



Climate Smart Communities

Bethlehem Local Waterfront Revitalization Program (LWRP) District

Sea Level Rise Vulnerability Assessment

May 2014

INTRODUCTION

The Climate Smart Communities (CSC) program is a New York State initiative to help local governments reduce greenhouse gas emissions, prepare for the effects of climate change, and save taxpayer dollars. The CSC program is designed to address 10 focus areas, or “pledge elements,” outlined in the CSC pledge. The CSC Regional Coordinator Pilot program was created by the New York State Energy Research and Development Authority (NYSERDA) to offer technical assistance to communities like Bethlehem that have adopted the CSC Pledge. In the Capital District, NYSERDA chose the Capital District Regional Planning Commission (CDRPC) and its consultant, VHB Engineering Surveying and Landscape Architecture, P.C. (VHB), to provide this support as the CSC Regional Coordinator.

On November 20, 2013 CDRPC and VHB conducted an In-Person Consultation with the Town of Bethlehem to discuss local climate protection priorities. During the consultation the Town discussed both challenges and opportunities in addressing *Pledge Element 7: Enhance Community Resilience and Prepare for the Effects of Climate Change*. Understanding what these challenges are is a crucial first step in preparing Bethlehem for a changing climate and it was decided that the best opportunity for technical assistance would be to conduct a vulnerability assessment with a focus on flooding within the Local Waterfront Revitalization Program (LWRP) District. This assessment would include measuring the projected increases in sea-level rise, identifying the sectors and systems that are potentially impacted, and developing some initial strategies that can be included in the updated LWRP Plan that the Town is embarking upon.

BACKGROUND

In 2008 the Town of Bethlehem developed a Local Waterfront Revitalization Program to comprehensively manage the Town’s waterfront properties under the New York State’s Waterfront Revitalization of Coastal Areas and Inland Waterways Act. The LWRP aims to protect and enhance the waterfront’s key cultural and environmental resources, revitalize vacant and underutilized water-influenced areas, improve public access, and provide opportunities for water dependent uses. The LWRP districts are located along the Hudson River, which are exposed to tidal flooding and vulnerable to the impacts of sea level rise. The [New York State 2100 Commission Report \(2013\)](#) projects that the Hudson River water level will likely to rise up to 72 inches by the year 2100. While the LWRP provides local land-use vision and policy framework for Bethlehem’s waterfront areas, it does not currently include strategies to address the potential impacts that sea level rise and flood elevations will have on local government operations and community resources.



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The CSC Regional Coordinators are providing the Town of Bethlehem with a preliminary evaluation of how potential Hudson River flooding will impact significant infrastructure, local government operations and community resources in the LWRP districts. This vulnerability assessment identifies key threats and addresses risks related to climate change, so that the Town can plan to increase community resilience in a cost effective and efficient manner. This document includes the methodology used to determine the projected increases in sea level rise that were estimated by Scenic Hudson. It outlines a step by step process that can be followed to apply sea level rise projections outside of the LWRP districts. This methodology is six maps that illustrate the sea level rise projects and a list of strategies that can be included in Bethlehem's updated LWRPC to address projected climate impacts from flooding.

SEA LEVEL RISE MAPPING METHODOLOGY

The vulnerability assessment was completed by creating a series of maps that included municipal and public systems and facilities that were located within the existing 100-year floodplain and the projected areas that would be impacted by sea level rise in the future. This vulnerability mapping process can be replicated by following the same process outlined in the 4 steps below:

- STEP 1:** Create Base Map of Town's Economic, Social and Environmental Components
 - STEP 2:** Establish Sea Level Rise Projection Timeline
 - STEP 3:** Create a Sea Level Rise Map with Estimated Inches for Each Time Period
 - STEP 4:** Compare Base Map and Sea Level Rise Map to Identify Vulnerabilities
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STEP 1: Create Base Map of Town's Economic, Social and Environmental Components

