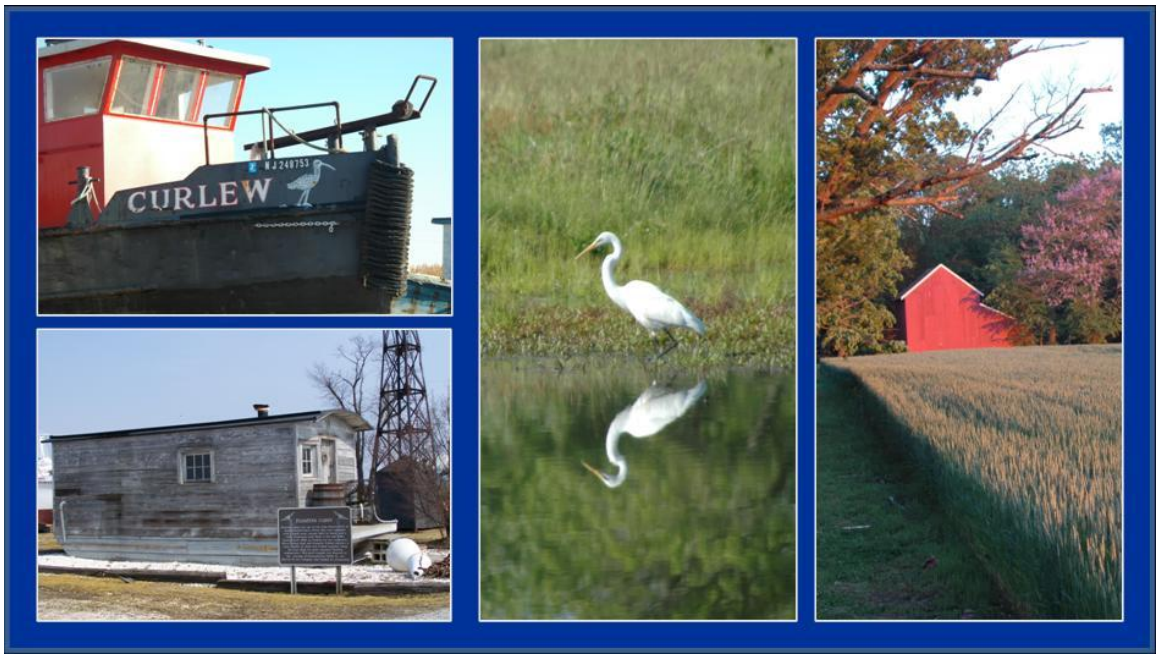
Coastal Community Vulnerability & Resilience Assessment Pilot

Greenwich Township, Cumberland County, NJ



COASTAL MANAGEMENT PROGRAM

June 2011 FINAL REPORT

Office of Coastal Management

New Jersey Department of Environmental Protection

Coastal Community Vulnerability & Resilience Assessment Pilot
Greenwich Township, Cumberland County, NJ

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ACKNOWLEDGEMENTS:
The New Jersey Office of Coastal Management would also like to express their gratitude towards representatives in Greenwich Township who were actively engaged in the vulnerability and resilience assessment. By participating as a pilot community for the New Jersey Office of Coastal Management's vulnerability mapping protocol and the resilience questionnaire, Greenwich Township has helped refine these tools for their future application along the New Jersey shore.

The Office of Coastal Management would also like to thank Trudy Hansen, Carey Hedlund, Mike Ivanick, and Larry Niles for sharing their photos for the development of this document.

TITLE PAGE PHOTOS PROVIDED BY MIKE IVANICK.

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Photo 1: View of the Bayside Tract in Greenwich Township, NJ Photo Credit: Carey Hedlund

Pilot Study Background

New Jersey is truly a coastal state, encompassing 127 miles of Atlantic coastline and nearly 1,800 miles of estuarine shoreline. Nearly 8 million people live within the coastal counties of the state, and these numbers increase drastically during the summer months as people vacation along the shore. New Jersey's coastal counties support the state's economy through tourism, recreation, shipping, commercial fishing, and aquaculture. While coastal communities, industries, and resources are crucial to sustaining the state's economy, the New Jersey shore has proven to be vulnerable to shallow coastal flooding, erosion, and storms. Unfortunately, climate change threatens to increase the frequency and intensity of coastal storms and permanently inundate some low-lying portions of the coast. As a result, more people, development, and natural resources will be vulnerable to the impacts of coastal hazards than in the past.

As natural hazards threaten the New Jersey shore, local decision-makers will have the greatest capacity to influence the resiliency of their communities. Historically, coastal communities have merely responded to the impacts of natural hazards. However, as disaster response and recovery have become increasingly more expensive, federal and state policies now mandate strong coastal construction standards, flood prevention ordinances, and pre-disaster mitigation planning for local governments to secure mitigation funding. Increasingly, coastal communities are making proactive measures to improve their resilience through land use planning, public education, and disaster preparedness. Unfortunately, the responsibilities of limiting hazard exposure, reducing vulnerability, and responding and adapting quickly to coastal changes are dispersed among many layers of government and municipal departments. Coastal decision-makers need opportunities for interdepartmental and intra-agency collaboration and access to resources, tools and science-based information that will help them make informed decisions to improve local resiliency to shallow coastal flooding, storms, and sea level rise.

Vulnerability the degree to which a human or natural system is unable to cope to the adverse affects of natural hazards.[1]

Resilience is the ability of a system to respond to and recover from disasters, by resisting or changing, in order to reach and maintain an acceptable level of functioning and structure.[2]

1. Worldwatch Institute. (2009).
2. Adapted from Cutter, S.(2009) and the Subcommittee on Disaster Reduction.(2005).

In recent years, federal and state agencies throughout the country have been working to develop tools and resources that will help communities better understand their vulnerability to coastal hazards and the threat of climate change. Through the financial assistance of Coastal Zone Management Section 309 funds, the New Jersey Coastal Management Office has developed two tools that are intended to build resilience capacity from the local level, including the *Coastal Community Vulnerability Assessment Protocol* (CCVAP) and the *Getting to Resilience* Questionnaire. These tools are intended to guide coastal communities through the development of a hazard vulnerability and resilience assessment.

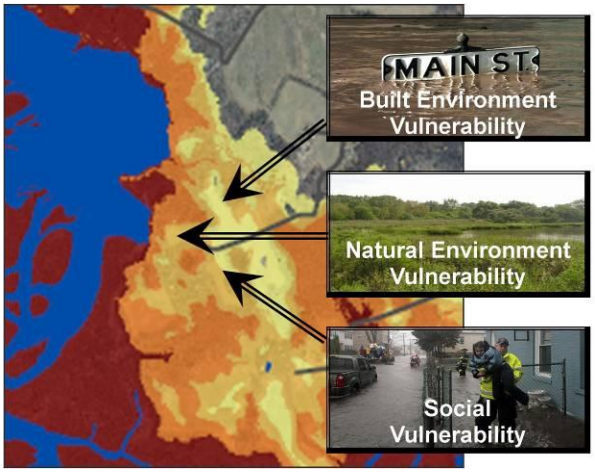
Assessment Tools

The New Jersey Coastal Management Office developed the *Coastal Community Vulnerability Assessment Protocol* and the *Getting to Resilience* questionnaire as part of its 2006-2011 Section 309 Strategy. Tools and technology are rapidly evolving to help understand how coastal hazards and climate change will impact communities throughout the coastal zone. The Coastal Management Office strategically approached the development of vulnerability and assessment tools so they are not only useful for identifying storm threats, but they also useful in helping state and local decision-makers focus on coastal hazards through a climate change lens. The Coastal Management Office wanted to ensure that coastal decision-makers could determine vulnerabilities within their communities and help them identify ways to incorporate mitigation and adaptation measures into existing programs and plans, such as local ordinances, land use plans, evacuation information, and all-hazard mitigation plans. As a result, the Coastal Management Office developed a vulnerability mapping methodology, known as the *Coastal Community Vulnerability Assessment Protocol*, which is intended to be coupled with *Getting to Resilience*, a facilitated questionnaire designed to spur ideas and collaboration among local decision-makers.

Coastal Community Vulnerability Assessment Protocol

Coastal Community Vulnerability Assessment Protocol (CCVAP) is a GIS-based methodology developed to assist land use planners, hazard mitigation planners, emergency managers, and other local decision-makers in the identification of their community's vulnerability to coastal hazards and sea level rise. Based off of a number of existing risk and vulnerability assessment methodologies,[1] *CCVAP* defines the necessary steps to geospatially identify vulnerable land areas under present and future inundation scenarios, whether it be shallow coastal flooding due to spring tides, storm surge, or sea level rise. Through the development of inundation scenarios, coastal decision-makers now have a greater ability determine the potential inundation threats to built infrastructure, sensitive natural resources, and special needs populations.

Figure 1: Coastal Community Vulnerability Assessment Protocol



[1] Cutter, S.L.; Mitchell, J.T.; and M.S. Scott. (2000). NOAA: CSC. (2010; 1999); Thieler, E.R and E.S Hammar-Klose (1999); Lennon et al (1996); Gornitz, V. M., Daniels, R. C., White, T. W., and Birdwell, K. R. (1994)

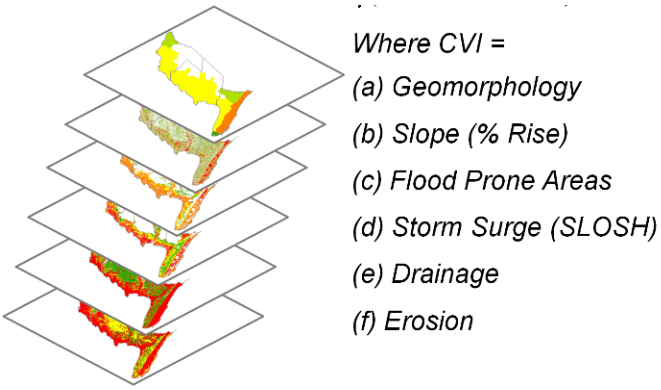
Inundation Mapping

The basis of the vulnerability assessment relies upon the development of inundation maps. NOAA Coastal Services Center's Inundation Toolkit defines the methodology for mapping shallow coastal flooding, storm surge, and sea level rise.[2] CCVAP recommends using the highest resolution elevation data available to map inundation. By the end of 2011, 2-3 meter resolution elevation data will be available for all coastal counties in New Jersey. High resolution elevation data, also referred to as Light Detecting and Ranging (LiDAR), combined with NOAA's Vertical Datum Transformation Tool (VDatum)[3] not only generates more precise storm surge and sea level rise maps, it allows for inundation scenarios to account for tidal stages. By leveraging these innovative resources and data, coastal communities throughout New Jersey will be able to have a better perception of storm and inundation threats, allowing them to plan and prepare for potential impacts to cultural, historic, and natural resources, infrastructure, people, and other drivers of local character and economies.

