Susquehanna River	6342094	642094	Right	639036	Unadilla-1 Susquehanna Unprotected
Waverly-1	Cayuta Creek	10150	14669	Both	13621	Waverly-1 Cayuta Creek Unprotected
Whitney Point-1	Tioughnioga River	50574	55903	Right	52239	Whitney Point-1 Tioughnioga Protected

Figure 13 Rest of Area Reaches



6.3 Inundation Damage Functions

The computation of annual flood damages in this analysis is based on the application of depth-damage functions to structures and their contents during flood events of different annual exceedence probabilities. The depth-damage functions used for this study were the generic depth-damage functions for residential structures developed for use in USACE in 2000 and 2003, and the depth-damage functions for non-residential structures that were developed by USACE specifically for the Passaic River Basin flood damage reduction study during the 1980s. These functions were deemed appropriate for the analysis since they were developed for structurally-similar buildings in New York and New Jersey, which are anticipated to result in similar flood stage-damage associations.

Damage functions for single-family residential structures (and two- or multi-family structures with similar physical characteristics) without basements were applied in accordance with: *Economic Guidance Memorandum (EGM) 01-03, "Generic Depth-Damage Relationships", December 4, 2000.* Damage functions for single-family residential structures (and two- or multi-family structures with similar physical characteristics) with basements were applied in accordance with: *Economic Guidance Memorandum (EGM) 01-04, "Generic Depth-Damage Relationships for Residential Structures with Basements", October 10, 2003*. Passaic River Basin Damage functions for non-residential structures (plus apartment buildings and large multi-family structures) were applied in accordance with previous experience with similar flood risk reduction projects in northern New Jersey.

Contents of residential structures are valued at 50 percent of the structure value, divided by the number of stories, and is based on insurance industry averages cited in *IWR Report 93-R-7, "Guidelines to Estimating Existing Future Residential Content Values", June 1993*. Nonresidential structure contents are determined using the ratios described in *IWR Report 96-R-12, "Analysis of Nonresidential Content Value and Depth-Damage Data for Flood Damage Reduction Studies", May 1996.* Nonresidential structures are categorized by the type of business or building type and the corresponding content value to structure value is utilized in the analysis. The non-focus study area utilized a simplified method of multiplying the residential structure values by 0.32 to calculate the content value and multiplying the nonresidential structure values by 1.24 to calculate the content value. The ratios were determined by averaging known values in the Binghamton and EJV study areas.

6.4 Structure Inventory

Collection on Parcel Data

Data for this analysis was collected for ten 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 2015 county property appraiser's parcel centroids.

The structure inventory for the watershed study was 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 depreciated replacement value calculations for residential and nonresidential properties.

The structure inventory was compiled using geospatial data available from each county's GIS Portal. All processing was done with ArcGIS 10.4.1 using NY Central State Plane NAD 83 (US feet) for the horizontal datum and NAVD88 (US feet) as the vertical datum.

First Floor Elevation

Structures were viewed using Google Earth and Google Street View to estimate the first floor elevation relative to the ground elevation. Due to the large number of structures in the full inventory, assumptions were made for streets and blocks with similar structures. During the preliminary nonstructural analysis, general assumptions of 2.5 feet above ground elevation residential structures and zero feet above ground elevation for nonresidential structures were used to set first floor elevations.

Depreciated Replacement

County parcel data provided a wide number of characteristics for the structures including but not limited to the number of stories, square footage, building usage, year built, and presence of a basement. This data was used to calculate a depreciated replacement value using *"Square Foot Costs with RSMeans Data 2017"* for the Binghamton and Endicott-Johnson City-Vestal.

Using averages of the depreciated replacement values determined by RSMeans for Binghamton and EJV, the "rest of the area" structures used a calculation of 0.7 multiplied by the market value of residential structures and 0.9 times nonresidential structures for the initial analysis.

Summary of Structure Types and Values

A total of 11,276 structures were evaluated for the structure inventory of which 4,629 are in the Binghamton area, 3,518 are in the Endicott-Johnson City-Vestal area, and another 3,129 structures were evaluated on a preliminary analysis for nonstructural review. The structure inventory is 79 percent residential.

The Binghamton analysis area includes structures in Binghamton, Chenango, Conklin, Dickinson, Kirkwood, and Port Dickinson. Table 17 below summarizes the breakout of structure type and value.

Table 18 Binghamton Area Structure Inventory

	Number Structures	Total Depreciated Replacement (000)	Average Depreciated Replacement (000)	Total Content Value (000)	Total Value (000)
Residential - 1 Story No Basement	180	$16,355	$91	$8,177	$24,532
Residential - 2 Story No Basement	124	$14,696	$119	$3,852	$18,548
Residential - 1 Story With Basement	556	$54,792	$99	$27,394	$82,186
Residential - 2 Story With Basement	2,706	$299,032	$111	$78,229	$377,261
Residential - Split Level With Basement	25	$4,020	$161	$1,966	$5,986
Total Residential	**3,591**	**$388,895**	**$108**	**$119,618**	**$508,513**
Apartments	146	$111,237	$762	$15,825	$127,062
Commercial	367	$320,100	$872	$284,448	$604,548
Factory/Warehouse	201	$228,168	$1,135	$836,660	$1,064,828
Institutional	63	$135,573	$2,152	$61,486	$197,059
Office	136	$194,032	$1,427	$80,409	$274,441
Other*	125	$11,822	$95	$6,049	$17,871
Total Nonresidential	**1,038**	**$1,000,932**	**$964**	**$1,269,052**	**$2,269,984**
Total All Structures	**4,629**	**$1,389,827**	**$300**	**$1,388,670**	**$2,778,497**

* Other includes small post barn structures, parking garages with zero damages, and other unique structures not otherwise categorized

The Endicott-Johnson City-Vestal analysis area includes structures located in Endicott, Johnson City, Maine, Owego, Union, and Vestal. Table 18 below summarizes the structure types and values.

Table 19 EJV Area Structure Inventory

	Number Structures	Total Depreciated Replacement (000)	Average Depreciated Replacement (000)	Total Content Value (000)	Total Value (000)
Residential - 1 Story No Basement	137	$11,699	$85	$5,850	$17,549
Residential - 2 Story No Basement	46	$5,730	$125	$1,508	$7,238
Residential - 1 Story With Basement	628	$61,647	$98	$30,824	$92,471
Residential - 2 Story With Basement	2,072	$219,889	$106	$60,079	$279,968
Residential - Split Level With Basement	14	$1,709	$122	$856	$2,565
Total Residential	**2,897**	**$300,674**	**$104**	**$99,117**	**$399,791**
Apartments	115	$57,297	$498	$11,046	$68,343
Commercial	214	$218,515	$1,021	$277,788	$496,303
Factory/Warehouse	128	$112,076	$876	$434,701	$546,777
Institutional	36	$33,884	$941	$18,686	$52,570
Office	62	$38,031	$613	$22,303	$60,334
Other*	66	$1,793	$27	$878	$2,671
Total Nonresidential	**621**	**461,596**	**$743**	**$754,356**	$1,215,952
Total All Structures	**3,518**	**$762,270**	**$217**	**$853,473**	**$1,615,743**

* Other includes small post barn structures, parking garages with zero damages, and other unique structures not otherwise categorized

Nonstructural analysis focused on the areas of Bainbridge, Chenango, Greene, Norwich, Oneonta, Owego, Sidney, Unadilla, Waverly and Whitney Point. Estimates using average ratios of Binghamton and EJV areas were used to calculate this area of analysis. A summary of the structures is below in Table 19.

Table 20 Rest of Area Structure Inventory

	Number Structures	Total Depreciated Replacement (000)	Average Depreciated Replacement (000)	Total Content Value (000)	Total Value (000)
Bainbridge					
Residential	47	$5,937	$126	$1,900	$7,837
Nonresidential	15	$2,854	$190	$3,540	$6,394
Chenango					
Residential	38	$7,060	$186	$2,259	$9,319
Nonresidential	1	$109	$109	$135	$244
Greene					
Residential	109	$14,596	$134	$4,655	$19,251
Nonresidential	21	$4,890	$233	$6,076	$10,966
Norwich					
Residential	741	$71,893	$97	$23,006	$94,899
Nonresidential	99	$44,934	$454	$55,048	$99,982
Oneonta					
Residential	163	$23,771	$146	$7,607	$31,378
Nonresidential	25	$17,999	$720	$22,319	$40,318
Owego					
Residential	626	$67,644	$108	$21,646	$89,290
Nonresidential	260	$99,973	$385	$123,967	$223,940
Sidney					
Residential	373	$32,813	$88	$10,500	$43,313
Nonresidential	128	$41,831	$327	$51,871	$93,702
Unadilla					
Residential	222	$31,231	$141	$9,994	$41,225
Nonresidential	52	$13,662	$263	$16,941	$30,603
Waverly					
Residential	68	$7,153	$105	$2,289	$9,442
Nonresidential	44	$13,399	$305	$16,615	$30,014
Whitney Point					
Residential	70	$7,935	$113	$2,539	$10,474
Nonresidential	27	$6,854	$254	$8,499	$15,353
Total Structures	**3,129**	**$516,538**	**$165**	**$391,406**	**$907,944**

7 EVALUATION OF ALTERNATIVES

The feasibility study plan formulation considered a range of structural and nonstructural measures to reduce the risk of flood damage in the study areas. Through an iterative planning process, potential FRM measures were identified, evaluated, and compared. After a preliminary analysis and discussion with the local sponsors, there were two key areas of interest – Binghamton and Endicott-Vestal-Johnson City (EJV). Further details about the refinement of the focus array of alternatives is described in the *Upper Susquehanna River Basin Comprehensive FDR Feasibility Study Completion Report.* Cities and towns outside of the focus area were reviewed for further nonstructural analysis. A description of the economic evaluation of the Binghamton area, EJV, and the nonstructural analysis are described in the following sections.