The first step of the vulnerability assessment was to compile mapping layers into ArcGIS to create a base map of the Town's municipal infrastructure and facilities, residential and commercial structures, and open space within the Town of Bethlehem's LWRP districts. This base map was used to identify the significant infrastructure, local government operations and natural resources that may be at risk along the Hudson River. Future vulnerability assessments can add, modify or update these overlay maps if more detailed mapping information becomes available. The [NYS GIS Clearinghouse](#) provides GIS overlay maps that have been developed according to published research and reports conducted by:

- New York State Department of Environmental Conservation (NYSDEC)
- U.S. Environmental Protection Agency (EPA)
- EPA Facility Registry System (EPA FRS)
- U.S. Census Bureau



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- Federal Emergency Management Agency (FEMA)
- Hudson River National Estuarine Research Reserve

STEP 2: Establish Sea Level Rise Projections

The second step of the vulnerability assessment was to review the timeline associated with projected sea level rise. The [NYS Sea Level Rise Task Force Report \(2010\)](#) and the [NYS 2100 Commission Report \(2013\)](#) were used to develop sea level rise projections for Bethlehem between 2020 and 2100. These reports include two scenarios of sea level rise that demonstrate conservative and aggressive projections based on the identified cause of sea level rising. The conservative projection captures the central range or median average of the sea level rise caused by higher seawater temperatures – known as thermal expansion – which is a slower process. The aggressive projection reflects rapid ice melt scenarios by measuring the current rate of melting ice in Greenland and the West Antarctic.¹ Table 1 summarizes the [NYS Sea Level Rise Task Force Report \(2010\)](#) conservative and aggressive projections of sea level rise in inches for the Mid-Hudson and Capital Region.

Table 1: NYS Sea Level Rise Task Force Report - Projected Sea Level Rise (Inches)

Year	2020s	2050s	2080s	2100s
Conservative Projection (Central Range)	1"-4"	5"-9"	8"-18"	11"-26"
Aggressive Projection (Rapid Ice Melt)	4"-9"	17"-26"	37"-50"	52"-68"

STEP 3: Create a Sea Level Rise Map with Estimated Inches for Each Time Period

The third step of the vulnerability assessment was to download sea level rise mapping layers from Scenic Hudson to create a flooding projection map in ArcGIS. The Scenic Hudson mapping tool does not attempt to assign a time period to its GIS layers and only provides the impacts of sea level rise in 6 inch increments. However, the established time periods from Step 2 can be used to align Scenic Hudson’s sea level rise data with the [NYS Sea Level Rise Task Force Report \(2010\)](#). [Table 2](#) summarizes the Town of Bethlehem’s conservative and aggressive projections of sea level rise in 6 inch increments across four time periods: 2020s, 2050s, 2080s, and 2100s.

¹ [NYS Sea Level Rise Task Force Report \(2010\)](#). P. 16



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Table 2: Town of Bethlehem – Scenic Hudson Projected Sea Level Rise (Inches)

Year	2020s	2050s	2080s	2100s
Conservative Projection (Central Range)	0" - 6"	7" - 12"	13" - 18"	24" - 30"
Aggressive Projection (Rapid Ice Melt)	0" - 12"	18" - 30"	36" - 48"	54" - 72"

After estimated sea level rise projections were assigned to the four time periods in [Table 2](#), GIS layers were downloaded from [Scenic Hudson’s Sea Level Rise Mapper Tool](#).² This was completed in 3 steps using ArcGIS:

1. Download the Sea Level Rise 100-year floodplain raster layer from [Scenic Hudson’s Sea Level Rise Mapper Tool](#).
2. Redefine this raster layer to group datasets to simulate sea level rise in inches for conservative and aggressive projections of the 100-year floodplain as shown in [Table 2](#).
3. Overlay the 100-year floodplain map on top of the Town’s base map of economic, social and environmental components to identify vulnerabilities.