Coastal Vulnerability Index

While inundation mapping help coastal communities visualize hazard threats, inundation mapping alone may not clearly define the most hazard prone areas in and around a community. Inundation is just one concern of coastal communities, erosion, historic shoreline change, and past flood events can help a community determine where hazards are likely to impact the next time around. In order to determine where the most high hazard areas are within a community or within the coastal zone as a whole, the New Jersey Coastal Management Office developed a geospatial, composite overlay model, otherwise known as a coastal vulnerability index. The model incorporates six geospatial inputs, including storm surge inundation scenarios, low slopes, flood prone areas, poorly drained soils, erosion prone areas, and geomorphology. By incorporating sea level rise scenarios into existing storm surge models, the Coastal Management Office was then able to visualize how climate change may shift high hazard areas further inland overtime. While the CVI is not an essential part of a hazards profile or vulnerability assessment, it may prove to be useful in identifying locations for the investment of mitigation assistance. It may also help determine where engineering and adaptation to climate change may be extremely difficult or ineffective.

Figure 2: Coastal Vulnerability Index Layers



[2] NOAA: CSC. Inundation Toolkit. http://www.csc.noaa.gov/digitalcoast/inundation/
[3] NOAA: NDS. (2010). Vertical Datum Transformation Tool (VDatum). http://vdatum.noaa.gov/

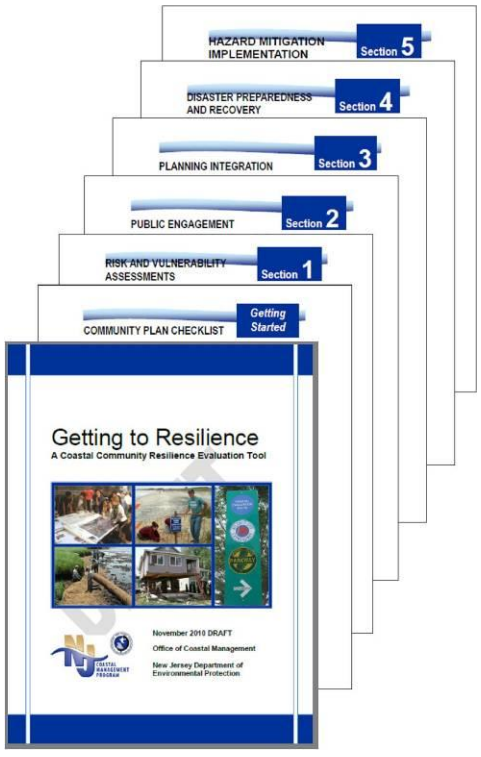
Getting to Resilience

Getting to Resilience is a facilitated questionnaire that was developed as a non-regulatory tool to assist local decision-makers in the collaborative identification of planning, mitigation, and adaptation opportunities to reduce vulnerability to coastal storms and sea level rise, thus building capacity for coastal community resilience. The questionnaire incorporates the key components of existing local government evaluation tools, developed by academics, international and federal agencies, and planning practioners to improve community resilience to natural hazards. While this questionnaire incorporates many concepts and questions from existing tools, it defers in the fact that it is not intended to grade the resiliency of a community. However, it is intended to start a dialogue among various decision-makers, spawning creative thinking and collaboration on ways for their community to become more resilient for existing and future generations. The questionnaire highlights the importance of local plan integration and consistency with municipal building codes and ordinances. It also identifies the importance of localized hazard assessments and their necessary link to planning, outreach, mitigation, response, and recovery.

The questionnaire is divided into five sections:
(1) Risk and Vulnerability Assessments,
(2) Public Engagement,
(3) Planning Integration,
(4) Disaster Preparedness and Recovery, and
(5) Hazard Mitigation Implementation.

It highlights the importance of local plan integration and stresses the need for consistency among municipal building codes, ordinances, and zoning. The questionnaire also identifies the importance of linking localized risk and vulnerability assessments to land use planning, public expenditures, mitigation, and disaster preparedness and response because the responsibilities of limiting hazard exposure and reducing vulnerability to coastal hazards are dispersed among many local departments and offices. In order to initiate information sharing and spawn collaborative decision-making, the facilitation of the questionnaire should include, but are not limited to, land use planners, hazard mitigation planners, floodplain managers, emergency managers, stormwater engineers, and natural resource planners.

Figure 3: Getting to Resilience



Delaware Bay Focus Area

The Delaware Bay has served as a region of particular concern by the New Jersey Coastal Management Office and partner organizations because this area contains the majority of the state's coastal wetlands and serves as a breeding ground and migratory stopover location for many species. The rural landscape is comprised mainly of farmland, tidal wetlands, and a handful of narrow beaches and is part of the nationally designated Delaware Bay Estuary. The Delaware Bay is rich in biodiversity, serves as the largest spawning ground for horseshoe crabs in the world, and is the second largest avian staging area for migratory shorebirds in the Western Hemisphere. Salem, Cumberland, and Cape May counties alone provide an estimated $2.25 - $3.17 billion annually in ecosystem services, mainly due to the immense acreage of wetlands along the Bay.[4] Unfortunately, high rates of erosion have resulted in a loss of tidal marshes and beachfront, threatening habitat and historic resources alike. As sea level rise accelerates, erosion rates and inundation from storms will only increase, exacerbating the loss of critical habitat and natural storm buffers. As development meets capacity along the New Jersey shore, many vacationers, outdoor enthusiasts, and retirees are likely to discover the assets of living on the Bay and its tidal creeks. Fortunately, the communities along the Delaware Bayshore and their surrounding natural resources will likely have the ability to adapt to changing coastal conditions, making it an ideal location for the New Jersey Coastal Management Office to develop inundation models and provide community outreach on hazards.

In 2007, the New Jersey Office of Coastal Management partnered with state and federal agencies to obtain two-meter resolution elevation data for Salem, Cumberland, and Cape May counties. Elevation data serves as the single most important dataset to determine coastal inundation patterns and vulnerability. Recent improvements in elevation data and the development of tools like VDatum, which allows GIS users to identify tidal elevations, have greatly improved the ability to identify areas of potential inundation under various storm scenarios. It can also be used to identify flooding may change over the course of the next century as sea level rise increases the flooding extent of coastal storms.

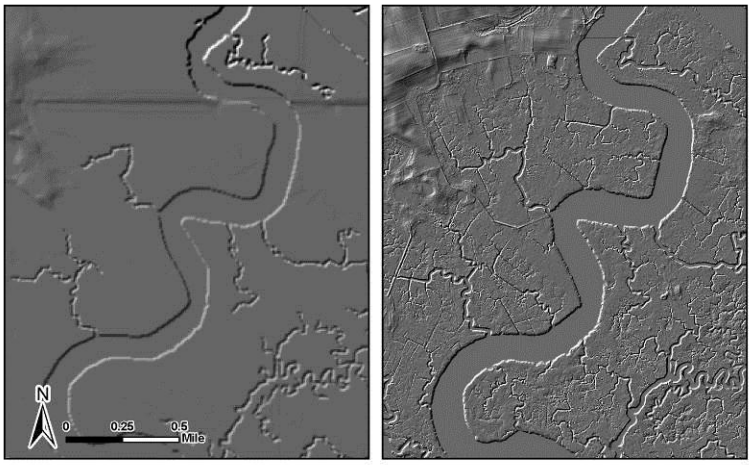
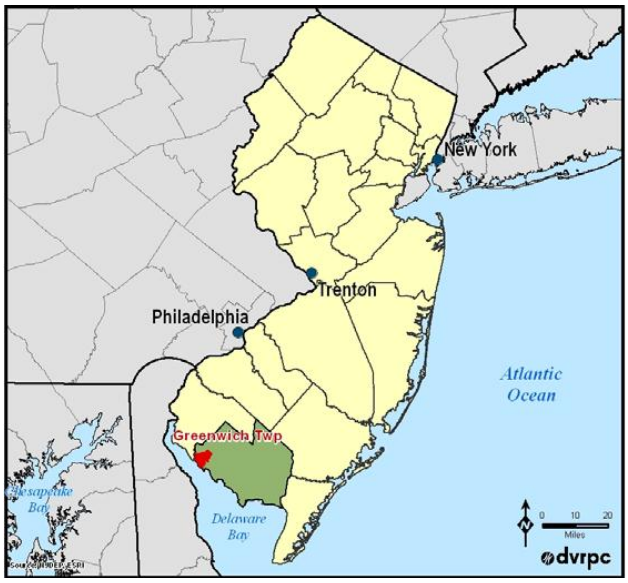


Figure 4: Ten- and Two-Meter Resolution Elevation Data along the Cohansey River

[4] NJDEP. (2007). *Valuing New Jersey's Natural Capital*.

Greenwich Township, Cumberland County, NJ

Greenwich Township is a rural community located along the Delaware Bayshore in the southwestern corner of Cumberland County between the Cohansey River and Stow Creek. The township encompasses nearly 19 square miles of the New Jersey coastal plain and is compromised mainly of grasslands, farmland, and tidal wetlands.



Map 1: Location of Greenwich Township.
Map credit: DVRPC

Originally inhabited by Native Americans, Greenwich was settled by the Dutch in 1683 and later by the English in 1664 who were seeking refuge from persecution in Europe. Greenwich Township established itself as one of the first trading hub along the Delaware River. Prior to the Revolutionary War, tea that was being transported by land from the port to Philadelphia was burned in protest to British oppression. During the 19th Century, Greenwich Township once again served as a place of refuge, providing a safe haven for approximately 300 slaves who traveled the Underground Railroad from the South. After the Civil War, Greenwich served as the epicenter of the sturgeon industry that has since been exhausted. Today, Greenwich Township is recognized as a rural, agricultural community.

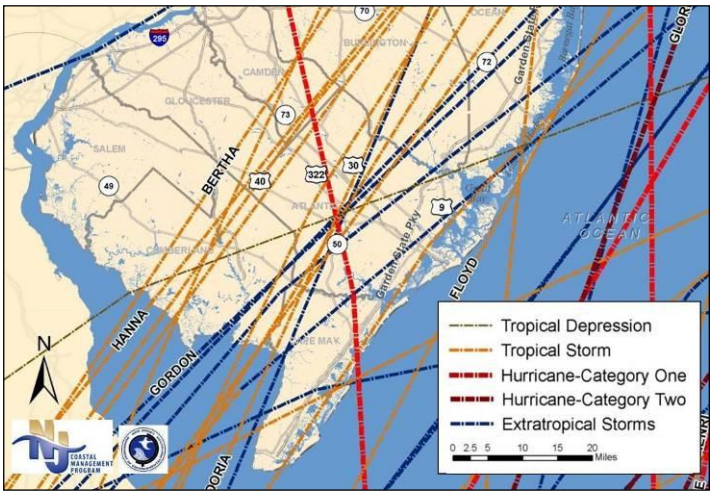
Photo 2: Farmland comprises the majority of the developed landscape in Greenwich Township.
Photo Credit: Mark Ivanick

While the township is zoned mainly for agricultural use, housing and minor commercial development is concentrated in the historic areas of Greenwich Village, Head of Greenwich, and Springtown. Historic homes continue to dominate housing in these communities with some dating back as far as the 1700s. Despite Greenwich's tenure, fewer people live there today than are estimated to have lived in former Native American settlements. The 2010 Census indicates that 804 people presently reside in the township, nearly 100 fewer residents than the 1990 population.

Greenwich Township has worked to maintain its rural character and lifestyle. The goals defined within Greenwich Township's Master Plan clearly convey its dedication to preserving the cultural, historic, and natural resources that characterize the community. These goals include:

1. Preserve the existing historical character of Greenwich Village, Head of Greenwich, Springtown and the surrounding communities.
2. Protect the environment and natural resource base.
3. Maintain agriculture as a mainstay of the community.
4. Designate and manage the cultural landscape as a special quality of life feature of the township.
5. Allow for housing opportunities that are in keeping with existing community character.
6. Provide for limited locally oriented development opportunities.
7. Provide for sustainable economic and recreational opportunities adapted to the township's natural resources.