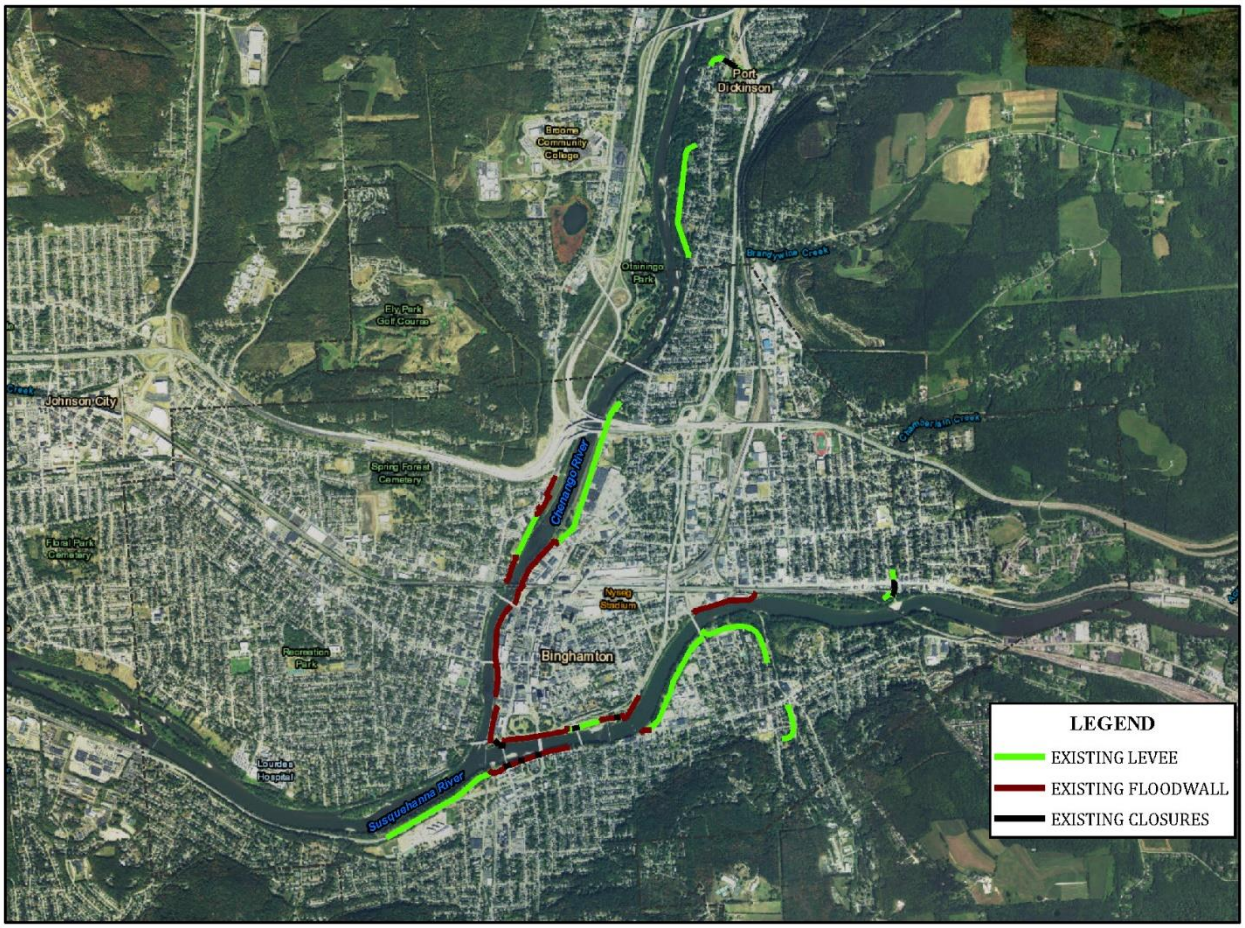
7.1 Binghamton Area

Existing Condition

The City of Binghamton and Village of Port Dickinson are currently protected by the existing Binghamton FRM project, originally authorized by the Flood Control Act of 1936, as amended in 1938. The Binghamton FRM project includes three separate levee systems that reduce risk from riverine flooding primarily from the Chenango River and the Susquehanna River. The Binghamton systems include Northeast Binghamton, Northwest Binghamton, and South Binghamton. The flood risk area with the existing FRM projects are shown in Figure 14.

The Binghamton and Port Dickinson area are primarily affected by residual flood risk from infrequent, high intensity events which can overtop levees and floodwalls and overwhelm interior drainage pumps. The levees and floodwalls in the Binghamton FRM project have been identified as freeboard deficient since they do not meet current freeboard requirements. The point of overtopping in this system is at the confluence of the Chenango River and Susquehanna River, where coincident peaks can result in higher water surface elevations, and flooding areas behind the levee.

Figure 14 Binghamton Existing Flood Risk Management



Following the methodology described in section 6 *Economic Analysis Methods* HEC-FDA models were run to determine existing annual damages. Damages are summarized in Table 20.

Table 21 Binghamton Existing Damages

Damage Reach Name	Description	# Structures	Annual Damages ($000)	Annual Nonresidential Damages ($000)	Annual Residential Damages ($000)
Binghamton-1	Binghamton-1 Chenango Unprotected	25	188.67	185.27	3.40
Binghamton-2	Binghamton - 2 Chenango protected	253	1,399.80	1,373.04	26.76
Binghamton-3	Binghamton-3 SusquehannaRV unprotected	201	734.46	594.88	139.58
Binghamton-4	Binghamton-4 PierceCK unprotected	7	0.72	-	0.72
Binghamton-5	Binghamton - 5 Chenango protected	1003	1,540.21	1,023.88	516.33
Binghamton-6	Binghamton-6 Chenango unprotected	373	638.08	353.10	284.98
Binghamton-7	Binghamton-7 SusquehannaRV unprotected	58	585.98	73.55	512.43
Binghamton-8	Binghamton-8 SusquehannaRV protected	27	11.89	5.53	6.36
Binghamton-9	Binghamton-9 SusquehannaRV protected	74	136.31	120.81	15.50
Binghamton-10	Binghamton-10 SusquehannaRV protected	87	285.60	272.48	13.12
Binghamton-11	Binghamton-11 SusquehannaRV protected	2	32.99	32.99	-
Binghamton-12	Binghamton-12 SusquehannaRV protected	24	846.55	843.81	2.74
Binghamton-13	Binghamton-13 SusquehannaRV protected	837	1,861.51	1,624.70	236.81
Binghamton-14	Binghamton-14 SusquehannaRV unprotected	32	125.21	-	125.21
Binghamton-15	Binghamton-15 SusquehannaRV unprotected	35	289.98	283.03	6.95
Binghamton-16	Binghamton-16 SusquehannaRV unprotected	3	882.00	882.00	-
Chenango-2	Chenango-2 Chenango Unprotected	411	853.39	653.00	200.39
Conklin-1	Conklin-1 Susquehanna Unprotected	21	72.91	-	72.91
Conklin-2	Conklin-2 Susquehanna Unprotected	364	2,701.85	1,497.67	1,204.18
Conklin-3	Conklin-3 Susquehanna Unprotected	163	43,489.55	42,057.60	1,431.95
Dickinson-1	Dickinson-1 Chenango Unprotected	176	328.33	242.90	85.43
Kirkwood-1	Kirkwood-1 Susquehanna Unprotected	175	7,961.40	7,634.20	327.20
Port Dickinson-1	Port Dickinson-1 Chenango River Unprotected	41	29.26	4.57	24.69
Port Dickinson-2	Port Dickinson-2 Chenango River Protected	161	94.29	6.67	87.62
Port Dickinson-3	Port Dickinson-3 Chenango River Protected	76	65.62	40.98	24.64

Total annual damages in 2017 dollars is $65.2 million ($59.8 million in nonresidential damages and $5.4 million in residential damages). Development in the City of Binghamton is composed of a mix of residential, commercial, and industrial land uses with dense commercial development in Downtown Binghamton.

Binghamton Structural Alternatives

Increase Height of Existing Levee - the project delivery team developed conceptual designs for raising the height of existing levees and floodwalls in Binghamton to address flood risk reduction needs. Further information on the engineering methodology can be found in the Engineering Appendix. The resulting conceptual designs are shown in Figures Figure 15 through Figure 17.

Figure 15 Northeast Binghamton Proposed Raising Concept Design

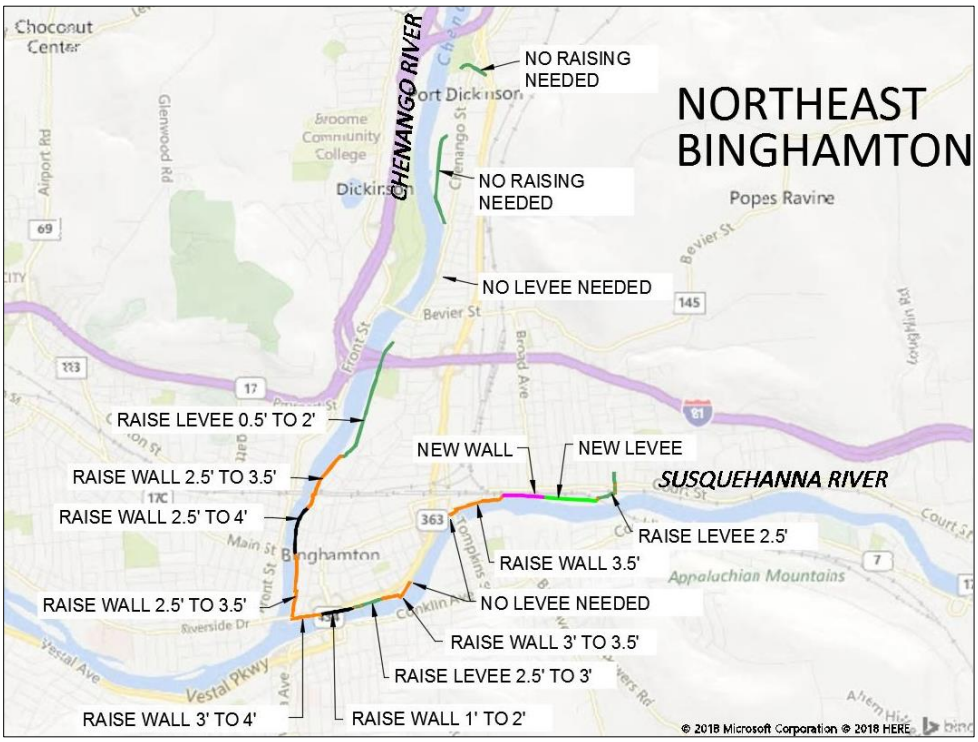


Figure 16 Northwest Binghamton Proposed Raising Concept Design

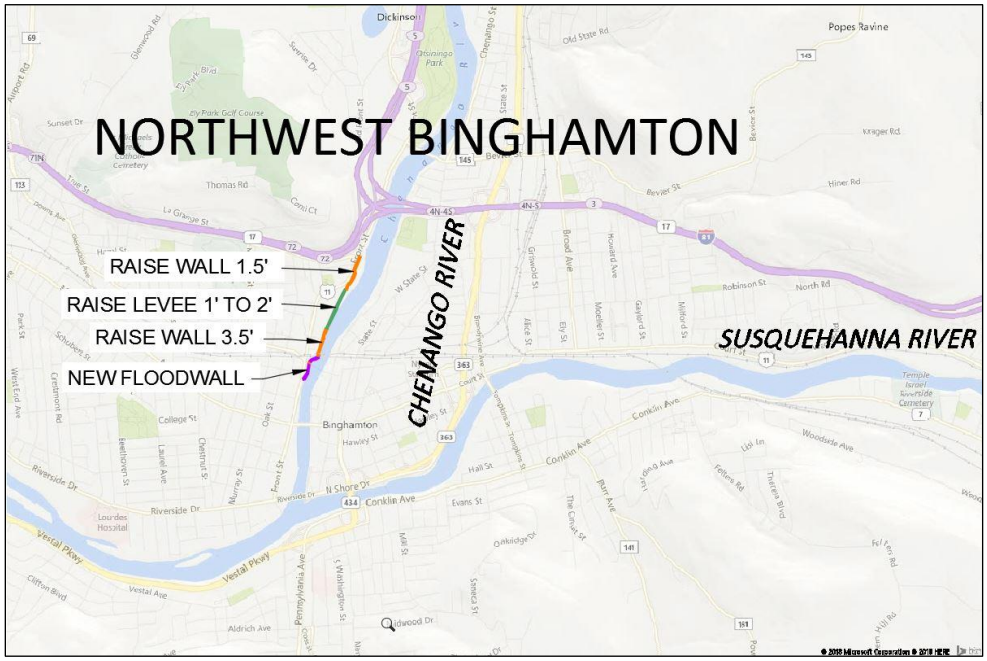
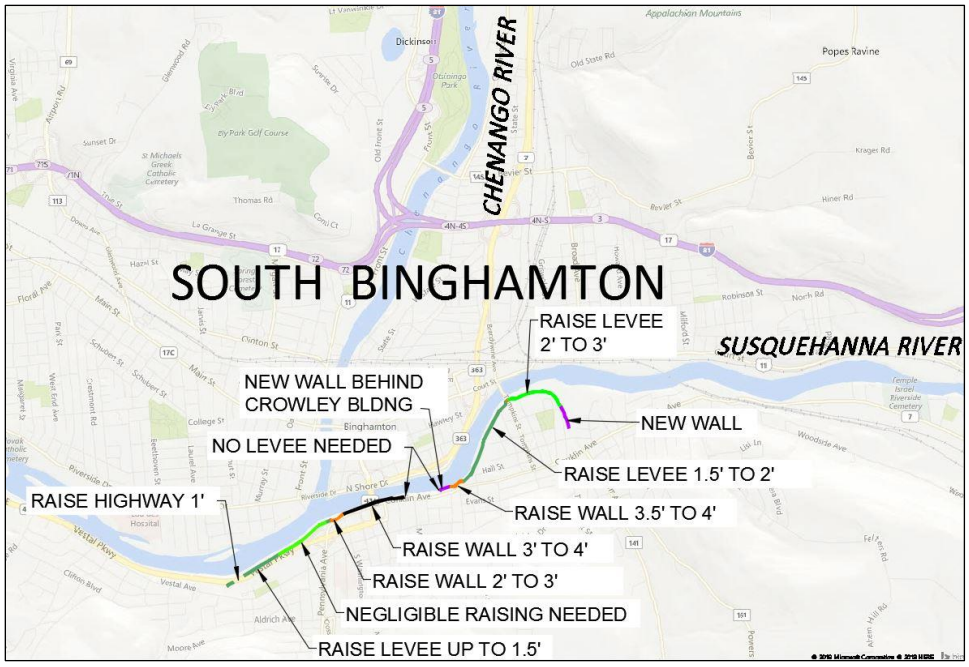