STEP 4: Compare Base Map and Sea Level Rise Map to Identify Vulnerabilities

The fourth step of the vulnerability assessment was to identify populations,

Background on Scenic Hudson GIS Data

Scenic Hudson is an organization committed to protecting and restoring the natural and man-made resources surrounding the Hudson River by supporting community efforts to develop climate adaptation plans by providing GIS mapping data to communities. Scenic Hudson modeled projected floodplains by establishing an estimated sea level baseline and measuring flood level increases using the FEMA Base Flood Elevations (BFE). To account for the Hudson River’s significant tidal fluctuations, sea level rise projections used a mean higher-high water (MHHW) baseline, which is the mean value for the highest tide each day and averaged over a 19-year period. This standard was selected to reflect the impact of flooding on dry land areas, so that impacts beyond regular tidal flooding are included in projections. The flood level projections were assessed by elevation, which was measured using remote sensing technology, called Light Detection and Ranging (LiDAR). Scenic Hudson remotely assessed which areas were low-lying or tidal and directly connected with the Hudson River. Additional information behind the development of [Scenic Hudson’s Sea Level Rise Mapping Methodology](#) is available online.

² "Sea Level Rise Mapper Tool." Scenic Hudson: Land, Parks, Advocacy. Scenic Hudson Organization, n.d. Web. 14 May 2014. <http://www.scenichudson.org/slr/mapper/about>



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infrastructure, public facilities and environmental features that are at risk according to the 100-year floodplain area for conservative and aggressive projections. Using the ArcGIS Clip Tool, these vulnerable features or elements from base map layers were extracted and quantified, such as the length of linear features (roads, water mains, street lights, etc.); number of point features (schools, sewers, pumps, etc.); and total effected land area.

[Table 4](#) summarizes the number of vulnerable systems within the Town’s LWRP districts based on the conservative and aggressive projections for each of the specified time periods within the 100-year floodplain. The Town’s vulnerability assessment identifies the number of social systems, infrastructure networks, public buildings and environmental facilities that will be impacted by the projected 100-year floodplain. The Town of Bethlehem can use this information to inform planning decisions and explore options to improve the resiliency of at-risk systems or facilities, such as the residential dwellings, pumping station, wastewater treatment facility, the 11 water production wells, or the 18 environmental facility sites.

Using these maps, VHB conducted a workshop with Town staff on April 8, 2014. A short presentation was given to introduce the staff to common terms (see PowerPoint: *Vulnerability Assessment for Bethlehem*), and assist in determining what systems and their sectors would be affected by the conservative and aggressive scenarios in Table 2. A system can be defined as:

A combination of related parts organized into a complex whole. Urban environments are comprised of interconnected social, infrastructure, and natural systems that provide essential functions and services.

Examples include natural systems, social systems and infrastructure/built systems. After reviewing the projected sea level rise scenarios, Bethlehem chose the following systems within the LWRP that are projected to be affected by sea level rise:

Residential

Natural/Cultural Resources

Economic

Built Environment

Infrastructure



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Once the systems were identified, the sectors within each system were discussed. A sector is defined as:

A sector is a component of an integrated system such as an economy or a society.

Sectors examined in a vulnerability assessment vary but often include agriculture/food, air, biodiversity/ecosystems, cultural resources, emergency preparedness, energy, fish/fisheries, forestry, infrastructure/built environment, insurance, land management, national security/defense, public health, technology, tourism/recreation, transportation, urban development/land use, water resources, and wildlife. Bethlehem chose nine sectors, organized by system, as presented in Table 4.