While the township has made great progress towards preserving its historic and natural landscape, coastal hazards threaten agriculture, historic properties, tidal wetlands, and the safety of township's residents. Greenwich Township is already experiencing coastal erosion along the Delaware Bay, saltwater intrusion into freshwater resources, habitat transition from freshwater to salt marshes, and shallow coastal flooding in low-lying areas. An increased frequency and intensity of coastal storms in the coming decades could have negative impacts to the resiliency of the township. In order to obtain a better understanding of the hazard vulnerabilities that threaten Greenwich Township and other portions of the Delaware Bay, the New Jersey Office of Coastal Management piloted the *Coastal Community Vulnerability Assessment Protocol* and the *Getting to Resilience* questionnaire with the assistance of township volunteers. Through the pilot study, the Coastal Management Office was able to assess the threat of existing vulnerabilities and identify how sea level rise may impact the community overtime. The pilot study also initiated collaboration among local decision-makers and identified opportunities to strengthen the long-term resilience of the township, while preserving its historic and cultural heritage.



Map 2: Historic Storm Tracks, 1850-2008
Data Provided by NOAA Coastal Services Center

Vulnerability Assessment

The New Jersey Office of Coastal Management piloted the *Coastal Community Vulnerability Assessment Protocol* in Greenwich Township to help the township identify infrastructure, natural resources, and vulnerable populations that may be exposed to storm surge inundation and sea level rise. The application of *CCVAP* validated the vulnerability assessment protocol, and helped the Coastal Management Office understand the technical assistance needs of rural, coastal communities in the state.

Mapping Process and Data Collection

The Coastal Management Office worked with township representatives to accurately identify and map significant features of the built and natural environment, in addition to social characteristics, that exist within the township. Utilizing the checklist provided below, volunteers from Greenwich Township provided the Coastal Management Office with a list of features within the township that should be considered for a geospatial vulnerability assessment. The Coastal Management Office then assessed where these built and natural features intersected areas of potential inundation. The Coastal management Office also developed a social vulnerability index[5] to determine if vulnerable populations live within potential flooding and surge extents.

Figure 5: Vulnerability Mapping Considerations Checklist

✓	Built Environment Vulnerability
	Evacuation Routes
	Roads and Bridges
	Railroads
	Emergency Shelters
	Police & Fire
	Nursing Homes*
	Municipal Buildings*
	Public Works*
	Schools
	Houses of Worship*
	Community Center(s) or Meeting Halls*
	Shopping Centers*
	Libraries, Museums*
	Business District*
	Historic Homes*
	Parks*
	Landmarks*
	Dams and Levees
	Stormwater Discharge
	Other:

✓	Natural Environment Vulnerability
	Wetlands
	Forestlands
	Farmland
	Environmentally Sensitive Lands
	Conservation Easements*
	Blue Acres Land*
	Green Acres Land*
	Brownfield Sites
	Manufacturing Sites
	Landfills
	Drycleaners
	Gas Stations
	Point Source Pollution Surface Water Discharge
	Known Contamination Sites
	Other:

✓	Social Vulnerability (Census Data by Block or Block Group)
	Population Density per sq. mile
	Housing Units per sq. mile
	% Elderly, Age 65+
	% Youth, Age 5 and under
	% Youth, Age 17 and under
	% Minorities
	% Individuals Below the Poverty Level
	% Households without English Fluency
	% Individuals Without a High School Education
	% Disabled Individuals
	% Single Parent, Head of Household
	% Single Mothers, Head of Household
	% Properties Built Prior to the NFIP
	% of Housing that are Mobile Homes
	Other:

*Note: Please provide the names and address of any facilities that are marked with an asterisk. If your community is reliant upon any critical facilities that are located outside of your municipal boundaries, please provide their names and addresses as well.

[5] Hazards & Vulnerability Research Institute. (2008). The SoVI Recipe. University of South Carolina. http://webra.cas.sc.edu/hvri/docs/SoVIRecipe.pdf .

Inundation Mapping

The New Jersey Office of Coastal Management developed multiple inundation scenarios for Greenwich Township, including spring tide, storm surge, and sea level rise models. Two-meter resolution, digital elevation models (DEMs) derived from Light Detecting and Ranging technology were utilized as the topographic baseline for the development of the inundation models. NOAA's Vertical Datum Transformation Tool (VDatum)[6] was utilized to model inundation scenarios at high tide, while predicted tide elevations for 2010 and VDatum were used to model a spring tide. Storm surge was modeled at high tide using the National Hurricane Center's Sea, Lake, and Overland Surges from Hurricanes (SLOSH)[7] models, which are typically used by emergency managers for evacuation planning. And sea level rise scenarios were modeled using 0.5, 1.0, and 1.5 meters (~ 20 – 60 inches) of sea level rise on top of present day spring tide conditions.

The mapping revealed that Greenwich Township presently experiences shallow coastal flooding in low-lying areas during spring tides. While a category one hurricane may cause a great deal of wind damage, storm surge does not appear to be a major threat at this classification. Tidal wetlands will likely dampen the surge, protecting the majority of the community. However, category two - category four hurricanes pose the greatest threat to the township, as a large expanse of developed land could become inundated at these classifications. Higher intensity storms will undoubtedly generate greater flood depths and greater areas of inundation. For a storm traveling up the Delaware Bay at high tide, storm surge elevation models indicate that surges could easily over top dikes without even accounting for potential wave heights (see table below).[8] Through the development of numerous inundation maps, it became apparent that a category one storm strongly correlates with the 100-year floodplain and a 1.5 meter sea level rise scenario.

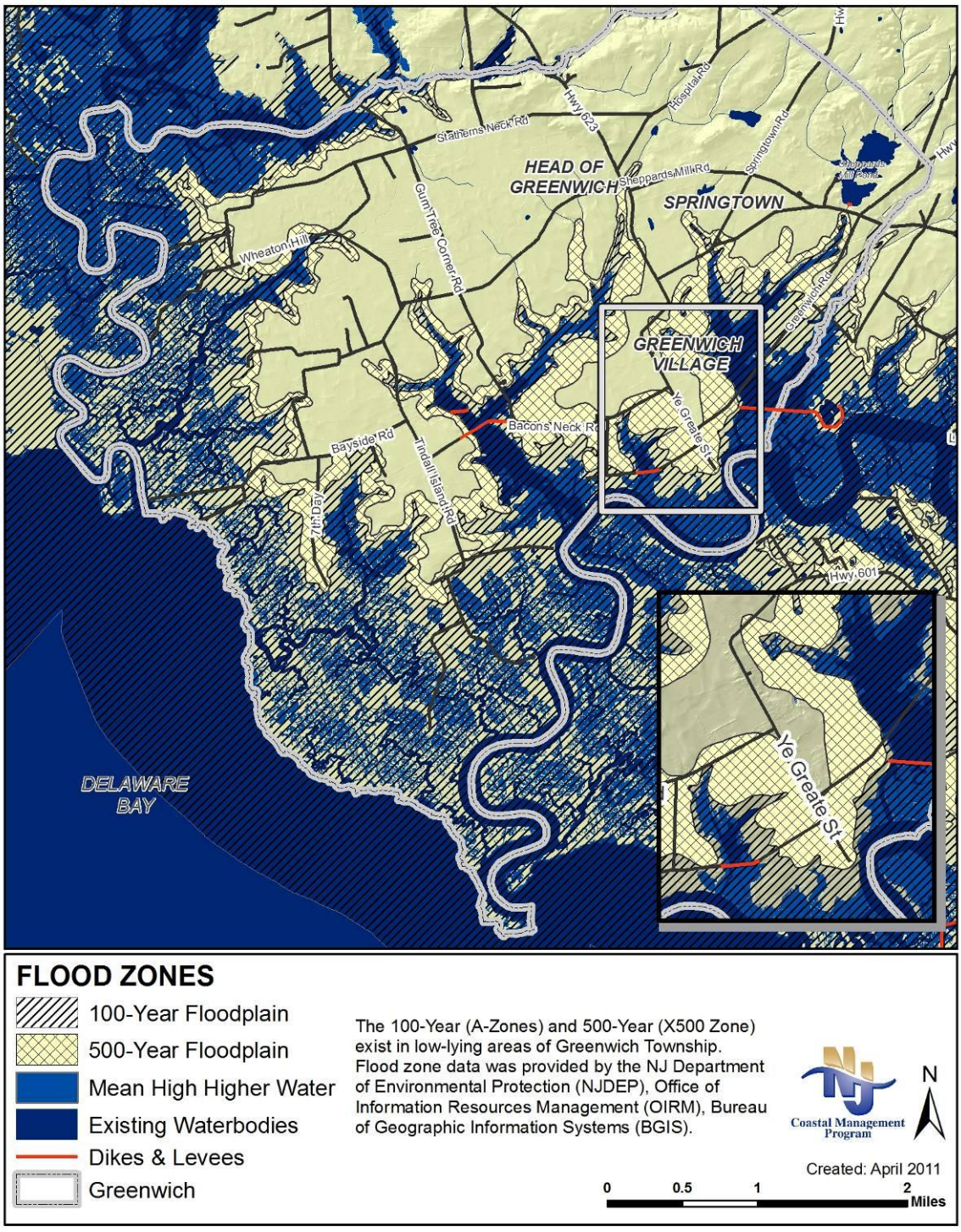
Table 1: Potential Water Depths (in feet)

LOCATION	CATEGORY HURRICANE			
	ONE	TWO	THREE	FOUR
Greenwich Road near dike	5.3	9.5	13.5	16.5
Bacons Neck Road near dike	3.5	9.2	19.7	24.8
Bacons Neck Road at Ye Greate Street	0	0.3	6.6	11.5
Market Lane at Ye Greate Street	0	2.8	7.8	13.0
Springtown Road at Ye Greate Street	0	0	6.3	10.7