Figure 17 South Binghamton Proposed Raising Concept Design



The HEC-FDA model was rerun, using the same parameters as the existing run, however new levee heights were used that aligned with the proposed projects. The resulting benefits and residual damages are summarized in Table 21.

Table 22 Binghamton With-Project Damages

Damage Reach Name	Description	# Structures	With-Project Target Stage	Annual Residual Damages ($000)	Annual Nonresidential Residual Damages ($000)	Annual Residual Residential Damages ($000)	Annual Benefits ($000)
Binghamton-1	Binghamton-1 Chenango Unprotected	25	840.46	188.67	185.27	3.40	-
Binghamton-2	Binghamton - 2 Chenango protected	253	850.50	1,336.68	1,310.45	26.23	63.12
Binghamton-3	Binghamton-3 SusquehannaRV unprotected	201	852.30	399.63	317.83	81.80	334.83
Binghamton-4	Binghamton-4 PierceCK unprotected	7	852.50	0.72	-	0.72	-
Binghamton-5	Binghamton - 5 Chenango protected	1003	851.00	1,337.05	887.00	450.05	203.16
Binghamton-6	Binghamton-6 Chenango unprotected	373	843.01	638.08	353.10	284.98	-
Binghamton-7	Binghamton-7 SusquehannaRV unprotected	58	834.79	585.98	73.55	512.43	-
Binghamton-8	Binghamton-8 SusquehannaRV protected	27	846.90	9.19	4.35	4.84	2.70
Binghamton-9	Binghamton-9 SusquehannaRV protected	74	847.00	75.41	65.98	9.43	60.90
Binghamton-10	Binghamton-10 SusquehannaRV protected	87	851.00	239.48	228.64	10.84	46.12
Binghamton-11	Binghamton-11 SusquehannaRV protected	2	848.50	32.36	32.36	-	0.63
Binghamton-12	Binghamton-12 SusquehannaRV protected	24	853.50	255.90	254.47	1.43	590.65
Binghamton-13	Binghamton-13 SusquehannaRV protected	837	858.00	-	-	-	1,861.51
Binghamton-14	Binghamton-14 SusquehannaRV unprotected	32	845.61	125.21	-	125.21	-
Binghamton-15	Binghamton-15 SusquehannaRV unprotected	35	847.95	289.98	283.03	6.95	-
Binghamton-16	Binghamton-16 SusquehannaRV unprotected	3	847.82	882.00	882.00	-	-
Chenango-2	Chenango-2 Chenango Unprotected	411	851.31	853.39	653.00	200.39	-
Conklin-1	Conklin-1 Susquehanna Unprotected	21	856.00	72.91	-	72.91	-
Conklin-2	Conklin-2 Susquehanna Unprotected	364	852.39	2,701.85	35,086.30	6,580.30	-
Conklin-3	Conklin-3 Susquehanna Unprotected	163	848.50	43,489.55	86,093.26	5,713.74	-
Dickinson-1	Dickinson-1 Chenango Unprotected	176	844.40	328.33	242.90	85.43	-
Kirkwood-1	Kirkwood-1 Susquehanna Unprotected	175	853.57	7,961.40	7,634.20	327.20	-
Port Dickinson-1	Port Dickinson-1 Chenango River Unprotected	41	846.50	29.26	4.57	24.69	-
Port Dickinson-2	Port Dickinson-2 Chenango River Protected	161	853.50	94.29	5.95	78.77	-
Port Dickinson-3	Port Dickinson-3 Chenango River Protected	76	855.00	65.62	37.08	22.28	-

* Highlighted cells represent reaches where the levee protection was adjusted to incorporate the proposed project illustrated in Figures Figure 15-Figure 17.

To organize the benefits, the reaches impacted by the proposed project were combined for a total benefit per system. The reach Binghamton-5 equates to the Northwest Binghamton system. Binghamton-2, Binghamton-10, Binghamton-12, and Binghamton-13 are combined under the Northeast Binghamton system. Binghamton-8, Binghamton-9, Binghamton-11, and Binghamton-3 are combined under the South Binghamton system. Table 22 below summarizes the total benefits by system. The benefits were determined by calculating the damages reduced due to the proposed project i.e. total damages of the existing condition minus the residual damages in the with-project condition. It is important to note that in many areas the entire levee will need to be replaced in the proposed alternatives to provide additional protection. However, according to USACE federal regulations, only the incremental benefits of the additional protection are included in the benefits calculation.

Table 23 Summary of With-Project Benefits

	Impacted Reaches	Annual Benefits ($000)
Binghamton Northwest	Binghamton-5	203
Binghamton Northeast	Binghamton-2, 10, 12, 13	2,561
Binghamton South	Binghamton -8, 9, 11, 3	399

Cost Estimate

The project delivery team developed cost estimates for each of the three systems in Binghamton based on quantities developed from conceptual designs by the engineering team. Cost estimates were developed with and without pump station improvements for the proposed design but the computations for the with-pump alternatives were not included in this Appendix because calculations are not within the current authorization. Cost estimates do not include the costs of mitigating induced flood impacts at this stage of the analysis. Therefore, costs are considered conservatively low.

Alternative 2a: Refers to the structural solution described in the previous section with levees providing flood protection.

Alternative 2b: Provides the same benefits as Alternative 2a but floodwalls provide flood protection.

For more detail on the structural alternatives described, refer to Appendix C – Engineering.

Table 23 summarizes the costs. Costs were calculated in 2018 dollars. To accurately compare with the benefits as calculated in 2017 dollars, a price level factor (0.97) was used to deflate the costs to 2017 dollars. The price level factor is calculated as the average of the Engineering Construction Cost Index (CCI) and the Implicit Price Deflator (IPD).

Table 24 Summary of With-Project Costs

	Alternative 2a Total Cost ($000)	Alternative 2b Total Cost ($000)
2018 Dollars		
Binghamton Northwest	16,744	17,226
Binghamton Northeast	75,962	78,960
Binghamton South	27,510	26,271
2017 Dollars		
Binghamton Northwest	16,242	16,709
Binghamton Northeast	73,683	76,591
Binghamton South	26,685	25,483

Cost-Benefit Analysis

Using the 2018 federal discount rate of 2.875% and a 50-year capital recovery factor of 0.037948, the total cost of the project was annualized. Then the annual cost was compared to the annual benefit and a BCR was determined. Table 24 below summarizes the cost benefit analysis.

Table 25 Benefit-Cost Analysis

	Average Annual Cost ($000)	Average Annual Benefits ($000)	Net Benefits ($000)	BCR
Alternative 2a				
Binghamton Northwest	616	203	(413)	0.33
Binghamton Northeast	2,796	2,567	(229)	0.92
Binghamton South	1,013	399	(614)	0.39
Alternative 2b				
Binghamton Northwest	634	203	(431)	0.32
Binghamton Northeast	2,906	2,561	(345)	0.88
Binghamton South	967	399	(568)	0.41

A benefit-cost ratio (BCR) of greater than one signifies that the project benefits outweigh the costs of the project and the project is economically justifiable. Alternatives were not economically justifiable because benefits include only the incremental benefits of additional coverage, as described in ER 1105-2-101. The difference between the with- and without-project expected annual damage represents the benefit associated with the alternative. Given that the project costs are conservative and none of the BCRs were above the value of one, the Binghamton projects were determined not to be economically justifiable, even before interest during construction is included.

However, costs in many of the areas include constructing entirely new floodwalls as necessary by engineering requirements. Given this, the incremental benefits are promptly outweighed by the costs.

Binghamton Nonstructural Alternative

A nonstructural solution was also evaluated in the Binghamton area.

Elevating and Flood-proofing

A proposed nonstructural solution is to elevate the first floor of residential structures up-to the level of the 0.01 Annual Exceedance Probability (AEP) flood plus 1 foot, and flood-proof nonresidential structures up-to the level of the 0.01 AEP flood plus 1 foot. The HEC-FDA model was run again for the with-project condition setting first floor elevations equal to the base-flood-elevation (equal to the 0.01 AEP) flood elevation plus one foot. The resulting residual damages are summarized in Table 25 below.

Table 26 Binghamton Elevation and Flood-proofing

Damage Reach Name	Total Structures to be Elevated or Flood-proofed	Nonresidential Structures Flood-proofed	Residential Structures Elevated	Annual Residual Damages ($000)	Annual Residual Nonresidential Damages ($000)	Annual Residual Residential Damages ($000)
Binghamton-1	15	11	4	42	39	3
Binghamton-2	71	50	21	906	882	25
Binghamton-3	201	52	149	236	162	73
Binghamton-4	1	-	1	1		1
Binghamton-5	702	103	599	854	549	306
Binghamton-6	136	17	119	225	125	99
Binghamton-7	46	4	42	50	9	40
Binghamton-8	19	2	17	10	4	6
Binghamton-9	51	29	22	67	54	13
Binghamton-10	55	32	23	217	206	11
Binghamton-11	1	1		32	32	-
Binghamton-12	17	11	6	144	142	2
Binghamton-13	683	161	522	1,044	882	162
Binghamton-14	21		21	8	-	8
Binghamton-15	25	14	11	21	15	6
Binghamton-16	3	3		19	19	-
Chenango-2	127	20	107	542	452	91
Conklin-1	17	-	17	5	-	5
Conklin-2	203	26	177	144	97	47
Conklin-3	150	58	92	892	801	92
Dickinson-1	55	14	41	180	125	55
Kirkwood-1	121	41	80	607	561	46
Port Dickinson-1	25	1	24	27	4	23
Port Dickinson-2	88	4	84	78	5	73
Port Dickinson-3	36	2	34	51	32	20

To estimate the costs to elevate residential structures, the Pawcatuck Coastal Flood Study and the Ellicott City Flood Study costs were reviewed. The Pawcatuck, Rhode Island study has a cost of elevating a '2 story complicated with basement' at $294,339 per structure. The Ellicott City, Maryland study has an average cost of elevating

residential structures of $183,775. Additionally, *The North Atlantic Coast Comprehensive Study: Resilient Adaptation to Increasing Risk, Appendix C, Planning Analysis* suggests that the cost to elevate a 1,400 square foot structure is $195,000. Therefore, for the USRB study, an average of these three costs was used so that the cost to elevate a residential structure is $224,371.