Table 3: Vulnerable Systems and Sectors in Bethlehem’s LWRP

System	Sector
Residential	Households and Homes
Economic	Businesses
Infrastructure	Municipal Utilities (sewer/water)
	Emergency Services
	Transportation (roads, railroad, port operations)
Natural/Cultural Resources	Agriculture
	Open Space
	Recreation
	Natural Habitat

Within these sectors, VHB generated a list of adaptation strategies that the Town could include in the updated LWRP. These are general strategies and would require further analysis, but are a starting point to continue planning to adapt to the estimated increase in sea level rise based on Scenic Hudson’s projections. These strategies can be found in the accompanying Excel spreadsheet: *Bethlehem LWRP Adaptation Strategies*. The spreadsheet includes a column for Department Head/Implementer to determine who may be responsible for implementing a specific strategy, the cross-cutting sectors or systems, and whether the strategy also has climate mitigation connections which would also assist the Town in reducing greenhouse gas emissions while adapting to climate change. These can be completed by the Town as these strategies are modified or refined. While these strategies are just a starting point, they provide a foundation for the Town to begin planning for the impacts of climate change.



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FUTURE VULNERABILITY ASESSEMENTS

The sea level projections used in this vulnerability mapping methodology are likely to change over time as new data and improvements in scientific modeling become available. Additionally, the Town of Bethlehem may want to update economic, social or environmental GIS mapping data, which can be incorporated into the basemap for future at-risk assessments. This vulnerability mapping process can be replicated by following the same process outlined in the 4 steps below:

STEP 1: Create Base Map of Town’s Economic, Social and Environmental Components

STEP 2: Align with Existing Sea Level Rise Projection Timeline

STEP 3: Create a Sea Level Rise Map with Estimated Inches for Each Time Period

STEP 4: Compare Base Map and Sea Level Rise Maps to Identify Vulnerabilities

Table 3: Quantitative Impact of the Projected Sea Level Rise 100-year Flooding on the LWRP Districts in Bethlehem

Systems	Vulnerable Features	Unit of Measurement	Conservative Projection					Aggressive Projection				
			2020	2050 (additional)	2080 (additional)	2100 (additional)	Total	2020	2050 (additional)	2080 (additional)	2100 (additional)	Total
General	Population	person	226	106	100	178	610	332	278	234	281	1,125
	Household ¹	household	109	51	49	87	296	160	136	116	139	551
	Land	acre	1,547.2	10.5	10.3	16.9	1,584.9	1,572.9	28.2	21.7	28.5	1,651.3
Infrastructure Networks	Road	mile	3.1	0.1	0.1	0.2	3.5	3.2	0.3	0.2	0.3	4.0
	Water Main	feet	13,884	189	285	631	14,989	14,069	898	755	749	16,471
	Water Network Structure	-	11 production wells	0	0	0	11	11 production wells	0	0	0	11
	Sewer Pressure Main	feet	0	0	0	0	0	0	0	0	0	0
	Sewer Gravity Main	feet	0	0	0	0	0	0	0	0	0	0
	Sewer Network Structure	-	1 pumping station 1 treatment plant	0	0	0	2	1 pumping station 1 treatment plant	0	0	0	2
Public Buildings	Library	-	0	0	0	0	0	0	0	0	0	0
	Public School	-	0	0	0	0	0	0	0	0	0	0
	Private School	-	0	0	0	0	0	0	0	0	0	0
Environmental Facilities	EPA FRS Facilities ²	-	18 sites	0	0	0	18	18 sites	0	1 sites	3 sites	22

Data Source: Town of Bethlehem, NYS GIS Clearinghouse, Scenic Hudson Sea Level Rise Projections (floodplain and census block data)

¹ 2010 Census block data was overlain with modeled inundation and 100-year flood zones to estimate the number of people and households at risk for inundation and flooding at each 6" increase in sea level rise. Data provided by Scenic Hudson.

² EPA Facility Registry System (FRS) - The Facility Registry System (FRS) is a centrally managed database that identifies facilities, sites or places subject to environmental regulations or of environmental interest. More information on FRS: <http://www.epa.gov/enviro/html/fri/index.html>



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Resources:

[New York State 2100 Commission Report \(2013\)](#)

[NYS Sea Level Rise Task Force Report \(2010\)](#)

[NYS GIS Clearinghouse](#)

[Scenic Hudson's Sea Level Rise Mapping Methodology](#)

[Scenic Hudson's Sea Level Rise Mapper Tool.](#)