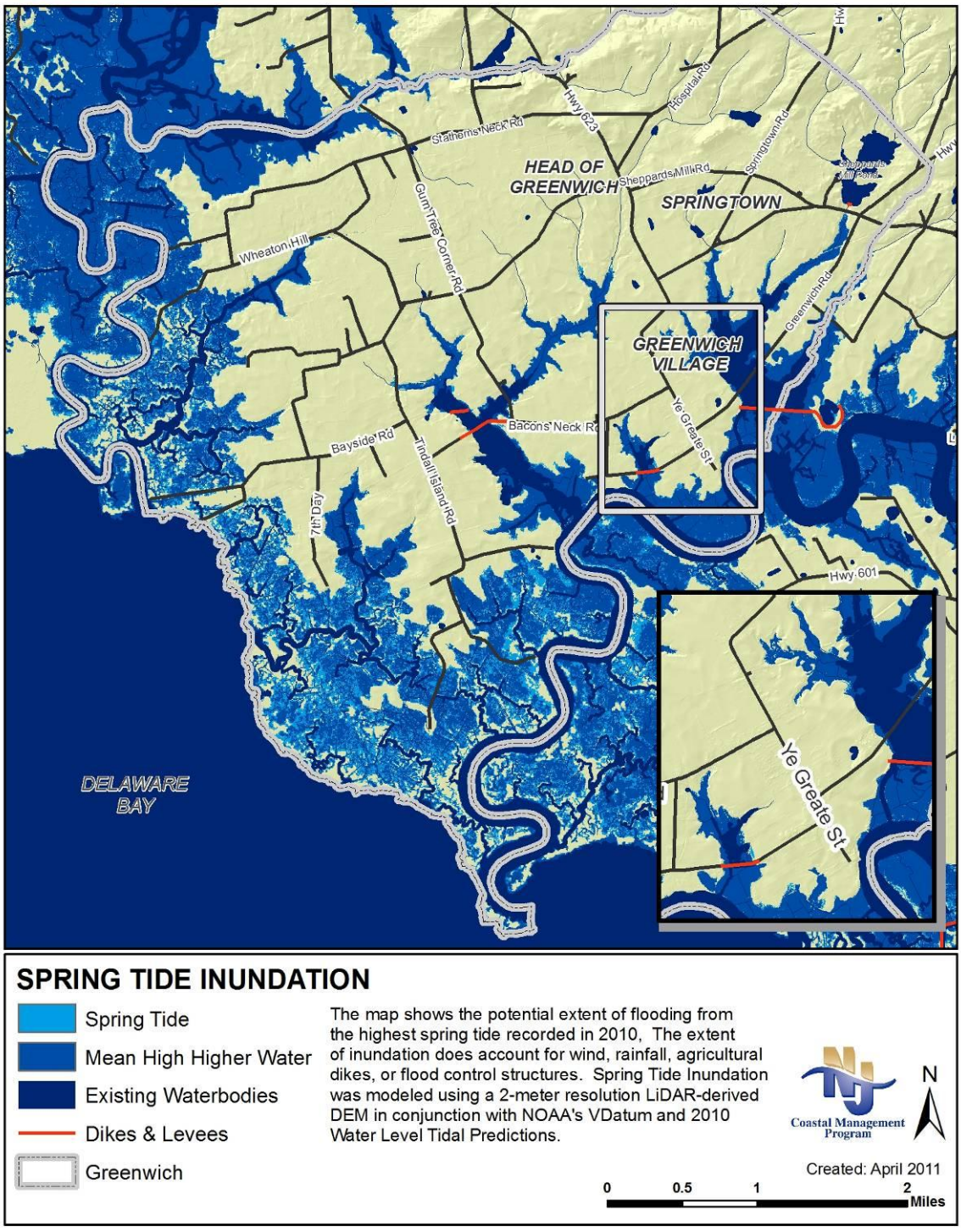
[6] NOAA. 2010. Vertical Transformation Tool (VDatum). http://vdatum.noaa.gov

[7] National Hurricane Center. SLOSH Model. http://www.nhc.noaa.gov/HAW2/english/surge/slosh.shtml

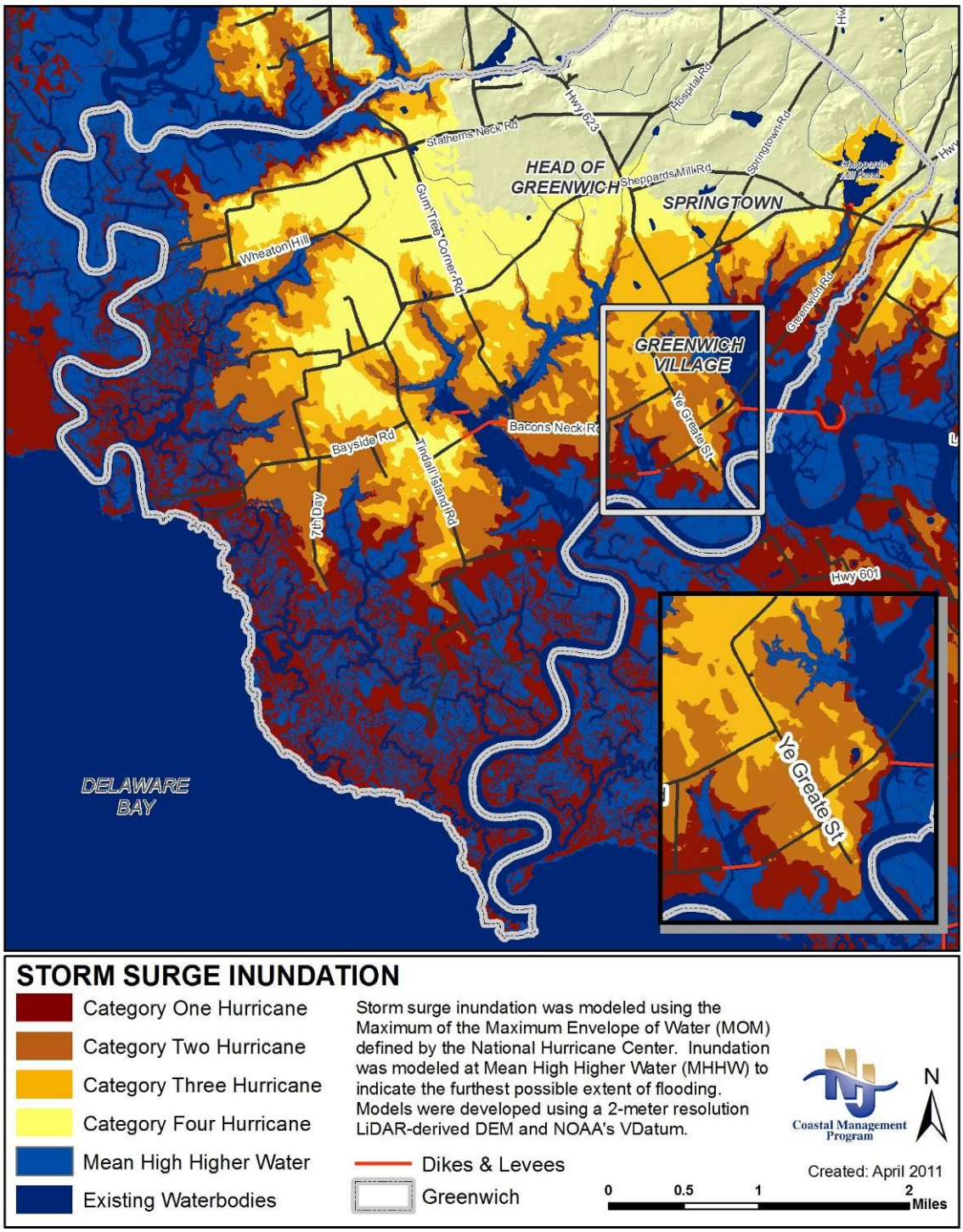
[8] Surge depths modeled with the National Hurricane Center's SLOSH, two-meter resolution LiDAR, and NOAA's VDatum are accurate within ± (20 percent + approximately 1 foot).



Map 3: Flood Zones, Greenwich Township



Map 4: Spring Tide Inundation, Greenwich Township



Map 5: Storm Surge Inundation, Greenwich Township

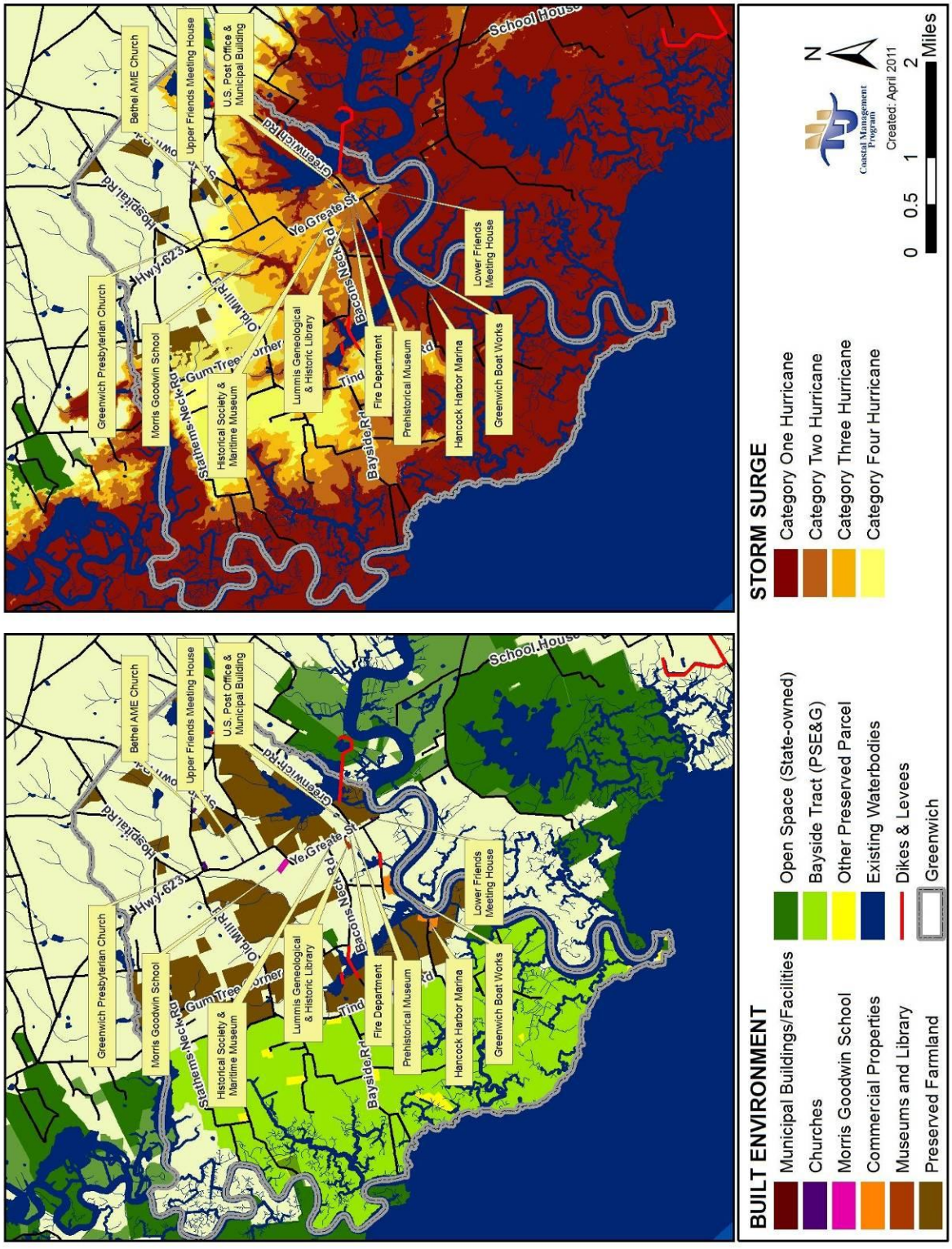
Built Environment Vulnerability

Greenwich Township is comprised mainly of preserved farmland, scenic marshlands, and historic properties. Some of the structures in the township date back to the 1700s, but a large majority of the properties were erected in the early 1800s through the mid-1950s. Luckily, Greenwich Township has never been directly hit by a hurricane, although it has experienced the flooding due to nor'easters and large snowfalls. Unfortunately, properties along the Cohansey River and surrounding diked areas of the township are susceptible to minor flooding during spring tide events. And a large portion of the township is susceptible to storm surge inundation of a category two hurricane. The destruction of a hurricane or major nor'easter could have an immense impact on historic resources in the township and result in short-term disruption of agricultural production; especially if freshwater resources are impacted by saline intrusion. If appropriate, residents should considering installing flood vents, elevating low-lying homes, and installing protective window treatments to ensure historically significant structures, community character, and public safety are not threatened by coastal storms. Additionally, new development should be designed to withstand hurricane-force winds and flood impacts; Fortunately, Greenwich has its own evacuation center, which is located outside of flood prone areas.