Similarly, the costs to flood-proof nonresidential structures used an average between the Pawcatuck Coastal Study, the Ellicott Flood Study, and the NACCS estimated values. The cost to flood-proof nonresidential structures in the Pawcatuck, Rhode Island study used an average of the costs between the Pawcatuck and of 'Apartments over retail', 'Residential', and 'commercial' (average cost $60,959). The average cost for small or medium dry flood-proofing and large dry flood-proofing form the Ellicott City, Maryland study was determined to be $127,475. Finally the NACCS suggests that sealing a structure could cost up to $100,000 for a 1,000 square foot structure. The average of these three estimates is $96,145. Results of the cost-benefit-analysis are in Table 26 below.

Table 27 Binghamton Elevation and Flood-proofing Costs and Benefits

Damage Reach Name	% damages reduced	Benefit	Annual Cost Flood-proof Nonresidential ($000)	Annual Cost to Elevate Residential Structures ($000)	Total Costs ($000)	Net Benefits ($000)	BCR
Binghamton-1	77%	146	40	34	74	72	2.0
Binghamton-2	35%	493	182	179	361	132	1.4
Binghamton-3	68%	499	190	1,269	1,458	(960)	0.3
Binghamton-4	0%	-	-	9	9	(9)	-
Binghamton-5	45%	686	376	5,100	5,476	(4,790)	0.1
Binghamton-6	65%	414	62	1,013	1,075	(662)	0.4
Binghamton-7	92%	536	15	358	372	164	1.4
Binghamton-8	18%	2	7	145	152	(150)	0.0
Binghamton-9	51%	69	106	187	293	(224)	0.2
Binghamton-10	24%	69	117	196	313	(244)	0.2
Binghamton-11	4%	1	4	-	4	(2)	0.4
Binghamton-12	83%	702	40	51	91	611	7.7
Binghamton-13	44%	818	587	4,445	5,032	(4,214)	0.2
Binghamton-14	94%	117	-	179	179	(61)	0.7
Binghamton-15	93%	269	51	94	145	125	1.9
Binghamton-16	98%	863	11	-	11	852	78.8
Chenango-2	36%	311	73	911	984	(673)	0.3
Conklin-1	93%	68	-	145	145	(77)	0.5
Conklin-2	95%	2,558	95	1,507	1,602	956	1.6
Conklin-3	98%	42,597	212	783	995	41,602	42.8
Dickinson-1	45%	149	51	349	400	(251)	0.4
Kirkwood-1	92%	7,354	150	681	831	6,524	8.9
Port Dickinson-1	8%	2	4	204	208	(206)	0.0
Port Dickinson-2	17%	16	15	715	730	(713)	0.0
Port Dickinson-3	22%	14	7	289	297	(282)	0.0

Based on the analysis there is probable evidence to suggest that elevation of residential structures and flood-proofing of nonresidential could provide a viable solution to reduce flood risk in the 0.01 Annual Exceedance Probability. Areas to consider further are in Binghamton, Conklin, and Kirkwood.

Buyouts

An alternative nonstructural solution to buy the properties in the floodplain was evaluated in the Binghamton area. The same structures evaluated for elevation and flood-proofing were utilized for the buyout analysis. The costs used for buyouts follows guidance in *The North Atlantic Coast Comprehensive Study: Resilient Adaptation to Increasing Risk, Appendix C, Planning Analysis* which states “costs for structure removal are estimated to be $70,000 in addition to the property purchase price. When acquiring properties, the government typically offers fair market value for a property”. Therefore the market price of the structure, as provided in the parcel data from the county government database was used plus an additional $70,000. Table 27 summarizes the results from the buyout analysis.

Table 28 Binghamton Buyout Results

Damage Reach Name	Residual Damages ($000)	Benefits ($000)	Buyout Cost Total ($000)	Buyout Nonresidential Total Cost ($000)	Buyout Residential Total Cost ($000)	Total Annual Buyout Costs ($000)	Net Benefits ($000)	BCR for Buyouts
Binghamton-1	8	181	5,517	4,744	773	209	(29)	0.9
Binghamton-2	353	1,047	91,093	88,443	2,650	3,457	(2,410)	0.3
Binghamton-3	-	734	36,281	15,703	20,578	1,377	(642)	0.5
Binghamton-4	0	0	164	-	164	6	(6)	0.1
Binghamton-5	49	1,491	109,341	33,545	75,796	4,149	(2,658)	0.4
Binghamton-6	64	574	18,677	3,137	15,540	709	(135)	0.8
Binghamton-7	3	583	15,114	4,031	11,083	574	9	1.0
Binghamton-8	1	11	3,543	685	2,858	134	(124)	0.1
Binghamton-9	10	126	10,290	7,502	2,788	390	(264)	0.3
Binghamton-10	63	222	33,623	30,696	2,927	1,276	(1,054)	0.2
Binghamton-11	31	2	118	118		4	(3)	0.4
Binghamton-12	3	843	4,315	3,638	677	164	679	5.1
Binghamton-13	119	1,743	144,560	72,001	72,559	5,486	(3,743)	0.3
Binghamton-14	1	124	2,544		2,544	97	27	1.3
Binghamton-15	1	289	4,693	3,258	1,435	178	111	1.6
Binghamton-16	-	882	389	389		15	867	59.8
Chenango-2	176	678	40,813	25,534	15,279	1,549	(871)	0.4
Conklin-1	0	73	2,284		2,284	87	(14)	0.8
Conklin-2	26	2,676	38,802	10,681	28,121	1,472	1,204	1.8
Conklin-3	20	43,469	28,616	16,585	12,031	1,086	42,383	40.0
Dickinson-1	98	231	16,647	9,143	7,504	632	(401)	0.4
Kirkwood-1	11	7,950	37,410	26,456	10,954	1,420	6,531	5.6
Port Dickinson-1	27	2	3,767	110	3,657	143	(141)	0.0
Port Dickinson-2	78	16	15,385	702	14,683	584	(567)	0.0
Port Dickinson-3	51	14	10,611	5,138	5,473	403	(388)	0.0

The analysis on buyouts has a similar conclusion to the elevation/flood-proofing analysis. It suggests that buyouts could be a viable solution in areas of Binghamton, Conklin, and Kirkwood.

7.2 Endicott, Johnson City, Vestal

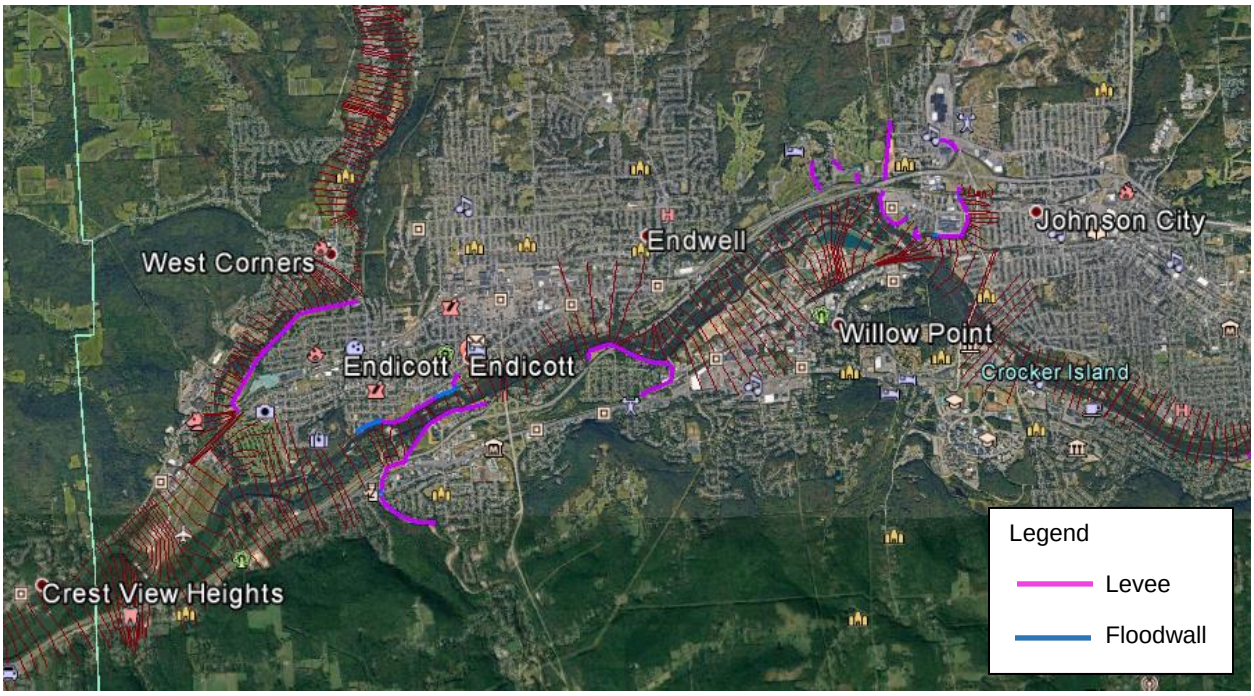
Existing Condition

Endicott, Johnson City, and the Town of Union are located on the right bank of the Susquehanna River. The tributaries of Little Choconut Creek, Finch Hollow Creek, and Nanticoke Creek cross developed areas in the Town of Union. The Town of Vestal is located on the left bank of the Susquehanna River, on the opposite bank of the Town of Union, and is located immediately downstream of the City and Town of Binghamton. The

tributaries of Willow Run and Big Choconut Creek traverse the Town of Vestal, emptying into the Susquehanna River.

The Endicott-Johnson City-Vestal FRM project provides FRM benefits to the Towns of Union and Vestal including a majority of the Village of Endicott and flood-prone areas of the Village of Johnson City. The EJV project was authorized by the Flood Control Act of 3 September 1954. EJV consists of three separate levee systems that reduce risk from riverine flooding from the Susquehanna River and its tributaries; the Endicott levee system, the Johnson City levee system, and the Vestal levee system. In addition to the EJV project, the non-federally constructed Fairmont Park and West Corners FRM projects are located in the Town of Union. The FRM projects in the area are shown in Figure 18.

Figure 18 EJV Existing Flood Risk Management



The Towns of Union and Vestal were affected by severe flooding in 2011, which resulted in flood waters overtopping the EJV FRM project resulting in the catastrophic loss of the BAE systems plant at Johnson City and damages throughout the region. A significant portion of the USRB's critical infrastructure, educational facilities, and concentration of employment are located in EJV, therefore a disruption of services caused by a major storm would have significant regional impacts.