Photo 3: Historic properties are prevalent throughout Greenwich Township.
Photo Credit: Trudy Hansen

Table 2: Potential Spring Tide and Hurricane Inundation versus the Built Environment

PROPERTY	SPRING TIDE	CATEGORY HURRICANE			
		ONE	TWO	THREE	FOUR
1. Municipal Building	-	-	X	X	X
2. Greenwich Township Fire House	-	-	X	X	X
3. Greenwich Country Store & Post Office	-	-	X	X	X
4. Morris Goodwin School (Evacuation Center)	-	-	-	-	-
5. Greenwich Presbyterian Church	-	-	-	-	-
6. Bethel AME Church	-	-	-	-	-
7. Friends Upper Meeting House	-	-	-	X	X
8. Friends Lower Meeting House	-	-	X	X	X
9. Hancock Marina and Bait Box Restaurant	-	X	X	X	X
10. Greenwich Boat Works	Partial	X	X	X	X
11. Ship John Inn Restaurant	Partial	X	X	X	X
12. Lummis Genealogical and Historic Library	-	-	X	X	X
13. Gibbons House/Greenwich Historical Society	-	-	X	X	X
14. Cumberland County Prehistorical Museum	-	-	X	X	X
15. John DuBois Maritime Museum	-	-	X	X	X



Map 6: Built Environment versus Storm Surge Inundation

Natural Environment Vulnerability

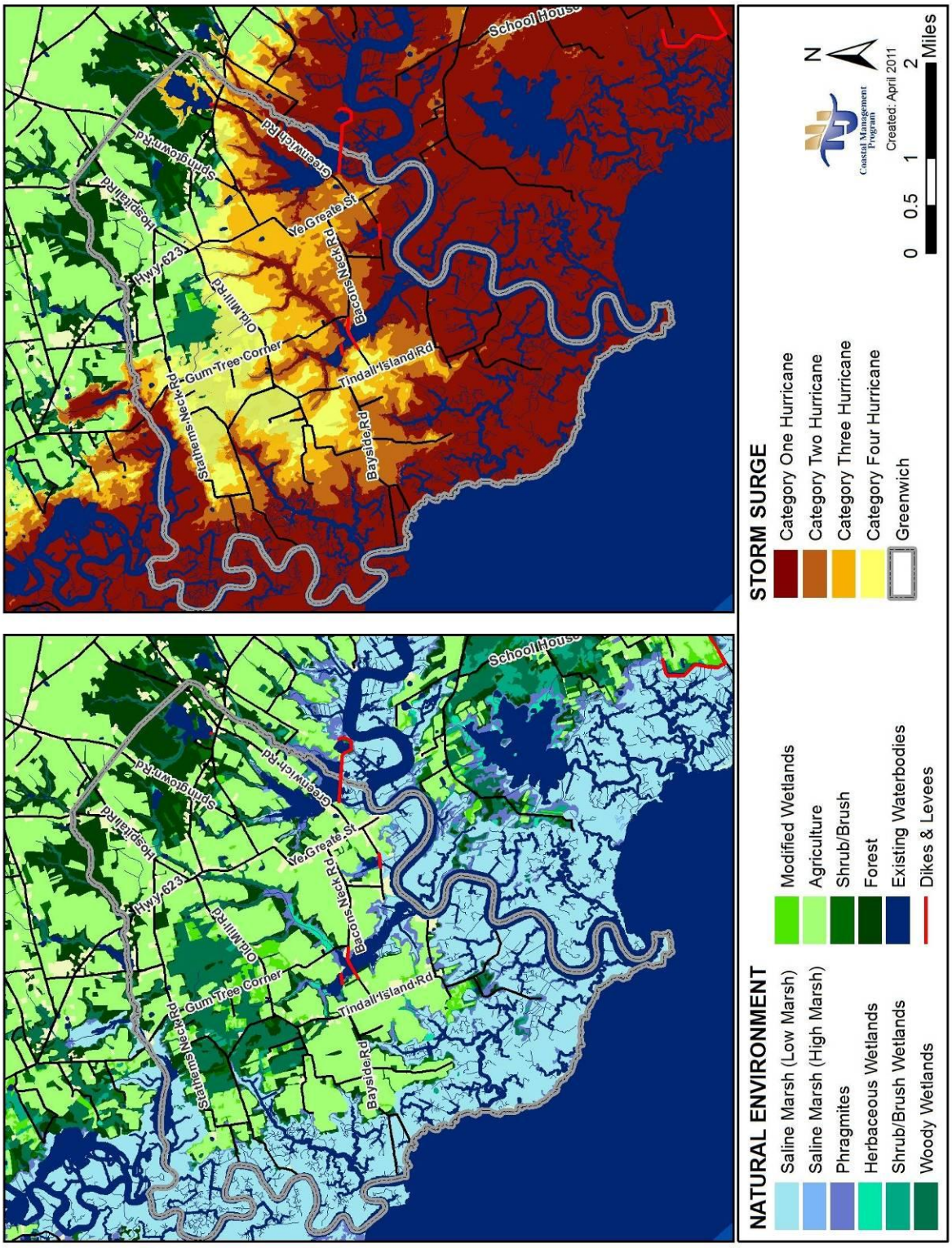
Saline and freshwater tidal marshes, grasslands, and forested areas in Greenwich Township provide significant habitat for wildlife. Wetlands make up nearly one-third of the vegetation in Greenwich Township, of which, a vast majority are contained within a preserved area known as the Bayside Tract. The diverse habitat along the Delaware Bay contributes to its significance as a prime stopover location for migratory birds. The Delaware Bay is also infamous for being one of the most significant spawning grounds for horseshoe crabs in the world. The vitality of these habitats are challenged by changes in salinity and increased rates of erosion. As indicated in the map on the following page, tidal wetlands serve as a buffer for the community, protecting it against the direct surge impacts of hurricanes.

Photo 4: Freshwater habitat in Greenwich Township has been compromised due to dike failure and salinity intrusion. Photo Credit: Leigh Wood

Significant storms threaten to disrupt, alter, or destroy existing habitats through flooding, erosion, saltwater intrusion, dike/levee failure, and high winds. In the last decade, a former agricultural dike at Greenwich Pier failed, resulting in the loss of freshwater habitat, which was established nearly 300 years ago for irrigation purposes. Tidal waters now flow past the weir at Bacons Neck Road into a formerly established freshwater wetland. While the degradation of agricultural dikes may allow for the reestablishment of saltwater marshes, diked, freshwaters in Greenwich Township provide habitat for endangered and threatened species. The USACE is currently working to secure funding restore a dike and create a wildlife management area along the Cohansey River at the mouth of Pine Mount Creek.[9]

Besides providing habitat, freshwater wetlands supply water for local farmers and help to recharge wells. While this study does not account for the potential impacts of storm surge and sea level rise on groundwater, the township should explore withdraw patterns to ensure that the community is taking appropriate measures to protect its water supply and minimize saline intrusion into the Kirkwood-Cohansey aquifer. The map on the following page represents the potential extent of storm surge in relationship to ecosystems in and around Greenwich Township. Accelerated rates of sea level rise will challenge the integrity of these natural resources, which may adapt to changing conditions or be lost over time.

[9] Cumberland County , New Jersey MHMP (Final Draft). (2009). P 6-68



Map 7: Natural Environment versus Storm Surge Inundation

Social Vulnerability

Approximately, 804 people reside in Greenwich Township, nearly 100 fewer people than resided there in 1990.[10] The vast majority of residents are within the working age of 18 to 65. Nearly 20 percent of the population is under age 18, and another 20 percent of the population is at or near retirement. In the event of a coastal storm, the threat of inundation will vary throughout the community. In the event of a hurricane, residents should be aware beforehand of evacuation procedures and if there are any possible threats posed by the Salem Nuclear Power Plant as a result of high winds, loss of electrical power, or flooding. Emergency management officials would benefit from knowing where special needs populations reside so they may focus their evacuation assistance efforts and ensure the safety of its residents.

In order to identify the location of the most susceptible people to coastal storms and to identify the areas of the community to focus evacuation assistance, the New Jersey Office of Coastal Management developed a social vulnerability index for the Delaware Bayshore, utilizing Census data and accounting for population density, housing density, age (youth and elderly), disabled, poorly educated, poverty, single mothers, and linguistically isolated residents. Many of the socio-economic data inputs were only available at the Census Block Group level, and the township's low population and rural character limited the ability to discern where the most vulnerable populations reside. The application of the social vulnerability index in Greenwich Township provided inconclusive results because Census data is not refined well in rural areas, giving a false impression of the geospatial distribution of vulnerable in relationship to storm hazards. In the event of a storm, whether it be a nor'easter or hurricane, municipal leaders and emergency managers would have a greater capability to identify the individuals that may need evacuation or recovery assistance by developing and using a local registry system.

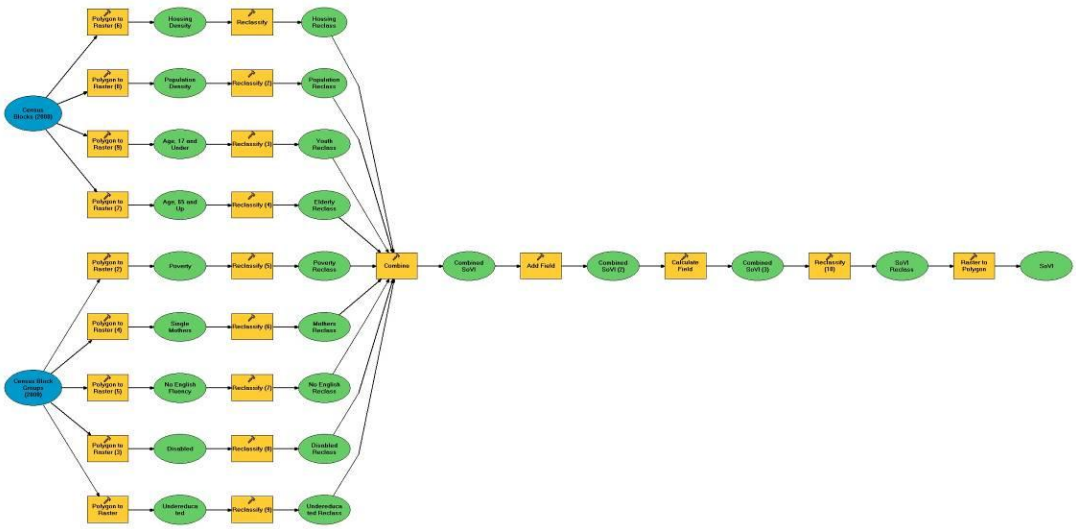
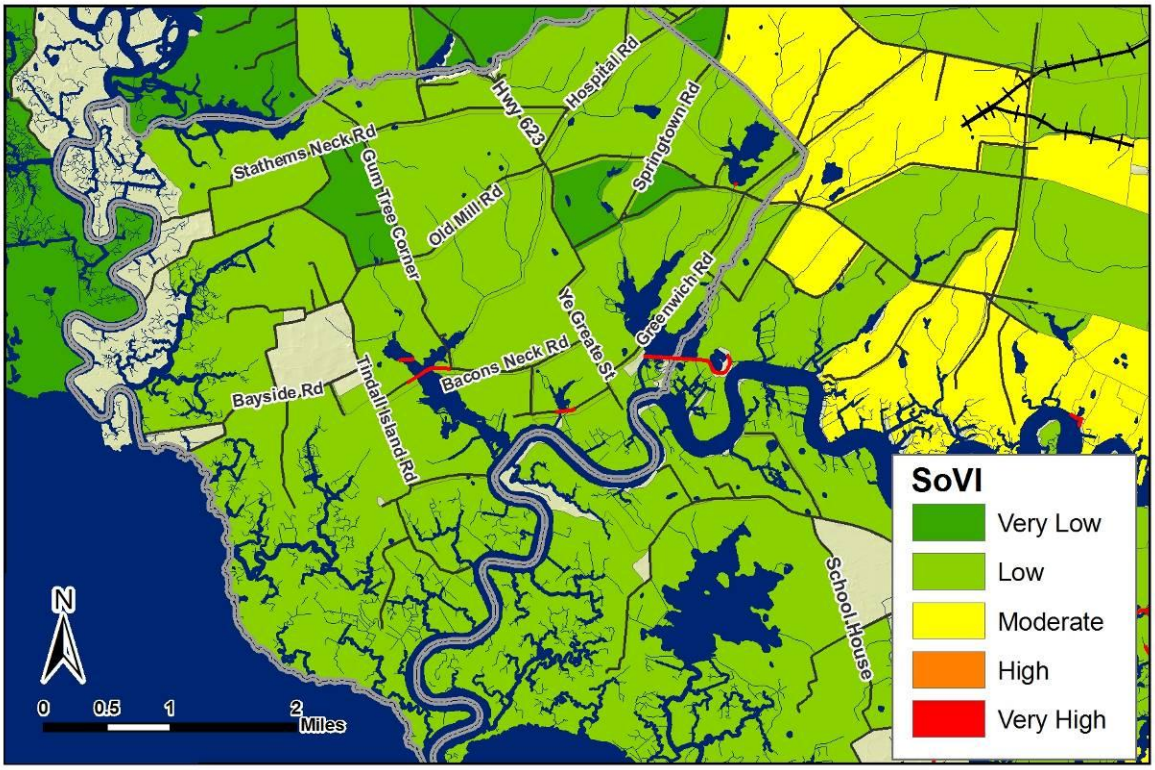


Figure 6: Visual Representation of the Social Vulnerability Index Model

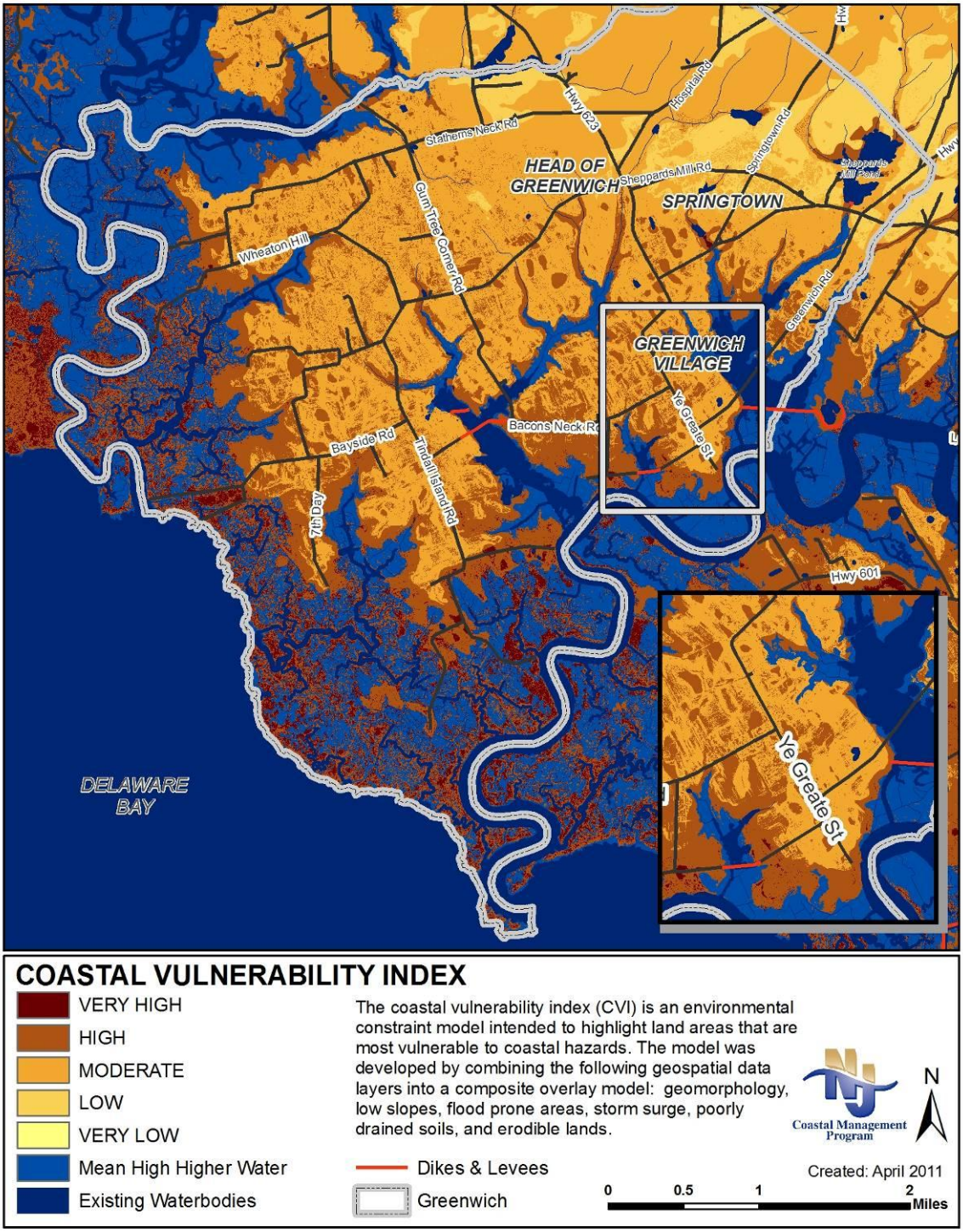
[10] American Factfinder. (2010). 2010 Census, Greenwich Township.



Map 8: Social Vulnerability Index, Greenwich Township

Coastal Vulnerability Index

Inundation mapping can inform planners, emergency managers, and environmental leaders of the potential exposure of built and natural resources and socio-economically vulnerable populations, while a coastal vulnerability index (CVI) can inform local government of land areas that are the most prone to the impacts of a number of coastal hazards. The CVI is a composite, environmental constraint model that incorporates six overarching inputs, including geomorphology, low slopes, flood prone areas, storm surge scenarios, and poorly drained and erosion prone soils. While these factors contribute to the vulnerability of coastal lands, other geospatial factors can be incorporated into a coastal vulnerability index. By combining the available data sets, the CVI revealed that the most hazard prone areas in and around Greenwich Township include the salt and freshwater wetlands in and around the community. High and Very High vulnerable areas correspond with the National Flood Insurance Program's 100- and 500-year flood zones.



Map 9: Coastal Vulnerability Index

Sea Level Rise Vulnerability

Historically, Greenwich Township has experienced approximately 4 mm/year of sea level rise since 1965. If this trend were extrapolated without the consideration of accelerated rates of sea level rise due to climate change, Greenwich Township could experience approximately 0.4 meters (16 inches) of sea level rise over the next century.

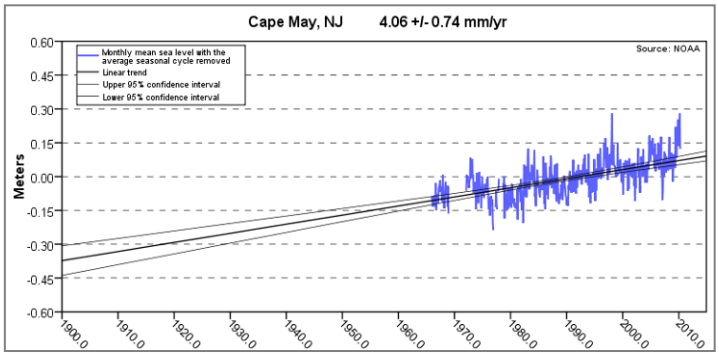


Figure 7: Cape May Point's Historic Sea Level Rise Trends
Source: NOAA. 2010. Sea Level Rise Trends

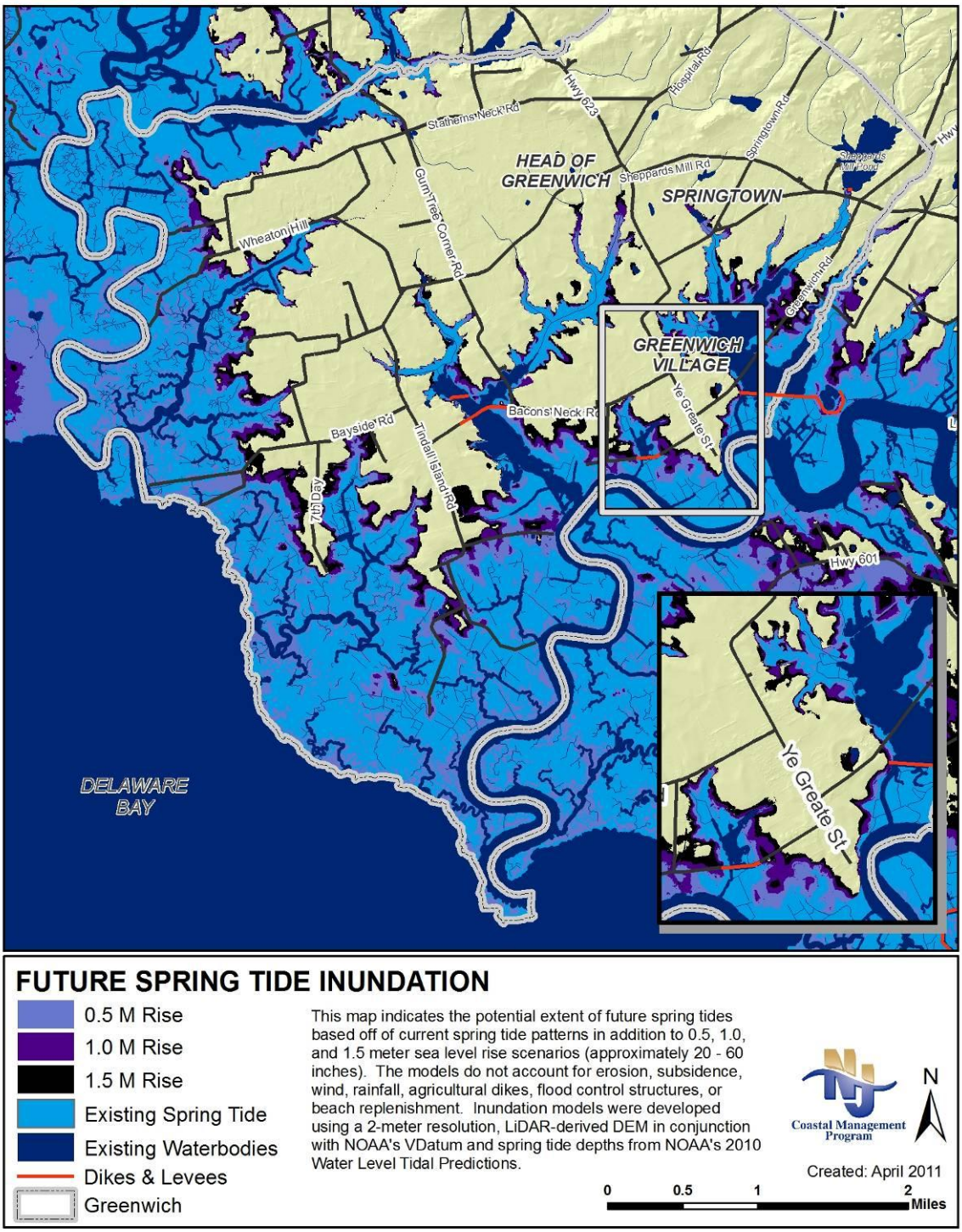
Unfortunately, sea level rise projections incorporating global climate trends indicate the Delaware Estuary will experience approximately 0.5 – 1.5 meters (20 – 60 inches) or greater of sea level rise by 2100.[11] As climate change alters the natural processes of the New Jersey shore, Greenwich Township will likely experience more regular shallow coastal flooding events, greater rates of salinity intrusion into freshwater resources, changes in and loss of critical habitat, and more intense and frequent coastal storms.