The Village of Endicott has historically been a manufacturing center with roots in shoe manufacturing and is best known as the birthplace of IBM. The Village of Johnson City has been primarily a residential area with important industrial, commercial, and institutional areas including a satellite campus of Binghamton University. The Towns of Vestal and Union have been primarily residential suburbs to Endicott, Johnson City, and Binghamton. Vestal also has a significant population of university students as the main

campus of Binghamton University is located on the eastside of the town. The population and demographic characteristics of EJV and Union are summarized in Table 21. Endicott, Johnson City, and Town of Union have experienced population declines, likely as a result of decline in employment opportunities resulting from decreases in manufacturing employment in the region. The Town of Vestal has a relatively stable population likely influenced by the presence of Binghamton University.

The EJV project is primarily affected by residual flood risk from infrequent, high intensity events, which can result in overtopping of levees and floodwalls and overwhelming of interior drainage pumps. Flooding from Tropical Storm Lee in 2011 resulted in overtopping of all three systems in the EJV project resulting in significant damages in affected communities. Additionally, flood risk may be affected by limited flood storage capacity in tributaries of the Susquehanna River, which can result in back-flooding, particularly along Little Choconut Creek, which can affect areas on the opposite bank of the existing levee. A final risk driver in Endicott includes driveways that are cutting into the levee crown just south of NYS Highway 17c where the levee ties in to high ground.

Following the methodology described in section Economic Analysis Methods *6 Economic Analysis Methods,* HEC-FDA models were run and existing annual damages were determined. Damages are summarized in Table 28.

Table 29 EJV Existing Damages

Damage Reach Name	Description	# Structures	Annual Damages ($000)	Nonresidential Damages ($000)	Residential Damages ($000)
Endicott-1	Endicott-1 Nanticoke unprotected	2	257	257	-
Endicott-2	Endicott-2 Nanticoke protected	222	-	-	-
Endicott-3	Endicott-3 Nanticoke unprotected	1	0	-	0
Endicott-4	Endicott-4 Susquehanna unprotected	3	268	268	-
Endicott-5	Endicott-5 Susquehanna protected	747	518	446	72
Endicott-6	Endicott-6 Susquehanna unprotected	2	423	423	-
Johnson City-1	Johnson City-1 Little Choconut unprotected	170	63	62	1
Johnson City-2	Johnson City-2 Little Choconut protected	118	852	833	19
Johnson City-3	Johnson City-3 Susquehanna unprotected	12	328	290	38
Maine-1	Maine-1 Nanticoke Creek unprotected	2	-	-	-
Owego-1	Owego-1 Susquehanna unprotected	196	1,363	933	430
Owego-2	Owego-2 Susquehanna unprotected	39	70	5	65
Union-1	Union-1 Little Choconut protected	169	104	70	34
Union-2	Union-2 Little Choconut unprotected	18	23	17	7
Union-3	Union-3 Nanticoke protected	455	-	-	-
Union-4	Union-4 Nanticoke unprotected	111	73	2	71
Union-5	Union-5 Nanticoke unprotected	11	1	-	1
Union-6	Union-6 Susquehanna unprotected	1	15	-	15
Union-7	Union-7 Susquehanna unprotected	40	2	-	2
Union-8	Union-8 Susquehanna unprotected	191	1,376	847	529
Union-9	Union-9 Susquehanna protected	36	23	12	11
Union-10	Union-10 Susquehanna unprotected	6	26	26	-
Union-11	Union-11 Susquehanna unprotected	11	10	-	10
Union-12	Union-12 Susquehanna unprotected	2	-	-	-
Union-13	Union-13 Susquehanna protected	48	24	15	9
Union-14	Union-14 Susquehanna unprotected	63	65	53	12
Vestal-1	Vestal-1 Susquehanna unprotected	78	292	121	171
Vestal-2	Vestal-2 Susquehanna unprotected	45	104	38	67
Vestal-3	Vestal-3 Susquehanna protected	285	-	-	-
Vestal-4	Vestal-4 Susquehanna unprotected	74	216	0	216
Vestal-5	Vestal-5 Susquehanna protected	334	183	88	95
Vestal-6	Vestal-6 Susquehanna unprotected	43	1,968	1,965	3
Vestal-7	Vestal-7 Susquehanna unprotected	6	64	63	1
Vestal-8	Vestal-8 Susquehanna unprotected	16	17	7	10

Total annual damages were determined to be $8.7 million with $6.8 million in nonresidential damages and $1.9 million in residential damages.

Cost Estimate for Structural Alternative

Using the 2018 federal discount rate of 2.875 percent and the capital recovery factor of 0.037948 over 50 years. Total project costs that would be supported if 100 percent and 50 percent of the damages were reduced were calculated and summarized in Table 29 below.

Table 30 EJV Project Cost Supported

Damage Reach Name	Description	# Structures	Project cost supported if 100% damages reduced ($000)	Project cost supported if 50% damages reduced ($000)
Endicott-1	Endicott-1 Nanticoke unprotected	2	6,772	3,386
Endicott-2	Endicott-2 Nanticoke protected	222	-	-
Endicott-3	Endicott-3 Nanticoke unprotected	1	12	6
Endicott-4	Endicott-4 Susquehanna unprotected	3	7,068	3,534
Endicott-5	Endicott-5 Susquehanna protected	747	13,637	6,819
Endicott-6	Endicott-6 Susquehanna unprotected	2	11,134	5,567
Johnson City-1	Johnson City-1 Little Choconut unprotected	170	1,671	835
Johnson City-2	Johnson City-2 Little Choconut protected	118	22,446	11,223
Johnson City-3	Johnson City-3 Susquehanna unprotected	12	8,654	4,327
Maine-1	Maine-1 Nanticoke Creek unprotected	2	-	-
Owego-1	Owego-1 Susquehanna unprotected	196	35,908	17,954
Owego-2	Owego-2 Susquehanna unprotected	39	1,849	924
Union-1	Union-1 Little Choconut protected	169	2,752	1,376
Union-2	Union-2 Little Choconut unprotected	18	610	305
Union-3	Union-3 Nanticoke protected	455	-	-
Union-4	Union-4 Nanticoke unprotected	111	1,922	961
Union-5	Union-5 Nanticoke unprotected	11	32	16
Union-6	Union-6 Susquehanna unprotected	1	392	196
Union-7	Union-7 Susquehanna unprotected	40	60	30
Union-8	Union-8 Susquehanna unprotected	191	36,259	18,129
Union-9	Union-9 Susquehanna protected	36	603	302
Union-10	Union-10 Susquehanna unprotected	6	688	344
Union-11	Union-11 Susquehanna unprotected	11	251	126
Union-12	Union-12 Susquehanna unprotected	2	-	-
Union-13	Union-13 Susquehanna protected	48	637	318
Union-14	Union-14 Susquehanna unprotected	63	1,720	860
Vestal-1	Vestal-1 Susquehanna unprotected	78	7,693	3,846
Vestal-2	Vestal-2 Susquehanna unprotected	45	2,745	1,372
Vestal-3	Vestal-3 Susquehanna protected	285	-	-
Vestal-4	Vestal-4 Susquehanna unprotected	74	5,704	2,852
Vestal-5	Vestal-5 Susquehanna protected	334	4,821	2,410
Vestal-6	Vestal-6 Susquehanna unprotected	43	51,861	25,930
Vestal-7	Vestal-7 Susquehanna unprotected	6	1,682	841
Vestal-8	Vestal-8 Susquehanna unprotected	16	458	229
Total			**230,038**	**115,019**

Cost-Benefit Analysis

During the scoping phase of the project, there were four alternatives that posed the highest potential for a supported structural solution. The costs of the projects are described in Table 30 below. The cost of the project does not include real estate easements, mitigating flooding, or contingency. Therefore a contingency value of 42 percent was applied based on risk and uncertainty, using the Binghamton cost estimate as a baseline.

Table 31 EJV Project Costs

Alternatives under consideration	Description of Alternative	Project Cost ($000)	Cost with Contingency ($000)	Reaches	Project supported, 100% reduction ($000)	Project supported, 50% reduction ($000)
Alternative 2.1: Modification: Raising Endicott Levee System	Raise all levees and floodwalls in Endicott; 11,113 ft levee; 2220 floodwall	12,597	17,888	Union-3, Endicott-5, Endicott-2	13,637	6,819
Alternative 2.2: Modification: Raising Vestal Levee System (West)	174 ft floodwall; 15,523 feet levee	16,284	23,123	Vestal-3	-	-
Alternative 2.3: Modification: Raising Vestal Levee System (East)	6177 feet of upstream levee	6,449	9,158	Vestal-5	4,821	2,410
Alternative 3: Modification: Raising Johnson City Levees and Floodwalls	~Raise all floodwalls/levees ~Fix floodwall elevations ~Install wall on crest of levee	10,595	15,045	JohnsonCity-2, Union-1	25,197	12,599

Following discussions with the project delivery team, including the engineering team, it was determined that potential projects would have costs that exceed the benefits. There were also concerns of induced flooding from raising a system and additional costs (ie. including pump stations). Therefore it is not economically justifiable to continue to evaluate a structural project in the Endicott-Johnson City-Vestal area.

Nonstructural Alternative

Additional analysis was performed to review a nonstructural alternative for EJV including elevation, floodproofing, and buyouts. .

Elevating and Flood-proofing

A proposed nonstructural solution is to elevate the first floor of residential structures up-to the level of the 0.01 AEP flood plus 1 foot, and flood-proof nonresidential structures up-to the level of the 0.01 AEP flood plus 1 foot. The HEC-FDA model was run again for the with-project condition setting first floor elevations equal to the base-flood-elevation (equal to the 0.01 AEP) flood elevation plus one foot. The resulting residual damages are summarized in Table 31 below.

Table 32 EJV Elevating and Flood-proofing Benefits

Damage Reach Name	Total Structures to be Elevated or Flood-proofed	Nonresidential Structures Flood-proofed	Residential Structures Elevated	Annual Residual Damages ($000)	Annual Residual Nonresidential Damages ($000)	Annual Residual Residential Damages ($000)
Endicott-1	2	2	-	5	5	-
Endicott-2	79	14	65	-	-	-
Endicott-3	1	-	1	-	0	-
Endicott-4	3	3	-	5	5	-
Endicott-5	365	96	269	381	313	68
Endicott-6	2	2	-	19	19	-
Johnson City-1	4	3	1	33	32	1
Johnson City-2	80	33	47	488	473	16
Johnson City-3	67	11	56	114	74	39
Maine-1	-			-		
Owego-1	73	12	61	81	22	59
Owego-2	24	4	20	11	1	10
Union-1	120	31	89	63	40	23
Union-2	9	3	6	11	7	4
Union-3	288	6	282	-	-	-
Union-4	32	2	30	22	1	21
Union-5	-	-	-	1	-	1
Union-6	1	-	1	1	-	1
Union-7	-	-	-	2	-	2
Union-8	93	29	64	232	190	42
Union-9	27	1	26	15	7	8
Union-10	4	4	-	3	3	-
Union-11	3	-	3	3	-	3
Union-12	2	2	-	-	-	-
Union-13	20	1	19	21	13	7
Union-14	10	2	8	20	2	17
Vestal-1	35	7	28	36	15	21
Vestal-2	32	1	31	38	18	20
Vestal-3	163	69	94	-	-	-
Vestal-4	36	-	36	6	0	6
Vestal-5	246	5	241	128	60	68
Vestal-6	20	19	1	674	672	2
Vestal-7	4	3	1	16	16	0
Vestal-8	8	1	7	7	4	3

To estimate the costs to elevate and flood-proof, the same method to calculate costs were used as described in the Binghamton nonstructural section. Results of the cost-benefit-analysis are in Table 32 below.

Table 33 EJV Elevating and Flood-proofing Benefit-Cost Analysis

Damage Reach Name	% damages reduced	Benefit	Annual Cost Flood-proof Nonresidential ($000)	Annual Cost to Elevate Residential Structures ($000)	Total Costs ($000)	Net Benefits ($000)	BCR
Endicott-1	98%	253	7	-	7	245	34.6
Endicott-2	0%	-	51	553	605	(605)	-
Endicott-3	100%	0	-	9	9	(8)	0.1
Endicott-4	98%	263	11	-	11	253	24.1
Endicott-5	26%	136	350	2,290	2,641	(2,504)	0.1
Endicott-6	95%	403	7	-	7	396	55.2
Johnson City-1	48%	31	11	9	19	11	1.6
Johnson City-2	43%	363	120	400	521	(157)	0.7
Johnson City-3	65%	215	40	477	517	(302)	0.4
Maine-1	0%	-	-	-	-	-	-
Owego-1	94%	1,282	44	519	563	719	2.3
Owego-2	84%	59	15	170	185	(126)	0.3
Union-1	40%	42	113	758	871	(829)	0.0
Union-2	52%	12	11	51	62	(50)	0.2
Union-3	0%	-	22	2,401	2,423	(2,423)	-
Union-4	70%	51	7	255	263	(212)	0.2
Union-5	0%	-	-	-	-	-	-
Union-6	95%	14	-	9	9	6	1.7
Union-7	0%	-	-	-	-	-	-
Union-8	83%	1,144	106	545	651	494	1.8
Union-9	34%	8	4	221	225	(217)	0.0
Union-10	88%	23	15	-	15	8	1.6
Union-11	74%	7	-	26	26	(19)	0.3
Union-12	0%	-	7	-	7	(7)	-
Union-13	15%	4	4	162	165	(162)	0.0
Union-14	70%	46	7	68	75	(30)	0.6
Vestal-1	88%	256	26	238	264	(8)	1.0
Vestal-2	63%	66	4	264	268	(202)	0.2
Vestal-3	0%	-	252	800	1,052	(1,052)	-
Vestal-4	97%	210	-	307	307	(96)	0.7
Vestal-5	30%	55	18	2,052	2,070	(2,016)	0.0
Vestal-6	66%	1,294	69	9	78	1,216	16.6
Vestal-7	75%	48	11	9	19	28	2.5
Vestal-8	59%	10	4	60	63	(53)	0.2

Given this analysis, it is recommended that further analysis may be needed to look at non-structural solutions in Endicott, Johnson City, Owego, Union, and Vestal.

Buyouts

An alternative nonstructural solution to buy the properties in the floodplain was also evaluated in the EJV area. The same methodology described in the Binghamton Buyout section was used with results presented below.

Table 34 EJV Buyout Results

Damage Reach Name	Residual Damages ($000)	Benefits ($000)	Buyout Cost Total ($000)	Buyout Nonresidential Total Cost ($000)	Buyout Residential Total Cost ($000)	Total Annual Buyout Costs ($000)	Net Benefits ($000)	BCR for Buyouts
Endicott-1	-	257	469	469	-	18	240	14.5
Endicott-2	-	-	12,551	2,897	9,654	476	(476)	-
Endicott-3	-	0	158	-	158	6	(6)	0.1
Endicott-4	-	268	3,439	3,439	-	131	138	2.1
Endicott-5	50	467	122,729	81,257	41,472	4,657	(4,190)	0.1
Endicott-6	-	423	7,682	7,682	-	292	131	1.4
Johnson City-1	1	62	4,710	4,550	160	179	(116)	0.3
Johnson City-2	121	731	30,019	23,039	6,980	1,139	(408)	0.6
Johnson City-3	20	309	20,086	12,203	7,883	762	(454)	0.4
Maine-1		-	-			-	-	-
Owego-1	15	1,348	56,385	45,231	11,154	2,140	(792)	0.6
Owego-2	2	68	3,165	525	2,640	120	(52)	0.6
Union-1	9	96	26,434	15,056	11,378	1,003	(907)	0.1
Union-2	2	21	4,531	3,648	883	172	(151)	0.1
Union-3	-	-	47,219	6,275	40,944	1,792	(1,792)	-
Union-4	6	67	5,261	554	4,707	200	(133)	0.3
Union-5	1	-	174	-	174	7	(7)	-
Union-6	-	15	153	-	153	6	9	2.6
Union-7	2	-	-	-	-	-	-	-
Union-8	108	1,268	18,175	9,179	8,996	690	578	1.8
Union-9	1	22	3,462	70	3,392	131	(110)	0.2
Union-10	1	25	544	544	-	21	5	1.2
Union-11	1	9	396	-	396	15	(6)	0.6
Union-12	-	-	140	140	-	5	(5)	-
Union-13	16	9	2,263	93	2,169	86	(77)	0.1
Union-14	4	61	1,534	417	1,118	58	3	1.1
Vestal-1	9	283	7,123	3,478	3,645	270	13	1.0
Vestal-2	4	101	5,951	840	5,111	226	(125)	0.4
Vestal-3	-	-	46,878	31,478	15,401	1,779	(1,779)	-
Vestal-4	0	216	5,792	-	5,792	220	(4)	1.0
Vestal-5	13	170	36,763	3,121	33,642	1,395	(1,225)	0.1
Vestal-6	427	1,541	129,437	129,320	117	4,912	(3,371)	0.3
Vestal-7	1	62	1,109	979	130	42	20	1.5
Vestal-8	2	15	1,357	680	677	51	(36)	0.3

Locations in Endicott, Union, and Vestal buyout alternatives is considered economically justifiable and therefore warrant further investigation.

7.3 Nonstructural Analysis of Remaining Study Area

The project delivery team in collaboration with the non-federal sponsor determined that the focus areas for structural solutions would be the Binghamton and EJV areas, following preliminary analysis of structural solutions in other areas of the watershed, most of which showed limited potential for a federal structural project. The team also wanted to perform due diligence by evaluating nonstructural solutions in the towns that were eliminated from the focus area. Therefore an analysis was performed following the methodology described in section *6 Economic Analysis Methods.*

Existing Conditions

The HEC-FDA model was run for the without-project condition and the existing damages are summarized in Table 34 below.

Table 35 Rest of Area Existing Damages

Damage Reach Name	Description	Total Structures	Nonresidential Structures	Residential Structures	Annual Damages ($000)	Annual Nonresidential Damages ($000)	Annual Residential Damages ($000)
Bainbridge-1	Bainbridge-1 SusquehannaRV Unprotected	62	15	47	267	192	75
Chenango-1	Chenango-1 Chenango Unprotected	39	1	38	173	14	160
Greene-1	Greene-1 Chenango Unprotected	27	11	16	3,189	2,741	448
Greene-2	Greene-2 Chenango Unprotected	103	10	93	5,618	1,279	4,339
Norwich-1	Norwich-1 Chenango Unprotected	262	29	233	18,767	11,531	7,236
Norwich-2	Norwich-2 Chenango Unprotected	158	19	139	32,161	25,334	6,827
Norwich-3	Norwich-3 Chenango Unprotected	420	51	369	-	-	-
Oneonta-1	Oneonta-1 Susquehanna Protected	188	25	163	-	-	-
Owego-1	Owego-1 Susquehanna Unprotected	886	260	626	3,158	2,671	487
Sidney-1	Sidney-1 Susquehanna Unprotected	500	128	372	888	583	306
Unadilla-1	Unadilla-1 Susquehanna Unprotected	274	52	222	649	324	325
Waverly-1	Waverly-1 Cayuta Creek Unprotected	117	44	68	0	-	0
Whitney Point-1	Whitney Point-1 Tioughnioga Protected	97	27	70	49	34	15

Elevating and Flood-proofing

A proposed nonstructural solution is to elevate the first floor of residential structures up-to the level of the 0.01 AEP flood plus 1 foot, and flood-proof nonresidential structures up-to the level of the 0.01 AEP flood plus 1 foot. The HEC-FDA model was run again for the with-project condition setting first floor elevations equal to the base-flood-elevation (equal to the 0.01 AEP) flood elevation plus one foot. The resulting residual damages are summarized in Table 35 below.

Table 36 Rest of Area Elevating and Flood-proofing Benefits

Damage Reach Name	Total Structures to be Elevated or Flood-proofed	Nonresidential Structures Flood-proofed	Residential Structures Elevated	Annual Residual Damages ($000)	Annual Residual Nonresidential Damages ($000)	Annual Residual Residential Damages ($000)
Bainbridge-1	46	13	33	22	10	12
Chenango-1	24	1	23	24	1	23
Greene-1	27	11	16	33	26	7
Greene-2	103	10	93	69	14	55
Norwich-1	262	29	233	201	90	111
Norwich-2	156	18	138	7,687	4,898	2,788
Norwich-3	-	-	-	-	-	-
Oneonta-1	-	-	-	-	-	-
Owego-1	474	113	361	300	186	114
Sidney-1	312	45	267	148	89	60
Unadilla-1	221	40	181	88	31	57
Waverly-1	1	0	1	0	-	0
Whitney Point-1	90	27	63	41	28	13

To estimate the costs to elevate and flood-proof, the same method to calculate costs were used as described in the Binghamton nonstructural section. Results of the cost-benefit-analysis are in Table 36 below.

Table 37 Rest of Area Elevating and Flood-proofing Benefit-Cost Analysis

Damage Reach Name	% damages reduced	Benefit	Annual Cost Flood-proof Nonresidential ($000)	Annual Cost to Elevate Residential Structures ($000)	Total Costs ($000)	Net Benefits ($000)	BCR
Bainbridge-1	92%	245	47	281	328	(83)	0.7
Chenango-1	86%	150	4	196	199	(50)	0.7
Greene-1	99%	3,156	40	136	176	2,980	17.9
Greene-2	99%	5,549	36	792	828	4,721	6.7
Norwich-1	99%	18,566	106	1,984	2,090	16,476	8.9
Norwich-2	76%	24,474	66	1,175	1,241	23,234	19.7
Norwich-3	0%	-	-	-	-	-	-
Oneonta-1	-	-	-	-	-	-	-
Owego-1	90%	2,857	412	3,074	3,486	(629)	0.8
Sidney-1	83%	740	164	2,273	2,438	(1,697)	0.3
Unadilla-1	86%	561	146	1,541	1,687	(1,126)	0.3
Waverly-1	92%	0	-	9	9	(8)	0.0
Whitney Point-1	17%	9	99	536	635	(626)	0.0

Given this analysis, it is recommended that further analysis may be needed to look at Greene and Norwich where there is potential for a nonstructural solution.

Buyouts

An alternative nonstructural solution to buy the properties in the floodplain was also evaluated. The same methodology described in the Binghamton Buyout section was used with results presented below.