The map on the following page reveals the extent of future spring tides, highlighting the threat to Greenwich Township over the next century. Most development will remain largely untouched by sea level rise and the future extent of spring tides.

Table 3: Built Environment and Sea Level Rise Inundation

PROPERTY	SPRING TIDE	SEA LEVEL RISE (METERS)		
		0.5	1.0	1.5
1. Municipal Building	-	-	-	-
2. Greenwich Township Fire House	-	-	-	-
3. Greenwich Country Store & Post Office	-	-	-	-
4. Morris Goodwin School (Evacuation Center)	-	-	-	-
5. Greenwich Presbyterian Church	-	-	-	-
6. Bethel AME Church	-	-	-	-
7. Friends Upper Meeting House	-	-	-	-
8. Friends Lower Meeting House	-	-	-	-
9. Hancock Marina and Bait Box Restaurant	-	Partial	X	X
10. Greenwich Boat Works	Partial	Partial	X	X
11. Ship John Inn Restaurant	Partial	Partial	X	X
12. Lummis Genealogical and Historic Library	-	-	-	-
13. Gibbons House/Greenwich Historical Society	-	-	-	-
14. Cumberland County Prehistorical Museum	-	-	-	-
15. John DuBois Maritime Museum	-	-	-	-

[11] Partnership for the Delaware Estuary. 2010. Climate Change and the Delaware Estuary. P. 6



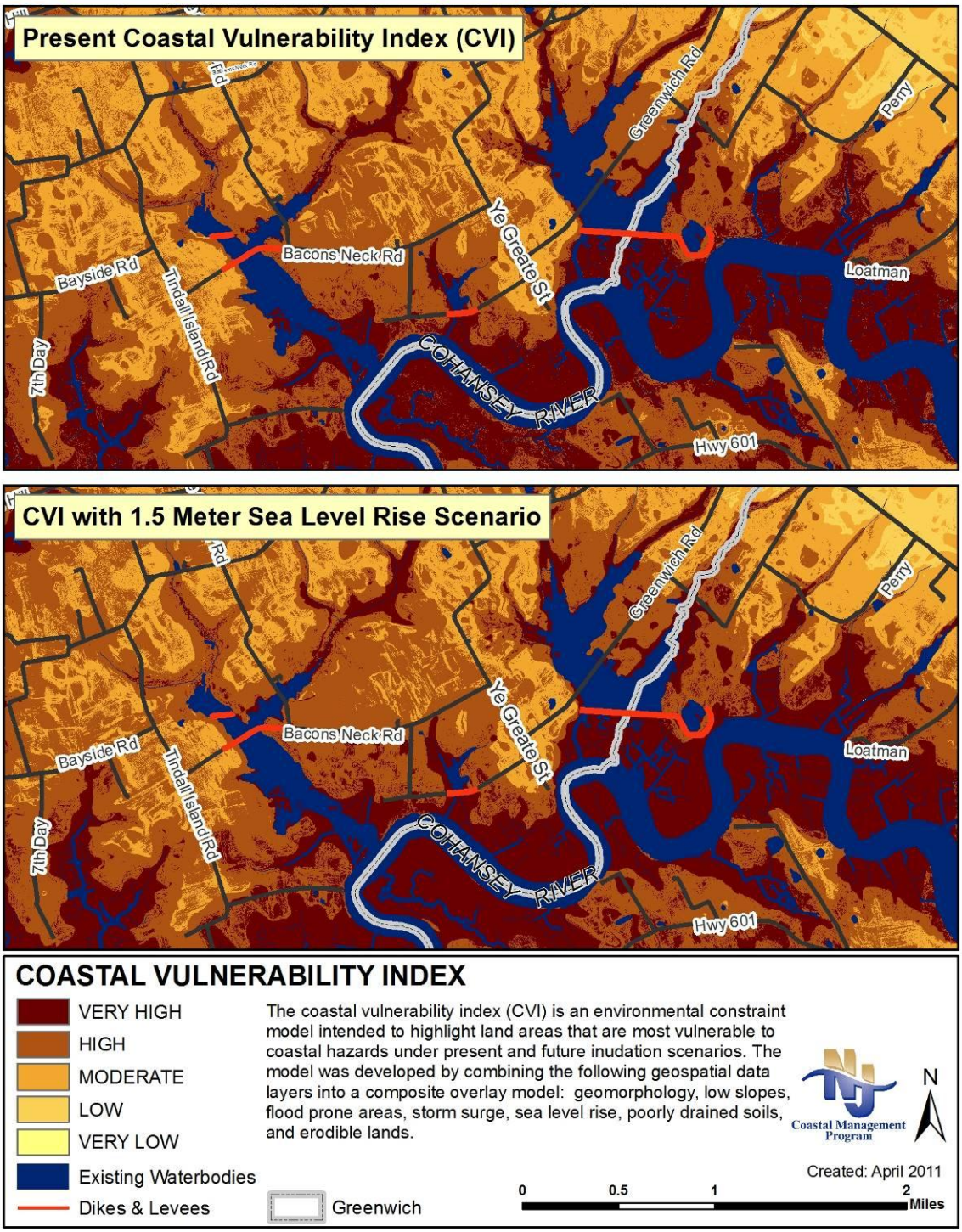
Map 10: Future Spring Tide Inundation Due to Sea Level Rise

Marshes, natural areas, preserved land, and marinas appear to be the most susceptible to permanent inundation from sea level rise. While most structures in the community will not be impacted by increased flooding and higher spring tides, tidal wetlands may be subjected to permanent inundation, resulting in the loss of substantial habitat and breeding grounds for aquatic species and migratory birds. Substantial loss of vegetated marshlands will make Greenwich Township more vulnerable to coastal storms due to the decreased storm buffer surrounding the community, and it will also result in the loss of carbon sequestration capacity. In addition, the inward movement of tidal waters could easily topple existing agricultural dikes and contaminate freshwater resources and wells with saltwater; thus, impacting agricultural production and water supply. Many dikes or levees are also associated with protecting roads into and around the township, such as Pine Mount – Mill Creek dike (right). The maintenance of existing dikes not only protects traffic flows. Greenwich Township must remain capable of evacuating during a possible nuclear fallout, and it must be able to continue to support agricultural production. Without the repair of these dikes, the character of this community will be comprised, habitat will be detrimentally altered and the township's economic staple could be damaged. The only foreseeable alternative to repairing or reinforcing existing dikes would be to allow them to fail and provide water and/or sewer services from an adjacent community to protect agricultural production, accepting the loss of habitat and transportation conduits- all of which would negate the goals of the township's master plan.

Photo 5: Pine Mount - Mill Creek dike provides flood protection and protects freshwater resources. Image: Google

Future Coastal Vulnerability Index

Sea level rise and climate change are expected to increase the spatial extent of high hazard areas. In order to visualize this change, the New Jersey Coastal Management Office added sea level rise into the storm surge scenarios of the coastal vulnerability index. The map on the following page indicates how high hazard areas will shift inland over time. Because this shift is difficult to discern, it should be assumed that the topography in most of the developed areas of the township will hinder sea level rise from drastically shifting flood prone areas inland, unless subsidence, erosion, and storm intensity increase into the future.



Map 11: Future Coastal Vulnerability Index

Resilience Assessment

The Getting to Resilience questionnaire was facilitated in a focus group setting to initiate a dialogue among local decision-makers about coastal hazards, vulnerability, and community resilience. The application of the tool was intended to highlight positive actions already underway within the township and identify opportunities to improve local resilience through existing planning, public outreach, mitigation, and response mechanisms. Over the course of approximately two hours, community leaders answered and discussed the portions of the questionnaire in which they were most familiar. The application of *Getting to Resilience* not only acted as a forum for discussing ways to improve resilience, it also informed the New Jersey Coastal Management Office of the technical and education needs of small, coastal communities. The Coastal Management Office intends to use its experience in piloting *Getting to Resilience* to improve its facilitation in other coastal communities in New Jersey.

Members of the environmental commission, an emergency responder, and a member of the county planning staff provided their knowledge of existing planning documents and local initiatives, assisting in the completion of the *Getting to Resilience* questionnaire. Due to a lack of representation from all township sectors, some portions of the questionnaire remained unanswered except for information readily evident in local planning documents. The local representatives who did participate in the completion of the questionnaire were able to discuss existing threats to the community and identify future opportunities to improve local resilience to shallow coastal flooding, episodic storm events, and gradual changes in the coastal environment. The following are some of the highlights from the five-part questionnaire:

Risk and Vulnerability Assessments

- Greenwich Township experiences shallow coastal flooding, and some residential structures are known to consistently have water in their basements. This may pose a safety and health risk to residents.
- Township leaders need access to risk and vulnerability assessments, including maps and potential costs of hazards.
- The Cumberland County Multi-Hazard Mitigation Plan (MHMP) includes a flood zone map and storm surge map of the county. Unfortunately, they are difficult to see at the scale provided, limiting their use.
- The plan identifies the potential cost and number of housing units that are susceptible to storm surge scenarios as defined by the USACE, but the plan indicates that there are nearly double the total number of housing units in the township than the 2010 Census indicates.
- The Cumberland County MHMP indicates that erosion hazards should be identified and mapped within the community.
- Risk and vulnerability assessments can help local decision-makers prioritize capital improvements and land conservation efforts.

Public Engagement

- The municipality relies heavily upon federal, state, and county efforts to educate citizens about storm hazards and evacuation procedures.
- Residents need access to information on storm vulnerability and hurricane evacuation procedures.
- Residents need information on flood vents, weather proofing, and window protection, especially storm protection that does not alter the historic character of the community.
- The Cumberland County MHMP indicates that Greenwich Township should utilize USACE surge maps for community education and outreach.