Table 38 Non-Focus Study Area

Damage Reach Name	Residual Damages ($000)	Benefits ($000)	Buyout Cost Total ($000)	Buyout Nonresidential Total Cost ($000)	Buyout Residential Total Cost ($000)	Total Annual Buyout Costs	Net Benefits ($000)	BCR for Buyouts
Bainbridge-1	1	266	11,589	3,947	7,642	440	(174)	0.6
Chenango-1	4	170	5,071	168	4,903	192	(23)	0.9
Greene-1	-	3,189	5,828	3,595	2,233	221	2,968	14.4
Greene-2	-	5,618	18,009	2,284	15,725	683	4,935	8.2
Norwich-1	201	18,566	42,167	11,383	30,784	1,600	16,966	11.6
Norwich-2	7,687	24,474	36,524	16,909	19,615	1,386	23,088	17.7
Norwich-3		-	-	-	-	-	-	-
Oneonta-1	-	-	-	-	-	-	-	-
Owego-1	67	3,091	86,745	36,677	50,068	3,292	(201)	0.9
Sidney-1	19	870	57,123	22,242	34,881	2,168	(1,298)	0.4
Unadilla-1	18	631	39,807	8,968	30,839	1,511	(880)	0.4
Waverly-1	0	0	-	-	-	-	0	-
Whitney Point-1	41	9	17,465	8,059	9,406	663	(654)	0.0

Greene and Norwich buyout alternatives is considered economically justifiable and therefore warrant further investigation.

Owego

Nonstructural Alternative Summary

A preliminary analysis on nonstructural solutions for the non-focus areas was evaluated. There is economic justification for further analysis of the Greene and Norwich for elevation and flood-proofing. There was economic justification for buyouts in Norwich and Greene. In reviewing social vulnerability, Norwich in particular has an elevated concern for vulnerable populations.

8 RISK AND UNCERTAINTY

Uncertainty factors include depth-damage relationships, structure values, content value percentages, first floor elevations and flood stage-probabilities. Uncertainty surrounding these variables was quantified and entered into the HEC-FDA model in order to estimate the uncertainty surrounding the stage-damage relationships developed for each study reach.

The HEC-FDA program computes stage-damage curves and annual damages based on water surface profiles by flood event probability, asset (structure) inventory, and damage relationship functions. Uncertainty or error distributions associated with estimating the depth damage functions, structure values, content value ratios, other value ratios, and first flood stage are used to develop the total aggregated stage-damage functions by damage categories for damage reach. The uncertainty of each parameter is defined by the type of distribution around each probability density function such as normal, triangular, or log normal distributions.

Structure and content valuation were estimated with uncertainty. Error associated with structure value is entered as the standard deviation, in percent of structure value, associated with the uncertainty in the structure value estimate for a particular structure occupancy type. For structure value, a normal distribution with a standard deviation of below 25 percent was used. Uncertainty in content value estimates was also entered as a normal distribution with a 20 percent standard deviation.

There is also risk and uncertainty associated with first-floor elevations. While the use of high resolution ground-based light detection ranging (LiDAR) datasets greatly improves precision, these data still imperfectly identify distinct objects and spaces. In addition, the location where elevations were estimated is subject to measurement error. It is unlikely that each point where elevation was calculated is the precise point of entry in a given structure. In general, the first floor elevation was calculated using the number of steps to the lowest first floor entry. A conservative estimate of 8 inches per step was utilized in the estimation. To capture uncertainty regarding first floor elevation estimates, a normal distribution with a 0.25-foot standard deviation was assumed.

Risk and uncertainty is elevated for the nonstructural analysis as it was based on estimated structure and content values for a preliminary analysis.

Project performance reports display information about hydrologic/hydraulic performance of a plan. Table 39 below shows the project performance for the existing Binghamton area, Table 40 displays the project performance of the proposed project conditions, and Table 41 exhibits the project performance of the EJV area.

Table 39 Project Performance Binghamton Area – Existing Condition

				Target Stage Annual Exceedance Probability[2]		Long-Term Risk - years (Probability that target stage will be reached within the given number of years)			Conditional Non-Exceedance Probability by Events (This is the probability that the levee will contain the flood at the named frequency)					
Damage Reach Name	**Stream Name**	**Description**	**Target Stage [1]**	**Median**	**Expected**	**10**	**30**	**50**	**10% (10-year)**	**4% (25-year)**	**2% (50-year)**	**1% (100-year)**	**.4% (250-year)**	**.2% (500-year)**
Binghamton-1	Chenango	Binghamton-1 Chenango Unprotected	840.35	0.1681	0.1677	0.8406	0.9959	0.9999	0.0913	0.0061	0.0060	0.0056	0.0000	0.0000
Binghamton-2	Chenango	Binghamton - 2 Chenango protected	850.00 L	0.0098	0.0137	0.1284	0.3379	0.4970	0.9997	0.9681	0.7248	0.5031	0.2388	0.0582
Binghamton-3	SusquehannaRV	Binghamton-3 SusquehannaRV unprotected	850.80 L	0.0157	0.0187	0.1720	0.4323	0.6108	0.9997	0.8969	0.5789	0.3386	0.1627	0.0463
Binghamton-4	PierceCK	Binghamton-4 PierceCK unprotected	852.50	0.0103	0.0137	0.1287	0.3385	0.4977	0.9998	0.9631	0.7207	0.4973	0.2555	0.0702
Binghamton-5	Chenango	Binghamton - 5 Chenango protected	850.00 L	0.0096	0.0135	0.1271	0.3348	0.4932	0.9997	0.9693	0.7291	0.5086	0.2431	0.0595
Binghamton-6	Chenango	Binghamton-6 Chenango unprotected	843.01	0.1129	0.1132	0.6993	0.9728	0.9975	0.3839	0.0567	0.0545	0.0186	0.0031	0.0000
Binghamton-7	SusquehannaRV	Binghamton-7 SusquehannaRV unprotected	834.79	0.4454	0.4327	0.9965	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Binghamton-8	SusquehannaRV	Binghamton-8 SusquehannaRV protected	845.90 L	0.0044	0.0086	0.0823	0.2272	0.3492	0.9998	0.9916	0.8645	0.7074	0.4763	0.2002
Binghamton-9	SusquehannaRV	Binghamton-9 SusquehannaRV protected	845.00 L	0.0094	0.0134	0.1261	0.3327	0.4904	0.9997	0.9634	0.7284	0.5133	0.2821	0.0885
Binghamton-10	SusquehannaRV	Binghamton-10 SusquehannaRV protected	850.00 L	0.0042	0.0082	0.0793	0.2196	0.3385	0.9998	0.9931	0.8752	0.7110	0.4890	0.2309
Binghamton-11	SusquehannaRV	Binghamton-11 SusquehannaRV protected	845.00 L	0.0273	0.0286	0.2522	0.5818	0.7661	0.9969	0.7143	0.3642	0.1641	0.0600	0.0111
Binghamton-12	SusquehannaRV	Binghamton-12 SusquehannaRV protected	850.00 L	0.0214	0.0233	0.2100	0.5070	0.6923	0.9995	0.8179	0.4693	0.2395	0.1006	0.0231
Binghamton-13	SusquehannaRV	Binghamton-13 SusquehannaRV protected	853.00 L	0.0039	0.0082	0.0792	0.2192	0.3379	0.9998	0.9935	0.8796	0.7193	0.4944	0.2430
Binghamton-14	SusquehannaRV	Binghamton-14 SusquehannaRV unprotected	845.61	0.3817	0.3784	0.9914	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Binghamton-15	SusquehannaRV	Binghamton-15 SusquehannaRV unprotected	847.95	0.3380	0.3377	0.9838	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Binghamton-16	SusquehannaRV	Binghamton-16 SusquehannaRV unprotected	847.82	0.4072	0.4021	0.9942	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Chenango-2	Chenango	Chenango-2 Chenango Unprotected	851.31	0.0259	0.0267	0.2371	0.5561	0.7417	0.9997	0.7462	0.3789	0.1806	0.0514	0.0064
Conklin-1	SusquehannaRV	Conklin-1 Susquehanna Unprotected	856	0.9990	0.9990	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Conklin-2	SusquehannaRV	Conklin-2 Susquehanna Unprotected	852.39	0.2219	0.2227	0.9195	0.9995	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Conklin-3	SusquehannaRV	Conklin-3 Susquehanna Unprotected	848.5	0.9990	0.9990	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Dickinson-1	Chenango	Dickinson-1 Chenango Unprotected	844.4	0.0682	0.6910	0.5114	0.8833	0.9721	0.7904	0.2791	0.1300	0.0384	0.0068	0.0000
Kirkwood-1	SusquehannaRV	Kirkwood-1 Susquehanna Unprotected	853.57	0.4821	0.4628	0.9980	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Port Dickinson-1	Chenango	Port Dickinson-1 Chenango River Unprotected	846.5	0.0310	0.0314	0.2735	0.6166	0.7976	0.9979	0.6524	0.3027	0.1295	0.0329	0.0033
Port Dickinson-2	Chenango	Port Dickinson-2 Chenango River Protected	853.50 L	0.0054	0.0092	0.0886	0.2429	0.3712	0.9997	0.9929	0.8559	0.6838	0.4069	0.1354
Port Dickinson-3	Chenango	Port Dickinson-3 Chenango River Protected	855.00 L	0.0039	0.0072	0.0695	0.1942	0.3023	0.9998	0.9975	0.9082	0.7762	0.5170	0.2037

1. Target Stage is the Top of Levee or the stage where significant damages start to occur. Significant is defined as residual damages equal to 5% of the total 0.01 AEP Event.
2. Value is computed from HEC-FDA Monte Carlo simulations

Table 40 Project Performance Binghamton Area – Proposed Project Condition

			Target Stage Annual Exceedance Probability[2]		Long-Term Risk - years (Probability that target stage will be reached within the given number of years)			Conditional Non-Exceedance Probability by Events (This is the probability that the levee will contain the flood at the named frequency)					
Damage Reach Name	Stream Name	Target Stage [1]	Median	Expected	10	30	50	10% (10-year)	4% (25-year)	2% (50-year)	1% (100-year)	.4% (250-year)	.2% (500-year)
Binghamton-1	Chenango	840.35	0.1681	0.1677	0.8406	0.9959	0.9999	0.0913	0.0061	0.0060	0.0056	0.0000	0.0000
Binghamton-2	Chenango	850.50 L	0.0084	0.0124	0.1176	0.3129	0.4649	0.9997	0.9776	0.7634	0.5511	0.2777	0.0738
Binghamton-3	SusquehannaRV	852.30 L	0.0050	0.0092	0.0885	0.2427	0.3709	0.9998	0.9901	0.8522	0.6727	0.4469	0.1998
Binghamton-4	PierceCK	852.50	0.0103	0.0137	0.1287	0.3385	0.4977	0.9998	0.9631	0.7207	0.4973	0.2555	0.0702
Binghamton-5	Chenango	851.00 L	0.0072	0.0111	0.1060	0.2855	0.4290	0.9997	0.9852	0.8011	0.6014	0.3232	0.0938
Binghamton-6	Chenango	843.01	0.1129	0.1132	0.6993	0.9728	0.9975	0.3839	0.0567	0.0545	0.0186	0.0031	0.0000
Binghamton-7	SusquehannaRV	834.79	0.4454	0.4327	0.9965	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Binghamton-8	SusquehannaRV	846.90 L	0.0030	0.0059	0.0579	0.1637	0.2577	0.9997	0.9977	0.9271	0.8227	0.6242	0.3204
Binghamton-9	SusquehannaRV	847.00 L	0.0031	0.0061	0.0597	0.1686	0.2649	0.9998	0.9974	0.9230	0.8140	0.6115	0.3092
Binghamton-10	SusquehannaRV	851.00 L	0.0032	0.0063	0.0610	0.1721	0.2701	0.9998	0.9975	0.9223	0.7980	0.5972	0.3225
Binghamton-11	SusquehannaRV	848.50 L	0.0081	0.0120	0.1139	0.3042	0.4537	0.9998	0.9744	0.7710	0.5548	0.3278	0.1245
Binghamton-12	SusquehannaRV	853.50 L	0.0032	0.0065	0.0631	0.1776	0.2781	0.9998	0.9972	0.9181	0.7901	0.5864	0.3121
Binghamton-13	SusquehannaRV	858.00 L	0.0001	0.0001	0.0010	0.0030	0.0050	0.9998	0.9992	0.9648	0.8894	0.7406	0.4793
Binghamton-14	SusquehannaRV	845.61	0.3817	0.3784	0.9914	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Binghamton-15	SusquehannaRV	847.95	0.3380	0.3377	0.9838	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Binghamton-16	SusquehannaRV	847.82	0.4072	0.4021	0.9942	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Chenango-2	Chenango	851.31	0.0259	0.0267	0.2371	0.5561	0.7417	0.9997	0.7462	0.3789	0.1806	0.0514	0.0064
Conklin-1	SusquehannaRV	856	0.9990	0.9990	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Conklin-2	SusquehannaRV	852.39	0.2219	0.2227	0.9195	0.9995	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Conklin-3	SusquehannaRV	848.5	0.9990	0.9990	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Dickinson-1	Chenango	844.4	0.0682	0.6910	0.5114	0.8833	0.9721	0.7904	0.2791	0.1300	0.0384	0.0068	0.0000
Kirkwood-1	SusquehannaRV	853.57	0.4821	0.4628	0.9980	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Port Dickinson-1	Chenango	846.5	0.0310	0.0314	0.2735	0.6166	0.7976	0.9979	0.6524	0.3027	0.1295	0.0329	0.0033
Port Dickinson-2	Chenango	853.50 L	0.0054	0.0092	0.0886	0.2429	0.3712	0.9997	0.9929	0.8559	0.6838	0.4069	0.1354
Port Dickinson-3	Chenango	855.00 L	0.0039	0.0072	0.0695	0.1942	0.3023	0.9998	0.9975	0.9082	0.7762	0.5170	0.2037

1. Target Stage is the Top of Levee or the stage where significant damages start to occur. Significant is defined as residual damages equal to 5% of the total 0.01 AEP Event.
2. Value is computed from HEC-FDA Monte Carlo simulations

Table 41 Project Performance EJV Area – Existing Condition

				Target Stage Annual Exceedance Probability[2]		Long-Term Risk - years (Probability that target stage will be reached within the given number of years)			Conditional Non-Exceedance Probability by Events (This is the probability that the levee will contain the flood at the named frequency)					
Damage Reach Name	**Stream Name**	**Description**	**Target Stage [1]**	**Median**	**Expected**	**10**	**30**	**50**	**10% (10-year)**	**4% (25-year)**	**2% (50-year)**	**1% (100-year)**	**.4% (250-year)**	**.2% (500-year)**
Endicott-1	Nanticoke Creek	Endicott-1 Nanticoke unprotected	820.05	0.3797	0.3775	0.9913	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Endicott-2	Nanticoke Creek	Endicott-2 Nanticoke protected	833.50 L	0.0001	0.0001	0.0010	0.0030	0.0050	0.9995	0.9988	0.9607	0.8924	0.7435	0.4596
Endicott-3	Nanticoke Creek	Endicott-3 Nanticoke unprotected	828.09	0.0199	0.0218	0.1980	0.4842	0.6683	0.9997	0.8447	0.4963	0.2644	0.1106	0.0224
Endicott-4	SusquehannaRV	Endicott-4 Susquehanna unprotected	820.06	0.3702	0.3676	0.9898	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Endicott-5	SusquehannaRV	Endicott-5 Susquehanna protected	833.00 L	0.0026	0.0051	0.0494	0.1411	0.2239	0.9997	0.9988	0.9457	0.8602	0.6827	0.3788
Endicott-6	SusquehannaRV	Endicott-6 Susquehanna unprotected	822.45	0.2870	0.2876	0.9663	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Johnson City-1	Little Choconut	Johnson City-1 Little Choconut unprotected	835.70	0.0153	0.0183	0.1685	0.4251	0.6025	0.9997	0.9047	0.5890	0.3526	0.1621	0.0382
Johnson City-2	Little Choconut	Johnson City-2 Little Choconut protected	838.6 L	0.0034	0.0067	0.0655	0.1839	0.2873	0.9997	0.9963	0.9088	0.7880	0.5729	0.2723
Johnson City-3	SusquehannaRV	Johnson City-3 Susquehanna unprotected	834.47	0.0470	0.0507	0.4055	0.7899	0.9258	0.9224	0.4389	0.1735	0.0536	0.0134	0.0017
Maine-1	Nanticoke Creek	Maine-1 Nanticoke Creek unprotected	863.50	0.9990	0.9990	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Owego-1	SusquehannaRV	Owego-1 Susquehanna unprotected	806.50	0.9990	0.9990	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Owego-2	SusquehannaRV	Owego-2 Susquehanna unprotected	811.67	0.2804	0.2810	0.9631	0.9999	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Union-1	Little Choconut	Union-1 Little Choconut protected	838.6 L	0.0034	0.0067	0.0655	0.1839	0.2872	0.9997	0.9963	0.9088	0.7881	0.5730	0.2722
Union-2	Little Choconut	Union-2 Little Choconut unprotected	833.68	0.0317	0.0333	0.2873	0.6380	0.8161	0.9917	0.6321	0.2892	0.1167	0.0352	0.0047
Union-3	Nanticoke Creek	Union-3 Nanticoke protected	833.5 L	0.0001	0.0001	0.0010	0.0030	0.0050	0.9995	0.9988	0.9606	0.8924	0.7434	0.4595
Union-4	Nanticoke Creek	Union-4 Nanticoke unprotected	822.51	0.1961	0.1976	0.8894	0.9986	1.0000	0.0287	0.0008	0.0008	0.0007	0.0000	0.0000
Union-5	Nanticoke Creek	Union-5 Nanticoke unprotected	845.87	0.1543	0.1573	0.8195	0.9941	0.9998	0.1139	0.0057	0.0056	0.0030	0.0000	0.0000
Union-6	SusquehannaRV	Union-6 Susquehanna unprotected	817.06	0.3816	0.3783	0.9914	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Union-7	SusquehannaRV	Union-7 Susquehanna unprotected	829.50	0.0100	0.0138	0.1297	0.3409	0.5008	0.9997	0.9597	0.7192	0.4987	0.2708	0.0828
Union-8	SusquehannaRV	Union-8 Susquehanna unprotected	822.83	0.4157	0.4094	0.9948	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Union-9	SusquehannaRV	Union-9 Susquehanna protected	837 L	0.0034	0.0068	0.0663	0.1861	0.2905	0.9997	0.9960	0.9057	0.7831	0.5692	0.2713
Union-10	SusquehannaRV	Union-10 Susquehanna unprotected	825.46	0.4249	0.4171	0.9955	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Union-11	SusquehannaRV	Union-11 Susquehanna unprotected	826.55	0.4018	0.3974	0.9937	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Union-12	SusquehannaRV	Union-12 Susquehanna unprotected	826.00	0.9990	0.9990	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Union-13	Nanticoke Creek	Union-13 Susquehanna protected	830.00 L	0.0083	0.0124	0.1176	0.3129	0.4650	0.9997	0.9713	0.7579	0.5480	0.3145	0.1044
Union-14	Nanticoke Creek	Union-14 Susquehanna unprotected	836.20	0.9990	0.9990	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Vestal-1	SusquehannaRV	Vestal-1 Susquehanna unprotected	820.15	0.3156	0.3159	0.9775	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Vestal-2	SusquehannaRV	Vestal-2 Susquehanna unprotected	823.34	0.1357	0.1389	0.7760	0.9888	0.9994	0.2010	0.0160	0.0159	0.0053	0.0000	0.0000
Vestal-3	SusquehannaRV	Vestal-3 Susquehanna protected	833.90 L	0.0001	0.0001	0.0010	0.0030	0.0050	0.9995	0.9988	0.9608	0.8925	0.7438	0.4596
Vestal-4	SusquehannaRV	Vestal-4 Susquehanna unprotected	816.50	0.9990	0.9990	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Vestal-5	SusquehannaRV	Vestal-5 Susquehanna protected	835.40 L	0.0028	0.0054	0.0524	0.1491	0.2360	0.9997	0.9985	0.9398	0.8473	0.6617	0.3569
Vestal-6	SusquehannaRV	Vestal-6 Susquehanna unprotected	828.44	0.0654	0.0680	0.5057	0.8792	0.9705	0.7963	0.3054	0.1191	0.0303	0.0067	0.0000
Vestal-7	SusquehannaRV	Vestal-7 Susquehanna unprotected	835.28	0.0390	0.0430	0.3554	0.7322	0.8887	0.9628	0.5100	0.2114	0.0722	0.0195	0.0025
Vestal-8	SusquehannaRV	Vestal-8 Susquehanna unprotected	837.70	0.0387	0.0425	0.3524	0.7284	0.8861	0.9649	0.5148	0.2137	0.0730	0.0196	0.0025

1. Target Stage is the Top of Levee or the stage where significant damages start to occur. Significant is defined as residual damages equal to 5% of the total 0.01 AEP Event.
2. Value is computed from HEC-FDA Monte Carlo simulations

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9 CONCLUSION

The purpose of the economic analysis for the USRB Comprehensive Flood Damage Reduction Feasibility Study was to evaluate existing flood damages and make recommendations for feasible, economically justified flood damage reduction alternatives. The project delivery team narrowed the focus of the study to the Binghamton existing levee system and the Endicott-Johnson City-Vestal (EJV) levee system. A nonstructural analysis was also completed to evaluate towns and villages outside of the focus area.

Using the risk-based economic model HEC-FDA, existing damages were calculated. When compared to estimated structural costs of alternatives in the Binghamton area, it was determined that the structural projects were not economically justifiable. Similarly, the calculated damages in the EJV area could not support the cost of a structural project.

When evaluating the remaining areas for nonstructural alternatives, results showed possible projects in the Binghamton and EJV focus areas. Additional non-structural alternatives in the remaining study area show potential economic viability in the towns of Greene and Norwich. Further work is needed to reduce the level of uncertainty and improve confidence in these results including conducting field surveys of elevations, developing detailed cost estimates, and determining the most suitable non-structural measure for each structure in the reach. If the non-structural solution is supported by the sponsors and stakeholders, further analysis is recommended using more detailed and site-specific structure elevations and cost estimates to display results in community or neighborhood groupings.

Despite the negative finding in the various structural alternatives examined, the preliminary analysis of non-structural measures results in a possible avenue for Federal involvement through FEMA's Hazard Mitigation Grant Program. The non-structural effort for flood damage reduction in the USRB is already being led by state and local stakeholders as part of the New York Rising Community Reconstruction Program.

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