Planning Integration

- Greenwich Township's Master Plan and ordinances and the County's Farmland Preservation Plan truly encompass sustainability and low-impact principles for coastal development and the preservation of rural character.
- The Master Plan addresses floodplain development, and local ordinances provide a consistent message by only allowing low-density development in the 100-year floodplain, requiring minimum 10-feet elevation of new structures above adjacent water bodies.
- The Master Plan highlights the importance of protecting wetlands for flood protection, and local ordinances support this by requiring vegetated buffers remain along water bodies.
- The Master Plan highlights the significance of stormwater management, wetland protection, and low density development as flood prevention measures that will also protect the character and integrity of the community.
- The Master Plan Reexamination, the Environmental Resource Inventory, and the Cumberland County MHMP all indicate the need to repair dikes within the township.

Disaster Preparedness and Recovery

- Residents are interested in flood protection options for non-elevated structures or structures that were built prior to the National Flood Insurance Program.
- Municipal emergency responders rely upon the direction of county and state emergency management officials to guide the evacuation and reentry process in Greenwich Township.
- The Cumberland County MHMP suggests installing a back-up generator at Morris Goodwin School, since it serves as a shelter for the township.
- The township's shelter is located outside of flood prone areas.
- Greenwich Township is located in a fallout area for the Salem Nuclear Power Plant. There are existing coordinated procedures in place to address such an event.

Hazard Mitigation and Implementation

- Greenwich Township is the only community in Cumberland County that is participating in the National Flood Insurance Program's Community Rating System to enhance risk management and decrease flood insurance premiums for policy holders. [12]
- Greenwich Township may need technical assistance to improve its Community Rating System score.
- Although the township's dikes were not designed for storm protection, the community relies upon dikes and levees to hamper flooding and storm surge.
- Dike restoration will require partnerships to finance and to maintain.
- The USACE is initiating the restoration of a local dike to establish a fish and wild sanctuary.
- While farmland preservation and the rural character of the township will help mitigate future flood losses, Greenwich should explore additional land acquisition funds, such as FEMA's Hazard Mitigation Grant Program, Flood Mitigation Assistance, or the Coastal and Estuarine Land Conservation Program.
- Greenwich Township should capitalize on the knowledge of local historians and restoration specialists to identify storm protection and mitigation opportunities for historic structures.

Greenwich Township Findings and Recommendations

Greenwich Township's rural setting, vast tidal marshes, and integrated planning efforts all help to protect and preserve its historic and scenic character. Unfortunately, the township is susceptible to periodic coastal flooding, coastal storms, and sea level rise. The *Coastal Community Vulnerability Assessment* revealed that the majority of Greenwich Township's structures are not threatened by minor coastal flooding or even the inundation of a category one hurricane. It did, however, reveal that a category two hurricane or greater could have immense impacts on the township, freshwater wetlands, and historic structures. Looking into the future, 1.5 meters of sea level rise during a spring tide has a similar inundation pattern that a category one hurricane could have today. While a category one storm would have minimal long-term impacts on the township, sea level rise of these heights could result in the drowning of saltwater wetlands and the conversion of diked, freshwater wetlands into saline marsh. Municipal officials should utilize the present and future inundation scenarios from this report to help guide future planning, mitigation, land acquisition, and public education.

The facilitation of the *Getting to Resilience* questionnaire revealed that municipal leaders in Greenwich Township are eager to ensure the safety of their residents and the protection of natural and historic resources. The township's Master Plan, Environmental Resources Inventory, and ordinances strongly integrate with one another, each supporting the other in a cohesive fashion. Cumberland County's Farmland Preservation Plan and Multi-

[12] Cumberland County , New Jersey MHMP (Final Draft). (2009). P 8-20.

Jurisdictional Mitigation Plan are both designed for implementation at the county scale, but take strong steps towards helping the Township maintain its Master Plan goals. The township should capitalize on these county plans, by augmenting and incorporating their recommendations into the Master Plan.

Greenwich Township has made extensive progress in preserving its rural character through farmland preservation and low density and agricultural zoning. As the township continues to focus on land acquisition, it should leverage land conservation programs as identified in the County Farmland Preservation Plan. It should continue to take advantage of the state's Green and Blue Acres Program and consider seeking additional funding through federal programs, like the Coastal and Estuarine Land Conservation Program (CELCP) and FEMA mitigation grants. FEMA mitigation grants, which are addressed in the County's Multi-Jurisdictional Hazard Mitigation Plan, can be used for elevating or relocating flood prone homes, repairing local infrastructure, and for land acquisition in extremely flood prone areas. While federal grants are very competitive, integrated planning on the local level reinforces the need for conservation, historic preservation, and flood protection, thus, making the township's grant applications more robust and successful.

Knowing that freshwater resources are threatened by saltwater intrusion and habitat conversion, Greenwich Township has some difficult and potentially costly decisions to make now and into the future. Agricultural dikes were established in the township over three centuries ago. These dikes not only provide water for irrigation, they provide habitat and groundwater recharge. While these dikes were not installed for flood protection, many of them now serve that purpose, as homes and roads have been built in the areas behind them. These dikes now serve a much greater purpose than they were originally intended, and their failure could impact water supply, agriculture, and habitat for threatened and endangered species. Greenwich Township is working with county, state, and federal partners to reestablish these dikes. Partnership for dike restoration will be costly, but restoration should also consider at least 1.0 meters of sea level rise by 2100. This minimum level of rise is consistent with research being supported by the New Jersey's Climate Office and local research. In order to account for sea level rise, dikes will need to be built higher and longer than a design that does not consider sea level rise. While this may appear to be costly upfront, it will ensure the investment is not futile due to an inadequate design.

While dike restoration is of prime importance to the community, it should also weigh the ecological benefits of allowing for saltwater wetlands to migrate inland in undeveloped areas. Sea level rise is anticipated to result in a net loss of saltwater wetlands, especially if bulkheads prohibit their natural migration. Saltwater wetlands are already struggling to maintain the pace of migration with current rates of sea level rise. Accelerated rates of rise will only result in greater loss of habitat and breeding grounds for aquatic and avian species. Reduction in the acreage of saltwater wetlands will reduce the natural ability of the Earth to sequester carbon dioxide and other greenhouse gases. Knowing this, the township should keep abreast of federal funding or research opportunities as programs,

like the EPA, the Partnership for the Delaware Estuary, and the Army Corps of Engineers, seek locations to monitor wetland migration, pilot living shoreline installations, and create new wetlands. Such research and adaptation measures will be pivotal to understanding climate change impacts throughout the Delaware Estuary.

Besides land conservation and habitat restoration, Greenwich Township and Cumberland County should actively engage residents through information sharing on coastal hazard vulnerability. As recommended by the Cumberland County MHMP, Greenwich Township could use existing flood plain and storm surge maps to target coastal hazard education and mitigation efforts. The township should take advantage of existing communication measures, like tax bills or police/fire updates, to inform people about storm vulnerability, evacuation procedures, and structural mitigation options. The township should utilize public forums and/or provide informational materials to its residents and businesses at least on a yearly basis. The township should continue to partner with the county to help develop county-wide programs and preparedness materials. Emergency responders should continue to refine and utilize their local registry program and the state's Register-Ready Program to account for individuals or families that may need assistance in a disaster event. A grassroots effort to educate the public about storm vulnerability, disaster preparedness, and evacuation procedures will build capacity for community resilience.

In all, the piloting of the *Coastal Vulnerability Assessment Protocol* and the *Getting to Resilience* questionnaire not only validated the appropriate process in which to engage coastal communities about hazards reduction, it fostered collaboration between state, local, and county governments. Coupling the use of these tools not only informed participants of existing inundation vulnerabilities, it spurred conversation about public education and hazard reduction. The township and county should utilize recommendations from this document to help guide their efforts to reduce their vulnerability and become more resilient to coastal hazards and the impacts of climate change.

Resources: Tools and Best Management Practices

There are numerous ways to improve coastal community resilience by completing a risk and vulnerability assessment, providing public outreach, integrating existing planning efforts, preparing and responding to coastal storms, and mitigating vulnerabilities within your community. The following are a handful of the tools and best management practices being utilized throughout the country.

Risk and Vulnerability Assessments

- HAZUS-MH
  - Software: http://www.fema.gov/plan/prevent/hazus/
  - Training: http://www.fema.gov/plan/prevent/hazus/hz_trngconf.shtm#3
- SLOSH
  - Website: http://www.nhc.noaa.gov/HAW2/english/surge/slosh.shtml
  - Obtain Access to GIS Data: http://slosh.nws.noaa.gov/sloshPub/disclaim.php
- NOAA Coastal Inundation Training: http://www.csc.noaa.gov/digitalcoast/training/inundationmap.html
- Coastal GIS Training: http://www.csc.noaa.gov/digitalcoast/training/index.html

Public Outreach and Engagement

- Public Participatory Mapping http://www.csc.noaa.gov/cms/human_dimensions/participatory_mapping.pdf
- Flood Signage
  - High Water Mark Signs: http://www.weather.gov/os/water/high_water/
  - Storm Surge Height Signs: http://www.hillsboroughcounty.org/pgm/hazardmit/stormsurge/
- Register Ready: https://www13.state.nj.us/SpecialNeeds/
- Storm Ready
  - National Weather Service: http://www.stormready.noaa.gov/
- Storm Preparedness
  - Cape May Point Ready Campaign: http://cmp-taxpayers.org/Documents/Ready%20Bundle.pdf

Planning Integration

- American Planning Association's Model Hazard Element: www.planning.org/GrowingSmart
- Florida's Land Use Planning Strategies and Best Management Practices for Minimizing Vulnerability to Flooding and Coastal Storms- DRAFT. http://www.dcs.state.fl.us/fdcp/dcp/publications/hazmitbp.pdf
- New Jersey Model Floodplain Ordinances: http://www.nj.gov/dep/floodcontrol/modelord.htm

Disaster Preparedness and Recovery

- Storm-Ready Communities: http://www.stormready.noaa.gov/resources/toolkit.pdf
- Community Emergency Response Team (CERT): http://www.citizencorps.gov/cert/
- Community Rating System: http://www.fema.gov/business/nfip/crs.shtm
- Hurricane Planning and Impact Assessment Reports http://www.csc.noaa.gov/hes/about.html
- Post-Disaster Redevelopment Plan http://www.dca.state.fl.us/fdcp/dcp/PDRP/overview.cfm

Hazard Mitigation Implementation

- Hazard Mitigation Planning Tools
    - Community Rating System http://www.fema.gov/business/nfip/crs.shtm
    - All-Hazards Mitigation Plan Crosswalk http://www.otsegocountymi.gov/uploads/Otsego-FEMA-Local-Crosswalk-2004.pdf
- Hazard Mitigation Grant Programs: http://www.fema.gov/library/viewRecord.do?id=4225
- Land Acquisition
    - New Jersey Green Acres/Blue Acres: http://www.nj.gov/dep/greenacres/
    - Coastal and Estuarine Land Conservation Program (CELCP): http://coastalmanagement.noaa.gov/land/welcome.html
    - Property Acquisition Handbook for Communities. http://fema.gov/government/grant/resources/acqhandchap.shtm
- Structural Mitigation Guidance
    - Homeowner's Guide to Retrofitting http://www.fema.gov/library/viewRecord.do?id=1420
    - Against the Wind: Protecting Your Home From Hurricane and Wind Damage http://www.fema.gov/library/viewRecord.do?id=1641
    - Catalog of FEMA Flood and Wind Publications, Training Courses, and Workshops: http://www.fema.gov/library/viewRecord.do?id=3184

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